INTEGRATED PEST MANAGEMENT PLAN
Maxwell National Wildlife Refuge
Colfax County, New Mexico

Written and Revised in 2002 by
Daniel R. Dinkler, Invasive Species Biologist

Edited by
Dr. Elaine Snyder-Conn, National Pest Management Coordinator

Approvals and Concurrence

Maxwell National Wildlife Refuge:

Project Leader

Signature Date

Southwest Regional Office:

National Wildlife Refuge System

Refuge Supervisor, Arizona & New Mexico:

Signature Date

Invasive Species and IPM Coordinator:

Signature Date

Regional Contaminants Coordinator:

Signature Date

Washington Office:

National Pest Management Coordinator:

Signature Date

INTEGRATED PEST MANAGEMENT PLAN
Maxwell National Wildlife Refuge
Colfax County, New Mexico

Introduction

The following is a comprehensive Integrated Pest Management (IPM) Plan for controlling or eliminating key weed and insect pests affecting Maxwell National Wildlife Refuge trust resources and to meet our compliance needs with State and Federal noxious and invasive species laws. This plan is developed under the authority of the Federal Plant Protection Act of 2000, the Federal Noxious Weed Act of 1974, Executive Order 13112, the Refuge Administration Act of 1965, the Refuge Improvement Act of 1997, and the New Mexico Noxious Weed Management Act of 1998, and is in following with the requirements of the Refuge Manual for the National Wildlife Refuge System (7 RM 14). This plan is also intended to address recent Director's priorities to control invasive species in the refuge system's "*Fulfilling the Promise*" document and related work group efforts.

Invasive and noxious weeds at Maxwell Refuge have already reduced wildlife habitat and biodiversity and are infesting neighboring lands. Not only are these invasive plants problematic on the refuge and across refuge boundaries, but when a cooperative farmer exports products off the refuge, such as alfalfa hay, and that hay contains invasive weeds, that hay can infest other off-refuge sites, providing a botanical version of "typhoid Mary". Such transport can also occur by wind or water, or by seed transport on farm or other equipment or the thousands of visitor vehicles traveling on and off the refuge. Obviously, these are not the kind of contributions to the ecosystem expected from our national wildlife refuges.

Maxwell Refuge recognizes the special importance of immediate and long-term attention to its invasive weeds based on the "3:1 principle" that for ***each year*** a treatment is delayed, it will take an ***additional three years*** to achieve the same level of control. That numeric value of "times three" applies to the increased labor and other costs, as well as to the volume of herbicides needed, if effective treatments are delayed. Thus, treatment costs can increase geometrically by delaying an effective control program . With this IPM Plan, Maxwell Refuge aims to demonstrate land stewardship in controlling invasive plants and other pests, while striving toward the goal of restoring native habitats and fauna, thereby re-establishing the health of the refuge ecosystem. The Director's Priority for invasive species also elevates the control of invasive species on all units of the refuge system to a high priority.

By definition, a weed is an unwanted plant, wherever it occurs. On Maxwell Refuge, insect and weed pests are common in and around farm fields. Numerous exotic plant species considered noxious or invasive in New Mexico are well established on Maxwell Refuge, competing with native plants for sunlight, water and nutrients, and jeopardizing the ability of the refuge to provide habitat for migratory birds, which is the primary purpose of the refuge. While many weeds establish by pioneering on disturbed sites, and are eventually followed in succession by native species, Maxwell Refuge also hosts a variety of more insidious, exotic, noxious plants termed "***invasive***." Such invasive plants are not only effective at pioneering disturbed sites, but

they also proliferate to the exclusion of native plants, interrupting the natural process of plant succession and permanently dominating the vegetative communities in the absence of natural biocontrols from their original source locations. Once established, invasive species can have a dramatic, negative impact on ecosystems. Millions of acres of the western landscape have rapidly been taken over by single invasive species, with yellow starthistle and leafy spurge providing two of the worst examples.

In the plan, we present IPM treatments selected to control pests according to the refuge's various site and soil types, with attention to resource needs. Both pesticide and non-pesticide control methods are considered, specific to each pest species, as are mapping, monitoring and prevention methods. Previous experiences in controlling pests are also described, so that only methods that are likely to be effective in the future are used. If there are sensitive resources present at some of the sites, such as rare or listed species or other species of concern, limiting treatment options, these resources and their locations are discussed and low-risk treatment options are selected to protect the sensitive species or sites. For example, if an infestation is adjacent to a perennial water source and a herbicide treatment would likely contaminate that water, then that treatment option would be inappropriate at that site. Similarly, a broad-spectrum herbicide would be inappropriate unless it was used as a spot treatment only on the pest in question and precautions are identified to reduce drift, leaching, and runoff to sensitive areas nearby. In many cases, more than one invasive weed species is present on a site. In these instances, treatments are designed to treat the highest priority invasive plant species. This plan recognizes that pest control, and particularly invasive species control, will require a multi-year commitment, with follow up monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods fail.

Site Description

Maxwell National Wildlife Refuge is situated in northeastern New Mexico near the western edge of the historical shortgrass prairie and just east of the Sangre de Christo Mountains (Figure 1) very near the historic Santa Fe Trail. Situated in the watershed of the nearby Canadian River, Maxwell Refuge falls into the Arkansas-Red River Ecosystem and is administered through the U.S. Fish & Wildlife Service's (Service) Southwestern Regional Office located in Albuquerque, New Mexico. The Refuge encompasses 2,792 acres of habitat acquired in fee title. Located in the highlands with elevations in the range of 6,100 feet, the topography includes areas that are almost flat interspersed with gently rolling, low hills, creating some sinks and playas, the largest of which have been converted to irrigation reservoirs that are owned and managed by the Vermejo Conservancy District.

Refuge History **-** Land acquisition for Maxwell NWR was initiated in 1966. Historically, lands that today comprise the refuge supported shortgrass prairie. Grassland plant communities included associations dominated by blue gramma (*Bouteloua gracilis*), and alkali sacaton (*Sporobolus airoides*), with buffalograss (*Buchloe dactyloides*), western wheatgrass (*Pascopyrum smithii*), fourwing saltbush (*Atriplex canescens*), alkali muhly (*Muhlenbergia asperifolia*), and inland saltgrass (*Distichlis spicata*) also common. The development of the first irrigation system in the area, which diverted water from the Vermejo River, dates to the late 1880's. Scattered ranches with farming operations sprouted up and livestock grazing increased with the availability of water for stock tanks and the irrigation of crops. Along with introducing cattle and numerous weeds, settlement of the area frequently included planting Siberian elm (*Ulmus pumila*, a.k.a.

Chinese or Russian elm) to provide shelter belts around areas of habitation. Limited farming continues on the refuge, but livestock grazing was terminated in the late 1960's as lands were acquired**.** Farming and grazing activities, along with the development of the irrigation system infrastructure, have altered most of the habitat on the refuge.

***Habitats* -** Refuge habitats include former pasture (referred to as range in this document), farm fields (both in use and abandoned), playa lakes and surrounding alkali flats, irrigation reservoirs and associated wetlands, and several wooded thickets associated with former home sites. In 2000, 371 acres were under cultivation, with the majority of those acres farmed under cooperative agreement with two local farmers. The remaining acres were farmed directly by the refuge. Crops grown include alfalfa, which provides a significant amount of green browse for migratory birds during the migration and wintering seasons, and "hot foods", or grain crops, that sustain birds and other wildlife in the cold of winter; typically barley, wheat or corn grown by the refuge or under cooperative farming agreements. In excess of 500 acres of previously-farmed and now-abandoned farm land await restoration to native prairie. Most the remainder of the refuge's 2,792 acres have been altered by historical grazing, but never broken out and farmed, largely due to their location on inferior, saline soils. These grazed areas would also benefit from restoration, but the abandoned farm fields are better candidates for restoration due to their location on better soils and having better access and, in some cases, irrigation capability.

Three irrigation reservoirs, identified as Lakes 12, 13 and 14, are located within the refuge, predate establishment of the refuge, and are considered permanent reservoirs. These reservoirs, and the surrounding land, are owned and managed by the Vermejo Conservancy District (District), with the District managing the water levels. Lake 13 is a very popular angling site for stocked trout and catfish, attracting thousands of vehicle-based visitors annually. Numerous irrigation ditches, either owned by the District, or operated by the District as rights-of-way, cris-cross the refuge, feeding the reservoirs and delivering water to area farmers. With the development of these reservoirs substantially more water currently exists on the refuge landscape today than was there historically. The reservoirs hold water all year, although water levels (and shorelines) vary with precipitation and irrigation demands.

With hundreds of acres of dammed-up standing water in the reservoirs, the water table in the vicinity of the dams is affected, creating moist soil conditions below the dams in some localized sites. The proliferation of irrigation ditches, both for inflow to supply the reservoirs and for delivery to area farms, creates seasonal open water areas and about 70 acres of cattail wetland and another 43 acres of rush/sedge wetland. These open water and wetland sites are sensitive areas which are important considerations when planning for the application of herbicides to the refuge landscape. The refuge has management agreements for about 900 acres of District-owned lands surrounding Lakes 12 and 14, bringing the total area managed by the refuge to about 3,700 acres.

Other sensitive areas that are largely seasonal in nature are water delivery canals and ditches that bring water into and out of the reservoirs, and seeps that develop below dams due to the hydraulic pressure exerted by standing water behind the dams**.** Also, heavy rains can create temporary standing water in low lying, poorly drained sites for short durations.

Roads **-** Several unpaved roads provide vehicle access around and through the refuge, primarily on section and half-section lines. The roads themselves, and disturbed sites next to the roads, provide important weed habitat and transportation corridors. Most roads are gravel Colfax County right-of-ways passing through, or along, Refuge borders. State Highway 505, a paved asphalt road, runs along the Refuge's southern boundary. The refuge owns and manages two miles of unpaved road, and manages the public access roads at Lakes 13 and 14 under agreement with the District. Road composition affects the likelihood of vehicles and equipment picking up and transporting seeds in mud, aiding in the distribution of invasives. The identity of each road's managing agency will be important in coordinating weed management activities, such as the timing of mowing.

Soils - Soils on Maxwell NWR are deep silty clay loams derived from the Cretaceous shale and deposited by alluvial and eolian processes. The more lowland soils fall into the Vermejo soil series and the upland sites are represented by soils from the Swastika Series. The silty clay loams of the Vermejo Series are easily erodible and often high in salts. The silty loams and silty clay loams of the Swastika Series are also high in salts, but somewhat less erodible in comparison to the Vermejo Series. Both soil series are relatively low in organic matter and high in salts and pH (i.e., they are alkaline). Low lying sinks and the margin of playas are characterized by the presence white alkali and are virtually barren of vegetation.

Most of the farm fields and range sites are dominated by soils with high clay content, such as the Swastika-Colmor clay loam. These soils typically do not drain well due to their high clay content, and translocation of pesticides through the soil profile into the water table could be expected to be minimal. The rolling topography offers gentle slopes, with runoff minimal in combination with scant amounts of moisture normally received in any precipitation event. There are no geological outcrops that provide sandy or gravely substrate anywhere on the refuge. Additional detail on soils and their location are available from the Colfax County Soil Survey and in the refuge files.

Climate **-** Due in part to elevation, the climate is dry and cool, with a short growing season of only about 120 days. Precipitation is typical of the Southwest, averaging about 14.5 inches. Precipitation events can be quite variable, with summer showers not uncommon, depending on how well developed the summer "monsoon" season is. As with any thunderstorm activity, rainfall amounts can vary drastically over a short distance within the refuge. Included in the annual precipitation total is snow melt, with snowfall averaging about 17.5 inches, providing about two inches of water when melted.

Paste Map Here. If possible, include some of the field locations.

High winds are not uncommon, especially during storms and in spring, and particularly in March and April. Late spring and summer mornings often begin with calm or light winds, typically changing to a southerly breeze as the day warms. Southerly winds that easily exceed the limits for boom spraying frequently prevail in the afternoon.

Sensitive Refuge Sites and Species - Sensitive areas on the refuge include the following:

- the permanent water found in irrigation reservoirs 12, 13 and 14.
- seasonal water flowing in irrigation delivery and inflow ditches.
- moist seeps, dam faces & roadside ditches, when standing surface water is present.
- susceptible crops, such as alfalfa and the clover mix used for rest/rotation.
- the two black-tailed prairie dog towns (candidate species - see map)
- range sites with dense nesting cover during the nesting season.
- public use areas (primarily the dam at Lake 13) and roads.
- a 80-acre Research Natural Area in the southwestern corner sited around the playa lake located adjacent to State Highway 505 (no special prohibition on controlling invasives).

A Section 7 Consultation covering black-tailed prairie dog towns was prepared and approved in 2001. Since there are no invasive infestations in or adjacent to either town, no conflicts with herbicide treatments are expected, and any insecticide application (for grasshoppers) will use a one quarter mile buffer from either town.

Two native thistle species, wavyleaf or silver thistle (*Cirsium undulatum*) and yellowspine (*Cirsium ochrocentrum*) occur on the refuge. Wavyleaf thistle is a common, widely distributed perennial with leaves grossly similar to musk thistle in appearance in early growth stages; yellowspine is a uncommon biennial or short-lived perennial with a very limited distribution on the refuge.

Drinking and Irrigation Water - Historically, there were domestic ground water wells on the refuge. However, the refuge currently gets its domestic water from the City of Maxwell and irrigation water from the District, either from Stubblefield reservoir or Laguna Madre. There are currently no wells pumping groundwater from anywhere on the refuge.

Surrounding Land Uses - The major industry and source of income in Colfax County is agriculture based, with cattle ranching predominating. Ecotourism is also an important and growing segment of the economy. Much of the open rangeland in the area is grazed, and growing alfalfa for hay to feed cattle and horses is an important component of the local agribusiness. To the extent that invasive species become established on rangeland and in fields and take over the landscape, the ability of that range and field crops to support livestock operations can be stressed beyond the already thin margin of economic viability that most operations run on in the arid New Mexico highland plains. Because of the short growing season, any form of competition from an infestation can adversely affect economic viability.

TABLE 1. BROADLEAF WEED SPECIES ON MAXWELL NWR

Priority invasive weed species are denoted by an asterisk (*). These invasive species are considered to present the greatest threats to the refuge environment.

Common Name (+)	Scientific Name	Synonym	Comments/Locations
field bindweed(C)	Convolvulus *arvense*	perennial morning glory	prolific, perennial
yellow sweetclover	*Melilotus officinalis*	yellow clover	prolific, winter annual
common cocklebur	*Xanthium strumarium*		common in fields, annual
spiny cocklebur	*Xanthium spinosum*[1]		C6 (1 plant found), annual
*hoary cress (A)	*Cardaria draba*	whitetop	B5, F1 and various, perennial
*Siberian elm (C)	*Ulmus pumila*	Russian elm	scattered groves
curlycup gumweed[2]	*Grindelia squarrosa*	rosinwood	rangeland, biennial or perennial
scarlet gaura[3]	*Gaura* parviflori	velvety gaura	farm fields, biennial or annual
halogeton	*Halogeton glomeratus*		Scattered, disturbed sites, annual
horseweed[3]	*Conyza canadensis*		rangeland, annual
*Russian knapweed (B)	*Centaurea repens*		several patches, perennial
kochia	*Kochia scoparia*		prolific, annual
prickly lettuce	*Lactuca serriola*	China or wild lettuce	common, biennial or annual
locoweed (3 varieties)	*Oxytropis spp.*	crazyweed	common in range sites, perennial, poisonous to ungulates
Venice mallow	*Hibiscus trionum*	rosemallow	farm fields, annual
common mallow	*Malva neglecta*	buttonweed	farm fields, annual, biennial or perennial
common mullein	*Verbascum thapsus*		various, biennial
*Russian olive (C)	*Elaeagnus angustifolia*		planted at refuge headquarters
common ragweed[3]	*Ambrosia artemisiifolia*		prolific in fields, annual
*saltcedar (C)	*Tamarix ramosissima*		scattered sites
spiny sowthistle	*Sonchus asper*		Common, annual
broom snakeweed[2]	*Gutierrezia sarothrae*	broomweed	overgrazed sites, perennial
*bull thistle (B)	*Cirsium vulgare*		dams, ditches, biennial, deep tap
*Canada thistle (A)	*Cirsium arvense*	rooted	widespread, perennial and deep
*musk thistle (B)	*Carduus nutans*		widespread, biennial or annual
Russian thistle	*Salsola iberica*	tumbleweed	widespread, annual
yellowspine thistle [2]	*Cirsium ochrocentrum*		limited to stackyard behind headquarters

[1] new in 2000. Exactly one spiny cocklebur plant was found in 2000 near the southwest corner of cooperatively farmed field C6.

[2] a native plant but undesirable as forage and/or unpalatable or poisonous to livestock and possibly some wildlife

[3] native to U.S. but proliferates in disturbed sites and grain crops. Horseweed is a nasal irritant to horses.

+ Class A, B, or C weed based on New Mexico Noxious Weed Management Act 1998 (see definitions Page 8).

Pests

Plant Pests **-** The Refuge conducted an intensive field scouting program in 2000 and 2001 to identify nonnative species on the refuge and map their locations as a necessary first step in the development control strategies and this IPM Plan. Field scouting revealed numerous infestations on the refuge. In addition to prolific infestations of hoary cress and Canada, musk, and bull thistles on the refuge, scouting forays in 2000 during the bloom revealed numerous Russian knapweed infestations on and adjacent to the refuge, especially along roadsides. Table 1 provides an extensive (but likely incomplete) list of exotic plants and other weeds established on Maxwell Refuge. Based on survey results and an assessment of threat and likelihood of effective control, the Refuge will focus control efforts on the following priority species: Russian knapweed; Canada, bull and musk thistles; hoary cress; Russian olive, saltcedar, and Siberian elm.

The selection of these priority invasive species was based on the rapid expansion capabilities of Russian knapweed, Canada, musk and bull thistles, and hoary cress in the refuge and their potential adverse impacts to farm and/or grasslands, including the toxic and allelopathic effects of many of these invasives (see following individual biology accounts). Also, Russian knapweed, Canada thistle, hoary cress, Siberian elm and saltcedar can form dense monospecific stands, suppressing crop yields and excluding native species. Prior to 2000, established saltcedar trees were uncommon, but a large invasion of seedlings erupted following the flood of May 1999 but did not become visually evident until 2001. Saltcedar exudes salts that are phytotoxic, drastically lowering species diversity where it occurs. In addition, saltcedar alters hydrology and has enormous water use as high as 200 gallons per tree each day, or more. As a result, there is less water and decreased biodiversity wherever saltcedar becomes established. There is typically a loss of both plant diversity and wildlife diversity as monospecific stands of saltcedar replace native species, a serious problem in riparian areas off the refuge and throughout the southwest. Russian olive and Siberian elm, like saltcedar, also present similar serious environmental threats.

In the New Mexico Noxious Weed Management Act of 1998, the New Mexico Department of Agriculture has identified offending invasive species in the State as either **Class A, B or C** noxious weeds. Class A weeds occurring on the refuge include Canada thistle and hoary cress, while Russian knapweed and musk and bull thistles are identified as Class B weeds. Class C weeds found on the refuge include field bindweed, Siberian elm, saltcedar and Russian olive. Class A weeds are given the highest priority towards prevention and elimination in the state of New Mexico, and Class B, the second highest priority. We therefore plan to cooperate fully with the county and State in working to eliminate these weeds from the refuge, although our strategies may sometimes differ, depending on the occurrence of sensitive plants and wildlife on the refuge.

Three important invasive species on Maxwell Refuge, not herein selected as priority species, are field bindweed, yellow sweet clover and kochia. Field bindweed could easily be included in the priority list if it were not for how well established and widespread it has become, making control with herbicide unrealistic and elimination virtually impossible. About the best manageable result that can be expected for bindweed is partial control or suppression in crop fields, although yet-untried biocontrols may hold some promise. Yellow clover, planted in refuge fields as part of the rest rotation cycle, has escaped and is also very well established in fields and range sites. Similarly, kochia is also very common in fields and ranges sites and would be extremely difficult

to control.

Several other invasive species on the refuge would immediately become priority species and treated or uprooted immediately if identified, including yellow starthistle and leafy spurge. Leafy spurge is established in at least three sites in Colfax County, and seeds from yellow starthistle and numerous other invasive species infestations are just a few hours drive up Interstate 25 in Colorado and Wyoming, waiting to hitchhike a ride over Raton Pass to Maxwell, New Mexico. In addition, weed species such as common mullein and halogeton will be suppressed on an opportunistic basis, especially when co-located with other weeds.

Minor weeds with lower rates of spread were also not identified as priority weeds. Only a few individual yellowspine thistle plants were discovered in 2000 in the cooperative farmer's stack yard behind headquarters, after flowering, perhaps demonstrating a late season growth habit. Russian thistle is a minor agricultural pest, preferring disturbed sites, and will be controlled incidentally to other farm weeds. Additionally, exactly one spiny cocklebur plant was discovered in 2000 near the southwest corner of cooperatively-farmed field C6. In addition to the above broadleaf "weeds", there are also a variety of non-native grass species, including smooth brome (*Bromus inermis*) that are less well-known as to their identity, distribution and the degree of their threat potential. Continued scouting with additional training on grass identification will enable the refuge to study possible control needs for grass species.

TABLE 2. DOMINANT GRASSHOPPERS IN MAXWELL NWR CROP AND RANGELANDS FROM 1988-1990.
Bomar, et al (1993) identified the following common grasshoppers on the refuge in 1988-1990:

Spurthroated grasshoppers (Melanoplinae):	
Melanoplus bivitattus	*two-striped grasshopper
M. femurrubrum	*redlegged grasshopper
M. lakinus	Lakin grasshopper
M. packardii	Packard grasshopper
M. fasciatus	-
M. differentialis	differential grasshopper
Hesperotittex viridis	snakeweed grasshopper
Phoetaliotes nebrascensis	*largeheaded grasshopper
Bandwinged grasshoppers (Oedipodinae):	
Encoptolophus costalis	dusky grasshopper
Slantfaced grasshoppers (Gomphocerinae)	
Amphitornus coloradus	striped grasshopper

* denotes most common species found in study

Insects Pests - The primary group of insect pests at Maxwell are grasshoppers (see Table 1). Significant grasshopper outbreaks have threatened both the economic viability of cooperative farmers and the ability of the refuge farming program to meet objectives in providing forage and habitat for migratory birds. Additionally, grasshoppers on the refuge provide a reservoir of invading grasshoppers for neighboring properties and can caused serious economic damage to

crops and livestock forage in neighboring lands.

The field study by Bomar, et al summarized in Table 1 is available in the refuge files, and includes voluminous data on species composition of grasshoppers encountered, levels of infection, and whether or not a given species consumed bait.

Refuge Management Objectives

In following with the establishment of Maxwell National Wildlife Refuge by the Migratory Bird Conservation Commission on August 24, 1965, and given that the purpose for establishing the refuge was "for migratory birds...and other management purposes", the principal objectives of the refuge are to:

- provide a feeding and resting area for wintering migratory waterfowl.
- provide habitat for other migratory birds and non-migratory wildlife.
- allow for fish and wildlife oriented recreation.

Key to Maxwell meeting the establishing purpose and meeting these principle objectives is the quality of habitat on the refuge. Understanding that the native landscape where the refuge is situated was short grass prairie, and that the native prairie has been fragmented and significantly altered and disturbed through a history of agricultural practices, is vital in developing a vision for the refuge pest management program and habitat restoration efforts. The goal of this Integrated Pest Management (IPM) Plan is not to just control pest plants, but to develop strategies that will allow for and promote the successful restoration of native short grass prairie habitat and therefore optimize the quality of native grassland habitat on the refuge. Restored, healthy prairie will not only provide quality habitat towards meeting the refuge purpose and objectives, it will also resist encroachment from invasive plants and other weeds.

In as much as the refuge farming program manages crops to provide nutrition for migratory birds and other wildlife, the presence of invasive plants and other weeds in crop fields reduces the ability of the farming program to provide forage for the stated refuge purpose and wildlife objectives. Controlling invasive plants and other weed pests in crop fields will significantly aid the ability of the farming program in successfully supporting the refuge purpose for migratory birds and aid in meeting principal objectives.

To fulfill the goal for the IPM Program in promoting the refuge purpose and aid in meeting refuge objectives, the following IPM Program goals are identified:

- increase the health and productivity of refuge crop fields by controlling or eliminating all invasive plant infestations in farm fields and reducing the population of other weed species.
- aid in the restoration of healthy short grass prairie habitats on the refuge by controlling or eliminating all invasive plant infestations on all of the abandoned farm fields that were cultivated but are no longer farmed, totaling about 500 acres. These sites will then be re-vegetated with native short grass prairie species, and the sites with the best soils, productivity and irrigation capability will be used to produce seed to re-vegetate other restoration sites. Migratory birds and other wildlife will benefit from the improved

habitat quality, and overall biodiversity will be increased on these sites.

- aid in the restoration of healthy historic short grass prairie or other native habitat types by controlling or eliminating all invasive plant infestations on approximately 500 acres of disturbed range sites identified for restoration, thereby benefitting migratory birds and promoting the historic biodiversity of these sites.

Herbicide use will decrease over time as effective treatments bring pest species under control and healthy habitats are restored. Refuge management strategies to reach these goals for the management of pests will be implemented on a priority basis, ranging from total elimination, to control, suppression, and containment, as follows:

- scout all areas of the refuge annually and identify, map, and monitor all infestations and treatment sites, applying standardized monitoring protocols.

- eliminate all newly discovered invasive plant infestations, and eliminate all infestations of **priority** invasive plants on and adjacent to farm fields, as rapidly as possible.

- control or eliminate invasive plants from all locations that present the best opportunities for infestations to spread, including roadsides, ditches, public use areas, work sites and stack yards; essentially anywhere vehicles and equipment could transport seeds or plant parts to new locations.

- control all existing infestations of **priority** and other invasive plants in non-crop range sites.

- control or suppress other agricultural weeds and insect pests in farm fields based on economic thresholds and seed bank reserves to reduce the future sprouting of seedlings.

- contain invasive plants around District dams and in District ditches serving as corridors for weed movement, in coordination with the Vermejo Conservancy District.

- apply the best weed science available, including biological controls, in developing and implementing the most effective individual strategy for controlling each pest species**.**

History of Pest Management on the Refuge

Invasive Species - Prior to 2000, there were no specific treatments targeted at invasive species in either crop or non-crop sites, with only two exceptions involving mowing and boom spraying musk with Canada thistles. Otherwise, musk, bull and Canada thistles, Russian knapweed and hoary cress were disced along with other weeds in agricultural fields, some of which were planted to corn and treated with 2,4-D post-emergence. These types of general treatments with discing and limited spray applications were ineffective, and the discing undoubtedly spread species with perennial root systems such as Canada thistle, Russian knapweed and hoary cress. Please note that the use of trade names in this document is for documentation purposes only and such references do not imply endorsement of any particular product over another by the author or the U.S. Fish & Wildlife Service.

As for the exceptions, a small scale and ineffective effort was initiated to treat combined infestations of Canada and musk thistles in two fields across from and north of headquarters in 1998 and 1999. In 1998 these two sites were mowed with an agricultural mower (i.e., a "bush hog") in June as the musk thistles began to bloom in earnest, then sprayed over-the-top with 8 ounces/acre Weedar 64 (46.8 % active ingredient 2,4-D) in August, using an agricultural boom sprayer. In 1999, the infested areas were similarly mowed in June and sprayed with 16

ounces/acre Weedar 64 in September. However, the Weedar 64 label specifies applying as much as eight times those rates in treating Canada thistle, which is co-located with the musk thistles being treated. The treatments failed to control Canada thistle vegetative growth or root systems. In the case of musk thistle, the timing of herbicide application was "post-bloom," so that the mowed musk thistle plants, assuming they had not already set seeds before mowing, were given the opportunity to regrow to a low height, flower, and go to seed rapidly after being stressed by mowing. The boom spraying could have been effective on musk thistle if the application had been two to three weeks after mowing, before the musk thistles regrew blooms and set seed. Because the timing and concentration of spray applications permitted musk thistle seed production and were too weak to suppress Canada thistle, the 1998 and 1999 control efforts were ineffective. The general 2,4-D treatments in fields also were ineffective in controlling Russian knapweed, hoary cress, and field bindweed when treated along with other agricultural weeds in corn fields.

In summary, prior to 2000, invasive species were generally not targeted for treatment, and the two range sites (actually abandoned crop fields) that were treated received ineffective treatments. Invasive species were not well understood as to their identity, biology or distribution. Also, prior to 2000, Maxwell NWR did not have the use of a four-wheeler cycle to provide low-impact, off-road access for field scouting, mapping, hand spraying, or follow up monitoring, limiting the amount of off-road area that could be scouted and managed.

In 2000, the refuge began using a four-wheeler to scout virtually all portions of the refuge to detect invasive weed species, including farm fields, range sites, right-of-ways, and around dams and ditches. The four-wheeler and scouting effort dramatically increased capabilities and success in locating, identifying, mapping, and treating infestations. Attempts were made to custom treat all infestations discovered in 2000, to the greatest extent possible, with the following treatments and combination of treatments applied:

- two **hoary cress** patches were detected and hand sprayed at two different rates with a tank mix of Escort (methsulfuron methyl) and Weedar 64 (amine formulation of 2, 4-D), but applications were later than ideal following the plants discovery, as the plants were already in bloom. While the plants seemed to be suppressed following spraying in 2000, neither rate seemed to decrease the regrowth and bloom of either treated patch in 2001. In 2001, these two sites and all additional discovered patches were treated with the higher rate of the Escort and Weedar tank mix at early bud, but the effectiveness of these treatments will not be seen until spring of 2002. Also in 2001, one newly discovered patch of hoary cress, growing among a larger patch of Russian knapweed located southeast of Dam 12, was sprayed with the same tank mix used for knapweed (see below). Note that with other species, the key to discovering hoary cress infestation was scouting during the bloom.

- thousands of **musk and bull thistle** plants were individually spot treated by hand with Weedar 64 in 2000, and, if plants were discovered after blooms had been set, a tank mix of Weedar 64 and Telar DF (chlorsulfuron) was spot applied to each of many hundreds of plants to arrest seed production. Larger patches in advanced flower stage (but before seed set) were mowed and then boom sprayed with Weedar 64, a combination mechanical-herbicide treatment that proved extremely effective at killing both the second year plants trying to go to seed and the first year seedlings that had just sprouted. A special effort was made to remove all musk thistles in crop fields. Hand hoeing hundreds of rosettes proved ineffective as the cut plant would eventually respond from the taproot and bloom. Spraying started earlier in 2001, with thousands of rosettes spot treated by hand with 2, 4-D. **Common mullein** was also sprayed opportunistically with 2, 4-D in 2000 and 2001, with excellent kill and control when treated before flowering. Both musk and bull thistle were easy to control with 2, 4-D if plants were treated before they

went to the bud stage, but locating all the rosettes in an area proved to be impossible, requiring a treatment regime that included revisiting treated sites to touch up plants that were missed on the first visit. There also seemed to be a delayed chronology with at least a few "late bloomers", so an effective treatment strategy requires more than one visit to an infested site some weeks apart.

- scouting during the "June bloom" indicated that **Canada thistle** was very well established and widely spread. It also proved difficult to control. Some Canada thistle patches were opportunistically hand treated either with 2, 4-D while spraying musk thistle (i.e., with Weedar 64, which proved ineffective) or with the 2, 4-D/clopyralid/picloram mix (i.e., with the Weedar 64/Reclaim/Tordon 22K mix, which was extremely effective) in the course of treating co-located Russian knapweed. Where smaller patches prevailed, a tank mix of 2, 4-D and Reclaim (clopyralid) was hand applied, including spot applications in alfalfa fields. The thistles treated in irrigated alfalfa fields regrew and were retreated two additional times in 2000. Where larger patches dominated the landscape the boom sprayer was used to apply the same tank mix of 2, 4-D and clopyralid. While these tank mixes achieved top kill, they gave variable results in the way of lasting control of regrowth later in 2000 and in 2001. Results ranged from apparent control to mixed control with limited suppression. One area heavily infested with both musk and Canada thistle was mowed and boom sprayed with 2, 4-D and Telar DF (chlorsulfuron) as the musk thistles were trying to regrow and go to bloom, with good results. In 2001, new strategies were employed to stress Canada thistle before herbicide treatment, either through discing in fields or mowing in range sites. Applications included treatments with the new WetBlade mower-applicator, after the area had been mechanically mowed, but it is too early to evaluate results.

- field scouting in 2000 discovered **Russian knapweed** for the first time on the refuge in several different habitat situations. G field was planted to corn before scouting determined that the field had a tremendous weed load including Canada thistle and Russian knapweed. Boom spraying the corn field with 2, 4-D post-emergence had virtually no effect on the knapweed, and hand applications with 2, 4-D and Reclaim (clopyralid) to individual plants stunted the knapweed's growth, but did not kill the plants. Other non-crop knapweed infestations were hand treated with a tank mix recommended by Whitson (in Sheley and Tetroff,1999) including (by active ingredient) 1 part clopyralid to 2 parts picloram to 4 parts 2, 4-D. This 1:2:4 mix was extremely effective on Russian knapweed when treatments were applied "spray to wet" at the early bud stage, using dye as an indicator. In fact, the infestations treated with this 1:2:4 "geometric mix" showed no regrowth in 2001 except on the edges of the stand where the application was likely not uniform. The scant regrowth in 2001 was touched up with the same geometric mix, and are expected to be eradicated within two or three spraying cycles. Note that no regrowth occurred until the next growing season. In general, any application that did not include Tordon 22K was ineffective on knapweed. Continued monitoring will determine the need for additional treatments.

- prior to 2000 **salt cedar** was not treated, but was only present as several scattered, individual plants. These individuals were sprayed with a foliar treatment of triclopyr (Garlon 3A), but the larger plants showed some regrowth in 2001. These were chainsawed and stump treated with 50% Garlon. However, just when we thought salt cedar had been eradicated on Maxwell, a disturbing discovery was made over the summer of 2001. Tens of thousands of young sprouts appeared above the water line around the drawn-down shoreline of Lakes 12 and 13, likely the product of seeds washed in from Stubblefield Reservoir in the May, 1999 flood. Thousands of these young seedlings at Lake 12 were hand sprayed with Garlon 3A on September 13th of 2001.

- a few **Russian elm** trees had been effectively sprayed over-the-top with foliar applications of Weedar 64 prior to 2000. In 2000 and 2001, stands of seedlings spreading out from larger trees were mowed with a bush hog. Some areas with larger trees, such as across from headquarters, were cut with a chainsaw and stump cut treated with 50% Garlon 3A The handful of **Russian olive** trees that were planted around headquarters met a similar fate in 2000 and 2001, as they were cut with a chainsaw and the stumps were painted with 50% Garlon 3A. Resprouting was touched up with a Garlon 3A treatment.

As control strategies progressed up the learning curve in 2001, treatments on Canada thistle were

expanded to include the use of a WetBlade rotary mower, combining mechanical and herbicide controls in a single treatment. Sites were prepared by mowing in late winter with a regular rotary mower (i.e., bush hog). This pretreatment provided multiple benefits, including the removal of dense growth from previous years, improving the efficiency of the WetBlade, and increasing visibility of the target pest plants, including underlying musk thistle, Russian knapweed and hoary cress infestations. Early pre-mowing also made the area less attractive to ground-nesting birds, minimizing the likelihood of impacting a nest or young when using the WetBlade later in the spring. Pre-mowing with a sturdy bush hog also allowed for the discovery and removal of various hazards that could damage the more fragile (and more expensive) WetBlade mower. Several mechanical problems were encountered in using the WetBlade in 2001, so the "jury is still out" on how useful and reliable the device will be and how effective the treatments were. However, the WetBlade mower applies only a small amount of herbicide to the area being cut (on the order of 1/5th to 1/10th the volume of boom spraying) and there is virtually no drift produced, a great advantage in the windy New Mexico highlands. As with any new tool, time and experience will show us the best management applications for this device.

Another new herbicide used on Canada thistle in 2001 was Roundup Ultra (glyphosate). Applications planned for 2001 included boom spraying in selected crop fields that were summer-fallowed and with the wetblade in range sites, but the results of the effects on the root system will not be apparent until the 2002 growing season demonstrates how much regrowth comes back from the root system.

Grasshoppers

Two insecticides have traditionally been used for grasshopper control over the years at Maxwell Refuge, Malathion and carbaryl (Sevin XLR). These products have been used to fend off larger grasshopper infestations, with use changing from Malathion to carbaryl in more recent years. Bomar, et al (1990), summarized the species composition of grasshoppers encountered, their levels of infection, whether or not a given species was consuming *Nosema locustae* bait, and whether the bait was effective. Results of the study indicated that the *Nosema* product, Nolobait, was most effective at infesting and controlling spurthroated grasshoppers, while the slantfaced species was unaffected as they did not consume the wheat bran-based product.

The study also showed that insectivorous birds were more common in treated sites, suggesting that the birds advantageously moved into treated areas to feed on sick, more easily caught grasshoppers (also likely in insecticide-treated sites). The parasitic wasp *Scelio opacus* was also found in the study, and may warrant additional consideration as a possible control agent, if a supply source can be found.

Results from this study will be used in assessing whether future infestations are attracted to treatment. However, results will not be used to predict effectiveness, since initial efforts may have been influenced by poor storage conditions and/or application of the product when grasshoppers were in the wrong instar stage.

Management Alternatives

No Action: Employing a "no action" alternative would allow invasive exotic plant infestations (including most conspicuously musk, bull and Canada thistles, Russian knapweed, hoary cress, salt cedar and Siberian elm) to continue spreading, invading additional refuge habitats, including fields, pastures, roadsides, and dams and irrigation ditches on and around the refuge. Taking no action would allow grasshopper infestations to decimate refuge crops and grasslands, including newly restored grasslands. This option would have significant negative impacts to the ecosystem, potentially crippling the refuge's ability to meet habitat objectives for migratory birds. The infestations would predictably spread to neighboring landowners' rangeland and pastures, reducing forage and yields and creating larger infestations, causing increasing economic impacts. "No action" would further increase anti-government sentiment. Additionally, Maxwell Refuge is an integral part of the interagency work group within Colfax County focusing on the control of invasive plants. Considering the purpose and objectives for the refuge and the presence of several noxious weeds classified by New Mexico as Class A or B noxious weeds, the "no action" alternative is unacceptable.

Options for management of pest species fall into two categories: controlling pest plant species, and controlling grasshopper species. Options for controlling pest plants include the application of mechanical treatments (mowing, discing, and hand pulling or hoeing), biological controls, grazing, prescribed fire, herbicide applications, and cultural controls. Also considered is the "wet blade" mower which combines mechanical mowing with a herbicide application in a single treatment. Options for controlling grasshoppers include biological controls, applying pesticides, and cultural controls including a planning process for planting crops that minimizes the opportunity for insect damage.

This IPM Plan for Maxwell National Wildlife Refuge draws from a combination of these options in what may be called a "**Preferred Alternative**" which assimilates all of the best management practices and weed science for controlling pest species.

Options for Pest Control: There are a variety of treatment options to consider in managing weeds and invasive plant and grasshopper infestations at Maxwell. The primary options for control are biological, cultural, mechanical and chemical (herbicide and insecticide). Prevention, as in preventing the spread of existing infestations and potential re-invasion, is also an important consideration in developing a successful integrated strategy for managing pest populations. The ultimate control action against invasive plant species on Maxwell's disturbed rangeland will be to reestablish healthy native short-grass prairie plant communities. Therefore, the rehabilitation of abandoned crop fields and altered range sites is in itself an important aspect of the preferred alternative. The specific control option, or combination of control options, is discussed for each pest species in the section IPM Methods fro Priority Species beginning on page 27.

Pest Management Elements: Because the "no action" alternative is unacceptable, priority pests will be managed on Maxwell NWR. Management will include three important components: scouting and mapping, treatment, and follow up monitoring.

Scouting and Mapping - A four-wheeler will be used to scout all areas of the refuge annually. All infestations will be mapped using a global positioning system (GPS) unit to acquire both the

location (in Universal Transverse Mercator [UTM] units using NAD83) and dimensions of the infestations to estimate the size of the area. Mapping will follow standardized protocols for the values used for "acres infested", ranging from 0.1 acres for small infestations (including single plants), to 0.1-0.5 acres, 1.0-5.0 acres, 5.0-10.0 acres, etc. Appropriate software will be employed (ArcView, TopoZone.com, etc.) so that the location of the computer's mouse cursor will correspond with a numeric value for that precise location displayed in UTMs, since this system enables more ready digitized mapping than traditional latitude/longitude and enables a user to "work backward" using the cursor to locate a point with a specific UTM value.

Treatment- Selected treatments will be comprehensive, including use of herbicide and non-herbicide methods, where possible. Mowing will be used in a number of ways, as described under selected management strategies for each species (see below). Part of the purpose of Maxwell as a National Wildlife Refuge "for migratory birds" is to provide nesting opportunities for those birds. Locally nesting species include not only ducks, but "grassland obligate" species such as the grasshopper sparrow and western meadowlark. These ground nesting species require overlying vegetation to nest successfully, and management needs to be mindful of their nesting requirements. Not more than 5% of the refuge will be mowed or burned in any one year to limit the removal of vegetation in those areas, and these treatments will not be applied during the nesting season unless the area was pre-mowed in late winter to remove dense cover.

Only herbicides expected to be effective have been selected as treatments in this plan, and among these, those that are lowest in environmental risk, considering specific resources at the site, are identified. Table 3 summarizes expected efficacy of selected herbicides that are relatively low in risk, based on "Weed Control Manual 2002 Recommendations," previous refuge experience, and other guidance. Weeds listed in this table include priority invasive species, as well as yellow starthistle and leafy spurge. The latter species are included because of their highly invasive character and their likelihood to colonize the Refuge in the very near future. Herbicides selected for potential use on the refuge are double-boxed.

Certain herbicides, prone to volatilization and/or runoff, and/or with potential adverse effects to non-target vegetation or wildlife, were excluded from consideration as alternatives even though they are effective against some of the above weed pests. Excluded herbicides included Atrazine (prone to both volatilization and runoff with likely subsequent contamination of groundwater and surface waters and toxicity to invertebrates, amphibians, and fish); 2,4-D ester formulations (more toxic than amine formulations to invertebrates and fish and more prone to volatilization and damage of nontarget plants and crops than amine formulations; MCPA (very persistent in some soils and waters and moderately to highly toxic to mammals and birds); oxyfluorfen (highly to extremely toxic to fish; moderately to highly toxic to invertebrates); and quinclorac (highly volatile with possible damage to adjacent broadleaf crops and native species [especially those in the Solenaceae] and also moderately toxic to mammals). Some formulations of quinclorac are also inhalation hazard to birds and mammals.

Additional information about each selected herbicide, as well as general safety and efficacy considerations, and the basis of the selection, are provided below. This list is not comprehensive as to potential tank mixes, but does address tank mixes that will be tried in 2002.

TABLE 3. OBSERVED EFFICACY OF HERBICIDES AT MAXWELL NWR.
"I" indicates ineffective, "S" indicates suppression, "C" indicates apparent control, and "E" indicates extremely effective. "Y" indicates yet to be determined and "V" indicates variable success and may indicate suboptimal application conditions or growth stage, or the development of some resistant genomes. A "-" indicates no treatment.

Herbicide	Canada Thistle	Musk/ Bull Thistle	Field Bindweed	Hoary Cress	Russian Knapweed	Salt Cedar	Russian Elm
2,4-D Amine	I	C	S	I	I	I	S / C
Metsulfuron-Methyl	-	-	-	I	-	-	-
2,4-D/ Clopyralid Tank Mix	V	C	-	-	I	-	-
2,4-D/ Clopyralid/ Picloram	E	-	-	-	E	-	-
Glyphosate	S	-	-	-	-	S	S
2,4-D/ Chlorsulfuron	C	C	-	-	-	-	-
2,4-D/ Triclopyr	-	-	-	-	-	C	C

Table 3 Notes: tank mixes generally failed to control hoary cress. This could be due to the different formulations of metsulfuron-methyl (Ally or Escort) and on whether the existing site was formerly fallow or pasture and rangeland. Beck et al. (1990) reported good musk thistle control with metsulfuron or chlorsulfuron at 221 g a.i./hectare during bolting, but the refuge had excellent results with just 2, 4-D at an early growth stage. The manual shows that picloram controls thistles and knapweeds, without identifying specific species. The efficacy of the 2, 4-D, picloram and clopyralid tank mix is based on refuge experience in controlling Russian knapweed and two isolated colonies of Canada thistle were also fully, or nearly fully controlled. Chlorsulfuron and Imazapyr are not listed for pasture or rangeland use, but are labeled for noncrop sites. Excellent control of two years of musk thistle growth occurred on the refuge by mowing followed by either a 2, 4-D or a 2,4-D/chlorsulfuron mix.

Best Management Practices during Herbicide Treatments. All applications will be planned and conducted with the coordination and under the supervision of a licensed applicator certified in the appropriate state category which covers the application. Boom spraying will only be conducted when wind speeds average 7 miles per hour (mph) or less, and preferably in the 3 to 5 mph range, with no gusts greater than 10 mph. Anti-drift nozzles will be utilized. Inversion conditions, typical in calm and very low wind conditions, will be avoided since these conditions facilitate large-scale herbicide drift off site. Only enclosed cab equipment with air conditioning will be used to boom spray, offering the maximum protection from contamination to the operator/applicator.

However, a standard enclosed cab tractor does not meet the PPE standard when applying products that require a respirator for the applicator. Due to frequent windy conditions during afternoon periods and early spring in general, boom spraying will typically be conducted in the early morning in late spring or summer, based on observations and the weather forecast. Spray applications will not be conducted on days when there is a 30% or higher forecast for rain within 6 hours, except for products that are rapidly rainfast (e.g., glyphosate in 1 hour). Applications of herbicides and insecticides prone to leaching will also not be made within 24 -48 hours of likely (greater than 50% chance of) moderate to heavy rainfall. Certain herbicides are less likely to leach and more effective following a light rainfall that moistens the soil, and these conditions are usually indicated as optimal on the label. Refuge herbicide applications will take these factors into consideration, and when feasible, will take advantage of these factors.

A hand held wind meter will be used to determine wind speed at the application site, and wind direction will also be evaluated relative to any sensitive sites. If the wind temporarily picks up during boom spraying, drift can be reduced by lowering the nozzle pressure, thereby reducing droplet size. However, this practice will reduce the application rate for the area affected, and would have to be combined with shifting to a lower gear (reduced speed) to approximate the same standardized application rate. When boom spraying, it is desirable to maintain the same combination of gear and rpm's used in calibrating the boom sprayer, so any exceptions to this standard practice will be minimized. Also, the refuge will routinely limit herbicide drift by using anti-drift nozzles with openings of not greater than 1/16 inch and boom pressures of no more than 30 psi, with 20 psi adjacent to sensitive sites not in the treatment area. A nontoxic anti-drift agent will also be used when allowed by the label, especially adjacent to sensitive sites.

To aid staff involved in mixing, a conversion table will be developed and posted in the mixing area stating the amount of product needed for any given percentage of tank mix for each size of tank used on the refuge. In the case of Maxwell , there are 14, 50 and 200 gallon herbicide tanks, so the table would state the amount of product needed to make up each percentage mix based on that tank size. Also, each tank will be clearly labeled "Pesticides Only", or in a similar warning.

Personal Protective Equipment. Applicators will wear personal protective equipment (PPE) in accordance with the specific labeling requirements for each product, and all PPE will be supplied by the station, as needed. The required PPE, as specified by the label, will be worn at all times during handling, mixing and application. Fresh clean clothing, such as coveralls, laundered after each use, will be put on daily before handling pesticides used in application and removed before engaging in other duties unrelated to the application. Mixers and applicators will wear a pair of footwear specially designated for herbicide use, and will not wear the designated footwear for other operations to minimize contamination.

As exposure to concentrated product is usually greatest at mixing, extra care will be taken during the mixing period. Persons involved in mixing will be best protected if they wear extra long gloves, an apron, designated footwear and face shield throughout the mixing process, in addition to the protective clothing required by the label. Coveralls and other clothing used in an application will be laundered separately from other laundry items, or disposable Tyvek clothing may be used. Transportation, storage, handling, mixing and disposal of pesticide containers will be consistent with label requirements, EPA and OSHA requirements, and Service policy. Anyone handling, mixing or applying herbicides will have a background medical examination including blood work to establish baseline data, and final blood work should also be done when anyone

leaves their position.

Currently, there are no products requiring the use of a respirator proposed in this plan. Should changes occur, any respirator use by Service personnel will take place following establishment of a written Respirator Program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator. Alternatively, the refuge may contract with a commercial certified pesticide applicator in the area for some applications.

Surfactants and anti-drift agents. Surfactants provide benefits by increasing plant uptake of the applied herbicide and will normally be used if specified on the label. To the maximum extent possible, consistent with label specifications, the refuge will select surfactants and anti-drift agents that are themselves low in toxicity by comparing information available from the product MSDS's and by consulting contaminant specialists when additional information is needed.

Dyes. A non-toxic dye may be used to assist applicators in visually determining target acquisition, potential drift or over-spray, the amount of treatment applied, and to aid in discovering equipment leaks. If a leak is discovered, the application will be stopped until repairs can be made. Any dyes used must also be non-toxic.

Spills. If a spill occurs, the top priority will be the decontamination of any personnel involved. Any gloves, clothing or other PPE involved in the contamination will be removed as soon as practical and cleaned or discarded appropriately, and the applicator will be provided with the time and opportunity to wash up and decontaminate as thoroughly as needed. A continuous emergency eye wash station will be available near the mixing station. Whenever possible, mixing stations will be located near a shower stall or other means of thoroughly washing off and decontaminating the entire body. A "spill kit" with absorbent material will be kept on hand wherever pesticides are stored, mixed, or when transported, and the storage and mixing areas will provide containment appropriate for the volume of material involved. A tarp will be used to cover any spill site until retrieval of the spilled material, cleanup or capping of the site occurs. If the spill can not be cleaned up and contained immediately, State spill response personnel will be contacted.

Labels and Material Safety Data Sheets. Prior to each treatment season and prior to mixing or applying any product for the first time each season, all applicators will review the label, MSDS, and Pesticide Use Proposal (PUP) for each product, determining the target pest, appropriate mix rate(s), PPE, and other variables listed on the label. Labels and MSDS's will be maintained both in the shop and as separate, laminated copies in the mixing area. A written reference for each tank to be mixed (on a note pad, chalk board, dry erase board, etc.) will be provided in the mixing area to use as a quick reference while mixing is in progress.

Notification. Staff, volunteers, and members of the public who could be in or near the treatment area within the stated reentry time period on the label will be alerted concerning treatment areas, and posting will occur in any site where the individuals might inadvertently become exposed to a pesticide during other activities on the refuge. Where required by the label, sites will also be posted on all corners and at other locations of likely site entry, such as trailheads. The Refuge will also notify any adjacent property owners of an intended application, if private individuals have requested notification. Special efforts will be made to contact neighbors that are beekeepers or who have indicated that they have special chemical sensitivities.

Pesticide Disposal. Empty product containers will be triple rinsed and the rinsate will be dumped into an appropriate tank mix for an application treatment. Empty containers will be triple rinsed and disposed of properly and a file record will be obtained and filed to document proper disposal. Solutions used to clean equipment after application such as water, or a water and ammonia mix, will be recaptured and reused or applied to a pest plant infestation, which happen to be conveniently located near the mixing area.

Training and Supervision of Pesticide Applicators. At least one staff member will be certified by the State of New Mexico as a "Public Lands Applicator", and any staff member applying a herbicide or insecticide must be operating under his/her **direct** supervision. Preferably, all staff involved in the station pest management program will be afforded the opportunity to attend appropriate training. New staff unfamiliar with the station procedures for storage, mixing, handling, applying and disposing of pesticides and containers, will receive orientation and training **before** handling or using any products, and documentation of that training, and related training, will be placed in the refuge files for documentation.

Log of Pesticide Use. A log will be maintained to record and document each application, applicator, amount of product(s) used, location, time of day, acreage and, for boom spaying treatments, wind speed. These records will assist in producing the annual Pesticide Use Report and will meet other documentation requirements.

SELECTED HERBICIDES

Glyphosate (Rodeo or Roundup, or similar products). Glyphosate is a systemic herbicide with little soil residual activity. Because glyphosate tends to suppress rather than control thistles and because it adversely affects both broadleaves and grasses, it will be mainly used be as a preplant or fallow treatment, or as a spot, wick, or wipe treatment to target plants amid desired species. Also, this herbicide will be used immediately adjacent to wetlands and water bodies. Trials in other locations show that glyphosate can provide excellent thistle control, but that control is reduced when glyphosate is tank-mixed with 2,4-D, so this practice will be avoided when the target is thistles.

On an acute toxicity basis (48-114 hour exposures, depending on species) , glyphosate ranks as slightly to moderately toxic to mammals and birds and slightly toxic to practically nontoxic to fish and aquatic invertebrates. At labeled doses, toxicity to wildlife is expected to be negligible. The surfactant in Roundup is somewhat more toxic to fish, amphibians, and invertebrates than glyphosate itself. Thus, Rodeo, a glyphosate product that lacks this surfactant, is labeled for wetland and aquatic sites rather than Roundup. The refuge will use Rodeo together with a nontoxic surfactants, such as LI700, in sites immediately adjacent to aquatic sites or in sites with invertebrate species of concern.

One attribute of glyphosate is that it sorbs well to soil and sediment with little continued herbicidal activity, making this herbicide less likely to leach or affect adjacent nontarget plants. Roundup at 1 qt/acre (or Rodeo in wetland and riparian sites) has been a very effective post-harvest treatment for Canada thistle in many locations, but was not used on thistles at Maxwell NWR. Several adjustments in previous practices may increase efficacy, including timing changes, changes in water source, and addition of ammonium sulfate to the tank mix. Efficacy

can be increased if there is no tillage occur for 14 days after application and there are at least 21 frost-free days after application. A possible problem with poor herbicide performance is that glyphosate tends to be most effective when diluted with low hardness, circumneutral, clean (sediment-free) water. Also, studies show that glyphosate tends to be most effective on Canada thistles when groundwater is close to the surface. Water high in solids or hardness [high alkalinity waters], can greatly diminish effectiveness. Sources of surface water on Maxwell NWR, including irrigation drainwater, are high in alkalinity, hardness and suspended sediments, potentially reducing glyphosate efficacy. Many of the refuge's Canada thistles are also located in dry soils not close to groundwater, also limiting efficacy in such sites. Also, in sites not immediately adjacent to water or wetlands, efficacy will be enhanced by adding ammonium sulfate.

Clopyralid (Transline, Reclaim or Stinger). Clopyralid alone is listed as controlling Canada and bull thistle, but not musk thistle (but an inexpensive application of 2, 4-D amine works fine on musk and bull thistles, anyway). A maximum rate of 1.33 pt/acre clopyralid will be used, with lower rates in tank mixes with other herbicides.

On an acute toxicity basis, clopyralid ranks as practically nontoxic to aquatic species and slightly to practically nontoxic to mammals and birds. Stands of perennial broadleaves usually improve after spraying if rainfall is adequate. Although these attributes are desirable, this compound remains highly phytotoxic to certain broadleaves (especially legumes) at very low concentrations and can affect native forbs in grasslands or adjacent broadleaf crops. Label restrictions do not allow its use when it can enter irrigation drain water due to potential downstream crop damage. The compound can be transported by wind on blowing dust or in the urine of large mammals, affecting nontarget vegetation. Therefore, limitations will be observed on its use in farmlands, near ditches, or near irrigation waters and reservoir berms (even the outside of berms). In the past, there has been excellent Canada thistle control in some refuge locations with clopyralid alone. In other locations, treatments were less successful, possibly due to the development of resistant Canada thistle genomes [Canada thistle resistance to clopyralid has been recorded in many U.S. locations]. Since the Refuge's experience has been variable and since this herbicide alone may not control musk thistle, a combination of herbicides or alternation of herbicides will be considered rather than long-term use of clopyralid alone, especially when musk thistle are present.

2,4-D. Rates of use will depend on the particular formulation selected, and species to be treated, but will generally be between 0.66 - 4 pt/acre, if used alone. The amine formulation of 2,4-D (e.g., Weedar 64) ranks as only slightly toxic to practically nontoxic to aquatic species and practically nontoxic to birds and mammals. Although this form is prone to leaching, it is less toxic to aquatic species and less likely than other(ester) 2,4-D formulations to volatilize and affect adjacent nontarget plants or crops through atmospheric transport. No threat will exist to drinking water contamination since there are no drinking water uses on the refuge. Also, 2,4-D amine has a short half-life in water, normally 1-3 weeks and is unlikely to persist. As discussed above, this herbicide alone was previously found to be ineffective on Canada thistle, but it may contribute to the effectiveness in tank mixes discussed below. Also, its effectiveness may improve if used when thistles are young and growing in the spring or fall rather than during the summer. Desired legumes are especially affected by 2,4-D, so precautions need to be taken near desired native legumes or crops such as alfalfa. Both musk and bull thistles, as well as multiple agricultural weeds such as cocklebur and common ragweed are effectively controlled by 2,4-D treatments.

2,4-D/Clopyralid Mixture (Curtail). This mixture has proved promising results on the refuge to date to control Canada and musk thistle, although a follow up treatment is sometimes necessary. It is also labeled for controlling Russian knapweed and yellow starthistle. It may control bull thistle, but is not listed as controlling bull thistle on the label (here again, 2,4-D works fine). The combination of the two pesticides is less likely to result in herbicide resistance in the thistles. Normally 2-4 qt/acre of the premix is applied. This combination is a control option for Canada thistle co-located with infestations of musk and bull thistle (but gave variable results on Canada thistle), and is also listed as suppressing Russian knapweed (but was quite ineffective on Russian knapweed on the refuge in G Field in 2000).

Because of the phytotoxicity of clopyralid, uses of this mix will need to be based on label restrictions discussed above and on protecting desired refuge broadleaves. Reseeding with any broadleaves in fallowed crop sites will only occur after bioassays or field observations of seedling growth indicate it is safe.

Picloram, 2,4-D, and Clopyralid Mixture. After Sheley and Petroff (1999). Picloram alone (Tordon 22K) is labeled for controlling broadleaf weeds in permanent pastures and grasslands west of the Mississippi River, with tank mixes recommended for treating selected plants, including Russian knapweed. This mix was the primary agent used on Russian knapweed, and proved to be very effective. It is also labeled for use in fallowed lands. It is not labeled for controlling Canada thistle in grassland, but is labeled for controlling this thistle in fallow land and as a post-harvest or fallow treatment in grains. Treatment is recommended prior to bud stage. Land must be fallowed for several years before replanting to broadleaves or broadleaf crops. This tank mix was nearly 100% effective on isolated Canada thistle patches near Russian knapweed control sites in 2001.

Picloram is a **restricted use** herbicide requiring greater safety precautions than most other herbicides proposed. There are also label restrictions on its use in croplands, since picloram remains phytotoxic to many plant species, including crop species, and has a half-life of 4-73 weeks, depending on soil microorganisms present. On an acute toxicity basis, picloram ranks as practically nontoxic to moderately toxic to mammals, practically nontoxic to birds, slightly to moderately toxic to aquatic species, and nontoxic to bees. The most sensitive fish tested include certain salmonids and catfish, and the later are stocked in Lake 13.

Along with its potential to be moderately toxic to certain aquatic species, picloram is highly soluble and leachable, with a long half-life possible in turbid or deep water. It has the capacity to accumulate in aquatic systems, if used repeatedly. Thus, this chemical is mostly suitable for upland non-farm sites with low-permeability soils (silts, clays or silty loams) where groundwater is not close to the surface or where there is an intervening low- permeability soil layer such as clay or caliche above groundwater aquifers. Wick, wipe, or WetBlade (trademark of Birch Company) treatments to foliage or stems may occur in other sun-exposed locations, since the compound does break down readily in light. There are specific use directions for use of picloram in New Mexico that the refuge will follow, found in the supplemental label for the State. Maxwell NWR will strictly follow label limitations, applying this mix no more than once per year per site, and avoiding use near surface waters or drainages to minimize environmental impacts. At labeled rates, impacts to birds and mammals are unlikely.

Metsulfuron Methyl (Ally, Oust, or Escort). This sulfonylurea herbicide ranks as slightly to moderately toxic to mammals; practically nontoxic to birds, fish, and invertebrates; and nontoxic to bees if exposures are short term. Known as an ALS inhibitor, it works by interfering with certain amino acid synthesis and may be highly effective if resistant biotypes have not yet developed. Like clopyralid, metsulfuron methyl is mobile in water and dust and remains phytotoxic to some broadleaf plant species at extremely low concentrations.

Metsulfuron methyl is especially leachable and persistent in alkaline sites, and thus should not be used in the refuge's alkaline flats or playas. Ally and Oust are listed as suppressing, but not controlling Canada thistle, and are not listed as either controlling or suppressing musk or bull thistle in rangeland, but Ally is listed as controlling musk thistle. The Escort formulation is also listed as controlling Canada thistle as either a pre-emergent or early post-emergent treatment for seedling weeds and as controlling hoary cress; but is not listed as controlling either bull or musk thistle. Therefore, metsulfuron methyl will mainly be considered for use in sites dominated by seedling Canada thistle, not adult plants, where other problem thistles do not occur. Because of its extreme phytotoxicity, its use will be avoided near desired native or crop broadleaves. Also, repeated use of this or other sulfonylurea and/or imidazolinone pesticides will be avoided so that herbicide resistance does not develop in the refuge.

2,4-D and Triclopyr (Crossbow or similar tank mix). Crossbow is a preformulated mix listed as controlling Canada, bull and musk thistles in rangeland and pastures. Reseeding cannot occur for 3 weeks due to soil residue activity. On an acute toxicity basis, triclopyr ranks as moderately to highly toxic to mammals; slightly to practically nontoxic to birds; and practically nontoxic to aquatic species and bees (triclopyr amine salt). Thus, the main precautions will be to protect applicator health during mixing. Like 2,4-D amine, the half-life of the amine formulation of triclopyr is short, about one week, in water. Therefore, use of this mix may be considered near sensitive aquatic sites with no known mammals of concern. Since the refuge has no experience with this mixture, it will probably only be considered if other proposed control measures appear insufficient.

Triclopyr (Garlon) used by itself is labeled for and effective on brush and some other broadleafs. Garlon 3A is labeled for elm, Canada thistle and field bindweed, and Garlon 4 is labeled for salt cedar and elm. The primary use of triclopyr on the refuge will be the control of invasive woody vegetation.

Dicamba/Triasulfuron (Rave)- This tank mix is labeled to control Canada thistle in grasslands, pasture, and fallow land. The label stipulates avoiding use before target weeds are exposed to extended freezing temperatures in the fall. Recropping depends on bioassay results. Triasulfuron, also a sulfonylurea herbicide and ALS inhibitor, is similar to metsulfuron in leaching characteristics (i.e., it is highly likely to leach in alkaline sites), although it is apparently less persistent in water with a half-life of 1.7 weeks reported at pH 7. A higher half-life is expected in the refuge's more alkaline sites. On an acute toxicity basis, triasulfuron is no more than slightly toxic to birds and mammals and practically nontoxic to most aquatic species, but slightly toxic to bivalves. It is nontoxic to bees. Dicamba is also rated as practically nontoxic to aquatic species and birds, but slightly to moderately toxic to mammals. Unfortunately, dicamba may be persistent in water (we were unable to locate degradation rates), and therefore its use should be limited to small spot treatments near aquatic sites, and only if glyphosate treatments fail. The refuge has no experience with this pesticide premix in controlling Canada thistle, but

will consider its use as a follow up treatment away from aquatic sites and sites with sensitive mammals if primary treatments fail. The dicamba product, Rave, is also labeled as controlling musk thistle and hoary cress. The refuge no experience with Dicamba, but it may be considered as an alternative product in the future.

Chlorsulfuron (Telar DF) - This is another sulfonylurea herbicide with the same ALS mode of action. It is rated as being practically nontoxic to aquatic species, birds, and mammals on a short-term basis. However, chlorsulfuron is likely to leach easily and persist for longer periods in alkaline sites, and appears to be the most soluble of all the sulfonylurea herbicides listed. It is labeled as suppressing but not controlling Canada thistle. As with other sulfonylurea herbicides, there has been growing resistance of Canada thistle to this herbicide. Its use on Maxwell NWR may therefore be less desirable than other herbicides identified above.

Imazapyr (Arsenal) is an imidazolinone herbicide which inhibits ALS, with a mode of action very similar to sulfonylurea herbicides described above. It is listed as controlling bull and Canada thistle in non-cropland, as well as field bindweed, Russian knapweed, and yellow starthistle. Its use is restricted to utility, fence row and other rights-of-way and similar sites, and to non-irrigation ditch banks, so use of this herbicide will be restricted to such labeled sites. However, on an acute toxicity basis, use of this compound would be low risk to wildlife since it ranks as slightly to no more than moderately toxic to mammals; no more than slightly toxic to birds; and practically nontoxic to fish and invertebrates. The main problem with imazapyr is that it is highly persistent in soil and maintains residual activity, preventing its use in crop or restorations sites in which grasses or broadleaves are desired. Imazapyr also does not hydrolyze easily, but it does breaks down rapidly in sunlight, making it likely to persist in groundwater and deep surface water, but not shallow surface water. The evidence concerning this herbicide's leachability is conflicting, but the substance has solubility characteristics that suggest it is likely to leach. Therefore, use will need to be further restricted near ground and surface water sources. The refuge has no experience with this product, but it is a proven agent against salt cedar, and may be used to control salt cedar on the refuge in the future.

Follow up Monitoring - In addition to annual scouting for, and mapping of, weed infestations, treated sites will be monitored to determine the success of treatments, with the goal of measuring the degree of control or suppression attained, expressed as the percent the stand was reduced. Success will be measured based on revised estimates of the "acres infested," as well as whether the treatment produced any undesired effects on nontarget species or impeded grassland restoration through residual effects. In addition to the acres infested, monitoring will estimate the percent canopy cover of the infestation, providing an additional measure of the effectiveness of control treatments.

IPM Methods for Priority Species

Canada Thistle

Biology **-** Canada thistle (*Cirsium arvense*), a native to southeastern Eurasia, is a highly aggressive, colony-forming perennial in the aster family (Asteraceae). Canada thistle causes lumpjaw in cattle and is a serious agricultural pest. Its leaves are considered irritating to most grazing animals, including wildlife, and the plant negatively impacts refuge crops and range sites by forming thickets through vegetative growth, without the need for seed production, crowding out other species. It can invade wet or dry areas in sandy, silty, or clay soil types. It can also invade saline soils. Although it primarily invades disturbed areas, including fields and roadsides, it can also invade natural areas, including wetlands and grasslands.

In comparison with native thistles, Canada thistle are a darker green plant with spiny, alternate leaves. Plants grow to a height of 2 - 4 ft. On Maxwell Refuge, plants produce off-pink flowers in June and July. Plants erupt and bolt in the spring to their full height with spine-tipped, wavy leaves. The trigger is at least 14 hr of daylight. This thistle develops a vigorous, extensive perennial root system that extends both horizontally and vertically in the soil. Even fragmented root parts from mechanical activities can result in production of new plants, rendering mechanical methods ineffective. The only exception is complete removal of young thistles in the early growth stage.

Plants spread either through vegetative growth from root material or, if both male and female plants are present in a colony, by seed. Patches on Maxwell seem to be reproducing vegetatively and may not be producing viable seed. Canada thistles can produce up to 5000 seeds per plant, but normally produce only about 1500. Most seeds remain viable for only 2-3 years. Canada thistle are sun-loving and thrive in disturbed or cultivated sites; shading by healthy native plants can be an important limiting factor. Growth ceases at temperatures above 30^{o}C (= 86^{o}F).

Extent of Problem **-** This Class A weed is very widespread on the refuge, infesting perhaps 500 acres or more. In year 2000 surveys, infestations of this thistle were found in at least 17 of 55 farm fields on the refuge (31%), as well as infestations of Canada thistle along the face of dams, roadsides, and ditches and in surrounding areas. The thistles are usually found in a cluster with a common root system, appearing to spread vegetatively in most established clusters. Five of the farm fields (B4 and B5, C1 and C4, and G) were so badly infested that cropping practices have been drastically modified to emphasize and facilitate “summer fallow” control activities.

Treatment Goal - The treatment goal for Canada thistle is total eradication of infestations in and adjacent to farm fields; control infestations in range sites wherever they are located; and containment, through perimeter control, of infested dam and ditch areas.

Treatment Options and Selected Management Methods **-** Control of this species will require at least a 3-5 year effort. Treatments will focus on eliminating seed production and attacking the perennial root system. As discussed above, manual and mechanical methods alone are ineffective and may actually promote the spread of Canada thistle. An exception to this rule is young plants without an established root system, atypical of the perennial patches found on the refuge.

No biocontrol organisms imported to date to control Canada thistle have been highly effective. The seedhead weevil, *Rhinocyllus conicus*, whose larvae forage on thistle flowers, reducing seed production, is sometimes partially effective on Canada thistle, and to a lesser extent, musk thistle. This species is less effective on bull thistle. Unfortunately, this species also attacks native thistles and poses a risk to their populations. Its use would be inconsistent with protecting native thistle species in New Mexico, some of which are declining or rare. However, the seedhead weevil has become established locally and will likely become part of the refuge fauna in the near future, if it has not already. Field scouting efforts should include attempts to document the presence of seedhead weevils or their larvae. The gall fly, *Urophora cardui*, may also assist somewhat in limiting Canada thistle populations, but supplies of this organism are not easily obtained. The Refuge will consider introducing this organism as a supplemental treatment if a supply of this becomes available.

Prescribed burning, or prescribed burning followed by an herbicide, have been suggested as treatments to reduce the number of mature plants, limit seed production, and foster native grass growth (www.fs.fed.us/database/feis/). However, this method is ineffective on many other invasive species on the refuge, including musk thistle, and may actually enhance the seed germination of such species, especially on the disturbed sites typically found on the refuge. Fire will therefore be considered as a viable management tool only on range sites that have been successfully restored and where invasives are not a particular management concern.

Repeated monthly mowing of Canada thistle over long periods of time has been demonstrated to control Canada thistle, but this method is not feasible on most sites, especially range sites, due to the size of the area involved and the staff hours required. Mowing or cutting do provide additional stress and may improve the efficacy of herbicide treatment. Good regrowth (4-6 inches) after mowing of the thistle is recommended if a systemic herbicide is to be applied (4 weeks or so). Therefore, mowing or cutting will be used on selected, accessible sites in advance of herbicide treatment as part of this refuge's primary control strategy. In areas with substantial overstory, a bush hog will also be used to remove the over-lying vegetation to aid in visually locating thistles and improve herbicide effectiveness, whether by hand-held spot treatment or over-the-top boom application.

The selected preferred alternative along roadways and in natural areas is boom and/or spot spraying with a tank mix of 2,4-D amine and clopyralid (Curtail or an equivalent tank mix), using an ATV with a small mounted tank and/or a backpack spot sprayer at a rate of 2-3 qt/acre (Note that the nozzle on the 14 gallon sprayer used on the 4-wheeler puts out about 40 gallons per acre). If evaluations of wet-blade mowing from 2001/2002 trials indicate good efficacy and if the WetBlade mower remains in good repair, this mower will be used to reduce herbicide use, especially in accessible, sensitive sites. Difficult-to-treat thistles may receive a follow up tank mix treatment such as with a tank mix of picloram, 2,4-D, and clopyralid or triasulfuron methyl and dicamba, depending on location and previous control effort results. Selected, small, isolated patches of Canada thistle that are not in sensitive sites may be spot treated by hand with the picloram tank mix used for Russian knapweed.

Preferred methods will be modified in wet sites, sites immediately adjacent to springs, tanks and water bodies, and in other sites considered **sensitive**. At wet sites, a glyphosate treatment with Rodeo will be used in place of clopyralid and/or 2,4-D. In drier highly sensitive sites, Roundup,

also a glyphosate formulation, may also be used. Cutting or mowing prior to herbicide treatment will be used to increase efficacy when practical.

Cropping practices in infested farm fields will be modified to facilitate treatments, including summer fallow of heavily infested sites (e.g., C1 and C4). In these sites, repeated mowing or discing will be used to interrupt the bloom cycle and stress the energy reserve in the roots. This will be followed by herbicide applications to attack the stressed roots. A late-season boom treatment with Roundup (½ pint to1 pint per acre) at the early bud stage is scheduled for field testing on these fallow crop field sites in 2001. Caution must be exercised when discing any area with a perennial rooted invasive to clean the equipment before leaving the field. The light concentration is essential so as not to top kill the plant before the plants have the opportunity to translocate the glyphosate to the roots. Trials to increase efficacy will use ammonium sulfate to maximize the success potential with glyphosate products. Also, to the maximum extent possible, the refuge will attempt to treat Canada thistle when plants are growing best, and when soils are moist. Otherwise, the fall period would be considered optimal since this is when plants are translocating nutrients and would also be translocating the most herbicide down to the roots, in theory. A winter crop of green feed (wheat) can be planted after this treatment, but the field should not be disced until total brownup occurs to avoid limiting the treatment to a topkill, and a notill planting would be preferable. Fields with smaller, isolated infestations, such as B4 and B5 may be summer fallowed and treated in this manner in future growing seasons to control patches of thistle.

Table 3 indicates the following additional herbicide treatment options: metsulfuron-methyl; a dicamba/triasulfuron tank mix; chlorsulfuron; a 2,4-D/triclopyr tank mix; or imazapyr, as being effective on Canada thistle. Maxwell NWR has no experience with which to evaluate efficacy of these options, but will consider their use in future years if the treatments proposed above fails and pilot trials do not indicate desired efficacy. Imazapyr has a long residual and may have limited uses, such as along fences and rights-of-way.

In addition to herbicide treatment, an important component of successful IPM for Canada thistle will be the purchase of weed-free seeds for use in agricultural sites and reseeding of grassland and disturbed sites with native species that can compete with and shade out the thistle. Prescribed burning, grazing or other forms of disturbance will be avoided until infestations are controlled and sites are successfully restored to healthy native vegetation.

Musk and Bull Thistles

Biology - The New Mexico Department of Agriculture has identified musk thistle as a Class B weed. It shares many attributes in common with bull thistles. Both thistles are invasives, native to southern Europe and western Asia. Like Canada thistle, musk thistle (*Carduus nutans*) and bull thistle (*Cirsium vulgare*) cause lumpjaw in cattle and are serious agricultural pests, in addition to adversely affecting refuge crops and range sites. However, unlike Canada thistle, these species are biennials that develop annual tap roots, but lack the perennial root system of Canada thistle. Both have pink to purple flowers, although musk thistle can occasionally have white flowers.

Musk thistles have alternate leaves with spiny margins that clasp the stem; rosettes are smooth to

densely hairy. Mature plants can reach 6 ft in height and have a fleshy taproot. This species has the potential to spread much more rapidly than Canada thistle due to its seed dispersal capabilities combined with its tremendous seed production (as mush as several thousand seeds per large plant). Seeds remain viable for up to 10 years. Although most easily established on bare soil or cracked soil, the plant can invade wetlands, grasslands, crop fields and other sites.

Growing in moist to dry soils of all textures, bull thistles can produce up to 4,000 seeds per plant. This thistle thrives on nitrogen-rich soils and is controlled by shading and or repeated cultivation. Like Canada thistle, musk and bull thistles form rosettes before bolting and flowering. Rosettes are more susceptible to uprooting and to chemical treatment; however, their prostrate growth habit makes them difficult to detect. The presence of the similar native wavyleaf thistle (*Cirsium undulatum*) should also be noted and will not be targeted for control.

Extent of the Problem - Musk thistle is even more widely spread than Canada thistle on the Refuge, but has not succeeded in taking over any individual crop fields yet. The worst loci of musk thistle infestations are currently found in abandoned fields and other range sites. A 5-inch rain in May 1999, together with no effective control that year, resulted in a huge seed crop that will continue to produce seedlings that form rosettes until perhaps 2009. Musk thistle infestations were so numerous in 2000 that there was insufficient time to treat all of them prior to flowering. Despite very successful control in 2000, infestations will probably continue to be large due to a significant seed bank earlier years. Bull thistle is much more sparse in distribution and overall numbers, and seems to like the moister sites below dams best.

Treatment Goal - The treatment goal for these thistles is total elimination in and around crop fields. In noncrop areas, scouting will occur throughout the refuge to locate and treat musk and bull thistles before they flower annual scouting, monitoring, and follow up control treatments will also occur, with the goal of elimination of isolated individuals and control of larger infestations in range and other non-farm sites.

Treatment Options and Selected Management Methods - Many years of control efforts may be required because of the lengthy seed viability. Manual/mechanical treatments are equally ineffective in controlling musk thistles as in controlling Canada thistle and the effect of fire is unknown. Mechanical control alone has proven to be ineffective at stopping seed production as cutting off the plant above the rosette will not kill the plant and will hasten the development of buds and flowers as the plant becomes stressed, requiring a follow up treatment of herbicide such as 2, 4-D. This mow, wait, and spray sequence, when mowing is done before seed set occurs and 2, 4-D is applied with a boom sprayer before flowers are set after regrowth, was proven to be extremely effective in controlling both first and second year thistles in 2000.

Musk and bull thistle patches that have started to go to seed should not be mowed as the action will only spread seeds and seed heads. In fact a plant with a maturing seed head will attempt to make seed if it is left attached to the plant. Where only a few individuals occur, young plants without flowers may be dug up at a point 2 inches below the rosette. If musk thistles do flower and set seeds, the seed heads can be pruned off, collected, and incinerated before seed drop occurs. Although this pruning method is also very labor intensive, it is the only way to eliminate seeds after seed set has occurred. These methods will be supplemental, at best, since this prostrate growth form is difficult to detect from any distance and sufficient staff for large efforts

are unlikely. This method may also be used in sensitive sites, such as around seeps or open water.

Because these thistles can be intermixed with Canada thistle, identified as the Refuge's top priority species to control, and generally susceptible to the same treatments, the same herbicide treatments proposed for control of Canada thistle can be used to control musk and bull thistle, with glyphosate, 2,4-D/clopyralid, and picloram/2,4-D/clopyralid tank mixes proposed depending on type of site and alternative herbicides proposed if the above treatments fail to provide needed efficacy or if populations become resistant. (For rates, see Canada thistle.)
For individual musk thistles and small or scattered stands, treatments with 2, 4-D early in the growing cycle are preferable, typically through hand held spot treatments form a 4-wheeler. If flower development has begun (late May or later), 2,4-D mixed with chlorsulfuron or metsulfuron will be used to arrest seed development in these sites. For large stands and when areas with maturing flowers can not be sprayed, the site will be mowed (before seed set has occurred) and then sprayed 2 to 3 weeks after mowing**.** Bull thistle will be treated in the same manner as musk thistle.

Careful monitoring and record-keeping will be used to track any herbicide resistant patches, and the refuge will attempt to alternate treatments from those of the previous year at such sites. Treatment opportunities will expand once Canada thistle is eliminated from sites. For example, 2,4-D and chlorsulfuron may also be used for spot treatments or when musk thistle is the dominant species. This treatment was effective even where flower development was advanced beyond the bud stage, and, therefore, this combination will be used in cases where musk thistle are beyond bud in order to inhibit seed production.

Another herbicide identified as effective on musk thistle is dicamba at 1 lb/acre or a combination of dicamba and 2,4-D. Dicamba is not effective on Canada thistle; therefore its use will likely be limited until Canada thistle is fully controlled.

Two biocontrols are available that could assist in musk thistle control, *Rhinocyllus conicus*, and *Trichosirocalus horridus*. Only the former is widely available, but this weevil species will also attack native thistles and therefore has been rejected from consideration for now. However, populations of *Rhinocyllus* are know to be in the area in Colfax County, and can be expected to populate the refuge in the future.

Minimizing disturbance and reseeding bare ground areas will also be important elements of thistle control and grassland restoration. Therefore, use of prescribed fire or grazing livestock was not considered a viable option for invasive weed control. Use of weed-free seed is an important preventative measure during both crop and grassland seeding.

Russian Knapweed

Biology **-** Russian knapweed (*Centauria repens*) is a perennial with a reputation for toughness in resisting control treatments. A single Russian knapweed plant has been reported to have spread over 14 yd^2 in two years, averaging a linear rate of over 10 feet each year. This knapweed species normally forms dense clusters with a common root system, although there are exceptions on the refuge with scattered stands of individual plants several feet apart west of Lake 14, across from Headquarters and southeast of Lake 12. It is chemically active, causing dermatitis to humans,

toxicity to equines, and exhibits allelopathy. While it freely expands stand size vegetatively, it is also good at pioneering new sites through transported seed, as it is all too commonly found along roadsides. The New Mexico Department of Agriculture has identified Russian knapweed as Class B weeds. Russian knapweed can be very hard to detect from any distance unless in bloom (June and July).

Extent of Problem **-** Numerous sites were detected with relatively small infestations of Russian knapweed in 2000, an invasive species previously unknown and untreated on the refuge. These sites were located in a curious variety of locations, including mostly roadsides, but also in G field, and additionally in some range sites without a clear connection to a source of seed or root material. Large stands exist northwest of Lake 14 or in the triangle southeast of Lake 12 (both in atypical, scattered stands). This highly invasive species is also especially prolific in fields G and A. It is likely that perennial species such as Russian knapweed will continue to expand its infestations at a rate of 5-10 feet or more per year at Maxwell NWR, if control measures are not continued.

Treatment Goal **-** The treatment goal for this species should be total elimination for all infestations, owing to the relatively few sites and small acreage infested, combined with its proclivity for pioneering from seed. In 2001, two fields (A and G) were infested, with G having the most serious portion of the field involved. Infested fields will be fallowed to facilitate treatment and promote visibility of the infestation. Monitoring in May 2002 indicated that the G field infestation was relatively healthy, but the infestation in A Field, like other sites treated with the picloram tank mix, with decreased by over 90%.

Selected Management Methods - Either picloram or tank mixes with picloram (2,4-D / Clopyralid/Picloram) were identified as the only effective treatments among trials conducted in 2000. All leaves must be sprayed until wet, or treatments will be less effective. The WetBlade also has potential in these treatments, and should be field tested on large stands, such as those northwest of Lake 14 or in the triangle southeast of Lake 12. The above herbicides will also be used for treatments of fields A&G and for spot treatment of isolated individuals. If these treatments are unsuccessful, metsulfuron methyl will substituted. Along fence lines and right-of-ways, imazapyr may also be used. Note that a general application of any picloram to a crop field will require that field to be fallowed more multiple years, suggestion that a hand held spot treatment to individual knapweed plants might be best in crop field situations. Care must also be taken not to disc the field so as not to spread and invigorate the root system, an unfortunate practice demonstrated by the extent of the infestation in G Field. Fallow, Spot Spray, No Till.

Hoary Cress

Biology **-** Hoary cress *(Cardaria draba)* is a perennial that forms clustered stands spreading from a common root system. This species can also spread from root fragments or seed, making discing an effective dispersal method and a totally ineffective control method. It is similar to perennial pepperweed, also sometimes called whitetop, and also to hairy and lens-podded whitetop because of white flower clusters at the tops of the stems. However, it can be distinguished by its heart-shaped seed capsules. This invasive weed produces flowers earlier than any other invasive species on the refuge. The plant is in the bud stage from late April to early May, the earliest of all refuge invasives, and infestation are best found by scouting while the patches are in bloom. Seed

set occurs by early summer.

Extent of the Problem - Infestations of this plant are primarily associated with irrigation ditches on Maxwell Refuge, but have also spread extensively into surrounding upland areas, highway right-of-ways, and roadsides. In 2000, we located three sites in range situations and a small colony on the south end of Field F2. Hoary cress is now also well established in fields B5 and F1, and other sites were found in scouting in 2001. We believe that hoary cress is expanding its infestations in the range of 5 to 10 ft/year at Maxwell, requiring prompt and effective control treatments to keep the problem manageable.

Treatment goal - The treatment goal is total eradication of all stands in all locations, including preventing seed production and avoiding the spread of root systems and other plant parts by other operations. Also, as with other invasive species, working with neighbors and other agencies to become aware of and take effective action against this invasive must be part of the overall solution For example, the practice of mowing roadsides is helping to rapidly spread infestations, whereas if patches were spot treated before seed production and top-killed, mowing later would not be a problem.

Selected Management Methods - Because it is the earliest priority weed to flower and is difficult to locate when it is not in flower, scouting and treatment will occur beginning in April, when the hoary cress are in bud or flowering. The ideal treatment stage is "bud stage" so mapping and the use of a GPS unit will be used to relocate patches for treatment in future years before they reach full bloom. Hoary cress resisted treatment with 2,4-D mixed with metsulfuron methyl (Escort) in 2000, so different treatments may be needed in monitoring indicates that follow up treatments in 2001 were also unsuccessful in preventing regrowth the following year.. Prior treatments with metsulfuron methyl were only effective in top-killing the stand, but the lack of control on root systems may owe to the late period of application relative to the bloom cycle in 2000. Therefore, field trials will be established during bud stage to compare the efficacy of metsulfuron methyl or chlorsulfuron with other products listed in Table 3.

Saltcedar

Biology - Saltcedar, also known as tamarisk *(Tamarix ramosissima*), is a highly invasive tree species that can grow to 20 ft or more in height. The plant is a deciduous evergreen from Eurasia that has now become a serious problem throughout the West, especially in riparian areas along streams and canals, reservoirs and other water bodies. Saltcedar displaces native tree species, such as cottonwood, by exuding salts that are phytotoxic, and they alter hydrology because of a larger water demand than native riparian species. Hence, sites infested with saltcedar are sometimes difficult to restore.

Extent of the Problem - Until recently, saltcedar only occurred on Maxwell Refuge as scattered saplings and isolated trees, and all of these were thought to be controlled due to aggressive treatments in 2000 and 2001. However, by fall of 2001 an extensive eruption was detected around lakes 12 and 13, likely dating to the flood of May 1999, wherein tens of thousands of seeds came into the refuge from upstream (including Stubblefield Reservoir) and germinated. This species will remain a priority for control due to its extreme invasiveness, high water demand, and potential for erupting in mass quantities, and the likelihood of continued new infestations via

upstream water deliveries. Salt cedar has become well established off the refuge in the Vermejo and Canadian watersheds, including the Vermejo Conservation District Dam reservoir and canal system that feeds into the refuge.

Treatment Goal - Total eradication in all sites. All mature plants were killed by 2001, but thousands of seedlings and saplings persist.

Selected Management Method - As with other invasives, annual scouting efforts in all likely moist areas of the refuge will occur during the spring growing season to locate any new infestations. Younger stands of this species will be mowed or cut with the WetBlade. The refuge has been highly successful in using Garlon 3A and Garlon 4, and will continue to use these products and spot treatment methods. Garlon 4 (triclopyr butoxy ester) ranks as moderately toxic to highly toxic to mammals; slightly to practically nontoxic to birds; highly toxic to fish; and highly to practically nontoxic to aquatic invertebrates depending on species. For this reason, applications of Garlon 4 will be limited to cut stump treatments and basal bark spot sprays. Garlon 3A, an amine salt formulation, is used in sensitive sites near water since it is lower in toxicity to fish and aquatic invertebrates. On an acute toxicity basis, it ranks as practically nontoxic to fish and aquatic invertebrates and similar in toxicity to birds and mammals.

Imazapyr (Arsenal) in dry sites, and Glyphosate (Rodeo) in wet sites, may also be used to control salt cedar. Bosque del Apache refuge has had good success with these products, including using them in combination. Innundation is not a viable control option for salt cedar at Maxwell due to the elevation of the infestations and the long duration of complete submersion needed to kill the plant and root system. Working with the Vermejo Conservancy District and other refuge neighbors towards the control of cedar and seed sources will be an important part of an effective salt cedar control program.

Russian Olive

Biology **-** This tree species (*Elaeagnus angustifolia*), introduced from Europe as an ornamental, grows to a height of 25 ft and is armed with 1-2 inch thorns. Although it is recognized as a source of food and habitat for wildlife, it invades moist rangeland, meadows and waterways, and can become a serious weed problem in New Mexico riparian systems. It may be the only plant capable of displacing salt cedar infestation in riparian situations.

Extent of the Problem **-** A few Russian olives were planted in the headquarters area several years ago, with only a single escaped olive sapling located and killed in 2000. Due to control efforts in 2000 and 2001, Russian olive are thought to be eradicated from the refuge, although it is likely that American robins and other seed eating birds may reintroduce seed from infestations along the Canadian or Vermejo Rivers, requiring continued monitoring and treatment.

Treatment Goal - Total eradication in all refuge sites. Work with neighboring landowners to reduce or eliminate offsite seed sources.

Selected Management Methods **-** The same methods will be used as for saltcedar (see above).

Siberian Elm

Biology - Also known as Russian elm (*Ulmus pumila*). Introduced by settlers for shade and as a windbreak around areas of habitation, this non-native tree is capable of spreading vegetatively though suckers and by seed.

Extent of the Problem - Scattered groves of this elm remain on the refuge on former home sites. These elm stands are spreading moderately across the refuge landscape either through vegetative suckers or seed dispersal, and are overtaking other habitat types.

Treatment Goal - Control the expanding new growth from existing stands by mowing and or herbicide application and or cut stump treatment with chainsaw. The removal of all trees is not considered desirable or necessary as long as expanding growth is culled every few years, which was never done until 2000.

Selected Management Methods - Siberian elm will be controlled by methods described above for saltcedar; mowing, spraying, or cut-stump treatments. Mowing younger saplings and touching up regrowth with 2, 4-D or Garlon will likely prove to be the easiest and most efficient means of control.

Grasshoppers

Northeastern New Mexico hosts as many as 70 species of grasshoppers. Known for their cyclic population eruptions and voracious appetites, grasshoppers can decimate any edible forage. Refuge crops, including cooperative farmers' alfalfa fields, are grown to help meet refuge purposes by providing forage for migratory birds. Fields planted in irrigated crops are a particularly susceptible source of food for foraging grasshoppers, and previous infestations have caused serious damage to refuge crops.

Biology - Because of the large number of species, individual biologies will not be discussed in detail here. Information on individual species is summarized in "Multiyear Evaluation of the Effects of *Nosema locustae* on Rangeland Grasshopper Density and Natural Biological Controls," by Bomar et al. (1993) and readers are referred to this document. The most common species encountered by Bomar were *Melanoplus bivitatus*, the two-striped grasshopper, *M. femurrubrum*, the redlegged grasshopper, and *Phoetaliotes nebrascensis*, the largeheaded grasshopper. These are all spurthroated grasshoppers.

It is important to emphasize the different dietary preferences among grasshopper species and preferences in consumption of wheat bran bait, or not, when considering treatment options. The spurthroated grasshoppers do eat bran baits. Some species have relatively narrow dietary preferences and eat only grasses, while other species have a wider dietary range, eating grasses and other plants, and not all species will be attracted to a bran bait product. Thus, the species composition involved in an infestation is important in considering control alternatives and locations.

Another important factor to consider in applying treatments is that not all growth stages, or instar, will eat the bran bait. The third and fourth instar stages of slantfaced grasshoppers will forage on bran bait, thereby infecting the population. Other stages, including adults, do not eat bran bait. However, adults may become infected with *Nosema* if they cannibalize other dead or dying grasshoppers that have consumed bran bait.

Extent of Problem **-** Maxwell NWR has experienced multiple grasshopper outbreaks, involving various species listed above, including outbreaks of those of grasshopper species that do eat bran bait, but also species of other types of grasshoppers, including bandwinged and slantfaced grasshoppers. Prior treatments with two different *Nosema* bait products, each used on separate outbreaks, have been mixed. The *Nosema* product used in the Bomar study gave good results, while the other used by the refuge in later outbreaks, did not. While it is unclear as to why the later treatment was ineffective, product freshness may have been a factor.

Selected Management Methods **-** In the future, Maxwell NWR will utilize three distinct types of control for grasshoppers: cultural, biological and insecticidal. Prior to initiating controls, the following scouting protocol will be conducted to monitor the distribution, abundance, species, and growth stage of infestations.

Scouting - The decision to control a grasshopper infestation will depend on 1) the dominant grasshopper species present and its (their) dietary preferences and propensities to cause crop or natural resource damage; 2) established action thresholds based on scouted grasshopper densities, and 3) whether biocontrol with Nosema bait, the first selected line of defense, is likely to be effective or not.

Thus, species identification and scouting will be crucial elements of the refuge's IPM program, and treatment will only occur to threatened sites. For example, for grass-eating grasshoppers, control efforts in and around alfalfa fields would be unneeded and a wasteful use of control agents, whereas treatment might be necessary in grain crop situations (e.g., wheat and corn). Also, if an infestation is comprised of species that do not eat oat bran (e.g., various species of "slantfaced" grasshoppers), then the application of a bran bait product is not a viable option for control, and other strategies must be applied.

Scouting for grasshoppers will begin when warmer spring conditions arrive, with efforts concentrated in areas likely to host grasshoppers. Scouting will occur on warm afternoons when grasshoppers are most active. Soil temperatures will also be monitored to predict emergences. When grasshoppers are detected, a weekly scouting schedule will be established (preferably on Monday afternoons) to determine grasshopper densities. Densities will be recorded and correlated with soil temperatures recorded at these same sites.

Standardized sampling will be conducted in following with guidelines developed by Patrick (1998), Extension Entomologist with the Texas A&M University System, using the square foot method, as follows:

> Within the sample area, the number of grasshoppers in an estimated square foot will be counted using a hand counter and recorded in 18 quadrants 20 paces apart. [Persons conducting these sampling counts will initially practice with a measured square foot until they become proficient at visually estimating that size area accurately.] The total number of grasshoppers will be divided by two, providing an average number of grasshoppers/yd^2 (=9 ft^2). If the grasshoppers are predominantly in the first to third instar (wingless and generally less than ½ inch long), the number will be divided by three to get the equivalent number of adults when an insecticide control is under consideration. Individuals in the

fourth instar and up will be considered adults. This determination will be made based on species identification, species ratios, growth stage (instar), and action thresholds for the dominant species. To determine thresholds for biocontrol, immature instar will be counted as one. Specimens will be collected and identified to determine species. Dietary preferences will be determined from previously collected data . Related data will be collected for future reference and to refine control strategies.

A minimum of four areas representing different geographic locations and habitats on the refuge will be sampled using this method, generating count data for a total of at least 8 yd^2 (72 ft^2). Sampling will occur in at least one non-barley crop location, one barley planting, and one non-crop range site. The sample from the barley planting will not be weighed into the overall average used to determine threshold levels, assuming that the barley will have few, if any, grasshoppers. However, sampling here will indicate whether grasshoppers are using the barley and whether the barley is an effective cultural management strategy.

The following action thresholds, based on those developed by Patrick, will serve as initial guides for insecticidal treatments. The threshold ratings are split into two categories, one for fields, which includes rangeland and field crops, and the second for margin areas outside fields, as follows:

Infestation	**Adult Count ($No./yd^2$)**	**Adults In Margin ($No./yd^2$)**
Non-Economic	0 - 2	5 - 10
Light	3 - 7	11- 20
Threatening*	8 - 14	21 - 40
Severe*	15 - 28	40 - 80
Very Severe*	28+	80+

Infestations at or above the "threatening" level will be considered candidates for the application of insecticide (*). A *Nosema* bait will be used on "light", or possibly the higher end of the "non-economic" range of infestations, on species which consume bait. Patrick's ratings and associated thresholds do not identify the infestation level warranting the application of biocontrol agents and may not reflect future cost effectiveness and/or refuge management goals. An additional factor to consider in the pondering the threshold to spray or not is the negative effect of an insecticide on non-target insect species, some of which may be beneficial (pollinators, beneficial predators, etc.). Hence, some experimentation with these thresholds will be done to assess *Nosema* effectiveness on various grasshopper species and adjust for detected benefits or adverse effects of any chemical uses on refuge trust species.

Cultural Control. The main cultural control will be the planting of barley, since prior refuge experience has observed some avoidance of this crop by grasshoppers, and it aids in meeting the dietary requirements of migratory waterfowl. Each winter, in the development of the Annual Crop Rotation Plan for the upcoming planting season, the acreage of barley grown as either a green browse and/or grain crop will be maximized. Additionally, barley will be planted as a buffer surrounding other crops in an effort to shield these crops from infestations. These buffers will be maximized, as reflected in the crop plan and in coordination with refuge cooperative farmers.

Biocontrol. The protozoan *Nosema locustae* is available as a wheat bran bait in multiple control products (such as NoloBait and Semaspore). This product will be used as the refuge's first line of defense if grasshoppers are in the 3rd and 4th instar stages when the grasshopper species of concern actually have a dietary preference for bran bait (provided that the bait can be obtained from a supplier in a timely manner). An advantage of this product is that, if it infects a grasshopper population successfully, it can spread among grasshoppers, infecting subsequent generations and providing long-term control. In the future, the refuge will also evaluate use of two other potential biocontrols: a fungal product, Mycotrol, and the parasitic wasp, *Scelio opacus*. As with other control agents for other species, refuge management will be on the lookout for other biocontrol agents for grasshoppers to add to the "toll box" used for integrated control efforts.

The *Nosema* bait has a short self-life and is susceptible to heat damage; therefore the product will be ordered as needed and put out with urgency, but never stockpiled. Optimal efficacy from *Nosema* may not be reached until 4 to 6 weeks after application. Consequently, regular scouting will continue to monitor the grasshoppers to assure that the population is not erupting, triggering the need for an insecticide. The refuge will also continue evaluating the effectiveness of *Nosema* and adapting the proposed scouting protocol, if needed to evaluate off-site source grasshopper sources. If scouting and use of *Nosema* and other possible biocontrols is ineffective, then chemical control will be implemented.

Chemical Control - The use of insecticides to control grasshopper outbreaks raises significant issues, especially in the context of Federal land managed as a National Wildlife Refuge. The primary consideration is toxicity, not only to non-target insects, but to native species and species biodiversity, as well as to health and safety of refuge staff applying the pesticide. Repeated applications and reliance on a chemical solution may result in the buildup of undesirable chemical residual in the environment or cumulative effects on biota, in addition to a buildup of resistance in the target population.

Three products will be considered for treatment of the grasshoppers: carbaryl (Sevin), Malathion, and pyrethrin. In the future, a new low-risk insecticide, Spinosad, may also be considered. However, it is not yet labeled for refuge crops or rangeland. Characteristics of carbaryl, the preferred insecticide, is reviewed below:

Carbaryl (Sevin). Carbaryl is a carbamate insect that causes acetylcholinesterase (AChE) inhibition, affecting nerve function in insects, and to a lesser extent other vertebrates. Among vertebrates, fish and frogs are especially sensitive to exposure to carbaryl. Repeated exposure at close frequency causes cumulative impacts to the central nervous system of vertebrates, and, if sufficient, can result in behavioral changes, convulsions and death. However, AChE inhibition by carbamates, unlike organophosphates, is reversible withing a period of days to weeks, limiting impacts except On an acute toxicity basis, both carbaryl and breakdown product, 1-naphthol, are rated as moderately to highly toxic to fish; moderately toxic to mammals; and slightly to moderately toxic to birds. Therefore, this product poses some risks to refuge resources. Fortunately, carbaryl degrades rapidly in soil and water, with a typical half-life in the range of 2-9 days on treated plants; one-two weeks on sandy loam soil; and about half a day in waters of pH 8 or higher.

Carbaryl (in this case, Sevin XLR) will remain an important defense in an integrated approach to managing grasshopper outbreaks, considering the potential for devastation resulting from high grasshopper densities.

Prevention

The ultimate control action against invasive plant species on Maxwell's rangeland will be to reestablish healthy native short-grass prairie plant communities. Therefore, the rehabilitation of abandoned crop fields and overgrazed range sites is in itself an important component of this IPM plan. However, the Refuge also intends to aggressively scout for, and eliminate, any new individuals or colonies of priority species that may recolonize refuge lands. Post-application monitoring to evaluate effectiveness and detect possible regrowth that may require a touch-up application will be a routine practice on Maxwell Refuge.

In addition to the priority weeds identified above, Maxwell Refuge intends to prevent the invasion and proliferation of invasive species likely to pose future problems to the refuge if not controlled immediately. Species in this category include *Halogeton*, leafy spurge and yellow starthistle. *Halogeton* can cause liver damage in livestock. Yellow starthistle is toxic to equines, causing chewing disease and possibly death. Leafy spurge is already established in Colfax County. Typically, these invasive plants, native to Europe or Asia, have found a variety of niches to exploit, frequently in disturbed sites. Maxwell NWR staff, volunteers, and visitors will be trained to recognize these species and instructed or asked to remove any of these species found or to notify the refuge manager of their location. Removal actions will occur immediately following documentation, including mapping with Global Positioning System.

Another aspect of prevention will be refuge emphasis on weed control along roadsides and irrigation ditch banks, in addition to refuge crop fields, since these are key production areas of seeds of invasive weeds, and seeds from these sites are especially likely to be transported by vehicles or water to other locations. Cleaning vehicles and equipment that is to be transported off refuge or brought onto the refuge is another important part of employing integrated cultural controls.

Farmers will also be requested to use weed-free seed. This will become a requirement in new farming agreements. In addition, farmers will be encouraged to select crop varieties that are resistant to any new insect or fungal pests encountered in the future, and farmers will be encouraged to time their cuts so that it occurs before weed seed production.

All equipment used off-road or in the field, including tractors, 4-wheelers, trucks and fire equipment, will be thoroughly cleaned with high pressure spray equipment before being taken to another location away from the station. Likewise, any equipment coming to the refuge from another area will be cleaned before arriving at Maxwell, preferably at its origin.

Outreach & Coordination

Since the ecosystem and the pest plant invasion do not start or stop at the refuge boundary, working with neighboring landowners and other partners in the community (e.g., Colfax County, the County Extension Agent, Highway Department, and Vermejo Irrigation District) is vital in the

successful management of invasive plant infestations both on and off Service lands. Organizing and/or participating in the Colfax County weed workgroup is providing a good vehicle for outreach and coordination on weed control and related issues and will continue.

In addition, Maxwell Refuge will familiarize all permanent and seasonal staff with the Refuge's invasive species control program, and will produce bulletins and pictures of unwanted invasive species, enabling staff, volunteers, and visitors to assist in its control efforts. Infestations of invasive species and their management will be an important subject for interpretation to refuge visitors, as well as to refuge neighbors and the community in general. Staff, volunteers, and visitors will also be encouraged to opportunistically uproot and properly dispose of easily recognized invasives or assist in cutting and other non-pesticide aspects of their control.

Summary of the Preferred Alternative

The preferred alternative for pest management at Maxwell National Wildlife Refuge is to implement aggressive IPM control strategies, including the minimum amount of effective herbicide(s) needed to produce the desired measure of control over invasive plant infestations. The refuge will employ combinations of biological, cultural, mechanical, herbicide and insecticide treatments that represent the best management practices available, based on current science and sound ecological principles, based on ample amounts of scouting and monitoring. Special attention will be paid to the availability of new biocontrol agents and new low-risk control agents, and to the most up-to-date equipment needed to ensure effective, environmentally responsible treatments.

Efforts will continue to identify invasive plant infestations and map infestations has been initiated and will be completed at the earliest opportunity. Although the vegetation survey conducted in 1999 produced a map, infested areas are identified with the generic, nonspecific term "herbaceous disturbance", with no reference as to the species present. Completing a comprehensive mapping effort in digital format, including an estimate of acres infested by each species, will provide a sound foundation to work from, as well as a meaningful tool from which to measure the success of subsequent treatments. Annual scouting efforts in all areas of the refuge during the spring growing season will reveal new infestations, likely reducing the intensity of new infestations and the resources required to eliminate future infestations.

Selective use of effective herbicides, or herbicides in combination with mowing, will provide the desired measure of control that is targeted for each species of invasive plant and agricultural weed. Refuge management treatments for pest plants will be implemented on a priority basis, ranging from total elimination, to control, and including suppression, and containment, as follows:

- eliminate all newly discovered invasive plant infestations, and eliminate all infestations of invasive plants in and adjacent to farm fields, as rapidly as possible.
- control all existing infestations of invasive plants in range sites and along roads.
- control or suppress other agricultural weeds in farm fields.
- contain invasive plants around District dams and in District ditches.

Treatments will be scheduled to eliminate seed production. If, for some reason, an entire infestation can not be treated, the perimeter of the infestation will be treated to contain and

minimize the expansion of the infestation. The use of herbicides is a necessary early step to restore healthy habitats on the refuge because of the severity of infestations. This plan also recognizes the need to rotate herbicides to prevent chemical resistance from developing. After a few years of effective herbicide treatments, the use of herbicides will be reduced sharply as invasives are eliminated or controlled, scouting reveals new infestations at an early stage, revised farming and other cultural practices minimize the spread of weeds, and range sites are restored.

Treated sites will be monitored to determine the success of treatments, with the goal of measuring the degree of control or suppression attained, expressed as the percent the stand was reduced. Management should be adaptive based on the results of various products, rates and tank mixes, progressing to employ the treatments that are most effective in the context of the Maxwell landscape. Rotation of herbicides to minimize pest plant resistance, using a different product with a differing mode of action, should be an integral part of the integrated pest management practices.

Control of grasshopper infestations will be based on the results of weekly scouting for grasshoppers and monitoring of soil temperatures as warmer spring conditions arrive. When grasshoppers are detected, quadrant sampling will begin. Control measures will be based on the dominant species in an infestation, and on food preference(s) of these species, with treatment based on action thresholds and the attractiveness of oat bran bait to that species. Barley, grown as either a green browse and/or grain crop, will be maximized and barley will be used as a buffer surrounding other crops.

Additional Elements for an Effective Control Strategy

The best management practice for controlling invasive plant infestations will include the integrated pest management approach elements identified in the "preferred alternative" discussed above. However, for the Control Strategy to work optimally there are other elements to bring into the strategy.

Restoration of Grassland Habitat**:** Once the control strategy is implemented and infestations are reduced, controlled, or eliminated, preventing re-infestation becomes a primary management concern. A primary means of invasive plant establishment is to colonize disturbed sites where good stands of competing native vegetation is lacking or altogether absent. Therefore, disturbed sites that hosted infestations should be restored by replanting native plants species and possibly providing irrigation water and/or low amounts of fertilizers, if former organic layers are absent. For the most part at Maxwell, this practice will involve using a range drill (not currently on hand) to plant native grass mixtures. One important consideration involving grassland restoration sites where Tordon is used is that picloram, especially at the higher application rates, has a residual effect inhibiting both grasses and broadleafs. Only lower Tordon rates (i.e., 1 pint/acre) should be applied in areas where grassland restoration is expected to take place within two years.

The Natural Resource Conservation Service (NRCS) can provide recommendations for appropriate seed mixtures for range, based on the soil type in the area to be planted. One potential strategy for restoration would be to convert farm field A, or another location that could be watered, to a restored native plant stand. The availability of irrigation could benefit germination and survival, ensuring a vigorous stand. This stand could then be hayed in alternate strips, timed for maximum seed production and maturity, with the hay then used to seed other

sites, year after year. If field A is to be used, a new flow meter must be installed before water can be delivered to ensure native grass germination and growth.

Securing Additional Funding: Maxwell has two RONS projects (projects included in the National Refuge Operational Needs System) that address the management of invasive plants, one for farm lands and the other for range restoration. "Lessons learned" involving RONS project #97005 for "Pest Plant Control", included the need for a biologist. The refuge received $20,000 in FY99 under RONS project 97005, to develop a vegetation map, including exotic infestations, for the refuge CCP. Ironically, although identification and delineation of exotic plants was part of the contract***, none*** of the notorious exotics were identified on the resulting map. Future projects will need be well written and implemented properly for the program to succeed. Another lesson driven home by the vegetative survey field work (and the resulting map) was that the field work was done at the wrong time of year when plants were not blooming or actively growing, again pointing to the need for understanding the biology of the pests on the Refuge. If the timing is not right, then objectives will not be met. With these lessons in mind, Maxwell NWR will seek additional funding through the aforementioned county weed workgroup for a National Fish & Wildlife Foundation Grant to control invasive plants, but a non-Federal match is a requirement that may prove somewhat difficult for the Colfax County Weed Taskforce to acquire. In-kind labor will be proposed as a match may be one partial solution. Logical inclusions in such a grant application would be funds for outreach materials, native grass seed mix and for a range drill, the latter needed to plant seed, with a minimum of soil disturbance that would encourage re-invasion. Funding may also be sought from other sources, including foundations.

References Cited

Bomar, CR; Lockwood, JA; Pomerinke, MA; and French, JD**.** Multiyear evaluation of the effects of *Nosema locustae* on rangeland grasshopper density and natural biological controls. Environmental Entomology, vol 22, no. 2, pp 489-497, 1993

Colorado Natural Areas Program, Colorado State Parks, Colorado Department of Natural Resources, and Colorado Department of Agriculture. 2000. Creating an Integrated Weed Management Plan: a Handbook for Owners and Managers of Lands with Natural Values. Caring for the Land Series Vol. IV. 341 pp.

MeisterPro Publishing Company. 2002. Weed Control Manual 2002. Willoughby, OH. 578 pp.

Patrick, C. 1998. Grasshoppers and their control. Texas Agricultural Extension Service, Texas A&M University. Report L-5201. 4 pp.

Sheley, R. L. and J. K. Petroff (eds.). 1999. Biology and Management of Noxious Rangeland Weeds. Oregon State University Press, Corvallis, OR.