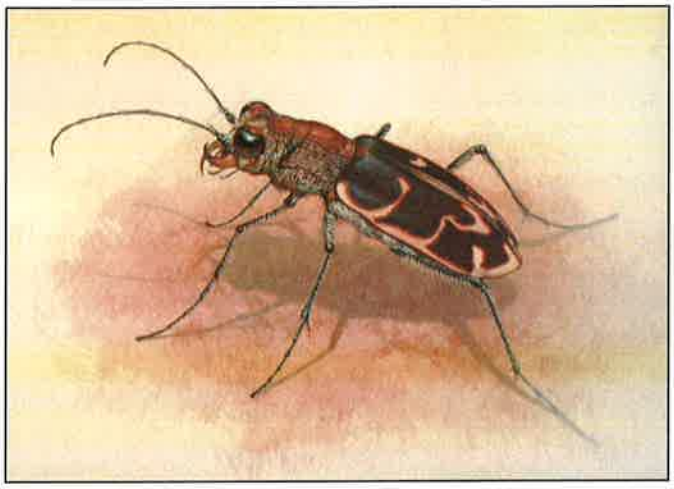
RECOVERY PLAN FOR THE SALT CREEK TIGER BEETLE
(Cicindela nevadica lincolniana)



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Prepared by:

Nebraska Ecological Services Field Office
U.S Fish and Wildlife Service
Wood River, Nebraska

Approved:_____
Matt Hogan
Deputy Regional Director, Mountain Prairie Region
U.S. Fish and Wildlife Service

Date: 1.3.2017

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U.S. Fish and Wildlife Service
Nebraska Ecological Services Field Office
9325 South Alda Road
Wood River, Nebraska 68883
Phone: 308-382-6468

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Mike Dekalb (Retired), Lincoln/Lancaster County Planning Department, 555 South 10th Street, Suite 213, Lincoln, Nebraska 68508

Mike Fritz, Nebraska Game and Parks Commission, 2200 North 33rd Street, PO Box 30370, Lincoln, Nebraska 68503

Robert Harms, U.S. Fish and Wildlife Service, Nebraska Ecological Services Field Office, 9325 South Alda Road, Wood River, Nebraska 68883

Dr. F. Edwin Harvey, National Park Service, Water Resources Division, 1201 Oakridge Drive, Fort Collins, Colorado 80525

Dr. Leon Higley, University of Nebraska—Lincoln, 706 Hardin Hall, Lincoln, Nebraska 68583

Ted LaGrange, Nebraska Game and Parks Commission, 2200 North 33rd Street, PO Box 30370, Lincoln, Nebraska 68503

Tom Malmstrom, Saline Wetlands Conservation Partnership, City of Lincoln, 3125 Portia Street, PO Box 83581, Lincoln, Nebraska 68501

Dr. Rick Schneider, Nebraska Game and Parks Commission, 2200 North 33rd Street, PO Box 30370, Lincoln, Nebraska 68503

Dan Schulz, Lower Platte South Natural Resources District, 3125 Portia Street, Lincoln, Nebraska 68501

Steve Spomer, University of Nebraska—Lincoln, 208 Entomology Hall, Lincoln, Nebraska 68583

EXECUTIVE SUMMARY

Current Species Status: The Salt Creek tiger beetle *(Cicindela [Ellipsoptera]nevadica lincolniana)* was listed as a federally endangered subspecies on November 7, 2005 (70 FR 58335, October 6, 2005). On May 6, 2014 (79 FR 26013), we published a revised final rule designating approximately 449 hectares (1,110 acres) of critical habitat for the Salt Creek tiger beetle in Lancaster and Saunders Counties in Nebraska. The Salt Creek tiger beetle has a recovery priority number of 6C, which means it is a subspecies that faces a high level of threat, including conflict with development activities; a priority number of 6C also indicates it has a low potential for recovery. The Salt Creek tiger beetle has one of the most restricted ranges of any insect in the United States and is currently limited to segments of Little Salt Creek and adjacent remnant saline wetlands in northern Lancaster County, Nebraska.

Habitat Requirements and Limiting Factors: The Salt Creek tiger beetle requires open, barren saline mud flats and mud banks of streams with saline seeps for constructing larval burrows, moving to and from dispersal corridors, foraging, and maintaining thermoregulation (ability of an organism to regulate its body temperature using internal and external mechanisms).

The primary threat to this species is loss and degradation of saline wetland and stream habitats due to commercial, residential, and agricultural development. Construction of levees, reservoirs, and additional channelization of Salt Creek resulted in the degradation and loss of saline wetlands and seeps and entrenchment of its associated tributaries (i.e., Rock, Little Salt, Oak, and Haines Branch Creeks). Contamination, artificial lights, invasive plants, floods, and drought can also have a negative impact on this insect. The Salt Creek tiger beetle is currently found on only one stream segment (Little Salt Creek), which makes it subject to high extinction risk should a catastrophic event occur.

Recovery Strategy: Our recovery strategy is to establish at least six metapopulations in four recovery areas. We identified recovery areas based on site inspections, soil surveys (including the presence of saline soils), and restoration feasibility. Accomplishing this strategy requires acquisition of land or conservation easements, focused habitat restoration and management projects, and reintroductions.

Recovery Goals, Objectives, and Criteria: The goal of our recovery plan is to recover the Salt Creek tiger beetle such that it no longer meets the Endangered Species Act's (Act) definition of threatened and can be removed from the Federal List of Endangered and Threatened Wildlife. The Service should consider downlisting from endangered to threatened and delisting of the Salt Creek tiger beetle when the threats have been removed or reduced as indicated by the following:

- Criteria (downlisting) – The criteria for downlisting is: a) establishment of three self-sustaining metapopulations of Salt Creek tiger beetles each numbering between 500 and 1,000 individuals to ensure viability; b) establishment of these three metapopulations in three recovery areas; and c) at a minimum, no net loss of saline wetlands and streams and their associated functions in the Rock, Little Salt, Oak, and Haines Branch Creeks and floodplains since the time of listing (October 2005), with a likely need for restoration and establishment of additional habitat to support recovered populations.

- Criterion (delisting) – In addition to the downlisting criteria, the criterion for delisting is the establishment of three additional self-sustaining metapopulations (for a total of six metapopulations) of Salt Creek tiger beetles each numbering between 500 and 1,000 individuals for a minimum 10 year average to ensure viability and sustainment spanning at least four recovery areas. There should be protective measures in place to ensure the long-term persistence of these sites in the absence of ESA protections.

The recovery criteria listed above are based on addressing threats to the Salt Creek tiger beetle. Cumulatively, these address the five listing factors (A-E) identified in section 4(a)(1) of the Act that were considered when the Salt Creek tiger beetle was listed in 2005. We estimate recovery will take 30 years, including 20 years to achieve the goals and a minimum of 10 years to maintain viable metapopulations and suitable habitat for the subspecies. This 10-year period will demonstrate that we have managed and reduced the threats of habitat loss and degradation (Factor A), overutilization through collection of individuals for insect collections (Factor B), predation and parasitism by other insects (Factor C), the inadequacy of regulatory mechanisms (Factor D), and catastrophic events such as floods and drought (Factor E) such that delisting of the Salt Creek tiger beetle is merited.

Actions Needed:

1.0 Recovery Area Protection
2.0 Recovery Area Restoration and Management
3.0 Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction
4.0 Metapopulation and Recovery Area Monitoring
5.0 Outreach and Education
6.0 Post-delisting Monitoring

Table 1. Total Estimated Cost of Recovery by Recovery Action Priority[1]

Years	Priority 1(a) Actions	Priority 1(b) Actions	Priority 2 Actions	Priority 3 Actions	Total Cost/Time Period (in thousands of dollars)
1 and 2	1,835	46	4	0	1,885
3 and 4	2,038	16	4	0	2,058
5 and 6	2,156	48	4	0	2,208
7 and 8	2,161	18	4	0	2,183
9 and 10	3,155	50	4	0	3,209
11 to 15	5,284	102	16	0	5,402
Downlist Cost					**$16,945**
16 to 30	13,389	408	16	25	13,838
Total Recovery Cost (in thousands of dollars)	**$30,018**	**$688**	**$52**	**$25**	**$30,783**

[1]A Recovery Action Priority is defined as an action that is necessary to recover a species.

Date of Recovery: If recovery actions are fully funded and carried out as outlined in this plan, criteria for downlisting could be met within 15 years and the subspecies could be delisted in approximately 30 years.

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ACRONYMS

The following acronyms are used in this recovery plan:

Act	Endangered Species Act
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
DPS	Distinct Population Segment
LPSNRD	Lower Platte South Natural Resources District
NGPC	Nebraska Game and Parks Commission
NRCS	Natural Resources Conservation Service
WMA	Wildlife Management Area
WRP	Wetland Reserve Program
Service	U.S. Fish and Wildlife Service
SWCP	Saline Wetlands Conservation Partnership

1 BACKGROUND

1.1 Introduction

The purpose of this recovery plan is to guide implementation of recovery actions to achieve the goal of recovering and delisting the Salt Creek tiger beetle. Section 4(f) of the Endangered Species Act (Act) requires development and implementation of recovery plans for the conservation and survival of endangered and threatened species. This recovery plan includes objective, measurable criteria that, when met, will allow the subspecies to be removed from the Federal List of Threatened and Endangered Species. Section 4(f) of the Act also requires that recovery plans include site-specific management actions necessary to achieve these criteria as well as provide time and cost estimates.

Recovery plans are not regulatory documents; instead, they are intended to provide guidance to the U.S. Fish and Wildlife Service (Service), states, and other partners on both methods of avoiding and minimizing threats to listed species as well as criteria that may be used to determine when recovery is achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without all criteria being fully met. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may judge that the threats have been minimized sufficiently and the species is robust enough to reclassify it from endangered to threatened or to delist. In other cases, we may identify recovery opportunities that were not known at the time the recovery plan was finalized. We may use these opportunities instead of methods identified in the recovery plan. Likewise, we may learn new information on the species that was not known at the time the recovery plan was finalized. This new information may change the extent that criteria need to be met for recognizing recovery of the species. Recovery of a species is a dynamic process requiring monitoring, assessment, and a feedback loop that allows adjustments to be made as needed; if new or unexpected information is found, adjustments may not fully follow the guidance provided in a recovery plan.

Status of the Species

The Salt Creek tiger beetle has one of the most restricted ranges of any insect in the United States and is currently limited to segments of Little Salt Creek and adjacent remnant saline wetlands in northern Lancaster County, Nebraska. We listed the Salt Creek tiger beetle *(Cicindela nevadica lincolniana)* as a federally endangered subspecies on November 7, 2005 (70 FR 58335, October 6, 2005). On May 6, 2014 (79 FR 26013), we published a revised final rule designating approximately 449 hectares (1,110 acres) of critical habitat for the Salt Creek tiger beetle in Lancaster and Saunders Counties in Nebraska. The Nebraska Game and Parks Commission (NGPC) listed the Salt Creek tiger beetle as endangered under the State's Nongame and Endangered Species Conservation Act in March 2001.

Recovery Priority Number with Rationale

Table 2. Recovery Priority Table

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	**6C**
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

The Service recently revised the recovery priority number for the Salt Creek tiger beetle to 6C. This ranking indicates that: a) the Salt Creek tiger beetle is a subspecies of *Cicindela nevadica*, but it is not a distinct population segment (DPS); b) it faces a high degree of threat; c) it has a low potential for recovery; and d) it is in conflict with development activities or other forms of economic activities. The high degree of threat is linked to species' biological constraints such as: 1) reduced number of individuals and abundance and distribution of metapopulations; 2) reduced genetic diversity, due to limited number of individuals; 3) inability of the subspecies to colonize and persist in unoccupied areas lacking suitable habitat or in high risk habitat; and 4) excessive freshwater intrusion and sedimentation, overgrazing, stream entrenchment, and saline wetland and stream loss and degradation. A number of these threats are related to development or economic activities. The low potential for recovery is based on the difficulty of achieving conservation through habitat protection and management techniques and the need for further research on the success of reintroducing the subspecies following captive rearing. This recovery priority number will be reviewed during the recovery planning process.

1.2 Species Description and Taxonomy

The Salt Creek tiger beetle is a member of the family Carabidae, subfamily Cicindelinae, genus *Cicindela*. Eighty-five species and more than 200 subspecies of tiger beetles in the genus *Cicindela* are known from the United States (Boyd et al. 1982; Freitag 1999). Casey (1916) originally described the Salt Creek tiger beetle as a separate species, *C. lincolniana*. Willis (1967) identified *C .n. lincolniana* as a subspecies of *C. nevadica* which evolved from *C. n. knausii*. Busby (2003) confirmed this sub-species' distinctiveness from other central Great Plains populations of *C. nevadica*.

The Salt Creek tiger beetle is metallic brown to dark olive green above, with a metallic dark green underside, and measures 1.3 centimeters (0.5 inch) in total length. The elytra (wing covers) are metallic brown or dark olive green, and the head and pronotum (thorax) are dark brown (Carter 1989). It is distinguished from other tiger beetles by its distinctive form, reduced markings, and the color pattern on its dorsal and ventral surfaces.

1.3 Metapopulation Trends and Distribution

The Salt Creek tiger beetle has one of the most restricted ranges of any insect in the United States (Spomer and Higley 1993; Spomer et al. 2004a), now only occurring along limited

segments of Little Salt Creek and adjacent remnant saline wetlands in Lancaster County, Nebraska. Researchers knew of six metapopulations of the subspecies when surveys began in 1991 (Figure 1; Appendix A). Identification of metapopulations was based on: (1) close proximity of spatially-separated populations (i.e., nearby, contiguous, or neighboring); (2) distances less than 805 m (2,640 ft) between populations where interaction could occur (Allgeier et al. 2003); and (3) the presence of both suitable saline wetland (i.e., barren salt flats) and stream (saline edges) habitats that form a saline wetland/stream complex. Each Salt Creek tiger beetle metapopulation consists of spatially separated, interacting populations as defined by Levins (1969).

These six metapopulations were once located on Rock (Jack Sinn Wildlife Management Area) and Oak Creeks, in addition to Little Salt Creek, but now the subspecies is only located on Little Salt Creek (Figure 1; Appendix A). Half of these six metapopulations were thought to have been extirpated since 1991. However, the Upper Little Salt Creek-South Metapopulation, thought to be extirpated since 1995, was re-discovered along the banks of Little Salt Creek at the Little Salt Creek Wildlife Management Area (WMA) in 2014. The six Salt Creek tiger beetle metapopulations, including the two that have been extirpated, are described below in order of abundance.

Extant Metapopulations

Little Salt Creek-Arbor Lake Metapopulation: The Little Salt Creek-Arbor Lake Metapopulation contains the largest number of Salt Creek tiger beetles (Appendix A). We believe that this metapopulation has persisted because it consists of several interacting populations (Wiens 1996) and occurs across a relatively intact and restored saline wetland and stream complex. The Little Salt Creek-Arbor Lake Metapopulation is located approximately 1.6 kilometer (km) (1 mile [mi]) north of the Interstate 80 and North 27th Street Interchange at the northern city limits of Lincoln, Nebraska (Figure 1).

Little Salt Creek-Roper Metapopulation: The Little Salt Creek-Roper Metapopulation was once the second largest metapopulation of Salt Creek tiger beetles (Appendix A). We believe that this metapopulation is in decline because of the reduction in the number of interacting populations and habitat degradation. This metapopulation is located immediately south of the Interstate 80 and North 27th Street Interchange, and approximately 1.6 km (1 mi) downstream of the Little Salt Creek-Arbor Lake Metapopulation (Figure 1).

Upper Little Salt Creek-North Metapopulation: The Upper Little Salt Creek-North Metapopulation is the third of four metapopulations of extant Salt Creek tiger beetles (Appendix A). This metapopulation is in decline because of habitat degradation and the increase in spatial separation distance reducing opportunities for population interaction. This metapopulation is located approximately 7.2 km (4.5 mi) upstream from the Little Salt Creek-Arbor Lake Metapopulation, and exists on the saline stream edges of Little Salt Creek and a single salt flat (Figure 1). This metapopulation is comprised of four populations along Little Salt Creek that were surveyed from 1991 to 2014.

Upper Little Salt Creek-South Metapopulation: The Upper Little Salt Creek-South Metapopulation was thought to have been extirpated since 1995 (Appendix A). However, a

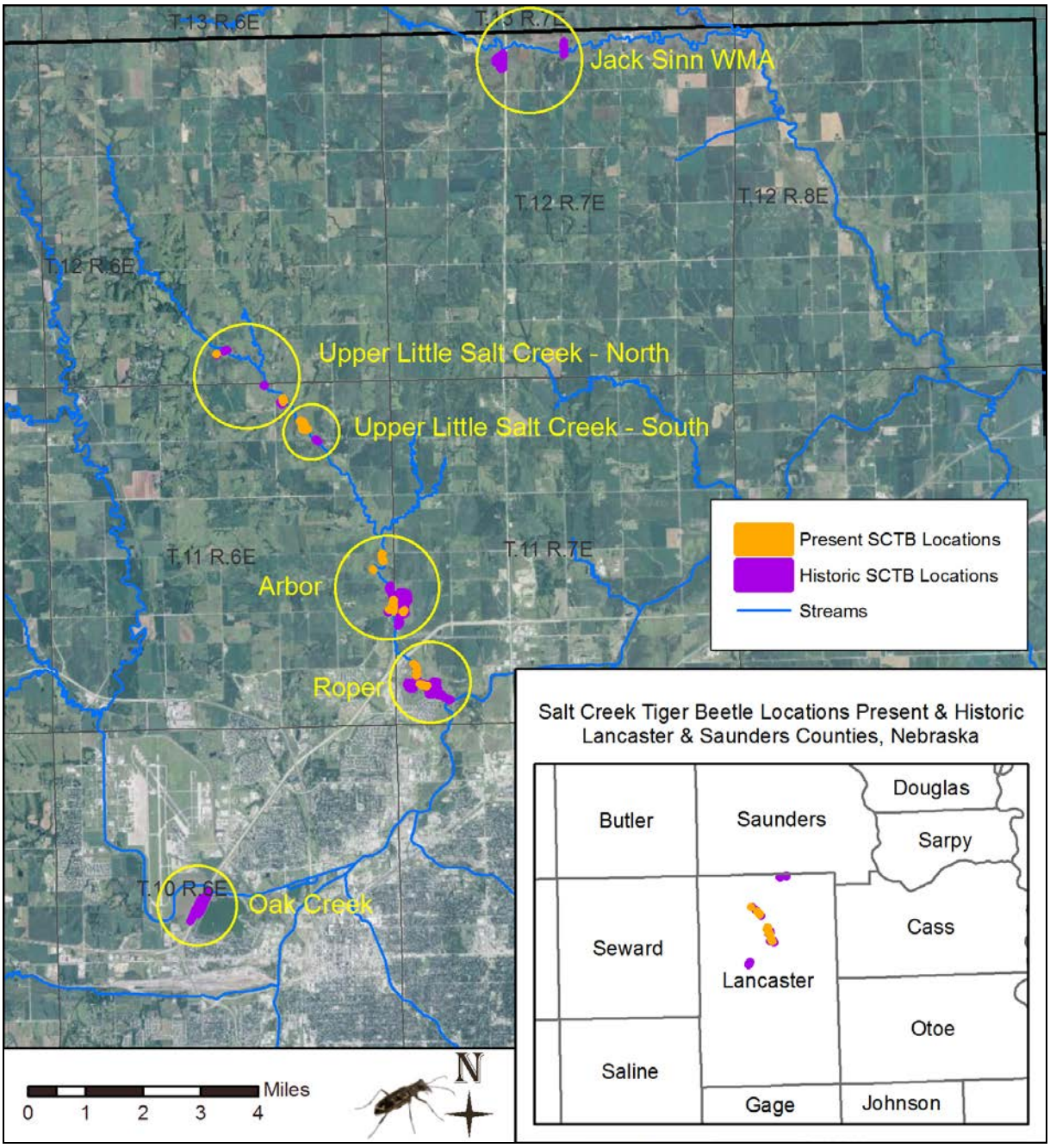
metapopulation was found using saline seeps along Little Salt Creek at the Little Salt Creek WMA in 2014. This metapopulation appears to consist of a single population making it at risk to local extirpation. This metapopulation is located approximately 5 km (3 mi) upstream from the Little Salt Creek-Arbor Lake Metapopulation (Figure 1). Degraded and non-functioning saline wetlands exist adjacent to Little Salt Creek at this site. Although this site was once devoid of vegetation, saline stream edge habitats here are now vegetated. Entrenchment of Little Salt Creek, over-covering of saline seeps with sediment, and drainage of saline wetlands has resulted in the loss of suitable habitat.

Presumed Extirpated Metapopulations

Jack Sinn WMA Metapopulation: This extirpated metapopulation consisted of two populations located near Rock Creek in southern Saunders and northern Lancaster Counties, approximately 20 km (10 mi) northeast of the Little Salt Creek-Arbor Lake Metapopulation on property owned by the NGPC (Figure 1). We believe that this metapopulation disappeared due to a reduction in the number of interacting populations and degradation of habitat along Rock Creek. Salt Creek tiger beetles have not been found at the Jack Sinn WMA since 1998 (Appendix A).

Oak Creek Metapopulation: Oak Creek and its associated saline wetlands, locally referred to as Capitol Beach, were historically one of the largest saline wetland tracts in eastern Nebraska, with a size of approximately 162 hectares (400 acres) (Cunningham 1985) (Figure 1). Although we do not have historic metapopulation estimates from this site, the presence of several specimens at the University of Nebraska State Museum, Systematics Research Collections suggest that it was once home to a large, sustainable metapopulation of Salt Creek tiger beetles. All that remains of suitable habitat at Oak Creek now is a large saline wetland located within the boundaries of the Lincoln Municipal Airport. Oak Creek is a 10 to 20 meter-wide (40 to 50 foot-wide) drainage that parallels Interstate 80 for approximately 0.8 km (0.5 mi), southwest of the Interstate 80 and Airport Interchange. No individuals have been found at Oak Creek since 1998 (Appendix A) (Spomer et al. 2002 and 2004a and b; Allgeier et al. 2003). Although this metapopulation is presumed extirpated, a large saline wetland on property owned by the Lincoln Municipal Airport has not been surveyed for over fifteen years due to lack of permission for access. Thus, it is possible that the Salt Creek tiger beetle is present at the saline wetland located on the Lincoln Municipal Airport property given the presence of suitable habitat and observations of other conspecific tiger beetles adjacent to the site.

Figure 1. Historic[1] and Current Metapopulations and Populations of Salt Creek Tiger Beetles[2]



[1]Since surveys began in 1991
[2]Map must be viewed in color to differentiate between present and historic Salt Creek tiger beetle locations.

1.4 Life History/Ecology

Life Cycle

Research indicates that the Salt Creek tiger beetle naturally has a two-year life cycle, not uncommon for tiger beetles (Allgeier et al. 2004; Spomer et al. 2004a). Wild adults are first observed as early as mid-May or as late as mid-June. Their numbers peak about two-weeks after the first individuals appear and begin to feed and mate. After mating, the male rides atop the female to prevent her from re-mating (a phenomenon known as mate-guarding). Females deposit their eggs on barren salt flats of saline wetlands, along sloping banks of streams in areas where the salt layer is exposed in the soil horizon, or along saline stream edges that are found in close association with water, near a seep. We believe that female Salt Creek tiger beetles lay approximately 50 eggs at night in the wild (Farrar 2003). Following mating and egg-laying, wild adult populations begin to die in late-July, likely due to senescence.

Spomer and Higley (1993), Spomer et al. (2004a), and Willis (1967) describe the life cycle of the Salt Creek tiger beetle in detail through egg, larval, and adult stages as follows. Eggs hatch approximately two weeks after being laid by the female. After the eggs hatch, the young larva digs a burrow and uses its head to scoop out soil. The larva takes these small mud clods to the burrow entrance and flips them outside the hole. The larva will plug its burrow and retreat inside during periods of very hot weather or dry conditions. As the larva grows, it molts to a larger instar (a life stage between molts), enlarging and lengthening its burrow. Typically, a Salt Creek tiger beetle larva will remain active until cold weather (late October-early November), at which time it plugs its burrow and estivates. The Salt Creek tiger beetle has three instars. It probably overwinters the first and second years as a second and third instar, respectively, then pupates in May and emerges as an adult. Before pupation, the larva seals its burrow entrance and digs a side chamber about 5 to 8 centimeters (2 to 3 inches) below the soil surface. After the adult emerges from the pupa, it remains in the chamber until its cuticle hardens, then leaves the burrow to feed and mate.

Feeding

A larval tiger beetle ambushes prey passing near the burrow entrance. Once it has captured its prey, the larval tiger beetle pulls it into the burrow with the aid of two pairs of hooks on the abdomen. These hooks also function to prevent the larva from being pulled from its burrow by larger prey or predators. Adults prey on other insects.

Habitat

The entire life cycle of the Salt Creek tiger beetle occurs in saline wetlands, on exposed saline mud flats, or along mud banks of streams and seeps that contain salt deposits and are sparsely vegetated (Carter 1989; Spomer and Higley 1993; LaGrange 1997; Spomer et al. 2004a). Larvae have been found only on moist salt flats and salt-encrusted banks of Little Salt Creek in northern Lancaster County (Spomer et al. 2004a). Adults prey on other insects on sandbar, mid-stream gravel bar, and salt flat habitats. Salt Creek tiger beetles require a permanent source of water; open, barren salt flat areas for construction of larval burrows, thermoregulation, and foraging;

and mid-stream gravel bars as dispersal corridors (Spomer and Higley 1993; Higley 2002, pers. comm.; Spomer 2005, pers. comm.).

A species-specific preference for salt and soil moisture is likely important for habitat partitioning and reduction in competition between the Salt Creek tiger beetle and other congener species of tiger beetles that live in saline wetlands (Hoback et al. 20009; Allgeier et al. 2004).

2 CRITICAL HABITAT, THREATS, AND CONSERVATION

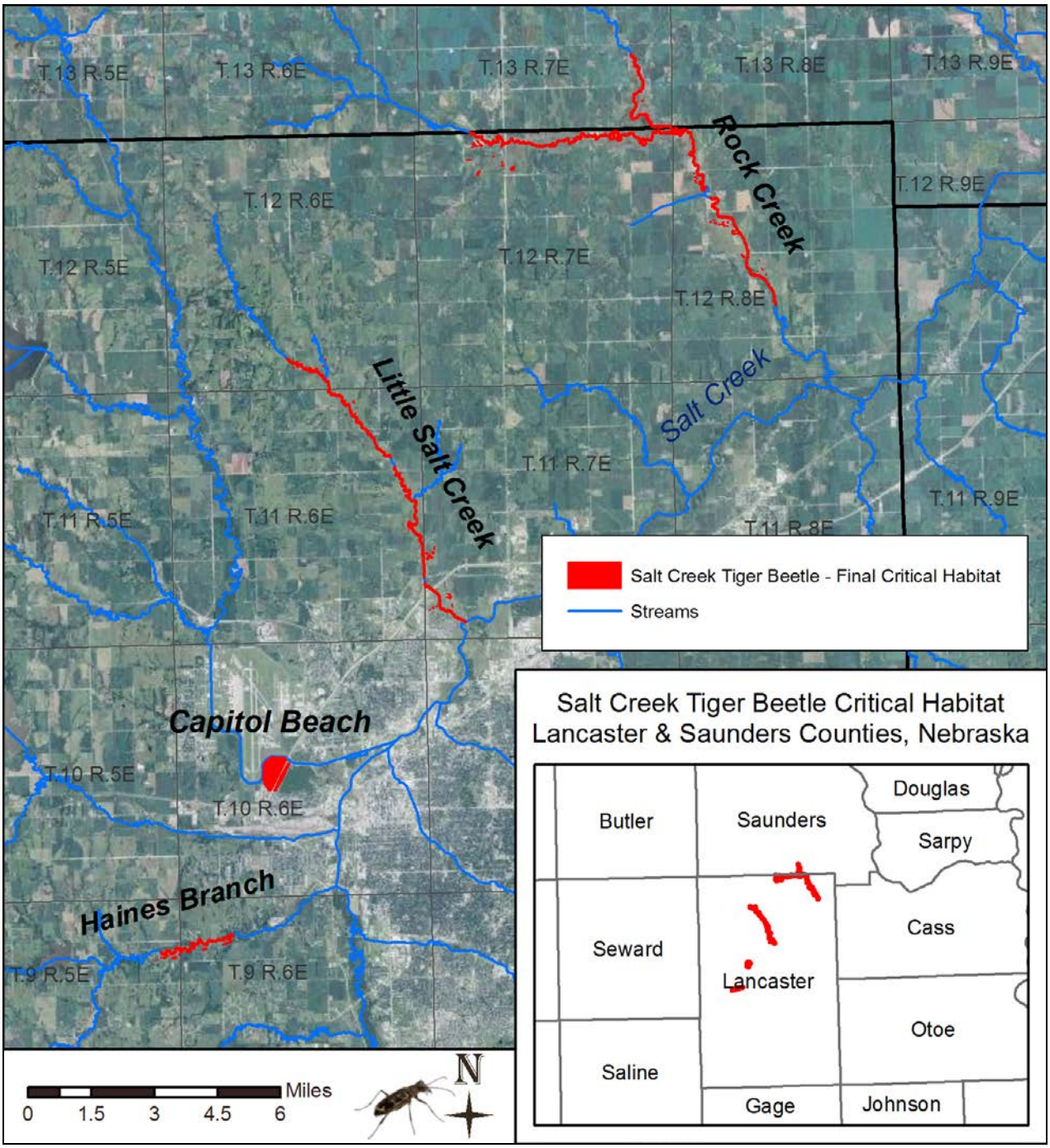
The Service designated critical habitat for the Salt Creek tiger beetle on May 6, 2014 (79 FR 26013). The 449 hectare (1,110 acre) designation includes saline seeps along Rock, Little Salt, Oak, and Haines Branch Creeks (Figure 2). We extended a 42 meter (137-foot) dispersal distance outward on either side of these creeks to provide the Salt Creek tiger beetle with access to saline wetland and seeps located in the floodplains of Rock, Little Salt, Oak, and Haines Branch Creeks. In some instances, we also included large saline wetlands if they were near one of the aforementioned streams and provided suitable habitat for the Salt Creek tiger beetle (e.g., saline wetland located on Lincoln Municipal Airport property). We selected Rock, Little Salt, Oak, and Haines Branch Creeks as critical habitat because we were familiar with these areas and their ability to provide the primary constituent elements to the Salt Creek tiger beetle.

We determined that the primary constituent elements specific to the Salt Creek tiger beetle are saline barrens and seeps found within saline wetland habitat in Little Salt, Rock, Oak, and Haines Branch Creeks. The Salt Creek tiger beetle requires two habitat types within suitable wetlands:

- Exposed mudflats associated with saline wetlands or the exposed banks and islands of streams and seeps that contain adequate soil moisture and soil salinity. These core habitats support egg-laying and foraging requirements.
- Vegetated wetlands adjacent to core habitats that provide shade for thermoregulation, support a source of prey for adults and larval forms of Salt Creek tiger beetles, and protect core habitats.

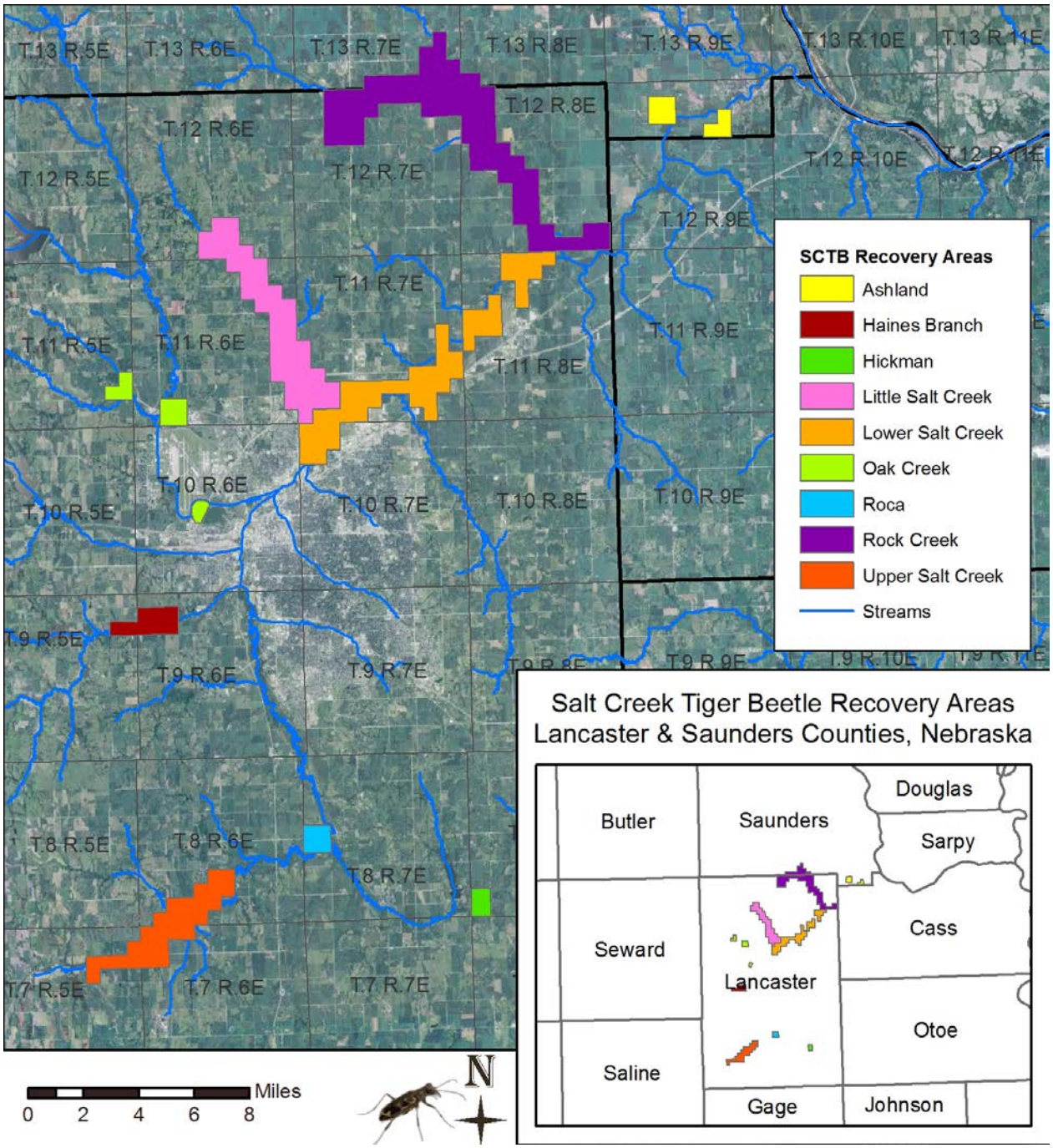
Our recovery approach is to establish six metapopulations of Salt Creek tiger beetles at the Rock, Little Salt, Oak, and Haines Branch Recovery Areas (Figure 3). These creeks were previously designated as critical habitat and provide the best opportunity for recovery of the subspecies. However, it is possible that these creeks may not be able to support six viable metapopulations due to past alterations to habitat and hydrology, the risk of erosion, and the potential for loss of larvae habitat from flood conditions. Under these circumstances, we believe that other habitat shown as recovery areas on Figure 3 (Ashland, Lower Salt Creek, Roca, Upper Salt Creek, and Hickman Recovery Areas), but not designated as critical habitat, may be useful for the recovery of the Salt Creek tiger beetle. These areas have the potential to provide alternative reintroduction and recovery sites.

Figure 2. Salt Creek Tiger Beetle Critical Habitat[1]



[1]Map must be viewed in color to identify designated critical habitat.

Figure 3. Potential Salt Creek Tiger Beetle Recovery Areas[1]



[1]Map must be viewed in color to identify recovery areas.

2.1 Threats

Researchers knew of six Salt Creek tiger beetle metapopulations when surveys began in 1991 (Figure 1; Appendix A). These were located on Rock, Little Salt, and Oak Creeks (Figure 1). However, several of these metapopulations are presumed to be extirpated (since 1991) due to the threats outlined below, the most significant threat being Listing Factor A, The Destruction, Modification, or Curtailment of Habitat. Below is a summary of the most significant threats to the Salt Creek tiger beetle and its saline wetland and stream bank habitats. A detailed discussion about the threats to the Salt Creek tiger beetle can be found in the final rule to list the subspecies as federally endangered (70 FR 58335, October 6, 2005).

Listing Factor A – the present or threatened destruction, modification, or curtailment of habitat or range

Commercial and Residential Developments

Commercial and residential developments pose a significant threat to the saline wetlands of eastern Nebraska as well as to plant and animal species that depend upon these habitats (Gilbert and Stutheit 1994; Ratcliffe and Spomer 2002). From the 1930s to the 1950s, saline wetlands were destroyed for the development of the City of Lincoln (Farrar and Gersib 1991). In the 1960s, construction of Interstate 80, through the heart of the remaining Salt Creek tiger beetle habitat, resulted in additional filling, dredging, diking, draining, and diversion (Farrar and Gersib 1991). Most of the remaining habitat is now composed of small habitat complexes (i.e., less than 0.04 hectare (0.09 acre)) that are unlikely to provide all of the necessary life history requirements for the Salt Creek tiger beetle to survive without restoration. This spatial distribution of remaining saline wetlands also reduces the connectivity between metapopulations and populations thereby eliminating genetic interchange and the ability to repopulate after catastrophic events (Murphy et al. 1990; Fahrig and Merriam 1994; Ruggerio et al. 1994; Noss 2002).

An example of development prompted by growth of the City of Lincoln is the conversion of a large saline wetland, flat, and seep complex, referred to as Salt Basin, to Capitol Beach at the turn of the 20th century. Salt Basin (now known as Capitol Beach and included in the Oak Creek Recovery Area), once approximately 162 hectares (400 acres) in size, was one of the largest saline wetlands in the area (Cunningham 1985). In 1895, Salt Basin was diked and Oak Creek was diverted to create a permanent lake for recreational purposes. In 1906, the lake was renamed Capitol Beach. To accommodate the residential and commercial developments there, saline wetlands and associated streams at Capitol Beach were further ditched, drained, and filled (Murphy 1992; Rus et al. 2003). Construction of Interstate 80 northwest of Capitol Beach resulted in the continued filling of saline wetlands. These activities caused the extirpation of the Oak Creek Metapopulation, possibly the largest historic metapopulation of Salt Creek tiger beetles and the location of the type locality for the subspecies. All that remains of Salt Basin is a large saline wetland and associated salt flat, which provides potentially suitable habitat for the Salt Creek tiger beetle, on property owned by the Lincoln Municipal Airport.

Construction of the North 27th Street interchange along Interstate 80 facilitated the conversion of

a large grassland, saline wetland, and stream complex to extensive commercial and residential developments. The Little Salt Creek-Roper Metapopulation of Salt Creek tiger beetles in the area of Interstate 80 and the North 27th Street interchange is nearly surrounded by commercial and residential developments.

Freshwater runoff from commercial and residential developments dilutes salinity. Reduced salinity concentrations on barren salt flats and along saline stream edges has encouraged the invasion of vegetation such as cattail (*Typha angustifolia*), reed canary grass *(Phalaris arundinacea*), and smooth brome *(Bromus inermis)* into habitats used by the Salt Creek tiger beetle. These plants, ordinarily unable to tolerate high salinity, are aggressive invaders that convert sunny, barren salt flats into habitat dominated by herbaceous overstory. The resulting vegetated habitat then becomes unsuitable for use by the Salt Creek tiger beetle. The overstory shades out open, sunny areas required by the Salt Creek tiger beetle to thermoregulate, forage, and lay eggs. Increased vegetative encroachment is the primary factor attributed to the extirpation of several populations of other *Cicindela* species (e.g., *C. abdominalis* and *C. debilis*) (Knisley and Hill 1992) and was one of the main threats to *C. ohlone* (66 FR 50340).

Stream Channelization, Bank Stabilization, and Incisement

Channelization of Salt Creek from Lincoln to Ashland, Nebraska was done to control flooding and protect infrastructure (Farrar and Gersib 1991; Murphy 1992). In the 1950s, a flood control plan was developed and implemented to reduce the frequency of flooding. The flood control plan resulted in the construction of levees and reservoirs and additional channelization of Salt Creek (Murphy 1992). Channelization of Salt Creek encouraged tributary streams (e.g., Little Salt, Oak, Rock, and Haines Branch Creeks) to head-cut, carving deeper into their beds to adjust to the change in stream bed gradient. This resulted in the gradual lowering of the water table and drainage of adjacent saline wetlands that are important to the Salt Creek tiger beetle (Wingfield et al. 1992). The on-going long-term effects of these past channelization projects continue to cause saline groundwater to be intercepted and directed into streams, thereby reducing flow of groundwater to surface seeps and causing the loss and degradation of saline wetlands and salt flats required by the Salt Creek tiger beetle (Harvey et al. 2007).

A stream channelization and bank stabilization project along Little Salt Creek significantly impacted the largest metapopulation of Salt Creek tiger beetles, the Little Salt Creek-Arbor Lake Metapopulation (Spomer and Higley 1993; Farrar 2003). In an attempt to control erosion and bank sloughing and to prepare for the widening of North 27th Street, a portion of Little Salt Creek was straightened, and its banks were armored with rock riprap. These actions destroyed about half of the remaining prime habitats for the Salt Creek tiger beetle along Little Salt Creek (Spomer and Higley 1993; Farrar 2003). The Little Salt Creek-Arbor Lake Metapopulation exhibited a corresponding 55 percent decline (see Appendix A) in the year (1991) after the project was completed (Spomer and Higley 1993).

Agricultural Development

Agricultural practices can threaten Salt Creek tiger beetle habitat, especially in the rural Upper Little Salt Creek-North, Upper Little Salt Creek-South, and Little Salt Creek-Arbor Lake Metapopulations. Livestock are attracted to exposed salt. Livestock can destroy or substantially degrade salt barren habitats for adult and larval forms of the Salt Creek tiger beetle through trampling, which can destroy larval burrows and the larvae that inhabit them (Spomer et al.

2001). Cattle grazing can also compact soil and modify soil hydrology, gradually drying out a site and making it unsuitable for adults and larvae (which prefer moist, muddy sites with encrusted salt on soil surfaces). For example, the Upper Little Salt Creek-North Metapopulation occurs along a segment of Little Salt Creek that flows through a pasture; this population was negatively impacted by cattle grazing (Spomer et al. 2004a). However, grazing has always been associated with saline wetlands since settlement and is undoubtedly an important component of their management. Grazing can be an effective land management tool to control encroachment of aggressive vegetation when done at appropriate stocking rates and times (USFWS 2016). Exclosures are used in conjunction with grazing to prevent damage to salt barrens and seeps along stream banks. Historically, large herds of bison *(Bison bison)*, pronghorn *(Antilocapra americana)*, and elk *(Cervus canadensis)* were known to spend a considerable amount of time grazing in the saline wetlands. It is relatively common to find bones of these large herbivores along Little Salt Creek.

Cultivation poses a threat to Salt Creek tiger beetle habitats generally through indirect means. Cultivation can increase sediment erosion and result in the introduction of pesticides into adjacent saline wetlands especially in the absence of a grass buffer. Depletion of groundwater for irrigation can reduce discharge in streams and modify saline seeps where Salt Creek tiger beetles are found. Adverse impacts can also occur if winter and spring thaws wash sediment from cultivated land and either cover larval burrows with a thick layer of sediment or encourage vegetative encroachment of saline stream edges through sediment accumulation. Flooding and overcovering by sediment originating from cultivated areas may have caused the extirpation of the Jack Sinn WMA Metapopulation of Salt Creek tiger beetles in 1998. Since larvae extract excess soil material out and away from their burrow, as opposed to inwards, the larvae were unable to remove the 8 to 10 centimeters (3 to 4 inches) of sediment deposited onto their burrows (Spomer et al. 2004a). The flood also changed the vegetation of the area; before the flood, there were large areas of saline wetlands and salt flats present. After the flood, a thick herbaceous overstory composed of reed canarygrass and cattails infested the area, making it unsuitable for the Salt Creek tiger beetle.

Listing Factor B – Overutilization for commercial, recreational, scientific, or educational purposes

Tiger beetles (genus *Cicindela*) are one of the most sought after genera of beetles by amateur collectors because of their unique metallic colors and patterns, as well as their fascinating habits. However, we do not have any information that suggests that over collection of adult Salt Creek tiger beetles is a factor contributing to its decline.

Listing Factor C – Disease or predation

Predators and parasitoids evolved in conjunction with the Salt Creek tiger beetle and would not normally pose a severe threat to the survival of a healthy and viable metapopulation. Similarly, congener species of tiger beetles may not ordinarily compete with the Salt Creek tiger beetle when prey and habitat resources are abundant. These issues are likely not a meaningful contributor to historical declines. However, in light of the subspecies current small number and limited distribution, predation, parasitism (Higley 2002, pers. comm.), and competition from other tiger beetles may be a significant source of mortality and an issue of concern.

Listing Factor D – The inadequacy of existing regulatory mechanisms

Clean Water Act

The U.S. Army Corps of Engineers (Corps) regulates the placement of fill materials into wetlands, streams, rivers, and other water features under section 404 of the Clean Water Act (CWA). Placement of fill into these water features requires a permit from the Corps. Stream channelization and bank stabilization projects on Salt Creek have caused channel entrenchment and the gradual drainage of adjacent saline wetlands over time in several tributaries. The effects of these kinds of activities could have substantial adverse impacts on saline wetlands and associated streams used by larval and adult Salt Creek tiger beetles, as discussed in Factor A. The CWA does not limit the impacts from these kinds of activities because the CWA does not regulate wetland drainage resulting from channel entrenchment or construction of drainage ditches nor does it apply to runoff of sediment originating from upland sources.

State Implemented Regulatory Mechanisms

Under section 401 of the CWA, the Nebraska Department of Environmental Quality issues a Water Quality Certification verifying that Nebraska State Water Quality Standards have been met whenever a permit is issued by the Corps. However, Water Quality Standards are not aligned with quantitative biological criteria. Thus, projects may meet certification standards but still have negative impacts on saline wetlands and associated streams, which provide habitats for both larval and adult Salt Creek tiger beetles. Additionally, the Nebraska Department of Environmental Quality can only take an enforcement action after an impact to a wetland has occurred.

Local Conservation Planning

In a joint effort to plan long-term development projects for the City of Lincoln and Lancaster County, city and county officials approved the 2002 Lincoln and Lancaster County Comprehensive Plan (City of Lincoln/Lancaster County 2002). Since then, the Comprehensive Plan has been updated with amendments through 2015 (City of Lincoln/Lancaster County 2011). The Comprehensive Plan is a guide for the growth and development for the City of Lincoln and Lancaster County. The Comprehensive Plan took a proactive approach to the conservation of saline wetlands and threatened and endangered species, including the Salt Creek tiger beetle, through the creation of the Saline Wetland Conservation Partnership (SWCP). The SWCP works with landowners to protect saline wetlands through land acquisition, conservation easements, and habitat restoration projects. However, the Comprehensive Plan can provide no assurances for the protection of habitat for the Salt Creek tiger beetle beyond the elected terms of the officials instrumental in its development and implementation. Additionally, while the Comprehensive Plan addresses larger scale residential and commercial developments, it does not limit the development of residential acreages which have the potential to impact management practices on adjacent saline wetlands.

Conclusion

The Act is the primary tool that we use to protect federally listed endangered species like the Salt Creek tiger beetle. Protections conveyed by the CWA, Nebraska Water Quality Certification, and comprehensive local planning efforts are helpful but, in the absence of federal listing, would not contribute to the ultimate goal of recovering the Salt Creek tiger beetle.

Factor E – Other natural or manmade factors affecting its continued existence

Small Metapopulation Size

Metapopulations of Salt Creek tiger beetles are isolated, small, and vulnerable to extinction by chance demographic events, disease, inbreeding, or other events such as changing water levels, succession of wetland vegetation, and habitat destruction (Murphy et al. 1990, Ruggerio et al. 1994, Gibbs 1993). Small metapopulations of Salt Creek tiger beetles are not sustainable and tend toward extirpation (for example, see Appendix A, Survey Results for Jack Sinn WMA and Oak Creek Metapopulations). Murphy et al. (1990) and Gilpin (1987) recognized a direct association between increased extinction rates of a species and reduced habitat areas, increased distances between populations, and small population size. The negative effects of habitat fragmentation and loss of the total number of individuals within a population include the loss of genetic diversity (Lacy 1987).

Climate and Weather Events

The remaining metapopulations of Salt Creek tiger beetles are highly susceptible to extinction as a result of weather events. Such events may include: a) heavy rain storms and severe flooding that drown and scour larvae away, dilute salinity, and result in sediment deposition and b) drought, which can dry out seeps and saline wetlands, making them unsuitable as habitat, and can change the diversity and abundance of prey. Climate change may also affect the Salt Creek tiger beetle through a gradual warming and drying trend in the Midwest resulting in the loss of saline wetland and seep habitats.

Pesticides

Corn, soybean, and sorghum fields and pasture dominate the Little Salt Creek watershed and are potential sources of pesticide exposure to Salt Creek tiger beetles and their habitat. Insecticides that enter occupied habitats of the Salt Creek tiger beetle through runoff have the potential for indirect impacts through reduction of prey availability. No studies have evaluated direct adverse impacts of pesticide exposure to Salt Creek tiger beetles; however, research on ground beetles (Carabidae) indicates that pesticide exposure may place adult Salt Creek tiger beetles at risk of decreased survival and reproduction (Mullin et al. 2010; Pisa et al. 2014). Insecticides and herbicides applied annually to lawns and landscaping in residential and commercial developments near Little Salt Creek also have the potential to enter the creek and impact the Salt Creek tiger beetle and its prey base.

Artificial Lights

The proliferation of artificial lights due to commercial and residential developments along streets and highways in Lincoln may also contribute to metapopulation losses of the Salt Creek tiger beetle because such lights have been implicated in population losses of nocturnal insects elsewhere (Pyle et al. 1981). Because female Salt Creek tiger beetles lay eggs at night, artificial light sources may reduce reproduction (Allgeier et al. 2003) by drawing females away from suitable breeding habitat. Movement away from habitat to lighted areas, such as areas surrounding major transportation routes (e.g., Interstate 80) and associated residential and commercial developments (e.g. north 27th Street development), may increase energy expenditure and reduce reproductive success, cause direct mortality through predation, and ultimately impact the survival of the two largest metapopulations of Salt Creek tiger beetles near the City of

Lincoln (Allgeier et al. 2004).

Conclusion

Direct and indirect loss of saline wetland and stream habitats prior to, and following listing in 2005, remains the greatest threat to the Salt Creek tiger beetle. Of these threats, indirect loss likely poses a greater risk than direct loss through filling activities post-listing, due to the increased regulatory oversight that has been applied through administration of section 404 of the CWA. However, the on-going, long-term effects of past channelization projects continue to cause the loss and degradation of saline wetlands and salt flats required by the Salt Creek tiger beetle. The Comprehensive Plan (City of Lincoln/Lancaster County 2011) has regulated development in the Little Salt Creek area and has helped guide proposed commercial and residential developments away from Salt Creek tiger beetle habitat.

Impacts caused by weather events such as drought, excessive rainfall, and flooding have significantly impacted the Salt Creek tiger beetle. Drought has been shown to play a role in the reduction of metapopulations through desiccation of saline wetlands and seeps along streams, making them unsuitable for egg laying and larval use. Excessive rainfall has been observed to cause direct loss of larvae and scouring of larval habitat along streams, bank sloughing and overcovering of larval habitat, and excessive flooding of saline wetlands over long periods of time, which likely affects the Salt Creek tiger beetle.

Artificial lights attract the Salt Creek tiger beetle away from habitat, subjecting it to risk from predation and unnecessary energy expenditure. Additionally, parasitism and predation may be a concern given the small number of metapopulations and small metapopulation sizes. Pesticide application likely has had a negative impact on the Salt Creek tiger beetle. We have no information that would support the conclusion that over collecting of individuals has had a negative impact on the Salt Creek tiger beetle.

2.2 Conservation Efforts

The SWCP, City of Lincoln, Lower Platte South Natural Resources District (LPSNRD), NGPC, and the Natural Resources Conservation Service (NRCS) have made protection of saline wetlands in eastern Nebraska a priority and have been extremely effective in the implementation of conservation projects. The focus of these efforts has been along Little Salt and Rock Creeks, but there have also been conservation efforts along Oak Creek. We anticipate that the efforts of the SWCP, LPSNRD, NGPC, and NRCS will continue into the future.

Saline Wetlands Conservation Partnership: The SWCP is a partnership between the City of Lincoln, Lancaster County, LPSNRD, The Nature Conservancy, and NGPC. An Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands guides the SWCP and provides a holistic watershed approach designed to preserve both wetlands and their surrounding watersheds (LaGrange et al. 2003). Plan implementation involves local, state, and federal agencies working in concert with private individuals and organizations to develop additional strategies and programs that encourage saline wetland conservation. The SWCP utilizes several strategies including purchase of wetlands from willing sellers, conservation easements that keep land in private ownership, and public outreach and education efforts (Saline Wetlands

Conservation Partnership 2014) (Figure 4). Funding for the SWCP has been provided through Nebraska Environmental Trust grants and state and federal funding programs, including several non-traditional Section 6 grants obtained by the NGPC for land acquisitions. Other partners have contributed to the conservation of saline wetland and steam complexes along Little Salt and Rock Creeks, including the Cooper Foundation, The Nature Conservancy, Ducks Unlimited, the Service, U.S. Environmental Protection Agency, Nebraska Department of Environmental Quality, Home Builders Association of Lincoln, Nebraska Wildlife Federation, Waschiska Audubon, Hugo and Thelma Aspegren Trust, Nebraska Sierra Club, Pheasants Forever, Conservation Alliance of the Great Plains, and several private landowners.

City of Lincoln: The City of Lincoln has been instrumental in the acquisition, restoration, and management of saline wetland and stream complexes in Lancaster County (Figure 4). The City of Lincoln has been especially effective at developing innovative restoration projects, including creation of barren salt flats along stream banks, which have benefited the Salt Creek tiger beetle.

Lower Platte South Natural Resources District: The LPSNRD has made a priority the acquisition, restoration, and management of saline wetland and stream complexes in Lancaster County (Figure 4). The LPSNRD has been effective at developing close relationships with private landowners to protect and conserve saline wetlands.

Nebraska Game and Parks Commission: The NGPC owns and manages several WMAs along Little Salt and Rock Creeks that include large blocks of saline wetland habitat (Figure 4). The largest of these saline wetland and stream complexes is the Jack Sinn WMA located along Rock Creek.

Natural Resources Conservation Service: The NRCS has spent a considerable amount of time working with private landowners to enroll saline wetland and stream complexes into Wetland Reserve Program (WRP) easements (Figure 4).

Land Management

Many saline wetlands and stream complexes shown in Figure 4 have been restored and are managed to encourage development of healthy saline systems. Many of these areas still need restoration. Restoration actions include flattening of stream banks to expose saline seeps, installation of water control structures, and removal of excess sediment. Routine management actions include grazing to control cattails and encourage development of saline wetland vegetation; prescribed burns; and control of noxious weeds, aggressive native plants, and woody vegetation. A high diversity, native seed mix has been planted at many of these areas to restore native vegetation. As a result of these restoration and management actions, researchers have used several of the areas shown on Figure 4 as experimental Salt Creek tiger beetle reintroduction sites.

Experimental Rearing, Propagation, and Reintroduction

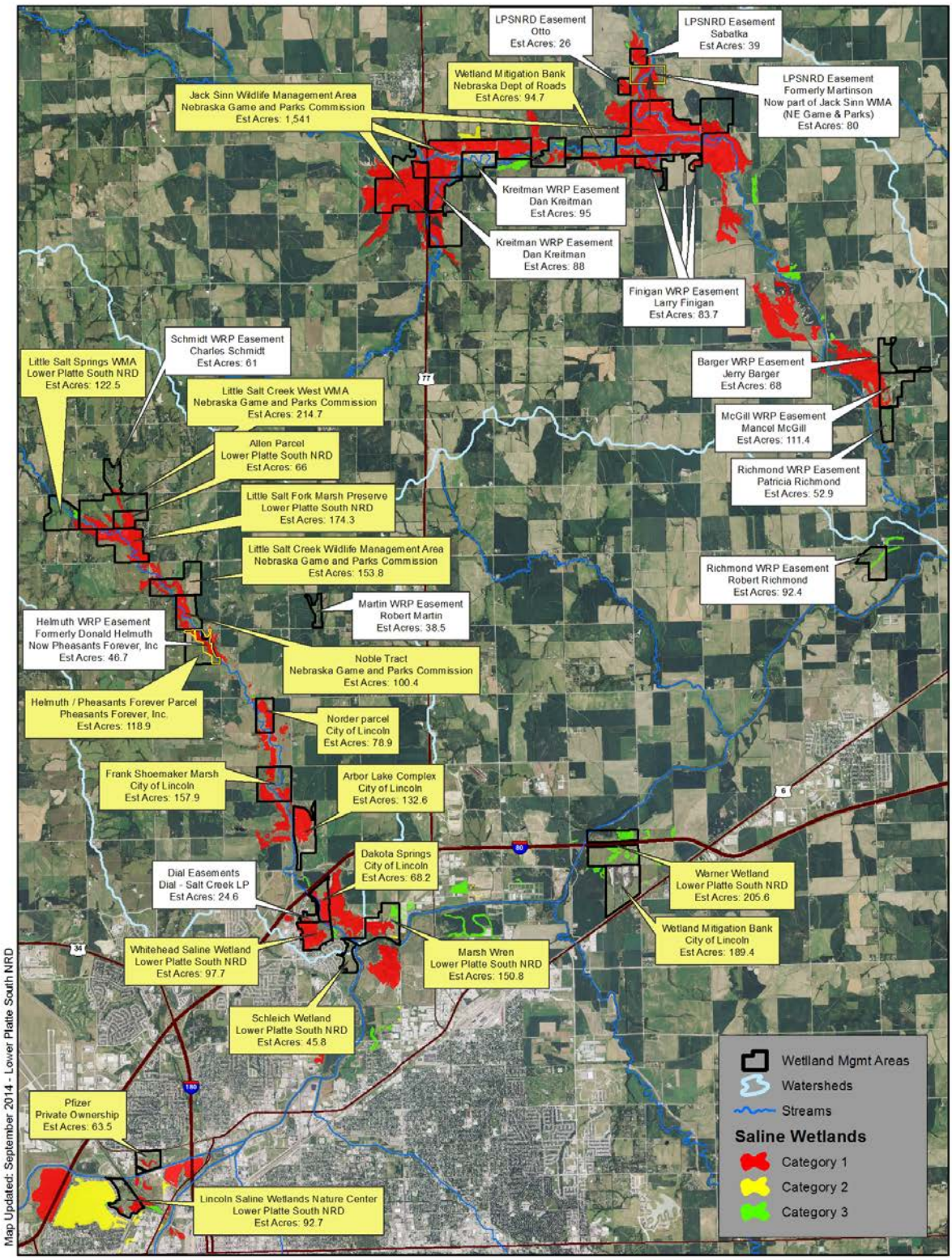
A partnership, including the Henry Doorly Zoo, Lincoln Children's Zoo, University of Nebraska Entomology Department, Master Naturalist Program, the Service, and NGPC was established in 2011 to rear and reintroduce the Salt Creek tiger beetle. Small-scale experimental reintroduction efforts have occurred since 2011 at several locations along Little Salt Creek. Methods and procedures used to rear and reintroduce the Salt Creek tiger beetle are described below.

Male and female pairs are collected in early-June, immediately after they emerge from their burrows. Pairs are placed in individual rearing containers with a 50 percent sand and 50 percent loam substrate at the Henry Doorly Zoo. A 0.5 molar solution of sodium chloride is misted on the substrate to simulate saline egg-laying conditions. Following mating, the female lays eggs and, in approximately 2-3 weeks, the larvae hatch. Larvae are collected and placed in containers and fed fruit flies and crickets until late fall at the Lincoln Children's Zoo, Henry Doorly Zoo, and University of Nebraska-Entomology Department. Larvae are induced to enter a diapause state in late-fall in rearing chambers through reduction in temperature, light, and feeding frequency. In April, temperature and light are increased to simulate spring conditions to bring larvae out of diapause. Larvae are then removed from containers and reintroduced at various areas with suitable habitat along Little Salt Creek. Master Naturalists, a group of citizen volunteers organized through the University of Nebraska, monitor the larvae, soil temperature, and moisture at reintroduction sites throughout the year and assist the zoos with care of larvae. Although the Salt Creek tiger beetle is believed to have a two-year life cycle in the wild, the life cycle can be reduced to a single year under lab conditions when food is regularly provided and temperature, humidity, and substrate conditions are kept at ideal levels. Female Salt Creek tiger beetles lay approximately 50 eggs at night in the wild (Farrar 2003), but they can lay more eggs in a lab setting. These two factors offer the potential to propagate significant numbers of Salt Creek tiger beetles for use in supplementing small and declining metapopulations. They also provide the opportunity to reintroduce individuals at extirpated sites once habitat is restored and appropriate management is implemented to maintain suitable habitat. The ultimate goal would be to increase metapopulation sizes so that future reintroduction efforts are no longer necessary.

2.3 Biological Constraints and Needs

The Captive Rearing and Reintroduction Program for the Salt Creek tiger beetle has been successful at rearing and reintroducing Salt Creek tiger beetle larvae. However, more research is needed to determine the success of adult emergence following larval reintroductions. Thus far, reintroductions have been in areas that already have a wild metapopulation of Salt Creek tiger beetles, making it difficult to discern between wild and zoo-raised adults. Additionally, monitoring reintroduced larvae and subsequent emergence of adults involves placement of enclosures around reintroduction sites. Enclosures would limit the ability of a newly emerged Salt Creek tiger beetle to obtain prey and water, which could result in mortality. Additional research is also needed to ensure development synchronization of wild and zoo-reared Salt Creek tiger beetles. Determining the survival and proliferation of released larvae and developmental synchrony is critical to determining the success and net benefit of experimental reintroductions and long term viability of reintroduction efforts. Additionally, information about the ability of habitat to support reintroduced larvae is needed to assist in meeting the recovery goal of 500 to 1,000 individuals.

Figure 4. Saline Wetland and Stream Complexes along Little Salt, Rock, and Oak Creeks



(From Saline Wetlands Conservation Partnership 2014)

[1]Map must be viewed in color to identify Saline Wetland and Stream Complexes. Definitions for Category 1, 2, and 3 saline wetlands follow Gilbert and Stutheit (1994).

3 RECOVERY

The following section presents a strategy to recover the Salt Creek tiger beetle, including objective and measurable recovery criteria, which will be used to achieve downlisting and delisting as required under section 4 of the Act. The Recovery Plan also addresses the five statutory listing/recovery factors (section 4(a)(1) of the Act) to demonstrate how the recovery criteria and actions will lead to removal of the Salt Creek tiger beetle from the list of Threatened and Endangered Species.

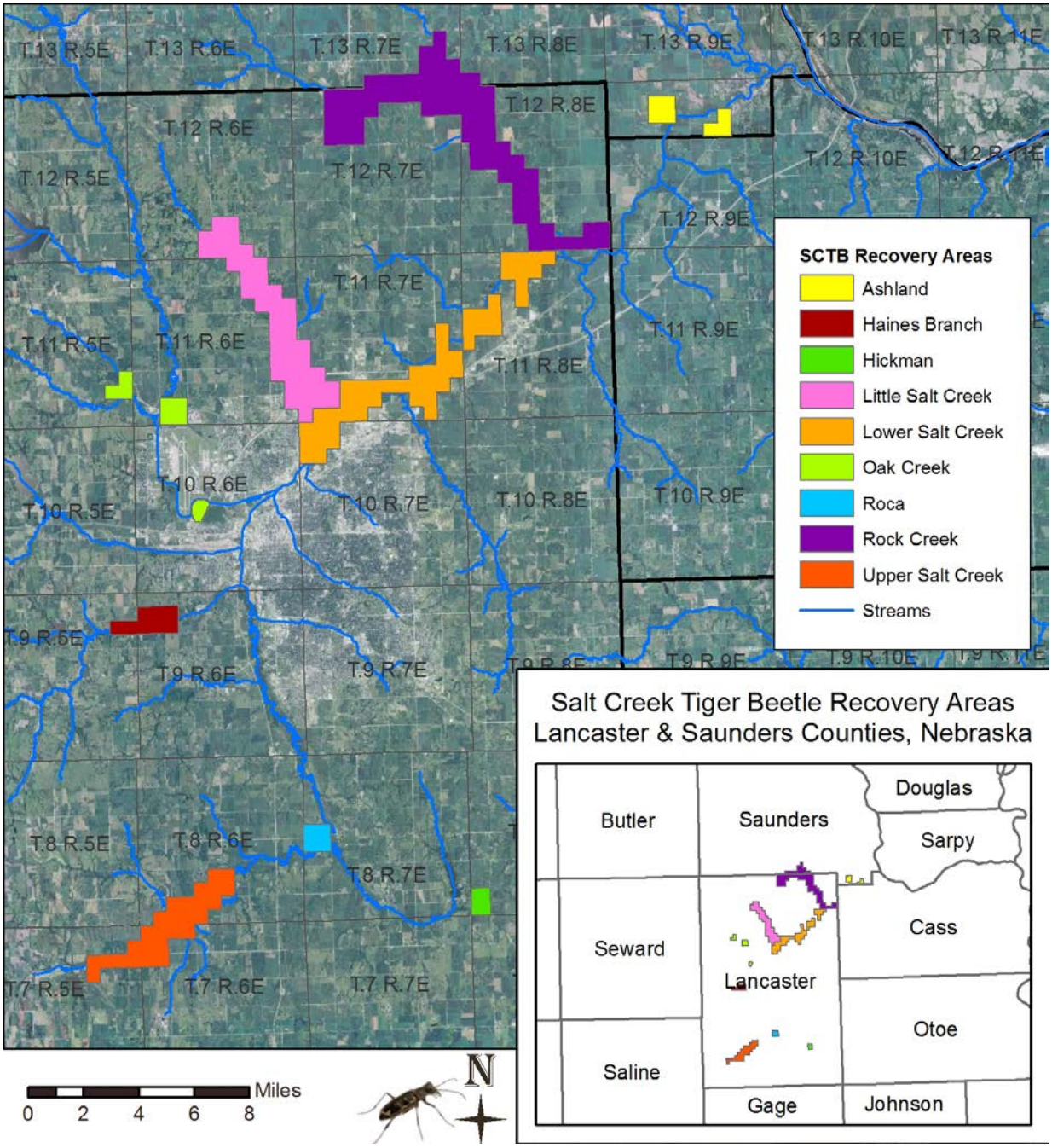
3.1 Recovery Strategy

Our recovery strategy is to establish a minimum of six self-sustaining metapopulations numbering between 500 and 1,000 individuals in four recovery areas. Recovery areas are specific to streams (Figure 4); distance varies between recovery areas and streams. Recovery areas located on multiple stream segments are required because this provides a buffer against risk that a catastrophic event may extirpate a single metapopulation that is located on a single stream. Metapopulations, which by definition contain multiple populations of Salt Creek tiger beetles, tend to remain present over time and not suffer local extirpation (e.g., Little Salt Creek-Arbor Lake Metapopulation). Metapopulations of Salt Creek tiger beetles that contain two or fewer populations have disappeared entirely (e.g., Capitol Beach and Jack Sinn WMA populations).

Our recovery strategy includes establishment of metapopulations in multiple stream segments along Rock, Little Salt, Oak, and Haines Branch Creeks. These sites are seen as having the highest probability of being successful and are currently envisioned as our highest priority reintroduction and recovery sites. However, it is possible that these recovery areas may not succeed as envisioned or that other opportunities may be worth pursuing as recovery efforts progress. Therefore, this plan also identifies alternative potential recovery areas that may be appropriate to consider including: Ashland, Lower Salt Creek, Roca, Upper Salt Creek, and Hickman. These alternative areas are not currently seen as essential to the conservation of the species but could (depending on a number of variables) play a role in the path to recovery. Figure 4 illustrates all of these potential recovery areas.

Recovery areas provide suitable habitat or have a high potential to provide suitable habitat for the Salt Creek tiger beetle. We identified recovery areas based on site inspections, soil surveys (including the presence of saline soils), and restoration feasibility. Currently, all metapopulations have fallen below a viable number of 500-1,000 individuals. We anticipate that land protection (through acquisition or easements), habitat restoration and management for the benefit of the Salt Creek tiger beetle, and reintroduction efforts are necessary to increase metapopulation sizes to within a range of 500-1,000 individuals.

Figure 5. Potential Salt Creek Tiger Beetle Recovery Areas



[1]Map must be viewed in color to identify recovery areas.

3.2 Goals, Objectives, and Criteria

Recovery Goal

The ultimate goal of the recovery plan is to recover the Salt Creek tiger beetle so that it no longer meets the Act's definition of threatened or endangered and can be removed from the Federal List of Endangered and Threatened Wildlife (i.e., delisted). An intermediate goal is to improve the species viability to a level where it no longer faces a high near-term risk of extinction (no longer "in danger of extinction") and can be reclassified to threatened.

Objective

Our recovery objectives are to: a) establish self-sustaining metapopulations (comprised of multiple populations); b) establish these metapopulations on multiple stream segments located in the recovery areas shown on Figure 4; and c) reduce or eliminate threats to the subspecies, especially those related to Risk Factor A (see Section 2.1).

Downlisting Criteria

Criterion for downlisting includes: a) establishment of three metapopulations of Salt Creek tiger beetles each numbering between 500 and 1,000 individuals to ensure population viability; b) establishment of these three metapopulations in three recovery areas; and c) at a minimum, no net loss of saline wetlands and streams and their associated functions in the Rock, Little Salt, Oak, and Haines Branch Creeks and floodplains since the time of listing (October 2005), with a likely need for restoration and establishment of additional habitat to support recovered populations.

Delisting Criteria

In addition to the downlisting criterion, the criterion for delisting includes the establishment of three additional metapopulations (for a total of six metapopulations) of Salt Creek tiger beetles. These metapopulations would each number between 500 and 1,000 individuals for a minimum 10-year period to ensure viability. The distribution of these metapopulations would span at least four recovery areas. There should be protective measures in place to ensure the long-term persistence of these sites in the absence of ESA protections.

Rationale

The risk of local extirpations of Salt Creek tiger beetle metapopulations is high given the low number of individuals, habitat specificity of the subspecies, and isolated nature of the metapopulations resulting in little opportunity for dispersal. Given these circumstances, it is difficult to conduct a robust population viability analysis to determine what a viable metapopulation should be to inform our downlisting and delisting criteria.

As an alternative to a population viability analysis, we reviewed 24 years of Salt Creek tiger beetle survey data (See Appendix A). All surveys were conducted at the same time of year using the same methods. Our data review showed that two metapopulations (Little Salt Creek-Arbor and Little Salt Creek-Roper) have consistently supported the Salt Creek tiger beetle over 24 years of species surveys. Of these, the Little Salt Creek-Roper is in decline ranging from a high of 258 individuals surveyed in 2002 to just 2 individuals surveyed in 2014. The Little Salt

Creek-Arbor Metapopulation has survived despite population fluctuations, with a high of 583 individuals in 2003 after a low of 62 individuals in 1993.

Based on the high degree of risk of local extirpation and a review of survey data from the Little Salt Creek-Arbor Lake Metapopulation, we concluded that a viable metapopulation (consisting of multiple populations) should range between 500 and 1,000 individuals over a 10-year period. Surveys to demonstrate that this criterion has been met would be done annually in late May-early June when adults are present.

Multiple metapopulations are necessary to adequately minimize the risk of extinction. We based our determination that six metapopulations are necessary on the historical distribution of the Salt Creek tiger beetle. Survey results show that the Salt Creek tiger beetle was known to have, at most, six metapopulations in 1991. We lack survey data to establish that the subspecies occupied additional locations, although it is possible that it was elsewhere but was not surveyed to establish its presence. For planning purposes, we identify other potential recovery areas that are not currently envisioned as essential to the conservation of the species. Although these areas are not seen as priority areas for recovery at this time or as having the highest probability of success, these alternative recovery areas do appear to provide suitable habitat and could (depending on a number of variables) be targeted for future reintroduction efforts. Identifying these alternative areas gives us flexibility to easily adjust recovery efforts as the situation dictates, which in turn may help maximize our chance of achieving recovery.

The Salt Creek tiger beetle has a two-year life cycle. Suitable conditions (e.g., habitat suitability, adequate hydrology, and food availability) during larval development influence the ability of adults to reproduce once they emerge in the second year. Additionally, populations of insects, including the Salt Creek tiger beetle, are naturally cyclical over time and the range of population size may be considerable on a yearly basis due to climatic variation, reproductive success, and observation conditions. As such, we will consider downlisting and ultimately delisting of the Salt Creek tiger beetle after 10 years have passed and the threats of habitat loss and degradation (Listing Factor A) have been managed and reduced. The criteria for management and reduction of habitat loss and degradation (Listing Factor A) is to have no net loss of saline wetlands and streams and their associated functions in the Rock, Little Salt, Oak, and Haines Branch Creeks and floodplains since the time of listing (October 2005), with a likely need for restoration and establishment of additional habitat to support recovered populations. We have no information to support over-collection (Listing Factor B) as being a threat to the Salt Creek tiger beetle. We believe that our criteria to have larger metapopulations of 500 and 1,000 individuals comprising six metapopulations on at least four recovery areas will sufficiently reduce the threats from disease and predation (Listing Factor C) and some of the threats in Listing Factor E, including small population sizes and catastrophic events such as floods and drought that can extirpate a single metapopulation. The saline wetland habitat required by the Salt Creek tiger beetle is a very unique and limited resource that is highly vulnerable to degradation from impacts that affect saline groundwater supplies to the saline seeps and wetlands. Protections conveyed by the CWA, Nebraska Water Quality Certification, and comprehensive planning efforts are helpful, as discussed in the Listing Factor D section, but, in the absence of federal listing, would not contribute to the ultimate goal of recovering the Salt Creek tiger beetle. In order to ensure the long-term viability of the Salt Creek tiger beetle, the sites occupied by the six metapopulations necessary to meet delisting criteria should have permanent acquisition or long-term conservation

agreements that will protect both the saline wetlands and saline groundwater and maintain suitable habitat for the Salt Creek tiger beetle. The protection of recovery areas should include the implementation of management plans and practices with the viability of the Salt Creek tiger beetle as a main objective.

3.3 Narrative of Recovery Actions

The following recovery actions represent a step-downed approach to our Recovery Plan for the Salt Creek tiger beetle. These items are discrete, specific actions and are listed in the Implementation Schedule and Cost Estimates in section 3.4 with associated time and cost estimates and potential partners and responsible parties.

1.0 Recovery Area Protection

1.1 Protection of the majority of recovery areas that count towards the demographic criterion above (from Figure 4) through purchase by fee title, perpetual conservation easements, enrollment in WRP, and establishment of buffers. To protect the Salt Creek tiger beetle, a considerable amount of land has been acquired and conservation easements have been put in place on Little Salt Creek (Figure 3). However, there are still gaps between areas that have easements or have been purchased. Purchase of these lands would ensure protection of the entire Little Salt Creek and Rock Creek corridors and enables the implementation of larger scale restoration activities, which will contribute to greater sustainability of suitable habitat for the Salt Creek tiger beetle. A significant amount of land has been purchased by the NGPC along Rock Creek; another significant area of land has been enrolled in the WRP by the NRCS. However, there are gaps between these lands that pose a risk to the Salt Creek tiger beetle and purchase of these lands would ensure protection of the entire Rock Creek corridor. Buffers should be established between commercially, residentially, and agriculturally developed areas to protect recovery areas. Purchase of lands, establishment of perpetual easements, and enrollment in the WRP should be done on the Haines Branch and Oak Creek drainages and other saline wetland and stream complexes shown as recovery areas (Figure 4) to ensure protection of these entire drainages and provide duplication of important saline wetland and stream habitats.

1.2 Protection of Recovery Areas through Land Use Planning. The Service has worked with representatives of Lancaster and Saunders Counties and the City of Lincoln Planning Department to provide technical assistance in land use planning in the Rock, Little Salt, Oak, and Haines Branch Creek drainages and other potential recovery areas shown in Figure 4. These efforts have contributed to continued protection of the Salt Creek tiger beetle and have resulted in limited land development in some of these areas. For example, limited utility development since listing the species has steered development away from the Little Salt Creek Recovery Area. However, the evaluation of potential conflicts between land development and identified recovery areas is needed to determine the feasibility of habitat restoration and Salt Creek tiger beetle reintroduction efforts. Some proposed

recovery areas include areas of current and proposed urbanization. Urban development will present a unique challenge as reintroduction would subject the Salt Creek tiger beetle to potential impacts such as lighting and runoff. Reintroduction efforts have the potential to impact development and planning decisions for local communities. As such, reintroductions in some recovery areas will require additional cooperation to ensure land use planning decisions benefit all parties and mitigate potential impacts. Urban and future urban reintroduction sites should be treated as a second level of opportunity after more rural sites have been fully explored.

2.0 Recovery Areas Restoration and Management

2.1 Restoration. Conduct saline wetland and stream restoration projects on Rock, Little Salt, Oak, and Haines Branch Creeks and other saline wetland stream complexes in other identified recovery areas shown in Figure 4 for the benefit of the Salt Creek tiger beetle. Potential restoration projects include, but are not limited to: a) removal of excess sediment; b) restoration of wetland hydrology through installation of water control structures; c) restoration of saline seeps through bank pull-backs; d) restoration of stream bank benches; e) restoration of saline flats and seeps on the floodplain adjacent to creeks, and f) management of saline groundwater. Successful restoration activities will provide additional suitable habitat into which existing Salt Creek tiger beetle metapopulations and populations can expand and areas where the Salt Creek tiger beetle would be reintroduced.

2.2 Management. Conduct land management activities at saline wetlands and streams at Rock, Little Salt, Oak, and Haines Branch Creeks and other saline wetland stream complexes in other identified recovery areas shown in Figure 4 for the benefit of the Salt Creek tiger beetle. The main objective of management activities should be the long-term viability of the Salt Creek tiger beetle through the optimization of suitable saline habitat. Such actions would include, but not be limited to, saline groundwater management, control of invasive weeds, prescribed grazing, prescribed burns, and water level management.

2.3 Research.

2.3.1 Conduct research on surface and groundwater roles in saline wetland and stream restoration and management. Information needs include: a) groundwater movement to the surface; b) groundwater interaction with surface hydrology and fresh groundwater; c) channel entrenchment and impediments to upward movement of saline groundwater; and d) methods for restoration and maintenance of soil salinity and moisture regimes. This research will be used to inform adaptive management and restoration, namely the use of groundwater and surface water sources to restore saline hydrology to salt barrens and seeps.

2.3.2 Conduct research on the appropriate frequency and intensity of prescribed grazing to inform adaptive management of invasive plants at saline wetlands

and to investigate the effect of such grazing on surrogate tiger beetle species.

2.3.3 Conduct research on potential competition with saline wetland-dependent tiger beetles to determine which habitat management methods most effectively support Salt Creek tiger beetle population increases. Managers will apply this research to adapt management and restoration techniques.

3.0 Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction

3.1 Refine propagation and rearing

3.1.1 Conduct experimental propagation and rearing techniques. Experimental propagation and rearing of Salt Creek tiger beetles involves collection of male and female pairs for breeding and care for larvae in the lab under variable substrate and salinity replications. Larvae would be translocated to larval habitat at identified recovery areas. Salt Creek tiger beetles would be reintroduced in occupied (Little Salt Creek) and unoccupied (Rock, Oak, and Haines Branch Creeks) recovery areas. Experimental efforts are underway by the Entomology Department of the University of Nebraska at Lincoln (UNL), Lincoln Children's Zoo, and Henry Doorly Zoo.

3.1.2 Synchronize wild and captive-reared life cycles.

3.1.3 Determine the best method for reintroducing captive-reared Salt Creek tiger beetles into the wild. Methods to be considered and evaluated include the use of second or third instar larvae, fall or spring reintroduction of larvae, or the release of adult Salt Creek tiger beetles.

3.1.4 Evaluate survival success of reintroduced larvae and adults. This may include monitoring larvae, conducting mark/recapture studies, and reintroducing Salt Creek tiger beetles into unoccupied recovery areas. Evaluate metapopulation stability and viability to determine if future reintroduction efforts are necessary.

3.2 Determine the microhabitat characteristics of larval habitat located at saline stream and wetland habitats. Collection of data from remote sensing units is underway at several locations to determine soil moisture, temperature, and range. This information will be used to identify suitable reintroduction sites for the Salt Creek tiger beetle.

3.3 Implement large-scale propagation and reintroduction efforts to restore populations of the Salt Creek tiger beetle at identified occupied and unoccupied recovery areas. We will reintroduce at sites with existing and/or restored suitable habitat; we will prioritize sites with permanent protection or long-term conservation agreements where management practices for the Salt Creek tiger beetle are the main objective. Priority reintroduction sites are to include areas acquired with funding from Section 6 grants for the recovery and conservation of the Salt Creek tiger beetle.

4.0 Metapopulation and Recovery Area Monitoring

4.1 Monitor Metapopulations and size. Annual surveys for the Salt Creek tiger beetle will be conducted to track status and trends. Develop standardized methods for conducting annual surveys to track trends in large populations. Evaluate metapopulations' stability and viability, potentially updating objective metapopulation sizes based on this research.

4.2 Monitor restoration and management actions to restore habitat at recovery areas. Evaluate success of habitat restoration and management practices to restore suitable Salt Creek tiger beetle habitat.

5.0 Outreach and Education

5.1 Educate the public about the Salt Creek tiger beetle and its habitat. Educational resources including, but not limited to, handouts, clothing, and video footage would be prepared. Local zoos, the Service, NGPC, City of Lincoln, LPSNRD, SWCP, University of Nebraska-Lincoln, the Master Naturalist Program, and others would provide outreach about the conservation of saline wetlands and streams and Salt Creek tiger beetle.

5.2 Provide instruction and information to the public. The primary emphasis will be the importance of saline wetlands and streams for the Salt Creek tiger beetle and other wildlife species. The goal would be to prevent further loss and degradation of saline wetlands and streams. Programs will be developed to educate all ages of people about saline wetlands and stream habitats and the importance of these habitats for the Salt Creek tiger beetle and humans alike. Information can be disseminated through websites, brochures, signs, workshops, classes, videos, and other avenues of public outreach.

6.0 Post-delisting Monitoring

Section 4(g)(1) of the Act requires that the Service monitor the status of all recovered species for at least five years following delisting. The Service's post-delisting monitoring guidance calls for development of a plan well ahead of delisting, using the methodology for years prior to delisting and using the data as supporting information in the delisting. In keeping with this mandate and monitoring guidance, a pre and post-delisting monitoring plan will be developed by the Service in cooperation with the NGPC, Federal agencies, academic institutions, and other appropriate entities. The post-delisting plan would continue following delisting for a period established by the plan (with a statutory minimum of five years). This plan will outline indicators that will be used to assess the status of the delisted species (considering population numbers and remnant threat monitoring), develop monitoring protocols for those indicators, and evaluate factors that may trigger consideration for relisting. Implement this methodology for several generations leading up to delisting, if possible, to assess its effectiveness.

6.1 Develop a post-delisting monitoring plan.

6.2 Implement the post-delisting monitoring plan.

3.4 Implementation Schedule and Cost Estimates

The implementation schedule (Table 3) follows the outline in Section 3.3 and estimates costs for implementing this recovery plan. It is a guide for meeting the objectives discussed in this section. This schedule indicates action priorities, action numbers, action descriptions, action duration, potential partners, and estimated costs. When these actions are completed, the objectives of this plan should be achieved. The Service has identified agencies and other potential partners to help implement the recovery of the Salt Creek tiger beetle. This plan does not commit any partners to actually carry out a particular recovery action or expend funds. Likewise, this schedule does not preclude or limit other agencies or parties from participating in the recovery program.

The estimated cost of recovery, according to each priority, is provided below. The implementation schedule contains the estimated monetary needs for all parties involved in recovery. Estimated funds for agencies include only project specific contracts and staff or operations costs in excess of base budgets. They do not include budgeted amounts that support ongoing agency staff responsibilities.

We estimate progress to the point of reclassification to threatened will take 15 years and cost $16,945,000. We estimate achieving full recovery will take 30 years and cost $30,783,000. Some additional costs will continue after delisting via required management; these costs are additional and not included in the above estimates as the Act only requires time and cost estimates to achieve delisting and the intermediate goal of reclassification to threatened.

Priorities in column one of the following Implementation and Cost Schedule are assigned using the following guidelines:

Priority 1 (a) – An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 1 (b) – An action that by itself will not prevent extinction, but is needed to carry out a Priority 1 (a) action.

Priority 2 – An action necessary to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 – All other actions necessary to meet the recovery objectives.

Actions and action numbers are taken from the Recovery Action Narrative.

Table 3. Implementation and Cost Schedule

Priority Number	Action Number	Action Description	Action Duration	Responsible Parties[1]	FWS Lead?	Total Cost ($1,000s)	FY[2] 1-2	FY 3-4	FY 5-6	FY 7-8	FY 9-10	FY 11-15	FY 16-30
1(a)	1.1	Purchase or implement other measures (e.g., conservation Easements; Wetland Reserve Program) to protect recovery areas	30	NGPC, NRCS, LPSNRD, City	No	15568	830	904	986	1078	2078	2769	6923
1(a)	1.2	Land use planning	30	Service, City, and NGPC	No	0	0	0	0	0	0	0	0
1(a)	2.1	Restoration	30	NGPC, LPSNRD, City	No	9900	760	770	780	790	800	1714	4286
1(a)	2.2	Management	30	NGPC, LPSNRD, City	No	3098	130	156	182	208	233	625	1564
1(b)	2.3.1	Surface and Groundwater Research	30	UNL, LPSNRD, City NGPC, Service	No	150	10	0	10	0	10	20	100
1(b)	2.3.2	Prescribed Grazing and Tiger Beetle effects Research	30	UNL, LPSNRD, City NGPC, Service	No	150	10	0	10	0	10	20	100
1(b)	2.3.3	Saline Wetland Tiger Beetle Competition Research	30	UNL, LPSNRD, City NGPC, Service	No	150	10	0	10	0	10	20	100
1(a)	3.1.1	Experimental Propagation and Reintroduction	5	Service, NGPC, UNL, HDZ, LCZ, MN, City, LPSNRD	Yes	30	30	0	0	0	0	0	0
1(a)	3.1.2	Adult Emergence Study	2	Service, NGPC, UNL, HDZ, LCZ, MN	No	82	41	41	0	0	0	0	0
1(a)	3.1.3	Wild and Captive-Reared Synchrony Study	2	Service, NGPC, UNL, HDZ, LCZ, MN	No	82	0	41	41	0	0	0	0
1(a)	3.1.4	Reintroduction Study	2	Service, NGPC, UNL, HDZ, LCZ, MN	No	82	0	0	41	41	0	0	0

Table 3. Implementation and Cost Schedule Continued

Priority Number	Action Number	Action Description	Action Duration	Responsible Parties[1]	FWS Lead?	Total Cost ($1,000s)	FY[2] 1-2	FY 3-4	FY 5-6	FY 7-8	FY 9-10	FY 11-15	FY 16-30
1(a)	3.1.5	Adult Survival Study	2	Service, NGPC, UNL, HDZ, LCZ, MN	No	82	0	41	41	0	0	0	0
1(a)	3.2	Microhabitat Study	2	Service, NGPC, UNL, HDZ, LCZ, MN	No	82	0	41	41	0	0	0	0
1(a)	3.3	Full Scale Propagation and Reintroduction	25	Service, NGPC, UNL, HDZ, LCZ, MN, City, LPSNRD	Yes	1012	44	44	44	44	44	176	616
1(b)	4.1	Monitor Metapopulations	30	UNL,MN,NGPC,	No	119	8	8	9	9	10	21	54
1(b)	4.2	Monitor recovery actions	30	MN, NGPC, UNL	No	119	8	8	9	9	10	21	54
2	5.1	Public Outreach	30	Service, UNL, NGPC, City, LPSNRD, MN	No	26	2	2	2	2	2	8	8
2	5.2	Public Education	30	Service, UNL, NGPC, City, LPSNRD, MN	No	26	2	2	2	2	2	8	8
3	6.1	Develop a Post-delisting Monitoring Plan	5	Service	Yes	5	0	0	0	0	0	0	5
3	6.2	Implement a Post-delisting Monitoring Plan	5	Service	Yes	20	0	0	0	0	0	0	25

[1]The following acronyms used in Table 3 are as follows: Saline Wetlands Conservation Partnership (SWCP), U.S. Fish and Wildlife Service (Service), Nebraska Game and Parks Commission (NGPC), University of Nebraska at Lincoln (UNL), Lower Platte South Natural Resources District (LPSNRD), Henry Doorly Zoo (HDZ), Lincoln Children's Zoo (LCZ), City of Lincoln (City), and Master Naturalist Program (MN).
[2]All costs by FY are in thousands of dollars, estimated in 2015 and not adjusted for inflation for future years.

4 LITERATURE CITED

Allgeier, W., S. Spomer, and L. Higley. 2003. NGPC Section 6 2002 Research Report. Biology and Conservation of the Salt Creek tiger beetle, *Cicindela nevadica lincolniana*, in Lancaster County, Nebraska. University of Nebraska, Lincoln, Nebraska. Unpublished Report. 16pp.

Allgeier, W., S. Spomer, and L. Higley. 2004. NGPC Section 6 2003 Research Report. Biology and Conservation of the Salt Creek tiger beetle, *Cicindela nevadica lincolniana*, in Lancaster County, Nebraska. University of Nebraska, Lincoln, Nebraska. Unpublished Report. 15pp.

Boyd, H.P., et al.. 1982. Checklist of Cicindelidae: The tiger beetles. Marlton, New Jersey, Plexus Publishing. 31pp.

Busby, W.H. 2003. Distribution and Subspecific Status of the Tiger Beetle *(Cicindela nevadica)* in Kansas. Project Number QR-F6-02-0. Kansas Biological Survey. Lawrence, Kansas. 19pp.

Carter, M.R. 1989. The biology and ecology of the tiger beetles (Coleoptera Cicindelidae) of Nebraska. Transactions of Nebraska Academy of Science17:1-18.

Casey, T.L. 1916. Further studies in the Cicindelidae. Memoirs Coleoptera 7:1-34.

City of Lincoln/Lancaster County. 2002. City of Lincoln/Lancaster County Comprehensive Plan, April 3, 2002. City Council/County Board Review Draft. Lincoln, Nebraska.

City of Lincoln/Lancaster County. 2011. City of Lincoln/Lancaster County Comprehensive Plan, accessible online at https://www.lincoln.ne.gov/city/plan/long/comp.htm

Cunningham, D. 1985. Villains, Miscreant, and the Salt of the Earth. Nebraska Game and Parks Commission. Lincoln, Nebraska. Nebraskaland 14-20 pp.

Fahrig, L., and G. Merriam. 1994. Conservation of fragmented populations. Conservation Biology 8(1): 50-59.

Farrar, J. 2003. Tigers of the Marsh. Nebraska Game and Parks Commission, Lincoln, Nebraska. *Nebraskaland* 50pp.

Farrar, J., and R. Gersib. 1991. Nebraska salt marshes: Last of the least. Nebraska Game and Parks Commission. Lincoln, Nebraska. 23pp.

Freitag, R. 1999. Catalogue of the tiger beetles of Canada and the United States. NRC Research Press, Ottawa, Ontario, Canada K1A 0R6. 195 pp.

Gibbs, J.P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. Wetlands Journal of the Society of Wetlands Scientists 13:25-31.

Gilbert, M.C. and R.G. Stutheit, eds., 1994. Resource Categorization of Nebraska's Eastern saline wetlands. Prepared for the Eastern Nebraska Saline Wetlands Interagency Study Project. U.S. Army Corps of Engineers, Omaha District, and the Nebraska Game and Parks Commission. 18 pp.

Gilpin, M.E. 1987. Spatial structure and population vulnerability. Pp. 125-139. In M.E. Soule' (ed.). Viable Populations for Conservation. Cambridge University Press, Cambridge England.

Harvey, F.E., J.F. Ayers, and D.C. Gosselin. 2007. Groundwater dependence of endangered ecosystems: Nebraska's eastern saline wetlands. Groundwater 45 (6): 736-752.

Hoback, W.W, D.A. Golick, T.M. Svatos, S.M. Spomer, and L.G. Higley. 2000. Salinity and shade preferences result in ovipositional differences between sympatric tiger beetle species. Ecological Entomology 25:180-187.

Knisley, C.B., and J.M. Hill. 1992. Effects of habitat change from ecological succession and human impacts on tiger beetles. Virginia Journal of Science 43:133-142.

Lacy, R.C. 1987. Loss of genetic diversity from managed populations: Interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1(2): 143-158.

LaGrange, T. 1997. Guide to Nebraska's Wetlands and their conservation needs. Nebraska Game and Parks Commission. Lincoln, Nebraska. 34pp.

LaGrange, Ted, T. Genrich, G. Johnson, D. Schulz, and B. Lathrop. 2003. Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands. Nebraska Game and Parks Commission Publications. Paper 24. Accessible online at http://digitalcommons.unl.edu/nebgamepubs/24

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of America 15: 237–240.

Mullin C.A., M. Frazier, J.L. Frazier, S. Ashcraft, R. Simonds, D. van Engelsdorp, and J.S. Pettis. 2010. High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health. PLoS One 5:e9754

Murphy, R.A. 1992. Problem identification and planning strategies for saline wetland protection in Lancaster County, Nebraska. Master Thesis. University of Nebraska, Lincoln, Nebraska. 161pp.

Murphy, D.D., K.E. Freas, and S.B. Weiss. 1990. An environmental approach to population viability analysis for a threatened invertebrate. Conservation Biology 4(1): 41-51.

Noss, R.F. 2002. Context matters. Considerations for large-scale conservation. Conservation in Practice 3(3): 10-19.

Pisa L., V. Amaral-Rogers, L.P. Belzunces, J.M. Bonmatin, C. Downs, D. Goulson, D. Kreutzweiser, C. Krupke, M. Liess, M. McField, C. Morrissey, D.A. Noome, J. Settele, N. Simon-Delso, J. Stark, J.P. van der Sluijs, H. van Dyck, M. Wiemers. 2014. Effects of neonicotinoids and fipronil on non-target invertebrates. Environmental Science and Pollution Research: 10.1007/s11356

Pyle, R., M. Bentzien, and P. Opler. 1981. Insect conservation. Annual Review of Entomology 26:233-258.

Ratcliffe, B.E., and S.M. Spomer. 2002. Nebraska's Endangered Species; Part 1: Introduction and the Insects. Museum Notes 113: 1-6. Lincoln: University of Nebraska State Museum.

Ruggerio, L.F., G.D. Hayward, and J.R. Squires. 1994. Viability analysis in biological evaluations: concepts of population viability analysis, biological population, and ecological scale. Conservation Biology 8(2): 364-372.

Rus, D.L., Dietsch, B.J., and Simon, A. 2003. Streambed adjustment and channel widening in eastern Nebraska: U.S. Geological Survey Water-Resources Investigations Report 03–4003, 63 p., CD-ROM.

Saline Wetlands Conservation Partnership. 2014. Saline Wetlands Conservation Partnership-2013 Progress Report. Lincoln City Council, Lower Platte South Natural Resources District Board of Directors, Nebraska Game and Parks Commission, and the Nature Conservancy. April 4, 2014.

Spomer, S.M., and L.G. Higley. 1993. Population status and distribution of the Salt Creek tiger beetle, *Cicindela nevadica lincolniana* Casey (Coleoptera: Cicindelidae). Journal of the Kansas Entomological Society 66(4):392-398.

Spomer, S.M., L.G. Higley, and W. Hoback. 2001. Salt Creek tiger beetle, *Cicindela nevadica lincolniana* population estimates. Unpublished report.

Spomer, S.M., L.G. Higley, W. Hoback, and W. Allgeier. 2002. Salt Creek tiger beetle, *Cicindela nevadica lincolniana* population estimates. Unpublished report.

Spomer, S.M., W. J. Allgeier, and L.G. Higley. 2004(a). Salt Creek Tiger Beetle (*Cicindela nevadica lincolniana* Casey) Recovery Plan. Department of Entomology, University of Nebraska, Lincoln, Nebraska. Unpublished report. 18 pp.

Spomer, S.M., L.G. Higley, W. Hoback, and W. Allgeier. 2004(b). Salt Creek tiger beetle, *Cicindela nevadica lincolniana* population estimates. Unpublished report.

U.S. Fish and Wildlife Service. 2001. Final Rule to list the Ohlone tiger beetle *(Cicindela ohlone)* as endangered. Federal Register 66: 50340-50350.

U.S. Fish and Wildlife Service. 2005. Final Rule to list the Salt Creek tiger beetle *(Cicindela nevadica lincolniana)* as endangered. Federal Register 70: 58335-58351.

U.S. Fish and Wildlife Service. 2014. Revision of Critical Habitat for the Salt Creek tiger beetle *(Cicindela nevadica lincolniana).* Federal Register 79: 26013-26038.

U.S. Fish and Wildlife Service. 2016. Grazing as a Management Tool, Rainwater Basin Wetland Management District, Nebraska. *In:* https://www.fws.gov/refuge/Rainwater_Basin_WMD/what_we_do/grazing/

Wiens, J. A. 1996. Wildlife in patchy environments: metapopulations, mosaics, and management. 53–84. *In:* McCullough, D. R., editor. Metapopulations and wildlife conservation Washington, D.C., USA Island Press. 439 pp.

Willis, H.L. 1967. The Cicindelidae of Kansas. Cicindela 2(1):1-27.

Wingfield, G., G. Steinauer, and J. Farrar. 1992. Nebraska's Vanishing Species. Nebraska Game and Parks Commission. Lincoln, Nebraska. Nebraskaland. 153pp.

PERSONAL COMMUNICATIONS

Higley, L. Personal Communication. University of Nebraska at Lincoln. Lincoln, Nebraska.

Spomer, S. Personal Communication. University of Nebraska at Lincoln. Lincoln, Nebraska.

APPENDIX A

Table 4. Metapopulation Survey Results from 1991 through 2002[1, 2]

YEAR	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
Little Salt Creek-Arbor Lake	171	94	62	376	459	437	406	254	208	225	434	511
Little Salt Creek-Roper	-	-	-	54	161	151	144	45	55	80	85	258
Upper Little Salt Creek-North	24	32	48	35	14	41	0	4	8	4	0	8
Upper Little Salt Creek-South	7	5	4	8	3	0	0	0	0	0	0	0
Jack Sinn WMA	15	11	1	0	0	1	-	1	0	-	0	0
Oak Creek	12	8	-	-	0	-	-	4	0	-	0	0
TOTALS	**229**	**150**	**115**	**473**	**637**	**630**	**550**	**308**	**271**	**309**	**519**	**777**

[1]"-" indicates no surveys for that metapopulation that year.
[2] all surveys were conducted by Steve Spomer of the University of Nebraska, Entomology Department

Metapopulation survey results from 2003 through 2015[1, 2]

YEAR	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15
Little Salt Creek-Arbor Lake	583	392	115	345	197	109	148	169	234	319	327	104	161
Little Salt Creek-Roper	162	154	22	97	32	17	21	16	66	47	11	2	2
Upper Little Salt Creek-North	0	12	16	97	33	39	25	20	18	8	27	19	11
Upper Little Salt Creek-South	0	0	-	-	-	-	-	-	-	-	0	18	10
Jack Sinn WMA	0	0	-	-	-	-	-	-	-	-	0	0	0
Oak Creek	0	0	-	-	-	-	-	-	-	-	0	0	0
TOTALS	**745**	**558**	**153**	**539**	**262**	**165**	**194**	**205**	**318**	**374**	**365**	**143**	**184**

[1]"-" indicates no surveys for that metapopulation that year
[2] all surveys were conducted by Steve Spomer of the University of Nebraska, Entomology Department

APPENDIX B

Summary of Public Comments and Peer Review

A Notice of Document Availability was published in the Federal Register (80 FR 42117) on July 16, 2015, announcing the availability of a draft Recovery Plan for the Salt Creek tiger beetle *(Cicindela nevadica lincolniana)* for a 60-day public review. At that time, we requested independent peer reviews from three experts knowledgeable about the Salt Creek tiger beetle and its saline wetland and stream habitats. We received comments from three peer reviewers and a single comment from the public. The following is a summary of comments and our responses. All comment letters are on file at our Nebraska Ecological Services Field Office, 9325 South South Alda Road, Wood River, Nebraska 68883.

Executive Summary

Comment 1—A commenter recommended including non-native plants as a factor negatively affecting the Salt Creek tiger beetle and its saline wetland and stream habitats.

Response 1—We modified text in the recovery plan to indicate that invasive plants, both native and non-native, could have a negative impact on the Salt Creek tiger beetle and its habitat.

Background Section

Comment 2—Commenters recommended that, due to a taxonomic change, the Salt Creek tiger beetle is now a member of the Carabidae family (ground beetles) and no longer a member of the Cicindelidae family.

Response 2—We modified text in the recovery plan to reflect these recent taxonomic changes.

Comment 3—A commenter recommended including text in the recovery plan indicating how metapopulations of Salt Creek tiger beetles were defined.

Response 3—We included an explanation in the recovery plan.

Comment 4—A commenter recommended that the recovery plan clarify between the terms metapopulation, population, and subpopulation.

Response 4—We added clarification between the terms metapopulation and population, as defined by Levins (1969). We deleted all references to the term subpopulation.

Comment 5—A commenter recommended clarifying the date of the historic populations in Figure 1.

Response 5—We added clarification to Figure 1.

Comment 6—Commenters recommended including a more detailed description of barren salt flat areas that the Salt Creek tiger beetle uses.

Response 6—We added descriptive text (i.e. sandbar, mid-stream gravel bar, and presence of a permanent water source) to the recovery plan.

Comment 7—A commenter recommended the removal of the Oak Creek Metapopulation as a recovery area because recovery actions may disrupt current and future operations at the Lincoln Airport. Additionally, the Salt Creek tiger beetle has not been found there since 1998.

Response 7—A review of the recovery plan confirmed that recommended actions in the plan are for guidance and planning purposes only. We would not take a recovery action at the Oak Creek Recovery Area without the property owner's consent and involvement. Additionally, recommended actions in the recovery plan do not create a legal obligation for any public or private party beyond existing legal requirements. Researchers have not completed a full Salt Creek tiger beetle survey of the Oak Creek Recovery Area, including the portion that is on property owned by the Lincoln Airport. Given the availability of suitable habitat, the Salt Creek tiger beetle could still be present at this site. As such, we made no changes to the recovery plan.

Critical Habitat, Threats, and Conservation Section

Comment 8—A commenter recommended revision and update of text addressing Salt Creek tiger beetle population size and distribution in the area of the Interstate 80 and North 27th Street exit in Lincoln, Nebraska.

Response 8—We determined that the information provided in the recovery plan was dated. We deleted the sentence to make the paragraph more concise.

Comment 9—A commenter recommended including annual survey data for each metapopulation.

Response 9—Appendix A of the recovery plan includes annual survey data by metapopulation.

Comment 10—A commenter recommended inclusion of water usage as a threat to the Salt Creek tiger beetle and its habitat.

Response 10—We added text to the recovery plan that identifies groundwater depletion as a threat to the Salt Creek tiger beetle and its habitat.

Comment 11—A commenter recommended inclusion of a section in the recovery plan about competition among tiger beetle species as a threat to the Salt Creek tiger beetle.

Response 11—We added a discussion about competition among tiger beetles and identified research as a needed recovery action in the recovery plan.

Comment 12—A commenter inquired if there was information indicating that over-collection of Salt Creek tiger beetles presents a risk to the species.

Response 12—We have no information that over-collection of the Salt Creek tiger beetle is a threat to the species.

Comment 13—A commenter recommended that additional text be added to the Local Conservation Planning section to show the relationship between the Lincoln and Lancaster County Comprehensive Plan and conservation of the Salt Creek tiger beetle.

Response 13—We added text to the recovery plan to show the relationship between the Lincoln and Lancaster County Comprehensive Plan and conservation of the Salt Creek tiger beetle.

Comment 14—A commenter suggested that artificial lights could cause direct mortality of the Salt Creek tiger beetle.

Response 14—We modified text in the recovery plan to acknowledge that artificial lights could cause direct through predation.

Comment 15—A commenter recommended deletion of a paragraph about the threat posed by electric insect traps (i.e., bug zappers) as the public no longer uses these traps for insect control.

Response 15—We deleted the paragraph.

Comment 16—A commenter recommended defining a bank "pull back."

Response 16—We modified text in the recovery plan.

Comment 17—A commenter recommended that Figure 3 in the recovery plan be enlarged to improve readability.

Response 17—We enlarged Figure 3.

Recovery Section

Comment 18—Commenters recommended the need to identify the carrying capacity of each recovery area to ensure that 500-1,000 individuals can be sustained.

Response 18—We acknowledge the need to determine carrying capacity for each recovery area. However, conducting this type of research with small population sizes is difficult. We added text indicating that, once population numbers increase at recovery areas, there is a need to evaluate metapopulation stability and viability through research.

Comment 19—A commenter inquired as to how we determined that a delisting criterion of six metapopulations with populations each numbering between 500-1,000 individuals was necessary.

Response 19—We revised the rationale section in the recovery plan to clarify how we determined that at least 500-1,000 individuals per metapopulation is sufficient.

Comment 20—A commenter suggested we are too conservative in requiring the passage of 10 years before downlisting or delisting would be considered.

Response 20—We are hopeful, despite the limited number of populations and number of individuals per population, that conditions will favor the recovery of the Salt Creek tiger beetle within 10 years. If that is the case, we will reevaluate whether downlisting or delisting is appropriate. We made no change to the recovery plan.

Comment 21—A commenter questioned the necessity of having a downlisting and delisting criteria of no net loss of wetlands.

Response 21—Recovery of the Salt Creek tiger beetle will require a greater amount of suitable habitat than what is currently available. Protection of existing saline wetlands and streams is critical to maintaining the suitable habitat currently present. Restoration of saline wetland and stream habitats will be a critical component of increasing the amount of suitable habitat and avoiding exceedance of the carrying capacity of a recovery area. We added language to the downlisting criteria to highlight the likely need for restoration and establishment of additional habitat to support recovered populations.

Comment 22—A commenter inquired about how competition with other cogenors would affect the recovery of the Salt Creek tiger beetle.

Response 22—We acknowledge the competition among tiger beetles for limited resources and have identified this research need in the recovery plan.

Comment 23—A commenter inquired as to how existing population numbers could be increased given the existing habitat size.

Response 23—We recognize that habitat restoration will be necessary to increase the population size. Restoration of suitable habitat is a high priority task in the recovery plan.

Comment 24—A commenter questioned the use of propagation and reintroduction efforts to recover the Salt Creek tiger beetle.

Response 24—The low number of populations and small number of individuals per population make it critical to use propagation and reintroduction efforts to recover the Salt Creek tiger beetle. We identified this as a high priority recovery task in the recovery plan. An equally important recovery task is acquisition and restoration of saline wetlands and stream habitats so that these areas can become potential reintroduction sites. We made no change to the recovery plan.

Comment 25—A commenter recommended inclusion of education as a conservation effort.

Response 25—We added text to acknowledge the importance of public education as a conservation tool.