Habitat Management Methods for Least Terns, Piping Plovers, and Whooping Cranes

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Prepared for:

Land Committee
Governance Committee

Platte River Endangered Species Partnership

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Habitat Criteria Subcommittee

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I. INTRODUCTION

The states of Wyoming, Colorado, and Nebraska and the U.S. Department of Interior ("the parties") signed the "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats Along the Central Platte River, Nebraska" (Cooperative Agreement) on July 1, 1997. In signing, the parties agreed to participate in and implement certain activities relating to four target species listed as threatened or endangered (interior least tern, whooping crane, piping plover, and pallid sturgeon) and to help prevent the need to list more basin associated species pursuant to the Endangered Species Act. In the Cooperative Agreement, the parties set forth a "Proposed Platte River Recovery Implementation Program" (Program). The proposed Program builds upon the Cooperative Agreement and includes certain activities and contributions from the states and the federal government to be conducted during the first increment (10-13 years) of the Program. The proposed Program will be analyzed in a Programmatic Environmental Impact Statement (PEIS) under the National Environmental Protection Act (NEPA). All parties need to agree on any final Program before it is implemented.

One of the objectives of the proposed Program is to acquire 10,000 acres of habitat in the first increment and ultimately 29,000 acres of habitat in central Nebraska for least tern, piping plover, and whooping crane habitat. The area of interest in central Nebraska begins at the junction of U.S. Highway 283 and Interstate 80 near Lexington and extends eastward to Chapman, Nebraska (1:200,000 Land status map and 1:12,000 Land Status maps developed by USFWS and BOR are available for review at the Central Platte NRD office, Grand Island, or the Cooperative Agreement's Executive Director's office, Cheyenne). The Land Committee of the Governance Committee was charged with evaluating past and ongoing habitat management practices for least terns, piping plovers, and whooping cranes in the central Platte River valley in milestone L2-1 of the Cooperative Agreement. The Cooperative Agreement does not identify the need for an evaluation of habitat management methods pertaining to pallid sturgeon. Milestone L2-1 states:

> "The Land Committee will develop criteria and guidelines for future habitat protection, restoration and acquisition under a Program, and will develop and implement processes/mechanisms/procedures as appropriate to acquire, administer, restore, and manage any land or habitat (wet meadows, channel, etc.) provided for wildlife for incorporation into or protection under a Program. Measures will include identification and evaluation of potential habitat areas; an evaluation of past and/or ongoing habitat management practices; and identification and evaluation of potential alternative habitat management methods. The Committee will also develop a process for acquisition, oversight and continued protection of land interests, including the reversion of or protection of land interests if a Program fails."

As part of completing milestone L2-1 the Land Committee formed the Habitat Management Criteria Subcommittee (Subcommittee). The Subcommittee and Land Committee felt that in order to complete pertinent and relevant portions of this milestone the following was needed: 1) a survey of all potential habitat management entities in the central Platte River valley, 2) a literature review

of habitat management techniques used not only in the central Platte but elsewhere, and 3) a technical meeting of species and habitat management experts. The results of the survey are used to evaluate and describe past and/or ongoing habitat management practices in the central Platte River valley based on information provided by habitat managers. The literature review describes different management practices that have worked and did not work in regards to tern, plover, and whooping crane habitats within and outside of the central Platte River region.–The Technical Meeting was used as a forum to discuss the survey and literature review portions of the document and to develop recommended best management practices for use during the Program. The information from these sections was used in developing the recommended best management practices for habitat protected through the proposed Program.

The information contained in this document was obtained from a variety of sources and is intended to provide decision-makers with general information regarding habitat management methods in the central Platte. The goal of the survey, literature review, technical meeting, and recommended best management practices is to provide information that can be used in preparing habitat management plans and making habitat management decisions for lands involved in the Program. This document was reviewed and accepted by the Habitat Criteria Subcommittee on May 8, 2000 and forwarded to the Land Committee and Governance Committee for review and approval. The Land Committee reviewed the document on June 12, 2000 and forwarded it to the Governance Committee for consideration. The Governance Committee reviewed and concurred with the document on August 3, 2000.

II. METHODS

A. SURVEY

The Land Management Evaluation Survey was sent to land management entities to document past and ongoing management efforts in the project area by inquiring about objectives of management activities, methods used, measures used to evaluate effectiveness, and various other aspects of their management activities (Appendix I). The survey and associated cover letter explaining the purpose and goals of the survey were mailed to 23 potential habitat management entities (Appendix II) on January 20, 1999 with a requested return date of March 1, 1999. Only five of the 23 entities surveyed responded by March 1. The remaining 18 entities that did not respond were contacted in mid-April by phone, email, or in person to remind them of the survey and its importance. The first follow-up resulted in seven more responses. The remaining 11 entities were ranked with respect to the amount of land and type of management they conducted. Those entities deemed to be "critical" to the success and completeness of this document were contacted several more times during May and June. The nineteenth, and final survey response was received on August 17, 1999. Copies of returned surveys are available for review at the Central Platte NRD office, Grand Island, or the Cooperative Agreement's Executive Director's office, Cheyenne.

While reviewing and compiling the information contained in the returned surveys it was necessary to contact many of the land managers again to clarify points and ask for additional information. These contacts were made by phone, email, and in person.

B. LITERATURE REVIEW

A literature search was conducted to obtain relevant literature on habitat management methods for the whooping crane, least tern, and piping plover available through the University of Wyoming library system, as well as other library systems. Several databases were searched including *Wildlife Worldwide, First Search, Infotrack, Agricola,* and *WYLDCat*. As information was gathered, references and citations were reviewed as another data source. In addition, federal and state agencies, conservation groups, electrical/irrigation districts, and professional scientists/managers were contacted to request copies of papers, documents, and other information relevant to the project. Contacts were made by either telephone or email. The following entities were contacted:

- U.S. Fish and Wildlife Service
- Army Corps of Engineers
- Nebraska Game and Parks Commission
- Nebraska Public Power District
- Central Nebraska Public Power and Irrigation District
- Platte River Whooping Crane Trust
- Northern Plains Research Institute
- South Dakota State University
- North Dakota Fish and Wildlife
- Lostwood National Wildlife Refuge, North Dakota
- U.S. Geologic Survey, Biological Resources Division

The goal of the literature review was to collect, review, and summarize in as thorough a manner as possible, available information on habitat management methods for the target species. Therefore, the search included both peer reviewed and non-peer reviewed sources. It should be noted that non-peer reviewed literature was often based on observations (often casual) and not actual experiments or studies. Both types of literature contained valuable information relevant to the project.

C. TECHNICAL MEETING

The Habitat Management Methods Technical Meeting (Technical Meeting) was held February 16-17, 2000 at the Platte River Whooping Crane Maintenance Trust facility near Grand Island, Nebraska. Fifty-one individuals representing landowners, Natural Resource Districts, U.S. Fish and Wildlife Service, Nebraska Game and Parks Commission, power and irrigation districts, conservation groups, and local species/habitat experts were invited to attend the meeting either by phone, email, or in person. Of these, 40 individuals attended at least a portion of the two day Technical Meeting (Appendix III). The Subcommittee invited six species/habitat experts from outside the central Platte region to attend the meeting. These "outside" experts were Casey Kruse (terns and plovers), John Sidle (terns and plovers), Jim Lewis (cranes), Gary Krapu (cranes), Carter Johnson (river morphology), and Randy Parker (river morphology). John Sidle and Randy Parker were unable to attend the meeting. Paul Kinzel attended the meeting in the absence of Randy Parker. The Technical Meeting was used to discuss *Section III. Survey Analysis* and *Section IV. Literature Review* portions of this document, determine possible permitting requirements for the various management practices, brainstorm new management ideas, and to

develop recommended best management practices for the various habitat types. Dale Strickland, Cooperative Agreement Executive Director, acted as meeting facilitator.

D. RECOMMENDED BEST MANAGEMENT PRACTICIES

The discussion of *Sections III and IV* during the Technical Meeting was used as the basis for development of the recommended best management practices. In general, all methods or techniques described were included in the best management practices. The recommended best management practices are also flexible enough to allow for the use of new methods and techniques as they are developed.

III. SURVEY RESULTS

Following is the summarized and compiled survey information by habitat type and management objective. This section is broken down first by habitat category (e.g., bottomland grassland) and then by management action used (e.g., haying).

The habitat categories described in this section are bottomland grassland, upland grassland, open (non-forested) river channel, open (non-forested) riverine and non-riverine areas (i.e., least tern and piping plover reproductive habitat), cropland, and other habitats (e.g., riparian forest). Bottomland grasslands (wet meadows) are utilized by whooping cranes as feeding, loafing, and secondary roosting areas. Whooping cranes and sandhill cranes also utilize upland grasslands. Both types of grasslands can be important sources of cover and forage for other bird species and wildlife in general. Open river channel habitat is important as roosting habitat for whooping cranes. Areas cleared to provide open river channel habitat may also be used by least terns and piping plovers if nesting habitat is available. Besides the areas cleared for open channel habitat, several habitat management entities in the central Platte maintain riverine and non-riverine areas specifically for least tern and piping plover reproductive habitat. Cropland and other habitats are also included because they could be used, or are used, by the three target bird species. For example whooping cranes have been observed utilizing croplands. While work conducted by Gary Krapu, USGS-BRD, indicates that corn may be limiting sandhill cranes in the central Platte River valley (presentation to Governance Committee, August 18, 1999), croplands have not been identified as being limiting to whooping cranes or the other target bird species. Management of large tracts of land for the target bird species does, however, often entail management of croplands as well as other habitats.

Several management entities in the central Platte River valley do not manage their habitats with a specific focus toward the Cooperative Agreement target bird species, but focus on other habitats and species. Many of these managed lands could be and are used by one or more of the target species. For example, the National Audubon Society's Lillian Annette Rowe Sanctuary is managed primarily for sandhill cranes but their areas provide habitat for and have been used by whooping cranes. Information from all land management entities that returned a survey is included in the analysis of habitat management methods.

A. BOTTOMLAND GRASSLAND

The term bottomland grassland in the draft "Documentation of Existing Conditions in the Central Platte Valley" (draft Baseline Document) (URS Greiner Woodward-Clyde 1999) is used to describe what is often referred to as wet meadow. Bottomland grassland will be used and defined in this document similar to how it is used and defined in the draft Baseline Document. For this document, bottomland grasslands are grasslands with areas of emergent vegetation or open water within them. These areas of emergent vegetation or open water are often in linear swales and depressions.

Several land management entities have conducted bottomland grassland restoration projects and/or are involved in bottomland grassland protection and management in the central Platte valley. The entities surveyed that are involved in bottomland grassland management and/or restoration are the U.S. Fish and Wildlife Service (USFWS), Nebraska Public Power District (NPPD), National Audubon Society's Lillian Annette Rowe Sanctuary (Audubon), State of Wyoming, City of Grand Island, Platte River Whooping Crane Maintenance Trust, (Trust), The Nature Conservancy (TNC), Nebraska Game and Parks Commission (NGPC), and Central Platte Natural Resources District (Central Platte NRD).

A.1. Management of Existing Bottomland Grassland

The City of Grand Island owns approximately 1,200 acres of bottomland grassland at their groundwater wellfield site. This site is managed for the primary purpose of supplying municipal water for Grand Island. The city leases the rights to hay the land once per year to area farmers/ranchers. The entire area is cut in August or September for hay. Noxious weed control, particularly of leafy spurge and musk thistle, is done on an as needed basis. No other habitat management of the grasslands is done except for a parcel involved in a project with Central Platte NRD. This area is described below under *Section III. A.2. Bottomland Grassland Restoration*.

NGPC reported that they own 12 areas ranging in size from 11.04-729.46 acres and totaling over 1,700 acres in the central Platte River region. The areas are managed primarily for either wildlife or fishing access. Within these areas NGPC owns approximately 107 acres of bottomland grassland at six different locations. The size of the individual areas varies from four to 30 acres. The grasslands are portions of combined forest/grasslands areas managed for fishing and hunting access.

TNC currently manages 1,005 acres, Audubon manages 424 acres, and the Trust manages 6,197 acres of existing bottomland grassland. Prior to management by these entities many of these areas were under season-long grazing or annual haying (once or twice per year). Some areas also contained scattered stands of Russian olive and other trees. These entities implemented diverse management programs that included removal of scattered trees, rest periods, burning, haying, and grazing to improve and maintain native plant diversity. Each of these management treatments can be effective on both small and large tracts of land.

The general management objectives for TNC, Trust, and Audubon are to maintain a diversity of tall and short stands of native grasses and forbs that provide habitat for whooping and sandhill cranes, breeding grassland birds, winter grassland birds, and other species of native wildlife. The application of these management methods is compiled below.

A.1.1. Haying

According to TNC, prior management of annual late season haying led to increased cool season exotic grasses and decreased forb and warm-season grass diversity in many bottomland grasslands. Continued haying has also led to a decrease in overall vigor of both warm and cool season plants due to annual removal of vegetation. TNC began an early June haying rotation in 1999 in an attempt to reduce cool season grasses and still provide rent income. TNC recommends a varied rotation including grazing, haying, and burning to prevent the loss of plant species diversity, as a set rotation will manage for certain species over others.

The Trust utilizes a four-field haying rotation on several of their tracts. In this rotation two fields are hayed after July 1 and two fields are rested. A given field is hayed for three years and then rested for three years. Fields typically yield 1.5 tons of hay per acre. The fields are also periodically burned (once every 3-4 years). The hayed fields are utilized by whooping and sandhill cranes, waterfowl, and shorebirds in the spring and fall migration and the rested fields are used by a variety of grassland bird species for breeding and foraging areas. Hayed fields are also used by several bird species as breeding areas, including red-winged blackbirds, upland sandpipers, bobolinks, grasshopper sparrows, and meadowlarks.

For the purpose of maintaining loafing, feeding, and secondary roost sites for sandhill cranes while still providing areas for ground nesting birds in the summer, Audubon uses a four-field rotation. In any given year one field is rested, one field is burned in the spring and hayed after August 15, and the other two fields are hayed after August 15. According to Audubon, this provides short grass areas in the spring for the cranes as well as an area with taller, denser grass for nesting birds. Over time, this management may select for cool season grasses and forbs over warm season plants.

A.1.2. Grazing

Audubon uses early season grazing (May - July) on one small bottomland grassland to increase use by ground nesting birds in the summer. Longer grazing rotations (May - September) are also used in some grassland areas to increase diversity and discourage cool season grasses.

One rotation regime used in the past by TNC is a four-pasture rotation in which a pasture is grazed using 0.8 to 1 Animal Unit Month (AUM) per acre May-June and September-October one year, July-August the second year, and rested two years. This rotation allows for season long grazing in the four pastures and provides rent income. Another rotation used by TNC in areas that were traditionally annually hayed is a rest/burn rotation with periodic early season intensive grazing (1.5 AUM/acre, May 1 – June 1). In general, TNC attempts to rest about 20% of their grasslands per year and about half of those rested for two years. TNC also burns the grasslands approximately once every 3-6 years. According to TNC this improves and maintains native plant diversity.

Currently, TNC is using more of a "random" rotation instead of a set rotation of pastures in an attempt to improve diversity of vegetation. According to TNC, this allows them to respond to year to year changes in the pastures, such as smooth brome or reed canary grass becoming too prevalent in particular pastures.

The Trust utilizes a rotational grazing regime that is similar to TNC. The Trust uses both a three-pasture and four-pasture rotation. In the three-pasture rotation, one pasture is grazed both early (mid-April through early-July) and late (mid-August through mid-October), one pasture is grazed mid-season (early-July through mid-August), and the other is rested. Grazing rates are variable depending on pasture and amount of forage. Approximate AUMs are 2 AUM/ac for the early and late grazing periods and 0.75-1 AUM/ac for the mid-season period. The Trust reported that this creates a patchy, heterogeneous habitat that accommodates a wide variety of birds while still providing rent income during the entire season. The Trust also reported that grazed pastures provide foraging and loafing areas for cranes, waterfowl, and other shorebirds in the spring and fall, and the rested section provides valuable breeding and foraging habitat for grassland nesting birds. The four-pasture plan provides a similar heterogeneous habitat as the three-pasture design. Similar to the three-pasture design, one pasture is grazed both early and late, one is grazed mid-season, and the other two are rested. According to the Trust this allows for fields to be rested longer and may provide additional benefits to species such as Henslow's sparrows and sedge wrens that prefer dense vegetation for nesting.

A.1.3. Prescribed Burning

Prescribed burning is often used when grasslands are rested for multiple years in a row. In the TNC four-pasture regime described above in *Section III. A.1.2. Grazing*, the area is often burned once during the two year rest period. The Trust often burns their grassland once every 3-4 years in April. The Trust believes that burning in late-April or early-May improves the vigor of native warm season plants and decreases the growth of cool season plants.

Prescribed burning has also been found by TNC and Audubon to be effective in decreasing and controlling woody vegetation encroachment. TNC has found that burning is effective in decreasing and controlling encroachment of red cedar, especially after removal of larger, mature trees. TNC has also found that sumac, dogwood, and cottonwoods can be controlled, but repeated burnings are necessary. According to TNC burning in areas with these trees allows for grasses to grow below previously closed canopies.

Burning has been conducted by NGPC in their hunting and fishing access locations. The prescribed burns were used to invigorate grassland growth, control invasive woody growth, increase relative composition of forbs, and to control cool season grasses. An evaluation of the effectiveness of this management was not supplied.

A.1.4. Resting

Rest periods from haying, grazing, and/or burning of two or more years have been found by TNC to result in increased vigor of warm season grasses and native forbs and allow for the accumulation of organic matter in the soil. Rest periods are an important component incorporated into a varied rotation regime (i.e., hay, rest, burn). The Trust has found that rested areas allow for tall, dense stands of vegetation to develop, and that these areas are often used by species such as Henslow's sparrows and sedge wrens.

A.1.5. Chemical Application

The NGPC has found that the application of Roundup herbicide in the fall after the first hard frost helps suppress cool season grasses such as smooth brome while allowing warm season grasses and forbs to increase.

A.1.6. Costs

Costs for improving existing native bottomland grasslands are variable and depend largely on the condition of the area when management activities are started. Practices that may result in higher initial costs are fencing for grazing purposes and removal of scattered trees. Once a rotational management system is in place, costs should be greatly reduced and may be compensated for by rent income from haying and grazing.

Prescribed burning	\$5/acre, Audubon \$8-10/acre, Trust \$8-13/acre, Central Nebraska Public Power and Irrigation District
Fall Roundup herbicide application	\$10-20/acre, for chemical, application costs would vary depending on method, NGPC
Removal of scattered trees	\$50/hour, USFWS
Barbed wire fence	\$0.60-0.80/foot, TNC

A.1.7. Land Rights

In this document *land right* is being used to include fee title ownership, leases, easements, partnerships, and all other methods of legal authority over land.

Lands that are currently being managed as bottomland grasslands in the Central Platte valley are controlled through fee title and easement. Both methods appear to work well for managing these grasslands.

A.2. Restoration and Creation of Bottomland Grassland

Several entities are involved in restoring bottomland grassland in the central Platte River valley. The entities and their respective acreage of restored bottomland grasslands are: TNC 626 acres; Trust 1,058 acres; Central Platte NRD (in cooperation with NPPD, Central, and NGPC) on lands owned by NPPD, Wyoming, and the City of Grand Island 320 acres; USFWS 265 acres; and Audubon 210 acres. Once restoration efforts are deemed complete, management generally follows that for existing bottomland grassland described above in *Section III. A.1. Management of Existing Bottomland Grassland*. This section will focus on the restoration efforts used by these entities and their outcomes. Efforts have focused on conversion of cropland, tree clearing, and hydrologic enhancement projects for bottomland grassland restoration.

A.2.1. Cropland Conversion

High Diversity Seeding

TNC has created and restored over 250 acres of poor quality cropland into bottomland grasslands using high-diversity seeding and creation of wetland depressions with bulldozers. Restored and created areas are planted with native grass and forb seeds collected from local grasslands. A combine is used to harvest dominant warm season grasses (big bluestem, indiangrass, and switchgrass) and hand collections are used to collect forbs and less dominant grass seeds. To minimize weed seed TNC generally only harvests areas that were either spring burned or spring grazed. According to TNC this is done so that the cool season exotic grasses are either missing (not allowed to flower) or the warm season plants are much taller so the combine can cut over the tops of the cool season exotic plants. TNC has used a mixture of 15 gallons per acre of the seed collected using the combine and 1.5 gallons per acre of hand collected seed. Seeds are hand broadcast onto disced fields in early spring and no other management is used until sufficient fuel accumulates to conduct an early spring burn. TNC has found that spring burning results in a quicker establishment of native plants after the initial growth of annual weeds the first couple of years after planting. These activities have been successful in establishing a high diversity of bottomland grassland species in previously poor agricultural fields, as shown by an increase in general bird use and nesting. TNC has also found that mowing the annual weeds does not accelerate native plant establishment, and may actually slow the establishment. According to TNC, bottomland grasslands restored from agricultural areas have needed approximately 5 years before regular management activities (described above in *Section III. A.1*) can be implemented.

The Trust is also involved in restoring bottomland grasslands in marginally productive crop fields. Areas that have been restored have varied in size from 21 to 327 acres. For use in high diversity restoration projects the Trust uses a combine to collect up to six of the most common native grass species (e.g., big bluestem, little bluestem, indiangrass, and switchgrass) and then hand collects other native grass and forb seeds. Areas to combine are carefully selected in fields that were burned the previous spring to minimize weed seed. Combining and hand collections result in a seed mixture of 150-230 different species of native grasses and forbs. The seeds are then hand broadcast onto disced fields in late winter or early spring, but the Trust notes that anytime between November and April will likely work. The Trust has done some mowing the first season after seeding to remove sunflowers but does not feel that this benefits development of the restoration in the long run. The Trust generally starts burning restored grasslands 3-4 years after initial seeding and continues to annually burn at least the wetter areas to remove cottonwood saplings until grasslands are incorporated into a grazing or haying rotation. The Trust has found that restored grasslands generally need 6-10 years before they can be placed into a haying or grazing rotation. This management has been used since 1992 on Trust lands and according to the Trust, has resulted in restored areas developing plant communities similar to native bottomland grasslands.

In leveled fields, TNC and the Trust have used bulldozers to create wetland depressions and swales. After the depressions are created, they are hand planted in the same manner as the rest of the grassland and undergo the same management described above. Information was not provided on the success of restoring the hydrologic regime of these areas.

Low Diversity Seeding

The Trust, TNC, and Audubon have been involved in low diversity seeding as a means of restoring cropland to bottomland grasslands. The Trust used low diversity seeding prior to 1992 when they switched to the hand broadcast high diversity seeding described above. The Trust planted a seed mix of 3-6 species (typically big bluestem, little bluestem, switchgrass, and indiangrass) using a drill in a fashion similar to management activities on Conservation Reserve Program (CRP) land. According to the Trust, the plant communities that became established are not similar to native bottomland grasslands and are not used by cranes and other birds to the same degree as native grasslands or areas restored using high diversity seeding. The Trust has not done a restoration of this type since 1992 and will likely not do any in the future. Like the high diversity seeding restorations done by the Trust, low diversity seeding restorations are incorporated into a grazing or haying rotation generally 6-10 years after seeding.

TNC has used low diversity seeding in restoration efforts since the early 1990s. Seeding is done by hand or use of an Eze Flow fertilizer spreader. Like the Trust, TNC currently does not restore many areas using low diversity seeding. When areas are restored with this method, seed types vary depending on the specific purpose of the restoration. They use grazing, haying, resting, and burning as described in *Section III. A.1* generally after five years to maintain a variety of vegetation structures for nesting grassland birds and migrating cranes. TNC has removed trees and fencerows from the grasslands to improve use by grassland bird species. Sandhill cranes have used the low diversity grasslands during spring migration with tall vegetation structure as well as short structure, but the short structured lands are used more often. According to TNC, these areas receive less bird use than native areas or areas restored using high diversity seeding.

Audubon has used what could be termed low diversity seeding on approximately 210 acres of their restored bottomland grasslands. For the most part, Audubon has not done any proactive seeding on these lands. When seed is provided to them (not on a regular basis or sufficient quantity to cover the entire fields), they use the opportunity for educational purposes by having groups come to the sanctuary and help broadcast the seeds. Audubon's objective with restored grasslands is to provide migrational habitat for cranes. To accomplish this, they use late season haying (after August 15). The overall rotation is a four field strategy incorporating resting, burning, and haying. Audubon has found that this provides a short vegetative structure for both the fall and spring migrations. However, Audubon believes that this management may select for cool season grasses. The infrequent seeding of warm season grasses is used to maintain a diversity of species. Audubon is starting a new rotation of resting lands for two years to help maintain more species diversity.

Neither the Trust, TNC, or Audubon described any methods to restore swales nor other wetlands in areas restored using low diversity seeding.

A.2.2. Tree Removal

A description of methods for clearing trees is also included in Section III. C. OPEN RIVER CHANNEL. This section focuses on tree removal as it pertains to bottomland grassland restoration/creation.

The Trust cleared a 380 acre tract of cottonwood forest in the mid-1980's to create bottomland grassland habitat. The Trust used chainsaws for large tree removal and a Kershaw Klearway for smaller trees and brush. The Klearway is a large articulated tractor that shreds trees up to eight inches in diameter and other brush using two front mounted 400 pound fly wheels. In an attempt to offset clearing costs at this location, the Trust set up a sawmill at the site. Lumber from the large trees was used for pallets and other general uses. This attempt to offset costs did not work because sale of the lumber did not offset the additional costs and time needed for operation of a sawmill. The Trust recommends simply bulldozing the large trees and brush into piles and burning, as this is as economical and considerably faster. No seeding of grassland plants was done in these cleared areas, and only minimal maintenance (e.g., no mowing or shredding) was done until the mid-1990's. The lack of maintenance allowed brush (e.g., dogwood) to become established. Since approximately 1996, the Trust has annually burned this tract of land to control woody vegetation. The Trust reported that today the plant communities in the created areas are becoming similar to those of native bottomland grasslands.

The Trust also restored approximately 60 acres of bottomland grasslands in the mid-1980s through clearing Russian olive woodlands. Russian olive trees were removed using bulldozers, chainsaws, and Klearway. Trees and brush were bulldozed into piles and burned. Because the trees were removed primarily using bulldozers, the entire tree and root system was removed. This resulted in little resprouting and no additional control has been necessary in these areas. The Trust feels that these areas now have plant communities similar to native bottomland grasslands with no additional seeding necessary.

As part of restoring open river channels through their Partners for Fish and Wildlife (PFW) program, the USFWS has conducted forest clearing to create open bottomland grasslands. The USFWS has created a total of 265 acres of bottomland grassland through tree removal at eight sites ranging in size from 1 to 172 acres. Five of the eight cleared sites involved removal of large cottonwoods and other small trees and brush. These sites ranged in size from 12 to 26 acres and totaled 83 acres. The USFWS cleared large trees from islands and accretion ground using bulldozers and excavators. Smaller trees and brush were cleared using the Klearway and a large disc. A bulldozer was used to pile the trees. When dried, the trees were burned and buried. In addition to removing trees, an excavator was used to remove silt and sediment deposits at two of the sites to restore and enhance backwaters and wetlands. At one location 500 linear feet of backwater was restored and at the other site 1,500 linear feet was restored.

The main goal of the five USFWS projects was to restore open-channel riverine habitat for waterfowl, sandhill and whooping cranes, other migratory waterbirds, and other fish and wildlife native to the central Platte River region, and in doing so they created bottomland grasslands. Four of the five USFWS projects involving removal of large trees occurred in 1998. Because of this, no information was available for management used after tree removal for these sites. The one site that was cleared in 1997 required additional discing and mowing in 1998, as well as grazing, to control unwanted vegetation growth. Some of the sites may be planted with warm season grasses in the future. Overall, USFWS reported that it is too early in the projects to evaluate the effectiveness of the management practices, but casual observations indicate that sandhill cranes and other waterfowl have been utilizing the areas more during spring and fall migration now than before clearing activities.

At another location, the USFWS cleared scattered cedar trees and other trees and brush from 172 acres using tree shears and chainsaws. After clearing, the trees were piled and burned. This work was done in the fall of 1997. Since that time, woody vegetation has remained absent from the site and sandhill cranes have been observed using the site as a secondary roost during spring migration. The landowner had grazed the land prior to tree removal and continues to graze the land. Grazing and haying will be used to curtail woody vegetation encroachment, but because the project was only completed in 1997 more time is needed to determine success of the project.

In 1994 the USFWS used a tree saw mounted on a tractor to clear trees from one acre of bottomland grassland. After clearing, the trees were piled and burned. Also at this site, an excavator was used to remove silt from the head of a side channel. The side channel required excavating again in 1997 to reconnect it to the main channel. The side channel has again silted in, and according to USFWS there are no plans to reconnect the channel with the main channel. Cleared areas were broadcast seeded with a native warm season grass mix in the spring of 1995. In 1997 the area was burned. The USFWS found that after burning, the grasses planted in 1995 responded well based on casual observations.

A.2.3. Hydrologic Enhancement

Central Platte NRD, NGPC, NPPD, and Central are involved in demonstration projects evaluating alternative methods to maintain and/or enhance wet meadow habitat in and along the Platte River on lands owned by NPPD, City of Grand Island, and the State of Wyoming. According to these entities the projects are primarily aimed at assessing the feasibility of enhancing the ecological integrity of bottomland grasslands using means other than streamflow. Two years of baseline conditions studies were conducted. Implementation of these projects began in 1998 using grants from the Nebraska Environmental Trust Fund.

The study area at NPPD's Cottonwood Ranch Property is approximately 160 acres in size and contains two swales. To increase the amount of water in these swales for plants and animals, a gravity feed system that utilizes water from a nearby groundwater drain was installed. The gravity feed system includes 2,180 feet of 10-inch PVC pipe and a portion of perforated pipe laid in the groundwater drainage ditch. The entire system can be controlled with a valve at the outlet from the ditch. An electric pump was also installed in the drain to operate independently or supplement the gravity flow operation. By using the pump and gravity flow, the entire system can deliver up to 700 gallons per minute at maximum flow. Testing has shown that the gravity flow system can maintain flows of 200-400 gallons per minute. Because this system has only been operational for a short period, the full benefits have not been determined, however the system does require more maintenance than originally anticipated.

About 140 acres of the 160 acres of the restored bottomland grassland at the Cottonwood Ranch Property was cropland prior to restoration activities. As part of the restoration project, native grass and forbs were planted on the cropland. Instead of hand broadcasting seed, NPPD obtained native grass hay from Audubon land and spread it on the cultivated field. Cattle were allowed to graze the hay in an attempt to work the seed into the soil. Because this was done in the spring of 1999, not enough time has passed to determine the success of this reseeding effort.

The City of Grand Island portion of this project is located at the Grand Island Wellfield site south of the city. The objectives for the wellfield site are to increase the amount of water and control the time water is at or near the soil surface. According to the participating entities, this will allow for increased water availability to plants and facilitate the establishment and enhancement of a native plant community. A groundwater well is used to pump up to 700 gallons per minute to the swales located within the study site. Because project treatments were not implemented until 1998, estimates of project success are preliminary. Project sponsors believe early results of their ability to affect the hydrology of study sites are very encouraging.

The entities are also involved in a bottomland grassland enhancement project on land owned by the State of Wyoming. The Wyoming site comprises approximately 25 acres. At this site, an excavator was used to remove soil from three areas to or near the groundwater level in an attempt to simulate temporary depressional wetlands and seasonal/semi-permanent wetlands. Two areas (playas) measuring approximately 100 feet by 60 feet were excavated to a depth of 2.5 feet to create temporary depressional wetlands. One of the wetlands receives additional water through pumping. One seasonal/semi-permanent wetland (linear slough) was created by excavating two feet of soil from an area that was 1,500 feet by 30 feet. This area received addition water through pumping in 1999. After excavation of the playas, 20-40 cubic yards of organic fill was placed back in the depressions and compacted using the tracks of the excavator. Organic fill was not placed in the linear slough but the soil was still compacted using the excavator. Excavated sites were also seeded using a high diversity native seed mix. Again, because of the short duration of this project, no determination of success has been made.

These three sites represent three different methods of increasing water at bottomland grassland sites. The restoration efforts are being conducted at both existing grasslands like the wellfield and Wyoming sites, and a restored site, the Cottonwood Ranch Property. Additional time and monitoring will be needed to determine the effectiveness of the various methods.

A.2.4. Other Projects

In 1996 the USFWS restored a 9 acre tract of bottomland grassland that had a small livestock watering pond excavated in it. A bulldozer was used to remove silt and sediment deposits and partially fill the dugout area. The dozer was also used to clear scattered trees in the grassland. Disturbed areas were reseeded using hand broadcasting with a low diversity native warm season grass and forb mix. Casual observation by the USFWS has indicated that growth of the planted seeds, as well as reestablishment of sedges, rushes, and smartweed along the edges of the wetland, has been positive. Sandhill cranes and other waterfowl have used the area during spring and fall migration.

A.2.5. Costs

Costs associated with restoring bottomland grasslands vary greatly depending on land type prior to restoration and methods of restoration used. Listed below are estimated costs reported by various entities for different activities.

<u>Cropland Conversion</u>

High Diversity Seeding	$100/acre to collect and plant seed, Trust

	$300/acre to collect and plant seed, Prairie Plains Resource Institute
Low Diversity Seeding	$20/acre to collect and plant seed, Trust
Tree and Brush Clearing	
Cottonwood Forest	$800-1,000/acre using chainsaws, Trust $734-875/acre using bulldozers and other heavy equipment, USFWS
Russian Olive, Cedar, Smaller Trees, Brush	$200-208/acre using Klearway and disc, Trust, USFWS $231/acre using tractor mounted tree saw, USFWS $50/hour for removing scattered cedars using shears and chainsaws, USFWS
Hydrologic Enhancements	
Gravity Feed/Electric Pump System	$20,000, Central Platte NRD
Land Contouring	$100-300/acre depending on water table depth, Trust
Backwater/Side Channel Restoration	$1.50-3.50/linear foot, USFWS
Other "Dirt Work"	$725/acre for removal of silt and partial filling of dugout, USFWS

A.2.6. Land Rights

Bottomland grassland restoration efforts have been conducted on land controlled through fee title and leases. Fee title allows the managing entity almost complete freedom in management decisions.

Audubon has some of their lands enrolled in the federal Wetland Reserve Program (WRP). This is advantageous in that Audubon is guaranteed an annual payment from the lands. However, the disadvantage is that there are restrictions on the type of activities allowed on WRP lands. For example, there are limitations to how WRP lands may be grazed or hayed.

The USFWS utilizes 10-15 year Wildlife Extension Agreements with landowners involved in the Partners for Fish and Wildlife Program (PFW). The objective of the PFW program is to work jointly with private landowners and other partners to restore and enhance habitat for waterfowl, sandhill and whooping cranes, other migratory waterbirds, and other fish and wildlife species native to the central Platte region. Funding for the restoration work comes from various partners including landowners, tenants, hunting clubs, USFWS, and other land

managing entities in the central Platte region. One advantage of this type of program is that landowners are involved and work with the USFWS in completing the projects.

Central Platte NRD and the other entities agreement's with NPPD, Wyoming, and Grand Island are planned to continue for a longer period (e.g., 10 plus years), but currently there is only one and a half years remaining in the current funding source.

B. UPLAND GRASSLAND

Upland grasslands are dry areas that are mostly free of woody vegetation. Many of the upland grassland sites have been converted to croplands in the past; however, there are still many acres of upland grassland in the central Platte valley. Many of these remaining upland grassland areas are being used for pasture.

Several land management entities in the central Platte valley are involved in upland grassland management. These entities are the USFWS, NPPD, Central, Audubon, City of Grand Island, Trust, United States Department of Agriculture-Natural Resources Conservation Service (NRCS), Central Platte NRD, and Tri-Basin Natural Resources District (Tri-Basin NRD). Many upland grassland parcels are associated with other land management efforts or are portions of large tracts of land.

B.1. Management of Existing Upland Grassland

The Trust currently manages 21 acres of upland grassland, Central 2,800 acres, NPPD 700 acres, and Audubon 67 acres. The City of Grand Island is also involved with Hall County, NGPC, and Nebraska Department of Roads in an Interlocal Cooperation Agreement to establish conservation easements in the area of a proposed Interstate 80 interchange. The total area of the conservation easement is 750 acres, but only a portion is upland grassland. The remainder of this site is riparian forest and open channel. The conservation easement will not change the management of the lands, only protect against future development.

The primary management objectives of the sites managed by the Trust, Central, NPPD, and Audubon are to provide diverse structural communities for nesting and foraging habitat for grassland bird species and to provide loafing and foraging areas for cranes. Management activities to provide diverse structural communities have included grazing, haying, burning, and resting. Like bottomland grassland management, these activities have been shown to be successful on small to large parcels of land.

B.1.1. Grazing

The 700 acres of grassland owned by NPPD are located on two large islands in the Platte River. The islands are approximately six feet above the river's bed. NPPD leases the land to an area rancher and allows grazing from May through October. NPPD reported that the grazing is not done to accomplish any management objective. NPPD has constructed three one-half acre exclosures on the islands to help determine plant species composition. They have found that several native grasses, big bluestem being the most common, are still present on the islands. Both islands are very open and free of woody vegetation and grazing helps to maintain this. The most common bird species found by NPPD on the islands are western meadowlark, eastern kingbird, and brown headed cowbird.

In 1999, Central began using a six pasture rotation on 2,800 acres of upland grassland. Central expects that the controlled grazing will improve the grassland and control encroachment of non-desirable woody species. A maximum of 300 cow-calf pairs or 600 yearlings will be allowed to graze the property at any given time. According to Central this will result in approximately 67% use of the available vegetation and should insure that overgrazing does not occur. Starting in 2000 one of the six pastures will be burned on an annual basis and then rested for the remainder of the year. Because Central started this grazing management in 1999, the rotation has not been evaluated for its effectiveness. The grazing and burning rotation is described in Table 1.

The Trust also utilizes grazing on 21 acres of upland grassland. Moderate grazing levels (1-2.4 AUM) are used for a short duration in mid-April through mid-July to provide diverse habitat for grassland birds such as grasshopper sparrows, red-winged blackbirds, and western meadowlarks. This 21 acre pasture is managed in conjunction with a 59 acre restored upland grassland area (see *Section III. B.2. Restoration of Upland Grassland*). According to the Trust, the combination of moderately grazing the native grassland and resting the restored area provides a wide diversity of habitats for grassland birds.

Table 1. Central's six pasture grazing and burning rotation at Jeffrey Island.

Month	1999	2000	2001
April		Pasture A burned	Pasture B burned
May	Rotation established	Rotation established	Rotation established
June	Pasture A grazed for 20-25 days	Pasture B grazed for 20-25 days	Pasture C grazed for 20-25 days
July – October	Pastures B-F grazed on a triple rotation of 10-15 days per pasture each rotation	Pastures A, C-F grazed on a triple rotation of 10-15 days per pasture each rotation	Pastures A, B, D-F grazed on a triple rotation of 10-15 days per pasture each rotation.

B.1.2. Haying

Audubon was the only entity that reported using haying as a management method on upland grasslands. Audubon hays a 27 acre grassland twice per year and obtains approximately 1.5 tons/acre annually. Audubon noted that this has resulted in a secondary roost for sandhill cranes in the spring and an opportunity for rent income. This grassland is adjacent to a 105 acre area that is maintained as open river channel. Audubon also hayed a 40 acre upland grassland area in August 1998 for native seed collection. The hay was used on the wet meadow demonstration site at the Cottonwood Ranch Property (see *Section III. A.2.3. Hydrologic Enhancement*).

B.1.3. Prescribed Burning

Audubon utilizes periodic spring burning (every 5-7 years) on 40 acres of upland grasslands that are adjacent to 120 acres of cleared accretion ground. The entire area is managed for

sandhill cranes and has provided excellent primary roosting habitat according to Audubon. The grasslands themselves also provide nesting areas for ground nesting birds. The area was hayed in August 1998 for native seed collection.

Central will also utilize burning as part of their six pasture rotation of upland grasslands. This information is contained above in *Section III. B.1.1. Grazing*.

B.1.4. Costs

Costs associated with management of upland grasslands include fencing, moving cattle between pastures, haying activities, and burning activities. While the tenant often conducts grazing and haying, burning would likely need to be paid for by the managing entity. While no entity estimated costs of burning upland grasslands, they would likely be comparable to estimates for bottomland grasslands (see *Section III. A.1.6. Costs*). Leasing grazing and haying rights to upland grasslands will result in rent income for the landowner.

B.1.5. Land Rights

Upland grasslands managed by NPPD, Audubon, and Trust are controlled through fee title and grasslands managed by Central are controlled through a lease with option for purchase in 2015. Each of these arrangements has worked for managing upland grasslands and can likely be used in the future.

B.2. Restoration of Upland Grassland

While upland grasslands are certainly utilized by various species of birds, mammals, reptiles, and insects, they have not been the focus of major efforts of restoration like bottomland grasslands. The most extensive restoration or conversion of cropland to grassland has been coordinated through efforts of the Natural Resources Districts (approximately 350 acres) and NRCS's Conservation Reserve Program (CRP) (410 acres). The USFWS has also been involved in restoring some areas of upland grassland through channel clearing activities for their Partners for Fish and Wildlife Program (PFW) (14 acres). A 40-80 acre portion of one island owned by NPPD at the Cottonwood Ranch Property was previously tilled for cropland. In addition to the 21 acres of existing upland grassland managed by the Trust, they have also restored 59 acres of land back to upland grasslands.

B.2.1. Conversion of Cropland

Tri-Basin NRD and Central Platte NRD are both involved in Wildlife Habitat Improvement Projects (WHIP) and Corners for Wildlife projects. Tri-Basin NRD also has easements for drainage improvement projects along creeks and ditches. The drainage improvement projects involve seeding grass filter strips that intercept sediment and agricultural chemicals before they enter the waterways. WHIP, Corners for Wildlife, and the drainage improvement projects are cooperative efforts that involve leases with landowners and other groups to convert less profitable and poorer cropland to wildlife habitat. While these projects involve seeding of native grasses and forbs (e.g., big bluestem, indiangrass, little bluestem, sideoats grama, switchgrass, and native legumes) to restore grasslands from croplands, the efforts also often include planting trees and other cover types that may not be conducive to use by sandhill or whooping cranes. However, these areas are valuable as habitat for upland game birds and other wildlife. Seeding of grasses and forbs is generally done from November 1 – May 31 using a grass drill or grain drill. Occasionally a more diverse seed mix (124 species) is hand

broadcast onto project lands. Management of these areas primarily consists of noxious weed control. Noxious weed control is the responsibility of the landowner or tenant and can consist of mowing, spraying, and hand-pulling. WHIP and Corners for Wildlife control the percentages of land that can be mowed or sprayed in anyone year. These cooperative projects can be effective on small and large tracts of land.

Lands enrolled in the CRP are similar in nature to WHIP, Corners for Wildlife, and filter strips in that they are previously farmed areas that are seeded with native seed mixes and trees for general wildlife habitat. Along with providing habitat for wildlife, management objectives for CRP land include controlling soil erosion and enhancing water quality.

The Trust restored 59 acres of upland grasslands in 1992 and 1993 from a dryland cornfield. Grass seeds were spread with a fertilizer spreader and forb seeds were broadcast by hand in May. The Trust feels that seeding this area earlier would have resulted in better restoration. This area was not burned, grazed, or hayed until 1999 when grazing was done from mid-May to mid-June at the low rate of 0.51 AUM. The Trust reports that the tall, thick vegetation that grew in this area provides benefits to grassland birds such as dickcissels and provides thermal protection for sandhill cranes during spring migration. Because seed producing forbs are a major component in this grassland, this area also provides food for wintering birds as well as thermal protection. This area is managed in conjunction with a native upland grassland area that receives moderate grazing on an annual basis (see *Section III. B.1.1 Grazing*). According to the Trust, the combined management provides a structurally diverse habitat for breeding, migrating, and wintering grassland birds.

The previously farmed island at the Cottonwood Ranch Property was converted back to grassland prior to ownership by NPPD. NPPD was not involved in the restoration efforts and was not able to provide any information regarding the restoration efforts. The restored lands are part of the normal grazing practices on the Cottonwood Ranch Property.

B.2.2. Tree Removal

Projects conducted by the USFWS through their PFW program to restore open-channels have resulted in the restoration of 14 acres of upland grassland. Trees were cleared from the areas using the Trust's Klearway or bulldozer and a large disc. Ten acres were initially cleared in 1992. This area was remowed and disced in 1998. The second area consisting of four acres was cleared in 1997. The primary objective of both of these projects was to provide open channel habitat with unobstructed views. Neither of these areas received supplemental seeding of native seed mixes, but the USFWS reported through casual observation that response of native grasses and forbs in the seed bank has been positive. According to the USFWS, the grasslands themselves are used primarily by grassland nesting birds. Based on the 10 acres cleared in 1992, efforts to control woody vegetation encroachment are needed 5-6 years after initial clearing.

B.2.3. Costs

Conversions of cropland to upland grasslands have been primarily done through cooperative efforts with Natural Resources Districts, NRCS, and private landowners. In these arrangements, the landowner is responsible for planting the vegetation and controlling weeds.

The Natural Resources Districts, state government, or federal government (depending on the program) pay the landowners an annual payment through their lease agreements.

Costs associated with clearing forest from upland grassland sites are the same as for bottomland grassland sites, see *Section III. A.2.5. Costs* above.

B.2.4. Land Rights

Restoration of upland sites has been conducted primarily on lands controlled with leases or easements. In the CRP, Natural Resources Districts, and USFWS programs, the management and restoration is done cooperatively with the agency and landowners. The cooperation can extend beyond the agency and landowner and involve groups such as Pheasants Forever and other private organizations. While these restoration efforts were on leased land, the Trust has conducted successful restorations on lands that they own.

C. OPEN RIVER CHANNEL HABITAT

A large portion of open river channel management involves riparian forest clearing. Riparian forest clearing has also been discussed above in regards to restoring bottomland grassland and upland grassland. This section will discuss management of open river channel habitat and the methods of riparian forest clearing used in management of this habitat.

Management and restoration of open river channel habitat with the goal of providing roosting habitat for sandhill cranes and whooping cranes is a major component of habitat management in the central Platte River. The Trust alone manages 1,580 acres of open river channel. Other entities that manage open channel habitat are TNC (235 acres), USFWS through their PFW program (239 acres), the State of Wyoming in cooperation with the USFWS (approximately 125 acres), and Audubon (427 acres). NPPD and Central are also involved in maintaining open river channel habitat, but the with the primary goal of providing least tern and piping plover habitat. Central and NPPD lands will only be briefly discussed in this section and are thoroughly covered in *Section III. D. Open Riverine and Non-Riverine Areas*. The USFWS, in conjunction with the State of Wyoming, and NGPC are planning additional channel clearing projects for the purpose of providing sandhill crane and whooping crane roosting habitat (20 acres of NGPC land and 120 acres of land owned by the State of Wyoming).

C.1. Riparian Forest and Brush Clearing

The main methods for clearing riparian forest and brush to open river channel habitats have been shredding using a Klearway, chainsaws, and heavy equipment such as bulldozers and excavators. In most instances a combination of these methods has been used to completely remove trees and brush. A discussion of the various methods and combinations of methods is found below.

C.1.1. Shredding and Mowing

Since 1982 the Trust has utilized various clearing methods to enhance open channel habitat along approximately 22 miles of the central Platte River. The goal of these clearings is to maintain roosting habitat for whooping cranes, sandhill cranes, and other waterfowl and nesting habitat for least terns and piping plovers. The Trust has experimented with methods for clearing smaller trees (<8 inches in diameter) and brush from islands and lands adjacent to the river. The clearing methods evaluated included mechanical and chemical methods and

combinations of these methods, including shredding (using the Klearway), shredding followed by discing or herbicide application, and herbicide application alone. According to the Trust shredding alone did not control woody plants because eight weeks following treatment, regrowth was up to three feet tall. Herbicide application alone was effective in killing vegetation (85-90%), but clearing of dead standing vegetation was needed to provide an unobstructed view for cranes. Shredding followed by aerial herbicide application of 2-4D was effective in controlling nearly 95% of regrowth, but the Trust's concern over the potential long-term environmental effects of herbicide use in the river channel discouraged them from continuing this combination. The Trust has found that the most effective and environmentally acceptable method, to them, for clearing river channel is shredding followed by discing. Currently the Trust's clearing activities follow this combination and are done in midsummer and early fall when it is typically possible to drive equipment across channels. The Trust reported in their returned survey that these methods have been successful in removing trees and other vegetation, maintaining unobstructed channels, and have resulted in increased use by cranes.

The Trust has also used shredding and discing in areas with large trees (>8 inches in diameter) after the large trees were removed using chainsaws, bulldozers, and/or other heavy equipment. After large trees are cut down they are piled and burned. The Trusts anticipates the need to use bulldozers, excavators, and chainsaws to remove large cottonwood trees prior to shredding and discing in a location yet to be cleared.

The Audubon property is located in an area where the river channel has not been encroached upon by trees to the same degree as other areas. However, Audubon has done some mechanical clearing of the river channel since the 1980's to improve roosting habitat for whooping cranes and sandhill cranes by providing a wide unobstructed channel. Most clearing activities involve shredding brush (e.g., willow, dogwood) with the Klearway or brushog, and then discing. According to Audubon this results in providing good primary roost sites for sandhill cranes. Audubon also reported that several of their areas have also been used by whooping cranes.

TNC has also conducted tree clearing activities on islands and accretion land to restore open river channel habitat. The goal for TNC in these clearing activities was to provide open river areas for migratory waterbird use. Clearings have been conducted using the same methods describe above (i.e., shredding using the Klearway) and have resulted in increased crane use based on casual visual observations by TNC and others and Trust aerial surveys during migration.

The USFWS, through its PFW program, has been involved in clearing 14 areas along the central Platte River. The primary goal for clearing areas is to provide roosting habitat for sandhill and whooping cranes and to also potentially provide least tern and piping plover nesting habitat. Several different methods and combinations of methods have been used by USFWS to clear riparian forest and brush. One of these methods involves the same strategy as that used by the Trust and others in which a Klearway is used to shred small trees and brush and a disc is used to remove the remaining vegetation. The USFWS has found this method to be effective when only small trees (<8 inches) and brush are to be cleared.

C.1.2. Chainsaws

In 1997 the USFWS used chainsaws to clear large trees (>8 inches) from islands and accretion ground at three different sites. After large trees were removed, small trees and brush were removed using the Klearway and large disc. Large trees and other debris were piled and burned on site. These clearing activities have been done on areas between 11 and 20 acres. USFWS feels that it is too early to evaluate the effectiveness of the management practices, but large concentrations of sandhill cranes and other waterfowl have been observed using the sites and some sites have been used by whooping cranes.

C.1.3. Bulldozers, Excavators, and Other Heavy Equipment

The USFWS used bulldozers and excavators to remove primarily large and to a lesser extent small trees prior to shredding by the Klearway on eight different sites. Bulldozed trees were piled, burned, and buried on site. After shredding with the Klearway, a large disc was used to remove any additional vegetation. The USFWS has used this process in clearing islands and accretion ground between in areas 6 and 72 acres. Several of these projects were recently completed and response has not been determined. The USFWS reported that sites that have been cleared for several years have received high use by cranes and waterfowl.

The USFWS cleared another area using techniques similar to those described above, except they did not disc the area. Discing was not done during the initial clearing or in subsequent maintenance. Like the areas in which discing was used, large concentrations of waterfowl and cranes have utilized this area for roosting. However, the USFWS feels that more time is needed to determine the long-term effectiveness.

The USFWS has also worked cooperatively with the State of Wyoming in clearing riparian forest and brush from lands owned by Wyoming. Approximately 125 acres of land have been cleared primarily using dozers and chainsaws. Chainsaws were used to down large trees and the dozer was used to pile the trees and remove brush in 1993. Not all acres were cleared in 1993. From 1994 through 1997 dozers were used to clear additional acres as time and money allowed. In 1998 the Klearway and disc were used to re-clear a large portion of the area. A brushogs and prescribed burning has also been used on the property to maintain cleared areas. This project has been determined to be successful through the casual observations of large concentrations of waterfowl and the use of the cleared channel by sandhill cranes. Further activities are planned for this site including more clearing and side channel and backwater restorations/creations.

NPPD has been involved in clearing trees and brush from islands within the Platte River. The objective for this clearing activity has been for creating and maintaining nesting habitat for least terns and piping plovers. NPPD utilized a Hydro-ax and bulldozer to initially clear large and small trees from islands in 1993. The Hydro-ax is a machine similar to the Klearway and is used for shredding of small trees (<6 inches) and brush. After clearing, stumps were chemically treated with Rodeo herbicide. Since the initially clearing, nothing has been done to control woody vegetation. A discussion pertaining to these areas is contained below in *Section III. D. Open Riverine and Non-River Areas*.

NGPC completed a 20 acre island tree clearing project in 1999. A bulldozer and excavator were used to remove and pile trees. After piling trees were burned. A large disc was used to

remove small trees and other vegetation. After clearing, the excavator was used to enhance or restore approximately 1000 feet of side channels within the island. Because this clearing was completed in 1999 no evaluation of success has been made. NGPC anticipates monitoring for sandhill crane, whooping crane, and waterfowl during migration and for least terns and piping plovers during the breeding season.

C.1.4. Other Methods

The USFWS has also used a tractor mounted tree saw to remove trees from one acre of river channel and one acre of bottomland grassland. According the USFWS, this method was successful in the small area. USFWS does not report if the same method could be used in larger areas. Additional information is contained above in *Section III. A.2.2. Tree Removal*.

C.1.5. Costs

Costs associated with clearing forest islands and other river channel sites using the Klearway, chainsaws, and bulldozers are the same as for bottomland grassland sites, see *Section III. A.2.5. Costs* above. Costs associated with clearing activities not reported above are shown below.

Large Trees	
Hydro-ax	$900/acre, NPPD
Mowing (brushog)	$80/hour, Audubon $50/acre, NPPD
Chemical Applications	
Rodeo to Stumps	$100/acre, NPPD
Aerial 2-4D application	$8-10/acre, Larry Wright, former applicator

C.1.6. Land Rights

The Trust, TNC, Audubon, and NPPD have conducted channel clearing activities on lands controlled through fee title. In their opinion, fee title is an effective control for lands in which clearing activities are to be conducted. NPPD has also conducted channel clearing activities on lands controlled through 30 year leases. The USFWS has conducted clearing activities through the PFW Program using 10-15 year agreements. The USFWS has found that landowners are very interested in entering into this program and working with the USFWS to clear river habitat. Fee title, leases, easements, and agreements all appear to be effective when river channel clearing is the desired management.

C.2. Maintenance of Open River Channel

Regardless of how the lands were initially cleared, all areas require some form of maintenance to preserve the desired conditions of low vegetative structure or no vegetation. The most common practices for maintaining conditions is some form of mowing/shredding, discing, burning, and chemical application.

C.2.1. Mowing/Shredding and Discing

To maintain open channel habitat the Trust uses mowing/shredding and discing on their cleared islands and accretion land. When clearing woody vegetation is a major component of maintenance, the Trust uses the Klearway. If maintenance needs require clearing of weeds,

grass, and smaller woody vegetation a brushog may be used. To maintain bare sand and to remove more vegetation after mowing/shredding, a discing is often used. Most areas require that mowing/shredding and discing be conducted on a biannual basis or as water levels permit crossing of channels. Like the Trust, Audubon utilized a brushog and Klearway along with a disc on an annual or biannual basis to maintain open channel habitat for primary crane roosting sites.

The USFWS initially cleared many of their management sites in 1996 or 1997. These sites were shredded using the Klearway and disced again in 1998 to remove unwanted vegetation that had resprouted. The USFWS anticipates needing to mow/shred and disc these sites on a periodic basis (annually/biannually) to control vegetation encroachment. Two sites that were cleared prior to 1996 have been remowed and disced on a periodic basis as water levels and time permit.

TNC has also conducted at least biannual mowing and discing to maintain open channel habitat. TNC also reports that some cleared areas are invaded heavily with purple loosestrife and that efforts are needed to control this exotic invasive weed.

C.2.2. Prescribed Burning

One area initially cleared by Audubon in the 1980's was mechanically cleared on a periodic basis until 1995 when burning became the management tool for maintaining the open river channel. Since 1995 this area has been burned in the fall or early winter. Audubon noted that this method does not result in as complete vegetation removal as mechanical methods and is dependent on low river flows and sufficient fuel to carry a fire.

The USFWS has burned several of their cleared river channels that are in association with grasslands in an attempt to remove unwanted vegetation and promote growth of native species. They have found that native warm season plants have done very well after burning. The Trust also anticipates utilizing burning in the future as a management tool on several of their cleared areas, but has not done so to date.

C.2.3. Chemical Application

NPPD and Central use a combination of methods to maintain areas cleared of vegetation for piping plover and least tern nesting habitat. Typical efforts entail using hand-pulling and discing in combination with chemical applications. Pre-emergent herbicides are used to inhibit vegetative growth during the spring because the areas can not be excessively disturbed when nesting plovers and terns are present. Central and NPPD have found that pre-emergent herbicide applications are successful in controlling vegetation growth.

As was reported in *Section III. C.1. Riparian Forest and Brush Clearing*, the Trust has experimented with using chemicals to control resprouting of vegetation after clearing. These experiments have found that chemicals successfully control resprouting, but the Trust feels that possible unknown effects of chemical use in and near the river warranted discontinuing their applications.

C.2.4. Costs

Costs associated with mowing, shredding, and discing to maintain minimal vegetative cover is addressed in *Sections III. A.2.5 and C.1.5. Costs*. Costs associated with burning and chemical applications are listed below.

Prescribed Burning	$5/acre, Audubon $8-13/acre, Central
Pre-emergent herbicide	$175/acre, NPPD

D. TERN AND PLOVER REPRODUCTIVE HABITAT

Central and NPPD have been the most active entities in managing open areas with the goal of providing reproductive habitat for least terns and piping plovers. While the sites managed by Central are upstream of Lexington (out of the area to be addressed by the proposed Program), information pertaining to them is important and will be included in this discussion. The three sites managed by Central for least tern and piping plover habitat total 72.7 acres in size, of which 35 acres is bare sand. NPPD manages six sites with a total of 145 acres of land, water, and buffer area as least tern and piping plover habitat (48 acres bare sand). NPPD sites are in the Lexington to Chapman study area.

Audubon, Trust, and USFWS also control islands and sandbars that could be managed for use by least terns and piping plovers as reproductive habitat. These lands were described above in *Section III. C. Open River Channel*. Islands and sandbars cleared of vegetation to provide roosting habitat for cranes may also be managed to provide reproductive habitat for least terns and piping plovers. The NGPC also plans to provide reproductive habitat for least terns and piping plovers through future clearing activities. The NGPC reports that they anticipate creating approximately 20 acres of cleared riverine habitat in conjunction with the USFWS. These areas may also be able to be managed as least tern and piping plover reproductive habitat.

D.1. Riverine Habitat

Central manages one riverine site for least terns and piping plovers. The site is located near the confluence of the North Platte and South Platte Rivers in Lincoln County. NPPD manages three islands for least tern and piping plover habitat in the area between Lexington and Chapman.

In the late 1980's, Central constructed a large sand diversion (essentially a sand spoil pile) to divert flows to the north side of the river. This was done to minimize sand and debris accumulation along their diversion canal structure. The entire island is approximately 100 acres, of which 14.7 is considered tern and plover habitat. This area is kept free of vegetation on an annual basis. Methods used for vegetation clearing include harrowing, chemical applications, hand-pulling of weeds and grasses, and cutting of willow and cottonwoods. The general area is posted with "Attention" signs to inform the public the terns and plovers are in the area and "Keep Out" signs in areas where active nests are located.

Three islands (3.6, 3.8, and 7.0 acres) were initially cleared by NPPD of trees and other vegetation (see *Section III. C.1.3. Bulldozers, Excavators, and Other Heavy Equipment* for

description of these activities) and developed as tern and plover habitat in 1990-1992. After vegetation clearing, a dredge was used to move sand from the bottom of the river to the tops of the islands, thus creating a clean, bare sand island. Hand-pulling, harrowing, rototilling, discing, and the use of pre-emergent herbicides have been used to control vegetation and maintain a bare sand habitat. Vegetation control is done generally on an annual basis. NPPD has found that hand-pulling of weeds and rototilling are not cost effective means of vegetation control. Harrowing and discing are most effective if used in combination with chemicals. Adjacent islands and buffer areas around the bare sand nesting islands are maintained free of woody vegetation and in lower vegetative structure through mowing and burning.

High flows in the spring of 1995 inundated and flooded the three nesting islands managed by NPPD. This resulted in the reconnection of one island with the bank and the reduction of the other two islands to 2.1 and 1.5 acres. To help alleviate erosion problems, Shoreline Erosion Arrestor (SEA) bags were placed on the upstream side of one island. SEA bags are large bags (3 feet by 15 feet) filled with sand. When flows exceeded 10,000 cfs in 1997 the bags eroded into the riverbed. NPPD reports that the viability of the SEA bags to protect islands is questionable.

NPPD has also utilized electrified mesh predator fence around the nesting portion of the islands. Fences consist of simple portable electric fence powered by solar recharged batteries. NPPD feels that fencing enhances the chances of nest success and fledging success for terns and plovers.

NPPD and Central report that managing and maintaining these islands is difficult due to erosion problems and other problems with working in a river system. However, all islands managed by Central and NPPD have resulted in production of least terns and/or piping plovers.

D.2. Non-Riverine Habitat

NPPD manages three open non-riverine areas (sandpits) for least tern and piping plover habitat along the central Platte River between Lexington and Chapman. Central manages two sandpits, both of which are upstream of Lexington.

In 1991, NPPD initiated a plan to develop and manage non-riverine sandpit habitat for piping plovers and least terns. This initiative was pursued to provide a comparative evaluation of sandpit habitat with riverine habitat. Currently areas of three sandpits are managed by NPPD for tern and plover reproductive habitat. NPPD's current vegetation control methods in these non-riverine areas include harrowing, discing, and pre-emergent herbicides. Vegetation management efforts are conducted on an annual basis around nesting locations.

NPPD also uses various predator fences in an attempt to minimize predation of nests and young. A portable electric fence has been used at one location and permanent fences are used at two locations. The portable electric fence is similar to those described above in *Section III. D.1. Riverine Habitat*. The permanent fences are used to discourage predators from entering peninsular areas. The fence consists of a combination of woven cattle fence wire and 1.2 m high poultry netting with 2.5 cm openings. The two styles of fences were wired together to prevent sagging of the poultry netting. The combined fence was buried 20 cm in the soil to discourage predators from digging under. Four hi-tensile electric wires were placed

approximately 15, 68, and 112 cm above the ground. "Hot and cold" wires were placed 6 cm apart at the 112 cm location to discourage avian predators from perching on the fence. Non-electrified cattle panels were used to extend the fences into the water. Studies conducted by NPPD indicate that efforts to reduce predation have contributed to improved reproductive success.

Central manages areas of two sandpits as reproductive habitat for piping plovers and least terns. Central primarily uses harrowing and herbicide to control and inhibit vegetative succession on to bare sand areas. They also use hand-pulling of grass and weeds and cut willow and cottonwood trees as needed. Efforts are generally made on an annual basis to maintain nesting areas free of vegetation and curtail vegetative encroachment. The general areas are posted with "Attention" signs to inform the public that terns and plovers are in the area and "Keep Out" signs are used in areas where active nests are located.

Management activities conducted by NPPD and Central at sandpits have resulted in reproductive habitat in non-riverine areas that are used by least terns and/or piping plovers on a regular basis. Under current conditions, commercial gravel mining creates new nesting habitat for least terns and piping plovers at a rate approximately equal to that at which sandpit habitat is being lost through development and vegetation encroachment.

In 1998, one piping plover was fledged from a sandpit managed by the Trust. This area was not actively managed as reproductive habitat for plovers, but the Trust does advocate enhancing this area and other areas for tern and plover reproductive habitat, including the use of predator exclosures to protect nesting birds.

D.3. Cost

Many costs associated with maintenance of island and sandpit habitat are comparable (e.g., hand-pulling of weeds) and are addressed together. Other construction and maintenance items are separated by island and sandpit. Costs associated with initial clearing of islands are the same as those described above in *Section III. A.2.5. Costs*.

<u>Island Enhancing</u>	
Sand Dredging	$15,000/acre 1 foot deep, NPPD
<u>Vegetation Control</u>	
Harrowing	$25/acre, NPPD
Rototilling	$25/hour, NPPD
Discing	$100/acre, NPPD
Hand-pulling	$250/acre, NPPD
Hand cutting of small trees	$1000/acre, NPPD
Pre-emergent herbicide	$175/acre, NPPD

SEA Bags for erosion	$250/bag, NPPD
Predator Exclosures	
Portable electric fence	$2.25-2.75/foot, NPPD
Permanent fence	$5/foot, NPPD

D.4. Land Rights

Both fee title and leases are used for control of least tern and piping plover habitat. Central owns the large island at the confluence of the North and South Platte Rivers. A local sand and gravel mining operation owns the two sandpits that are managed by Central. No fee is charged to Central by the mining operation for management of the areas. NPPD owns one island and leases the other two islands from private landowners with 30 year lease agreements. NPPD owns two of the sandpits and leases the other sandpit from a private landowner. Both fee title and leases appear to be effective for control and management of open riverine and non-riverine habitat areas for least terns and piping plovers.

E. CROPLAND

When large tracts of land are purchased to protect habitat for whooping cranes, piping plovers, or least terns, portion of the property often contain cropland. In some instances, this cropland is left as cropland and leased to local farmers. The Trust, Audubon, and NPPD all have cropland that they lease to tenants. These leases may or may not have restrictions in them that detail herbicide/ pesticide use, crop rotations, and other limitations.

The Trust does not have formal restrictions in their leases for the use of pesticides. They would like minimal use of pesticides but recognize that pesticide use is an important and valuable tool for farming practices. The Trust specifically does not want the use of Pencap on their lands, but this is not a formal restriction in the lease. The Trust does require the rotation of crops on lands that are suitable for rotation. A typical scenario is ¼ of the land in alfalfa, ¼ in soybeans, and the other ½ in corn. The Trust also allows cattle grazing in combined corn stocks on half of their land. The other half of the combined corn ground is left for use by cranes and other waterfowl. Lease payments vary depending on the land and requirements of the farmer. Leases are both cash rent and shares of the crop and expenses (e.g., Trust pays 40% of expenses and receives 40% of crop).

Audubon only has a small parcel of cropland that it leases to an area farmer. The only formal restriction placed on the farmer is that Audubon be notified of any application of herbicide or pesticide prior to application.

NPPD also has cropland, a part of the Cottonwood Ranch Property, which it leases to area farmers. NPPD requires its tenants to control noxious weeds and that they work with a crop consultant or extension agent when determining fertilizer and pesticide application rates and calibrating equipment. NPPD does not have any restriction on chemical use or cropping patterns.

F. OTHER HABITATS

Several land management entities control and manage lands for purposes other than those discussed above. While least terns, piping plovers, or whooping cranes may not use these lands, they are important for other species, recreation, and the local economies.

F.1. Riparian Forest

The City of Grand Island, TNC, USFWS, Trust, NGPC, State of Wyoming, and NPPD all responded that they own and/or manage riparian forest habitat along the central Platte River. As was the case with cropland discussed above, some of this habitat was purchased as part of a larger tract of land. These riparian forest areas are not used by the target species specified in the Cooperative Agreement, but they are used by a wide variety of other bird species, mammals, reptiles, and insects. The main objective of riparian forest habitat management by TNC, NPPD, USFWS, and the Trust is to maintain various stages of woodlands for these different species. While this is also an objective for riparian forest management for NGPC, their main objective is to provide recreational opportunities associated with big game hunting and waterfowl hunting. Other than protection from development, little has been done to directly manage these areas. Examples of direct management are exclusion of grazing to protect the riparian communities by TNC and USFWS, and small burns and cuttings to create openings in the forests by NGPC. Management done by these entities has resulted in improved riparian vegetation and use by wildlife. Information was not provided on the costs of these activities, but would likely be comparable to the costs of similar activities described above.

F.2. Public Fishing Areas

NGPC owns and manages seven areas in the central Platte valley as public fishing areas. These areas vary from put-in and take-out locations for boating and fishing on the Platte River to small lakes. Besides providing the public with fishing opportunities, these areas are another source of habitat for species other than the target species of the Cooperative Agreement. They are also an important source of recreational activities for local residents and tourists and thus benefit the local economies.

F.3. Crane Viewing Areas

Central Platte NRD owns or is involved in the management of five crane/wildlife viewing areas. These small viewing areas (0.22 acre to 9 acres) are used primarily to give the public safe and convenient locations to view cranes and other wildlife during the year. One of the crane viewing sites includes small portions of riparian forest, wetlands, and open channel habitat that are used for educational purposes. These viewing facilities benefit the local economies, but no formal estimates of monetary benefits have been made.

IV. LITERATURE REVIEW RESULTS

Over 50 peer-reviewed articles on whooping cranes, least terns, and piping plovers were reviewed. Sources included leading scientific journals such as *Journal of Wildlife Management, Conservation Biology, Journal of Field Ornithology, the Wilson Bulletin, Wildlife Society Bulletin, Wildlife Monographs, Ecological Monographs, Great Basin Naturalist, The Prairie Naturalist,* and others, as well as workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings*). Over 50 additional non peer-reviewed literature articles were reviewed. These articles were available from proceedings, trade literature, and unpublished reports and data from federal and state agencies, conservation groups, and NPPD and Central.

The focus of the literature review was on habitat management methods for the whooping crane, least tern, and piping plover. However, articles pertaining to habitat requirements and existing habitat conditions for the species were also reviewed and summarized to provide a background as to why various habitat management methods are used. Approximately two-thirds of the literature reviewed addressed habitat requirements and conditions, whereas only about one-third specifically described habitat management methods. It should be noted that numerous other articles about the target species are available, but were not included in this literature review because they dealt with aspects of the target species not directly related to habitat management (e.g. biology). Many of the articles and information were specific to the Platte River, while others addressed different areas of the target species ranges. All the articles included in the literature review are listed in *Section VII, References.*

There was wide agreement among authors that habitat loss is an important factor in the decline of the whooping crane, least tern, and piping plover (Cannon 1996; Lingle et al. 1984; Smith and Renken 1993; Rimmer and Deblinger 1992; Prindiville Gaines and Ryan 1988; Vaske et al. 1994; Ryan et al. 1993; Patterson et al. 1991; Schulenberg and Ptacek 1984; Currier et al. 1985). Hunting and competition for food were also cited as factors affecting the status of the whooping crane (Cannon 1996). Predation, human disturbance, and poor productivity have also been identified as causes for a decline in least tern and piping plover populations (Rimmer and Deblinger 1992; Vaske et al.1994; Melvin et al. 1992).

Habitat loss and alteration in the Platte River valley has been well studied and documented (e.g., Currier et al. 1985; Sidle et al. 1989; McDonald and Sidle 1992; Johnson 1994). The Platte River valley is an important stopover area during whooping crane migration, and habitat needs include roosting habitat and feeding habitat. Open riverine and non-riverine habitat is needed for nesting and rearing habitat for least terns and piping plovers (Kirsch 1996). Management efforts over the past few decades have focussed on restoring or increasing these habitat types, as well as reversing other causes of decline, such as providing protection from predators, limiting human activity, and educating hunters.

Following is a summary of the literature reviewed, organized according to habitat type. The habitat categories used correspond to those used in *Section III. Survey Results*, and include bottomland grassland, upland grassland, open (non-forested) river channel, open (non-forested) riverine and non riverine, and cropland. Some management methods were not habitat-specific and are discussed separately.

A. BOTTOMLAND GRASSLAND

Bottomland grassland is used to refer to "wet meadows", i.e., grasslands with areas of emergent vegetation or open water, typically located in linear swales and depressions (see *Section III*). These areas provide feeding and loafing habitat for whooping and sandhill cranes. Food sources typically found in bottomland grasslands consist of protein-rich aquatic organisms (Currier 1987). The USFWS (1981) shows that 20 of 119 (17%) confirmed feeding sites of migrating whooping cranes occurred in "wetland sites" (e.g., reservoir, playa, wetlands) or subirrigated meadows. Howe (1985) found that during migration through the Great Plains, whooping crane family groups used more wetlands and pasture/grasslands for feeding than non-family groups.

Based on the literature review, management techniques for this type of habitat include habitat protection, burning/grazing/haying, and restoration/creation.

A.1. Habitat Protection

A.1.1. Peer-Reviewed Literature

Cannon (1996) describes the history of both public and private entities involved in habitat protection for the whooping crane through purchase and set-asides. For example, in 1936, the Bureau of Biological Survey (forerunner to U.S. Fish and Wildlife Service) purchased Aransas Wildlife Refuge in Texas, the primary winter refuge for whooping cranes. Earlier, in 1922, Canada had designated a national park for bison, Wood Buffalo National Park, and in 1955 it was discovered this park was the primary summer nesting ground for whooping cranes. In addition to these public set-asides, private entities have set aside 4,800 ha (12,000 acres) in Nebraska for migration stopover habitat protection (Canon 1996). While Cannon (1996) gives no detail on the management of these set-asides, he notes that these efforts to protect habitat by purchase and set-aside throughout their range have helped to preserve the endangered whooping crane (Cannon 1996).

Currier (1987) described habitat protection efforts in the Platte River valley through acquisition/easements. He noted that the Trust has directed their efforts at identifying and preserving existing high quality roost and feeding habitat, since it is easier and cheaper to maintain roost sites and bottomland grasslands than it is to reclaim them. In 1987, the Trust managed approximately 2,800 ha (7,000 acres) through fee title and easements, and the Audubon managed an additional 480 ha (1,200 acre) (Currier 1987). Currier (1987) went on to note that easements have been used to maintain buffer zones around habitat complexes and to protect grasslands from being converted to cropland. No information was given on the cost of habitat protection.

Other authors have recommended protection of whooping crane habitat to enhance recovery, however few details were given beyond merely making the recommendation. These authors include Lingle (1985) and Faanes (1992a). Lingle (1985) recommended development of an acquisition or protection plan within the migration corridor to ensure perpetual protection of wetlands and native grasslands. Faanes (1988) described historical efforts at habitat preservation, including recommendations in 1952 and 1976 for the establishment of a refuge for whooping cranes on the Platte River.

Johnson (1981) suggested that the key to managing whooping cranes along the Platte River is habitat acquisition and maintenance. Johnson identified the top priority for acquisition as riverine habitats for roosting in association with extensive nearby wet meadows and native grasslands for feeding. He suggested that acquisition efforts continue to be spearheaded by private conservation organizations. Examples of such acquisition include 1) 324 ha (810 acres) of habitat along the Platte River acquired or leased by Audubon in 1974 and established as the Lillian Annette Rowe Sanctuary (Strom 1985), and 2) nearly 324 ha (810 acres) of prime habitat on Mormon Island acquired through a cooperative effort of TNC and the Trust in 1979 (Lingle 1981).

At the February 16-17 Technical Meeting, the idea of bank armoring to protect bottomland grasslands located adjacent to the Platte River from erosion was brought forward. A review of

the literature was conducted to identify information on methods for bank armoring. Evans and Stehn (1997) reported on the use of articulated concrete mats laid on geotextile fabric to armor 5,486 m of severely eroded shoreline to protect coastal marshes at Aransas National Wildlife Refuge. The concrete mats were anchored with polyester cables that allow that mats to move and conform to existing land features. This type of armoring might have application under very limited circumstances to protect bottomland grasslands adjacent to the Platte River from eroding.

A.1.2. Non Peer-Reviewed Literature

Little information was found in the non peer-reviewed literature concerning habitat protection as a tool for whooping crane habitat management. USFWS (1981) suggested protection, through purchase in fee title, of a series of grassland tracts near the Platte River ranging in size from a few hundred to several thousand acres for whooping crane habitat.

A.2. Burning/Grazing/Haying

The Nebraska Cooperative Extension provides a guide for prescribed burning of grassland (*Conducting a Prescribed Burn and Prescribed Burning Checklist EC 90-121).* The guide stresses the importance of having experienced personnel involved and notes that the following items are essential to consider when preparing for and conducting a prescribed burn:

1) Legal Obligations (e.g., a permit from the local fire chief)
2) Equipment, including:
    - water pumper
    - weather kit (a sling psychrometer to measure relative humidity and air temperature, an anemometer to determine wind speed, and a compass to determine wind direction)
    - ignition device (most commonly a drip torch with a 70 percent diesel and 30 percent gasoline fuel mixture)
    - fire suppression tools (e.g., shovels, axes, rakes, fire swatters, backpack sprayers, fence cutters)
    - two-way radios (for large areas)
    - protective clothing (cotton or wool clothing, leather gloves, boots, hard hat, eye protection)
3) Burning Prescription, or a guideline for a burn based on weather conditions, fuel characteristics, and topography. The more important weather variables are relative humidity (influences the moisture content of the fuel and the ease with which it ignites and burns), air temperature (high temperatures favor high fire temperatures and reduces the time needed to preheat fuel to the point of combustion), and wind speed (wind provides the fire with oxygen and accelerates the preheating of fuel ahead of the fire front).

Weather conditions under which burning should not be attempted.

Weather Variable	Do Not Burn
Relative Humidity (%)	Less than 20
Air Temperature (°F)	Greater than 80
Wind Speed (mph)	Greater than 20

Fuel characteristics include the amount of fine (grasses and some forbs) and coarse (woody) fuel, and vegetation continuity and volatility. Generally, at least 1,000 lb/acre (1,120 kg/ha) of uniformly distributed fine fuel is required to conduct a prescribed burn. In addition, knowing the volatility of dominant vegetation is important. Some vegetation (e.g., eastern red cedar) contains high amounts of volatile compounds such as fats, waxes, and oils, which create firebrands. Most grasses are not highly volatile.

Topographic features, aspect, and slope affect fire behavior by influencing weather and fuels.

4) Fireguard Construction refers to a break in the fuel (vegetation) that stops the fire. A fireguard should surround the entire burn area. Natural breaks in vegetation such as cattle trails, roads, or waterways can be used as fireguards. Fireguards can also be created by a combination of mowing and wetlining. A 15 to 20 ft (4.6 to 6.1 m) wide strip should be mowed around the perimeter of the burn area and the mowed debris should be moved away; wet the strip just prior to burning. A 4 to 8 ft (1.2 to 2.5 m) wide strip can be plowed or disked instead of mowing.
5) Ignition Techniques. Generally, both backfires and headfires are used in combination for a prescribed burn. A backfire backs into the wind, has a low flame height, is slow, and can be easily controlled. Headfires move with the wind, have taller flames, and generate a great amount of heat for a short time.
6) Smoke Management requires careful planning. A burn should be planned when the wind velocity and direction will carry smoke away from homes, towns, airports, roads, or other smoke-sensitive areas.
7) Personnel Requirements depend on several factors including volatility of vegetation, type of fireguards, size of area, and weather conditions. A seven-person crew can efficiently burn low-volatile vegetation in an area with established firebreaks.
8) Notification of Neighbors is a matter of common courtesy and should occur two to four weeks before the expected burn date.

A.2.1. Peer-Reviewed Literature

Little information was found in the peer-reviewed literature regarding the use of burning, grazing, or haying as a management technique specifically for bottomland grassland whooping crane habitat. Johnson (1981) noted that wet meadow and native grassland habitats must be maintained in an open condition with short vegetation in order to be used by whooping cranes. To achieve this, he suggested the use of periodic controlled burns, in combination with grazing and haying. He also noted that "wet meadow" habitat must be periodically monitored to insure that it is maintained in optimal condition. Johnson (1981) provided no further details, such as costs, beyond these management suggestions.

Faanes (1992a) noted that at the Lillian Annette Rowe Sanctuary, bottomland grassland habitats are subjected to a rotational burning program designed to enhance warm season grasses and the production of soil invertebrates. Faanes (1992a) provided no further information.

Because little information was found, the literature search was expanded to include any information on specific burning, grazing, or haying techniques that could be applied to

bottomland grasslands in the Platte River valley. It should be noted that even with the expanded search, limited information was found. Most of the peer-reviewed literature focused on effects of using a particular method (e.g., if you burn grasslands, the resulting productivity is…), rather than detailed descriptions of how to employ a specific method (e.g., to burn a grassland, the following conditions are necessary…). Even with the expanded search for specific techniques on the use of burning, grazing, and/or haying management, only information on burning techniques was found. Specific techniques on grazing and haying methods were not found in the literature, but were described by several land management entities in the Platte River valley during the survey portion of this project and the results of the survey are presented in *Section III.*

A.2.2. Non Peer-Reviewed Literature

Whitney (1999a) recommended clearing a prairie wetland cottonwood grove by simply dropping the trees and leaving them, and then burning when it is possible to accumulate fuels sufficient for a high-intensity fire; or using intense fires without cutting the trees to yield the same result, but over a longer time period. He suggested this methods to keep heavy equipment and associated disturbance out of the area, and he noted that cranes would use the area even if there were a few scattered live trees, decaying stands of timber, and fallen trees.

A.3. Restoration/Creation

A.3.1. Peer-Reviewed Literature

Currier (1987) reported on a program to create bottomland grasslands from a portion of forested floodplain by the Trust in 1984. The site was located near Elm Creek, Nebraska, downstream of the Kearney Diversion Canal, near a roosting site. The site contained mature cottonwoods, with an understory of rough-leaf dogwood, willow, red cedar, hackberry, green ash, and Russian olive. The shrub understory was cleared using a Klearway. The large trees were felled using chainsaws and were sold as lumber and smaller trees were piled and burned. A few trees (approximately 6 %) were left for raptors and other migrants. Currier (1987) noted that plans for maintaining a treeless grassland included shredding, burning, herbicide applications, and grazing. It took three years to clear the 160 ha (400 acres) site. In 1987 the cost of the operation was $1,720 per ha ($688 per acre), including the proceeds from the sale of the lumber (Currier 1987). Currier (1987) observed that the lumbering slowed the clearing work and provided little income relative to the time and effort involved; clearing costs would be reduced if trees were simply felled, piled, and burned. Updated information on this operation was provided in the survey, as described in *Section III. A.2 Restoration and Creation of Bottomland Grassland.*

Kauffeld (1981) described management of habitat for migrating sandhill and whooping crane use at two wildlife refuges in San Luis Valley, Colorado. Management practices included flooding meadows, sloughs, and ponds by pumping groundwater or diverting river water to provide loafing and roosting habitat for cranes. The meadows needed between 2 and 4 cm of water to attract cranes. These areas were primarily used for resting, preening, and other social activities. Kauffeld (1981) noted that when surrounding privately owned meadows were wet, they appeared to be more attractive to cranes than meadows on the refuges, probably because private meadows were grazed or hayed and the vegetation was shorter. Kauffeld (1981) also noted that the distances between roosting, loafing, and feeding areas (i.e., grain fields) were important factors influencing crane use. Optimum habitat had all these components within 1 to

2 km. Ten kilometers was reported as the maximum distance the cranes would fly from roost to feeding sites.

A.3.2. Non Peer-Reviewed Literature

Pfeiffer (1998) evaluated three bottomland grassland restoration techniques in the Platte River valley. The three techniques included: 1) low diversity (3-6 species) grass plantings on former crop fields, 2) high diversity (100 + species) plantings on former crop fields, including land surface recontouring to create ridge and slough topography typical of native meadows, and 3) cleared riparian forests. In conducting this evaluation, Pfeiffer (1998) compared 7 low diversity, 11 high diversity, and 4 cleared riparian forests to 14 native bottomland grassland reference sites. Quantitative cover values were measured at each site over two summers. Pfeiffer (1998) found that high diversity planting techniques appear to offer the best potential for bottomland grassland restoration. They developed vegetation that most closely resembles native bottomland grassland than either of the other restoration/creation methods. Pfeiffer (1998) noted that clearing riparian forests offers some potential as an acceptable bottomland grassland creation technique, however, species richness was lower (< 50) compared to reference sites and high diversity restorations, and controlling invasion of shrubs may be necessary. The low diversity plantings offered the least value for bottomland grassland restoration, and was not recommended (Pfeiffer 1998).

Whitney (1999b) reported on prairie and wetland restoration along the central Platte River between 1991 and 1998. This project was undertaken by the Prairie Plains Resource Institute to locate and document wild sources of native plant seeds, develop effective harvesting and seed handling techniques, work on site-specific seedbed preparation techniques, create wetlands, and involve volunteers in the process of restoration. This project was not specifically related to habitat restoration for whooping cranes or other species, however, some techniques described in this article could be applied to restoration efforts for whooping crane habitat. For example, Whitney (1999b) developed a hand-sowing method to hand-seed relatively large tracts (0.4 ha or larger) by flagging the corners of a plot, then walking in pairs in 5 to 6 m swaths. Progress downfield is marked on both sides of the planting unit by strategically placing flags that the sowers can always aim toward so as not to lose tract of what has been planted and what has not. Whitney (1999b) also noted that hand-sowing prairies develop uniformly without the straight rows caused from seeding with a grass drill. In addition, hand-sowing results in a more widely and evenly dispersed prairie since many small and heavy seed drop through a grass drill too quickly. In another article, Whitney (1991) also mentions seedbed preparation as a way to hinder fast-growing weeds to favor slower-growing native species. A seedbed that is packed very hard minimizes weed problems.

B. UPLAND GRASSLANDS

Upland grasslands are dry areas that are mostly free of woody vegetation. Upland grasslands provide forage for whooping cranes and provide cover for whooping cranes and other bird species and wildlife in general. It has been reported that whooping crane feeding sites in upland habitats are characterized by horizontal visibility, a lack of tall trees and dense shrubs immediately around the site, short vegetation, and little topographic relief (USFWS 1981). Although little is known about specific food habits of the whooping crane during migration, they are known to forage in a variety of habitats including upland grasslands (USFWS 1981). Eighty-four percent of 120 feeding sites investigated along the migration route in the Great Plains were upland habitats,

approximately 20 percent of these were upland grasslands (USFWS 1981). Whooping cranes likely feed on both vegetation and insects in upland grasslands. In areas that have been grazed, whooping cranes have been observed feeding from fresh cow droppings (most likely on milo heads that pass through cattle relatively intact) and turning over cow chips to obtain beetles (USFWS 1981).

Articles found during the literature review that address management techniques for upland grassland habitat include habitat protection, burning, grazing, and haying. Each is discussed below.

B.1. Habitat Protection

B.1.1 Peer-Reviewed Literature

Several authors suggested protection of whooping crane habitat to enhance recovery, however few details were given beyond merely making the suggestion (Johnson 1981 and Lingle 1985). For example, Johnson (1981) suggested the key to managing whooping cranes in the Platte River valley is habitat acquisition and maintenance (maintenance is discussed in *Section IV, B.2, B.3, and B.4*). Lingle (1985) listed the following, as one of ten recommendations for whooping crane migration habitat, "Develop an acquisition or protection plan within the migration corridor to ensure perpetual protection of wetlands and native grasslands". Cannon (1996) described the history of both public and private entities involved in habitat protection for the whooping crane through purchase and set-asides as described above (see *Section IV. A.1.1*).

B.1.2 Non Peer-Reviewed Literature

The USFWS (1981) suggested preservation of native grassland tracts (but did not specify type of grassland) in strategic locations (i.e., in close proximity to roosting habitat), and in a distribution that will ensure access by whooping cranes to meet nutritional requirements and dispersal patterns. To meet this goal, the USFWS (1981) suggested the most appropriate plan would be protection, through purchase in fee title, of a series of grassland tracts near the Platte River ranging in size from a few hundred to several thousand acres.

Slack and Hunt (1987) suggested protecting whooping crane upland habitat on the Aransas National Wildlife Refuge by minimizing the frequency and amount of human disturbance. Suggestions included the using road barriers; limiting permits to photographers and others for access to upland habitats during crane use; terminating the development of visit viewing towers and other facilities; seeking cooperative agreements with oil and gas operators, commercial and sport fishing boats, and helicopter operators; and increasing patrol and enforcement of all provisions aimed at reducing human disturbance to whooping cranes.

B.2. Prescribed Burning

B.2.1 Peer-Reviewed Literature

Over a 12-year period, Chavez-Ramirez et al. (1996) investigated whether whooping cranes use upland habitat in response to a recent fire treatment or whether they occur regularly on uplands regardless of burning at their wintering habitat at Aransas National Wildlife Refuge, Texas. They also investigated factors that may attract whooping cranes to recently burned areas. Two areas were burned in the winter, one in November and one in February; both consisted of mixed grassland with small live oaks. A third area was left unburned as a control.

Costs for these treatments were not included in the study. Chavez-Ramirez et al. (1996) found that whooping cranes were attracted to recently burned sites almost immediately after burning, but intensive use of upland burned areas declined rapidly eight to ten days after the burn. They also found that whooping cranes used burned upland areas to a significantly greater extent than unburned upland areas. Chavez-Ramirez et al. (1996) report that upland burned areas provide easy access to food resources such as snakes, lizards, insects, snails, and some plant foods such as wolfberry and acorns. Whooping cranes may also use burn sites for mineral procurement, social functions, and as loafing and rest sites because of their openness and low potential for predators. While whooping cranes primarily use salt marsh habitats at their winter range, burned uplands provide an important alternative food source during years when marsh foods are absent or low. Chavez-Ramirez et al. (1996) recommended that prescribed burning should be done consistently to facilitate use by whooping cranes.

Johnson (1981) noted that periodic controlled burns could be used in combination with grazing and haying to maintain native grassland habitat in an open condition for whooping cranes. He also noted that native grassland habitats must be periodically monitored to insure that they are maintained in optimal condition.

In a report on a proposed management plan for whooping crane habitat at the Lillian Annette Rowe Sanctuary, Nebraska, prescribed burns were included as a means for maintaining healthy, productive grasslands; reducing the height of vegetation; and increasing the availability of invertebrates for whooping cranes (Strom 1985). Specifically, burns were prescribed in spring to control cool season grasses and other exotic competitors, including invading woody species. Strom (1985) reported that an early spring burn in 1980 immediately attracted sandhill cranes, which fed on earthworms, and attracted whooping cranes five days later. Strom (1985) also noted that fall burning of grassland habitat on the sanctuary may not be as feasible as spring, because conditions are often too wet, or dangerously dry. Therefore, he suggested that fire cannot be relied on as the only tool for management. No information on cost of treatment was provided. It should be noted that this proposed management plan is dated from 1985; current management of the Lillian Annette Rowe Sanctuary is described in *Section III. Survey Results*.

B.2.2 Non Peer-Reviewed Literature

Currier (1994) described the use of fire as a management tool. He noted there are three reasons to use fire management: 1) to promote native species, 2) to control or suppress tree and shrub invasion, and 3) to promote species and habitat diversity. Currier (1994) noted the importance of timing to meet these objectives. For example, spring burning is used to stimulate warm-season grasses and suppress early-developing cool-season grasses, which often dominate in the absence of fire, reducing both structural and habitat diversity. Once a diverse mix of native species is established, maintenance burns are needed only at 3 to 5 year intervals. Currier (1994) also noted that fire is effective at controlling tree and shrub invasion, particularly red cedar. Other species are not easily eliminated by fire, such as willow and false indigo.

Slack and Hunt (1987) recommended the use of burns on uplands at the Aransas National Wildlife Refuge on a 3 to 5 year rotation schedule in order to maintain habitat openness and increase acorn availability. To facilitate burns, they suggested increasing the number and size

of fire breaks to allow prescribed burning during a variety of wind directions, and they suggested clearing brush and mowing around structures and oil and gas facilities to minimize danger. Further suggestions included burning areas that had not previously been burned to expand upland habitat suitable for cranes and to maintain a permanent upland "control" area that is free from burning or other management practices to evaluate the effectiveness of management actions.

B.3. Grazing

B.3.1 Peer-Reviewed Literature

As described in *Section IV. B.2.2*, Johnson (1981) noted that grazing could be used in combination with periodic controlled burns and haying to maintain native grassland habitat in an open condition for whooping cranes. He also noted that native grassland habitat must be periodically monitored to insure that it is maintained in optimal condition.

In a report on a management plan for whooping crane habitat at the Lillian Annette Rowe Sanctuary, Nebraska, grazing was included as a means of providing short-stature vegetation for whooping cranes, along with haying and burning (Strom 1985). Strom (1985) noted that grazing is generally preferred over haying as a prairie management tool, but he did not explain why. He did note that grazing, however, is not effective at controlling woody plant invaders. No information on cost of treatment was provided. It should be noted that this proposed management plan is dated from 1985; current management of the Lillian Annette Rowe Sanctuary is described in *Section III. Survey Results*.

B.3.2 Non Peer-Reviewed Literature

Slack and Hunt (1987) suggested elimination of livestock grazing on upland habitats used by whooping cranes on the Aransas National Wildlife Refuge in Texas where whooping cranes winter. The stated reason for this suggestion is that livestock grazing is ineffective in increasing the "openness" of shrub habitat and may contribute to excessive long-term brush encroachment. They also noted that livestock grazing is associated with additional human disturbance and reduces the abundance of crane foods such as wolfberry, insects, and freshwater aquatic organisms.

B.4. Haying

B.4.1 Peer-Reviewed Literature

As described in *Section IV. B.2.2*, Johnson (1981) noted that haying could be used in combination with periodic controlled burns and grazing to maintain native grassland habitat in an open condition for whooping cranes. He also notes that native grassland habitat must be periodically monitored to insure that they are maintained in optimal condition.

In a report on a management plan for whooping crane habitat at the Lillian Annette Rowe Sanctuary, Nebraska, haying was included as a means of providing short-stature vegetation for whooping cranes, along with grazing and burning (Strom 1985). Strom (1985) noted that benefits of haying over grazing include better success in controlling woody plant invaders (specifically Russian olive) and avoid the need for fencing with its known dangers to cranes (i.e., collisions). Strom (1995) also noted, however, that haying can reduce the nutrient reserves of grasses, but this loss can be minimized by waiting until after September 30th to hay. No information of cost of treatment was provided. This proposed management plan is dated

from 1985; current management of the Lillian Annette Rowe Sanctuary is described in *Section III. Survey Results*.

B.4.2 Non Peer-Reviewed Literature

No information was found in the non peer-reviewed literature regarding the use of haying as a management technique for upland grassland whooping crane habitat.

C. OPEN RIVER CHANNEL HABITAT

Open river channel habitat refers to the in channel habitat whooping cranes use for roosting. Whooping cranes generally select roost sites based on security offered by the site and proximity to feeding areas (Faanes et al. 1992). Several authors (USFWS 1981; Faanes 1992b; Faanes et al. 1992; Lingle et al. 1984) have studied the characteristics of roosting habitat and found that important features include: broad channels free of woody vegetation commonly greater than 150 m (492 ft) wide (Faanes et al. 1992) and with a minimum of 731 m (2,398 ft) of unobstructed view upstream/downstream (Faanes 1992b); slow flows, typically 0.6 to 2.4 km/hr (1 to 4 mi/hr) at roost (Lingle et al. 1984; USFWS 1981); water depth less than 30 cm (12 in) (Faanes et al. 1992); sandy substrate (Lingle et al. 1984; USFWS 1981); open overhead visibility (Lingle et al. 1984; USFWS 1981); proximity to feeding areas, usually less than 1.6 km (1 mi) (Faanes et al. 1992); isolation from human development, typically at least 0.4 km (0.24 mi) and with wooded visual barrier (Lingle et al. 1984); and gently sloping (1° to 2°) sandbars with sparse vegetation nearby (USFWS 1981). Faanes et al. (1992) found that roost sites are generally a minimum of 6 to 9 m (20 to 30 ft) from shore or emergent vegetation, and generally are surrounded by deeper water. Faanes et al. speculated that this may serve as a barrier to potential mammalian predators.

Several authors have described the loss of open channel habitat over the past century due to changes in flows in the Platte River system and encroachment of woody vegetation (Williams 1978; USFWS 1981; Currier 1995; Currier 1996; Johnson 1997). Williams (1978) reported that upstream from Overton, Nebraska, the Platte River channel in 1969 was only about 10 to 20% as wide as in 1865. The channel in the reach from Overton to Grand Island, Nebraska, was approximately 60 to 70% as wide in 1969-1977 as it was in 1865 (Williams 1978). Williams (1978) concluded that the channel changes are most likely the result of a systematic decrease in water and sediment discharge due to the creation of on-stream reservoirs and the greater consumptive use of river water. In a more recent paper, Currier (1996) described continuing declines in channel width, including an 18.7 % decline in channel area between 1984 and 1995 in the Big Bend reach of the Platte River between Overton and Shelton, Nebraska. Currier (1995) noted that even in areas where channel habitat is actively managed, declines in river channel width of 17-18 % occurred over a 6-year period (1988 to 1994). Johnson (1997) agreed that channel narrowing occurred in the first half of the century, however, he went on to conclude that since the late 1960's, open channel area in most Platte River reaches has either increased or remained relatively stable and may have reached a new steady state. Johnson (1994) conducted research that found the steady state developed because flows have come into balance with active channel area, thereby reducing recruitment and increasing the mortality of tree seedlings.

Management techniques for open river channel habitat have largely focused on removing or controlling the encroachment of woody vegetation. Various methods that have been tried or recommended include clearing vegetation through the use of mechanical means, herbicides, burning, or grazing, and regulation of water flows.

It should be noted that some authors have expressed concerns with vegetation clearing. Johnson (1997) brought up the concern that vegetation clearing (he did not specify by mechanical means) may locally oversupply the river with sediment, thus initiating channel narrowing and encroachment of woody vegetation downstream of the cleared site. Johnson and Boettcher (1999, In Press) question whether vegetation clearing in the Platte River valley is an ecologically sound practice based on an analysis showing that considerable woodland historically occurred in the river. It has also been noted that soil disturbance associated with clearing promotes weeds, particularly purple loosestrife, a non-native highly invasive plant that threatens wetlands in many states (Whitney 1999b, Johnson and Boettcher 1999, In Press). In addition, clearing is expensive, releases sediment into the channel during floods, and removes woodland habitat composed chiefly of native species that is home is many songbirds and migrants (Johnson and Boettcher 1999, In Press).

In regards to purple loosestrife, several papers on control methods were reviewed and are summarized below. This information is included to make land managers aware of purple loosestrife concerns when implementing management methods that disturb bottomland grassland habitat. Purple loosestrife is an introduced species that occurs in wetland habitats. Once established, it displaces native vegetation through rapid growth and prolific seed production (Nelson et al. 1995). Reproduction is primarily sexual, with vegetative reproduction being of minor importance (Friisoe nd). Seed dispersal is by both wind and water (USGS 1999, Friisoe nd). Seeds remain viable for at least 3 years. Moist soil and exposure to sunlight in needed for purple loosestrife seedlings to become established and these conditions must prevail for about 50 days to allow the seedlings to grow to sufficient size to survive the winter; therefore spread of purple loosestrife in undisturbed habitats is slow (USGS 1999). The blooms on mature plants are brightest and most obvious during July. The most likely wetland sites for the appearance of purple loosestrife are along water supply entrances, or on any disturbed area within the upper flood contour (USGS 1999).

Minimizing the spread of purple loosestrife can be accomplished by conducting annual searches in wetland habitat and implementing control measures before it spreads (USGS 1999). This is relatively easy in July when the rose purple flowers are bright and obvious on stems averaging 6 to 7 feet high. Another prevention measure includes using weed-free crop seed, hay, and equipment when working in bottomland grasslands (Friisoe nd).

Methods to control purple loosestrife infestations include physical, biological, and chemical. Physical methods are limited to hand-pulling for small infestations. Plants less than two years old are usually easily removed, but older plants must be dug out with the entire rootstock removed or the remaining fragments will resprout (Friisoe nd). Other physical methods such as flooding, mowing, burning, and tillage have not proved effective for purple loosestrife (Friisoe nd, USGS 1999, Nelson et al 1995). Biological control may be an effective means of controlling purple loosestrife. Several species have been identified for use with a biological control program including a weevil and two beetles (Friisoe nd). However a national biological control program has not yet been implemented (USGS 1999) and further research in needed (Frissoe nd). Chemical control can be an effective control method for large infestations. Some of the herbicides currently used to manage purple loosestrife include glyphosate (Rodeo), 2,4-D, and triclopyr (Nelson et al. 1995). Of these, glyphosate and 2,4-D are registered for use in aquatic and wetland areas.

Glyphosate is nonselective and very effective on grasses, sedges, and broadleaf weeds. 2,4-D and trichopyr are both used for selective control of broadleaf weeds. New herbicides are also being developed.

C.1. Mechanical Clearing

C.1.1 Peer-Reviewed Literature

In his description of a management plan for the Lillian Annette Rowe Sanctuary, Strom (1985) identified the need for repeated mechanical clearing to open and maintain river roost sites for whooping cranes. Currier (1987) went on to describe mechanical clearing of two roost sites near Mormon and Shoemaker Islands by the Trust beginning in 1982. Clearing was conducted in mid-summer and early fall when the river was low and equipment could be driven across river channels. Initial clearing was done using chainsaws and a tractor fitted with a brushhog mower. Vegetation ranged from 2 to 8 m (6.6 to 26.4 ft) in height and was composed of dense stands of 5 to 15 year old cottonwood, willow, and false indigo. Trees were generally 8 to 10 cm (3 to 4 in) in diameter, but occasionally up to 30 to 40 cm (12 to 16 in). Other mechanical or mechanical/herbicide methods tested included shredding, and shredding followed by discing or herbicide application. Currier (1987) found that shredding followed by discing was the most effective and environmentally acceptable method. Currier (1987) noted that this method in combination with high flows eliminated some islands elevated as much as 1 m (3.3 ft) above the streambed. Costs (in the early 1980's) were approximately $443/ha ($177/acre). Shredding alone was not effective in controlling woody growth. Shredding followed by herbicide application (both Graslan and Roundup were used) was also effective but not recommended because of uncertainties about long-term environmental effects. Costs were slightly higher than shredding and discing ($459/ha, $183/acre). More up-to-date information on mechanical open river channel clearing by the Trust is found in *Section III. Survey Results*. Currier (1987) describes early efforts and costs that have since been refined and updated over the years.

Lingle et al. (1984) noted that a site that had been mechanically cleared of woody vegetation had been used by whooping cranes, thus reinforcing the contention that roost sites can be restored for whooping cranes. However, Lingle et al. (1984) provided no further detail on how the site was cleared and the associated costs.

In other habitat types around the country, different mechanical clearing techniques have been used that may be applicable to open river channel habitat in the central Platte River. For example, in the southwest, bulldozing and chaining are used to control woody vegetation on range sites. Skousen et al. (1986) compared vegetation patterns resulting from bulldozing and two-way chaining followed by seeding on a central Utah pinyon-juniper big game range. While no specific information was provided on the treatment methods (other than bulldozing vs. two-way chaining followed by seeding), Skousen et al. (1986) found that, in terms of eliminating juniper, bulldozing was the most effective treatment; there were 42% more trees on the two-way chained area than the bulldozed site. The bulldozing killed 81% of the juniper, whereas two-way chaining killed only 54% when compared to a nearby control area. The authors note that age structure of the juniper stand before treatment is an important factor in determining actual tree kill from mechanical treatments. The presence of small, flexible trees can make chaining treatments less effective than bulldozing. Similarly, Holechek et al. (1989) state that cabling or chaining is most effective in controlling even-aged, mature shrubs or small

tress with stem diameters of 8 cm or more, and that bulldozing is effective on sparse stands and medium-sized trees. They further note that cabling or chaining is most effective in areas with lighter-textured sandy or loamy soils.

C.1.2. Non Peer-Reviewed Literature

Little information was found in the non peer-reviewed literature. The USFWS (1981) noted that mechanical clearing (no particular method specified) is probably effective in removing seedlings once they have been established, but such clearing is costly, labor intensive, and would require repeated use to control woody vegetation.

C.2. Herbicide Application

C.2.1 Peer-Reviewed Literature

Currier (1987) described the use of herbicides and herbicides in combination with mechanical clearing (see *Section IV. C.1.2* above) to control woody vegetation in open river channel habitat. Clearing was conducted at two crane roost sites near Mormon and Shoemaker Islands by the Trust beginning in 1982. The vegetation consisted of dense stands of 5 to 15 year old cottonwood, willow, and false indigo, ranging in height from 2 to 8 m (6.6 to 26.4 ft). Trees were generally 8 to 10 cm (3 to 4 in) in diameter, but occasionally up to 30 to 40 cm (12 to 16 in). The herbicides used were Graslan (tebuthiuron) at a rate of 2.26 kg/ha and a 1.5 % solution of Roundup (glyphosate). Shredding followed by application of the herbicide was found to be effective in clearing woody vegetation and controlling regrowth (95 %). Costs were $459/ha ($183/ac) (in early 1980's). Although effective, widespread use was not recommended because of uncertainties about long-term environmental effects. Herbicide use alone was 85 to 95 % effective in controlling standing shrubs, but problems in uniform application were noted (Graslan, applied by hand-held applicators in pellet form, was easier to apply uniformly than spraying Roundup). Currier (1987) also noted that even though standing trees were killed by herbicide use, they still must be removed.

Lingle (1981) chose not to use herbicides at Mormon Island Crane Meadows in 1981 because of potential hazards on a riparian system. Lingle (1981) did not identify the potential hazards.

Evans and Young (1985) reported on controlling trees in a western juniper woodland using Picloram pellets. Picloram was applied around the edge of the tree canopies (as prescribed by the herbicide label in effect at the time of application) at the rate of 14g/m of tree height of 10% ai (active ingredient) granular formulation. Evans and Young (1985) report that the Picloram was "very effective" in controlling trees, but no quantitative data were provided since the focus of the study was directed at plant succession following control with Picloram.

C.2.2. Non Peer-Reviewed Literature

As with mechanical clearing, little information was found in the non peer-reviewed literature on the use of herbicides to manage open river channel habitat. USFWS (1981) noted that herbicide use is probably effective, but is costly, labor intensive, and would require repeated use to control woody vegetation.

C.3. Prescribed Burning

C.3.1 Peer-Reviewed Literature

Little information was found in the peer-reviewed literature on the use of burning to manage open river channel habitat; however Johnson (1981) listed it as an option for vegetation removal in open channel habitats without providing any further detail. Lingle (1981) chose not to burn at Mormon Island Crane Meadows due to a lack of fuel. Early attempts (no date was given) to burn vegetation on islands at the Lillian Annette Rowe Sanctuary were either unsuccessful or only partially successful because of a lack of fuel to carry the fire, however a later attempt (in 1984) appeared to be effective, but no monitoring or cost data were given (Strom 1985).

C.3.2. Non Peer-Reviewed Literature

Whitney (1999a) suggested a method for tree and shrub clearing that would result in a prairie community for grassland birds and cranes. He considers this method "less aggressive", but one that works with the ecological dynamism of the grass/shrub/forest mosaic. This method allows for a more gradual transition from forest to prairie and avoids problems with invasive plant species, however the main drawback is that it takes longer than other methods. The method includes the use of prescribed fire/grazing combined with selective cutting and prairie overseeding. Whitney (1999a) suggests the use of this method on 20 to 30 acre sites. The method involves selective tree felling and shrub cutting annually with limited or no slash removal. When these areas build up fuel, burn them annually. These high intensity, frequent fires with the temporary absence of cattle grazing will eventually remove big and medium trees, prune the shrubs, and allow more grass to grow. Forbs can be overseeded throughout the process.

C.4. Grazing

C.4.1 Peer-Reviewed Literature

Goats have been used successfully in the southern United States to control woody vegetation, specifically several species of oak (Davis et al. 1975). Davis et al. (1975) found that the success of goat browsing is largely dependent on animal grazing preference and the physiology of the plants. During their study, goats were rotated among three different pasture types ranging from 4 to 6 acres in size. The pasture types were 1) undercut oak, which resulted in vigorous root sprouting after treatment, 2) undisturbed oak, ranging in size from small, undisturbed plants to large, mature specimens up to 15 feet tall, and 3) combined-treatment of oak, where the pasture was one-third roller-chopped, one-third bulldozed and brush-raked, and one-third undisturbed. The goats were moved from a pasture when 90 to 95% of the oak leaves were utilized, and returned when new leaves were produced. Goats were initially stocked at a rate of approximately 200/acre, but the stocking rate dropped with each successive year of the study as a result of the decrease in the number of live sprouts available. Results from the Davis et al. (1975) study show goats can be effective in controlling oakbrush, however the oakbrush must first be treated mechanically to allow full access to the foliage, and time of goat browsing is important. Repeated annual defoliation during times of low carbohydrate storage in oak roots is most effective. Problems encountered during the study included the need for goat-proof fencing or herding, and the need for a rotational scheme and therefore several pastures (Davis et al. 1975).

C.4.2. Non Peer-Reviewed Literature

No information was found in the non peer-reviewed literature on the use of grazing to manage open river channel habitat

C.5. Flow Regulation

Several authors recognized flow regulation as an important management tool for open river channel habitat, both directly and indirectly (Johnson 1981, Lingle 1985, Lingle 1993a, Lingle 1993b, Faanes 1985, Currier 1995, Faanes and Bowman 1988, Johnson In Press). Direct management refers to regulation of water levels to provide recommended flows for whooping crane roost sites. Indirect management refers to water flow management as a means of controlling vegetation encroachment.

C.5.1 Peer-Reviewed Literature

As an example of direct management, Johnson (1981) recommended water flow regimes be maintained during the spring (late March to early May) and fall (early October to mid-November) for whooping crane roost sites, however he did not recommend a specific water level or discuss costs. He did suggest leasing or purchasing of water rights to insure adequate flows as a means of obtaining the recommended water.

Another example of direct management, Faanes et al. (1992) suggested that flows at approximately 60 cms (2,000 cfs) are necessary in the Platte River during spring and fall migration periods to provide an adequate distribution of deeper water channels to aid whooping cranes in selecting roost sites. This suggestion is based on a study Faanes et al. (1992) conducted examining the characteristics of whooping crane roost sites in the Platte River, but they did not examine costs or methods for maintaining such flows.

Ziewitz (1988) came up with a similar suggested flow as Faanes et al. (1992) to provide optimal conditions for whopping crane roosting in the Big Bend section of the Platte River. Ziewitz (1988) determined flows of 60 to 72 cms (2,000 to 2,400 cfs) provide optimum roosting habitat conditions. This determination was based on a model Ziewitz developed and described (1988) to quantify the relationship between river discharge and roosting habitat suitability for whooping cranes. Again, Ziewitz (1988) did not include costs of maintaining such flows or provide further details.

Lingle et al. (1984) noted that in 1983 the Nebraska Game and Parks Commission recommended a flow of 51cubic meters/second (cms) (1,700 cfs) in the Platte River during migration to maintain whooping crane roosting habitat. During their study on physical characteristics of a whooping crane roost site on the Platte River channel between Overton and Grand Island in October 1983, Lingle et al. (1984) measured the flow at their study site to be 38 cms (1,260 cfs). They found that this flow was adequate at that particular roost site because it was located on a stretch of the river where all of the water flowed essentially in a single channel. They did note that at other stretches of the river, where there are several major channels, 38 cms (1,260 cfs) would not be adequate to provide whooping crane habitat. Lingle et al. (1984) did not provide any further information such as costs or methods to maintain recommended flows.

Shoemaker et al. (1981) developed minimum streamflow recommendations for maintenance of whooping crane habitat on the Niobrara River, Nebraska, downstream of a proposed dam. The recommendations are seasonal, but since they are specific to the Niobrara River, they are

not included here. Principal controlling factors for maintaining channel width and area were identified as high winter and spring flows combined with ice breakup.

Johnson (1994, In Press) conducted research to identify factors that have permitted the cottonwood/willow woodland to expand into the formerly active channels of the Platte River. Statistical models indicated that sandbar succession to woodland was regulated by three environmental factors: June flows, summer drought, and ice (Johnson 1994). Consequently, Johnson (1994) outlined the following options for water flow management to minimize woodland expansion 1) prohibit recruitment in the active channel by augmenting June flows, and increase seeding mortality 2) raising winter flows to increase ice scouring, 3) increasing spring peak erosive flows to remove seedlings, or 4) reducing late-summer flows to increase seedling desiccation. Johnson (1994) notes that experimentation would be required for successful use of water management as a tool for minimizing woodland expansion. Success may require a combination of the above-listed options. Climate would be an important variable. Also, the response of both the biota and physical environment is poorly known. Success would further depend on special cooperation between the dam operators and ecologists (Johnson 1994).

Faanes and Bowman (1992) studied the relationship of channel maintenance flow to whooping crane use of the Platte River. They found that periodic high flows are necessary to scour vegetation and redistribute sediment in the channel. Peak and mean annual flows have been reduced by as much as 70 % from pre-development times (Williams 1978), but channel maintenance flows still occur, although at a much reduced frequency and magnitude (Faanes and Bowman 1992). Three to five years of reduced flow levels apparently are sufficient to permit encroaching vegetation to become permanent. Based on historic duration of peak flows, Faanes and Bowman (1992) recommend a minimum of 5 consecutive days of 240 cms (8,000 cfs) (present peak flow) to maintain the existing channel configuration. Channel degradation begins when peak flows decrease to 150 cms (5,000 cfs). Faanes and Bowman (1992) do not give cost estimates or details on how to provide and maintain recommended peak flows.

C.5.2. Non Peer-Reviewed Literature

Several authors have recommended regulating flows to control the encroachment of woody vegetation. For example, USFWS (1981) said water manipulation is probably the most effective means of controlling encroachment by woody vegetation. This study documented that seedling establishment of cottonwoods and willows (the most common trees to invade sandbars and former channels of the Platte) occurs primarily on sites with a high percentage soil moisture, fine textured soils, and exposed substrate during the time when viable seed is available (USFWS 1981). Seed germination and seedling establishment can be effectively controlled by raising river stage levels during the seed viability period (mid-May to August), inundating sandbars either throughout the period of seed germination or for sufficient time to prevent seed germination and seedling establishment (USFWS 1981). No costs were included. USFWS (1981) also noted that once seedlings are established, major floods and scouring are necessary to remove them. USFWS (1981) further reported that experimentation has shown 15-cm tall cottonwood seedlings were able to survive 30 days of inundation and recover, and willow seedlings were able to survive 32 days and recover.

Like USFWS (1981), Currier (1995) noted that woody seedlings cannot develop on the Platte River bed when flows occupy the channels. Currier (1995) reports that at flows of 60 cms (2,000 cfs) and greater, 95 % or more of the channel is underwater, and virtually no areas are available for seedling establishment. At 30 cms (1,000 cfs), 25 % of the bed is exposed; at 24 cms (800 cfs) 34 % is exposed; and at 12 to 6 cms (400 to 200 cfs), 70 to 80 % of the riverbed is exposed. Thus, reports Currier (1995), the maintenance of a base flow of 24 to 30 cms (800 to 1,000 cfs) in the channel during the seed germination and establishment period (mid-May through August) would limit additional seedling recruitment on a majority of the remaining open, unvegetated riverbed. No costs for maintaining these flows were provided. Currier (1995) also stated that regular channel-forming flows would result in removal of seedlings that do develop. He suggested spring and early summer pulse flows would dislodge and remove woody seedlings and saplings that become established. At a minimum, the pulse flows should be in the 80 to 239 cms (2,650 to 7,950 cfs) range; pulse flows in the 360 to 480 cms (12,000 to 16,000 cfs) range need to occur with a return period of 2.5 to 3 years in order to effectively maintain channels in the Platte River.

D. TERN AND PLOVER REPRODUCTIVE HABITAT

Open riverine habitat refers to the islands and sandbars used by least terns and piping plovers for reproductive habitat. They also use suitable non-riverine habitat (e.g., sand pits and beaches) for nesting. A number of articles (more than all other habitats), both peer-reviewed and non peer-reviewed, were found during the literature search regarding management of riverine and non-riverine habitat for least terns and piping plovers. Both species have similar habitat requirements for nesting habitat, namely, sandbars and beaches barren of vegetation and with clear visibility (Faanes 1983). Habitat management methods that have been used or recommended in riverine and non-riverine habitats for least terns and piping plovers include vegetation clearing, habitat creation/restoration, predator control, flow regulation, and minimization of human disturbance. It should be noted that concerns expressed regarding vegetation clearing described in *Section IV.C. Open River Channel Habitat*, would also apply for vegetation clearing for tern and plover reproductive habitat.

D.1. Vegetation Clearing

D.1.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature on vegetation clearing methods of riverine and non-riverine least tern and piping plover habitat.

D.1.2. Non Peer-Reviewed Literature

Boyd (1993) reported that least tern nesting habitat along the Cimarron River in Kansas has been lost to vegetation encroachment and deterioration of sandbars. Vegetation clearing was conducted at a least tern colony along the Cimarron River in Meade County, Kansas, as part of study on reproductive success (Boyd 1993). The study site was a sandbar island located on a former channel of the Cimarron River. According to Boyd (1993) the sandbar would normally have been built up during spring floods, however spring flood levels at the time of the study and in the previous decades did not occur with the intensity and frequency need to scour vegetation and build up the sandbar. In March 1985, a 100m x 40m (328 x 131 ft) area was cleared by hand of salt cedar. In September of that year, another 140m x 50m (459 x 164 ft) area on the sandbar island was bulldozed to more completely clear salt cedar and inland salt grass and improve drainage. The sandbar was bulldozed again in August 1986 and April 1989.

The area was sprayed with Rodeo herbicide in 1987 and 1989 for weed control. Finally, the area was disked in September 1990. Bulldozing was reported to be the most effective method of clearing vegetation, but also the most expensive (no actual costs were given). Herbicide use was not considered viable due to risks of applying herbicide once nesting had commenced. The number of breeding least tern pairs at this site fluctuated from 7 to 15 over a 12-year period (Boyd 1993).

Latka et al. (1993) studied several vegetation removal methods on the Missouri River system, including tilling, herbicides, bulldozing, mowing, disking, and burning to improve nesting habitat for least terns and piping plovers. The study took place on a sandbar complex over a 6-year period. In October 1987, the first year, 1.6 ha (4 acres) of young trees (1-3 years old) were tilled with a tiller pulled by a tractor. By 1988, revegetation was widespread. In August 1988, vegetation was aerially sprayed with Rodeo herbicide at a rate of 6 pints/acre. The area treated was expanded on the original island (Latka et al. 1993 did not specify by how much) and included 5 to 8 year old cottonwoods, as well as the addition of a second sandbar, which covered about 30 acres with cottonwood and willow trees. Within 2 weeks, a total kill was documented and an attempt was made to burn the dead vegetation, but was unsuccessful. In September, the vegetation was cleared using a bulldozer, tractor, disk and/or mower; it was piled and again an attempt was made to burn it, but too much sand was mixed in. In 1989, the area was again expanded to include a third 10-acre vegetated sandbar island further downstream and the previous year's herbicide treatment was used (in September) along with a pre-emergent herbicide and mowing. The pre-emergent (Norosac 10-G) was applied in April aerially and using a tractor at two test rates of 100 and 200 lb/acre, in combination with mowing and tilling. An in-depth analysis was made of the combination of Norosac and mechanical treatments at one of the islands. Stem counts and percent cover determinations were made, and the results indicate no difference between application rates, and that tilling in combination with the lower rate of Norosac was the most effective. In 1989, 11 least tern and 2 piping plover nests were established on the sandbar; all were destroyed by a predator. In April 1990, mowing, disking, and Norosac (at 100 lb/acre) were again used, brush piles were moved to a depression on the island since they may have been providing cover for predators. In 1990, least tern and piping plover nests were again established and some young of both species fledged. In 1991, budget constraints prevented vegetation clearing. In 1992, heavy equipment was used in April to mechanically scrape vegetation and reshape the islands and a volunteer operation of hand-pulling and hand-clearing was done. In September, Rodeo herbicide was again applied using a backpack sprayer. No cost information was provided for the treatments.

Danley and Smith (1997) reported on management efforts for piping plovers at alkali lake habitat in Lostwood National Wildlife Refuge, North Dakota. Their methods included prescribed burning of sweet clover from potential nesting beaches when conditions allowed (they did not define appropriate conditions). They also pulled sweet clover by hand at several traditional piping plover beaches. Danley and Smith (1997) did not explain whether these methods were effective and provided no further detail.

D.2. Habitat Creation/Restoration

D.2.1. Peer-Reviewed Literature

Ziewitz et al. (1992) studied habitat conservation for nesting least terns and piping plovers on the Platte River, Nebraska. They report that least terns and piping plovers have used artificial nest sites in coastal areas, and that habitat restoration is the cornerstone for recovery of the endangered California least tern. Ziewitz et al. (1992) recommend creation of sandbars by dredging to provide suitable nesting substrate for least terns and piping plovers, and note use of such an island by least terns and piping plovers near Elm Creek, Nebraska. They offer the following guidelines for habitat restoration in the central Platte River, but do not provide cost information: 1) restoration projects should be conducted in the widest channels, 2) dredge a mid-channel sandbar to provide a high, clean, and smooth nesting substrate at least 1.45 ha (3.6 acres) in size, 3) restore sandbars by dredging at least 0.8 ha (2 acres) to a height greater than 1.06 m (3.5 ft) and at least 0.4 ha (1 acre) to a height greater than 1.76m (5.8 ft).

Smith and Renken (1991) studied least tern nesting habitat in the Mississippi River valley and found that sandbars used by least terns for nesting differed from unused sandbars by the length of time (at least 100 days) sites were continuously exposed above the river. They also found that colony sites averaged 2.8 m (9.24 ft) in height above the river on June 1, whereas unused sites averaged 1.7m on that date. Tern nests were often near small sticks or other drift material. Smith and Renken (1991) recommend enhancing existing sandbars or creating new ones. Sandbars that are too low to remain continuously exposed for at least 100 days could be raised to a suitable elevation (approximately 2.8 m [9.24 ft] above the river) by modifying dike structures or constructing chevron dikes (chevron dikes are not described in Smith and Renken 1991).

Sidle and Kirsch (1993) studied use of sandpits along the Platte River by least terns and piping plovers. Sandpits can be considered a created habitat, and are made by commercial dredging for sand and gravel, which produce ponds bordered by gently sloping piles of bare sand and gravel. They are often in close proximity to the river (within 1.5 km [0.9 mi]), however they are not inundated by periodic increased river flows. Sandpits provide an alternative nesting area where sandbar habitat is limited, particularly along the central Platte River. Least terns and piping plovers nested at 68 % of 78 sandpits identified suitable (based on substrate) at least one year of a 3-year study (Sidle and Kirsch 1993). More sandpits than sandbars were used in the central Platte River because of poor condition of sandbars and availability of sandpits. Sidle and Kirsch (1993) found active or recently abandoned sandpits are most often used, since abandoned pits are often developed, reclaimed, or naturally revegetate. Sidle and Kirsch (1993) did not describe how nests were found in relation to the actual excavation operations. They did note that government, industry, and conservation groups have been working together to protect eggs and chicks at sandpit nesting areas and recommend continuation of these efforts. They also recommend enhancement and protection of riverine habitat.

Prindiville Gaines and Ryan (1988) studied piping plover habitat use at alkali wetlands in North Dakota. In comparing occupied vs. unoccupied habitat, they found that important habitat components include beach width (> 25m wide), sparse or clumped vegetative cover, and gravel substrate that is evenly distributed. Apparently, beach habitats with a pattern of sparse, clumped vegetation and abundant, evenly distributed gravel create large blocks of homogenous substrate attractive to piping plovers and provide a camouflaging background for their nests (Prindiville Gaines and Ryan 1988). They also found that factors limiting nest success include predation, human and cattle disturbance, and vegetative characteristics. Based

on their findings, management recommendations focus on improving habitat quality. For example, beaches less than 20 m (66 ft) wide could be widened by spreading gravel or reducing water levels. Other suggestions include increasing the amount and distribution of gravel and reducing vegetative cover. One suggested method of reducing vegetation is spraying with salt water from adjacent alkali lakes after plovers have left. Prindiville Gaines and Ryan (1988) note that research on effectiveness and costs are needed. They also suggest exclusion of cattle and all-terrain vehicles from alkali beach nest sites.

Not all habitat creation efforts have been successful. Koenen et al. (1996) created nest ridges in least tern habitat at Salt Plains National Wildlife Refuge in Oklahoma to provide elevated habitat safe from sheet flooding. The nest ridges were created by plowing ridges 10 m (33 ft) long x 1 m (3.3 ft) wide x 0.5 m (1.65 ft) high. While least terns did use the ridges for nest sites, no difference in nest success was found between nests on the ridges and off.

D.2.2. Non Peer-Reviewed Literature

In Kansas, where flooding and predation were found to be limiting factors for least terns at a nesting colony, nest pads were constructed over a five-year period to minimize flooding impacts (Boyd 1993). Nest pads consisted of a ring of bricks approximately 0.6 m (2 ft) in diameter filled with coarse sand, or two 5-gallon buckets, one with rocks for the base, and one with coarse sand flattened to create a pad approximately 1 m (3.3 ft) in diameter and about 15-20 cm (6 to 8 in) high. Costs of the nest pads were not reported. The nest pads were surrounded by an electric fence to reduce predation. During the first year of use (1985), seven least tern and piping plover nests were built on the nest pads. The following year (1986), which was very wet, the nest pads were not widely used (2 of 24 nests), despite the use of decoys to attract least terns. In 1987, 6 of 27 least tern nests were built on pads, and all but one were destroyed in heavy rains and hail. No observations were made in 1988. In 1989, 5 out of 23 least tern nests were built on pads, and an additional 7 pairs nested on an old well pad that was leveled off by adding sand. Based on these early successes, 181 additional pads were built in the fall of 1989. This large number appeared to confuse coyotes. Since 1990, Boyd (1993) reports continued success of use and fledging rate with the nest pads. Boyd (1993) stated that nesting pads definitely resulted in an increase in hatching success, but not necessarily fledging success.

Habitat creation and restoration efforts have been carried out since 1993 in Colorado on the lower reaches of the Arkansas River where monitoring of least tern and piping plover habitat showed decline (Nelson 1999). At this site, habitat restoration efforts have included manually clearing approximately 100,000 trees (heavy equipment could not get to the island). These efforts were augmented by naturally high water levels during the restoration period that submerged and killed cottonwoods. Controlled fires were also used on herbaceous vegetation (kochia and clover). In addition, island habitats were elevated through favorable natural conditions and submerging cleared vegetation in the shallow water, which accumulated sand from the water and built up over time. One island rose 77 cm (30 inches) over a 1-year period. No costs were provided for these management efforts. As a result of these efforts, piping plovers and least terns are reported to be "hanging on" in Colorado (Nelson 1999).

Gordon and Kruse (1999) reported on nest relocation as a management alternative for threatened nest sites. On the Missouri River/Reservoir systems, nests are often impacted by

fluctuating water. They found relocating piping plover and least tern nests over a 5-year period were effective; incubation at 92 % of the piping plover nests and 100 % of the least tern nests was resumed after relocation. Nests were relocated using three different methods: 1) The obliterate/re-create method involved moving eggs to a new, safe location and re-creating the original "micro-site" at a secure site. At the new site, a nest bowl was formed by hand and lined with material (e.g. pebbles and debris) from the original nest; eggs were maintained in the original orientation; and visual landmarks (e.g., rocks, sticks, vegetation, cow pies, etc.) were placed in the original orientation. The original nest was obliterated. 2) The obliterate/platform method was similar to the first method described, however the new nest was constructed on a platform to simplify subsequent moves. The platform was constructed with 45, 60, or 75 cm (18, 23, or 29 in) square plywood bases with drainage holes, and buried 4 to 8 cm (1.5 to 3 in). 3) The cylinder/plate/platform method involved pressing a cylinder (coffee can) into the substrate around a nest to approximately 4 to 8 cm (1.5 to 3 in) deep. Substrate from one side of the cylinder was then excavated and a 20 to 35 cm (8 to 14 inch) square aluminum plate was slid under the can and nest and the nest was lifted out of the ground and placed on a platform at the new location. At the new site, visual elements were replaced as with the other methods. Prior to moving a nest, hands, footwear, and tools were washed in biodegradable, unscented soap. No costs were given for moving nests. Success was achieved while relocating to both natural and artificial substrates (Gordon and Kruse 1999).

NPPD has developed several islands on the Platte River to use as nesting habitat for piping plovers and least terns (NPPD 1997). These include Elm Creek Island, Lexington Island, and Overton Island. Elm Creek Island, approximately 1.4 ha (3.6 acres) in size, was started in November of 1990 and completed in March 1991 at a cost of approximately $143,000. Construction of this island was described by Plettner (1993) and is summarized below. Lexington Island, approximately 2.8 ha (7 acres) in size, was started in October 1991 and completed in March 1992 at a cost of approximately $124,500. Overton Island, 1.4 ha (3.6 acres) in size, was started in June of 1992 and completed in April 1993 at a cost of approximately $125,000. NPPD has also developed three sandpit sites for least tern and piping plover nesting: Johnson Sandpit (1991), Lexington Sandpit (1991), and Blue Hole Sandpit (1996). Little information was found describing methods used to develop these sandpits, however NPPD (1997) noted enhancement activities at Blue Hole Sandpit have included burning, dozing sandpiles, fencing, and installing warning signs (NPPD 1997).

Plettner (1993) described the methods used to create Elm Creek Island. Work on this 1.4 ha (3.6 acre) island located adjacent to the north bank of the main channel on the Platte River included clearing the understory by mowing; removing large trees by treating them with herbicide, bulldozing, and chainsawing; and earthwork. Clearing was also conducted on a nearby buffer area. Earthwork consisted of isolating the island by moving soils from the north channel onto the island and filling in low spots. Dredge soil from a local sandpit was then deposited onto the island and smoothed out with a bulldozer. A layer of sand/gravel mix was then spread over the island. The mix reduced surface erosion and protected nesting birds from blowing sand. The island height was designed to protect nesting birds from inundation based on a 32-year flow (i.e., 0.4 ha [1 acre] was approximately 1.8 m [6 ft] above the lowest portion of the riverbed and the remainder was approximately 1.2 m [4 ft] above the riverbed). Driftwood was scattered to provide natural material for adults to nest by. Decoys were placed to attract birds. Shelters (circular drain tiles) were provided to protect chicks from avian

predators and provide shade. An electric fence was also installed to protect nesting birds from predators. Further information pertaining to NPPD efforts is found in *Section III. Survey Results.*

Currier and Lingle (1993) reported on creation of two nesting islands (2.8 ha and 1.0 ha [7 acres and 2.5 acres]) for piping plover and least tern habitat using a dredge and patterning the islands after spoil piles created by sand and gravel operations near the Platte River. Construction costs were approximately $25,000 per island. Vegetation growth was reported as low (less than 5 %) over a 2-3 year period, probably due to use of soil with a non-viable seedbank. Nesting occurred at one of the sites during the two nesting seasons following creation.

The U.S. Army Corp of Engineers (ACOE) has been involved in habitat creation efforts for the least tern and piping plover along the main stem of the Missouri River since the 1980's. These efforts have been described in a variety of annual reports (ACOE 1999, ACOE 1998, ACOE 1993, ACOE 1992, ACOE 1991) and by Latka et al. (1993). Activities have occurred from Fort Peck Lake in Montana downstream to Gavins Point Dam on the South Dakota/Nebraska border. Habitat creation methods have included creating new islands using dredge material, increasing island elevation using bulldozers and sand (snow) fences, and installing floating islands. In addition, SEA bags and crushed oyster shells have been used to help stabilize created habitat from water and wind erosion.

Latka et al. (1993) described some of the methods used by the ACOE in detail. Sand fences were used in North Dakota. They were constructed from plastic snow fence and electric fence posts to trap sand (detailed information on sand fences is included in ACOE 1992, Appendix 6). Sand dunes up to 1 m (3 ft) high formed in only a few months. Young willows were also used to mimic a "snow fence" effect and build up new dunes at another location along the Missouri River. These willows were sprayed, but left standing. Oyster shells were successfully used to reduce wind erosion of the created sand dunes. At other locations along the main stem Missouri River, bulldozers were used to reshape islands by piling low-elevation sand onto higher areas to reach a target elevation of 46 cm (18 in) above water surface elevations during peak summer flows. Crane-on-barge dredging of bottom sediments was also used to increase island elevations. Sediment was piled onto existing low-elevation sandbars. To combat water erosion of the newly created islands, sandbags or heavy-duty marine SEA bags were used. Latka et al. (1993) did not include costs for these habitat creation efforts, and use of these created habitats by least tern and piping plover was not studied since not enough time had elapsed since creation.

In addition to the methods described above by Latka et al. (1993), the ACOE (1992, 1993) has also used floating islands on the Missouri River main stem system to create least tern and piping plover habitat. These "islands" consist of Schwimmenkampen floating modular units, constructed of PVC tubing and other durable buoyant materials. Each unit is triangular in shape and multiple units can be fastened together to create varied configurations and sizes. The islands are anchored using ropes and anchors, typically such that they can move with fluctuating water levels and wave swells. Local sand was used as a substrate on the islands at a location in Montana in April 1993. ACOE (1993) noted that the sand used had a tendency to blow off. At the Montana location, three floating islands were initially placed on existing low

elevation islands, one floated up during high summer flows. Decoys were used to attract least terns to the islands. ACOE (1993) reports that the islands were unused by birds during the 1993 nesting season, however no nesting occurred in the vicinity of the floating islands. No additional information was found in subsequent reports provided by the ACOE on the use of floating islands on the Missouri River main stem (ACOE 1998, 1999).

D.3. Predator Control

Predator control techniques, such as exclosures, electric fencing, and chick shelters, are used at least tern and piping plover reproduction sites to reduce the impacts of predation. Predator control has been widely used throughout the range of least terns and piping plovers. Predation has been identified as an important factor affecting the survival of these species (Rimmer and Deblinger 1990, Prindiville Gaines and Ryan 1988, Melvin et al. 1992, Smith and Renken 1993, Espie et al.1996, Mayer and Ryan 1991, Patterson et al. 1991). Common least tern and piping plover nest predators vary throughout their range, but include coyotes, foxes, raccoons, skunks, crows, gulls, herons, and raptors (Melvin et al. 1992, Mayer and Ryan 1991).

D.3.1. Peer-Reviewed Literature

Predator exclosure use at piping plover nests were studied by Melvin et al. (1992) on outer Cape Cod, Massachusetts. The exclosures consisted of a 1 x 10 m (3.3 x 33 ft) piece of 5 x 10 cm (2 x 4 inch) galvanized wire mesh fencing placed in a 3.2 m diameter circle 9 cm (3.5 inches) deep around the nest. The fencing was stapled to wooden posts approximately 150 cm tall. The top of the posts was below the level of the wire mesh to discourage perching by avian predators. Total cost of each exclosure was approximately $15.00. Melvin et al. (1992) noted that modifications could be made, such as burying the exclosure deeper or extending a wire-mesh apron laterally from the base to discourage predators from digging under the exclosure. The top of the exclosure can be angled outward to discourage predators from jumping over. Twine or monofilament line can be stretched over the top to discourage avian predator; however this is only recommended where avian predation has been documented because piping plovers were observed flying up and out of the exclosures when disturbed. Based on the success of this study, Melvin et al. recommend the use of predator exclosures to protect piping plovers at sites where predation has been documented as a significant and limiting factor and where species of nest predators have been identified. They further recommend symbolic fencing, public education, and/or enforcement to minimize human disturbance.

Rimmer and Deblinger also studied wire mesh exclosures to protect piping plover nests (1990) and least tern nests (1992) at Crane Beach in Ipswich, Massachusetts. Wire mesh fencing with 5 x 5 cm (2 x 2 inch) openings was used in both studies. The exclosure was triangular with a 30.5 m (100 ft) perimeter. Black twine was placed in parallel rows over the top during the study to protect against avian predators (Rimmer and Deblinger 1990). Metal posts driven into the ground supported the fencing, and tops of the posts were below the top of the mesh to discourage avian predators from perching. The exclosure was approximately 75 to 80 cm (30 to 32 inches) high, and buried 20 to 25 cm (8 to 10 inches) underground. Cost per exclosure was approximately $50.00. In both studies, they found exclosures were effective in increasing hatching success and recommend their use.

Vaske et al. (1994) studied the impact of predator exclosures on piping plover nest abandonment. Information on 211 exclosures was gathered from state and provincial agencies. Exclosures were erected soon after nest discovery between April 23 and July 12. Construction time varied from 5 to 90 minutes; between 1 and 6 people were used to build an exclosure. Styles and shapes of exclosures varied, but all were 5 x 5 cm (2 x 2 inches) or 5 x 10 cm (2 x 4 inches) mesh with the base buried in the substrate. Fence posts were metal or wood; one structure, however, was self-supporting. Eighty eight percent had some type of cover to reduce avian predation. Vaske et al. (1994) found that installation of exclosures did not cause an increase in nest abandonment. Abandonment rates of nests protected with exclosures were similar to unexclosed nests. Based on this study, Vaske et al. recommends the use of predator exclosures at breeding sites where predation limits hatching success.

Mayer and Ryan (1991) studied electric fencing as a means of controlling/reducing mammalian predation on piping plover nests and chicks in North Dakota. Fencing enclosed all available nesting habitat at four wetland beaches. The fences were constructed between 22 April and 4 May. The fences were approximately 55, 70, 250, and 300 m (180, 230, 820, and 984 ft) long, enclosing about 0.4, 2.0, 2.4, and 2.0 ha (1, 5, 6, and 5 acres) respectively. Fences were constructed of 1.3 m (4.3 ft) high, 2.5 cm (1 inch) wire mesh, supported by steel T-posts. The bottom portion of the mesh curved outward. Three strands of electrically-charged, 17-gauge wire were placed on the outside of the exclosure and fastened to the T-posts with plastic clips that held the wire about 12 cm (4.7 inches) from the mesh. The wires were approximately 10, 65, and 130 cm (4, 25, and 51 inches) above the ground. A 12-V automobile battery and an energizer manufactured for livestock control supplied electric current to each fence. A 1.3 m (4.3 ft) copper rod driven into the substrate provided the electrical ground. A wooden board was placed under each battery to prevent discharge. Vegetation and debris along fences were removed by hand or grass trimmer. Cost of material was $1.20/m ($0.37/ft). Construction time averaged 48 person-hours per fence. They found that electric fencing, in combination with habitat protection and enhancement and control of avian predators, offers promise for stabilizing or increasing the piping plover population in the northern Great Plains. Electric fences offer several advantages over single nest exclosures because they can be installed prior to piping plover arrival at nesting sites, left in place year after year, and require little maintenance (Mayer and Ryan 1991). In addition, since piping plovers tend to nest in a clumped distribution, they can be used over a larger area rather than labor-intensive single nest exclosures.

Koenan et al. (1996) used solar-powered electric fencing at Salt Plains National Wildlife Refuge in Oklahoma around a 16-ha least tern nesting site. Fences were powered by a deep cycle 12-V marine battery supported by a Gallaghar B-150 solar energizer resulting in a 1000-6000 volt charge. Wire strands were placed approximately 14, 28, 42, 62, and 86 cm (6, 11, 17, 24, and 34 inches) from the ground. Wires were fastened to steel posts with plastic insulators. Fence costs were estimated at $0.85/m ($0.26/ft). The fence was found to be effective at reducing predation on least tern nests, however they did note some problems. 1) The fences only protected a fraction of the nesting terns, i.e., not all nest were located within a fenced area. 2) The least tern colonies shifted between years, sometimes leaving the fences unused. 3) Fences need to be checked daily to ensure that they are functioning properly. 4) Some predators can jump through or over the fences. 5) The fences do not protect chicks if

they leave the fenced area. 6) Avian predators are not hindered by the electric fences and may be attracted to the posts for perching.

Minsky (1980) reported success in the use of an electric fence, one-mile in circumference, for preventing red fox predation at Cape Cod National Seashore, Massachusetts. The fence consisted of 3 strands of wire 15, 30, and 45 cm (6, 12, and 18 inches) from the sand, connected to a 12-V battery-operated charger and an 8-ft copper ground rod. Minsky (1980) also noted high costs ($345.71 complete) and limited utility in areas of human congestion.

The use of chick shelters to prevent avian predation of least tern chicks on Nantucket Island, Massachusetts was studied by Jenks-Jay (1982). The chick shelters provided protection from both predators and shade. The shelters were constructed from wooden slats in a conical shape with space between the slates to allow access by chicks. They were placed throughout least tern colonies prior to hatching, no closer than 3 m (10 ft) from an active nest. The shelters were used by chicks most when temperatures were hottest. No avian predation was observed. The shelters also provided protection from dogs and humans.

D.3.2. Non Peer-Reviewed Literature

Similar to data found in the peer-reviewed literature (mainly from the Atlantic coast and Great Lakes regions), predator control measures were found to be effective in improving least tern and piping plover nest success and fledging rates in interior areas. These conclusions were found in several recent studies from the northern Great Plains including a 1995 North Dakota study (Smith and Heilhecker 1995); a 1997 North Dakota study (Danley and Smith 1997); a 1998 North Dakota study (Hoovestol 1998); and a 1999 summary report from Montana and North Dakota (USFWS 1999). In addition, Jenniges and Plettner (1999) reported on predator control techniques at sandpit habitat in the central Platte River.

Smith and Heilhecker (1995) reported on the use of fencing to control predators at Lostwood National Wildlife Refuge in North Dakota. Wire mesh galvanized fencing was used in areas where the waterline at a given beach is relatively static. Portable, mesh-electric fences were used on beaches with dynamic water levels. Where mesh-electric fences ended at the water edge, and a 3-strand, electric fence or 5-6 m (16 to 20 ft) of mesh-galvanized fencing (not electrified) extended into the water and curved back toward shore. In addition, circular fence exclosures were placed directly over most nests in conjunction with electric and galvanized mesh fencing. No cost information was provided, but these measures appeared to be effective at improving piping plover production (Smith and Heilhecker 1995).

Danley and Smith (1997) and Hoovestol (1998) also studied piping plover productivity at Lostwood National Wildlife Refuge in North Dakota. The fencing program described above by Smith and Heilhecker (1995), continued to be used by Danley and Smith (1997) and Hoovestol (1998). Danley and Smith (1997) and Hoovestol (1998) reported the same results as Smith and Heilhecker (1995); namely improved piping plover fledging rates with the combination of mesh-galvanized fences and cages.

In a 1999 summary report on piping plover conservation efforts at a “core area” of alkali lakes from central North Dakota to northeastern Montana, USFWS (1999) describes the use of

predator exclusion fences to reduce predation on piping plover eggs and chicks. The exclosures were wire mesh "cages" of various dimensions (5 x 5 cm [2 x 2 inches] or 5 x 10 cm [2 x 4 inches] mesh; 1 to 3 m [3 to 10 ft] diameter x 0.8 m [2.6 ft] high). These cages were placed over nests and secured with stakes. In areas where nesting pairs were concentrated on peninsulas, entire nesting beaches were protected by electric fencing. Nest success was 72 %, but did not appear to be significantly enhanced by predator exclosures. This is partly because adult plovers at 12 cages were depredated, and nearly all these nest subsequently failed. The addition of electric fences appeared to improve nest success (74 % cage/fence combination or 83 % fence only).

Jenniges and Plettner (1999) reported on predator control techniques at sandpit habitat in the Central Platte River. These techniques included electric fencing, removal of potential predator hiding places in the vicinity of nesting areas, strobe lights, snake fences, and traps and predator removal by U.S.D.A Animal Damage Control. They did not provide further detail on the implementation of the these methods, or costs, but they did report that these techniques, combined with vegetation control and limiting human access, resulted in increased nest success and fledging rates compared to sandpits with no management.

D.4. Flow Regulation

D.4.1. Peer-Reviewed Literature

Least terns and piping plovers nest on sandbars and beaches along rivers, lakes, and reservoirs (North 1986) and flooding can destroy nests during the nesting period (Cairns 1982, Sidle et al. 1992). On regulated systems, water releases may be managed to minimize flooding of nests. Prindiville Gaines and Ryan (1988) recommend drawing water levels down to maximize habitat during the nesting season. However, North (1986) highlighted the difficulties inherent in such management since nests may be found both above and below a dam. For example, a reduction in water outputs to prevent flooding of sandbars below a dam may result in destruction by flooding of nests along the shore of the reservoir or impoundment.

Sidle et al. (1992) studied the effects of flooding on least terns and piping plovers. They observed extensive mortality of both species caused by natural flooding on the Platte River in 1990. However, they also found that the floods scoured vegetation from sandbars, thus potentially creating suitable nest habitat for the least tern and piping plover, as well as for whooping crane roosting. They recommend management of water to maintain habitat but avoid flow regimes that cause frequent mortality.

Faanes (1983) noted that maintenance of water levels may limit predators and humans from accessing islands where the target species roost and nest.

D.4.2. Non Peer-Reviewed Literature

Lingle (1993a,b) observed least tern and piping plover nest success and flow relationships on the central Platte River. He found that in 5 of the 7 years from 1985 to 1991, failures in 37 % of the unsuccessful least tern and 61 % of the unsuccessful piping plover nests were due to flooding. Consequently, Lingle (1993b) makes the following recommendations: 1) Maintain adequate annual flows in the Platte to provide secure nest sites. A summer flow (June through August) of 30 cms (1,000 cfs) as measured at Grand Island would be adequate and flows should not drop below 12 cms (400 cfs) at any time during the year. 2) NGPC should continue

to attempt to secure an instream flow right. 3) Implement a plan whereby Central curtails releases to the river via J-2 Return during local thundershowers to minimize the potential for flooding nests and young.

D.5. Minimization of Human Disturbance

Human disturbance has been shown to decrease reproductive success of least tern and piping plover nests, and reduce the amount of time they spend foraging (Burger 1994, Melvin et al. 1994, Powell and Cuthbert 1992, Smith and Renken 1993).

D.5.1. Peer-Reviewed Literature

Melvin et al. (1991) studied piping plover mortalities caused by off-road vehicles (ORV) on Atlantic coast beaches. They found that ORV use is a threat to unfledged piping plover chicks and adults during brood-rearing periods. Therefore, they recommend banning recreational vehicles and all but essential service vehicles on sections of beaches where unfledged piping plover chicks are present. Closure should begin at least one day before hatching. They also recommend monitoring to help determine which beach areas should remain closed and if alternative access points or travel corridors may be used to route vehicles away from broods. Beaches should remain closed until all chicks are able to fly. Melvin et al. (1991) do not specify how far away vehicles should be kept from brood-rearing area, nor do they provide costs on such management practices.

Human activity can be limited through use of visual fencing (signs and painted wooden lathes with baling twine strung between) (Kirsch 1996). Kirsch (1996) notes that such measures are usually effective in deterring human intrusion. Signs should be placed at least 100 m (328 ft) from the closest nest, if possible. Signs should be put up before the birds arrive at known nesting locations, however Kirsch (1996) acknowledges a risk of having the birds colonize outside the posted area or not return to the known site. Such posting occasionally attracts attention and vandalism, however, if colonies are posted with signs informing people that the birds are protected under the Endangered Species Act, vandals and intruders can be more easily prosecuted Kirsch (1996).

Burger (1994) studied the effect of human disturbance on foraging behavior and habitat use by piping plovers in New Jersey. She examined three colony sites; each contained three habitat types, beach, dune, and backbay. Human use within 100 m (328 ft) of the observed plovers was significant at two of the three sites, and generally consisted of walking, fishing, sunbathing, or jogging. At the two sites with human use, plovers spent more time feeding in the habitats with fewer people. At the site where no people were present, plovers spent similar amounts of time feeding in each habitat, and overall more time feeding. Burger suggests that piping plovers on the Atlantic coast have adapted to the coastal environmental and space competition with people by diversifying their habitat use. Preserving diverse habitats, where available, helps to minimize human disturbance to foraging piping plovers (Burger 1994).

Smith and Renken (1993) examined reproductive success of least terns in the Mississippi River valley and found that human disturbance (specifically all-terrain vehicle [ATV] use) was a hazard to nesting terns. ATV's gained access to islands when river levels were low and islands accreted to the shore. In 1988, ATV's passed through or near 25 nests, 18 of which failed. ATV users also killed two chicks that had recently hatched in a nest. Based on this data, Smith

and Renken (1993) recommended that least tern colony islands be posted as seasonal refuges. They note that in Missouri, the combination of posting seasonal refuges and a public information campaign reduced human disturbance to nesting terns.

D.5.2. Non Peer-Reviewed Literature
Cooper and Fries (1993) documented the use of "river patrols" by law enforcement officials on the Missouri and Platte Rivers on busy holiday weekends. Contacts with river and sandbar users stressed awareness and education. These efforts were coupled with an intensive public awareness campaign.

E. CROPLAND

E.1. Peer-Reviewed Literature

Shields and Benham (1969) experimented with providing farm crops as a supplemental food source at whooping crane wintering grounds in Aransas National Wildlife Refuge, Texas. A 97-acre field was developed in an upland area near the center of several crane territories. A chain link fence of 5 cm (2 inch) mesh with 2.4 m (8 ft) of fabric above ground and 0.3 m (1 ft) below ground was constructed to keep mammals (white tailed deer, javalina, raccoons, feral hogs, and cattle) out of the fields. An electric fence was installed to repel climbing mammals. Corners were rounded to assist cranes in escaping in the event a bobcat or other predator should gain entrance. The field was cleared of live oak by bulldozing and burning. Heavy fertilization was needed. The field was strip-disked with 12-ft lanes of Bermuda grass left undisturbed between 24-ft lanes of tilled land. Planting occurred in December. Row crops were not feasible because of live oak roots, however the following species were planted using a grain drill: beets, kohlrabi, hegari (grain sorghums), corn, and wheat. Geese and sandhill cranes began feeding on the fields in October, whooping cranes were noted starting in November. Shields and Benham (1969) report that of the crops planted, only grain sorghums and wheat warranted future use. They also report that most whooping cranes whose territories were within 4.8 km (3 miles) of the field were believed to have used it until the supply was exhausted.

Shields and Benham (1969) report that the second year of the study, a second field was completed, similar in design and size to the first. Crops planted in Field 1 in mid-August and early September included peanuts, chufa, three varieties of grain sorghums, field peas, and sweet potatoes. Field 2 crops included two varieties of field peas, annual rye grass, wheat, and clover. Scare guns were used to discourage sandhill cranes and other waterfowl until whooping cranes arrived. Fall use of the fields by whooping cranes was virtually non-existent. Ample marine fauna may have encouraged feeding along tidal flats. Non-use of the fields suggested a preference for crustaceans and other marine life over crops (Shields and Benham 1969).

In subsequent years, crops were again planted in the fields and wheat and milo were spread after the crops had been consumed. The artificial feeding resulted in increased use by whooping cranes. Artificial feeding concentrated whooping cranes more than the provision of planted crops, and was discontinued because of the possibility of disease outbreak. Shields and Benham (1969) suggest the use of supplemental feeding only during times of food scarcity. They did not provide information on costs of the supplemental feeding programs. They found

that sandhill cranes and geese consumed a considerable portion of food intended for whooping cranes.

Kauffeld (1981) described management of habitat for migrating sandhill and whopping crane use at two wildlife refuges in San Luis Valley, Colorado. Management practices included planting cropland each year to provide feed for cranes. Crops were rotated every year because soils at the refuges are marginal in productivity. Crops included barley, wheat, field peas, and potatoes; sweet clover, volunteer barley, wild oats, and other plants were allowed to grow in idle fields and then plowed under to provide organic matter. Fields were deep chiseled every 3 years to break up the hardpan and provide cranes access to grubs and other insects for short periods after chiseling. Kauffeld (1981) reported that cranes seem to prefer wheat over barley. Most of the crops were left standing in the fall and then mowed during February to provide spring feed. In the fall, most private cropland surrounding the refuges has been harvested by the time cranes arrive and cranes feed on these stubble fields. Kauffeld (19981) reports that fall feeding activity caused little conflict with the private land owners. If necessary, crops would be harvested to provide emergency feed.

E.2. Non Peer-Reviewed Literature

The USFWS (1981) notes that 91 of 119 (76%) confirmed feeding sites of migrating whooping cranes along their entire migratory route were in agricultural lands of some type (e.g., milo, barley, corn). Krapu and Brandt (1999) studied the availability of waste corn on cropland in the central Platte River valley for migrating sandhill cranes. They found a sharp decline in waste corn available to cranes over the past 20 years, despite that the area of corn harvested has expanded over the past 20 years. The decline is due primarily to increasing efficiency of the corn harvest. Other factors include increased foraging by geese and cattle consumption. In addition, they found that more waste corn is available during the fall migration than during the spring migration. Krapu and Brandt (1999) suggest a long-term broad-based strategy to minimize impacts to sandhill crane populations that may result from declining waste corn availability. For example, they suggest keeping sandhill cranes as dispersed as possible by restoring degraded river channels for roosting habitat and managing flows to provide optimal roosting conditions. Other suggestions include seeking ways to discourage high use by geese in early spring if competition from geese continues to increase, and growing corn specifically to supplement waste corn stocks but in ways that would not lead to crowding and diminished access for cranes. Krapu and Brandt (1999) note that whooping cranes also feed on waste corn, agricultural crops, and a variety of animal foods during migration, and thus can be expected to benefit nutritionally from steps taken to enhance foraging conditions for sandhill cranes.

F. MANAGEMENT METHODS NOT SPECIFIC TO A CERTAIN HABITAT

Several authors reported on crane collisions with utility lines and fences. Johnson (1981) noted that upland grassland management for whooping cranes should include removal or relocation of telephone lines, power lines, and fences from the vicinity of feeding areas and between feeding and roosting areas to minimize the potential for collisions. Lingle, (1985) suggested marking utility lines adjacent to key habitat with highly visible plastic balls or strips. Kauffeld (1981) reported on whooping crane mortality caused by collisions with powerlines and fences at two wildlife refuges in Colorado. He noted that most mortality occurred during foggy mornings or periods of high

winds. Kauffeld (1981) recommended aerial obstructions should be minimized to the maximum extent practical. In a Nebraska study, Morkill and Anderson (1991) and Morkill (1990) found that powerlines marked with 30-cm diameter yellow balls significantly affect flight behavior of sandhill cranes, such that they avoided marked wires. They expect whooping cranes to react similarly to marked powerlines. Morkill reported that sandhill crane mortality from collisions with powerlines was significantly reduced at marked segments. In a similar study in Colorado, Brown and Drewien (1995) evaluated two power line markers (yellow spiral vibration dampers and yellow fiberglass swinging plates) for reducing crane and waterfowl mortality. Both marker types reduced mortality. Birds reacted to marked lines at greater distances and increased their altitude as compared to unmarked lines.

As part of a *Contingency Plan for Federal-State Cooperative Protection of Whooping Cranes*, a public education element was included to minimize human impacts to migrating whooping cranes (Lewis 1988). These efforts were aimed at educating the public through television, radio, magazines, newspapers, signs, pamphlets, and audio and visual public service announcement on identifying whooping cranes and distinguishing them from similar species. The purpose was to encourage reporting of sighting during migration and diminish the likelihood that sportsmen might misidentify and shoot a whooping crane. Because this information was reported as part of a plan, no information was given on whether it was successful.

V. TECHNICAL MEETING DISCUSSION

The Technical Meeting held February 16-17 was the third piece of a three-pronged approach (survey, literature review, and technical meeting) being used by the Habitat Criteria Subcommittee to address milestone L2-1. The meeting brought together representatives of area landowners, Natural Resource Districts, USFWS, NGPC, power and irrigation districts, species/habitat experts, and members of the subcommittee (Appendix III) to discuss the Survey Results and Literature Review portions of this document. Meeting participants generally discussed each topic, as well as identified missed information, identified fatal flaws in any of the management techniques, and determined possible permitting requirements for the various management practices. When appropriate and possible *Sections III and IV* were augmented after the meeting to include the "missed information". The goal of the meeting was to recommend best management practices for the various habitat types that could be used when habitat managers are developing habitat management plans during the Program. During the meeting no fatal flaws were identified for the various habitat management techniques (i.e., no management techniques were eliminated), however several techniques and ideas were identified as having minimal application. This section is used as a record of the discussions at the Technical Meeting. The recommended best management practices resulting from the meeting are summarized in *Section VI. Recommended Best Management Practices*.

A. RESTORATION AND CREATION OF BOTTOMLAND GRASSLANDS

Meeting participants discussed at length various aspects of restoring and/or creating bottomland grasslands. Note, for this document, bottomland grasslands are defined as grasslands with areas of emergent vegetation or open water within them. These areas of emergent vegetation or open water are often in linear swales and depressions. Most of the discussion related to bottomland grasslands

centered on various techniques missed in *Sections III and IV* (discussion summarized below). Topics not directly related to missed information included time needed to recognize the benefits of restored/created grasslands and seeding densities. Meeting participants noted that many creation/restoration techniques require significant time before bottomland grassland characteristics are realized (e.g., 5-20 years) and that this needs to be a consideration when developing management plans and lease/easement options. Most restoration/creation efforts in the central Platte region now use high density seeding (50-250 different species); however, there may be places that low density seeding (4-6 common species) is needed to augment the natural seed bank or for buffer areas. These topics along with other best management practices discussed during the meeting are included in *Section VI. Recommended Best Management Practices*.

A.1. Missed Information

A.1.1. Bank Armoring

Jim Lewis brought forward the idea of bank armoring to protect bottomland grasslands located adjacent to the Platte River from erosion. It was pointed out that armoring of banks to protect whooping crane habitat from erosion has been done at Aransas National Wildlife Refuge. Bank armoring on the Platte River may be an option in limited instances to protect vitally important bottomland grasslands if the river changes course and threatens the grassland. Paul Kinzel noted that it would be technologically possible to armor sections of banks along the Platte River. It was noted that allowing the river to meander within its banks and create new channels was the intent of many of the proposed management activities (e.g., tree clearing to create open channels and free sediment). Participants discussed concerns related to the many river stabilization structures currently in place along the central Platte River and the impacts that these structures are having on the river's ecology. Meeting participants agreed that bank armoring has many logistical and ecological problems associated with it, but agreed to include bank armoring as a management possibility with the understanding that it has very limited application.

A.1.2. Bottomland Grasslands as Roosting Habitat

The topic of creating/restoring bottomland grasslands so they can function as whooping crane roosting habitat as well as loafing and foraging habitat was discussed. It was noted that to accomplish this there would need to be significant water management in the bottomland grassland and that this would add further cost. As an example of using water management for whooping crane roosting habitat, Jim Lewis briefly described the operations at Bosque del Apache, New Mexico. Gary Krapu noted that management of bottomland grasslands should focus on providing foraging and loafing habitat because the river can provide roosting habitat. Dr. Krapu also noted that if bottomland grasslands are managed to provide roosting, loafing, and foraging habitat that careful consideration should be given to timing and water levels so that macro-invertebrates used as a food source by whooping cranes were not reduced. Further research may be needed to determine exactly when and to what extent these areas could be flooded. Further research is also needed to investigate the exact foraging requirements of whooping cranes to understand if foraging habitat is limiting.

Other points discussed included 1) the differences in topography and shape of depressions if the desire is to create roosting habitat verses loafing/foraging habitat; 2) concern that moist soil management could lead to mono-cultured stands of vegetation; 3) use of water for wetlands verses croplands in dry years; and 4) the effects on target flows from pumping water to fill

larger wetlands. Further understanding of the effects of creating roosting habitat as a component of bottomland grassland on the groundwater will be gained through the current Cooperative Hydrologic Study (COHYST). If groundwater or surface water is used to create larger wetlands, third party impacts will need to be considered. The point was also made that the proposed Program may not be able to restore/create in-channel roosting habitat in all reaches of the river and in these instances including roosting habitat along with loafing and foraging habitat in created/restored bottomland grasslands may be important.

Participants agreed that roosting habitat should be considered when developing bottomland grasslands, however roosting habitat should only be created in such a way that foraging and loafing habitat characteristics of the bottomland grassland are not compromised.

A.1.3. Negative Impacts from Tree Clearing and Methods to Minimize Impacts
Carter Johnson noted that *Sections III and IV* do not fully discuss the impacts of tree clearing and possible methods to minimize the impacts. Possible negative consequences discussed by Dr. Johnson and others included reduction of biodiversity (scale dependant), proliferation of invasive plants, increased sediment in the river leading to possible narrowing of the channel downstream, and third party impacts. It was noted that in some instances increased erosion and sedimentation in the river were a desired result of tree and vegetation clearing. Several meeting participants felt that before clearing trees for bottomland grassland creation/restoration, the proposed Program's land manager should consider all possible negative and positive impacts. It was also noted that recent work conducted by Amy Richert, UNL, indicates that whooping cranes may be more tolerant of trees than previously thought and that this should be considered before clearings proceed.

The group discussed possible methods to minimize disturbance to cleared areas. One of the methods discussed was to kill the trees slower through use of chemicals, burning, girdling, or other methods. Another method suggested was to fell the trees with chainsaws but to not immediately remove the trees. These techniques would allow the grassland to develop before the trees were removed. Dead trees would need to be removed through burning, mechanical means, or some combination. Another method discussed was to consider the time of year for tree removal. Removal of trees during the winter when the ground is frozen may result in less disturbance to the soil and thus possibly less erosion and invasion of exotic species.

The question was raised as to whether clearing of one type of tree is better than another type for bottomland grassland creation/restoration in regards to the impacts on the biology and ecology of the area (e.g., clearing cedars verses cottonwoods). Carter Johnson responded that cottonwoods appear to be more valuable as habitat for birds than cedars or Russian olives but was unsure for mammals, invertebrates, reptiles, etc. It was pointed out that Amy Richert's recent research has indicated whooping cranes may be more tolerant of trees in general and that more research may be needed in this area.

Another topic discussed related to clearing of cottonwood forest to *create* bottomland grassland verses clearing of Russian olive and cedar trees to *restore* bottomland grassland. The point was made that both types of activities have been used but that clearing of Russian olive and cedar trees was generally less expensive may result in a "functioning" bottomland grasslands quicker. For example, the Trust has cleared a large area of cottonwoods and

through intensive management the area has many of the characteristics of a bottomland grassland, however, it has taken approximately 10 years. As another example, the USFWS cleared a large area of cedar trees and with little further management the area was restored to open bottomland grassland relatively quickly. It was also noted that creation of bottomland grasslands on the accretion ground might be exceedingly difficult because of the potential incompatibility of accretion ground soil types compared to bottomland grassland soil types. Carter Johnson also noted that since cottonwood and willow germinate on areas free of vegetation, areas cleared near the river that may periodically be inundated by flows could result in new growth of cottonwoods and willows. If higher areas are cleared and grasses are allowed to grow, regrowth of trees would not be as likely.

Participants agreed that restoration of bottomland grassland through Russian olive and cedar tree removal and creation of bottomland grassland through cottonwood and willow tree removal were both options for the proposed Program. Because of cost and time considerations and impacts to the biology and ecology of the area, restoration efforts through cedar and Russian olive removal may be more effective.

A.1.4. Consideration of Soil Types

The point was made that *Sections III and IV* do not currently consider soil types when restoring bottomland grasslands in cropland areas. Many of the current efforts attempt to restore bottomland grasslands in areas that do not contain hydric soils. If hydric soils are not present, possibly through past ditching and leveling, soils should be removed from the old swales when possible. In one instance TNC was able to use old aerial photographs to aid in removing soil along the original drainages.

A.1.5. Alteration of Drainage Ditches

It was noted that the possibility of blocking, filling, or raising the water level in drainage ditches for the restoration of bottomland grasslands was not in *Section III or IV*. In *Section III.A.2.3. Hydrologic Enhancements* the option of pumping or siphoning water from these ditches is addressed. There were significant concerns regarding third party impacts from blocking or filling groundwater drainage ditches if it resulted in water being drained slower or raising groundwater levels on neighboring property. The group agreed that there may be a very limited opportunity to conduct these activities (e.g., most upstream or downstream property on the ditch) and third party impacts should be the first consideration.

Several land managing entities in the central Platte region have reconstructed ditches in their bottomland grassland areas to be more sinuous. This results in a net gain in the total length of the ditch or swale on their property without building any structures and not slowing water leaving neighboring property.

A.1.6. Reclamation of Sandpits

Neither *Section III nor IV* discusses the possibility of reclaiming sandpits for the creation/restoration of bottomland grasslands. It was pointed out that this would have minimal applicability because of the large amount of fill needed, but that restoring these areas to a shallow wetland instead of a deeper pond may be possible. If restoring to either a bottomland grassland or wetland having an available source of topsoil is desirable. Caution was given to

weigh restoration of these areas for bottomland grasslands against the possible benefits for tern and plover reproductive habitat.

B. MANAGEMENT OF EXISTING/ESTABLISHED BOTTOMLAND GRASSLANDS

The majority of the discussion regarding management of existing and established bottomland grasslands centered on best management practices suggestions. Meeting participants discussed the need to keep timing of management activities (e.g., burning, grazing) open and flexible, because with a flexible management scheme land managers will be better able to maintain and promote species diversity and minimize encroachment of invasive species. Several examples were given for varying the management. One example was to graze or hay early in some years to promote warm season species and minimize cool season species. Another example of varied management regarding burning was to burn some areas in May to help keep cool season grasses in check, burn some areas in March to attract whooping cranes, and burn some areas in the fall to control woody vegetation. It was suggested that the best management practices section needs to include a range of alternatives and provide guidance when each management options should be used. Gary Krapu mentioned that one of the deciding factors in management should be to maximize the habitat for whooping crane food production. More research may be warranted to look at the varying effects of the different management practices on such things as invertebrate assemblages.

Other topics discussed included the use of chemicals, biological control, and the cost effectiveness of various management techniques. Meeting participants agreed that chemicals are useful in controlling various species of weeds and grasses and that their use should take into consideration size of area to be controlled, species, and time of year. Biological agents were also identified as a means to control various weed species (e.g., musk thistle, leafy spurge). Meeting participants discussed the cost effectiveness of haying, grazing, burning, chemical use, and biological controls and agreed that cost should be a consideration when designing management plans. The example was given that haying requires less infrastructure than grazing (e.g., fences, stock tanks) and may result in more income. Concern was raised that hay produced on Program lands could compete with hay produced by private landowners. See *Section V. Best Management Practices Recommendations* for a more complete discussion of best management practices.

B.1. Missed Information

Meeting participants identified two potential management options that were not included in *Sections III or IV*. These options were mowing to create open habitat for whooping cranes and the use of biological agents to control weed species.

B.1.1. Mowing

Mowing was identified as a possible management option for grasslands. The point was made that mowing has been used in other areas to provide a landing area for cranes near turbid water. Before mowing, cranes appeared to be reluctant to use the area because they would not land in the turbid water and the adjacent grasslands contained tall vegetation. The tall vegetation was mowed and cranes started landing on the grassland and walking into the water to roost/loaf. Mowing in the central Platte region may have limited utility, but it will be included as a management option.

B.1.2. Biological Control for Weeds

The use of biological agents to control weeds was not discussed in *Section III and IV*. Meeting participants noted that biological control methods have been developed for use on leafy spurge, musk thistle, and possibly other potentially invasive plant species. Meeting participants realized that biological agents do not completely eliminate the plants from an area but only reduce the numbers. Meeting participants also noted that the use of biological agents would not result in short term results, but could be used if the objective was long-term control. Local weed control agents and neighbors may not accept biological agents as sufficient means to control weeds.

C. RESTORATION, CREATION, AND MANAGEMENT OF UPLAND GRASSLANDS

Meeting participants noted that the term "upland grassland" is not well defined in the literature and has been used inconsistently. For this document, upland grasslands have been defined as dry areas mostly free of woody vegetation. The group agreed that the Program would likely manage some upland grassland habitat. Jim Lewis and others noted that upland grasslands are used by cranes and appear to be important more for family groups than non-breeding individuals. It was also noted that sandhill cranes in the central Platte region utilize upland grasslands with tall vegetation during harsh weather.

Meeting participants discussed the creation/restoration of upland grassland habitat from cropland. Some members of the group questioned whether or not conversion of cropland to upland grassland was a wise habitat management practice. It was noted that costs to the Program would be lower to leave as cropland and rent the acreage to area farmers. It was also noted that cranes could utilize cropland as well as upland grassland areas. The point was made that if the protected area contained a wetland, upland grassland habitat may be useful as buffer. If croplands are converted to upland grassland the group felt that high density seeding should be done. Caution was given that fences installed around grasslands for grazing purposes can potentially result in collision problems for both whooping and sandhill cranes.

The removal of cedars and Russian olive trees for the restoration/creation of upland grassland was discussed. Meeting participants noted that skid-loaders and tree-shears effectively remove either species with little disturbance to the soils and that fire can be effective for removal of cedars. Fires may not be as effective in older or denser stands of trees. One participant noted that he had had success killing cedar trees with chemicals. Dead trees would have to be removed through repeated burnings or mechanical means.

C.1. Missed Information

C.1.1. Trees as a Buffer

It was noted that it might be beneficial to leave some trees near powerlines and fences to act as a natural buffer. The trees may aid in keeping cranes away from these structures and lessen the chances for collisions.

D. CROPLAND

Meeting participants discussed crop rotation, ideas for "sharecropping", chemical use, tillage practices, and other cropland management ideas. Gary Krapu indicated that corn availability is becoming a concern and that it would be best to maintain widely distributed food sources. The group felt that a rotation of corn and alfalfa on Program cropland would be the most useful for cranes and most acceptable rotation for area farms. Where possible, sorghum could be a consideration in the crop rotation. As a means to provide corn for cranes and other waterfowl the group discussed different types of sharecropping. Possibilities include farmers leaving a portion of the corn crop standing (which could be knocked over during crane migration) or allowing some corn to pass through the combine as a lease condition. The group also discussed the potential benefits of reducing grazing of corn stocks in the fall to allow for more waste corn to be available to migrating cranes.

Meeting participants agreed that chemical use was needed but use should be minimized. Meeting participants also agreed that management plans for cropland should include the use of soil and water testing by an agronomist as part of precision agriculture techniques in a lease. The group discussed the benefits of not conducting fall tillage and agreed that fall tillage should be discouraged on Program lands. This would benefit cranes through food availability and would also conserve water. Another idea discussed was recommending ridge-tilling or no-tilling practices to minimize chemical use and to alleviate the need for fall tillage.

D.1. Missed Information

Meeting participants did not identify any missed management practices for croplands in *Sections III and IV*.

E. RIPARIAN FOREST CLEARING FOR OPEN RIVER CHANNEL HABITAT

Meeting participants discussed the various methods used to clear riparian forest when creating or restoring open river channel habitat for whooping cranes. It was noted that many of the same issues and caveats discussed in *Section V.A.3. Negative Impacts from Tree Clearing and Methods to Minimize Impacts*, applied to this discussion (e.g., biodiversity concerns, possible third party impacts, consider limiting soil disturbance). One of the topics discussed was that shredding/mowing and/or discing can be used and is used to open vistas along the river, but that frequent maintenance (i.e., every 1-3 years) is needed to keep the areas cleared or in a low vegetative state. It was pointed out that whooping cranes and sandhill cranes have used cleared areas and monitoring is continuing to evaluate the use. One area of concern that was raised was whether clearing open river channel habitat should continue if "normal" flows can not maintain cleared areas. Another area of concern was that the monitoring of sandhill and whooping crane use that indicates they prefer wide, open channels only occurs when weather conditions are favorable. During harsh weather cranes be require the narrower, more protected areas to survive.

The group discussed the time necessary to offset the costs with the benefits associated with channel clearing activities. It was noted that when using heavy equipment, costs can be as much as $1,000/acre but that open channel habitat is created immediately. The USFWS currently conducts these sort of clearing projects under 10-year partnerships with landowners. Other methods, such as chemicals, may a less expensive means to kill the trees, but it may take longer and other efforts will be needed to clear the dead standing timber. The group realized that many landowners might find short-term leases more attractive when starting relations with the Program and that these

short-term leases could turn into long-term arrangements. Shorter-term leases will likely be more attractive in areas that require no to little restoration. The Program will need to consider the cost-benefit relationship associated with restoration when determining the lease options and management plans.

Meeting participants discussed the possibility of using commercial sawmill operators to remove larger trees. It was noted that past experience has shown this to difficult due to time, problems with "slash" and the difficulty in removing stumps as compared to the entire tree. The current methods employed on the central Platte are to pile the trees, burn, and bury any remains. The group agreed this would be the primary method for consideration by the Program but that other methods, such as use of closely supervised sawmills, could be used.

E.1. Missed Information

E.1.1. Discing

It was noted that neither *Section III* nor *Section IV* discussed discing by itself as a means to clear riparian areas. Nebraska Game and Parks Commission has used this technique in the past and has found that approximately four passes of a disc are needed to fully incorporate the grasses and smaller brush into the soil. This technique is not possible in areas with larger or dense woody vegetation and seems to work better on lower islands compared to higher islands. One important aspect of this method is that it loosens the soil and allows easier erosion of islands, which can be one of the primary objectives of forest clearing. Caution was given that possible third party impacts should be considered when clearing areas to liberate sediment if the sediment causes river narrowing downstream.

E.1.2. Use of Flows

Meeting participants noted that the use of flows to clear, or maintain, open channel habitat was not fully discussed in *Sections III or IV*. Some literature is available that discusses the flows necessary to fill the channel and inundate the bare sand, effectively eliminating the substrate needed for cottonwood and willow germination. Carter Johnson noted that he would provide these references for inclusion in the document. Flows of approximately 3,200 cfs can prohibit most seedling germination by nearly filling the active channel and higher flows may remove some seedlings. It was pointed out that to clear higher islands using flows, over island flooding would be required and that the Cooperative Agreement and proposed Program can not contribute to flows that flood outside the banks (e.g., flows of approximately 16,000 cfs may be needed to move islands and flows of 6,000-8,000 are considered flood stage at Kearney).

It was noted that the Program envisions creating and maintaining wide, open, shallow channels. To accomplish this, it was suggested that one option was to lower the flows during certain times of the year. It was pointed out that while this may work for isolated cases, the overall effect on the river would not be desirable (e.g., bare sand would be quickly colonized by cottonwood and willow seedlings).

E.1.3. Drowning

One meeting participant noted a fairly sizeable tract of riparian forest had been drowned after beavers had dammed a drainage ditch. The drowned trees had lost most of their branches but many were still standing. Participants agreed that drowning might be used in very limited areas to kill trees, but other methods would be needed to remove standing trunks.

F. MAINTENANCE OF OPEN RIVER CHANNEL HABITAT

Meeting participants noted that the methods used to maintain open river channel habitat are very similar to many methods used to create open river channel habitat (e.g., shredding, mowing, discing). One participant suggested establishing grass and wild flowers through seeding on the more permanent islands. If this is done, the less expensive option of periodic burning could be used to maintain the area free of woody vegetation as opposed to the more expensive mechanical means. All methods will be considered for maintaining open river channel habitat during the Program. Meeting participants noted that regardless of maintenance method, problems with purple loosestrife were likely (see *Section V.F.1.1. Purple Loosestrife Control*)

F.1. Missed Information

F.1.1. Purple Loosestrife Control

There was significant discussion regarding the need to control and methods used to control purple loosestrife. Purple loosestrife is currently being considered for formal listing in Nebraska as a noxious weed. Some meeting participants questioned whether or not purple loosestrife needed to be controlled in any different manner than willow and cottonwood growth. Other participants responded that loosestrife was different in that 1) it forms monotypic stands, which effects the ecology and biodiversity of a system; 2) impacts on the river for target species are unknown; and 3) conventional mowing/shredding/discing can cause the plant to spread through vegetative reproductions, leading to further problems downstream (i.e., resulting in third party impacts). The point was also made that large stands of purple loosestrife can develop quickly, possibly causing bank stabilization and channel narrowing.

To control purple loosestrife, meeting participants discussed mowing, shredding, discing, chemical use, water levels, minimization of soil disturbance, and biological agents. As noted above, mowing/shredding/discing can cause loosestrife to spread through vegetative reproduction, but meeting participants did say that these methods are effective at removing the existing stand. The herbicide Rodeo was identified as being useful on purple loosestrife; however, Rodeo will also kill all other vegetation and this may not be desirable for the Program. Loosestrife will also quickly recolonize an area after it has been chemically treated. Chemicals may be useful on a limited basis to control isolated stands of loosestrife. Some meeting participants suggested flow management might be used to control loosestrife. In years with high water levels, several participants noticed less loosestrife in areas typically covered; however, this will likely only move the sites suitable for germination to higher areas of the river. Biological agents were suggested by many meeting participants as the preferred method of long-term control for purple loosestrife. Biological agents will not result in immediate affects, but over the course of 20-30 years may control, not eliminate, loosestrife.

The group agreed that more emphasis was needed in *Section III. Literature Review* regarding what is currently known and used for controlling purple loosestrife. Several participants recommended sources of information specifically for Nebraska and the central Platte region. Most research has focused on controlling loosestrife and not on the ecology of the species. Meeting participants suggested that a best management practices document be developed for controlling purple loosestrife on Program lands. Control of loosestrife will be important in maintaining positive relations with neighboring landowners.

G. CREATION/RESTORATION OF LEAST TERN AND PIPING PLOVER HABITAT

One opinion voiced at the beginning of the discussion was that past efforts to create or restore least tern and piping plover habitat have not worked. Some meeting participants questioned the need to continue the restoration/creation efforts based on the past. Several participants noted that the Cooperative Agreement and proposed Program participants have agreed to create/restore least tern and piping plover reproductive habitat during the Program. Some of the group noted that the recommended best management practice should note the concerns and limitations in creating and maintaining tern and plover habitat, but they should also be flexible enough to allow managers to make decisions based on each specific site and try different techniques.

The group discussed what constitutes suitable least tern and piping plover reproductive habitat. Casey Kruse responded that the area needs to be in-channel or along a sandpit, lake or reservoir, unvegetated, close to foraging habitat, and secure from high predation rates. Dr. Kruse also noted that on the Missouri River a ratio of 2:1 wet sand to dry sand seem to provide the best foraging habitat for piping plovers and if good foraging is available chicks fledge sooner. Others responded that groups currently involved in habitat creation, some as directed by their FERC license, have been using information from the Platte River Joint Study and Ziewitz et al. 1992. These document say that one acre needs to be at least 5.8 feet above the river bed and two acres need to be 3.5 feet above the river bed. These efforts have been costly, see discussion under Section III, and islands have been eroded by high flows over the years.

Dr. Kruse suggested less emphasis should be given to a few permanent islands and more emphasis should be given to several lower islands that would be topped with water on a periodic basis (see *Section V.G.1.1 Habitat Complexes and Use of Flows*). If this is done it is likely nests would be lost to flooding during high water years. Both species appear to have evolved with this environmental constraint. In a "good year" both species can produce relatively large numbers of fledged young. These good years carry the population through "bad years" (e.g., when all or most nests flood) when there is minimal fledging success. To measure the relative success of these species it may be better to look at fledging rates and population size over a longer time period and not on an annual basis.

Several meeting participants noted the different degrees of site fidelity in terns and plover. In general terns and plovers seem to move over a larger system, at a minimum up and down the Platte River but also between drainages and states. However, some birds have been observed returning to the same site on an annual basis.

Carter Johnson noted that many of the management techniques discussed in this document focus on removing vegetation and flattening and widening channels. This will effectively create a "smooth" river channel. Dr. Johnson cautioned that this smoothing might be working against creating high islands. Some evidence indicated that higher islands are created when the channel is "rough" (e.g., existing low islands contain some vegetation, irregularities in channel bed). Meeting participants noted that high flows could create higher islands in association with such things as river bends and logs. Another point made was that the "ramping" of flows up to and after the peak flow was important to island formation. The group agreed that more input is needed from geomorphologists.

G.1. Missed Information

G.1.1. Habitat Complexes and Use of Flows

Casey Kruse discussed the information that he and others are gathering from monitoring and research efforts on the Missouri River. Dr. Kruse noted that until the mid-1990's the Missouri River was similar to the current situation of the central Platte in that there were permanent managed sites for terns and plovers. These permanent sites developed predator problems similar to what is seen in the central Platte River. During periods of high water from 1995-1997 many complexes of lower, less permanent islands and sandbars were created. In 1998, the system had record production with little predation problems. Since 1998 the habitat complexes have been disappearing and the river is returning to the more permanent islands that will likely require more aggressive management. Dr. Kruse noted that least terns and piping plovers likely evolved with a very ephemeral system and it might be difficult for them to adapt to the more permanent sites. Also, the larger sandbar/island complexes that are ephemeral in nature seem to decrease the predation rate when compared to permanently managed sites.

Dr. Kruse and others suggested the need to consider managing reaches of the central Platte River instead of permanent sites. Possible ways to achieve this that were suggested included 1) opportunistically using a combination of sediment and flow management to maximize island complex formation in years when natural high flows permit and 2) have "rolling habitat" in which several islands in a reach of river are created/restored for terns and plovers, but only one or two are cleared of vegetation in any given year. Dr. Kruse noted that it might be necessary to allow islands to be topped during nesting some years to promote island building process. If this happens, an annual 'yardstick' for measuring tern and plover success would not be appropriate. Dr. Kruse and several other participants cautioned that the Program might not have the flow capacity to use flooding to create tern and plover habitat. Others cautioned that the Program can not cause out of bank flooding, and this is likely what would be required to create the larger habitat complexes. Because the Program can not cause flooding, the group discussed other possible methods to use flows more effectively in creating and managing tern and plover habitat. Suggestions included using smaller flows to make islands just a little higher, using artificial ridges in the river to create sandbars, using other items such as logs to create sandbars in specific locations, and using flows during different times of the year (e.g., winter) to more effectively use the limited water. Further discussions with geomorphologists may be warranted to determine what can be accomplished in the central Platte given the limited amount of water and concerns regarding flooding.

Several meeting participants noted that nests on permanent islands appear to experience higher predation rates than nests on new sites. A meeting participant asked if there is a correlation between proximity to vegetation and predation rates. Dr. Kruse responded that he has not observed such a correlation. The primary influence on predation rates appears to be the amount of habitat in complexes, with large amounts of habitat predators seem to be less effective.

H. MAINTENANCE OF LEAST TERN AND PIPING PLOVER HABITAT

The group discussed the different factors that can result in adult/chick mortality or nest loss. These factors are predation, flooding, human disturbance, and weather. The group agreed that the

Program can not impact weather related problems, but may be able to influence the other factors. For example, to reduce human disturbance the Program could sign nesting areas to alert people of the nesting birds. There are also active (lethal) and passive (non-lethal) methods the Program could employ to reduce predator impacts. The Environmental Account may be used to try and minimize impacts of nest flooding by keeping lower sandbars covered with water when the birds arrive and begin nesting.

Meeting participants discussed concerns regarding predation and methods to reduce predation. Both lethal and non-lethal methods have been used in the central Platte River in the past. There was not agreement that the Program should or should not use predator control. Some factors the Program managers will need to consider are what measures the USFWS will be evaluating success of the Program by, costs, and general acceptability. The point was again made that lower predation rates are observed when large ephemeral habitat complexes are available compared to individual permanent sites.

H.1. Missed Information

H.1.1. Predator Exclosures

Casey Kruse cautioned that in some areas of the country predators are keying in on exclosures and learning to capture the adult birds as they flush. Dr. Kruse expected that the USFWS will be advising against or prohibiting the use of exclosures in some areas, and if they are used careful and frequent monitoring will be needed. It was noted that very few exclosures are used in the central Platte and this learned behavior is unlikely.

H.1.2. Modifying Whooping Crane Roosting Habitat

The possibility of maintaining sandbars and islands as tern and plover habitat within large reaches of river cleared for whooping crane in channel roost habitat was suggested as a management option. Within the large cleared area only a few islands would be maintained free of vegetation (e.g., through chemical application) in any given year. The islands that are maintained free of vegetation would rotate through the area. This would help achieve the idea of habitat complexes discussed above in *Section V. G.1.1*.

H.1.3. Winter Flows

Meeting participants suggested that small pulse flows during ice cover conditions could potentially have a large impact on maintaining areas cleared for tern and plover reproductive habitat as well as on whooping crane roosting habitat. Examples of possible benefits include moving gravel to the tops of islands, cause "rough" channel, and provide significant action with less flow. More information from geomorphologists will be needed to evaluate what benefits could be realized. Caution was given that winter pulses can cause ice dams, resulting in localized flooding and potential third party impacts.

I. POSSIBLE PERMITTING REQUIREMENTS

The Technical Meeting participants identified several permits that may be required during various management activities (Table 2). Not all permits will be needed for each project. For instance, different permits will likely be required if working in or near the river verses in restored cropland. Actual permitting requirements will need to be determined on a site by site basis. It is possible that permits not identified by the meeting participants may be needed.

Table 2. Possible permits needed for management activities.

Permit	Authority	Example of when needed
Section 404 Permit	Corps of Engineers	When work results in fill being placed in wetlands
401 State Certification	State Department of Environmental Quality	State permit when working in wetlands, companion to Section 404 Permit
National Pollution Discharge Elimination System (NPDES)	State Department of Environmental Quality	When clearing five acres or more
402 Storm Water Permit	EPA, State Department of Environmental Quality	When clearing five acres or more
Surface Water Storage, Diversion and Use	Nebraska Department of Natural Resources	When using surface water
Cultural Resources Review	State Historic Preservation Office	Before excavating
Flood Plain Ordinance	Nebraska Department of Natural Resources	When building in floodplain (e.g., island construction)
Burn Permit	Local Fire District	When conducting prescribed burn
Ground Water Management and Protection Act	Natural Resources District	Permit may be required before pumping or using ground water
Health Permit	Nebraska Department of Health	When installing new groundwater well or utilizing an open groundwater drainage ditch
Endangered Species Act Permit	U.S. Fish and Wildlife Service	When working with tern and plover nests.

VI. RECOMMENDED BEST MANAGEMENT PRACTICES

Discussions during the Habitat Criteria Subcommittee Technical Meeting, February 16 and 17, 2000 were used to develop the recommended best management practices (BMP). During the meeting, species and habitat experts, landowners, Subcommittee members, and other interested parties discussed the management practices described in *Sections III and IV* as well as other management practices (see *Section V. Technical Meeting Discussion*). Meeting participants did not identify any practices that could not be used to manage lands protected by the Program; however, the group did prioritize several activities. Meeting participants also noted that careful consideration and site specific planning needs to occur when making decisions regarding habitat management. This section describes the best management practices and priorities.

A. BOTTOMLAND GRASSLANDS

A.1. Restoration and Creation of Bottomland Grasslands

Sections III and IV discuss several possible means by which bottomland grasslands can be restored or created. The sections center on cropland conversion, tree removal, and hydrologic enhancements. All methods and techniques were adopted as possible practices for use during the Program; however, priority was given to restoration of bottomland grassland through cropland conversion or hydrologic enhancement because of lower restoration costs, reduced maintenance, and shorter time to functioning bottomland grassland habitat.

Technical Meeting participants noted that a major consideration for any restoration or creation activity should be the duration of protection. It may take considerable time (5-10 years) for biological and physical structures to develop (e.g., invertebrates, and soils) in a restored or created bottomland grassland and if long-term protection is not possible, major restoration and management expenditures may not be warranted.

A.1.1. Cropland Conversion

Sections III and IV discuss the use of high diversity and low diversity seeding as two techniques for restoring bottomland grasslands. The recommended BMP for Program lands is to use high diversity seeding whenever possible. High diversity seed mixes (50-250 species) will need to be hand collected or commercially obtained. The seed mixture should be hand sown or seeded in such a manner that even distribution is obtained. Low diversity seeding may be useful as a technique to augment the existing seed bank or as a cover in buffer areas. Low diversity seeding may be done using conventional grass drills or other methods. Restoration of bottomland grassland in marginal cropland should include an analysis of soil types to insure that wetland soils are present, were present, or the soils are conducive for developing into wetland soils given the correct conditions. If old swales are present they may need to be excavated to remove fill added during years of cultivation. Methods and techniques described in *Section III.A.2.1* should be used as a starting point in the development of management plans; however, the habitat manager has the flexibility to use alternative methods if appropriate.

Restoration of marginal cropland into bottomland grasslands can be done for the purpose of whooping crane foraging, loafing, and roosting areas. In the past, restorations have been done with the primary purpose of providing foraging and loafing areas. During the Technical Meeting, it was noted that creating/restoring wetland roosting sites near areas of the river where in channel roosting areas are not conducive might be a cost-effective way of providing additional whooping crane habitat from Lexington to Chapman. If a restoration is aimed at providing roosting habitat, the management should be done such that the loafing and foraging characteristics of the bottomland grassland are not compromised. Careful consideration will be needed in the development of management plans to insure management of bottomland grasslands and associated wetlands do not impact target flows or result in negative third party impacts (e.g., use of water for wetlands verses cropland in dry years). Management of bottomland grasslands as roosting areas should be considered in conjunction with, and not replace, in channel roosting habitat.

A.1.2. Tree Removal for Bottomland Grasslands

Sections III and IV discuss removal of cottonwood forest and removal of Russian olive and cedar trees for the creation/restoration of bottomland grasslands. Both forest types have been successfully removed in the past. The recommended BMP for the Program allows for removal of either type but restoring bottomland grasslands through removal of Russian olive and cedar trees should be considered before creation of bottomland grasslands through removal of cottonwood forest. This is based on lower initial costs, less maintenance, potentially lower impacts to the biodiversity in the region, and shorter time to realization of more fully functioning bottomland grasslands.

In the past, tree removal projects to restore/create bottomland grasslands often entailed removal of larger trees and brush through mechanical means that significantly disrupt the soil (e.g., use of excavators and discs). To reduce soil disturbance and potentially reduce the influx of invasive plant species (e.g., purple loosestrife, musk thistle), the habitat manager should consider alternative strategies. These strategies include felling trees with chainsaws, allowing the grasses to develop, and burning when sufficient fuel accumulates to remove dead trees. Another potential method is to use the heavy machinery, but during winter months when the ground is frozen. By reducing the influx of invasive plants, the risk of negative third party impacts may also be reduced. Potential negatives to these alternatives include a longer time before the area is free of woody vegetation and reduced options for maintenance activities (i.e., difficulties in mowing around stumps and logs). The habitat management plan should contain a description of the positives and negatives to the proposed tree clearing activity and techniques to be used.

Techniques used to remove trees in the past have included the use of heavy equipment, chainsaws, skid-loaders, discs, sawmills, and tree shears. Other potential options to remove trees include the use of chemicals and flooding to kill trees in very limited applications. All techniques are included as options in the recommended BMP and the habitat manager should explore new options where appropriate.

A.1.3. Hydrological Enhancements

Section III discussed the use of water from open groundwater drains, wells, and excavation of depressions to depths near or within the groundwater as methods to augment the moisture regime of bottomland grasslands. During the Technical Meeting additional methods were discussed. One of these methods was to restructure drainage ditches or natural drainages to create a more sinuous alignment. This would create a larger proportion of wetlands without reducing the flow in the drainages. Another alternative method discussed was to block or fill open drains. This could only be implemented in very limited circumstances because of the potential for negative third party impacts if water is impeded from leaving a neighbor's property or if groundwater levels are raised on neighboring properties. Some points to consider before proceeding with alteration of drains include potential conflicts with existing easements and land rights and the need to coordinate with the proper ditch owner/operator. The recommended BMP includes all options discussed and the land manager should explore other new methods if possible; however, caution is needed to not negatively impact neighboring property owners and to maintain good neighbor relations in general.

A.1.4. Other Restoration/Creation Activities

Section III discusses using earth moving equipment to partially fill a dugout and remove silt and sedimentation in another area to restore bottomland grassland. A similar option was discussed during the Technical Meeting and entailed reclaiming sandpits as bottomland grassland habitat. Caution was given that the positives of reclaiming sandpits as bottomland grassland habitat needed to be weighed against the potential negative effects the reclamation could have on least tern and piping plover reproductive habitat. The recommended BMP is to include filling of dugouts and reclamation of sandpits for bottomland grasslands. Careful consideration needs to be given to potential negative impact on tern and plover habitat.

A.2. Maintenance of Existing or Established Bottomland Grassland Habitat

Management of bottomland grasslands discussed in *Sections III and IV* include burning, grazing, haying, resting, and chemical use. Use of biological agents to control certain plant species was discussed during the Technical Meeting. When possible biological agents should be used to control species such as musk thistle, leafy spurge, and others, but careful consideration is needed to avoid potential conflicts with neighbors and Weed Districts.

Regardless of the management technique, application times need to be varied. If haying, grazing, burning or other treatment is done at the same time annually, the management will select for certain species over others. Also, the management methods should be varied to include as many of the options as possible. For example, late spring haying can be used to check cool season grasses in some areas and March burning may be done in some areas to encourage whooping crane use. The varied management should be aimed at maintaining and/or promoting species diversity (especially warm season species) for the purpose of whooping crane loafing and foraging habitat. The varied management also minimizes encroachment of woody and invasive species.

Other considerations when developing a management plan for bottomland grasslands include maintenance costs and potential cost benefits from leasing haying or grazing rights. In general, income is higher from leases of hay ground compared to grazing range. Also, no fences are needed when utilizing haying operations. However, management plans should consider the positive effect on the grassland from "hoof action". Regardless of the methods used, bottomland grassland management should be done to increase forage for whooping cranes whenever possible. To accomplish this, the recommended BMP includes all management options and remains flexible to include new techniques as they are developed.

B. UPLAND GRASSLANDS

Meeting participants noted that the definition of upland grasslands is somewhat unclear. Upland grasslands are defined in this document as drier grasslands completely or mostly free of woody vegetation. Whooping cranes and sandhill cranes have been observed using habitat considered upland grasslands. In some areas of the whooping crane's migration route, including the Rainwater Basins, upland grasslands appear to be important habitat for crane family units. Cranes have been observed using upland grasslands very quickly after a fire, presumably because of the easy access to forage. While upland grasslands are not a major habitat component in the proposed Program, the Program will likely manage some of this habitat type in conjunction with other habitat types.

B.1. Restoration and Creation of Upland Grasslands

B.1.1. Cropland Conversion

Conversion of cropland to upland grasslands may not be cost effective for the Program because of the value in leasing the cropland to area farmers. However, if grassland habitat in general is limited in a particular region, conversion of some cropland to upland grassland may be warranted. Upland grassland habitat may also be useful as a buffer habitat if a wetland is located in the cropland. In general, the recommended BMP for the conversion of cropland to upland grassland is to consider the activity as low priority but effective if a buffer region is needed or grasslands are limiting. If croplands are converted to upland grassland, high diversity seeding should be done using methods similar to those used for bottomland grasslands (i.e., hand-broadcasting seed).

B.1.2. Tree Removal Related to Upland Grassland

Section III discusses tree removal projects that resulted in the creation/restoration of upland grassland habitat. Technical Meeting participants noted that if the area was historically upland grassland there would not be cottonwood or willow trees but there may be other tree/brush species that have encroached since fire suppression. Removal of trees would open more grassland areas for cranes and other grassland birds, but may be cost prohibitive. To minimize costs, prescribed burning can be used effectively to remove cedar trees and tree shears or skid-loaders can be used to remove cedars, Russian olives, and other brush with little disturbance to the soil. Chemicals may also be used to kill cedar trees and then fire or other means can be used to remove the dead trees. It may be beneficial to leave tree rows that grow parallel to power lines and fences for visual barriers and prevent crane from colliding with the objects. Because whooping cranes use upland grassland habitat, tree removal projects to restore/create this habitat may be useful; however, the benefits may not justify the costs associated with many tree-clearing activities. If trees are cleared for upland grassland, using burning, chemicals, or minimal mechanical means should be used to minimize costs.

B.2. Management of Existing or Established Upland Grasslands

Management of upland grasslands is similar to bottomland grasslands and includes burning, grazing, haying, and resting. The recommended BMP for upland grasslands follows the discussion above in *Section VI.A.2. Management of Existing or Established Bottomland Grasslands.*

C. OPEN RIVER CHANNEL HABITAT

C.1. Riparian Forest and Brush Clearing

Sections III, IV, and V discuss several methods that have been used to remove riparian forest and brush when restoring open river channel habitat. Riparian forest and brush clearing has been done primarily using mechanical techniques. The use of properly timed and regulated flows are also discussed to prevent further narrowing and as a possible means to remove smaller vegetation. All techniques were adopted as possible practices for use during the Program; however, careful consideration is needed to prevent or minimize negative third party impacts.

Management plans for riparian forest and brush clearing should include careful consideration of all positives and negatives associated with each clearing. The caveats and concerns included in *Section VI. A.1.2.* are also pertinent to tree removal projects for the restoration of open channel habitat. For example, work that significantly disrupts the soil may lead to an influx of exotic/noxious vegetation (e.g., purple loosestrife) and methods to avoid or minimize this should be considered. Alternative methods as described in *Section VI.A.1.2* include felling trees to allow grasses to become established and conducting work when the ground is frozen. Management plans should implement the most cost-effective method given the amount of time needed to realize management benefits (i.e., how long to open channel habitat) and the amount of time the habitat is protected (e.g., short-term lease, ownership).

C.1.1. Mechanical Methods

Mechanical methods used to clear riparian forest and brush include the use of shredders, mowers, discs, chainsaws, bulldozers, excavators, and other heavy equipment. Typically, a combination of these methods are used (e.g., shredder to remove smaller trees, bulldozer for removal of larger trees and piling debris, and then a disc to incorporate the materials with the soil). For complete removal of larger trees a bulldozer or excavator will eliminate the difficult task of stump removal. Discing alone may be useful when clearing lower islands of small brush and trees. Four passes are recommended if discing is used by itself.

Often, one of the reasons for clearing riparian areas is to liberate sediment and create wide shallow channels. To liberate the sediment, soil disruption is generally needed either through discing or other tree/vegetation removal methods. This can create a favorable germination environment for cottonwoods, willows, purple loosestrife and other species. Conducting clearing work outside the seed dispersal time for these species may help in minimizing the initial influx of these undesirable vegetation species. A management plan will need to include follow-up vegetation control for several years after clearing and methods to minimize or avoid negative third party impacts.

Sections III and IV discuss the use of commercial sawmill operations to remove larger trees. In the past, groups have had problems with slash clean up and completion time when using this method. The preferred method for complete removal of trees and brush is to pile and burn the larger trees along with the brush. However, use of commercial sawmills may be feasible with careful oversight and monitoring by Program personnel. All methods are available to the habitat manager and the habitat manager should be progressive in developing new methods.

C.1.2. Flows

Technical Meeting participants discussed the use of flows to create and maintain open river habitat. Because the Program can not cause or add to out of bank flooding, river flows can not be used to remove larger, established vegetation. River flows at the proper time and amount can be used to remove cottonwood and other seedlings or to minimize their germination and are included in the recommended BMP for open channel habitats.

C.2. Maintenance of Open River Channel Habitat

C.2.1. General Practices

Maintaining open river channel habitat often uses many of the same techniques used to clear channels. These methods include mowing, shredding, and discing to remove unwanted

vegetative growth. If significant woody vegetation is present the area needs to be first mowed or shredded; otherwise, the area can be disced to remove small woody vegetation. Some habitat management entities in the central Platte are attempting to develop sufficient grasses and forbs on islands such that prescribed burning can be done to control woody vegetation encroachment. Chemicals can also be used to maintain open river channel habitat. Habitat management plans developed for maintaining open river channel habitat should be flexible enough to allow these and other methods as site specific characteristics dictate.

C.2.2. Flows

Sections IV and V discuss the use of flows to maintain open river channel habitat. Several papers have been written that discuss flows necessary to effectively cover cottonwood and willow germination sites along the central Platte River. Coordination between the Program's habitat manager and Environmental Account manager will be needed too effectively use flows in maintaining open river channel habitat.

C.2.3. Purple Loosestrife

Besides encroachment of woody vegetation into cleared open channel habitat, the Program needs to control and minimize the proliferation of purple loosestrife in these areas. The first consideration should be on minimizing the establishment of purple loosestrife through techniques described above and other methods as needed. If loosestrife becomes established, the recommended method for control is the use of biological agents. This will not eliminate purple loosestrife and significant time might be required to control the growth. Coordination will be needed with Weed Districts and neighbors to ensure biological control is not in conflict with their needs. Another method of control includes the use of herbicides. Herbicides include both non-selective (e.g., Rodeo) and selective (e.g., Triclopyr) types. The non-selective type herbicides can be effective in the spot treatment of homogeneous stands of loosestrife but more selective types are needed in general application. Carefully controlled water levels may also have limited application when preventing loosestrife from germinating. Control methods that do not appear to be appropriate are mowing, discing and burning. Burning has been found to not be effective in controlling loosestrife in the central Platte. Mowing and discing can cause further spread of loosestrife through vegetative means.

The recommended BMP for purple loosestrife control to use biological control agents when available and where appropriate. Other control methods will be needed to augment this control. Coordination with agencies such as Weed Districts will help insure proper measures are taken to control purple loosestrife when maintaining open channel habitat.

D. TERN AND PLOVER REPRODUCTIVE HABITAT

D.1. Restoration and Creation of Tern and Plover Reproductive Habitat

Technical Meeting participants discussed the difficulties and limitations when creating and restoring tern and plover reproductive habitat in the central Platte River (see *Section V* for complete discussion). Two possible directions were discussed during the meeting: 1) development and management of semi-permanent sites and 2) management for large habitat complexes. Both options have inherent problems. For example, while it is possible to create and maintain semi-permanent habitat using techniques discussed in *Section III*, this "permanent" reproductive habitat can quickly develop predation problems and reduced

reproductive success. Predation problems may dictate further management through the used of predator control and exclosures. Another problem with the creation of permanent reproductive sites is the high cost of maintenance. Regardless of problems, managed sites have successfully fledged tern and plover chicks in the past and will likely continue to in the future.

Relying on large habitat complexes is another management option. Creating large complexes of reproductive habitat typically requires some sort of flood event, and this is something the Program can not create or contribute too. The Program should consider developing conditions such that when there are natural flood events, the opportunity is used to create habitat complexes. This management may entail creation of sand ridges or placement of structures in strategic locations, however further input from a geomorphologist is needed before attempting this management. Continued management of permanent sites might be warranted to insure nesting locations are available in the central Platte River on an annual basis.

Another option includes a combination of the above two. This option looks at maintaining "rolling habitat". Several islands would be managed together, but only one or two would be maintained clear of vegetation during a given year. An area of "rolling habitat" may be used to provide a habitat complex, but significant hands-on management is likely needed to maintain islands clear of vegetation.

To create and restore least tern and piping plover habitat, the recommended BMP includes all techniques, but is not limited to those, discussed in *Sections III, IV, and V*. The Program's habitat manager should fully consider the limitations of each method and technique and include this in the development of management plans. Management plans also need to be developed based on the most cost and time effective methods. Habitat management plans for least tern and piping plover reproductive habitat may include one or a combination of the above methods. Also, care is needed to minimize and eliminate possible negative third party impacts associated with creation of tern and plover reproductive habitat.

D.2. Maintenance of Tern and Plover Reproductive Habitat

D.2.1. Habitat Maintenance

If the Program relies totally on flows to create and maintain reproductive habitat for terns and plovers, methods described in *Section III and IV* will not apply. However, if the Program maintains some areas (islands and/or sandpits) various management techniques are available to maintain the habitat free of vegetation. These techniques include chemical application, rototilling, discing, hand pulling and cutting, and other similar techniques. The Program may also consider armoring islands to keep permanent sites from eroding. The recommended BMP for tern and plover habitat maintenance includes all options discussed in previous sections and encourages investigating other methods. Like all management, cost and time effectiveness will need to be considerations in development of management plans.

D.2.2. Predator and Human Disturbance Issues

There are differing opinions on the use of predator fencing and control and the use of predator exclosures around nests. Management plans need to carefully weigh the positives and negatives of predator issues so informed decisions are made whether or not to implement the techniques. Human disturbance includes intentional and unintentional activities. Intentional activities include use of predator exclosures and moving nests to areas above the anticipated

waterline. Unintentional activities include off-road vehicle traffic and other disturbances. The recommended BMP for predator issues includes all options discussed in *Sections III and IV* and other techniques as needed. The recommended BMP for intentional human activities include allowing their use if warranted. To dissuade unintentional activities known reproductive habitat areas should be signed and possibly patrolled to some degree.

E. RECOMMENDED BMP FOR CROPLAND

The recommended BMP for developing cropland management plans covers crop rotation, "sharecropping", grazing of stocks, and chemical and water use. The crop rotation for Program lands could include corn and alfalfa. However, there may be areas where this rotation is not feasible and in these instances other crops should be used. As a lease consideration, the Program may offer farmers the sharecropping option of leaving a portion corn crops standing or allowing a set amount of corn to pass through the combine during harvest in lieu of a portion of rent payment. This would increase the amount of waste corn left in field for use by cranes and other waterfowl during spring migration. Management plans may also prohibit or curtail grazing of corn stocks after harvest. This would also increase the amount of waste corn left in fields for use by cranes and other waterfowl during spring migration. To insure the most effective use of water and chemicals, the recommended BMP for croplands is to employ precision agriculture techniques (e.g., testing by professional agronomist) on Program lands.

All topics discussed above may impact tenant farmers to varying degrees. These financial and logistic impediments need to be considered when developing leases to insure good neighbor relations and minimize negative third party impacts.

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Acknowledgments

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Habitat Criteria Subcommittee Co-Chairs,
Mark Czaplewski and Don Batie

APPENDIX I - Land Management Evaluation Survey

LAND MANAGEMENT EVALUATION SURVEY

#1. Please identify (map and written description) all properties owned, leased, or under management agreements by your organization. For each piece of property please include the type of control (ie fee title, conservation easement, etc.), number of acres, date acquired and location. Please utilize 1:24,000 scale USGS Quadrangular maps in property identifications. If you need such maps provided t you, contact: Clayton Derby, Platte River Endangered Species Partnership, 2003 Central Ave., Cheyenne, WY 82001.

#2. How many acres of each piece of property are managed as:

Open grasslands:
Wet meadows:
Open River channel:
Nest or foraging areas for least terns and/or piping plovers:
Riparian forests:

#3. Please identify the management goal for each unit and how long that unit has been so managed. Also, please identify any previous management activities that were utilized on those units, the length of time those management activities were carried out, and the reason for changing the activities. Please provide this information for as far back as you have records.

#4. What management techniques were used to achieve the management goals and dates of management implementation on each unit? For example: You may have conducted tree-clearing activities for a specific management goal. Describe the particular clearing methods used, the location and number of acres treated, the initiation and duration times, were there any follow-up treatments (e.g.: chemical applications), etc.

#5. How was it determined if management was effective in meeting the management goal for each unit? For example: What measurements or formal evaluations of the management techniques were conducted; how were those measurements/evaluations used; how successful were the management techniques?

#6. Please identify the benefits and negatives of all management efforts, including but not limited to positive or negative response by target and non-target species, cost, logistics of implementation and feasibility of implementation on a scale larger than what you attempted.

Please indicate the name of the individual completing this survey, or the individual to contact if follow-up questions or clarification is necessary.

Name _____
Phone _____
Address _____

PLEASE RETURN COMPLETED INFORMATION BY MARCH 1, 1999.

APPENDIX II - Entities that Received Survey

U.S. Fish and Wildlife Service
Grand Island, Nebraska

U.S. Army Corps of Engineers
Omaha, Nebraska

U.S. Bureau of Reclamation
Grand Island, Nebraska

Natural Resources Conservation Service
Grand Island, Nebraska

Nebraska Game and Parks Commission
Lincoln, Nebraska (2 sent)

Nebraska Board of Educational lands and Funds
Lincoln, Nebraska

Nebraska Department of Roads
McCook, Nebraska

Central Platte NRD
Grand Island, Nebraska

Tri-Basin NRD
Holdrege, Nebraska

Audubon's Lillian Annette Audubon Sanctuary
Gibbon, Nebraska

Platte River Crane Trust
Wood River, Nebraska

The Nature Conservancy
Aurora, Nebraska

Prairie Plains Resources Institute
Aurora, Nebraska

Ducks Unlimited
Bismarck, North Dakota

Pheasants Forever
Belgrade, Nebraska

Wyoming Water Development Commission
Cheyenne, Wyoming

Nebraska Public Power District
Kearney, Nebraska

Central Nebraska Public Power and Irrigation District
Gothenburg, Nebraska

City of Grand Island
Grand Island, Nebraska

City of Kearney
Kearney, Nebraska

Big Bend Waterfowl Association
Kearney, Nebraska

Izaak Walton League
Grand Island, Nebrask

APPENDIX III – Habitat Management Methods Technical Meeting Participants

Habitat Management Methods Technical Meeting
Habitat Criteria Subcommittee
Platte River Trust, Wood River, Nebraska

February 16, 2000

Name	Organization
Clayton Derby	Executive Director's Office
John J. Dinan	NE Game and Parks Commission
Casey Kruse	US Army Corps of Engineers
Kent Pfeiffer	Platte River Crane Trust
Paul Obert	Natural Resources Conservation Service
David Zelenka	Wyoming Water Development Commission
Phil Ogle	Wyoming Water Development Commission
Kirk Schroeder	US Fish and Wildlife Service
Erika Wilson	US Fish and Wildlife Service
Rocky Plettner	Nebraska Public Power District
Mike Fritz	Nebraska Game and Parks Commission
Jim Jenniges	Nebraska Public Power District
David Rafferty	Tri-Basin NRD
Myles Ramsey	Landowner
Don Kennedy	Denver Water
Steve Dougherty	ERO Resources/Platte River Project
Jay Maher	CNPPID
W. Carter Johnson	South Dakota State University
Paul Kinzel	USGS-WRD
Gary Lingle	Univ. Nebraska Cooperative Extension
Jim Lewis	Univ. of New Mexico, USFWS Retired
Hal Nagel	Univ. of Nebraska, Kearney
Gary Krapu	USGS, Northern Prairie WRC
Mark Czaplewski	Central Platte NRD
David Carlson	US Fish and Wildlife Service
Rick Brown	Colorado Water Conservation Board
Kenny Dinan	US Fish and Wildlife Service
Bill Taddicken	Audubon Rowe Sanctuary
Mark Humpert	Nebraska Game and Parks Commission
Daylen Figgs	Nebraska Game and Parks Commission
Amy Richert	UNL State Museum
Wally Jobman	US Fish and Wildlife Service
Dale Strickland	Executive Director, Cooperative Agreement
Rhodell Jameson	Land Committee Co-Chair
John Shadle	Nebraska Public Power District

February 17, 2000

Name	Organization
Clayton Derby	Executive Director's Office
John J. Dinan	Nebraska Game and Parks Commission
Casey D. Kruse	US Army Corps of Engineers
Kent Pfeiffer	Platte River Trust
Paul Obert	Natural Resources Conservation Service
David Zelenka	Wyoming Water Development Commission
Phil Ogle	Wyoming Water Development Commission
Kirk Schroeder	US Fish and Wildlife Service
Erika Wilson	US Fish and Wildlife Service
Rocky Plettner	Nebraska Public Power District
Mike Fritz	Nebraska Game and Parks Commission
Jim Jenniges	Nebraska Public Power District
Paul Tebbel	Audubon Rowe Sanctuary
Jim Lewis	Univ. of New Mexico, USFWS Retired
W. Carter Johnson	South Dakota State University
Gary Lingle	Univ. of Nebraska Cooperative Extension
Dennis Sherrerd	Landowner
Gary Krapu	USGS, Northern Prairie WRC
Mark Czaplewski	Central Platte NRD
Steve Dougherty	ERO Resources/Platte River Project
Don Kennedy	Denver Water
Hal Nagel	Univ. of Nebraska, Kearney
Andrew Simpson	Univ. of Nebraska, Kearney
Jay Maher	CNPPID
Bob Henszey	Platte River Trust
Gary Lindstrom	Tri-Basin NRD
Rick Brown	Colorado Water Conservation Board
Wally Jobman	US Fish and Wildlife Service
Kenny Dinan	US Fish and Wildlife Service
Bill Taddicken	Audubon, Rowe Sanctuary
Mark Humpert	Nebraska Game and Parks Commission
Daylan Figgs	Nebraska Game and Parks Commission
Amy Richert	UNL State Museum
Dave Carlson	US Fish and Wildlife Service
Rhodell Jameson	Land Committee Co-Chair
Dale Strickland	Executive Director, Cooperative Agreement