TC-R128(a)

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

THIS DRAFT ONLY ADDRESSES THE SURVEY ANALYSIS PORTION OF A LARGER DOCUMENT. THE ENTIRE DOCUMENT WILL INCLUDE A LITERATURE REVIEW AND RESULTS OF A TECHNICAL MEETING.

DO NOT CITE!

September 7, 1999

Prepared for:

Habitat Criteria Subcommittee
Land Committee
Governance Committee

Prepared by:

Clayton Derby, Elizabeth G. Lack, and Dale Strickland
Western EcoSystems Technology, Inc.
2003 Central Avenue
Cheyenne, Wyoming 82001

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see A.2.1.

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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). 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 (Figure 1 – ~~MAPS WILL BE PROVIDED BY BUREAU OF RECLAMATION~~). 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. 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 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 work and did not work in regards to tern, plover, and whooping crane habitats outside of the region. The technical meeting was used to bring species and management experts from outside the central Platte valley together with species and management individuals from within the valley. During the technical meeting habitat managers and species experts discussed application of the various management methods and identified other potential management strategies not discussed in the literature review or survey analysis.~~

The goal of the survey, literature review, and technical meeting is to provide information that can be used in preparing habitat management plans for lands involved in the Program. This document compiles and summarizes the survey results and describes the past and current successes and failures of the various management activities conducted in the central Platte valley, ~~describes management practices used outside of the central Platte in the literature review section, and summarizes the outcome and discussions at the technical meeting~~. This information will be invaluable when habitat management decisions are made during the Program.

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. The early return date was used in an attempt to have managers complete the survey before the busy field season. However, only five of the 23 entities surveyed responded by March 1.

The remaining 18 non-responding entities were contacted in mid-April by phone, email, or in person to remind them of the survey and its importance. Because April is part of the field season for many of the managers, the first follow-up resulted in only seven more responses. The remaining 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 survey response was received on August 17, 1999.

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, in person, and email.

B. LITERATURE REVIEW

C. TECHNICAL MEETING

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 (i.e., bottomland grassland) and then by management action used (i.e., haying).

The habitat categories described in this section are bottomland grassland, upland grassland, open river channel, least tern and piping plover reproductive habitat, cropland, and other habitats (i.e., riparian forest). Bottomland grasslands are an important feeding and secondary roosting area for whooping cranes and sandhill cranes. Upland grasslands are used to a lesser extent than bottomland grasslands by whooping and sandhill cranes, but they are important sources of cover and forage for other bird species and wildlife in general. Open river channel habitat is important as primary roosting habitat for whooping cranes. Areas cleared to provide open river channel habitat are also used by least terns and piping plovers as nesting habitat. Besides the areas cleared for open channel habitat, several habitat management entities in the central Platte maintain open riverine and non-riverine areas specifically for least tern and piping plover reproductive habitat. Cropland and other habitats are also included in this section. While these are not vital to the target species, management of larger tracts for the target species often entails management of these habitat as well.

A. BOTTOMLAND GRASSLAND

The term bottomland grassland in the draft "Documentation of Existing Conditions in the Central Platte Valley" (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 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 evolved in bottomland grassland management and/or restoration are the U.S. Fish and Wildlife Service (FWS), Nebraska Public Power District (NPPD), National Audubon Society's Lillian Annette Rowe Sanctuary (Rowe), 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/ranches. 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 management of the grasslands is done except for a small parcel involved in a project with Central Platte NRD. This area is described below under *A.2. Bottomland Grassland Restoration.*

NGPC owns approximately 107 acres of bottomland grassland at six different locations. The size of the individual areas varies from four to 30 acres. NGPC does not conduct any management specifically for bottomland grasslands. The grasslands are simply portions of areas managed for fishing access and hunting access.

TNC currently manages 1,005 acres, Rowe 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 management objectives for TNC, Trust, and Rowe are to maintain a diversity of tall and short stands of native grasses and forbs that provide habitat for 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. Starting in 1999, TNC will begin an early June haying rotation 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 lands. 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 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, Rowe uses a four-field rotation. In any one 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 Rowe, this provides short grass areas in the spring for the cranes as well as an area with taller, denser grass for nesting birds. Overtime, this management may select for cool season grasses and forbs over warm season plants. ~~NUMBER OF BALES OR TONS OF HAY PRODUCED~~.

A.1.2. Grazing
Rowe uses early season grazing (~~dates~~) on one small bottomland grassland to increase use by ground nesting birds in the summer (~~AUM'S~~). Longer grazing rotations (~~dates~~) are also used in some grassland areas to increase diversity and break up the cool season grasses. ~~AUM'S~~

One effective rotation regime used by TNC is a four-pasture rotation in which a pasture is grazed 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 (~~AUM'S~~). Another rotation used by TNC in areas that were traditionally annually hayed is a rest/burn rotation (~~annual?~~) with periodic early season intensive grazing (1.5 AUM/acre, May 1 – June 1). According to TNC this improves and maintains native plant diversity.

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 Animal Unit Months (AUM) 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. Burning
Burning is often used when grasslands are rested for multiple years in a row. In the TNC four-pasture regime described above in *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.

Burning has also been found by TNC and Rowe 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 also 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.

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. 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. No specific cost estimates on managing existing bottomland grasslands were reported by survey respondents. ~~Cost of burns?~~

A.1.6. Control

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

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

A.2. Restoration 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 conjunction with NPPD, Wyoming, and the City of Grand Island 320 acres; FWS 265 acres; and Rowe 210 acres. Once restoration efforts are deemed complete, management generally follows that for existing bottomland grassland described above in Section *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 water enhancement projects for bottomland grassland restoration.

A.2.1. Cropland Conversion

<u>High Diversity Seeding</u>

TNC has restored over 250 acres of poor quality cropland into bottomland grasslands using high-diversity seeding and re-creation of wetland depressions with bulldozers. Restored areas are planted with native grass and forb seeds collected from local grasslands. A combine is used to harvest dominant warm season grasses (~~NAMES, any attempt to eliminate weed seeds?~~) and hand collections are used to collect forbs and less dominant grass seeds (~~EXAMLES~~). TNC has used a mixture of 15 gallons per acres of the seed collected using the combine and 1.5 gallons per acres of hand collected seed. Seeds are hand broadcast onto disced fields in ~~DATE~~ and no other management is used until sufficient fuel accumulates to conduct an early spring burn~~(ANY RESEEDING OR IRRIGATOIN)~~. TNC has found that spring burning results in a quicker establishment of native plants after the initial growth of annual weeds during the first couple of years after planting. TNC has also found that mowing the annual weeds does not accelerate native plant establishment, and may actually slow the establishment. These activities have been very successful in establishing a high

diversity of bottomland grassland species in previously poor agricultural fields, as shown by the increase in bird use and nesting. According to TNC, restored bottomland grasslands from agricultural areas have needed approximately 5 years before regular management activities (described above in 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 (~~NAME, any attempt to eliminate weed seed?~~) and then hand collects other native grass and forb seeds. This results in a seed mixture of 150-230 different species of native grasses and forbs. The seeds are then hand broadcast onto disced fields in ~~DATE. MANAGEMENT AFTER SEEDING – IRRIGATION, RESEEDING~~. 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 recreate 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 Rowe 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 (~~NAME~~) using a drill in a fashion similar to 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. ~~(ANY GRAZING OR HAYING, AFTER HOW LONG?)~~

TNC has used low diversity seeding in restoration efforts since the early 1990s. Seeding has been done using a drill ~~(SEED TYPES, DATE OF SEEDING, HOW LONG UNTIL REGULAR MGMT?)~~. They use grazing, haying, resting, and burning as described in A.1 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. According to TNC, these management actions have resulted in higher bird diversity and species richness than most private land in the area. Sandhill cranes have used ~~(feeding and loafing?, when?)~~ the low diversity grasslands with tall vegetation structure as well as short structure, but the short structured lands are used more often. Areas restored by TNC using low diversity seeding do not receive the same amount of bird use as native areas or areas restored using high diversity seeding.

Rowe has used what could be termed low diversity seeding on approximately 210 acres of their restored bottomland grasslands. For the most part, Rowe has not done any formal seeding activities 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. Rowe'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. Rowe has found that this provides a short vegetative structure for both the fall and spring migrations. However, Rowe 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. Rowe is starting a new rotation of resting lands for two years to help maintain more diversity of species.

Neither the Trust, TNC, or Rowe 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 C. OPEN RIVER CHANNEL. This section focuses on tree removal as it pertains to bottomland grassland restoration.

The Trust has cleared a 380 acre tract of cottonwood forest to restore 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 of 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, but significant maintenance was required in the years following the clearing. These activities included using the Klearway, mowing, and burning to prevent trees and brush from resprouting ~~(HOW OFTEN, HOW LONG WAS CLEARING NEEDED).~~ The clearing was done in the mid-1980s. The Trust reported that today the plant communities are very 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 chainsaws and a Klearway. Trees and brush were bulldozed into piles and burned. Like the cleared cottonwood forest areas, the cleared Russian olive areas required maintenance to control resprouting and encroachment of trees through burning and use of the Klearway ~~(HOW OFTEN).~~ 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, the FWS has conducted forest clearing to restore open bottomland grasslands. FWS has restored 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 FWS 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 channel was restored and at the other site 1,500 linear feet was restored.

The main goal of these FWS five 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 restored bottomland grasslands. Four of the five FWS 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, FWS reported that it is too early in the projects to evaluate the effectiveness of the management practices, but sandhill cranes and other waterfowl have been observed using the areas during migration (~~spring and fall?~~).

At another location, the FWS 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 FWS 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 FWS 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 FWS found that after burning, the grasses planted in 1995 responded well.

A.2.3. Water Enhancement

Central Platte NRD, NGPC, NPPD, and Central Nebraska Public Power and Irrigation District (Central) are involved in "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. The site owned by NPPD (Cottonwood Ranch), and portions of the Wyoming site also required reseeding of native plant species. Work on these projects began in 1998 using grants from the Nebraska Environmental Trust Fund.

The Cottonwood Ranch site 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. It was anticipated that the system would deliver up to 700 gallons per minute at maximum flow. Testing has shown that the 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.

About 140 acres of the 160 acres of the restored bottomland grassland at Cottonwood Ranch 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 Trust land and spread it on the cultivated field. Cattle were allowed to graze the hay and waste grain from the previous harvest 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 this project was not started until 1998, no estimates of project success have been made.

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, several areas were excavated using bulldozers to or near the groundwater level in an attempt to simulate temporary depressional wetlands and seasonal/semi-permanent wetlands (~~SIZE~~). ~~Two to seven~~ areas measuring approximately 175 feet by 35 feet were excavated to a depth of two feet to create temporary depressional wetlands. There were also ~~two to seven~~ areas measuring 175 feet by 35 feet that were excavated to two feet that will receive additional groundwater through pumping. ~~Two to four~~ seasonal/semi-permanent wetlands were created by excavating two to four feet from areas that were 325 feet by 65 feet. In all cases, the top layer of soil was set aside and reapplied following excavation. The soil was compacted (~~how?, when?, to what degree?~~) to increase the water holding capacity of the wetlands. 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, Cottonwood Ranch. Additional time and monitoring will be needed to determine the effectiveness of the various methods.

A.2.4. Other Projects

In 1996 the FWS 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 (~~HOW~~) with a native warm season grass mix (~~examples~~). According to FWS, growth of the planted seeds, as well as reestablishment of sedges, rushes, and smartweed along the edges of the wetland, has been positive (~~HOW MEASURED~~). 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.

Cropland Conversion	
High Diversity Seeding	$100/acre to collect seed, Trust ~~$?/acre to plant, ?~~
Low Diversity Seeding	$20/acre to collect seed, Trust using their own combine ~~$?/acre to plant, ?~~
Tree and Brush Clearing	
Cottonwood Forest	$800-1,000/acre using chainsaws, Trust $734-875/acre using bulldozers and other heavy equipment, FWS
Russian Olive, Cedar, Smaller Trees, Brush	$200-208/acre using Klearway and disc, Trust, FWS $231/acre using tractor mounted tree saw, FWS $14/acre for removing scattered cedars using shears and chainsaws, FWS
Land Contouring	$100-300/acre depending on water table depth, Trust
Channel Clearing	$2.25-3.33/linear foot, FWS
Other "Dirt Work"	$725/acre for removal of silt and partial filling of dugout, FWS

A.2.6. Control

Bottomland grassland restoration efforts have been conducted on land controlled through fee title and leases. The Trust, Rowe, and TNC utilize fee title control. This allows the managing entity almost complete freedom in management decisions.

Rowe has some of their lands enrolled in the federal Wetland Reserve Program (WRP). This is advantageous in that Rowe 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 FWS utilize 10-15 year leases 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. Funding for the leases and work come from various partners including landowners, tenants, hunting clubs, FWS, 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 FWS in completing the projects. A disadvantage is the relatively short lease duration.

Central Platte NRD and the other entities agreement's with NPPD, Wyoming, and Grand Island are only for a short duration, currently only two years of funding. The reason for the short duration is that these projects are meant to be a study of alternative methods for maintaining and enhancing bottomland grasslands.

B. UPLAND GRASSLAND

Upland grasslands are dry areas that are mostly free of woody vegetation. Most of these areas are limited to the loess bluffs one to two miles from the river and higher areas within the floodplain. 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 FWS, NPPD, Central, Rowe, 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). With the exception of NPPD and Central, these entities primarily have smaller parcels of land and many 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 at Caraway, Central 2,800 acres at Jeffrey Island, NPPD 700 acres at Cottonwood Ranch, and Rowe 67 acres at two locations. 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 Rowe are to provide diverse structural communities for nesting and foraging habitat for grassland bird species and to provide roosting and foraging areas for cranes. Management activities to provide the 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 four feet above the river's surface. NPPD leases the land to area ranchers and allows grazing from May through October. NPPD reported that the grazing is not done to accomplish any management objective. NPPD has constructed several small 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 in maintain this. The most common bird species found by NPPD on the islands are western meadowlark, eastern kingbird, and brown headed cowbird.

The Trust also utilizes grazing on its 21 acres of upland grassland at Caraway. Moderate grazing levels (1-2.4 AUM) are used for short a 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 area also at Caraway (see *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.

In 1999 Central will begin using a six pasture rotation on 2,800 acres of upland grassland that it leases on Jeffrey Island. Central expects that the controlled grazing will improve the grassland and control encroachment of non-desirable vegetation (~~woody or other, examples if other~~). 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 of Jeffrey Island in 1999, the rotation has not been evaluated for its effectiveness. The grazing and burning rotation is described in Table 1.

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 –	Pastures B-F	Pastures A, C-F	Pastures A, B,

October	grazed on a triple rotation of 10-15 days per pasture each rotation	grazed on a triple rotation of 10-15 days per pasture each rotation	D-F grazed on a triple rotation of 10-15 days per pasture each rotation.

B.1.2. Haying

Rowe was the only entity that reported using haying as a management method on upland grasslands. Rowe hays a 27 acre grassland twice per year (~~Dates, amount of hay~~). Rowe 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. Rowe also hayed a 40 acre upland grassland area in August of 1998 for native seed collection. (~~how much was obtained, what happened to the hay, why was it done only in 1998~~)

B.1.3. Burning

Rowe utilizes periodic (~~how often, when~~) burning of 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 Rowe. The grasslands themselves also provide nesting areas for ground nesting birds. The area was hayed in August of 1998 for native seed collection.

Central will also utilize burning as part of their six pasture rotation of the grasslands on Jeffrey Island. This information is contained above in Section *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 conductes grazing and haying, burning would likely need to be paid for by the managing entity (~~cost estimate~~). Leasing grazing and haying rights to upland grasslands will result in rent income for the landowner.

B.1.5. Control

Upland grasslands managed by NPPD, Rowe, and Trust are controlled through fee title and grasslands managed by Central are controlled through a long-term 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 insect, 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 FWS 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). One of the islands owned by

NPPD at Cottonwood Ranch was previously tilled for cropland (~~x acres~~). The Trust has 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 grass and forbs (~~species, methods~~) to restore grasslands from croplands, the efforts also often include planting trees and other cover types that are not conducive to use by sandhill or whooping cranes. However, these areas are valuable as habitat for upland game birds and other species of birds. Management of these areas primarily consists of noxious weed control (~~methods~~). 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 what~~). 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 *B.1.1 Grazing*). According to the Trust, the combined management provides a structurally diverse habitat for breeding, migrating, and wintering grassland birds. (~~what methods were used to do the actual restoration – seed mixes, methods, weed control, time of year?~~)

The previously farmed island at Cottonwood Ranch was converted back to grassland prior to ownership by NPPD. NPPD was not involved the restoration efforts and was not able to provide information regarding the restoration. The restored lands are part of the normal grazing practices on the islands. (~~any information on what was done, when~~?)

B.2.2. Tree Removal

Projects conducted by the FWS 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 FWS reported that response of native grasses and forbs in the seed bank has been positive (~~how measured?~~). According to FWS, the grasslands themselves are used primarily by grassland nesting birds. Based on the 10 acres cleared in 1992, efforts to control 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 and federal government 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 *A.2.5. Costs* above.

B.2.4. Control

Restoration of upland sites has been conducted primarily on lands controlled with leases or easements. In the CRP, Natural Resources Districts, and FWS 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. One possible drawback of leases and easements described above is the relatively short duration (typically 10 years). While these restoration efforts were on leased land, the Trust has conducted successful restorations on lands that they own.

C. OPEN RIVER CHANNEL

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), FWS through their PFW program (239 acres), the State of Wyoming in cooperation with the FWS (approximately 125 acres), and Rowe (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. These lands will only be briefly discussed in this section and are thoroughly covered in Section *D. Open Riverine and Non-Riverine Areas*. The FWS, 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 (40 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 herbicide application (~~type and method~~) 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 prevented 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 clearing activities follow this combination and are done in midsummer and early fall when it is possible to drive equipment across channels. 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 Rowe 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, Rowe 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 (i.e., willow, dogwood) with the Klearway or brushog, and then discing. According to Rowe this results in providing good primary roost sites for sandhill cranes. Rowe 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 bird 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 FWS, through its Partners for Fish and Wildlife Program (PFW), 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 cranes and whooping cranes and to also provide least tern and piping plover nesting habitat. Several different methods and combinations of methods have been used by FWS 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 FWS 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 FWS 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. FWS 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 the sites have been used by whooping cranes.

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

The FWS 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 FWS have used this process in clearing islands and accretion ground between 6 and 72 acres. Several of these projects were recently completed and response has not been determined. The FWS reported that sites that have been cleared for several years have received high use by cranes and waterfowl.

The FWS 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 FWS feels that more time is needed to determine the long-term effectiveness.

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 *D. Open Riverine and Non-River Areas*.

C.1.4. Other Methods

The FWS 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 FWS, this method was success

in the small area. FWS does not report if the same method could be used in larger areas. Additional information is contained above in Section *A.2.2. Tree Removal.*

~~The FWS 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 using (methods, results, goals, etc.)~~

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 *A.2.5. Costs* above. Costs associated with clearing activities not reported above are shown below.

Large Trees	
Hydro-ax	$125/acre, NPPD
Mowing (brushog)	~~$?/acre. Rowe~~
Chemical Applications	
Rodeo to Stumps	$100/acre, NPPD
General application	~~$?/acre, Trust~~

C.1.6. Control

The Trust, TNC, Rowe, and NPPD have conducted channel clearing activities primarily 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. The FWS has conducted their clearing activities through the PFW Program in which relatively short-term leases (10-15 years) are used for control. The FWS has found that landowners are very interested in entering into this program and working with the FWS to clear river habitat. Fee title, leases, and easements 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 and grass 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, Rowe 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 FWS 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 FWS 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 noxious weed.

C.2.2. Burning

One area initially cleared by Rowe 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. Rowe 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 FWS 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 control vegetative growth on areas cleared 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 *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 *A.2.5 and C.1.5. Costs*. Costs associated with burning and chemical applications are discussed below.

Burning	~~$?/acre, Rowe~~
Pre-emergent herbicide	$175/acre, NPPD

D. OPEN RIVERINE AND NON-RIVERINE AREAS

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.

Rowe, Trust, and FWS also manage islands and sandbars that could be utilized by least terns and piping plovers for reproductive habitat. These lands were described above in Section *C. Open River Channel*. Islands and sandbars cleared of vegetation to provide roosting habitat for cranes may also 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. NGPC anticipates providing approximately 40 acres of suitable habitat.

D.1. RIVERINE HABITAT

Central manages one riverine site for least terns and piping plover. 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 areas between Lexington and Chapman.

In ~~DATE~~, 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 *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 effect 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, 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 predator fence exclosures 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 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. Portable electric fences have been used two of the locations and a permanent fence is used at one location. The portable electric fences are similar to those described above in Section *D.1. Riverine Habitat*. The permanent fence is used to discourage predators from entering a peninsular area. 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 places 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. NPPD believes 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.

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 (i.e., 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 *A.2.5. Costs*.

Island Enhancing	
Sand Dredging	$15,000/acre 1 foot deep, NPPD
Vegetation Control	
Harrowing	$25/acre, NPPD
Rototilling	$25/hour, NPPD
Discing	$100/acre, NPPD
Hand-pulling	$250/acre, NPPD
Mowing (brushog)	$50/acre, NPPD
Hand cutting of small trees	$1500/acre, NPPD
Pre-emergent herbicide	$175/acre, NPPD
SEA Bags for erosion	$400/bag, NPPD
Predator Exclosures	
Portable electric fence	$0.50/foot, NPPD
Permanent fence	$5/foot, NPPD

D.4. CONTROL

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, Rowe, 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 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 (i.e., Trust pays 40% of expenses and receives 40% of crop).

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

NPPD also has cropland, a part of Cottonwood Ranch, 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, FWS, 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 threatened or endangered species addressed 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, FWS, 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 FWS, 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

V. TECHNICAL MEETING RESULTS

VI. SUMMARY

APPENDIX I - Example 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 Rowe Sanctuary
Gibbon, Nebraska

Platte River Whooping Crane Maintenance 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, Nebraska

II. METHODS

B. Literature Review

A literature search was conducted to obtain relevant ~~published~~ literature on habitat management methods for the whooping crane, least tern, and piping plover. ~~The search was conducted using the University of Wyoming library system.~~ Several databases were searched including *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. Contact ~~was~~ made by ~~both~~ telephone and email ~~(if available).~~ The following agencies/organizations were contacted:

- U.S. Fish and Wildlife Service, Grand Island?
- Army Corp of Engineers
- Nebraska Game and Parks
- 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
- Lost Wood National Wildlife Refuge, North Dakota

All articles and information collected were carefully reviewed and grouped according to "published" or "gray" literature. "Published" literature refers to published, and? peer-reviewed articles typically found in professional journals, books, and databases available through libraries or commercially. "Gray" literature refers to sources of information that are not published, generally not peer-reviewed, and typically available from sources outside the "normal" publishing system. Examples of gray literature include conference papers, and information generated by research establishments, government agencies, private publishers, corporations, trade associations/unions, think tanks, and academia.

IV. LITERATURE REVIEW RESULTS

Over 50 ~~published~~ articles on whooping cranes, least terns, and piping plovers were reviewed. Sources included leading scientific journals such as *Journal Wildlife Management, The Prairie Naturalist, Conservation Biology, Great Basin Naturalist, Journal of Field Ornithology, the Wilson Bulletin, Wildlife Society Bulletin, Wildlife Monographs, Ecological Monographs* and others. Forty additional ~~gray literature~~ articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings* and the *Missouri River and It's Tributaries Piping Plover and Least Tern Symposium/Workshop*), as well as unpublished reports and data from federal and state agencies, conservation groups, and the irrigation and electric districts.

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 were also reviewed in order to gain an understanding of 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 the "References" section.

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, 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 (Johnson 1994, Johnson 1997, Johnson 1998, Sidle et al. 1989, McDonald and Sidle 1992). As an important stopover area during migration, habitat needs in the Platte River valley for whooping cranes include roosting habitat (open river channel) and feeding habitat (bottomland and upland grasslands) (Currier et al 1985, citations). In addition, open riverine habitat is needed for nesting and rearing habitat for least terns and piping plovers (citations). Management efforts over the past few decades have focussed on restoring or increasing these habitats, 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 river channel, open riverine and non riverine, cropland, and other habitats (e.g.).

A. BOTTOMLAND GRASSLAND

Bottomland grassland generally refers 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 primary feeding and secondary roosting habitat for whooping and sandhill cranes.

B. UPLAND GRASSLAND

Upland grasslands are dry areas that are mostly free of woody vegetation. ~~While this habitat type is not widely used by the target species,~~ upland grasslands are a ~~secondary~~ source of forage for whooping cranes and provide cover for whooping cranes and other bird species and wildlife in general.

Relatively few articles were found on management techniques for upland grassland habitat during the literature review. Those that were found include habitat acquisition, burning, grazing, haying, and other. Each are discussed below.

B.1. Habitat Acquisition

B.1.1 ~~Published~~ Literature

No information was found in the ~~published~~ literature that directly relates to habitat ~~acquisition~~ as a tool for whooping crane habitat management, however 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. Private entities have set aside 4,800 ha in Nebraska for migration stopover habitat protection. While Cannon (1996) gives no detail on the management of these set-asides, he notes that these efforts at habitat protection by purchase and set-aside have no doubt helped to preserve the endangered whooping crane (Cannon 1996).

B.1.2 ~~Gray~~ Literature

Several authors have suggested ~~acquisition~~ of whooping crane habitat to enhance recovery, however few details were given beyond merely making the suggestion (Johnson 1981, USFWS 1981). 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 Sections B.2.2, B.2.3, and B.2.4). The USFWS (1981) suggested preservation of native grassland tracts 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.

B.2. Burning

B.2.1 Published Literature

Over a 12-year period, Chavez-Ramirez et al. (1996) investigated whether whooping cranes use upland habitat ~~primarily~~ 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 area. 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 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. Prescribed burning should be done consistently to facilitate use by whooping cranes (Chavez-Ramirez et al. 1996).

B.2.2 Gray Literature

Little information was available in the gray literature on burning upland grasslands as a management technique for whooping crane habitat. 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. Johnson (1981) provided no further detail beyond these management suggestions.

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 upland grassland whooping crane 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 can not 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.3. Grazing

B.3.1 Published Literature

No information was found in the published literature regarding the use of grazing as a management technique for upland grassland whooping crane habitat.

B.3.2 Gray Literature

As described in Section 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. Johnson (1981) provided no further detail beyond these management suggestions.

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 grazing is not effective at controlling woody plant invaders. No information of 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.4. Haying

B.4.1 Published Literature

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

B.4.2 Gray Literature

As described in Section 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. Johnson (1981) provided no further detail beyond these management suggestions.

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 *Eleagnus angustifolia*) and avoiding the need for fencing with its known dangers to cranes. Strom (1995) also noted, however, that haying can reduce the nutrient reserves of grasses, but this loss can be avoided by waiting until after September 30th to hay. No information of cost of treatment was provided. It should be noted that this proposed management plan is dated from 1985;

I have not been using sage. I see no but maybe we should. What do you think?

current management of the Lillian Annette Rowe Sanctuary is described in Section III, Survey Results.

B.5. Other

B.5.1 Published Literature

No information was found in the published literature on other management techniques for upland grassland whooping crane habitat.

B.5.2 Gray Literature

Little information was found in the gray literature on other techniques for upland grassland management, however 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.

II. METHODS

B. Literature Review

A literature search was conducted to obtain relevant ~~published~~ literature on habitat management methods for the whooping crane, least tern, and piping plover available ~~in~~ through the University of Wyoming library system, as well as other library systems. Several databases were searched including *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 agencies/organizations were contacted:

- U.S. Fish and Wildlife Service, ~~Grand Island?~~ Clayton
- Army Corp of Engineers
- Nebraska Game and Parks
- 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
- Lost Wood National Wildlife Refuge, North Dakota

The goal of the literature review was to collect and review, 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. Both types of literature contained valuable information relevant to the project.

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. Forty additional non peer-reviewed literature articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings* and the *Missouri River and It's Tributaries Piping Plover and Least Tern Symposium/Workshop*), popular literature, and unpublished reports and data from federal and state agencies, conservation groups, and the Districts.

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 were also reviewed in order to gain an understanding of

II. METHODS

B. Literature Review

A literature search was conducted to obtain relevant published literature on habitat management methods for the whooping crane, least tern, and piping plover. The search was conducted using the University of Wyoming library system. Several databases were searched including *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. Contact was made by both telephone and email (if available). The following agencies/organizations were contacted:

- U.S. Fish and Wildlife Service
- Army Corp of Engineers
- Nebraska Game and Parks
- Nebraska Public Power District
- Central Nebraska Public Power District
- Platte River Whooping Crane Trust
- Northern Plains Research Institute
- South Dakota State University ~~(Carter Johnson)~~
- North Dakota Fish and Wildlife
- Lost Wood National Wildlife Refuge, North Dakota

All articles and information collected were carefully reviewed and categorized as to "published" or "gray" literature. "Published" literature refers to published, peer-reviewed articles typically found in professional journals, books, and databases available through libraries or commercially. "Gray" literature refers to sources of information that are not published, generally not peer-reviewed, and typically available from sources outside the "normal" publishing system. Examples of gray literature include conference papers, and information generated by research establishments, government agencies, private publishers, corporations, trade associations/unions, think tanks, and academia.

IV. LITERATURE REVIEW RESULTS

The literature search revealed a considerable amount of information available on whooping cranes, least terns, and piping plovers. Over 50 published articles were reviewed, most from leading scientific journals such as *Journal Wildlife Management, The Prairie Naturalist, Conservation Biology, Great Basin Naturalist, Journal of Field Ornithology, the Wilson Bulletin, Wildlife Society Bulletin, Wildlife Monographs, Ecological Monographs* and others. An additional __ gray literature articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings* and the *Missouri River and It's Tributaries Piping Plover and Least Tern Symposium/Workshop*), as well as unpublished reports and data from federal and state agencies, conservation groups, and the ~~water and~~ Irrigation

electric ~~power industry~~ districts. The literature review focussed on articles and information that addressed habitat management methods, habitat requirements, and habitat condition. It should be noted ~~to the reader~~ that numerous other articles on 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 the project (e.g. biology) or they addressed a related species (e.g. sandhill crane). 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 the "References" section.

Both the published literature and the gray literature contained important information relevant to the project. The literature search revealed a large amount of gray literature on the whooping crane and its habitat, and relatively few published articles. The opposite was true for the least tern and piping plover (i.e., more published articles than gray literature). The following sections summarize the literature reviewed for both categories of information; published literature is presented first, followed by gray literature.

A. Published Literature Review

The focus of the literature review was on habitat management techniques for the whooping crane, least tern, and piping plover. However, in order to gain an understanding of why various habitat management methods are used, it was also important to review articles dealing with habitat requirements of the target species, the existing habitat conditions, and reasons for decline. A considerable amount of work has been done in these areas. Approximately two-thirds of the published literature reviewed addressed these questions. While some work has been done specifically on habitat management techniques, only about one-third of the available published literature retrieved during the literature search specifically addressed this topic.

A.1. Background

Many of the articles reviewed ~~studied~~ focused on habitat use and requirements of the three target species. Habitat requirements in the Platte River valley are similar for all three species, namely, relatively undisturbed barren sandbars near open stretches of river channel (Lingle, et al. 1984, Faanes 1983). Whooping cranes use this habitat for roosting during their spring and fall migrations. ~~The Platte River valley is an important stopover area during migration (Lingle, et al. 1984).~~ In addition to the river roost habitat, whooping cranes also use nearby ~~wetlands~~ bottomland grasslands (with wetlands) and fields as feeding habitat (Sidle, et al. 1989). Least terns and piping plovers use the sandbar habitat for nesting during the spring and summer months (Faanes 1983).

There is 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, Gaines and Ryan 1988, Vaske et al. 1994, Ryan et al. 1993, Patterson et al. 1991, Schulenberg and Ptacek 1984). Hunting and competition for food have also been 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 (Johnson 1994, Johnson 1997, Johnson 1998, Sidle et al. 1989, McDonald and Sidle 1992). Habitat loss has been primarily attributed to impoundment and diversion of water in the Platte River system for agriculture and power generation (Sidle et al.1989, Ziewitz et al.1992). This has reduced water and sediment discharge into the Platte River, and has resulted in a transformation of a river with open channels and scattered woodlands to one with much narrower tree-lined channels and extensive riparian forest on its floodplain (Ziewitz et al.1992, Carter 1997, McDonald and Sidle 1992). The reduction in peak and seasonally high flows does not allow for the movement of sediment needed to maintain a wide and shallow channel and to scour seedlings (Sidle et al.1989).

Despite the habitat loss, the Platte River valley still provides important habitat for the target species and others, and management efforts over the past few decades have focussed on restoring or increasing habitat. Management efforts have also been aimed at reversing other causes of decline.

A.2. Habitat Management Methods

A variety of management techniques have been tried over the past several decades aimed at restoring or improving habitat for the whooping crane, least tern, and piping plover. Loss or disturbance of habitat has been often cited in the literature as a major factor in the decline of these species (Cannon 1996, Lingle et al. 1984, Smith and Renken 1993, Rimmer and Deblinger 1992, Gaines and Ryan 1988, Vaske et al.1994, Ryan et al.1993, Patterson et al. 1991, Schulenberg and Ptacek 1984). In the case of the whooping crane, habitat losses have occurred at nesting, migration, and wintering habitats, and habitat management efforts have occurred throughout its range (Cannon 1996). In the case of the least tern and piping plover, habitat management efforts have been focussed on nesting habitat, and techniques to improve chick survival.

Based on the literature review, the methods listed below (in no particular order) have been studied to manage habitat for the whooping crane, least tern, and piping plover. Each are discussed in more detail below.

- Purchase or set aside
- Creation or restoration of habitat
- Minimization of human disturbance
- Vegetation management
- Predator control
- Water management

Note that not all the information reviewed fit preciously into one category or another. Sometimes a combination of techniques was used in a particular study. These categories

were chosen based on the literature review, and are intended as a general grouping of management methods.

A.2.1 Purchase or Set Aside

Several authors have recommended protection of habitat as a means of protecting the target species, either by purchase or other means (McDonald and Sidle 1992, Sidle, et al. 1989, Sidle and Kirsch 1993, Schulenberg and Ptacek 1984).

As Cannon (1996) explains, both public and private entities have been involved in habitat protection for the whooping crane through purchase and set-asides. 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. Private entities have set aside 4,800 ha in Nebraska for migration stopover habitat protection. These efforts at habitat protection by purchase and set-aside have no doubt helped to preserve the endangered whooping crane (Cannon 1996). These efforts have likely benefited the least tern and piping plover as well.

A.2.2. Creation and/or Restoration of Habitat

Habitat creation has been recommended or studied by several authors (Ziewitz et al. 1992, Patterson et al. 1991, Powell and Cuthbert 1992, Koenen and Utych 1996, Prindiville Gaines and Ryan 1988). Habitat creation has been largely focussed on creating sandbars in river channels, important habitat for all three target species but particularly least terns and piping plovers for nesting. Other authors have suggested or studied alteration of existing habitat.

Ziewitz et al.(1992) studied habitat conservation for nesting least terns and piping plovers on the Platte River in Nebraska. They report least terns and piping plovers use artificial islands, and recommend creation of sandbars by dredging to provide suitable nesting substrate for least terns and piping plovers. As further support for habitat creation, Downing (1973) conducted a survey of least terns and black skimmers from Mississippi to New Jersey, and found that 80 percent of habitat used was manmade, mostly dredging and development spoil. As noted by Sidle and Kirsch (1993), the Nebraska Public Power District has constructed sand and gravel islands in the Platte River channel for least tern and piping plover habitat under the terms and conditions of their license to operate Kingsley Dam. The authors recommend continuation of these and similar efforts (Sidle and Kirsch 1993). 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 sites were continuously exposed above the river. They recommend restoration or creation of sandbars by raising them to a suitable elevation by modifying dike structures or constructing chevron dikes. As an additional benefit, Powell and Cuthbert (1992) and Ziewitz et al.(1992) note that sandbar islands (including created islands) have fewer predators and lower human disturbance.

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 they provide an alternative nesting area where sandbar habitat is limited, particularly along the central Platte River. They found active sandpits are most often used, since abandoned pits are often developed, reclaimed, or naturally revegetate. Sidle and Kirsch 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. However, they further recommend enhancement and protection of riverine habitat.

Prindiville Gaines and Ryan (1988) studied piping plover habitat use in North Dakota, and found beach width and gravel (among others) to be important habitat components. She suggests widening beaches that are < 20 m wide by spreading gravel. Increasing the amount and distribution of gravel may reduce nest losses.

Not all habitat creation efforts have been successful. Koenen and Utych (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 long x 1 m wide x 0.5 m 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.

A.2.3. Minimization of Human Disturbance

The whooping crane, least tern, and piping plover prefer habitats with minimal human disturbance (Cannon 1996, Burger 1994, Brunton 1997, Schulenberg and Ptacek 1984). 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).

Limiting human activity in least tern and piping plover nesting habitat during the breeding season has been recommended and used as a means of reducing human disturbance. For example, Melvin et al. (1991) recommends banning recreational vehicles on sections of beaches where unfledged piping plover chicks are present. Monitoring, research, and law enforcement should accompany such bans (Melvin et al. 1991). Powell and Cuthbert (1992) report that beach areas on Great Lakes islands have been closed during nesting season. Brunton (1997) reports similar restrictions on human activity at Sandy Point in Connecticut. Human activity can be limited through use of signing and fencing (Patterson et al.1991, Kirsch 1996, Melvin et al.1992). Kirsch (1996) reports these measures have been effective in deterring human intrusion. Other activities to reduce disturbance have included distribution of educational materials, conflict resolution, and patrols to thwart trespassers (Sidle and Kirsch 1993).

Other techniques also serve to indirectly minimize human disturbance. For example, in both Atlantic coastal habitats and on Great Lakes island beaches, it was found that a diversity of habitats available near nesting sites can help to reduce competition with humans (Burger 1994, Powell and Cuthbert 1992). Therefore, protection of diverse

habitat would help to minimize the impacts of human disturbance. In addition, the creation of island habitat has been shown to be effective at minimizing human disturbance (Powell and Cuthbert 1992, Ziewitz et al.1992).

Anything for Cranes?

Types of veg
- cottonwood
- juniper
- shrubs
- tall grass

Any mention of these species or others?

A.2.4 Vegetation Management

Several techniques have been used to manage vegetation for whooping cranes, least terns, and piping plovers. These techniques range from providing supplemental food crops, to clearing vegetation on roosting and nesting sites using methods such as mechanical clearing and burning (Chavez-Ramirez et al. 1996, Shields and Benham 1969, Prindiville Gaines and Ryan 1988).

Shields and Benham (1969) experimented with providing farm crops as a supplemental food source at whooping crane wintering grounds in Texas. They suggest the use of supplemental feeding only during times of food scarcity. They found that sandhill cranes and geese consumed a considerable portion of food intended for whooping cranes.

Chavez-Ramirez et al. (1996) found that, while at their wintering range in Texas, whooping cranes were attracted to fire-treated uplands (as opposed to other uplands) as an alternative food source. The burning gave access to food resources such as vertebrate and invertebrates killed by the fire. Chavez-Ramirez et al. (1996) suggested that if used, burning be done consistently during the winter. Like Shields and Benham (1969), Chavez-Ramirez et al. suggest prescribed burning be based on reduced availability of marsh food resources. (1996)

Faanes (1983) determined clear visibility is an essential habitat component for least terns and piping plovers. He recommended vegetation clearing during the non-nesting season, noting success with clearing in California. Similar success has been noted by Lingle et al. (1984), who report whooping crane use of a site that had been mechanically cleared. Other authors also recommend vegetation control (prior to nesting season), including Schlenberg and Ptacek (1984) and Prindiville Gaines and Ryan (1988).

Any other info for cranes?

It should be noted that some authors, most notably Johnson (1994, 1997, 1999, Prindiville Gaines and Ryan 1988), have raised concerns about vegetation clearing practices. Johnson has shown that open channel and woodland areas along the Platte River have reached an equilibrium since the 1960's (Johnson 1997), and clearing of the woodlands may be detrimental to the Platte River ecosystem (Johnson 1999). For example, soil disturbance associated with clearing promotes weeds and releases sediment, and the woodlands provide nesting and migrational stopover habitat for a large number of bird species. In addition, Johnson (1997) has shown that areas where vegetation has been removed to increase open channel habitat for migrating whooping cranes may have the opposite effect downstream by locally oversupplying the river with sediment and initiating channel narrowing and woodland expansion ~~(1997)~~. Johnson (1994) also notes that migrating cranes seek out roosting areas protected by trees and shrubs during inclement weather ~~(1999)~~. Other concerns regarding the use of mechanical treatments include

undesirable surface disruption in piping plover habitat (Prindiville Gaines and Ryan 1988).

A.2.5 Predator Control – Can the previous sections be "beefed-up" so they contain the same level of detail as this section, or does the info not exist?

Predator control techniques, such as exclosures, electric fencing, and chick shelters, are used primarily for least terns and piping plovers to reduce the impacts of predation. 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). Koenen et al. 1996 found nest predation higher nearer vegetated areas. Predators were not listed in the literature reviewed as a major factor in the survival of the whooping crane. However, predators (including bobcats, wolves, black bears, coyotes, and raptors) will go after young and sickly birds and eggs in their nesting range (Cannon 1996).

Predator exclosure use at piping plover nests were studied by Melvin et al.(1992) on outer Cape Cod, Massachusetts. The exclosures consisted of galvanized wire mesh fencing placed in a 3.2 m diameter circle around the nest. Modifications such as burying the exclosure deeper or extending a wire-mesh apron laterally from the base can be made to discourage predators from digging under the exclosure. Similarly, twine or monofiliment line can be stretched over the top to discourage avian predators; 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). 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 and found that abandonment rates ~~with~~ 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. 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. 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 and Utych (1996) also studied electric fencing and found them to be effective at reducing predation on least terns, however they did note some problems. 1. The fences only protected a fraction of the nesting terns. 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 successful use of an electric fence one-mile in circumference, in preventing red fox predation at Cape Cod National Seashore, but noted high costs 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 Mueller (1981). 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 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.

A.2.6 Water Management

Water management was identified as a tool in several published articles to either directly or indirectly manage habitat for the target species (North 1986, Johnson 1994, McDonald and Sidle 1992, Lingle et al. 1984, Smith and Renken 1993, Ryan et al. 1993, Faanes 1983). Direct management refers to regulation of water levels to avoid flooding nesting habitat and nest sites of least terns and piping plovers (North 1986). Indirect management refers to water flow management as a means of controlling vegetation encroachment (Johnson 1994). It should be noted that none of the articles assessed an actual case where water management has been used to manage avian habitat specifically, instead water management has merely been suggested or recommended.

Direct Management:

Least terns and piping plovers nest on sandbars and beaches along rivers, lakes, and reservoirs (North 1986). Flooding can destroy nests during the nesting period (generally from April trough June) (Cairns 1982, Kirsch and Dinan 1992). On regulated systems, water releases can be managed to minimize flooding of nests. Prindiville Gaines and Ryan (1988) recommend drawing water levels down to maximize habitat during 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.

Indirect Management:

Water impoundment and diversion in the Platte River system for agriculture and power generation has been cited repeatedly as a direct cause of vegetation encroachment on the Platte River in Nebraska, and the resulting loss of habitat for the target species (Johnson 1998, Johnson 1994, McDonald and Sidle 1992). McDonald and Sidle (1992) found that the cumulative effect of water projects throughout the Platte River system (not ~~only~~ in Nebraska) is responsible for the habitat changes. Analyses have shown that the rate of vegetation encroachment is inversely related to June streamflow (Johnson 1994). Other flow-related factors affecting vegetation encroachment include ice scouring, peak spring flows, and late-summer flows (Johnson 1994). Based on this information, Johnson (1994) has recommended the following options for water flow management to minimize woodland expansion:

- Prohibit recruitment in the active channel by augmenting June flows.
- Increase seeding mortality by:
  raising winter flows to increase ice scouring,
  increasing spring peak erosive flows to remove seedlings, or
  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.

Kirsch and Dinan (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 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.

Other authors have noted that maintenance of water levels prevent predators and humans from accessing islands where the target species roost and nest (Faanes 1983).

B. Gray Literature Review

As mentioned previously, the gray literature was an important source of information on the three target species and management of their habitat. In particular, the gray literature contained a lot of information on the whooping crane and general habitat conditions along the Platte River in Nebraska. The *Proceedings of the North American Crane*

Workshops were particularly helpful, as were data provided by government agencies, conservation groups, and industry. Over 50 percent of the gray literature reviewed was related to whooping cranes or habitat along the Platte River, with the remainder related to least terns and piping plovers. As with the published literature, information concerning habitat requirements of the target species, the existing habitat conditions, and reasons for decline was reviewed along with information specifically related to habitat management methods.

B.1. Background

Several often-cited documents describing habitat for whooping cranes, least terns, and piping plovers in the Platte River valley are found in the gray literature. These include a U.S. Geological Survey report *The Case of the Shrinking Channels – the North Platte and Platte Rivers in Nebraska* (Williams 1978) and *Migratory Bird Habitat on the Platte and North Platte Rivers in Nebraska* (Currier et al. 1985). While both of these documents are somewhat dated, they provide valuable background information on the habitat that exists today. Williams (1978) documents the decreases in channel width and vegetation encroachment on the North Platte and Platte Rivers over the past century due to water regulation and diversion. Currier et al. (1985) also describe historical changes on the rivers and the impact of habitat changes on migratory birds, which includes loss of habitat for the target species. In addition, they provide recommendations for managing migratory bird habitat.

Another useful report is available from the U.S. Fish and Wildlife Service (USFWS 1991), *The Platte River Ecology Study, Special Research Report.* This document also reports whooping crane habitat degradation associated with channel shrinkage due to a decline in flows. USFWS (1991) identifies the importance of preservation and management (e.g. grazing and burning) of native grasslands adjacent to roosting sites, and well as roosting habitat, for whooping cranes and other species.

B.2. Habitat Management Methods

As with the published literature, a variety of management methods aimed at restoring or improving habitat for the whooping crane, least tern, and piping plover have been documented in the gray literature. These methods can generally be categorized as follows (in no particular order):

- Purchase or set aside
- Creation or restoration of habitat
- Minimization of human disturbance
- Vegetation management
- Predator control
- Water management

Note that not all the information reviewed fit preciously into one category or another. Sometimes a combination of techniques was used in a particular study. These categories

were chosen based on the literature review, and are intended as a general grouping of management methods.

B.2.1 Purchase or Set Aside

Numerous documents in the gray literature recommend purchase or set aside of suitable habitat as a means of protection for the target species (Johnson 1981, Lingle 1985, Lingle no date, Faanes 1988). Johnson (1981) says the key to managing whooping cranes along the Platte River is habitat acquisition and maintenance. Furthermore, Johnson identifies the top priority for acquisition as riverine habitats for roosting in association with extensive nearby wet meadows and native grasslands for feeding. He suggests acquisition efforts be continue to be spearheaded by private conservation organizations. Examples of such acquisition include 1.) 810 acres of ~~pristine~~ habitat along the Platte River were acquired or leased by the Audubon Society in 1974 and established as the Lillian Annette Rowe Sanctuary (Strom 1985), and 2.) nearly 810 acres of ~~prime~~ habitat on Mormon Island were acquired through a cooperative effort of The Nature Conservancy and the Platte River Whooping Crane Critical Habitat Maintenance Trust in 1979 (Lingle 1981). The Platte River Whooping Crane Critical Habitat Maintenance Trust is an organization established through an agreement with Basic Electric Power Cooperative to preserve migratory bird habitat on the Platte River (VanDerwalker 1981).

B.2.2 Creation or Restoration of Habitat

In Kansas, where flooding and predation were found to be limiting factors for least terns at a nesting colony, nest pads were constructed to minimize the impacts of the flooding (Boyd 1993). Nest pads consisted of a ring of bricks 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. The nest pads were surrounded by an electric fence to reduce predation. At this site, the number of fledglings per breeding pair increased during the 2-year period nest pads and fencing were used as compared to the previous 12-year average (Boyd 1993).

Habitat creation and restoration efforts have been carried out in Colorado on the lower reaches of the Arkansas River where monitoring of least tern and piping plover habitat showed decline (Nelson 1999). Snake predation was found to be problematic and predator exclosures were tried, but with no success since most exclosures described in the literature are not intended for, or effective against, snake predation. At this site, habitat restoration efforts included manually clearing and burning approximately 100,000 trees. 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. In addition, island habitats were elevated through favorable natural conditions and use of cleared vegetation that was submerged in the shallow water. This submerged vegetation accumulated sand from the water and built up over time. One island rose 30 inches over a 1-year period. As a result of these efforts, piping plovers and least terns are "hanging on" in Colorado (Nelson 1999).

What did this do to "correct" the snake prob discussed ju prior in the

Latka et al. (1993) also assessed creating additional piping plover and least tern nesting habitat by increasing the elevation of low sandbars. They used snow fences to create dunes from wind-blown sand, oyster shells to reduce wind erosion on remaining sand dunes, bulldozers to reshape islands, and crane-on-barge dredging of bottom sediments and piling them onto existing low-elevation sandbars.

What were the effects of this mgt

Gordon and Kruse (1999) report on nest relocation as an 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 percent of the piping plover nests and 100 percent of the least tern nests was resumed after relocation. Nests were relocated using three different methods, and success was achieved while relocating to both natural and artificial substrates.

What were the 3 methods? Did all work the same?

The Nebraska Public Power District has developed ~~several~~ three islands on the Platte River to use as nesting habitat for piping plovers and least terns (NPPD 1997). The first was located near Elm Creek (Plettner 1993). Work on this 1.4 ha 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 chain sawing; 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, 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. 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.

One island has been "reconnected" the river bank is not used.

Wasn't it dredge right at the isl location?

What about the other two isl what was the succe in bring birds to the islands, nesting, fl

In addition to the island habitat created by Nebraska Public Power District, the District has developed off-river sandpit habitat for least tern and piping plover nesting through a lease agreement with a private landowner (Plettner 1993).

3 sandpits

Howe (1985) identified the importance of close proximity (< 1 km) of feeding (wetlands and croplands) and roosting sites for migrating whooping cranes. Large wetlands did not appear to be important, rather many smaller wetlands < 1 ha in size. Howe suggested creations of such wetlands to expand suitable habitat for migrating cranes.

What shall the wetlands consist of Sp veg., depth? Any suggestion on creation metho

B.2.3 Minimization of Human Disturbance

Several strategies were suggested in the gray literature to minimize human disturbance at whooping crane, least tern, and piping plover habitat. For example, Johnson (1981), suggested removal or relocation of telephone lines, power lines, and fences from feeding areas and between roosting and feeding areas to minimize potential for collision. Lingle, (1985) suggested marking utility lines adjacent to key habitat with highly visible plastic

For Cranes only or all 3 sp.?

balls or strips. Cooper and Fries (1993) document 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.

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.

B.2.4 Vegetation Management

Boyd (1993) reported on removal of salt cedar and inland salt grass at least tern habitat along the Cimarron River in Kansas. Removal was carried out by bulldozing, disking, and spraying with herbicides. Bulldozing was the most effective method.

Faanes (1988) documented the importance of unobstructed visibility, both width and length, for roosting migrating whooping cranes. Faanes suggests active management of the riverine channel using mechanical means, coupled with adequate stream flows, may be the best method to ensure adequate open channel width and length for migrating whooping cranes.

Latka et al.(1993) studies several vegetation removal methods on the Missouri River system, including tilling, herbicides, bulldozing, mowing, disking, and burning. Herbicide use in combination with tilling or disking was the most successful, but herbicide use was not recommended due to limited data on toxicity. Burning was not successful due to sparse vegetation, and mechanical removal was not very effective.

Johnson (1981) suggests both indirect and direct methods of vegetation control to create or maintain open habitat for the target species. Indirect methods include maintaining water flow regimes during both the summer and the winter. Summer flows would prevent germination and establishment of seedlings on sandbars; winter flows would facilitate ice formation and subsequent flushing of ice during breakup resulting in scouring of vegetation. Direct vegetation management methods for clearing whooping crane roosting sites include manual clearing, mechanical clearing, burning, island obliteration (clearing and leveling), and application of herbicide (Johnson 1981). Direct methods for managing vegetation at feeding sites include grazing, controlled burns, cutting, or a combination.

A variety of methods for clearing woody vegetation at whooping crane roosting sites were investigated near Mormon and Shoemaker Islands (Currier no date). Currier found the most effective method to clear woody islands and sandbars was shredding followed

by diskings. Herbicides were also found to be effective, but not recommended, due to uncertainties about long-term environmental effects.

During the first decade of management at the Lillian Annette Rowe Sanctuary (1975 – 1985), management of grassland feeding habitat consisted of maximizing wetlands and grasslands for feeding habitat. This was accomplished through burning, grazing, haying, and various combinations (Strom 1985).

B.2.5 Predator Control

Similar to data found in the published literature from the Atlantic coast and Great Lakes regions, predator control measures (nest cages and electric fences) were found to be effective in improving 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); two studies from 1997, one in Montana (Casler and Rabenberg 1997) and one in North Dakota (Danley and Smith 1997); a 1998 North Dakota study (Hoovestol 1998); and a 1999 Montana summary report from Montana and North Dakota (USFWS 1999).

what did the exclosures & cage look like - size mesh, single wi area covered, e

Jennigés 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, snake fences, and traps and predator removal by U.S.D.A Animal Damage Control. They found 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.

Any more det regarding the examples given

B.2.6 Water Management

Many authors recognize water level management as an important management tool (Johnson 1981, Lingle 1985, Lingle 1993a, Lingle 1993b, Faanes 1985, Currier 1995, Faanes and Bowman 1988).

Johnson (1981) recommends water flow regimes be maintained during the spring and fall because whooping cranes require water for roosting. He also suggests leasing or purchasing of water rights to insure adequate flows.

In Currier (1995, 1996), the author documents a continuing trend toward narrowing of the river channel in whooping crane roost areas along the Platte River. Currier predicts channel-narrowing trends will continue unless water is managed to maintain fluctuating spring and summer pulse flows and mid-summer base flows. He recommends land management (clearing of vegetation) in combination with water management to preserve open riverine habitat.

Any suggestio on flows, timing, etc

Faanes and Bowman (1988) found that 3 to 5 years of reduced flow levels apparently are sufficient to permit encroaching vegetation to become permanent. They recommend a minimum of 5 consecutive days of 8,000 cfs to maintain the existing channel

good - similar info for others?

configuration. Ziewitz (1988) found flows of approximately 2,000 cfs to 2,400 cfs provide optimal conditions for whooping crane roosting on the Platte River.

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II. METHODS

B. Literature Review

Databases searched:
First Search
Infotrack
Agricola
WYLDCat

A literature search was conducted to obtain relevant published literature on habitat management methods for the whooping crane, least tern, and piping plover. The search was conducted using the University of Wyoming library system, including the __ database and the ____ database. 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. Contact was made by both telephone and email (if available). The following agencies/organizations were contacted:

- U.S. Fish and Wildlife Service
- Army Corp of Engineers
- Nebraska Game and Parks
- Nebraska Public Power District
- Central Nebraska Public Power District
- Platte River Whooping Crane Trust
- Northern Plains Research Institute
- South Dakota State University (Carter Johnson)
- North Dakota Fish and Wildlife
- Lost Wood National Wildlife Refuge, North Dakota

Consider combining these two ¶

The search distinguished between two types of literature: 1) published, peer-reviewed papers typically found in professional journals, books, and databases available through libraries or commercially, and 2) "gray literature," or sources of information that are typically outside the "normal" publishing system and only available through specialized channels. Examples of gray literature include unpublished conference papers, and information generated by research establishments, government agencies, private publishers, corporations, trade associations/unions, think tanks, and academia.

some of the "gray literature" available @ the lib (e.g., Proc. N. Amer. Crane Workshops, Army Corps of Engineers Tech. Reports

All articles and information collected were carefully reviewed and categorized as to published or gray literature, and then further classified as to the management technique described, or as background information.

IV. LITERATURE REVIEW RESULTS

The literature search revealed an abundance of information on whooping cranes, least terns, and piping plovers. Over __ published articles were reviewed, most from leading scientific journals such as *Journal Wildlife Management, The Prairie Naturalist, Conservation Biology, Great Basin Naturalist, Journal of Field Ornithology, the Wilson Bulletin, Wildlife Society Bulletin, Wildlife Monographs, Ecological Monographs* and others. An additional __ "gray literature" articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane*

II. METHODS

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 in the University of Wyoming library system, as well as other library systems. Several databases were searched including *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 agencies/organizations were contacted:

- U.S. Fish and Wildlife Service
- Army Corp of Engineers
- Nebraska Game and Parks
- 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
- Lost Wood National Wildlife Refuge, North Dakota
- USGS - BRD

The goal of the literature review was to collect and review, 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. Both types of literature contained valuable information relevant to the project.

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. Forty additional non peer-reviewed literature articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings* and the *Missouri River and It's Tributaries Piping Plover and Least Tern Symposium/Workshop*), popular literature, and unpublished reports and data from federal and state agencies, conservation groups, and the Districts.

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 were also reviewed in order to gain an understanding of

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; 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). As an important stopover area during migration, habitat needs in the Platte River valley for whooping cranes include roosting habitat (open river channel) and feeding habitat (bottomland and upland grasslands) (Currier et al 1985). In addition, 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 habitats, 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 river channel, open 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 roosting habitat for whooping and sandhill cranes (Currier 1987). Several authors noted that the presence of some type of wetland (i.e., bottomland grassland habitat) is a requirement of whooping crane migration habitat (Howe 1985, USFWS 1990).

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

A.1. Habitat Protection

A.1.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature that directly relates to habitat protection as a tool for whooping crane habitat management, however 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).

A.1.2. Non Peer-Reviewed Literature

Currier (1987) describes habitat protection efforts in the Platte River valley through acquisition/easements. He notes that the Platte River Whooping Crane Habitat Maintenance Trust (Trust) has directed their efforts at identifying and preserving existing high quality roost and feeding habitat, as it is far easier and cheaper to maintain roost sites and wetland meadows than it is to reclaim them. At the time of this publication (1987), the Trust managed approximately 2,800 ha (7,000 acres) through fee title and easements, and the National Audubon Society managed an additional 480 ha (1,200 acre) sanctuary (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), USFWS (1981), and Faanes (1988). Lingle (1985) recommended development of an acquisition or protection plan within the migration corridor to ensure perpetual protection of wetlands and native grasslands. 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. 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) says the key to managing whooping cranes along the Platte River is habitat acquisition and maintenance. Furthermore, Johnson identifies the top priority for acquisition as riverine habitats for roosting in association with extensive nearby wet meadows and native grasslands for feeding. He suggests acquisition efforts continue to be spearheaded by private conservation organizations. Examples of such acquisition include 1.) 324 ha (810 acres) of pristine habitat along the Platte River acquired or leased by the Audubon Society 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 The Nature Conservancy and the Platte River Whooping Crane Critical Habitat Maintenance Trust in 1979 (Lingle 1981). The Platte River Whooping Crane Critical Habitat Maintenance Trust is an organization established through an agreement with Basin Electric Power Cooperative to preserve migratory bird habitat on the Platte River (VanDerwalker 1981).

A.2. Burning/Grazing/Haying

A.2.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature regarding the use of burning, grazing, and/or haying as a management technique for bottomland grassland whooping crane habitat.

A.2.2. Non Peer-Reviewed Literature

Some information was found in the non peer-reviewed literature that suggests the use of burning, grazing, and/or haying as a management tool for bottomland grassland. 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 suggests the use of periodic controlled burns, in combination with grazing and haying. He also notes that "wet meadow" habitat must be periodically monitored to insure that they are maintained in optimal condition. Johnson (1981) provides no further details, such as costs, beyond these management suggestions.

Faanes (1988) noted that at the Lillian Annette Rowe Sanctuary, wet meadow habitats are subjected to a rotational burning program designed to enhance warm season grasses and the production of soil invertebrates. Faanes (1988) provided no further information.

A.3. Restoration

A.3.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature regarding restoration of bottomland grasslands whooping crane habitat.

A.3.2. Non Peer-Reviewed Literature

Currier (1987) reported on a program to restore a portion of forested floodplain back into a wetland meadow complex 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", a machine that when driven through vegetation, chips trees and shrubs up to 120 cm (47 in) in diameter. The trees were felled using chainsaws; large trees were sold as lumber and smaller trees were piled and burned. A few trees (approximately 6 percent) 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, Survey Results, subsection A.2.2.

In a more recent article, Pfeiffer (1998) evaluated three wet meadow restoration techniques in the Platte River valley. The three techniques include: 1) low diversity (3-6 species) grass plantings on former crop fields, 2) high diversity (100 + species) 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 reclaimed restored wet meadows to 14 native wet meadow 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 wet meadow restoration. They developed vegetation that most closely resembles native wet meadows than either of the other restoration types. Pfeiffer (1998) noted that clearing riparian forests offers some potential as an acceptable restoration 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 wet meadow restoration, and was not recommended (Pfeiffer 1998).

B. UPLAND GRASSLAND

Upland grasslands are dry areas that are mostly free of woody vegetation. Upland grasslands are a secondary source of forage for whooping cranes and provide cover for whooping cranes and other bird species and wildlife in general.

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

No information was found in the peer-reviewed literature that directly relates to habitat protection as a tool for whooping crane habitat management, however Cannon (1996) describes the history of both public and private entities involved in habitat protection for the whooping crane through purchase and set-aside (see Section A.1.1).

B.1.2 Non Peer-Reviewed Literature

Several authors have suggested protection of whooping crane habitat to enhance recovery, however few details were given beyond merely making the suggestion (Johnson 1981, Lingle 1985, USFWS 1981). 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 Sections B.2.2, B.2.3, and B.2.4). Lingle (1985) lists, 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". USFWS (1981) suggested preservation of native grassland tracts 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.

B.2. 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 area. 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 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.

B.2.2 Non Peer-Reviewed Literature

Little information was available in the non peer-reviewed literature on burning upland grasslands as a management technique for whooping crane habitat. 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 notes that native grassland habitat must be periodically monitored to insure that they are maintained in optimal condition. Johnson (1981) provided no further detail beyond these management suggestions.

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.3. Grazing

B.3.1 Peer-Reviewed Literature

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

B.3.2 Non Peer-Reviewed Literature

As described in Section 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 notes that native grassland habitat must be periodically monitored to insure that they are maintained in optimal condition. Johnson (1981) provided no further detail beyond these management suggestions.

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.4. Haying

B.4.1 Peer-Reviewed Literature

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

B.4.2 Non Peer-Reviewed Literature

As described in Section 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. Johnson (1981) provided no further detail beyond these management suggestions.

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 avoiding the need for fencing with its known dangers to cranes. Strom (1995) also noted, however, that haying can reduce the nutrient reserves of grasses, but this loss can be avoided by waiting until after September 30th to hay. No information of 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.

C. OPEN RIVER CHANNEL

Open river channel habitat refers to the habitat whooping cranes use for roosting located in the river channel. 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 1988; 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 (0.45 mi) of unobstructed view

upstream/downstream (Faanes 1988); slow flows, typically 1 to 4 mi/hr (0.6 to 2.4 km/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 1984). Faanes et al. (1992) also 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, which may serve as barriers to potential mammalian predators.

Several authors have described the loss of open channel habitat over the past century due to the reduction in flows in the Platte River system and encroachment of woody vegetation (Williams 1978; USFWS 1981; Currier 1995; Currier 1996; Johnson 1997). Williams (1978) reports that upstream from Overton, Nebraska, the Platte River channel in 1969 was only about 0.1 to 0.2 as wide as in 1865. The channel in the reach from Overton to Grand Island, Nebraska, was approximately 0.6 to 0.7 as wide in 1969-1977 as it was in 1865 (Williams 1978). Williams (1978) concludes 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) describes continuing declines in channel width, including an 18.7 percent 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 percent occurred over a 6-year period (1988 to 1994). Johnson (1997) agrees that channel narrowing occurred in the first half of the century, however, he goes 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 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, or burning, and regulation of water flows. These are described below in more detail.

C.1. Mechanical Clearing

C.1.1 Peer-Reviewed Literature

The peer-reviewed literature contained very little information specific to mechanical clearing methods for open river channel habitat. 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. 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 (1998) also noted that soil disturbance associated with clearing promotes weeds, is expensive, and removes woodland habitat composed chiefly of native species that is home is many songbirds and migrants.

C.1.2. Non Peer-Reviewed Literature

In his description of a management plan for the Lillian Annette Rowe Sanctuary ~~from 1985~~, 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 disking or herbicide application. Currier (1987) found that shredding followed by disking was the most effective and environmentally acceptable method. This method also 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 disking ($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, ~~subsection C.1.~~ Currier (1987) describes early efforts and costs that have since been refined and updated over the years.

Other authors have suggested the use of mechanical clearing to manage open river channel habitat, however these authors have provided no or little additional information beyond simply suggesting this method (Faanes 1988; Johnson 1981; USFWS 1981). USFWS (1981) noted that mechanical clearing 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

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

C.2.2. Non Peer-Reviewed Literature

Currier (1987) described the use of herbicides and herbicides in combination with mechanical clearing (see Section C.1.2 above) to control woody vegetation in open river channel habitat. Clearing was conducted at two 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 percent solution of Roundup (glyphosate). Shredding followed by application of an herbicide was found to be effective in clearing woody vegetation and controlling regrowth (95 percent). 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 percent 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. More up-to-date information on herbicide use by the Trust to manage open river channel clearing is found in Section III, Survey Results, subsection C.1. Currier (1987) describes early efforts and costs that have been refined and updated over the years.

As with mechanical clearing, other authors have suggested the use of herbicides to manage open river channel habitat, however these authors have provided no or little additional information beyond simply suggesting this method (Johnson 1981; USFWS 1981). USFWS (1981) noted that herbicide use is probably effective, but is costly, labor intensive, and would require repeated use to control woody vegetation. 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.

C.3. Burning

C.3.1 Peer-Reviewed Literature

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

C.3.2. Non Peer-Reviewed Literature

Little information was found in the non 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) at island burning 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 (Lingle 1981).

C.4. 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). Direct management refers to regulation of water levels to provide minimum recommended flows for whooping crane roost sites. Indirect management refers to water flow management as a means of controlling vegetation encroachment.

C.4.1 Peer-Reviewed Literature

Lingle (1984) noted that in 1983 the Nebraska Game and Parks Commission recommended a flow of 51cms (1,700 cfs) in the Platte River during migration to maintain whooping crane roosting habitat. During his study on physical characteristics of a whooping crane roost site on the Platte River channel between Overton and Grand Island in October 1983, Lingle (1984) measured the flow at his study site to be 38 cms (1,260 cfs). He 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. He 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 (1984) did not provide any further information such as costs or methods to maintain minimum flows.

Johnson (1994) 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 by 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).

C.4.2. Non 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.

In 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 trenches to aid whooping cranes in selecting roost sites. This suggestion is based on a study they conducted examining the characteristics of whooping crane roost sites in the Platte River, but Faanes et al. (1992) did not examine costs or methods for maintaining minimum flows.

Who is "they" Faanes et al. or was it an entity?

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 minimum flows or provide further details.

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.

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 percent or more of the channel is underwater, and

virtually no areas are available for seedling establishment. At 30 cms (1,000 cfs), 25 percent of the bed is exposed; at 24 cms (800 cfs) 34 percent is exposed; and at 12 to 6 cms (400 to 200 cfs), 70 to 80 percent 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.

Faanes and Bowman (1988) 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 percent from pre-development times, but channel maintenance flows still occur, although at a much reduced frequency and magnitude (Faanes and Bowman 1988). 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 (1988) 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 (1988) do not give cost estimates or details on how to provide and maintain recommended peak flows.

D. OPEN RIVERINE AND NON-RIVERINE AREAS

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.

non-peer reviewed ↓ Additional information was recently provided on riverine, non-riverine management methods. This information has not yet been incorporated into this section, but will be added in the next draft. ← from the ACOE Omaha

D.1. Vegetation Clearing

mechanically scrape vegetation and reshape the islands and a volunteer operation of hand-pulling and hand-clearing was done. In September, Rodeo 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 in 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 in 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.) conduct habitat restoration in approximately 0.75 mi (1,200 m) reaches where channel width is at least 907 ft (275 m), 2.) dredge a mid-channel sandbar to provide a high, clean, and smooth nesting substrate at least 1.45 ha (363 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 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 of constructing chevron dikes.

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 in 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

percent of 78 sandpits identified suitable (based on substrate) at least one year of a 3-year study. 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 did not describe how nests were found 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 blacks 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. Prindiville Gaines and Ryan (1988) also suggest exclusion of cattle and all-terrain vehicles from alkali-beach nest sites.

Not all habitat creation efforts have been successful. Koenen and Utych (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 (3.3 ft) m wide x 0.5 (1.65 ft) m 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 to minimize the impacts of the flooding (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 with sand added. Based on these early successes, 181 additional pads were built in the fall of 1989. This large number helped to confuse coyotes. Since 1990, Boyd (1993) reports continued success of use and fledging rate with the nest pads. Boyd (1993) state that the 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 "hanging on" in Colorado (Nelson 1999).

Latka et al. (1993) described habitat creation methods for piping plover and least tern nesting habitat by increasing the elevation of low sandbars along the Missouri River. They constructed sand fences from plastic snow fence and electric fence posts to trap sand. Sand dunes up to 1 m (3 ft) high formed in only a few months. Oyster shells were successfully used to reduce wind erosion of the created sand dunes. Bulldozers were used to reshape islands by piling low-elevation sand onto higher areas. The target elevation was 46 cm (18 in) above water surface elevations during peak summer flows. Crane-on-barge dredging of bottom sediments was also used. 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. No costs for these habitat creation efforts were provided, and use of these created habitats by least tern and piping plover was not studied since not enough time had elapsed since creation.

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 percent of the piping plover nests and 100 percent 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 simply 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 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. When moving nests, hands, footwear, and tools were washed in biodegradable, unscented soap prior to moving a nest. No costs were given for moving nests. Success was achieved while relocating to both natural and artificial substrates (Gordon and Kruse 1999).

The Nebraska Public Power District 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 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 7 acres in size, was started in October 1991 and completed in March 1992 at a cost of approximately 124,500. Overton Island, 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 created three sandpit sites for least tern and piping plover nesting: Johnson Sandpit (1991), Lexington Sandpit (1991), and Blue Hole Sandpit (1996). No information was found describing methods used to create these sandpits, however costs were reported as $53,000, $138,600, and $5,500 respectively (NPPD 1997). 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 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 chain sawing; 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, 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. 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.

Currier and Lingle (1993) reported on creation of two nesting islands (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. Construction costs

were approximately $25,000.00 per island. Vegetation growth was reported as low (less than 5 percent), probably due to use of a depauperate seedbank.

D.3. Predator Control

Predator control techniques, such as exclosures, electric fencing, and chick shelters, are used for least terns and piping plovers 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 piece of 5 x 10 cm galvanized wire mesh fencing placed in a 3.2 m diameter circle 9 cm 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 can be made, such as burying the exclosure deeper or extending a wire-mesh apron laterally from the base can be made 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 openings was used in both studies. The exclosure was triangular with a 30.5 m perimeter. Black twine was placed in parallel rows over the top during the piping plover 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 high, and buried 20 to 25 cm 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 5cm or 5 x 10cm mesh with the base buried in 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 with 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 long, enclosing about 0.4, 2.0, 2.4, and 2 ha respectively. Fences were constructed of 1.3 m-high, 2.5 cm wire mesh, supported by steel T-posts. The bottom portion of the mesh cured 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 from the mesh. The wires were approximately 10, 65, and 130 cm 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 copper rod driven into the substrate provided the electrical ground. A wooden board was placed under each board to prevent discharge. Vegetation and debris along fences were removed by hand or grass trimmer. Cost of material was $1.20/m. 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. 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 and Utych (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 strand were placed approximately 14, 28, 42, 62, and 86 cm from the ground. Wires were fastened to steel posts with plastic insulators. Fence costs were estimated at $0.85/m. 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, 6 in, 12 in, 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.

convert to metric

The use of chick shelters to prevent avian predation of least tern chicks on Nantucket Island, Massachusetts was studied by Mueller (1981). 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 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.

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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 is used in areas where the waterline at a given beach is relatively static. Portable, mesh-electric fences are used on beaches with dynamic water levels. Where mesh-electric fences ended at the water edge, a 3-strand, electric fence or 5-6 m 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 appear to be effective at improving piping plover production.

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 or 5 x 10 cm mesh; 1 to 3 diameter x 0.8 m 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 percent, 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 percent cage/fence combination or 83 percent 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). Flooding can destroy nests during the nesting period (generally from April trough June) (Cairns 1982, Sidle et al. 1992). On regulated systems, water releases can be managed to minimize flooding of nests. Prindiville Gaines and Ryan (1988) recommend drawing water levels down to maximize habitat during 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 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.

Other authors have noted that maintenance of water levels prevents predators and humans from accessing islands where the target species roost and nest (Faanes 1983).

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 185 to 1991, failures in 37 percent of the unsuccessful least tern and 61 percent of the unsuccessful piping plover nests were due to flooding. Consequently, Lingle (1993) makes the following recommendations: 1.) Maintain adequate annual flows in the Platte to provide secure nest sites. A summer flow (June through August) of 1,000 cfs would be adequate as measured at Grand Island. Flows should not drop below 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 the Districts curtain releases to the river via J-2 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 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 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 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 of the observed plovers was significant at two of the three sites, and generally consisted of walking, fishing, sunbathing, or jogging. Plover spent more time feeding in the habitats with fewer people at the two sites where people were present. 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.

Smith and Renken (1993) examined reproductive success of least terns in the Mississippi River valley and found that human disturbance (specifically 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

Several strategies were suggested in the non peer-reviewed literature to minimize human disturbance at whooping crane, least tern, and piping plover habitat. Lingle, (1985) suggested marking utility lines adjacent to key habitat with highly visible plastic balls or strips. 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.

I DIDN'T SEE A REFERENCE TO STUDIES RELATED TO MARKING POWERELINES COMPLETED BY STAN ANDERSON AND A GRADUATE STUDENT AT WYOMING.

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 2-inch mesh with 8 ft of fabric above ground and 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, 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 3 miles of the field were believed to have used it until the supply was exhausted.

Shields and Benham (1969) report that the following year, 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 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 suggests a preference for crustaceans and other marine life over crops.

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.

E.2. Non Peer-Reviewed Literature

No information was found in the non peer-reviewed literature on cropland management techniques for whooping crane, least tern, or piping plover habitat.

F. METHODS NOT HABITAT-SPECIFIC

F.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature on other management techniques for whooping crane, least tern, or piping plover habitat.

F.2. Non Peer-Reviewed Literature

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.

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. – Was this successful?

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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. The sandbar would normally have been built up during spring floods, however current flood levels are not high enough to scour vegetation due to decreased flows for irrigation. In March 1985, a 100m x 40m area was cleared by hand of salt cedar. In September of that year, another 140m x 50m area on the sandbar island was bulldozed to clear salt cedar and inland salt grass and improve drainage. Bulldozing was also conducted 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, and may be in jeopardy of being lost (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 the herbicide Rodeo at a rate of 6 pints/acre and the original area was expanded, which included 5 to 8 year old cottonwoods. 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 and the previous year's treatment was used (in September) along with a pre-emergent herbicide. 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. 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 housing predators. In 1990, least tern and piping plover nest 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

II. METHODS

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 in the University of Wyoming library system, as well as other library systems. Several databases were searched including *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 agencies/organizations were contacted:

- U.S. Fish and Wildlife Service
- Army Corp of Engineers
- Nebraska Game and Parks
- 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
- Lost Wood National Wildlife Refuge, North Dakota

The goal of the literature review was to collect and review, 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. Both types of literature contained valuable information relevant to the project.

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. Forty additional non peer-reviewed literature articles were reviewed. These articles were available from workshop/symposium proceedings (e.g., the *North American Crane Workshop Proceedings* and the *Missouri River and It's Tributaries Piping Plover and Least Tern Symposium/Workshop*), popular literature, and unpublished reports and data from federal and state agencies, conservation groups, and the Districts.

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 were also reviewed in order to gain an understanding of

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; 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). As an important stopover area during migration, habitat needs in the Platte River valley for whooping cranes include roosting habitat (open river channel) and feeding habitat (bottomland and upland grasslands) (Currier et al 1985). In addition, 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 habitats, 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 river channel, open 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 roosting habitat for whooping and sandhill cranes (Currier 1987). Several authors noted that the presence of some type of wetland (i.e., bottomland grassland habitat) is a requirement of whooping crane migration habitat (Howe 1985, USFWS 1990).

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

A.1. Habitat Protection

A.1.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature that directly relates to habitat protection as a tool for whooping crane habitat management, however 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).

A.1.2. Non Peer-Reviewed Literature

Currier (1987) describes habitat protection efforts in the Platte River valley through acquisition/easements. He notes that the Platte River Whooping Crane Habitat Maintenance Trust (Trust) has directed their efforts at identifying and preserving existing high quality roost and feeding habitat, as it is far easier and cheaper to maintain roost sites and wetland meadows than it is to reclaim them. At the time of this publication (1987), the Trust managed approximately 2,800 ha (7,000 acres) through fee title and easements, and the National Audubon Society managed an additional 480 ha (1,200 acre) sanctuary (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), USFWS (1981), and Faanes (1988). Lingle (1985) recommended development of an acquisition or protection plan within the migration corridor to ensure perpetual protection of wetlands and native grasslands. 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. 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) says the key to managing whooping cranes along the Platte River is habitat acquisition and maintenance. Furthermore, Johnson identifies the top priority for acquisition as riverine habitats for roosting in association with extensive nearby wet meadows and native grasslands for feeding. He suggests acquisition efforts continue to be spearheaded by private conservation organizations. Examples of such acquisition include 1.) 324 ha (810 acres) of pristine habitat along the Platte River acquired or leased by the Audubon Society 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 The Nature Conservancy and the Platte River Whooping Crane Critical Habitat Maintenance Trust in 1979 (Lingle 1981). The Platte River Whooping Crane Critical Habitat Maintenance Trust is an organization established through an agreement with Basin Electric Power Cooperative to preserve migratory bird habitat on the Platte River (VanDerwalker 1981).

A.2. Burning/Grazing/Haying

A.2.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature regarding the use of burning, grazing, and/or haying as a management technique for bottomland grassland whooping crane habitat.

A.2.2. Non Peer-Reviewed Literature

Some information was found in the non peer-reviewed literature that suggests the use of burning, grazing, and/or haying as a management tool for bottomland grassland. 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 suggests the use of periodic controlled burns, in combination with grazing and haying. He also notes that "wet meadow" habitat must be periodically monitored to insure that they are maintained in optimal condition. Johnson (1981) provides no further details, such as costs, beyond these management suggestions.

Faanes (1988) noted that at the Lillian Annette Rowe Sanctuary, wet meadow habitats are subjected to a rotational burning program designed to enhance warm season grasses and the production of soil invertebrates. Faanes (1988) provided no further information.

A.3. Restoration

A.3.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature regarding restoration of bottomland grasslands whooping crane habitat.

A.3.2. Non Peer-Reviewed Literature

Currier (1987) reported on a program to restore a portion of forested floodplain back into a wetland meadow complex 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", a machine that when driven through vegetation, chips trees and shrubs up to 120 cm (47 in) in diameter. The trees were felled using chainsaws; large trees were sold as lumber and smaller trees were piled and burned. A few trees (approximately 6 percent) 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, Survey Results, subsection A.2.2.

In a more recent article, Pfeiffer (1998) evaluated three wet meadow restoration techniques in the Platte River valley. The three techniques include: 1.) low diversity (3-6 species) grass plantings on former crop fields, 2.) high diversity (100 + species) 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 reclaimed restored wet meadows to 14 native wet meadow 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 wet meadow restoration. They developed vegetation that most closely resembles native wet meadows than either of the other restoration types. Pfeiffer (1998) noted that clearing riparian forests offers some potential as an acceptable restoration 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 wet meadow restoration, and was not recommended (Pfeiffer 1998).

B. UPLAND GRASSLAND

Upland grasslands are dry areas that are mostly free of woody vegetation. Upland grasslands are a secondary source of forage for whooping cranes and provide cover for whooping cranes and other bird species and wildlife in general.

Johnson also notes that migrating cranes seek out roosting areas protected by trees and shrubs during inclement weather (DESCRIBE WEATHER AND THE DATA THIS CLAIM IS BASED ON) (1999).

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

No information was found in the peer-reviewed literature that directly relates to habitat protection as a tool for whooping crane habitat management, however Cannon (1996) describes the history of both public and private entities involved in habitat protection for the whooping crane through purchase and set-asides (see Section A.1.1).

B.1.2 Non Peer-Reviewed Literature

Several authors have suggested protection of whooping crane habitat to enhance recovery, however few details were given beyond merely making the suggestion (Johnson 1981, Lingle 1985, USFWS 1981). 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 Sections B.2.2, B.2.3, and B.2.4). Lingle (1985) lists, 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". USFWS (1981) suggested preservation of native grassland tracts 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.

B.2. 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 area. 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 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.

B.2.2 Non Peer-Reviewed Literature

Little information was available in the non peer-reviewed literature on burning upland grasslands as a management technique for whooping crane habitat. 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 notes that native grassland habitat must be periodically monitored to insure that they are maintained in optimal condition. Johnson (1981) provided no further detail beyond these management suggestions.

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.3. Grazing

B.3.1 Peer-Reviewed Literature

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

B.3.2 Non Peer-Reviewed Literature

As described in Section 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 notes that native grassland habitat must be periodically monitored to insure that they are maintained in optimal

condition. Johnson (1981) provided no further detail beyond these management suggestions.

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.4. Haying

B.4.1 Peer-Reviewed Literature

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

B.4.2 Non Peer-Reviewed Literature

As described in Section 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. Johnson (1981) provided no further detail beyond these management suggestions.

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 avoiding the need for fencing with its known dangers to cranes. Strom (1995) also noted, however, that haying can reduce the nutrient reserves of grasses, but this loss can be avoided by waiting until after September 30th to hay. No information of 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.

C. OPEN RIVER CHANNEL

Open river channel habitat refers to the habitat whooping cranes use for roosting located in the river channel. 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 1988; 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 (0.45 mi) of unobstructed view upstream/downstream (Faanes 1988); slow flows, typically 1 to 4 mi/hr (0.6 to 2.4 km/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 1984). Faanes et al. (1992) also 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, which may serve as barriers to potential mammalian predators.

Several authors have described the loss of open channel habitat over the past century due to the reduction in flows in the Platte River system and encroachment of woody vegetation (Williams 1978; USFWS 1981; Currier 1995; Currier 1996; Johnson 1997). Williams (1978) reports that upstream from Overton, Nebraska, the Platte River channel in1969 was only about 0.1 to 0.2 as wide as in 1865. The channel in the reach from Overton to Grand Island, Nebraska, was approximately 0.6 to 0.7 as wide in 1969-1977 as it was in 1865 (Williams 1978). Williams (1978) concludes 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) describes continuing declines in channel width, including an 18.7 percent 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 percent occurred over a 6-year period (1988 to 1994). Johnson (1997) agrees that channel narrowing occurred in the first half of the century, however, he goes 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 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, or burning, and regulation of water flows. These are described below in more detail.

C.1. Mechanical Clearing

C.1.1 Peer-Reviewed Literature

The peer-reviewed literature contained very little information specific to mechanical clearing methods for open river channel habitat. 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. 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 (1998) also noted that soil disturbance associated with clearing promotes weeds, is expensive, and removes woodland habitat composed chiefly of native species that is home is many songbirds and migrants.

C.1.2. Non Peer-Reviewed Literature

In his description of a management plan for the Lillian Annette Rowe Sanctuary from 1985, 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 disking or herbicide application. Currier (1987) found that shredding followed by disking was the most effective and environmentally acceptable method. This method also 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 disking ($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, subsection C.1. Currier (1987) describes early efforts and costs that have since been refined and updated over the years.

Other authors have suggested the use of mechanical clearing to manage open river channel habitat, however these authors have provided no or little additional information beyond simply suggesting this method (Faanes 1988; Johnson 1981; USFWS 1981). USFWS (1981) noted that mechanical clearing 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

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

C.2.2. Non Peer-Reviewed Literature

Currier (1987) described the use of herbicides and herbicides in combination with mechanical clearing (see Section C.1.2 above) to control woody vegetation in open river channel habitat. Clearing was conducted at two 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 percent solution of Roundup (glyphosate). Shredding followed by application of an herbicide was found to be effective in clearing woody vegetation and controlling regrowth (95 percent). 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 percent 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. More up-to-date information on herbicide use by the Trust to manage open river channel clearing is found in Section III, Survey Results, subsection C.1. Currier (1987) describes early efforts and costs that have been refined and updated over the years.

As with mechanical clearing, other authors have suggested the use of herbicides to manage open river channel habitat, however these authors have provided no or little additional information beyond simply suggesting this method (Johnson 1981; USFWS 1981). USFWS (1981) noted that herbicide use is probably effective, but is costly, labor intensive, and would require repeated use to control woody vegetation. 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.

C.3. Burning

C.3.1 Peer-Reviewed Literature

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

C.3.2. Non Peer-Reviewed Literature

Little information was found in the non 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) at island burning 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 (Lingle 1981).

C.4. 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). Direct management refers to regulation of water levels to provide minimum recommended flows for whooping crane roost sites. Indirect management refers to water flow management as a means of controlling vegetation encroachment.

C.4.1 Peer-Reviewed Literature

Lingle (1984) noted that in 1983 the Nebraska Game and Parks Commission recommended a flow of 51cms (1,700 cfs) in the Platte River during migration to maintain whooping crane roosting habitat. During his study on physical characteristics of a whooping crane roost site on the Platte River channel between Overton and Grand Island in October 1983, Lingle (1984) measured the flow at his study site to be 38 cms (1,260 cfs). He 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. He 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 (1984) did not provide any further information such as costs or methods to maintain minimum flows.

Johnson (1994) 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 by 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).

C.4.2. Non 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.

In 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 trenches to aid whooping cranes in selecting roost sites. This suggestion is based on a study they conducted examining the characteristics of whooping crane roost sites in the Platte River, but Faanes et al. (1992) did not examine costs or methods for maintaining minimum 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 minimum flows or provide further details.

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.

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 percent or more of the channel is underwater, and virtually no areas are available for seedling establishment. At 30 cms (1,000 cfs), 25 percent of the bed is exposed; at 24 cms (800 cfs) 34 percent is exposed; and at 12 to 6 cms (400 to 200 cfs), 70 to 80 percent 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.

Faanes and Bowman (1988) 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 percent from pre-development times, but channel maintenance flows still occur, although at a much reduced frequency and magnitude (Faanes and Bowman 1988). 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 (1988) 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 (1988) do not give cost estimates or details on how to provide and maintain recommended peak flows.

D. OPEN RIVERINE AND NON-RIVERINE AREAS

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.

~~Additional information was recently provided on riverine, non-riverine management methods. This information has not yet been incorporated into this section, but will be added in the next draft.~~

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. The sandbar would normally have been built up during spring floods, however current flood levels are not high enough to scour vegetation due to decreased flows for irrigation. In March 1985, a 100m x 40m area was cleared by hand of salt cedar. In September of that year, another 140m x 50m area on the sandbar island was bulldozed to clear salt cedar and inland salt grass and improve drainage. Bulldozing was also conducted 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, and may be in jeopardy of being lost (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 the herbicide Rodeo at a rate of 6 pints/acre and the original area was expanded, which included 5 to 8 year old cottonwoods. 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 and the previous year's treatment was used (in September) along with a pre-emergent herbicide. 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. 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 housing predators. In 1990, least tern and piping plover nest were again established and some young of both species fledged. In 1991, budged 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 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 in 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 in 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.) conduct habitat restoration in approximately 0.75 mi (1,200 m) reaches where channel width is at least 907 ft (275 m), 2.) dredge a mid-channel sandbar to provide a high, clean, and smooth nesting substrate at least 1.45 ha (363 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 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 of constructing chevron dikes.

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 in 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 percent of 78 sandpits identified suitable (based on substrate) at least one year of a 3-year study. 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 did not describe how nests were found 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 blacks 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. Prindiville Gaines and Ryan (1988) also suggest exclusion of cattle and all-terrain vehicles from alkali-beach nest sites.

Not all habitat creation efforts have been successful. Koenen and Utych (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 (3.3 ft) m wide x 0.5 (1.65 ft) m 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 to minimize the impacts of the flooding (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 with sand added. Based on these early successes, 181 additional pads were built in the fall of 1989. This large number helped to confuse coyotes. Since 1990, Boyd (1993) reports continued success of use and fledging rate with the nest pads. Boyd (1993) state that the 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 tot 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 "hanging on" in Colorado (Nelson 1999).

Latka et al. (1993) described habitat creation methods for piping plover and least tern nesting habitat by increasing the elevation of low sandbars along the Missouri River. They constructed sand fences from plastic snow fence and electric fence posts to trap sand. Sand dunes up to 1 m (3 ft) high formed in only a few months. Oyster shells were successfully used to reduce wind erosion of the created sand dunes. Bulldozers were used to reshape islands by piling low-elevation sand onto higher areas. The target elevation was 46 cm (18 in) above water surface elevations during peak summer flows. Crane-on-barge dredging of bottom sediments was also used. 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. No costs for these habitat creation efforts were provided, and use of these created habitats by least tern and piping plover was not studied since not enough time had elapsed since creation.

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 percent of the piping plover nests and 100

percent 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 simply 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 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. When moving nests, hands, footwear, and tools were washed in biodegradable, unscented soap prior to moving a nest. No costs were given for moving nests. Success was achieved while relocating to both natural and artificial substrates (Gordon and Kruse 1999).

The Nebraska Public Power District 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 3.6 acres in size, was started in November of 1990 and completed in March 1991 at a cost of approximately $143,00. Construction of this island was described by Plettner (1993) and is summarized below. Lexington Island, approximately 7 acres in size, was started in October 1991 and completed in March 1992 at a cost of approximately 124,500. Overton Island, 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 created three sandpit sites for least tern and piping plover nesting: Johnson Sandpit (1991), Lexington Sandpit (1991), and Blue Hole Sandpit (1996). No information was found describing methods used to create these sandpits, however costs were reported as $53,000, $138,600, and $5,500 respectively (NPPD 1997). 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 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 chain sawing; 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, 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. 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.

Currier and Lingle (1993) reported on creation of two nesting islands (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. Construction costs were approximately $25,000.00 per island. Vegetation growth was reported as low (less than 5 percent), probably due to use of a depauperate seedbank.

D.3. Predator Control

Predator control techniques, such as exclosures, electric fencing, and chick shelters, are used for least terns and piping plovers 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 piece of 5 x 10 cm galvanized wire mesh fencing placed in a 3.2 m diameter circle 9 cm 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 can be made, such as burying the exclosure deeper or extending a wire-mesh apron laterally from the base can be made 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 openings was used in both studies. The exclosure was triangular with a 30.5 m perimeter. Black twine was placed in parallel rows over the top during the

piping plover 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 high, and buried 20 to 25 cm 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 5cm or 5 x 10cm mesh with the base buried in 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 with 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 long, enclosing about 0.4, 2.0, 2.4, and 2 ha respectively. Fences were constructed of 1.3 m-high, 2.5 cm wire mesh, supported by steel T-posts. The bottom portion of the mesh cured 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 from the mesh. The wires were approximately 10, 65, and 130 cm 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 copper rod driven into the substrate provided the electrical ground. A wooden board was placed under each board to prevent discharge. Vegetation and debris along fences were removed by hand or grass trimmer. Cost of material was $1.20/m. 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. 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 and Utych (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 strand were placed approximately

14, 28, 42, 62, and 86 cm from the ground. Wires were fastened to steel posts with plastic insulators. Fence costs were estimated at $0.85/m. 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, 6 in, 12 in, 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 Mueller (1981). 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 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 is used in areas where the waterline at a given beach is relatively static. Portable, mesh-electric fences are used on beaches with dynamic water levels. Where mesh-electric fences ended at the water edge, a 3-strand, electric fence or 5-6 m 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 appear to be effective at improving piping plover production.

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 or 5 x 10 cm mesh; 1 to 3 diameter x 0.8 m 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 percent, 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 percent cage/fence combination or 83 percent 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). Flooding can destroy nests during the nesting period (generally from April trough June) (Cairns 1982, Sidle et al. 1992). On regulated systems, water releases can be managed to minimize flooding of nests. Prindiville Gaines and Ryan (1988) recommend drawing water levels down to maximize habitat during 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 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.

Other authors have noted that maintenance of water levels prevents predators and humans from accessing islands where the target species roost and nest (Faanes 1983).

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 185 to 1991, failures in 37 percent of the unsuccessful least tern and 61 percent of the unsuccessful piping plover nests were due to flooding. Consequently, Lingle (1993) makes the following recommendations: 1.) Maintain adequate annual flows in the Platte to provide secure nest sites. A summer flow (June through August) of 1,000 cfs would be adequate as measured at Grand Island. Flows should not drop below 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 the Districts curtain releases to the river via J-2 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 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 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 the known site. Such posting occasionally attracts attention and vandalism, however, if colonies are posted with signs informing 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 of the observed plovers was significant at two of the three sites, and generally consisted of walking, fishing, sunbathing, or jogging. Plover spent more time feeding in the habitats with fewer people at the two sites where people were present. 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.

Smith and Renken (1993) examined reproductive success of least terns in the Mississippi River valley and found that human disturbance (specifically 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 of 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

Several strategies were suggested in the non peer-reviewed literature to minimize human disturbance at whooping crane, least tern, and piping plover habitat. Lingle, (1985) suggested marking utility lines adjacent to key habitat with highly visible plastic balls or strips. 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.

I DIDN'T SEE A REFERENCE TO STUDIES RELATED TO MARKING POWERELINES COMPLETED BY STAN ANDERSON AND A GRADUATE STUDENT AT WYOMING.

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 2-inch mesh with 8 ft of fabric above ground and 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 till 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, 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 corps planted, only grain sorghums and wheat warranted future use. They also report that most whooping cranes whose territories were within 3 miles of the field were believed to have used it until the supply was exhausted.

Shields and Benham (1969) report that the following year, 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 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 suggests a preference for crustaceans and other marine life over crops.

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.

E.2. Non Peer-Reviewed Literature

No information was found in the non peer-reviewed literature on cropland management techniques for whooping crane, least tern, or piping plover habitat.

F. METHODS NOT HABITAT-SPECIFIC

F.1. Peer-Reviewed Literature

No information was found in the peer-reviewed literature on other management techniques for whooping crane, least tern, or piping plover habitat.

F.2. Non Peer-Reviewed Literature

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.

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.

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