Habitat Quality for Wetland-Dependent Priority Wildlife Species in the Lower South Platte River Basin, Colorado: Species Assessments and Monitoring Protocols

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EXECUTIVE SUMMARY

The Lower South Platte River Basin (LSPRB), located within the northeast quadrant of Colorado, supports 18/34 (53%) Colorado Parks and Wildlife (CPW) wetland-dependent priority wildlife species/subspecies within 18 wetland habitats:

Wetland-dependent priority wildlife species

Gadwall *Anas strepera*
American wigeon *Anas americana*
Mallard *Anas platyrhynchos*
Blue-winged teal *Anas discors*
Cinnamon teal *Anas cyanoptera*
Northern pintail *Anas acuta*
American green-winged teal *Anas crecca*
American bittern *Botaurus lentiginosus*
Greater sandhill crane *Grus canadensis tabida*
Piping plover *Charadrius melodus*
Long-billed curlew *Numenius americanus*
Short-eared owl *Asio flammeus*
Northern leopard frog *Rana pipiens*
Plains leopard frog *Rana blairi*
Northern redbelly dace *Phoxinus eos*
Brassy minnow *Hybognathus hankinsoni*
Red-sided garter snake *Thamnophis sirtalis*
River otter *Lontra canadensis*

Wetland habitats

Natural wetland habitat types
Beaver pond
Emergent marsh
Playa
Riparian wetland – herbaceous plants
Riparian wetland – shrub-scrub
Sandbar
Stream channel
Warm water slough
Wet meadow

Human created/influenced wetlands
Irrigation-influenced wet meadow
Irrigation ditch
Gravel pits
Moist soil unit
Recharge pond
Recharge pond/Moist soil unit
Reservoir
Sewage lagoon
Stock pond
Urban runoff ponds

The wetlands cover approximately 102,612 hectares (253,559 acres) or 3% of LSPRB's land. CPW and other partners have identified the LSPRB as a high priority conservation area, as evidenced from millions of dollars invested in over one hundred wetland improvement projects since 1997.

In partnership among the Colorado Natural Heritage Program (CNHP), CPW, and the South Platte Wetland Focus Area Committee (SP-WFAC), this LSPRB project is third in a series of Wetland Profile and Condition Assessment projects in Colorado, funded through the Environmental Protection Agency (EPA), with the San Luis Valley first and North Park second. Each project has become more comprehensive, based on knowledge gained from the previous projects. The North Park project included identification of key habitat variables important for dabbling ducks along with some suggestions on methods to measure the variables.

The LSPRB project extends what was accomplished in the North Park project by including all 18 wetland-dependent priority species occurring within the LSPRB and working with CNHP to incorporate the identified habitat variables into existing protocols used in the field to assess wetland condition.

The ultimate purpose of this project is to provide a set of methods and tools that can be used in wetland assessments that will directly link wildlife habitat requirements with quality of the wetlands, which will assist with prioritization of effective on-the-ground conservation actions. This project has relied heavily on the expertise provided by the SP-WFAC, especially the Steering Committee, formed with SP-WFAC partners. The products resulting from the project will also assist SP-WFAC and its partners with information that can guide prioritization based on existing and potential values of wetlands to priority species within LSPRB. This report, *Habitat Quality for Wetland-Dependent Priority Wildlife Species in the Lower South Platte River Basin, Colorado: Species Assessments and Monitoring Protocols*, is the companion document to the *Lower South Platte River Basin Wetland Profile and Condition Assessment*, written by CNHP staff.

We conducted a crosswalk between and among (1) 18 wetland habitats for the priority wildlife species, (2) 10 ecological systems, and 111 National Wetlands Inventory (NWI) codes. The products include the results of these crosswalks as well as a glossary of wetland habitat terms and a field key to habitat types. For each of the priority species, with several species placed into guilds (ducks, frogs, and fish), a species (or guild) profile is provided with brief population distribution summaries, seasonal occurrence in wetland habitats within the LSPRB, and key habitat variables that are most important.

Not including food resources, 21 key habitat variables were identified as either high or medium importance to the 18 priority species under consideration. Landscape context is of high importance to all 18 priority species and is, therefore, the most important variable, followed by size of habitat, water depth, dominant vegetation type, and percent of emergent cover.

Most of these variables were incorporated into the existing sampling framework used by CNHP for their wetland assessments. The data will enhance CPW's ability to determine the quantity and quality of wetland habitat available for each priority species and, in concert with some additional GIS work, will further provide information on locations of important conservation areas, which can guide management decisions and allocations of funding resources.

ACKNOWLEDGEMENTS

We thank all the members of the South Platte Wetland Focus Area Committee who provided their expertise, information, and comments, especially the Steering Committee: Colin Lee (Mountain Bird Observatory, RMBO, and Natural Resources Conservation Service, NRCS), Noe Marymor (RMBO, and NRCS), Matt Reddy (Ducks Unlimited, DU), and Greg Stoebner (U. S. Fish and Wildlife Service, USFWS).

Robert Andrews (International Educator, currently Liberia, Africa) provided feedback regarding the distribution and occurrence of wetland-dependent priority birds that have a spotty or questionable distribution in the Lower South Platte River Basin. The following experts provided reviews as described in the methods section, under Review Processes:

- American bittern: Pete Walker (Colorado Parks and Wildlife, CPW) and Colin Lee (NRCS)
- Frog guild and red-sided garter snake: Tina Jackson (CPW)
- Fish guild: Boyd Wright (CPW) with thanks also to Jim White and Paul Foutz (CPW) for initial feedback on distribution and for recommending Boyd Wright
- Dabbling duck guild: Brian Sullivan (CPW)
- Long-billed curlew: Colin Lee with thanks also to Seth Gallagher (RMBO)
- Short-eared owl and greater sandhill crane: Rick Schnaderbeck (USFWS)
- Piping plover: James Fraser (Department of Fish and Wildlife Conservation, Virginia Tech)
- River otter: Eric Odell and Scott Wait (CPW)

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LIST OF ACRONYMS AND ABBREVIATIONS

BBS	Breeding Bird Survey
BCR	Bird Conservation Region
CBC	Christmas Bird Count
cm	Centimeter
CNHP	Colorado Natural Heritage Program
COBBA	Colorado Breeding Bird Atlas
COPIF	Colorado Partners in Flight
CPW	Colorado Parks and Wildlife
DU	Ducks Unlimited
EPA	Environmental Protection Agency
ha	Hectare
ICF	International Crane Foundation
IUCN	International Union for Conservation of Nature
km	Kilometer
LSPRB	Lower South Platte River Basin
m	Meter
NGO	Non-government Organization
NWI	National Wetland Inventory
NRCS	Natural Resources Conservation Service
PLJV	Playa Lakes Joint Venture
RMBO	Rocky Mountain Bird Observatory
SP-WFAC	South Platte Wetland Focus Area Committee
USDA	U. S. Department of Agriculture
USFWS	U. S. Fish and Wildlife Service
WFAC	Wetland Focus Area Committee

1.0 INTRODUCTION

The South Platte River Basin, located within the northeast quadrant of Colorado, supports 70% of Colorado's human population. It sits within the Central Flyway (Figure 1) and Bird Conservation Region (BCR) 18. The Lower South Platte River Basin (LSPRB), the study site for this project (Figure 1), does not include the high-elevation western portion of the more comprehensive South Platte River Basin. The National Wetland Inventory (NWI) identifies 102,612 hectares (253,559 acres) of wetlands within the LSPRB, representing 111 NWI codes and 3% of the LSPRB surface area.

Humans have altered the natural hydrology (Propst and Carlson 1986, Young et al. 1986) and greatly modified the landscape of the LSPRB (Baron et al. 1998, 2000), particularly over the last century. Nevertheless, in addition to the existing wetlands, with over four thousand hectares (or over one million acres) of irrigated agricultural lands (Colorado Geological Survey 2012) interspersed with grasslands and sand sage (PLJV 2006, 2008), the LSPRB remains important to a wide diversity of wildlife species. Because of the high importance of the LSPRB to wetland-dependent wildlife as well as other wildlife species, Colorado Parks and Wildlife (CPW) identified the LSPRB as a high priority emphasis area for wetland conservation in Colorado (CPW 2011). For example, CPW and other partners have invested millions of dollars on over a hundred wetland improvement projects in the LSPRB since inception of the Colorado Wetland Wildlife Program in 1997 (Lemly 2010).

In their Wetland Wildlife Conservation Program Strategic Plan, CPW identified 34 wetland-dependent priority species/subspecies: 8 species of ducks and 26 species/subspecies (12 birds, 4 mammals, 2 reptiles, 3 amphibians, and 5 fishes) that are either at risk or declining in populations (CPW 2011, Table 1). While the CPW Wetland Wildlife Conservation Program targets these 34 species/subspecies in their funding prioritizations, many other wetland-dependent and wetland-facultative wildlife species will benefit from conservation efforts directed at improving populations of the priority species.

In order to facilitate habitat improvements for these species, it is critical to identify the key habitat variables that define high quality habitat and contribute to stabilizing or increasing populations through recruitment and/or survival. Many habitat variables overlap among species regarding their importance to recruitment and/or survival; in other words, enhancement of a single variable may benefit several priority species. On the other hand, a single target condition will not benefit all priority species, and some of the priority species identified for this project (see methods and results for selected species) need non-overlapping conditions, which may be detrimental to other priority species. For example, habitat conditions that favor American bitterns (*Botaurus lentiginosus,* e.g., ponds fringed with extensive cattails and other tall and robust wetland plants) often do not favor dabbling ducks. Therefore, in order to accommodate appropriate conditions for all priority species on the landscape, a diversity of conditions must be provided.

Key habitat variables that are important to wetland-dependent wildlife include both those within the wetland, itself, and conditions on a landscape scale – up to many miles beyond the wetland boundaries. Within wetland boundaries, variables identified as either important or critical to many wetland-dependent wildlife species often include, but are not limited to, dominant vegetation type (Kaiser et al. 1979, Kantrud, 1986, Gammonley 1996, Dechant et al. 2003b, Earnst and Holmes 2012), relative amount of vegetation (Wiggins 2004, Gregory 2011, Krapu et al. 2011), vegetation height (Young et al. 1988, Herkert et al. 1999, Dechant et al. 2003b, Gregory 2011), how vegetation is dispersed within the wetland (interspersion; Murkin et al. 1982, Euliss and Harris 1987, Rehm and Baldassarre 2007), water depth (Gilbert et al. 1994, Austin and Miller 1995, Leschack et al. 1997, Johnson and Rohwer 2000), water quality (Bestgen 1989, Nichols 2006, Stasiak 2006), food availability (Dechant et al. 1998, Ballard et al. 2004, Nelms et al. 2007, Crowley et al. 2012), and size of wetland (Brown and Dinsmore 1986, Paquette and Ankney 1996, Fleskes et al. 2007). Some wetland-dependent wildlife species require additional conditions (Gaines and Ryan 1988, Gilbert et al. 1994, Stasiak 2006, Germaine and Hays 2009, Depue and Ben-David 2010). The landscape context often significantly contributes to the overall quality of wetlands and can determine, to some degree, the extent of occupancy by wildlife. Landscape variables often identified include, but are not limited to, the distance of and abundance of other wetlands (Tacha et al. 1992, Niemuth and Solberg 2003, Arnold et al. 2007) and distance and abundance of other habitat types, such as grasslands, certain crops, and grazing (Wiggins et al. 2006, Saalfeld et al. 2010). All of these habitat variables can be measured at one or more levels (1-2-3, EPA 2011), depending on available resources, and most can be measured within the existing framework adopted by the Colorado Natural Heritage Program (CNHP, EPA 2011).

While measurements of key habitat variables can be useful for determining overall habitat quality and aid in conservation efforts, certain assumptions should be evaluated: (1) what appears as high quality habitat, measured in terms of all the important key habitat variables, can sometimes be "ecological traps." For example, even if all other key habitat variables suggest high quality, if a frog brood-rearing pond is so infested with predatory fish or bullfrogs that they consume all or most of the next generation of frogs, it will not contribute to the frog population. (2) Wildlife species cannot always assess ecological traps, and their abundances do not necessarily correlate with quality. In a well-cited example, Johnson and Temple (1986) found in a tall-grass prairie that individual abundance and nest success were inversely related; if they had identified the habitat with highest abundance as being the highest quality, this would have led to counterproductive management practices.

In partnership between CNHP and CPW, this LSPRB project is third in a series of Wetland Profile and Condition Assessment projects in Colorado, funded through EPA, with the San Luis Valley first and North Park second. Each project has become more comprehensive, based on knowledge gained from the previous projects. The North Park project included identification of key habitat variables important for dabbling ducks along with some suggestions on methods to measure the variables. The LSPRB project extends what was accomplished in the North Park project by including all relevant CPW priority species, working with CNHP to incorporate the identified habitat variables into existing protocols, and developing standards to rank the quality of wetlands for the priority wildlife species. The ultimate purpose of this project is to provide a set of methods and tools that can be used in wetland assessments that will directly link wildlife habitat requirements with quality of the wetlands, which will assist with prioritization of effective on-the-ground conservation actions.

In Colorado, Wetland Focus Area Committees (WFAC) enhance CPW's conservation efforts through local expertise and knowledge about wetland needs, potential projects, local resources, and outreach to landowners. The importance of local expertise is exemplified by local partners selecting and evaluating potential sites for recharge ponds within LSPRB (Shrier et al. 2008). Many of Colorado's 11 WFACs were formed in 1997 in response to the formation of the Colorado Division of Wildlife Wetlands Program, now called the Wetland Wildlife Conservation Program. The South Platte Wetland Focus Area Committee's (SP-WFAC) primary mission is "*to conserve wetlands that sustain the natural integrity of the South Platte ecosystem*" (SP-WFAC 2002). As is typical of the Focus Area Committees throughout the state, SP-WFAC consists of a wide diversity of interested partners, representing private landowners, land managers, Federal, state, and local agencies, non-profit organizations, non-governmental agencies, and special interest groups. This project has relied heavily on the expertise provided by the SP-WFAC, especially the Steering Committee, formed with SP-WFAC partners (see acknowledgements and methods for more details). The products resulting from this project will also assist SP-WFAC and its partners with information that can guide prioritization based on existing and potential values of wetlands to priority species within LSPRB.

This project contributes to several goals in the Strategic Plan for the Wetland Wildlife Conservation Program. Specifically, identification of best management practices and monitoring protocols for key habitat variables contributes to both Biological Planning Strategies and Conservation Design Strategies in the plan (CPW 2011). This information directly links wetland assessments with habitat quality for wildlife, and it can be used to better inform sampling selection for wetland assessments, which will assist with prioritization of effective on-the-ground conservation actions. Decisions based on biological knowledge can lead to the most meaningful landscape conservation, which will benefit not only priority species, but also functional communities and connectivity for movement and gene flow across the landscape.

The major goals of the LSPRB Wetland Profile and Condition Assessment project include "(1) create a digital map of wetlands in the Lower South Platte River Basin and determine its accuracy; (2) Conduct a thorough and systematic review of habitat requirements of wildlife species on the CDOW's [CPW] Wetlands Program target list; (3) Identify a set of reference condition wetlands in the basin to refine existing Level 2 and develop Level 3 assessment methods appropriate for use in Colorado's High Plains Ecoregion; and (4) Conduct a statistically valid, field-based survey of wetland condition in the basin" (From the proposal: Lemly 2010). This report focuses on the second goal, with the following tasks:

"1. From the list of CDOW [CPW] Wetlands Program priority wildlife species (*n*=34; see previous attachment), identify those that occur in the Lower South Platte Basin by studying available range/distribution maps.
2. For each species, identify important wetland types used by the species, and describe in general wetland categories familiar to wildlife biologists (e.g., floodplain marshes, reservoirs, warm water sloughs, playas, etc.).

3. For each wetland type, describe period of seasonal use by the species (e.g., spring and fall during migration).
4. For each wetland type, develop a crosswalk with the NWI classification system.
5. For each wetland type and season of use, describe the biotic and abiotic factors known to influence use by the wildlife species (e.g., dominant vegetation, interspersion of open water and vegetation, residual cover, proximity to other wetlands, etc.).
6. For each factor, qualify or quantify if possible the wildlife value. E.g., for dominant vegetation, grasses=high, willows mixed with grasses=medium, willow=low for duck nesting).
7. For each factor, develop field measurement protocols.
8. For each factor, describe management practices used to influence the factor and potentially benefit wildlife use."

Although not the specific goal of this scope of work, the information acquired from this project may be transferable to other wetland basins within and outside of Colorado.

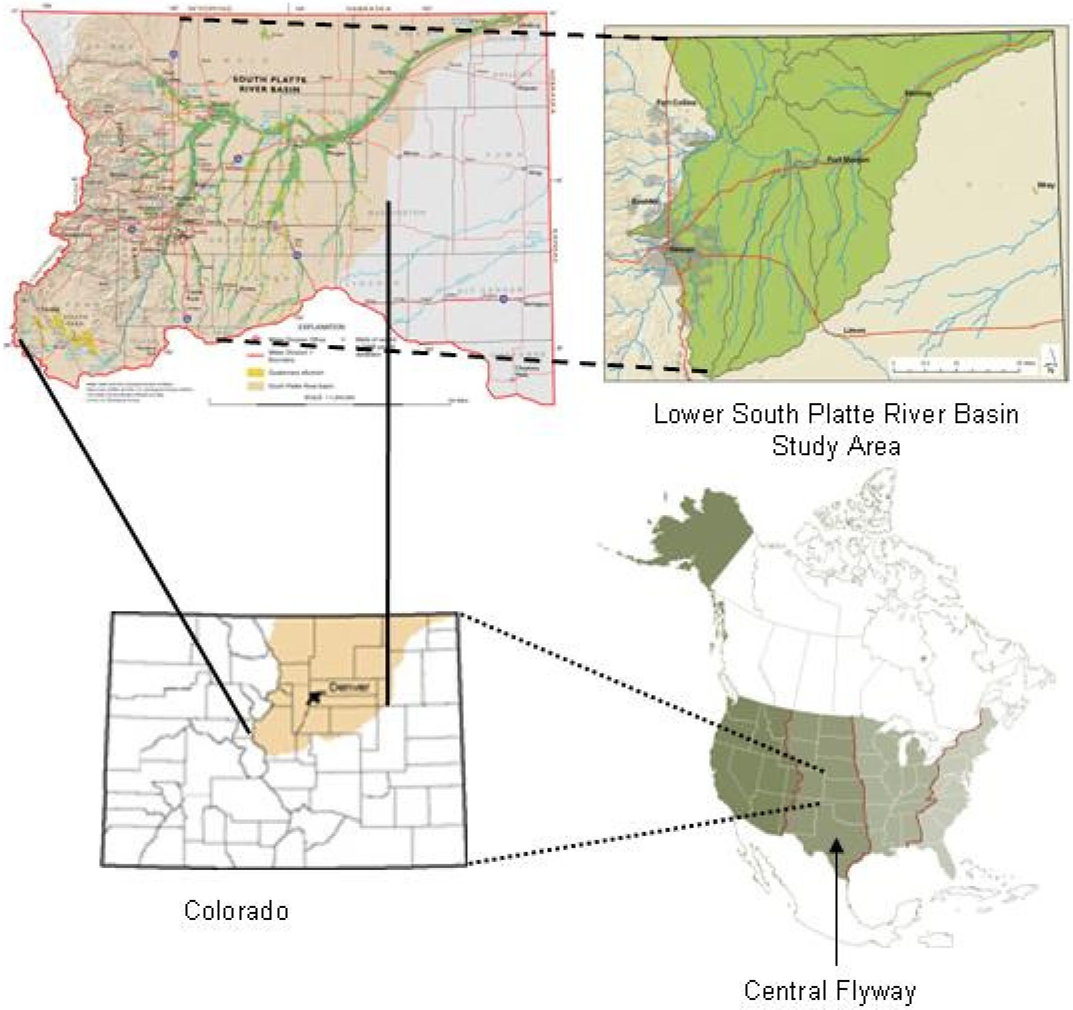


Figure 1. Location of the Lower South Platte River Basin in relation to the entire South Platte River Basin, Colorado, and the Central Flyway. Maps from Colorado Geological Survey (2012) and USFWS 2012.

Table 1. Wetland-dependent wildlife priority species for the Wetland Wildlife Conservation Program (CPW 2011) state-wide and species included in the Lower South Platte River Basin (LSPRB) Wetland Profile and Condition Assessment.

CPW Wetland-dependent Priority Species	Included in LSPRB Assessment	Population Status	Listing Status
Waterfowl species (8 species)			
Gadwall *Anas strepera*	√		
American wigeon *Anas americana*	√		
Mallard *Anas platyrhynchos*	√		
Blue-winged teal *Anas discors*	√		
Cinnamon teal *Anas cyanoptera*	√		
Northern pintail *Anas acuta*	√		
American green-winged teal *Anas crecca*	√		
Lesser scaup *Aythya affinis*			
At-risk species/subspecies (26 species/subspecies, all Tier 1)			
Amphibians			
Boreal toad *Bufo boreas boreas* (S. Rocky Mtn. Population)		Low	SE
Northern leopard frog *Rana pipiens*	√	Low	SC
Plains leopard frog *Rana blairi*	√	Medium	SC
Birds			
American bittern *Botaurus lentiginosus*	√	Unknown	
Bald eagle *Haliaeetus leucocephalus*		Low	ST
Greater sandhill crane *Grus canadensis tabida*	√	Medium	SC
Piping plover *Charadrius melodus*	√	Low	FT, ST
Western snowy plover *Charadrius alexandrinus nivosus*		Low	SC
Long-billed curlew *Numenius americanus*	√	Low	SC
Least tern *Sternula antillarum*		Low	FE, SE
W. yellow-billed cuckoo *Coccyzus americanus occidentalis*		Low	FPT, SC
Short-eared owl *Asio flammeus*	√	Low	
Lewis's woodpecker *Melanerpes lewis*		Medium	
Red-naped sapsucker *Sphyrapicus nuchalis*		Medium	
Southwestern willow flycatcher *Empidonax traillii extimus*		Low	FE, SE
Fish			
Northern redbelly dace *Phoxinus eos*	√	Low	SE
Southern redbelly dace *Phoxinus erythrogaster*		Low	SE
Brassy minnow *Hybognathus hankinsoni*	√	Low	ST
Arkansas darter *Etheostoma cragini*		Medium	ST
Plains orangethroat darter *Etheostoma spectabile*		Low	SC
Mammals			
Preble's jumping mouse *Zapus hudsonius preblei*		Low	FT, ST
New Mexico jumping mouse *Zapus hudsonius luteus*		Low	FPE
River otter *Lontra canadensis*	√	Low	ST
Dwarf shrew *Sorex nanus*		Unknown	
Reptiles			
Yellow mud turtle *Kinosternon flavescens*		Low	SC
Red-sided (common) garter snake *Thamnophis sirtalis*	√	Medium	SC

Listing Status: SC=State Species of Concern, ST= State Threatened, SE= State Endangered, FT= Federally Threatened, FE= Federally Endangered, FPT=Federally Proposed Threatened, FPE=Federally Proposed Endangered.

2.0 METHODS

2.1 Selection of Species

CPW identified 34 wetland-dependent priority wildlife species/subspecies for the Wetland Wildlife Conservation Program (CPW 2011). The list of priority species for the entire state includes eight species of ducks that contribute to nearly 90% of the state's duck harvest and 26 species/subspecies that are declining or at risk (Table 1, CPW 2011). Of these 34 species, 15 do not occur at all or occur very rarely in the LSPRB (details in Appendix I). We removed three species that do occur in the LSPRB: lesser scaup (*Aythya affinis*), bald eagle (*Haliaeetus leucocephalus*), and Preble's jumping mouse (*Zapus hudsonius preblei*) for reasons identified in Appendix I.

Removing the above 18 species resulted in a tentative list of 16 species. The SP-WFAC, in a meeting on February 1, 2012, suggested that we reconsider two of the species removed from the initial list because (1) river otter (*Lontra canadensis*) populations appear to be increasing in the LSPRB, and (2) piping plovers (*Charadrius melodus*) might increase in the LSPRB with management of sandbar habitat. Therefore, river otters and piping plovers were added back to the list. The final list consists of 18 species, from here on, referred to collectively as priority species (see Table 1).

2.2 Literature Review

For each of the 18 priority species, I conducted a thorough literature review, including published scientific literature, credible on-line resources, and databases. I gleaned out information regarding their distribution, population status, seasonal occurrence in each wetland habitat type, relative value of each wetland habitat type, key habitat quality variables, food preferences, foraging methods, and any additional information that could be useful in determining habitat quality. I also conducted a literature review on protocols used to measure key habitat quality variables.

2.3 Review Processes

Experts reviewed this work in two phases: (1) review of initial information, and (2) review of the species assessments (Section 3.2, Priority Species). For all species except one, local experts familiar with the LSPRB were used. For piping plovers, a national expert, who works with populations throughout their range, served as a reviewer. Reviewers are listed in the Acknowledgements section.

The first round of reviews consisted of evaluating three tables, confirming or correcting any information and filling in gaps. The three tables included (1) identification of key habitat variables and descriptions of conditions that make these variables high, medium, or low quality, (2) seasonal occurrence in each relevant wetland habitat type and the relative importance (high, medium, or low) of these wetland habitat types, and (3) numerical rankings for key habitat variables (highest to lowest importance). In addition to the tables, the reviewers were provided with more detailed information and citations from the literature used to create the tables. All comments and/or additions of the reviewers were incorporated into these tables, which were subsequently used in the species assessments (Section 3.2, Priority Species).

The second round of reviews consisted of reviewers evaluating the species assessments and incorporating comments and suggestions (Section 3.2, Priority Species).

2.4 Focus Area Committee and Steering Committee

We met with the SP-WFAC, chaired by Noe Marymor, to obtain feedback on the *Lower South Platte River Basin Wetland Profile and Condition Assessment* project, including this section, *Habitat Quality for Wetland-Dependent Priority Wildlife Species in the Lower South Platte River Basin, Colorado: Species Assessments and Monitoring Protocols*. We met with the SP-WFAC on February 1, 2012, in Brush, Colorado, to introduce the committee to the project and to obtain immediate feedback regarding the priority wetland-dependent wildlife species that should be included (see Section 2.1, Selection of Species). We also met on June 27, 2012, in Brush, Colorado, to update the committee on the progress of the project. At this meeting, we suggested forming a Steering Committee, consisting of members who have the ability and knowledge to provide more intensive feedback on a more frequent basis (see Acknowledgements section for members of this committee). We met with the Steering Committee on November 1, 2012, in Greeley, Colorado, to discuss and refine some of the wetland habitat types.

2.5 Wetland Crosswalk with CNHP

For the overall project, we use three classification schemes to describe wetland ecosystems: (1) the National Wetland Inventory (2), the Ecological Systems classification, adopted by CNHP for this project, and (3) wetland systems that describe wildlife habitats. To facilitate communication, particularly between CNHP and CPW, we conducted a crosswalk among these classification systems, resulting in several products: (1) a glossary of wetland habitat types, (2) a field key to wetland habitat types, and (3) results of the crosswalk among the three classification schemes, which consists of a table listing all ecological systems and NWI categories that describe each wetland habitat.

2.6 Selection of Metric Protocols

After determining the key habitat quality variables (see Section 2.2., Literature Review), I conducted another literature review to identify existing methods of measuring the most important key habitat quality variables for all 18 priority species. In most cases, important habitat variables overlapped considerably among species. I prepared a document listing the habitat variables and all applicable levels (EPA 1-2-3 levels) and methods of measuring them in the field. I compared these with variables with the existing protocol that CNHP has used in the field.

Prior to the field season of 2012, I met with CNHP staff (Joanna Lemly and Laurie Gilligan) and CPW staff (Brian Sullivan) to discuss and refine the field protocol and how to incorporate measurements of key habitat quality variables that were not already in the CNHP protocol. We then tested the protocol in the field, evaluating whether the protocol would result in collection of all data required to determine habitat quality for the priority wildlife species. The field testing resulted in further discussions and adjustments to the protocol.

3.0 RESULTS

3.1 Wetland Types

We identified 18 wetland habitats in the LSPRB: 9 natural and 9 human-created habitats (Table 2). Definitions of relevant wetland habitats and a field key to wetland habitats within the LSPRB are provided in Appendices II and III, respectively. These 18 habitats correspond with ten ecological systems. The importance to wildlife of each wetland habitat depends on the species, condition and habitat variables (e.g., size of wetland, water levels, dominant vegetation, pH), as well as the overall landscape context and time of year (Table 3).

Table 2. Crosswalk between wildlife habitat types and ecological systems in the Lower South Platte River Basin.

Habitat	Description	Ecological System(s)	NWI Codes
Natural wetland habitat types			
Beaver pond	Impoundment created by beaver dam, usually made of mud and woody plant material.	• Open Freshwater Depression Wetland[1] • Riparian Woodland and Shrubland[2] • Floodplain Woodland and Shrubland[2] [1]If dominated by emergent marsh or aquatic vegetation [2]If dominated by overstory vegetation	PABGb, PEMFb
Emergent marsh	A shallow water wetland that is frequently or continuously inundated and supports herbaceous plants adapted to saturated conditions; can be isolated or along reservoirs and other water bodies.	• Open Freshwater Depression Wetland	PABF, PABG, PEMF, PEMFd, PUBF, PUBG
Playa	An isolated depressional wetland with distinctive wet and dry seasons, fed by precipitation and runoff.	• Closed Depression Wetland • Saline Depression Wetland • Inter-Mountain Basins Playa	PEMAf, PEMJ, Pf, PUSA, PUSAh, PUSAx, PUSC, PUSCh, PUSCx, PUSJ, PUSKA, PUSKC
Riparian wetland (herbaceous)	Wetland adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by herbaceous phreatophytic plants.	• Floodplain Wet Meadow	PEMA, PEMAd, PEMB, PEMC, PEMCd

Table 2, continued.

Habitat Type	Description	Ecological System(s)	
Natural wetland habitat types			
Riparian wetland (scrub-shrub/forested)	Wetland adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by woody phreatophytic shrubs.	• Riparian Woodland and Shrubland[*] • Floodplain Woodland and Shrubland[*] • Rocky Mountain Riparian Woodland and Shrubland[1] [*] Lumped into Riparian and Floodplain Woodland and Shrublands	PSSA, PSSAd, PSSAh, PSSAx, PSSB, PSSC, PSSCd, PSSCh, PSSJ, PSSKA, PSSKC
Wet meadow	Grassy areas within the floodplain saturated at or near the surface for part of the year.	• Floodplain Wet Meadow • Isolated Wet Meadow	PEMA, PEMAd, PEMB, PEMC, PEMCd
Warm water slough	Slowly moving shallow water adjacent to river; source originates from ground water; in winter water temperature warmer than in river and under normal conditions does not freeze during winter.	• Open Freshwater Depression Wetland • Riparian Woodland and Shrubland • Floodplain Woodland and Shrubland	
Sandbar	Accumulation of sand and/or gravel along a river channel; often maintained by scouring action.	• Riparian Woodland and Shrubland • Floodplain Woodland and Shrubland	R2USA. R2USC, R3USA, R3USC, R4USA, R4USC. R4USCx
Stream channel	Area of river confined by banks and a streambed.		

Table 2, continued.

<table>
<tr><th>Habitat Type</th><th>Description</th><th>Ecological System(s)</th><th></th></tr>
<tr><td colspan="4">Impoundments and other human created wetlands</td></tr>
<tr><td>Irrigation-influenced wet meadow</td><td>Meadows receiving surface or subsurface irrigation waters</td><td>• Irrigated Hay Wet Meadow</td><td>PEMK, PEMKC, PEMKF</td></tr>
<tr><td>Irrigation ditch</td><td>Excavated canal that supplies water to dry land.</td><td>• Open Freshwater Depression Wetland*
• Riparian Woodland and Shrubland*
* If vegetated</td><td>R4SBCx</td></tr>
<tr><td>Gravel pit</td><td>Steep-sided excavation, usually in association with gravel mining operations; may or may not have sloped wetlands on fringe.</td><td>• Open Freshwater Depression Wetland*
*Only the vegetated edges considered wetlands</td><td></td></tr>
<tr><td>Moist-soil unit</td><td>Managed wetland with dike and water control structure; manipulated to flood intermittently or seasonally to maximize production of moist-soil annual and/or perennial herbaceous plants; sometimes planted with crops that provide seeds, vegetation, and/or roots that benefit wetland-dependent species.</td><td rowspan="6">• Open Freshwater Depression Wetland
• Wet Meadow</td><td rowspan="6">PABFh, PABFx, PABGh, PABGx, PEMAh, PEMAx, PEMCh, PEMCx, PEMFh, PEMFx, PUBFh, PUBFx, PUBGh, PUBGx, PUBK, PUBKF, PUBKG</td></tr>
<tr><td>Recharge pond</td><td>Diked shallow water impoundment on ephemeral drainage designed to retime S. Platte River flows into Nebraska according to legal mandates.</td></tr>
<tr><td>Reservoir</td><td>Impoundment used to store and regulate water for agricultural or municipal use; usually > 2 ha.</td></tr>
<tr><td>Sewage lagoon</td><td>Impoundment fully contained by dikes and receiving domestic/industrial/agricultural effluent; usually near urban areas or feedlots; rectangular or square in shape</td></tr>
<tr><td>Stock pond</td><td>Diked pond on ephemeral drainage in pasture or prairie; used for watering livestock; usually created by humans and < 2 ha.</td></tr>
<tr><td>Urban runoff pond</td><td>Ponds that capture effluent from urban storm runoff</td></tr>
</table>

Table 3. Relative importance of each wetland habitat to CPW wetland-dependent priority species occurring in the Lower South Platte River Basin. Ranges of value depend on the condition of the wetland, especially water levels, dominant vegetation, and proximity and connectivity with other wetlands on the landscape.

Wetland habitat type	**Dabbling Duck Guild**	**American Bittern**	**Greater Sandhill Crane**	**Piping Plover**	**Long-billed Curlew**	**Short-eared Owl**	**Frog Guild**	**Garter Snake**	**Fish Guild**	**River Otter**
Natural wetland habitat types										
Beaver pond	M-H	L-H					H	H	H	H
Emergent marsh	H	H	M-H			H	H	H		
Playa	L-H		M-H		L-H	M	M	L-H		
Riparian wetland –herbaceous plants	H	L					H	H		
Riparian wetland –shrub-scrub	L						M	M-H		
Sandbar	M			H			L	L		
Stream channel	L						M-H		H	H
Warm water slough	H	L					H	H	H	H
Wet meadow	H	L	M-H		H	M	H	H		
Impoundments and other human created wetlands										
Irrigation-influenced wet meadow	M-H	L	M-H		H	M	H	H		
Irrigation ditch	L						L-M	L-M	H	
Gravel pits	L-M	L					L-H	L-H		
Moist soil unit	H		M-H				L-M	L-M		
Recharge pond/Moist soil unit	M-H		M-H				M	M-H		
Reservoir*	L-H		L-H				L-H	L	Size?	
Sewage lagoon	M						L-H	L-H		
Stock pond	L-H						L-H	L-H		
Urban runoff ponds	L-M						L-H	L-H		

L= low, M = medium, H = high; empty cells indicate that these wetland habitat types are not used on a regular basis by the species. "Size?" indicates that presence is usually size-dependent.
*Mostly unvegetated shores.

3.2 Priority Species

Species profiles for the CPW wetland-dependent priority species are provided below with brief population summaries, seasonal occurrence in wetland habitats within the LSPRB, and key habitat variables that are most important.

3.2.1 Dabbling Ducks

The dabbling duck guild includes gadwall (*Anas strepera*), American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), blue-winged teal (*Anas discors*), cinnamon teal (*Anas cyanoptera*), northern pintail (*Anas acuta*), and green-winged teal (*Anas crecca*). The CPW Wetland Wildlife Conservation Program does not consider the LSPRB as an important breeding area for dabbling ducks; therefore, summer months are not considered in this report. However, dabbling ducks depend on high quality habitat within the LSPRB during winter as well as spring and fall migration. The quality of habitat during these stressful months directly affects body condition, which influences reproductive success and recruits to the population (Miller 1986; Ballard et al. 2004, 2006; Moon et al. 2007; Yerkes et al. 2008). Therefore, the condition of wetlands in the LSPRB has a direct effect on populations wintering and migrating through the region. Although the dabbling ducks are grouped together as a guild, each species has different habitat needs; thus, the habitat will influence the presence of particular species within the guild.

Range, population status, conservation status. The dabbling ducks in this guild are widely distributed (Figure 2), and all, except cinnamon teal, have a distribution beyond the Americas. The population status differs among species. The only species with a consistent wide-spread population increase is the gadwall (Table 4, Sauer et al. 2012).

American wigeon. According to the Breeding Bird Survey (BBS), American wigeons have experienced wide-spread and significant population declines (Sauer et al. 2012). From 1966–2011, American wigeon populations declined significantly throughout the BBS survey-wide area and within the BBS Central Region where the LSPRB is located (Table 4). However, the negative trend became less severe in these survey areas from 2001–2011, and Mowbray (1999) pointed out that during 1997, the population exceeded the long-term average of 3 million individuals. Data from the Audubon Society's Christmas Bird Count (CBC) indicates a decreasing trend of wintering American wigeons throughout the United States and an increasing trend in Colorado, emphasizing the possible importance of available wintering habitat in Colorado for American wigeons (Figure 3).

Northern pintail. Northern pintails had been declining in the BBS Central Region and survey-wide (Sauer et al. 2011), but new analysis suggests this decline is no longer significant (Sauer et al. 2012). However, Sauer et al. (2012) report northern pintails to still be in decline in the Eastern and Western BBS regions. CBC data show negative trends in both Colorado and throughout the United States during the winter (Figure 3). Concerns have been expressed about continual declines of northern pintail populations (Ballard et al. 2006, Haukos et al. 2006, Fleskes et al. 2007, Lee et al. 2007), especially concerns that northern pintail populations remain well below both the long-term average and the goal in the North American Waterfowl

Management Plan of 5.6 million individuals (Miller and Duncan 1999, Richkus et al. 2005, Moon et al. 2007, Pearse et al. 2011).

All ducks in this guild are federally protected game birds in the United States, Canada, and Mexico. CPW designated these ducks as priority species because they provide valuable hunting and viewing opportunities.

Wetland habitat types. Dabbling ducks occupy all 18 wetland habitats within the LSPRB during spring and fall (Table 5). During winter, most wetland habitats within the LSPRB become frozen, and the majority of ducks congregate in wetland habitats with deeper, unfrozen water, such as open parts of river channels, warm water sloughs, reservoirs, and deep gravel pits, or on land immediately adjacent to open water, such as sandbars. The most important wetland habitats for dabbling ducks include beaver ponds, emergent marshes, riparian wetlands dominated by an herbaceous plant community, warm water sloughs, wet meadows, and moist soil units (Table 5).

Key habitat quality variables. Measurable habitat quality variables for dabbling ducks include dominant vegetation (both type and structure), emergent cover, submergent vegetation, aquatic invertebrates, the relationship to other habitats within the landscape (landscape context), size of habitat patch, stream order, and water depth (Table 6). Not all habitat quality variables are relevant for each wetland habitat type, and the metric values or categories of the habitat quality variables differ among the species of dabbling ducks.

Dominant vegetation. Vegetation provides both food and cover. Ducks consume vegetation directly (e.g., seeds, vegetative parts, and roots), and they consume aquatic invertebrates, many of which depend on aquatic vegetation as a substrate. Vegetation also provides cover, which is especially important at night for protection from predators and for providing a suitable micro-climate. If, however, vegetation is too dense and/or too rigid to move through easily and rapidly, it can impede access to open water. Vegetation that provides a combination of nutritious food, cover, and ease of access to open water is of the highest quality to dabbling ducks.

In general, grasses, sedges, rushes, submergent plants, and plants with high seed production are preferred over other herbaceous plants with little to no food value for ducks, and these other herbaceous plants are preferred over willows and other woody or stiff vegetation. While some variation exists among the seven species of dabbling ducks in their preference for foods (Table 7), preferences overlap and, therefore, some generalizations can be made for the dabbling duck guild (Table 8). However, no single vegetation type fulfills all needs of a single species, much less the entire dabbling duck guild.

Emergent cover. The preferred percent of emergent cover differs considerably depending on wetland habitat type and time of day. It also differs between the breeding season and the seasons considered in this report. In general, in the fall and spring, dabbling ducks prefer wetlands with more open water during the day; for nocturnal roosting, they prefer more densely vegetated wetlands or large expanses of open water (e.g., reservoirs or gravel pits). Therefore, the quality of this key habitat variable is closely linked with the landscape context. The closer preferred diurnal wetlands are to high-quality nocturnal roosts, the more valuable they are to dabbling ducks. In other words, landscapes with interspersion of relatively open wetlands and more density vegetated wetlands and/or larger reservoirs are the most valuable to dabbling ducks during these seasons.

Invertebrate food requirements. Most dabbling ducks consume far more invertebrates during the breeding season compared with other times of year (Austin and Miller 1995, Gammonley 1996, Leschack et al. 1997, Mowbray 1999, Drilling et al. 2002, Rohwer et al. 2002). Ingestion of invertebrates outside the breeding season for some dabbling ducks is thought to be incidental (Leschack et al. 1997, Mowbray 1999, Drilling et al. 2002). For blue-winged teal during the spring, snails, aquatic insects, and crustaceans may be important; during the fall, ingestion of invertebrates may be more incidental (Rohwer et al. 2002). In addition to vegetable material and seeds, cinnamon teal consume midges (Chironomidae), gastropods, and water fleas (Cladocera) during spring and gastropods during the fall (Thorn and Zwank 1993, Gammonley 1996). The diet of northern pintails during the winter consists primarily of seeds, but during fall, the amount of invertebrates they consume varies considerably (Austin and Miller 1995); thus, ingestion of invertebrates could be considered opportunistic rather than incidental. Green-winged teal eat mostly vegetable matter and seeds, but a small part (< 10%) of their winter diet may consist of mollusks (Johnson 1995).

Landscape context. Dabbling ducks not only move from diurnal wetlands to nocturnal wetlands, but they also move a fair amount during the day in search of a variety of foods and safe loafing areas. Numerous investigators have found wetland adjacencies to other landscape variables important to dabbling ducks. The most important landscape context variables include proximity to agricultural fields containing food resources (Drilling et al. 2002), proximity of appropriate feeding and nocturnal roosting habitat, and juxtaposition and amount of other flooded habitat (Naugle et al. 2001, Moon and Haukos 2006, Fleskes et al. 2007). In a study on the roles of various landscape variables on habitat suitability and conservation efforts, Naugle et al. (2001) concluded that small (< 0.5 ha) wetlands exert a significant effect on suitability of larger wetlands within a landscape. Specifically, they concluded that for northern pintails, the number of suitable wetlands > 0.5 ha decreased by 21% when wetlands < 0.5 ha were removed from the landscape, suggesting the conservation and functional importance of small wetlands for connectivity.

To some degree, ducks disperse seeds and larval forms of their own food resources, both aquatic invertebrates (Charalambidou and Santamaría 2005) and plants (Mueller and van der Valk 2002, Charalambidou and Santamaría 2005, Wongsriphuek et al. 2008). The potential distance of dispersal from the source is typically only 20–30 km (Mueller and van der Valk 2002) but may be much less, emphasizing the importance of proximity to other wetlands on the landscape.

Size of habitat. The precise size requirements for wetlands during migration and winter do not appear well understood, other than larger wetlands may attract more ducks (Stafford et al. 2007). In general, larger wetlands have the capacity to result in a greater diversity of plants and other food resources and, therefore, maximize species richness and abundance. Larger wetlands also often have a greater diversity of water depths and may, thus, accommodate the requirements of all the dabbling ducks as well as other waterfowl. The role of smaller wetlands, however, is essential in a landscape context.

Stream order. Increasing stream order generally results in higher quality habitat for dabbling ducks simply because under most normal circumstances, the water has more access to flood plains with increasing stream order. The wetlands most affected by stream order include riparian wetlands, some beaver ponds, sandbars, as well as the river channel, itself.

Submergent Vegetation. An abundance of submergent vegetation is important for dabbling ducks (Baldwin and Loworn 1994, Johnson 1995, Gammonley 1996, Leschack et al. 1997, Mowbray 1999, Drilling 2002), not only as a source of plant material, but as a substrate for other organisms consumed by ducks (Rohwer et al. 2002). There seems to be a paucity of information regarding the desired range of percent submergents in the water column; however, Gammonley (1996) reported a positive correlation between winter distribution of cinnamon teal and standing crop of submergents; similarly, Hargeby et al. (1994) found that duck abundance increased with submergents.

Water depth. Dabbling ducks prefer water depths less than 30 cm (Euliss and Harris 1987, Thorn and Zwank 1993, Austin and Miller 1995, Leschack et al. 1997, Rohwer et al. 2002, Heitmeyer 2006), and even shallower waters (< 20 cm) are often preferable (Mowbray 1999, Johnson and Rohwer 2000), especially for mallard and teal species. Gadwall feed in deeper water than any of the other species of dabbling ducks, from the surface up to depths of 30 cm (Leschack et al. 1997). In some cases, depending on the topography of the wetland and surrounding area, increases in water level may increase the available surface area of shallow water and improve conditions for staging dabbling ducks (Boertmann and Riget 2006). Wetlands with varying water depths will provide for the largest number of species and individuals.

Ranking of habitat quality variables. Most habitat quality variables for ducks can be considered of high importance (Table 9). The size of the wetland may be less important than the other variables, although the size of the wetland may restrict the number of dabbling duck species because small wetlands are not as likely as larger wetlands to provide as much diversity of other variables, such as water depth and plant community.

Table 4. Adjusted population trends (2.5% CI, 97.5%CI) for dabbling ducks from the Breeding Bird Survey (Sauer et al. 2012) in Colorado, the United States, and survey-wide.

Species Region	Trends	
	1966–2011	**2001–2011**
Gadwall		
Colorado [b]	-0.3 (-3.0, 2.3)	-0.2 (-6.4, 5.4)
BBS Central [a]*	3.4 (2.4, 4.6)	4.9 (1.6, 8.7)
United States [a] *	2.9 (1.7, 4.0)	2.4 (-1.1, 5.6)
Survey-wide [a] *	3.1 (2.1, 4.0)	4.7 (1.9, 7.9)
American wigeon		
Colorado [c]	5.0 (-0.7, 10.4)	5.0 (-3.4, 12.3)
BBS Central [a]**	-2.7 (-4.0, -1.2)	0.1 (-3.0, 4.7)
United States [b]	-0.8 (-2.5, 0.6)	0.5 (-3.5, 4.8)
Survey-wide [a]**	-2.8 (-4.6, -1.6)	0.3 (-2.1, 3.6)
Mallard		
Colorado [a]	-1.1 (-2.3, 0.2)	-1.3 (-4.1, 1.4)
BBS Central [a]	0.6 (-0.2, 1.4)	1.2 (-0.8, 3.4)
United States [a]*	1.8 (1.1, 2.4)	1.4 (-1.1, 3.7)
Survey-wide [a]	0.2 (-0.5, 0.9)	1.1 (-0.5, 2.7)
Blue-winged teal		
Colorado [b]	-0.8 (-4.4, 3.0)	-4.1 (-14.3, 4.9)
BBS Central [a]	1.2 (0.0, 2.3)	5.1 (1.3, 9.3)
United States [c]	0.4 (-19.5, 2.0)	2.5 (-2.2, 7.6)
Survey-wide [c]	0.1 (-18.1, 1.4)	4.3 (0.9, 8.1)
Cinnamon teal		
Colorado [b]	-1.0 (-4.5, 2.6)	-3.6 (-12.9, 3.7)
BBS Central [c]	2.6 (-3.2, 7.1)	9.1 (1.1, 28.2)
United States [c]	-2.8 (-20.9, -0.8)	0.4 (-2.9, 7.2)
Survey-wide [c]	-2.5 (-20.7, -0.6)	0.9 (-2.3, 7.3)
Northern pintail		
Colorado [b]	-3.3 (-7.0, 0.4)	-2.6 (-11.7, 7.8)
BBS Central [a]	-0.9 (-3.5, 1.2)	10.6 (4.8, 17.0)
United States [b]	-0.7 (-4.0, 1.3)	4.3 (-2.1, 11.1)
Survey-wide [a]	-1.3 (-4.2, -0.6)	9.8 (4.4, 15.8)
Green-winged teal		
Colorado [b]	-1.8 (-4.6, 1.2)	-1.6 (-7.3, 4.3)
BBS Central [b]	-0.4 (-3.2, 1.4)	2.1 (-2.5, 8.4)
United States [b]	-1.4 (-4.7, 0.2)	-1.8 (-7.8, 3.9)
Survey-wide [b]	-0.3 (-2.6, 1.0)	1.9 (-1.8, 6.1)

* Significantly increasing trend, $P < 0.05$
** Significantly decreasing trend, $P < 0.05$
[a] Indicates the data for this region have moderately precise results over time.
[b] Indicates the data for this region have some deficiencies with imprecise results over time.
[c] Indicates the data for this region has important deficiencies with very imprecise results over time.

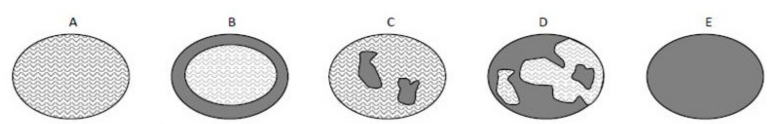
Table 5. Occurrence and seasonal importance to dabbling ducks of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland habitat type	**Spring (Ice Thaw-mid May)**	**Fall (Sept.-Ice Formation)**	**Winter**	**Relative Range of Importance**
Natural wetland habitat types				
Beaver pond	√	√		Medium-high
Emergent marsh	√	√		High
Playa	√	√		Low-high
Riparian wetland (shrub-scrub)	√	√		Low
Riparian wetland (herbaceous)	√	√		High
Sandbar	√	√	√	Medium
Stream channel	√	√	√	Low
Warm water slough	√	√	√	High
Wet meadow	√	√		High
Impoundments and other human created wetlands				
Irrigation-influenced wet meadow	√			Medium
Irrigation ditch	√	√		Low
Gravel pits	√	√	√	Low-medium
Moist soil unit	√	√		High
Recharge pond/Moist soil unit	√	√		Medium-high
Reservoir	√	√	√	Low to high
Sewage lagoon	√	√		Medium
Stock pond	√	√		Low-high
Urban runoff ponds	√	√		Low-medium

Table 6. Quality (high, medium and low) of key habitat quality variables for dabbling ducks in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	**Value**		
	High	**Medium**	**Low**
Dominant vegetation			
General type	Grasses, sedges, rushes submergents, and other seed-producing plants	Herbaceous plants that provide little to no food resources for ducks	Willows and other woody shrubs
Structure	Soft and easy to move through	Courser, more rigid, and dense	Woody or stiff and dense
% emergent (soft) cover			
Reservoirs/gravel pits	> 5%	1–5%	0%
Diurnal	21–50%	5–20%	< 5% or > 50%
Nocturnal	61–80%	21–60%	10-20%
Interspersion pattern (does not include open water areas that are not wetlands)[a]			
Diurnal	C or D	B	A or E
Nocturnal	C or D		A, B, or E
Invertebrates			
(Not considered during summer months)	Gastropods, other mollusks, midges		None
Landscape context			
Distance to roosts (Known locations)	< 8 km	8–16 km	> 16 km
% water within 8 km	> 2% other wetlands on landscape	1-2% other wetlands on landscape	< 1% other wetlands on landscape
Distance to agricultural fields, especially corn	< 8 km	8–16 km	> 16 km
Size of habitat			
Wet meadows	> 8 ha	2–8 ha	< 2 ha
Reservoirs/gravel pits	> 8 ha	4–8 ha	< 4 ha
Others	> .8 ha	.2–.8 ha	< .2 ha
Stream order			
	5th or 6th order	3rd or 4th order	1st or 2nd order
% Submergent vegetation			
	31-60%	11-30%	0-10%
Water depth (cm)			
	10-30 cm	31–60 cm	> 60 cm

[a] Interspersion pattern refers to the following diagram:



A: Open Water	Habitat feature is essentially not vegetated and covered exclusively by open water
B: Fringe	Habitat feature has vegetation around the perimeter of the wetland with central open water
C: Partially interspersed	Habitat feature contains a few vegetation patches in the central portion
D: Complex	Habitat feature contains vegetation interspersed in many patches
E: Closed	Habitat feature has few or no areas of open water

Table 7. Food preferences for dabbling ducks.

Species	Foods	References
Gadwall	Submergents, seeds, aquatic invertebrates; milfoil particularly important	Sousa 1985, Leschack et al. 1997
American wigeon	Herbivorous: submergents, leafy aquatic and upland vegetation and seeds	Turnbull and Baldassarre 1987, Mowbray 1999, Guillemain et al. 2002
Mallard	Mostly vegetarian, seeds, aquatic plants, arrowhead tubers, crops (e.g., corn)	Hughes and Young 1982, Turnbull and Baldassarre 1987, Johnson and Rohwer 2000, Drilling et al.2002
Blue-winged teal	Seeds, aquatic invertebrates, aquatic plants, duckweed, algae, grains; milfoil particularly important	Rollo and Bolen 1969, Bellrose 1980, Rohwer et al. 2002
Cinnamon teal	Seeds, aquatic invertebrates, aquatic plants; in spring invertebrates particularly important	Thorn and Zwank 1993, Gammonley 1995, 1996
Northern pintail	Aquatic vegetation (e.g., sago pondweed), aquatic invertebrates, crops (e.g., corn)	Euliss and Harris 1987, Austin and Miller 1995, Pearse et al. 2011
Green-winged teal	Seeds, invertebrates, plant material	Hughes and Young 1982, Euliss and Harris 1987, Johnson 1995, Anderson et al. 2000

Table 8. Food value to dabbling ducks of plants existing within the Lower South Platte River Basin.

Common Name	Scientific Name	Reference
High value		
Nodding beggarticks	*Bidens cernua*	LaGrange et al. 1999, Nelms et al. 2007
Threelobe beggarticks**	*Bidens comosa*	LaGrange et al. 1999, Nelms et al. 2007
Devil's beggarticks	*Bidens frondosa*	LaGrange et al. 1999, Nelms et al. 2007
Sedges	*Carex* spp.	Hughes and Young 1982, Johnson 1995
Redroot flatsedge*	*Cyperus erythrorhizos*	LaGrange et al. 1999
Chufa or Yellow nutsedge*	*Cyperus esculentes*	LaGrange et al. 1999, Taylor and Smith 2005, Nelms et al. 2007
Flatsedge spp.	*Cyperus spp.*	Rollo and Bolen 1969, Austin and Miller 1995, Johnson 1995
Crabgrass	*Digitaria* spp.	Nelms et al. 2007
Barnyardgrass	*Echinochloa crus-galli*	Rollo and Bolen 1969, Euliss and Harris 1987, Austin and Miller 1995, Johnson 1995, LaGrange et al. 1999, Anderson et al. 2000, Drilling et al. 2002, Rohwer et al. 2002, Nelms et al. 2007, Pearse et al. 2011
Rough barnyardgrass	*Echinochloa muricata*	LaGrange et al. 1999, Nelms et al. 2007
Blunt spikerush*	*Eleocharis obtusa*	Nelms et al. 2007

Common Name	Scientific Name	Reference
High value		
Spikerush spp.	*Eleocharis* spp.	Sousa 1985, Johnson 1995, Gammonley 1996, Mowbray 1999, Leschack et al. 1997, Anderson et al. 2000, Drilling et al. 2002
Teal lovegrass**	*Eragrostis hypnoides*	Nelms et al. 2007
Rice cutgrass	*Leersia oryzoides*	LaGrange et al. 1999, Drilling et al. 2002, Nelms et al. 2007
Duckweed	*Lemna* spp.	Mowbray 1999
Sprangletop	*Leptochloa* spp.	Euliss and Harris 1987, Johnson 1995, Nelms et al. 2007
Shortspike water milfoil	*Myriophyllum exalbescens*	Mowbray 1999
Water milfoil spp.	*Myriophyllum* spp.	Leschack et al. 1997
Panic grass	*Panicum* spp.	Johnson 1995, Mowbray 1999, Nelms et al. 2007
Pink (Pennsylvania) smartweed	*Polygonum bicorne*	Rollo and Bolen 1969, LaGrange et al. 1999, Anderson et al. 2000, Nelms et al. 2007
Curly-top knotweed (willow-weed)	*Polygonum lapathifolium*	LaGrange et al. 1999, Drilling et al. 2002
Spotted lady's thumb	*Polygonum persicaria*	LaGrange et al. 1999
Annual smartweeds	*Polygonum* spp.	Austin and Miller 1995, Johnson 1995, Gammonley 1996, Leschack et al. 1997, Anderson et al. 2000, Nelms et al. 2007
Longleaf pondweed**	*Potamogeton nodosus*	LaGrange et al. 1999
Pondweeds	*Potamogeton* spp.	Rollo and Bolen 1969, Sousa 1985, Johnson 1995, Leschack et al. 1997
Arumleaf arrowhead	*Sagittaria cuneata*	LaGrange et al. 1999, Nelms et al. 2007
Broadleaf arrowhead	*Sagittaria latifolia*	LaGrange et al. 1999, Nelms et al. 2007
Long-barb arrowhead ???	*Sagittaria longiloba*	LaGrange et al. 1999
Chairmaker's bulrush	*Schoenoplectus americanus*	Nelms et al. 2007
Bulrush spp.	*Schoenoplectus* spp.	Rollo and Bolen 1969, Austin and Miller 1995, Johnson 1995, Gammonley 1996
Sorghum (milo)	*Sorghum bicolor*	LaGrange et al. 1999
Common wheat**	*Triticum aestivum*	LaGrange et al. 1999, Drilling et al. 2002
Horned pondweed**	*Zannichelia palustris*	Austin and Miller 1995, Gammonley 1996
Corn	*Zea maize*	LaGrange et al. 1999, Drilling et al. 2002, Rohwer et al. 2002, Nelms et al. 2007, Pearse et al. 2011
Medium value		
American water plantain ???	*Alisma subcordatum*	LaGrange et al. 1999, Nelms et al. 2007
Red-root amaranth	*Amaranthus retroflexus*	LaGrange et al. 1999
Amaranthus spp.	*Amaranthus spp.*	Euliss and Harris 1987, LaGrange et al. 1999, Nelms et al. 2007, Pearse et al. 2011
Disk waterhyssop*	*Bacopa rotundifolia*	LaGrange et al. 1999
Shortbeak sedge	*Carex brevior*	LaGrange et al. 1999
Woolly sedge	*Carex pellita*	LaGrange et al. 1999

Common Name	Scientific Name	Reference
Medium value		
Awlfruit sedge**	*Carex stipata*	LaGrange et al. 1999
Lambsquarter**	*Chenopodium album*	LaGrange et al. 1999
Narrowleaf goosefoot	*Chenopodium leptophyllum*	LaGrange et al. 1999
Desert goosefoot	*Chenopodium pratericola*	LaGrange et al. 1999
Tapertip flatsedge**	*Cyperus acuminatus*	LaGrange et al. 1999
Great Plains flatsedge*	*Cyperus lupulinus*	LaGrange et al. 1999
Bearded flatsedge	*Cyperus squarrosus*	LaGrange et al. 1999
Needle spikerush	*Eleocharis acicularis*	LaGrange et al. 1999
Flatstem spikerush	*Eleocharis compressa*	LaGrange et al. 1999
Blunt spikerush*	*Eleocharis obtusa*	LaGrange et al. 1999
Green ash**	*Fraxinus pennsylvanica*	LaGrange et al. 1999
Common sunflower	*Helianthus annuus*	LaGrange et al. 1999, Pearse et al. 2011
Blue mudplantain*	*Heteranthera limosa*	LaGrange et al. 1999
Common duckweed	*Lemna minor*	LaGrange et al. 1999
Duckweed spp.	*Lemna spp.*	LaGrange et al. 1999
Bearded sprangletop	*Leptochloa fascicularis*	LaGrange et al. 1999
Alfalfa	*Medicago sativa*	LaGrange et al. 1999
Fall panicgrass*	*Panicum dichotomiflorum*	LaGrange et al. 1999
Water smartweed	*Polygonum amphibium*	LaGrange et al. 1999
Variable pondweed**	*Potamogeton gramineus*	LaGrange et al. 1999
Pondweeds	*Potamogeton spp.*	LaGrange et al. 1999
Pale dock**	*Rumex altissimus*	LaGrange et al. 1999
Curly dock	*Rumex crispus*	LaGrange et al. 1999
Dock	*Rumex spp.*	Euliss and Harris 1987, LaGrange et al. 1999, Anderson et al. 2000, Nelms et al. 2007
Common threesquare	*Schoenoplectus pungens*	LaGrange et al. 1999
Yellow foxtail*	*Setaria pumila*	LaGrange et al. 1999
Green bristlegrass	*Setaria viridis*	LaGrange et al. 1999
Broadfruit bur-reed**	*Sparganium eurycarpum*	LaGrange et al. 1999, Nelms et al. 2007
Common bladderwort*	*Utricularia vulgaris*	LaGrange et al. 1999

*Occurs in one or two counties within LSPRB (NRCS 2012).
**Occurs in two to four counties within LSPRB (NRCS 2012).
Unless otherwise indicated, occurs in five or more counties within LSPRB (NRCS 2012).

Table 9. Importance, ranking, and EPA monitoring level of key habitat quality variables for dabbling ducks in the Lower South Platte River Basin, Colorado.

	Importance				EPA Level		
Habitat Variable	**Rank**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Dominant vegetation	1	√				√	√
% emergent cover	2	√			√	√	√
Landscape context*	3	√			√		
Water depth	4	√					√
% submergents	5	√			√	√	√
Interspersion pattern	6	√			√	√	√
Size of habitat	7		√		√	√	
Invertebrates	8		√				√

*Identification of high-quality diurnal wetlands and wetlands appropriate for nocturnal roosting depends on both dominant vegetation (Levels 2 and 3 assessments) and percent of emergent vegetation (Levels 2 and/or 3 assessments).

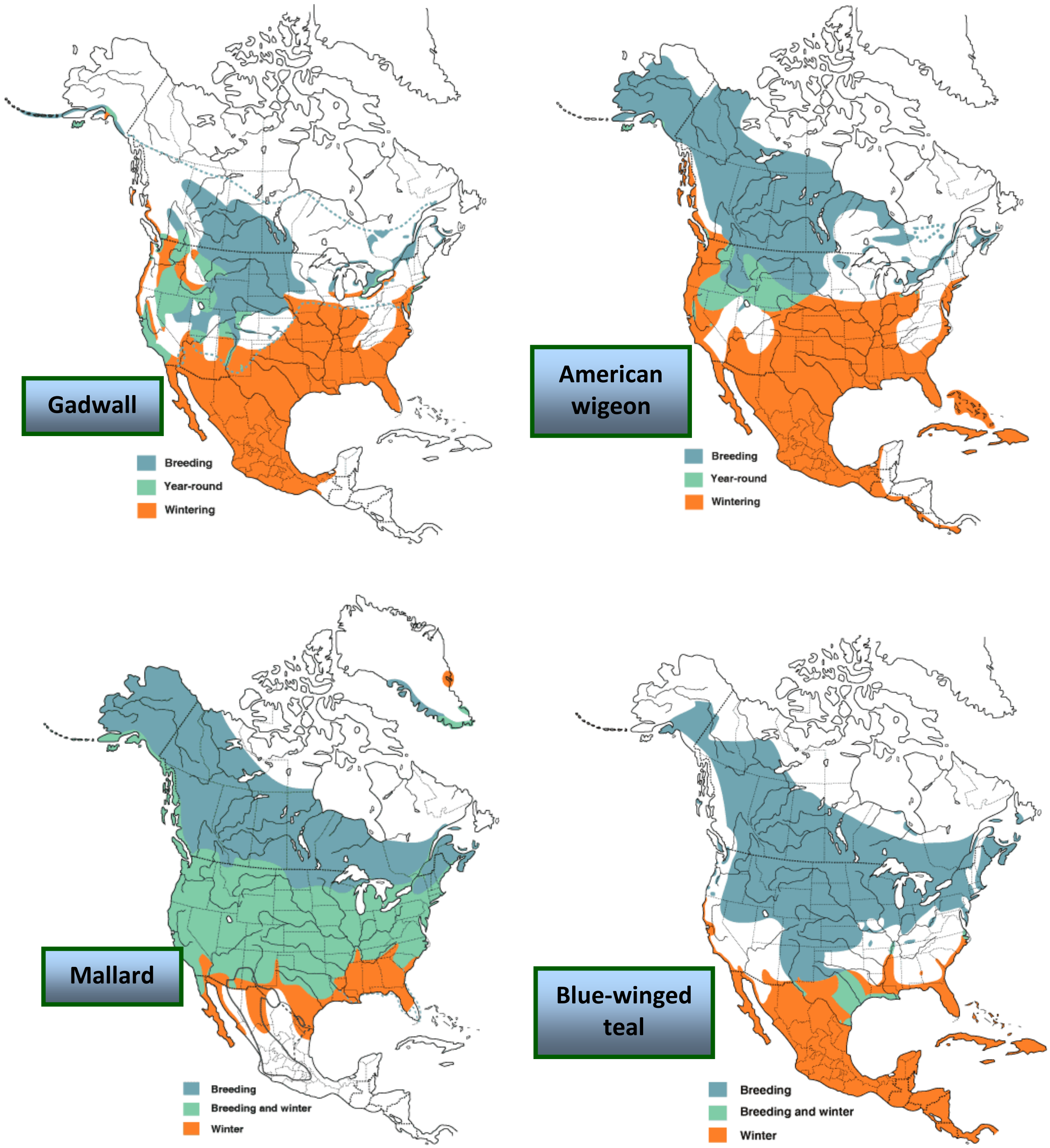


Figure 2. Distribution of dabbling ducks:
Distribution of gadwall (Leschack et al. 1997), American wigeon (Mowbray 1999), mallard (Drilling et al. 2002), and blue-winged teal (Rohwer et al. 2002).

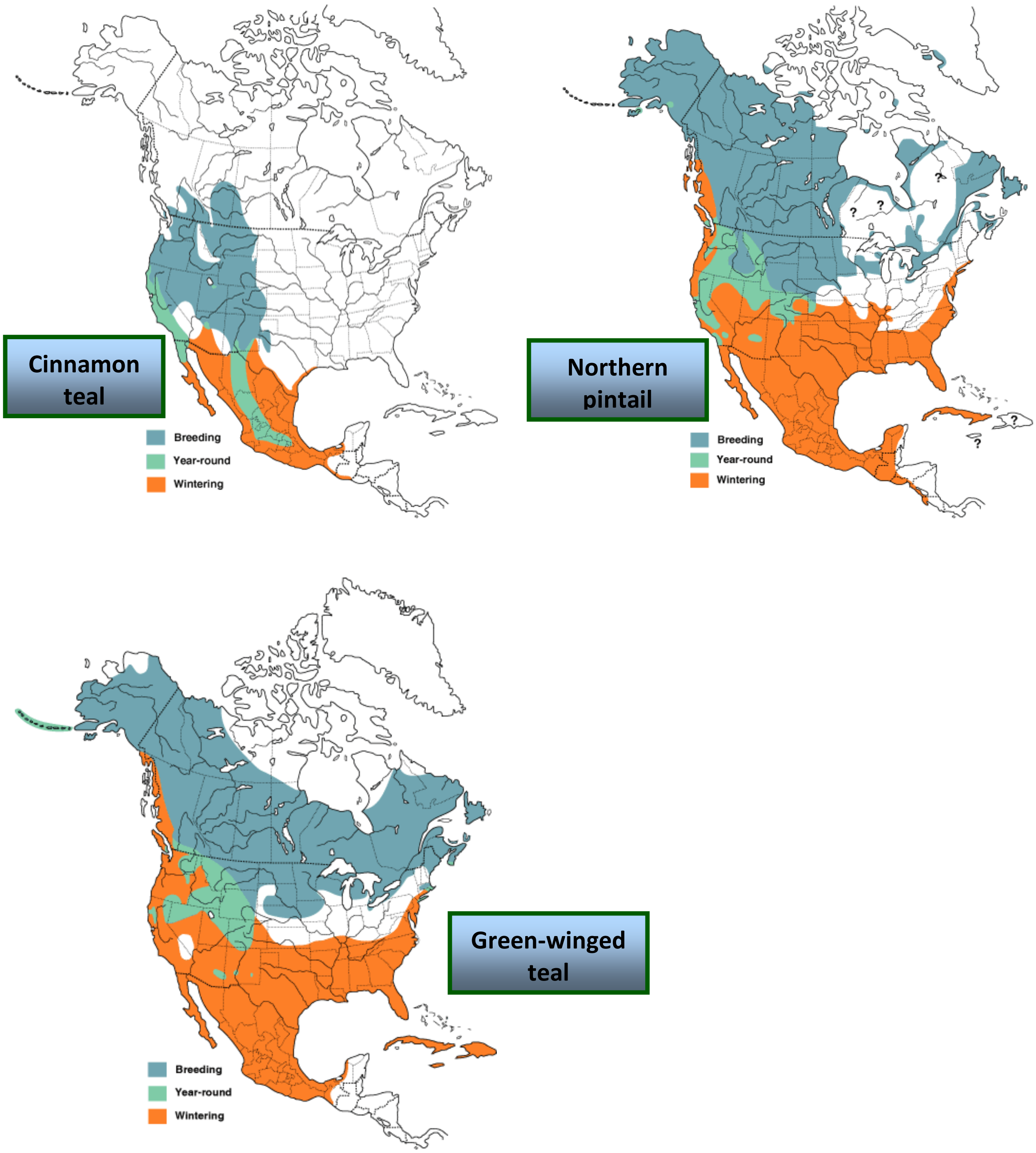


Figure 2, continued. Distribution of cinnamon teal (Gammonley 1996), northern pintail (Austin and Miller 1995), and green-winged teal (Johnson 1995).

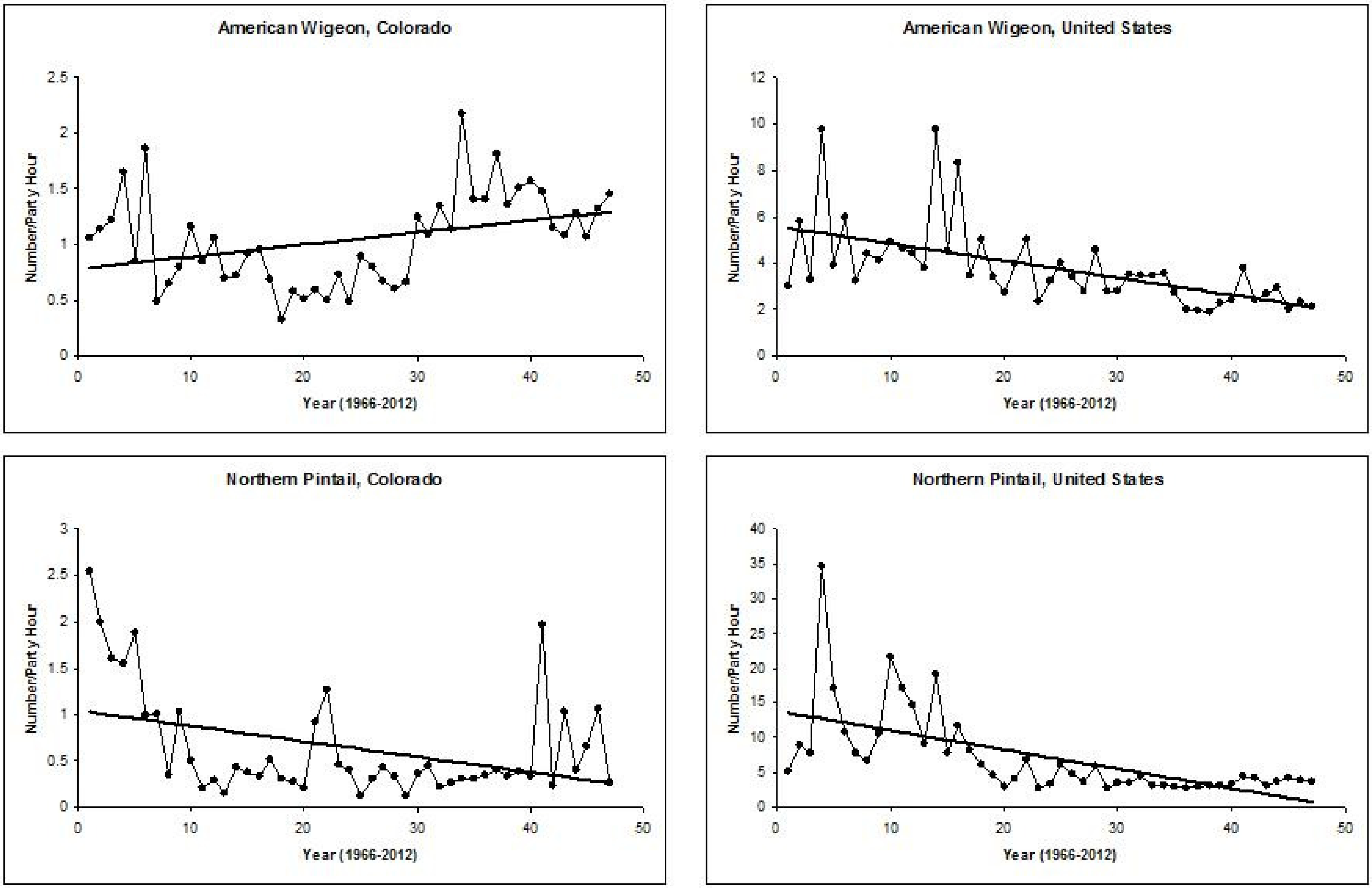


Figure 3. Wintering population trends of American wigeons and northern pintails in Colorado and throughout the United States from 1966 through 2012. Figures generated from the Audubon Society Christmas Bird Count (http://netapp.audubon.org/cbcobservation/)

3.2.2 American Bittern

Range, population status, conservation status. American bitterns (*Botaurus lentiginosus*) breed from the mid United States through northern Canada (Figures 4 and 5A). They have declined throughout much of their breeding range since 1966, but the population trend throughout the United States recently changed from a significant decline (Sauer et al. 2011) to a non-significant decline (Table 10, Sauer et al. 2012). Lor and Malecki (2006) and Nadeau et al. (2008), however, pointed out that American bitterns are easily missed in national and local surveys because they are difficult to see and are not consistently vocal enough to be aurally detected. Nevertheless, they are probably not common in the LSPRB (Figures 4 and 5A). Only two blocks within the LSPRB in the first Colorado Breeding Bird Atlas (COBBA) had possible breeding records (Yaeger 1998). The BBS map indicates a decline in the LSPRB (Figure 5B), but the second COBBA shows a small increase in the number of blocks with detections (probable breeding codes) compared with the first atlas (COBBAII 2013, accessed 12-6-2013). They were historically described as fairly common on the eastern plains of Colorado (Sclater 1912 cited in Wiggins 2006).

American bitterns were listed by the USFWS in 1982 and 1987 as a Nongame Species of Management Concern, and they were on the Audubon Society's Blue List from 1976–1986 (Lowther et al. 2009). They are variously listed by states as endangered (Connecticut, Illinois, Indiana, Massachusetts, Missouri, New Jersey, and Ohio), imperiled (Pennsylvania), at risk (Montana), species of special concern (Michigan, New York, and Wisconsin), and species of greatest conservation need (Minnesota). BirdLife International (2013) also lists the population as decreasing, but because of its extensive range, it is considered in the category of least concern on the International Union for Conservation of Nature (IUCN) Red List.

Wetland habitat types. American bitterns probably occupy only one wetland habitat in the LSPRB on a regular basis: emergent marshes. However, they could potentially be found in six additional habitats, depending on conditions (Table 11).

Key habitat quality variables. Important habitat variables for American bitterns include dominant vegetation, emergent cover, interspersion, the relationship to other habitats within the landscape (landscape context), residual cover depth, and size of habitat patch (Table 12).

Dominant vegetation. American bitterns prefer tall, dense emergent vegetation, regardless of wetland habitat type (Dechant et al. 2003b). For example, mean preferred height is 1.3 m (Brininger 1996 and Hanowski and Niemi 1988, cited in Dechant et al. 2003b), and Hanowski and Niemi (1988, cited in Dechant et al. 2003b) reported a mean vegetation density of 114 grass stems/m^2.

Percent emergent cover. Naugle (1997) found a positive relationship between occupied sites and percent of emergent cover. Similarly, Rehm and Baldassarre (2007) found a positive relationship between amount of emergent cover edge and relative abundance of American bitterns.

Interspersion. Bitterns use a variety of cover:water interspersion ratios and patterns, but prefer complex patterns (Lowther et l. 2009). Gibbs et al. (1991 cited in Lowther et al. 2009) described bitterns as requiring a high degree of cover:water. Some investigators have found that bitterns are most common in wetlands with open water and fringe vegetation (Weber 1978, Weber et al. 1982, cited in Dechant et al. 2003b). Bitterns often feed at the interface between open water and vegetation edge on the wetland interior; therefore, more extensive and complicated interspersion patterns will provide the most interior edge (Rehm and Baldassarre 2007).

Landscape context. Some authors have suggested a very high importance of an undisturbed buffer surrounding the wetland. An undisturbed and uncontaminated buffer provides protection from predators as well as increased foraging success because many of their prey items are sensitive to contamination (Table 13, Wiggins 2006). Wiggins (2006) suggested a buffer > 200 m free from disturbance (including livestock grazing, mowing, and burning) would benefit American bitterns. They tend to occupy wetlands that are surrounded by idle grasslands (Dechant et al. 2003b) and not isolated from other wetlands on the landscape. Niemuth and Solberg (2003) found that the distribution and density of American bitterns was correlated with the number of wetlands on the landscape.

Residual cover. Residual cover appears important enough to have evolutionarily influenced the cryptic plumage of the American bittern, making them difficult to distinguish from dried cattails and other dried emergent vegetation (Ortega 1988, Lowther et al. 2009). Manci and Rusch (1988) found American bitterns only in areas with dry cattails.

Size of habitat. American bitterns will sometimes use smaller marshes, but they prefer habitat patches > 10 ha (Brown and Dinsmore 1986) or larger (> 20 ha, Craig 2008). Yet, other occupied sites in Minnesota averaged 36.7 ha (Hanowski and Niemi 1986).

Water depth. Water depth of occupied sites vary from 3–91 cm (reviewed by Dechant et al. 2003b), but American bitterns appear to require at least some open water.

Ranking of habitat quality variables. All habitat quality variables identified for American bitterns can be considered of high importance (Table 14).

Table 10. Adjusted population trends (2.5% CI, 97.5%CI) for American bitterns from the Breeding Bird Survey (Sauer et al. 2012) in the United States, and survey-wide.

Species Region	Trends 1966–2011	 2001–2011
BBS Central*	0.0 (-1.5, 1.5)	1.7 (-2.4, 6.1)
United States*	-1.2 (-4.0, 0.0)	-0.8 (-4.5, 2.9)
Survey-wide*	-0.6 (-2.6, 0.4)	2.2 (-0.3, 4.6)

* Indicates the data for this region have some deficiencies with imprecise results over time.

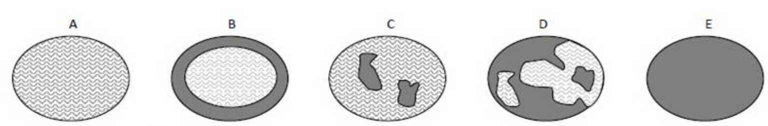
Table11. Occurrence and seasonal importance to American bitterns of wetland habitat types in the Lower South Platte River Basin, Colorado.

Habitat Type	Spring Ice Thaw-mid May	Summer	Fall Sept.-Ice Formation	Winter	Relative Range of Importance
Natural wetland habitat types					
Beaver pond	Possibly	Possibly	Possibly	Absent	Low-high
Emergent marsh	√	√	√	Absent	High
Riparian wetland (herbaceous)	Possibly	Possibly	Possibly	Absent	Low
Warm water slough	Possibly	Possibly	Possibly	Absent	Low
Wet meadow	Possibly	Possibly	Possibly	Absent	Low
Impoundments and other human created wetlands					
Gravel pits	Possibly	Possibly	Possibly	Absent	Low

Table 12. Quality (high, medium and low) of key habitat quality variables for American bitterns in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	Value		
	High	**Medium**	**Low**
Dominant vegetation			
	Cattails/Bulrush/Sedges/ Reed grasses/Bur-reeds	Other tall/medium emergents	Short (e.g., sedges) or no emergents
Dominant vegetation height			
	Tall (1-2 m)	Medium (0.5-< 1 m)	Short (< 0.5 m)
% emergent cover			
	61–80%	31–60% or 81-100%	15–30%
Interspersion [a]			
	B, C, or D		A or E
Landscape context			
	> 200 m buffer from disturbance		
% Residual cover			
	41–60%	21–40% or 61-100%	10–20%
Residual cover depth			
	> 10-20 cm		
Size of habitat			
	>10 ha	5–10 ha	1-5 ha
Water depth (cm)			
	5–20 cm	> 21–100 cm	< 5 cm or >100 m

[a] Interspersion pattern refers to the following diagram:



A: Open Water	Habitat feature is essentially not vegetated and covered exclusively by open water
B: Fringe	Habitat feature has vegetation around the perimeter of the wetland with central open water
C: Partially interspersed	Habitat feature contains a few vegetation patches in the central portion
D: Complex	Habitat feature contains vegetation interspersed in many patches
E: Closed	Habitat feature has few or no areas of open water

Table 13. Food preferences for American bitterns.

Foods	References
Insects	References in Lowther et al. 2009
Amphibians, especially frogs and salamanders	Bailey 1925, References in Lowther et al. 2009
Fish	References in Lowther et al. 2009
Crayfish	References in Lowther et al. 2009
Small mammals, e.g., meadow voles	References in Lowther et al. 2009
Snakes	Ingram 1941
Crabs	References in Lowther et al. 2009
Spiders	References in Lowther et al. 2009
Various other invertebrates	References in Lowther et al. 2009

Table 14. Importance, ranking, and EPA monitoring level of key habitat quality variables for American bitterns in the Lower South Platte River Basin, Colorado.

	Importance				EPA Level		
Habitat Variable	**Rank**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Size of habitat	1	√			√		
Residual cover	2	√					√
% emergent cover	3	√					√
Dominant vegetation	4	√				√	√
Vegetation height	5	√					√
Landscape context*	6	√			√		
Interspersion	7	√				√	√
Water depth	8	√					√

Figure 4. Distribution of American bitterns Lowther et al. (2009).

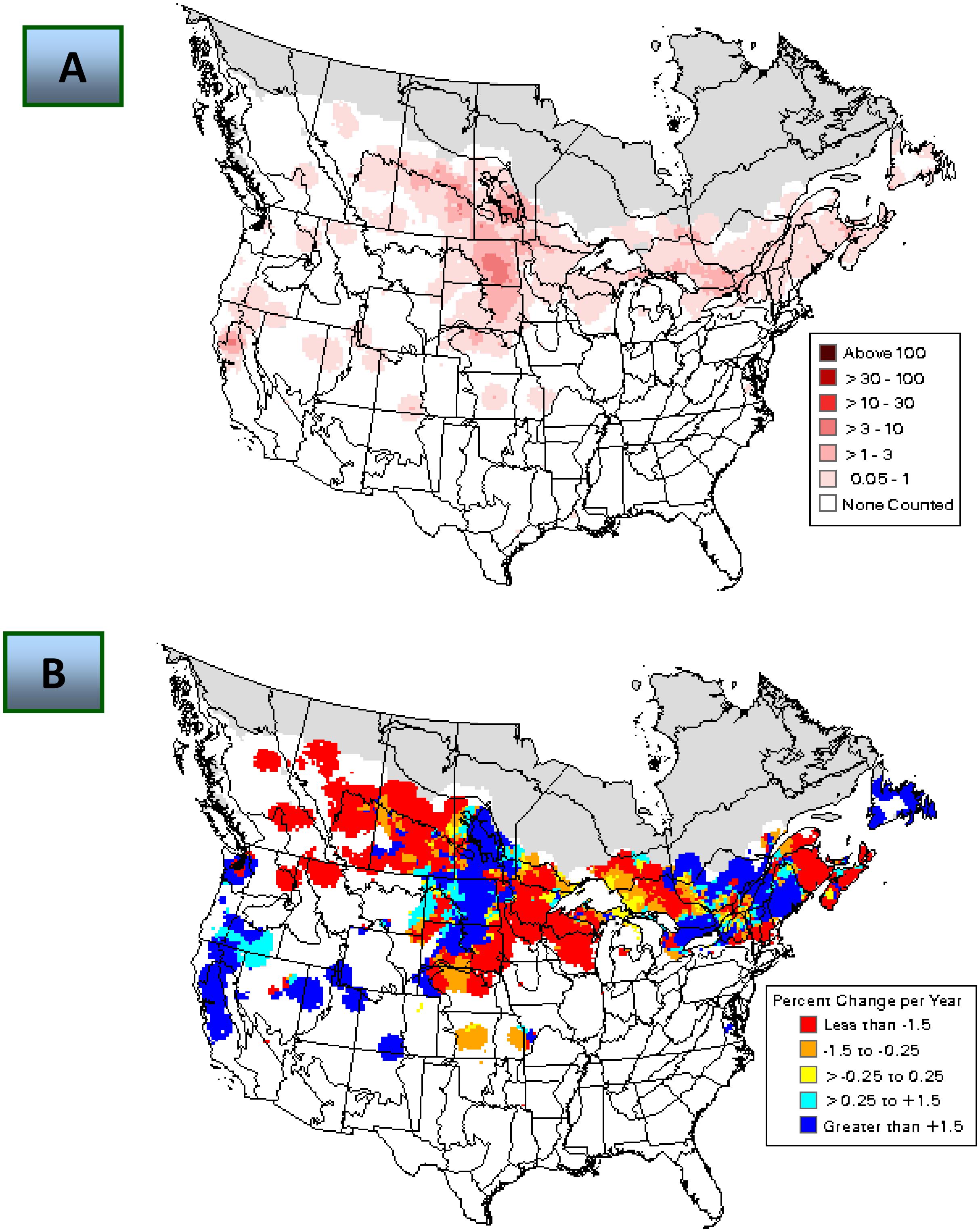


Figure 5. (A) Abundance map, and (B) population trend for American bittern Breeding Bird Survey (Sauer et al. 2011). Abundance map is based on data from 2006-2011; population trend map is based on data from 1966-2011.

3.2.31 Greater Sandhill Crane

Range, population status, conservation status. Six subspecies of sandhill cranes (*Grus canadensis*) are often recognized (but see Tacha et al. 1985, 1992).[1] The subspecies on the CPW priority list (State Species of Concern), the greater sandhill crane (*G. c.s tabida*), winters primarily in Rio Grande County, New Mexico, with spring and fall stopovers in the San Luis Valley of Colorado. Although two other subspecies (*G. c. pulla* and *G. c. nesiotes*) are listed as endangered under the Endangered Species Act (ESA), sandhill crane populations appear to be stable or increasing in most areas (Tacha et al. 1992, Sauer et al. 2012, Table 15).

Greater sandhill cranes breed in a variety of northern regions, including northwestern Colorado (Drewien and Bizeau 1974). Although they do not breed within the LSPRB (Andrews and Righter 1992, Barrett 1998b), the SP-WFAC suggested that at least some sandhill cranes use the LSPRB as a migratory stopover, and Krapu et al. (2011) clearly show the LSPRB falls within the autumnal migratory path of the Western Alaska–Siberia population (Figure 6). Tacha et al. (1992) identified four populations of the greater sandhill crane: Eastern, Rocky Mountain, Colorado River Valley, and Central Valley. None of these populations breed in the western Alaska and Siberia regions (Tacha et al. 1992, Krapu et al. 2011). Therefore, most sandhill cranes that use the LSPRB are likely from the mid-continental population, subspecies *G. c. canadensis* and may not represent the target priority species.

Wetland habitat types. Sandhill cranes probably occupy up to seven wetland habitats in the LSPRB during spring and fall migration (Table 16). Depending on the conditions, especially water depth and landscape context, all these wetland habitats could potentially provide migrating cranes with suitable resting and feeding opportunities.

Key habitat quality variables. Measurable habitat quality variables for sandhill cranes include dominant vegetation, percent emergent cover, landscape context, size of habitat, and water depth (Table 17). Nesting and wintering habitat is not considered.

Dominant vegetation. During migration, dominant vegetation is applicable only to feeding sites, which are most likely to be croplands with waste grains, particularly corn stubble, alfalfa, wheat, sorghum, barley, and oats (Krapu et al. 1984, Armbruster 1987, Iverson et al. 1987, Laubhan and Gammonley 2001). Interestingly, however, Sparling and Krapu (1994) found that cornfields were under-utilized according to availability compared with daily foraging in native grasslands and planted hay lands. Taylor and Smith (2005) reported sandhill cranes in moist-soil units in New Mexico used underground food resources, especially chufa tubers (*Cyperus esculentu*).

Percent emergent cover. During nocturnal roosting, sandhill cranes seek shallow-water wetlands with an open view and little to no emergent vegetation (Krapu et al. 2011).

[1] The Sandhill Crane Foundation (ICF, 2012) recognizes six subspecies: lesser sandhill crane (*Grus canadensis canadensis*), Greater sandhill crane (*G. c. tabida*), Canadian sandhill crane (*G. c. rowani*), Florida sandhill crane (*G. c. pratensis*), Mississippi sandhill crane (*G. c. pulla*) and Cuban sandhill crane (*G. c. nesiotes*).

Landscape context. Many investigators have reported on juxtaposition of feeding sites and nocturnal roosting sites (Krapu et al. 1984, Iverson et al. 1987, Tacha et al. 1992, Sparling and Krapu 1994, Krapu et al. 2011). Among other research needs, Kruse et al. (2011) suggested that we need to better understand the agricultural landscape as it relates to high quality habitat for sandhill cranes because of potential changes in crop types, particularly corn. Cropland is a critical component influencing migration patterns; prior to agriculture, sandhill cranes probably had to be more flexible and opportunistic in their migration patters (Krapu et al. 2011). Lovvorn and Kirkpatrick (1981) found that in the eastern population, greater sandhill cranes roosted closer to human disturbance if their open-water roosts were surrounded by trees.

Size of habitat. Folk and Tacha (1990) reported that 90% of sandhill cranes roosting in Nebraska used habitat widths of greater than 23 m, and only 10% used widths between 12–22 m, but Krapu et al. (1984) found a preference between 50 and 150 m from shore.

Water depth. Sandhill cranes are found in water depths of less than 20 cm (Lovvorn and Kirkpatrick 1981, Folk and Tacha 1990, Tacha et al. 1992).

Ranking of habitat quality variables. Numerous investigators have suggested that water depth of nocturnal roosts and landscape context are two of the most important habitat quality variables explaining the use of areas by sandhill cranes (Krapu et al. 1984, Iverson et al. 1987, Tacha et al. 1992, see Table 18).

Table 15. Adjusted population trends (2.5% CI, 97.5%CI) for greater sandhill crane from the Breeding Bird Survey (Sauer et al. 2012) in Colorado, the United States, and survey-wide.

Species / **Region**	**Trends** 1966–2011	**Trends** 2001–2011
Colorado [c]	15.5 (7.8, 25.3)	14.5 (2.5, 24.8)
BBS Central [b] *	9.0 (5.9, 12.1)	10.2 (4.9, 15.1)
United States [a] *	5.3 (4.4, 6.2)	7.8 (6.3, 9.5)
Survey-wide [a] *	5.3 (3.5, 6.3)	8.3 (6.2, 10.6)

* Significantly increasing trend, P > 0.05
[a] Indicates the data for this region have moderately precise results over time.
[b] Indicates the data for this region have some deficiencies with imprecise results over time.
[c] Indicates the data for this region has important deficiencies with very imprecise results over time.

Table 16. Potential occurrence and seasonal importance to Greater Sandhill Crane of wetland habitats in the Lower South Platte River Basin, Colorado.

Habitat Type	Spring Ice Thaw–mid May	Summer	Fall Sept.–Ice Formation	Winter	Relative Range of Importance
Natural wetland habitat types					
Emergent marsh	√	Absent	√	Absent	Med-High
Playa	√	Absent	√	Absent	Med-High
Wet meadow	√	Absent	√	Absent	Med-High
Impoundments and other human created wetlands					
Irrigation-influenced wet meadow	√	Absent	√	Absent	Med-High
Moist soil unit	√	Absent	√	Absent	Med-High
Recharge pond/Moist soil unit	√	Absent	√	Absent	Med-High
Reservoir	√	Absent	√	Absent	Low-High

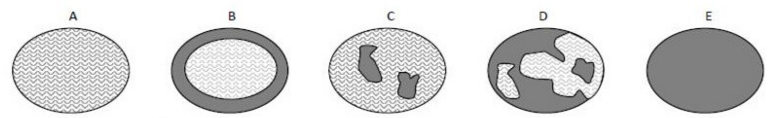
Table 17. Quality (high, medium and low) of key habitat quality variables for greater sandhill crane in the Lower South Platte River Basin, Colorado. Roosting habitats include emergent marshes, playas, and reservoirs; feeding habitats may include emergent marshes, playas, wet meadows, and recharge ponds/moist soil units.

Habitat Quality Variable	Value		
	High	Medium	Low
Dominant vegetation			
Roosting	NA	NA	NA
Feeding	Grasses, sedges, crops (particularly corn stubble)		Dense woody vegetation
Dominant vegetation height			
Feeding	<0.5 m	.05-1 m	1-2 m
% emergent cover			
Roosting	0–20%	21–40%	> 40%
Interspersion pattern [a]			
Roosting	A	B or C	D or E
Landscape context			
Roosting and feeding	≥ 1 wetland within 4 km of the roost site; relatively free from human disturbance		
% water within 8 km	> 2% other wetlands on landscape	1-2% other wetlands on landscape	< 1% other wetlands on landscape
Size of habitat			
Roosting	50–150 m from shore OR >1 ha	26–50 m from shore OR 1 ha	15-25 m from shore OR < 1 ha

Table 17, continued.

Habitat Quality Variable	**Value**		
	High	**Medium**	**Low**
Water depth (cm)			
Roosting	5–20 cm	20–40 cm	> 40 cm or dry
Feeding	Usually dry or shallow hummocks		

[a] Interspersion pattern refers to the following diagram (next page):



A: Open Water	Habitat feature is essentially not vegetated and covered exclusively by open water
B: Fringe	Habitat feature has vegetation around the perimeter of the wetland with central open water
C: Partially interspersed	Habitat feature contains a few vegetation patches in the central portion
D: Complex	Habitat feature contains vegetation interspersed in many patches
E: Closed	Habitat feature has few or no areas of open water

Table 18. Importance, ranking, and EPA monitoring level of key habitat quality variables for greater sandhill crane in the Lower South Platte River Basin, Colorado.

	Importance				**EPA Level**		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Water depth	1	√					√
Landscape context	2	√				√	
% emergent cover	3	√					√
Size of habitat	4	√				√	
Interspersion	5			√		√	√
Dominant vegetation	6			√		√	√

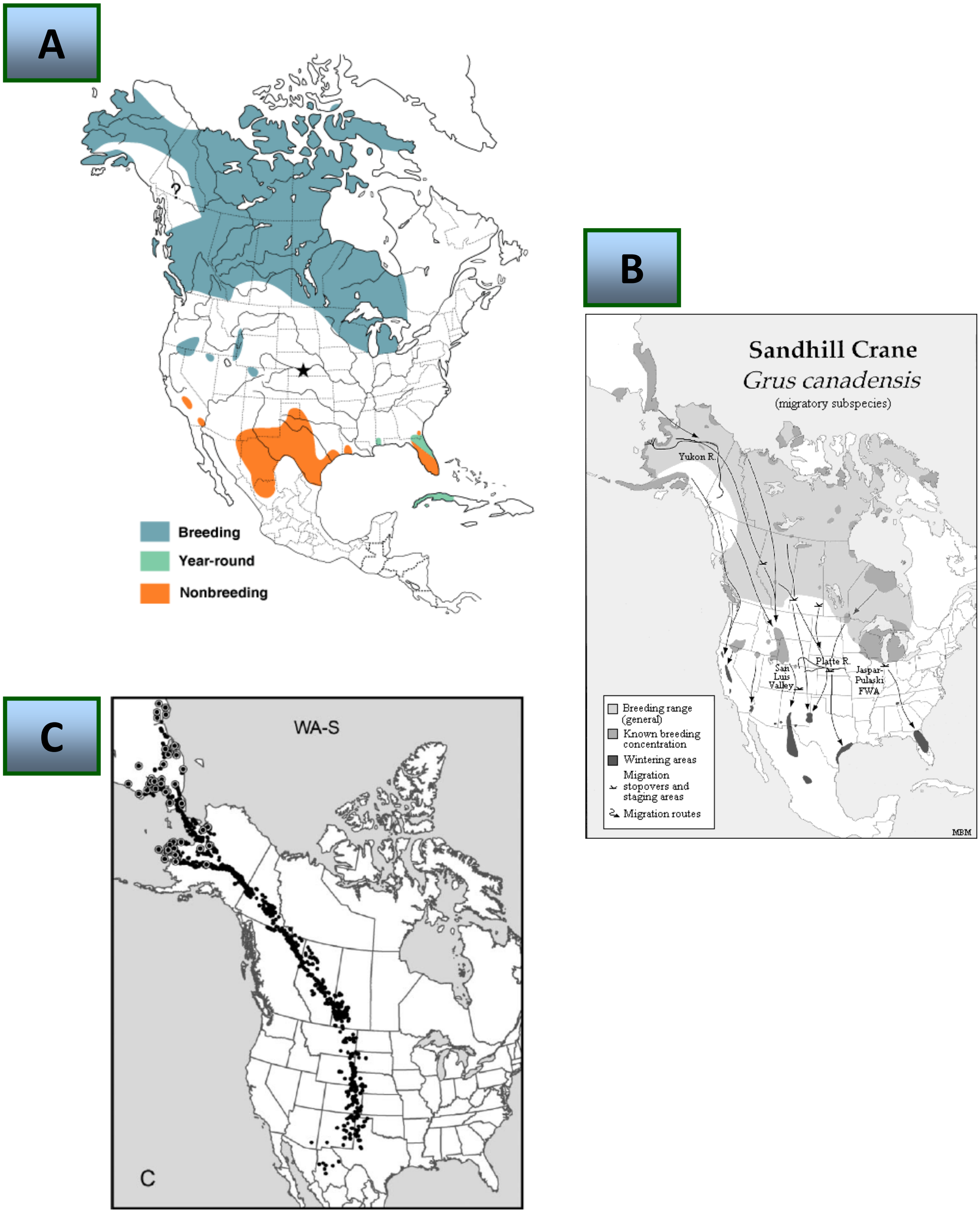


Figure 6. Distribution of Sandhill Cranes
(A) Tacha et al. (1992), (B): ICF (2012), (C) Western Alaska–Siberia population, Krapu et al. (2011).

3.2.4 Piping Plover

Range, population status, conservation status. The interior population of piping plovers (*Charadrius melodus*) is on the federal and State of Colorado threatened list (Elliott-Smith and Haig 2004, Brown et al. 2011, CPW 2012). In Colorado, they occur in the far eastern part of the state, mostly along the edges of reservoirs (Haig and Plissner 1993, Elliott-Smith and Haig 2004, Brown et al. 2011, Figure 7). They very rarely occur in the LSPRB, only as spring and fall migrants (Andrews and Righter 1992, Andrews, pers. comm. in Appendix 1), and they have not appeared within the LSPRB in the Colorado Breeding Bird Atlas (Nelson 1998c, COBBAII 2013).

Wetland habitats. The only wetland habitat in the LSPRB piping plovers would use is unvegetated or sparsely-vegetated sandbars.

Key habitat quality variables. The key habitat quality variables for piping plovers include dominant vegetation, landscape context, percent open sand or gravel area, proximity to objects, size of habitat, and percent of vegetation cover (Table 19).

Dominant vegetation. Piping plovers prefer sparse clumps of grasses or sedges (Gaines and Ryan 1988, Powell and Cutbert 1992).

Landscape context. Gaines and Ryan (1988) reported lower nest success in grazed areas and areas with motorized traffic compared to sites without these disturbances. Piping plovers nest on the ground, and the daily nest survival in some studies is extremely low (see Table 7 in Brown et al. 2011); therefore any anthropogenic landscape changes that result in increased abundance of predators will likely lower the success of piping plover nests.

Open sand or gravel area on sandbar. Piping plovers prefer open sandbars, either newly created or relatively free of vegetation, which normally occurs through scouring action of flood events (Sidle et al. 1992, Sidle and Kirsch 1993, Busby et al. 1997, Poff et al. 1997, Le Fer et al. 2008). Gaines and Ryan (1988) reported more abundant and evenly distributed gravel at sites occupied by piping plovers compared with unoccupied sites.

Proximity to large object, e.g., rocks, logs. Some authors have reported that nests are placed more often near larger objects (e.g., rocks, stones, logs) than would be expected by chance (Elliott-Smith and Haig 2004), but this has not been well defined.

Size of habitat. Gaines and Ryan (1988) found mean beach widths of occupied sites 27–39 m compared with mean beach widths 12–16 m of unoccupied sites. Similarly, Powell and Cuthbert (1992) found mean beach widths of 23–24 m for occupied sites. J. Fraser (pers. comm.) suggests that the larger habitat patches are better.

Vegetation cover. Piping plovers select for a very sparse amount of vegetation (e.g., 4% cover, Gaines and Ryan 1988).

Ranking of habitat quality variables. The importance of habitat variables is summarized in Table 20.

Table 19. Quality (high, medium and low) of key habitat quality variables for piping plovers in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	**Value**		
	High	**Medium**	**Low**
Dominant vegetation			
	Sparse grasses clumps preferred	Denser grasses	Woody vegetation
Landscape context			
	Along river with natural flow regimes and ungrazed		Sites away from river (less successful)
% open sand or gravel area			
	Near 100% open		Less than open
Proximity to large object, e.g., rocks, logs			
	Close	More distant	Far
Size of habitat			
	> 20 m wide (the larger the better)	15–20 m wide	10-15 m wide
% vegetation			
	0–5%	6–10%	11-20%

Table 20. Importance, ranking, and EPA monitoring level of key habitat quality variables for piping plovers in the Lower South Platte River Basin, Colorado.

	Importance				**EPA Level**		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
% open sand or gravel area on sandbar	1	√			√		
Size of habitat	2	√			√		
% vegetation cover	3	√					√
Landscape context	4	√			√		
Dominant vegetation	5	√				√	√
Proximity to large object, e.g., rocks, logs	6	?	?			√	√

Figure 7. Distribution of piping plovers
Elliot-Smith and Haig 2004

3.2.5 Long-billed Curlew

Range, population status, conservation status. Long-billed curlews (*Numenius americanus*) breed in the western United States, including eastern Colorado, and southwestern Canada (Figure 8). They do not breed abundantly in the LSPRB (Andrews and Righter 1992, Nelson 1998b, COBBAII 2013, Figure 9a) and do not occur in Colorado during winter months (Dugger and Dugger 2002). Although declines have occurred elsewhere (Figure 9b), Colorado is the only region covered by BBS that has experienced significant declines (Sauer et al. 2012, Table 21). However, along the east coast, where they were once common during migration, they are now rarely observed (Dugger and Dugger 2002). The long-billed curlew is listed as a Colorado Species of Concern (CPW 2012). They are also listed as a USFWS Bird of Conservation Concern (Fellows and Jones 2009). Jones et al. (2008) suggested that long-billed curlews are underestimated in BBS surveys.

Wetland habitats. Long-billed curlews may be found within the LSPRB in playas as well as natural and irrigation-influenced wet meadows (Table 22).

Key habitat quality variables. Key habitat variables include dominant vegetation, landscape context, proximity to water and to large objects, size of habitat, percent vegetative cover, vegetation height, and water depth (Table 23).

Dominant vegetation. Long-billed curlews prefer short grasses and generally avoid areas with trees, dense shrubs, and tall grasses (McCallum et al. 1977, Pampush and Anthony 1993, Dugger and Dugger 2002). However, a wide variety of plant species are used by long-billed curlews, and it appears that plant structure is more important than species (Dugger and Dugger 2002). They will even nest in cheatgrass fields (Allen 1980, Pampush and Anthony 1993, Earnst and Holmes 2012). Saunders (2001) found in Alberta, Canada, that when abundantly available, curlews preferred native grasslands over human-influenced pastures.

Landscape context. Mueller (2000) suggested that habitat heterogeneity is important with juxtaposition of "short-growth grasslands, agricultural fields, meadows, prairies, grazed mixed-grass, and scrub communities." Similarly, Saalfeld et al. (2010) found that curlews were positively associated with wetlands and hay or pasture meadows and negatively associated with shrub/scrub and forested habitats on a landscape scale. In Colorado, foraging may take place in nearby agricultural fields (King 1978 cited in Dugger and Dugger 2002), but curlews do not generally use agricultural fields for nesting (Dark-Smiley and Keinath 2004, Dechant et al. 2003a). In southeastern Colorado, King (1978 cited in Dark-Smiley and Keinath 2004) reported 55% of foraging observations occurred in grasslands and 40% in croplands. Livestock grazing promotes the short grass conditions favored by long-billed curlews, but cattle pose a significant trampling effect on nests, and sheep pose an even greater risk (Sugden 1933, Timken 1969, Clarke 2006); therefore, manipulations of timing, density and distribution of cattle may increase nest success (Clarke 2006, Mueller 2000).

Proximity to water. Although long-billed curlews are rarely observed using water (COPIF 2012), proximity to standing water (< 400 m) appears to be a feature that curlews select for nest sites (McCallum et al. 1977, Clarke 2006), and Saalfeld et al. (2010) found a positive association with wetlands. However, the actual nest sites are dry. Preference for water depth, also, does not seem to be well understood, and Davis and Smith (1998) reported out of 30 species studied during migration in the Playa Lakes Region, long-billed curlews were the only species using water with depths not differing from availability. Fellows and Jones (2009) pointed out that the role water plays probably varies geographically and with local conditions; also, the heavy grazing near water sources provides the short grass conditions that curlews prefer.

Proximity to large objects, e.g., rocks, logs, branches, dirt mounds, cattle manure, discarded trash from humans . Some authors have reported that nests are placed more often near larger objects than would be expected by chance (Allen 1980, Dugger and Dugger 2002).

Size of habitat. In northern California, Colwell et al. (2002) found a relationship during the non-breeding season between home range and diet although both varied; they found an average home range of 3 ha during the breeding season and suggested that home range size is habitat specific. Allen (1980) reported the smallest defended territories in areas where the habitat and topography were most varied with a range in size of 6–20 ha. In South Dakota, Clarke (2006) reported much larger home range sizes of 15–489 ha (mean of 187 ha) across the breeding season. In California, Mathis (2000) found much smaller summer home range sizes: 1.3–7.5 ha. Mueller (2000) and Pampush and Anthony (1993) suggested 14–49 ha and 4.4–20 ha, respectively, depending on habitat and topographic diversity.

Percent vegetation cover. King (1978,cited in COPIF 2012) reported a range of 50–95% vegetation cover in Colorado. The average grass cover was 44% and bare ground 33% at brooding sites in Gregory's (2011) study in South Dakota.

Vegetation height. Long-billed curlews use short grass habitat for foraging and breeding activities, e.g. < 10–20 cm (Allen 1980), 10–27 cm (Clarke 2006), 7.5–23 cm (Mueller 2000), 4–15 cm (Saalfeld et al. 2010), <10–30 cm (COPIF 2012). In Colorado, King (1978 cited in COPIF 2012) reported a mean of 11 cm. Gregory (2011) found a negative relationship between vegetation height and nest success.

Diet. Long-billed curlews probe or peck for invertebrates, including mollusks, worms, crustaceans (Stenzel et al. 1976, Colwell et al. 2002), and spiders (Abbott 1944). Insects, such as grasshoppers (COPIF 2012), may be especially important in some areas (Dugger and Dugger 2002). They also consume some vertebrate species, including fish (Colwell et al. 2002), amphibians (Mueller 2000), and bird eggs/nestlings (references in Sedgwick 2006).

Ranking of habitat quality variables. The importance of habitat variables for long-billed curlews is summarized in Table 24.

Table 21. Adjusted population trends (2.5% CI, 97.5%CI) for long-billed curlews from the Breeding Bird Survey (Sauer et al. 2012) in Colorado, the United States, and survey-wide.

Species **Region**	**Trends**	
	1966-2011	**2001-2011**
Colorado [b] **	-4.1 (-6.8, -0.8)	-3.0 (-7.6, 6.1)
BBS Central [c]	-0.7 (-2.4, 0.4)	0.4 (-1.6, 2.8)
United States [c]	0.3 (-2.0, 1.2)	1.5 (-0.3, 3.5)
Survey-wide [c]	0.1 (-1.8, 0.9)	1.2 (-0.3, 2.8)

** Significantly decreasing trend, $P < 0.05$. Data for all regions have moderately precise results over time.

[a] Indicates the data for this region have moderately precise results over time.

[b] Indicates the data for this region have some deficiencies with imprecise results over time.

[c] Indicates the data for this region has important deficiencies with very imprecise results over time.

Table 22. Occurrence and seasonal importance to long-billed curlews of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	**Spring Ice Thaw-mid May**	**Summer**	**Fall Sept.-Ice Formation**	**Winter**	**Relative Range of Importance**
Natural wetland types					
Playa	√	?	√	Absent	Low-High
Wet meadow	√	√	√	Absent	High
Impoundments and other human created wetlands					
Irrigation-influenced wet meadow	√	√	√	Absent	High

Table 23. Quality (high, medium and low) of key habitat quality variables for long-billed curlews in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	**Value**		
	High	**Medium**	**Low**
Dominant vegetation			
Playas	Sparse, short, soft		Dense, tall, woody
Wet meadows	Open, short grasses		Trees/high grass
Dominant vegetation height			
	Short (< 50 cm)	Medium (50–100 cm)	Tall (1-5 m)
% emergent cover			
Playas	0-33%	34-50%	50-70%
Landscape context			
	Wet meadows near agricultural field and wetlands; within 400 m of water		
% water within 8 km	> 2% other wetlands on landscape	1-2% other wetlands on landscape	< 1% other wetlands on landscape
Proximity to large objects (near nest)			
	Close	More distant	Far
Size of habitat			
	> 20 ha	5–20 ha	3-5 ha
Water depth (cm)			
Playas	0–16 cm[a]	17-18 cm	> 19 cm
Wet meadows	Dry	Hummocks?	Deep

[a]Used in proportion to availability.

Table 24. Importance, ranking, and EPA monitoring level of key habitat quality variables for long-billed curlews in the Lower South Platte River Basin, Colorado.

	Importance in playas				**EPA Level**		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Landscape context	1	√			√		
% emergent cover	2	√				√	√
Water depth	3	√					√
Size of habitat	4		√		√		
Dominant vegetation	5			√			√
	Importance in wet meadows				**EPA Level**		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Vegetation height	1	√				√	√
Landscape context	2	√			√		
Water depth	3	√					√
Size of habitat	4		√		√		
Dominant vegetation	5			√			√

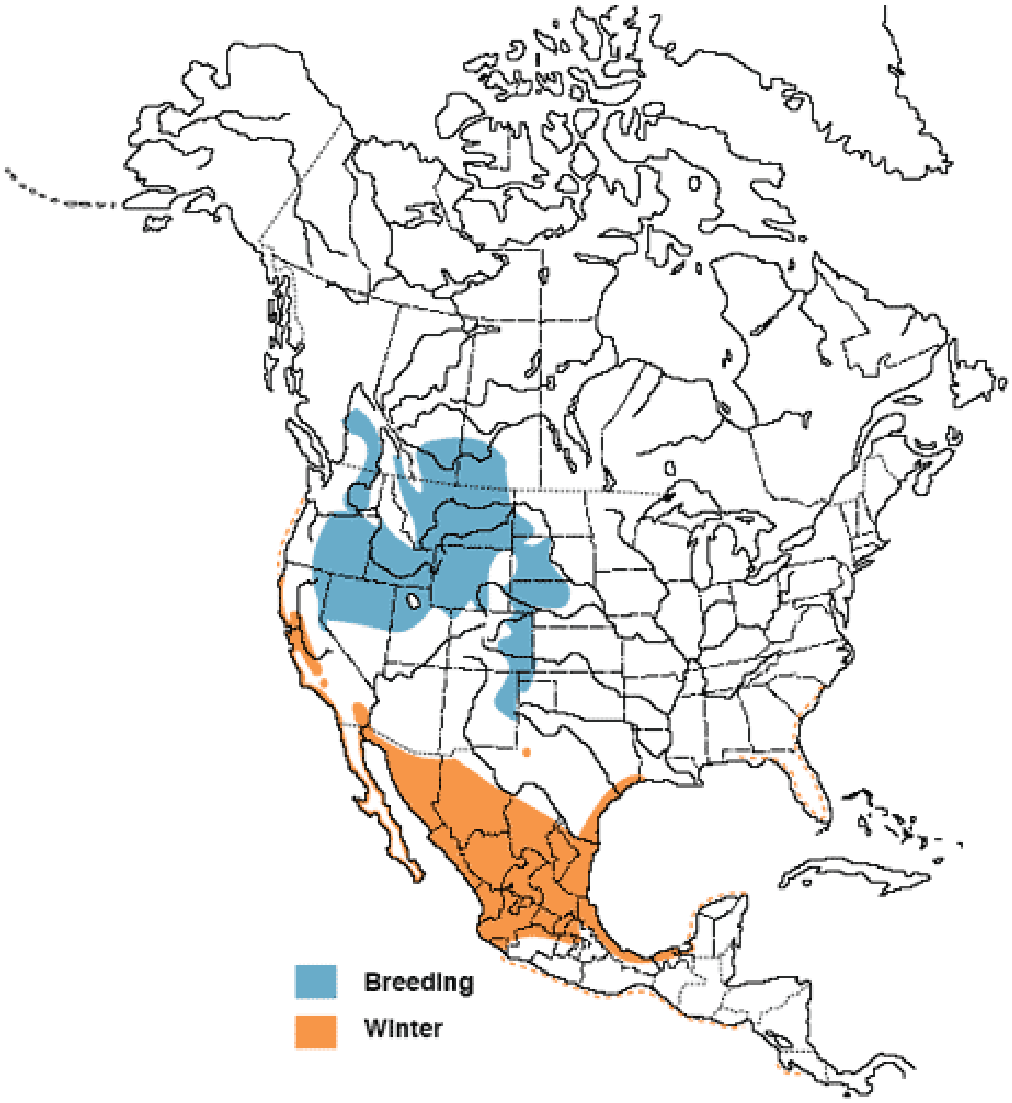
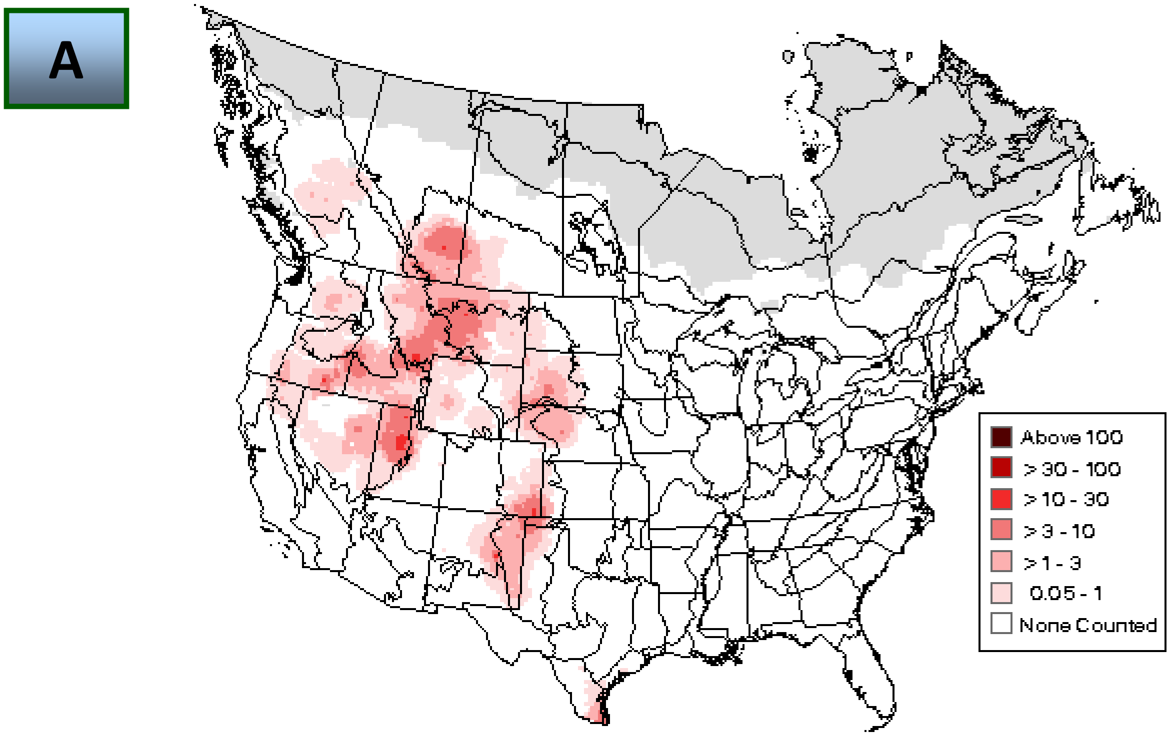


Figure 8. Distribution of long-billed curlews Dugger and Dugger 2002.



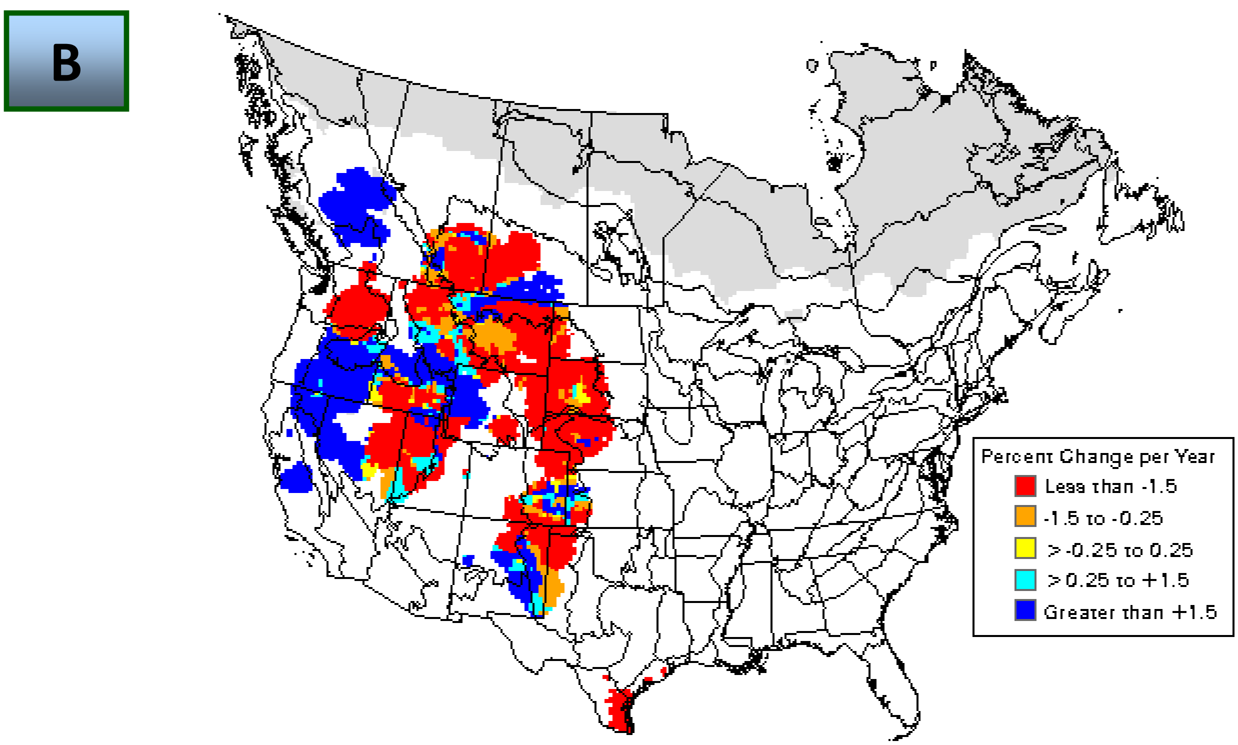


Figure 9. (A) Abundance map, and (B) population trend map for long-billed curlew Breeding Bird Survey (Sauer et al. 2012). Abundance map based on data from 2006-2011; population trend map based on data from 1966-2011.

3.2.6 Short-eared Owl

Range, population status, conservation status. Short-eared owls (*Asio flammeus*) exist throughout much of the world, including numerous islands (Wiggins et al. 2006, IUCN 2013). Although their populations are declining in many of these areas, including the United States (Table 25, Sauer et al. 2012), IUCN lists them as a species of least concern. The short-eared owl is a year-round resident in much of the LSPRB and occurs throughout the LSPRB outside the breeding season (Figure 10). Although the BBS results suggest they breed only in the northern portion of the LSPRB (Figure 11), Andrews and Righter (1992) and Boyle (1998) identified breeding records extending farther south; however, the second Colorado Breeding Bird Atlas (COBBAII 2013) shows no confirmed breeding records in the LSPRB between 2007 and 2012. BBS trends reflected this potential decline in Colorado, with a positive population trend from 1966–2010 switching to a negative trend between 1999 and 2010 (Sauer et al. 2011). With the addition of 2011 data, this trend reversed to an increase (Table 25, Sauer et al. 2012); Wiggins et al. (2006) pointed out that the BBS surveys do not adequately sample short-eared owls because their populations are prone to wide fluctuations. Nevertheless, declines have occurred throughout much of their range (Wiggins 2004, IUCN 2012).

Wetland habitats. Within the LSPRB, short-eared owls use emergent marshes, playas, and wet meadows (Table 26). Extensive grasslands may be the most important habitat, especially during the breeding season; therefore, the wetland habitats closest to large tracts of grasslands will be of highest value to short-eared owls. While many authors mention marshes as one habitat that short-eared owls occupy, very few details have been published regarding their use of marshes and other wetland habitats.

Key habitat quality variables. The key habitat variables that determine quality for short-eared owls include dominant vegetation, landscape context, residual cover, size of habitat, % vegetation cover, vegetation height, and water depth (Table 27).

Dominant vegetation. For nesting, short-eared owls rarely use wet sites (references in Wiggins et al. 2006). Short-eared owls are most often found in grasslands and areas with sparse woody vegetation (Vukovich and Ritchison 2008).

Landscape context. Short-eared owls are strongly associated with a mosaic of grasslands with relatively shorter grasses (30–60 cm) and marshes. In some areas, they commonly use agricultural fields with stubble (Goelitz 1918, Clark 1975 cited in Wiggins 2004, Dechant et al. 2001, Wiggins et al. 2006), especially during winter. Close proximity of other habitats to large grasslands with grasses < 60 cm seems to be essential (Wiggins 2004). At least in some studies, short-eared owls prefer ungrazed grasslands to grazed areas (Skinner et al. 1984 cited in Dechant et al. 2001, Wiggins 2004).

Residual cover. Duebbert and Lokemoen (1977, cited in Dechant et al. 2001) found short-eared owls nesting in residual cover 2–8 years old.

Size of habitat. Dechant et al. (2001) indicated that short-eared owls require more than 100 ha; Wiggins (2004) also suggested large grasslands are required. However, short-eared owls can also be found in much smaller parcels, suggesting that the amount of grassland in the general area may be more important than size of individual grassland tracts (Herkert et al. 1999).

% Vegetation cover. Most reports suggest that short-eared owls prefer dense grasslands, but "dense" has not been well defined (references in Dechant et al. 2001, Wiggins 2004).

Vegetation height. Holt and Leasure (1993) and Duebbert and Lokemoen (1977, both cited in Dechant et al. 2003) reported that the majority of nests were in vegetation less than 50 cm and 30–60 cm, respectively. Herkert et al. (1999), also found short-eared owl nests in vegetation less than 50 cm. Vukovich and Ritchison (2008) reported a mean of 24 cm in foraging areas; similarly, Young et al. (1988) reported grass height of 30–35 cm in grasslands used for foraging.

Water depth. Very little is published about short-eared owl water depth preference other than nest sites are dry.

Diet. The diet of short-eared owls consists almost entirely of small mammals, especially voles (*Microtus* spp., Fisher 1960, Baker and Brooks 1981, Holt 1993, Dechant et al. 2001) and in some areas mice (*Peromyscus* spp., Hendrickson and Swan 1938, Maser et al. 1970) and shrews (*Cryptotis* spp. Hogan et al. 1996). To a far lesser degree, they eat birds (Munro 1918, Errington 1937, Hughes 1982, Wiggins et al. 2006). Some investigators have found that populations of short-eared owls fluctuate with voles (Village 1987, Korpimäki 1994) or mice (Snyder and Hope 1938). Food robbing by (Bildstein and Ashby 1975) and from (Berger 1958, Korpimäki 1984) short-eared owls is common.

Ranking of habitat quality variables. The ranked importance of habitat variables for short-eared owls is summarized in Table 28.

Table 25. Adjusted population trends (2.5% CI, 97.5%CI) for short-eared owl from the Breeding Bird Survey (Sauer et al. 2012) in Colorado, the United States, and survey-wide.

Species / **Region**	**Trends** 1966–2011	**Trends** 2001–2011
Colorado [c]	3.5 (-3.6, 14.5)	0.3 (-22.2, 23.1)
BBS Central [b]	0.3 (-3.6, 3.5)	14.4 (4.9, 26.4)
United States [b]	0.0 (-3.5, 2.7)	7.1 (-0.6, 18.7)
Survey-wide [b]	-0.7 (-4.9,-1.7)	9.9 (3.2, 19.1)

[a] Indicates the data for this region have moderately precise results over time.
[b] Indicates the data for this region have some deficiencies with imprecise results over time.
[c] Indicates the data for this region has important deficiencies with very imprecise results over time.

Table 26. Seasonal importance to short-eared owl of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	Spring Ice Thaw–mid May	Summer	Fall Sept.–Ice Formation	Winter	Relative Range of Importance
Natural wetland types					
Emergent marsh	√	√	√	√	High
Playa	√	√	√		Medium
Wet meadow	√	√	√	√	Medium
Impoundments and other human created wetlands					
Irrigation-influenced wet meadow	√	√	√	√	Medium

Table 27. Quality (high, medium and low) of key habitat quality variables for short-eared owl in the Lower South Platte River Basin, Colorado.

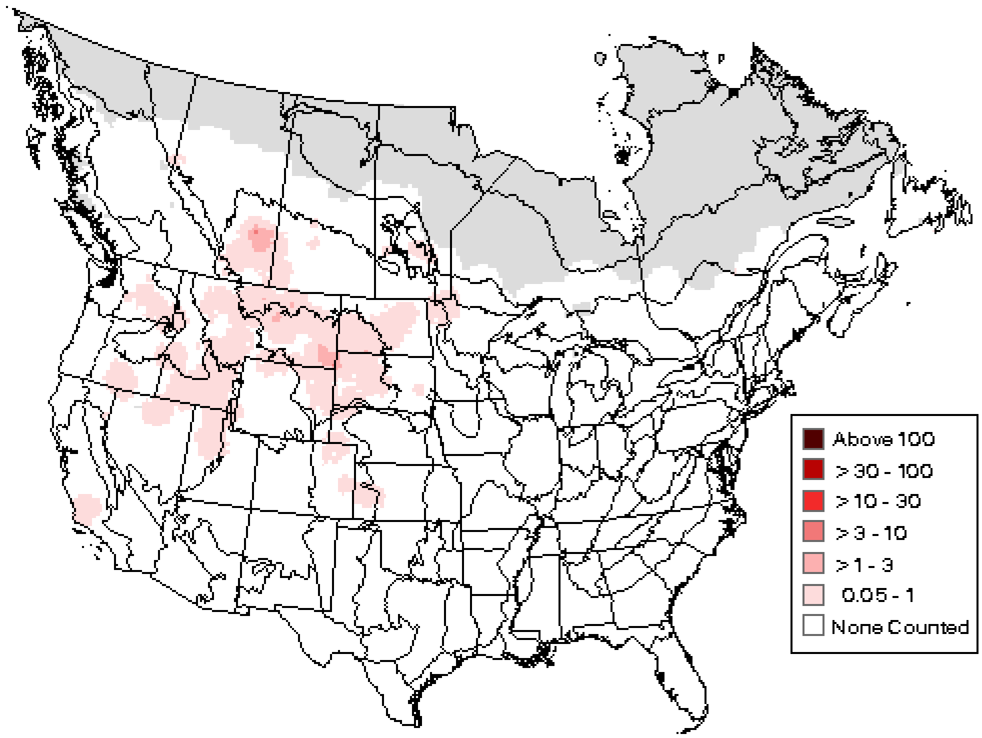
Habitat Quality Variable	Value		
	High	Medium	Low
Dominant vegetation			
	Grasses	Fields with woody vegetation	Trees (but will occasionally roost in trees)
Landscape context			
	Juxtaposition of large grasslands and wetlands; ungrazed		
% grass on the landscape within an 8-km buffer	35-70%		< 35%
% Residual cover			
For nesting	41-60%	21-40%	10-20%
Size of habitat			
	> 100 ha	50–100 ha	25-50 ha
Vegetation height			
	30–60 cm		> 60 cm
Vegetation cover			
	Close to 100%		
Water depth (cm)			
	0 cm	1-2 cm	3-20 cm

Table 28. Importance, ranking, and EPA monitoring level of key habitat quality variables for short-eared owl in the Lower South Platte River Basin, Colorado.

	Importance				EPA Level		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Vegetation height	1	√					√
Landscape context*	2	√			√		
% vegetation cover	3	√					√
Residual cover depth	4	√					√
Size of habitat	5	√			√		
Dominant vegetation	6		√			√	√
Water depth	7		√				√

Figure 10. Distribution of short-eared owls Wiggins et al. 2006.

A



B

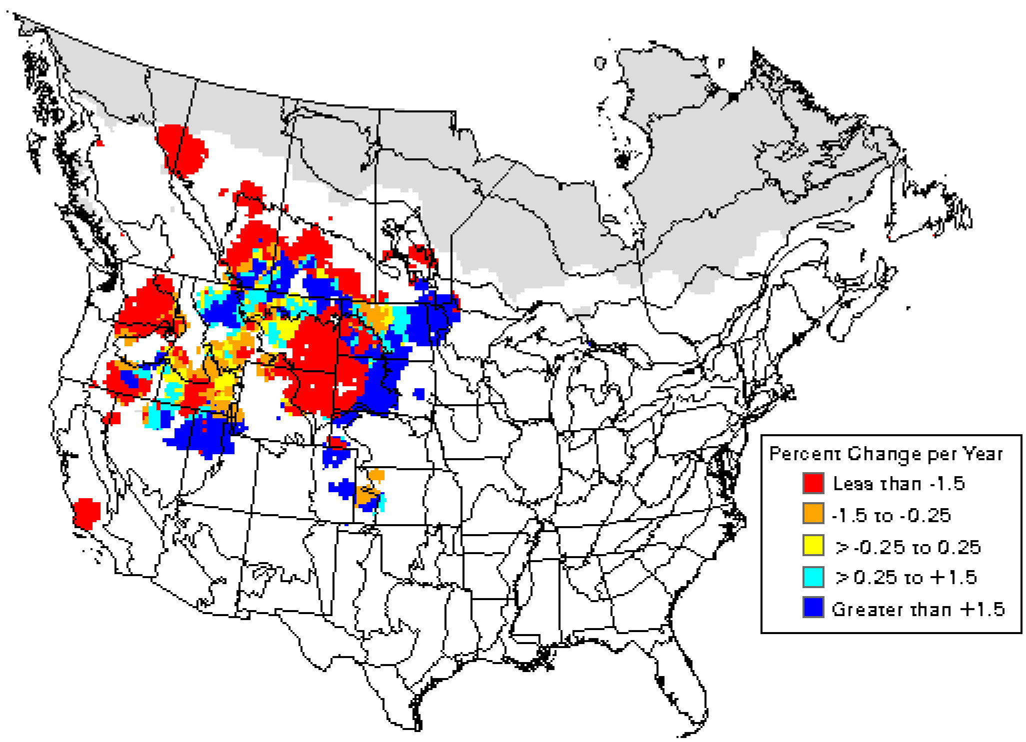


Figure 11. (A) Abundance map, and (B) population trend map for short-eared owl Breeding Bird Survey (Sauer et al. 2012). Abundance map based on data from 2006-2011; population trend map based on data from 1966-2011.

3.2.7 Frog Guild

Lynch (1978) noted that in Nebraska, northern leopard frogs (*Rana pipiens*, also *Lithobates*) occur mainly in areas with sandy soils, whereas plains leopard frogs (*Rana blairi*, also *Lithobates*) occur more frequently in loess soil areas. In general, however, their habitat needs are similar enough to combine the two species into a frog guild. Where appropriate, differences in their needs are identified.

Range, population status, conservation status.

Leopard frogs range from the northern United States and Canada as well as the more northern parts of the southwest United States (Figure 12a). They occur throughout the LSPRB (Figure 12b, NDIS 2012). Their populations are decreasing, and a petition to have them listed as threatened under the ESA (Nichols 2006) was found unwarranted by USFWS on 5 October 2011 (Federal Register 2011). IUCN (2013) lists them as a species of least concern because they are abundant, widespread, and consist of thousands of populations. Nevertheless, population declines appear to have occurred throughout their range (Clarkson and Rorabaugh 1989, Lannoo et al. 1994, Leonard et al. 1999, Kendall 2002, Germaine and Hays 2009), and they are listed in all western states and Canada as sensitive, threatened, or endangered (Germaine and Hays 2009). Both frog species are lists as Colorado species of concern. At nine sites in Larimer County where northern leopard frogs formerly bred, Corn and Fogleman (1984) found failure to breed and subsequent extinction of all these populations. In addition to habitat loss, numerous other environmental factors have been identified as agents of extermination, including (but perhaps not limited to) predation by introduced species, toxins, acid rain, parasites, pathogens, and global climate change (Clarkson and Rorabaugh 1989, Werner 2003, King et al. 2008). In regions that have been buffered from habitat loss and other disturbances (e.g., national parks), amphibians, in general, have not declined as dramatically as they have in more disturbed areas (Hossack et al. 2005).

Plains leopard frogs have a much smaller distribution than northern leopard frogs, occurring through the Great Plains (Brown and Morris 1990, Figure 13a) into southeastern Arizona (Frost and Bagnara 1977), and they are likely to occur in the eastern counties of the LSPRB (Figure 13b, NDIS 2012). Their populations are considered widespread, abundant, and secure (USDA 2003). As such, plains leopard frogs are considered a species of least concern (IUCN 2013). However, as Smith and Keinath (2005) pointed out, very little is known about population trends of plains leopard frogs, precluding meaningful information on threats to the species. Smith and Keinath (2005) assume, though, that the threats to plains leopard frogs are similar to those of northern leopard frogs.

Wetland habitats. Due to their complicated life history traits, especially their developmental patterns, frogs occupy many habitats during different seasons and stages of development, but they are closely associated with wet environments. In general, leopard frogs occupy three categories of habitat: (1) over-wintering habitat with deep water that does not freeze solid, (2) foraging habitat for adults, which may consist of uplands, riparian areas, and wet meadows, and (3) breeding habitat suitable for egg development and tadpole survival. Within the LSPRB, northern and plains leopard frogs likely inhabit most of the wetland habitats, depending on condition of the wetland and landscape context (Table 29).

Key habitat quality variables. The key habitat variables that determine quality for frogs include absence of predatory fish and bullfrogs (*Rana* [*Lithobates*] *catesbeiana*), dominant vegetation, percent emergent cover, landscape context, exposure to sunlight, size of habitat, vegetation height, water depth, and water quality (Table 30). Not all key habitat variables are applicable to all three main categories of habitat (breeding, foraging, wintering).

Absence of predatory fish and bullfrogs. Leopard frogs are usually found in ponds devoid of predatory fish and bullfrogs (Leonard et al. 1999, McAllister et al. 1999, Germaine and Hays 2009), but it is not necessarily clear whether frogs select for ponds devoid of these predators or whether the frogs/tadpoles are absent because they have been depredated. Regardless of cause and effect, the association has clear implications for management as these predators can cause local extinctions (Germaine and Hays 2009).

Dominant vegetation at breeding wetlands. Vegetation is a critical component of breeding ponds because egg masses are usually attached to emergent vegetation, such as cattails (Smith 2003, Smith and Keinath 2004), sedges and rushes (Dole 1965, Corn and Livo 1989), reed canary grass (Gilbert et al. 1994), or attached to submergent vegetation (Hine et al. 1981 cited in McAllister 1999). Very occasionally, egg masses are attached to woody vegetation, such as willow, or not attached to any vegetation (Corn and Livo 1989). Vegetation surrounding breeding ponds is important for subadult dispersal and may include grasses, sedges, rushes, and spike rushes (Corn and Fogleman 1984).

Dominant vegetation in adult foraging wetlands. Wetlands for foraging adults may consist of a variety of dominant vegetation types, including (but probably not limited to) grasses, sedges, alfalfa (McAllister et al. 1999, Germaine and Hays 2009).

Landscape context. Proximity to the three main habitat categories (breeding, over-wintering, and adult foraging habitats) appears to be one of the most important features that can predict leopard frog occupancy. While distances can be longer (e.g., 5 km, Dole 1971), 1–2 km between habitats is often noted (references in McAllister et al. 1999 and Nichols 2006, Germaine and Hays 2009). Hine (1981 cited in McAllister et al. 1999) found breeding habitat of leopard frogs by surveying all temporary ponds within 1.6 km of permanent deep-water habitat where frogs could potentially over-winter. Mushet et al. (2012) similarly suggested that deep-water over-wintering habitat in the landscape partially defined suitable habitat for frogs, and conservation programs (e.g., Conservation Reserve Program, Wetlands Reserve Program, Partners for Wildlife Program) that preserve important grassland features are important at the landscape level.

At the one-square km scale in Washington, Germaine and Hays (2009) defined sites occupied by leopard frogs as having deeper ponds with more herbaceous vegetation and fewer ponds occupied by bullfrogs and/or carp (*Cyprinus carpio*). In New York, where acid rain is relatively common, Gibbs et al. (2005) reported the most important landscape-scale variables defining occupancy as less acidic soil, lower elevations, intermediate amount of pasture land, less swamp but more marsh, and more open water. Grazing on the landscape may or may not have a negative effect, depending on the management. Knutson et al. (2004) reported a negative effect of grazing on multiple species of amphibians, including northern leopard frog; they attributed the negative effect to loss of emergent vegetation, loss of shrub and tree community surrounding ponds, and poor water quality, especially turbidity, low oxygen, and elevated nitrogen levels.

Percent vegetation cover. Very little exists in the literature regarding adequate amount of emergent cover, but Hine et al. (1981 cited in McAllister et al. 1999) suggested that leopard frogs may prefer a 67% fringe of emergent vegetation around breeding/tadpole ponds, and Germaine and Hays (2009) suggested 30–90%. Others have used more qualitative terms, such as extensive (Smith and Keinath 2004) or luxuriant (Dole 1965). Hine et al. (1981 cited in McAllister et al. 1999) suggested that submergent vegetation of about 50% would provide attachment of eggs, adequate cover for escape, and food sources for tadpoles. In adult foraging habitats, areas lacking vegetation are avoided as are heavily grazed and mowed areas (Merrell 1977, Mazerolle and Desrochers 2005, both cited in Nichols 2006). Hine et al. (1981 cited in McAllister et al. 1999) suggested that frogs prefer a gradual slope to the deepest part of breeding ponds, allowing for more emergent vegetation.

Size of habitat. The size of habitat patches that are sometimes used by leopard frogs can be as small as 0.001 ha (Dole 1965) or 0.03 ha (Corn and Fogleman 1984). Dole (1965) found that both quality and size of the habitat influenced home range size, with frogs in smaller, less suitable habitat (albeit with standing water) having smaller home ranges.

Sunlight. In general, leopard frog eggs are laid in ponds with high sunlight exposure, where the sun warms the water (Hine et al. 1981 cited in McAllister et al. 1999), or areas of a pond that are well exposed to sunlight (Gilbert et al. 1994). Exposure to sunlight also promotes algal growth, which is a major food resource for tadpoles. However, embryos of plains leopard frogs exposed to higher levels of UV-B radiation resulted in sublethal effects (Smith et al. 2000) or lethal effects (Tietge et al. 2001) at the tadpole stage.

Vegetation height in adult foraging wetlands. Adult leopard frogs seem to tolerate a range of vegetation heights in foraging areas but may avoid areas greater than 1 m (McAllister et al. 1999). Others have suggested various ranges, including 15–30 cm (Merril 1977 cited in McAllister et al. 1999).

Water depth at breeding wetlands. Water depth in breeding ponds where egg masses are laid varies greatly: less than 65 cm (Gilbert et al. 1994), less than 1.5 m (Hine et al. 1981 cited in McAllister et al. 1999), 75–100 cm (Germaine and Hays 2009), 1.5–2 m (Merril 1977 cited in McAllister et al. 1999), mean depth of 12.9 cm (Corn and Livo 1989[2]). Hine et al. (1981 cited in McAllister 1999) reported that suitable ponds maintain water most years but periodically dry up, thereby eliminating predatory fish. Germaine and Hays (2009) recommended drawdowns in late summer after metamorphosis is completed.

Water depth for winter hibernation. For hibernation, the water must be deep enough not to freeze to the bottom.

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[2] This is the mean depth taken at Sawhill Ponds, Boulder County, on the far western edge of the Lower South Platte River Basin.

Water quality. The permeability of their skin makes amphibians, in general, highly susceptible to toxins in the water (Blaustein et al. 2003). Schlichter (1981 cited in Nichols 2006) found that a pH of no less than 6.0 to be optimal for fertilization and development of leopard frog eggs, and in an experimental preference test, frogs chose a neutral pH (7.0) over 5.5 or less (Vatnick et al. 1999). Vatnick et al. (1999) found 72% mortality of frogs kept in a pH environment of 5.5 for 10 days. Leopard frogs must overwinter in well-oxygenated water, and they apparently cannot survive anoxic conditions, such as mud (Stewart et al. 2004). In overwintering habitat, leopard frogs prefer inflow areas of ponds and other water bodies where dissolved oxygen levels are higher (Smith 2003).

Diet. Adult leopard frogs primarily eat insects and other invertebrates, including crustaceans, mollusks, and worms as well as small vertebrates, such as other amphibians and snakes (references in Smith and Keinath 2005, Nichols 2006). Leopard frog tadpoles are herbivorous and considered primary consumers, eating mostly free-floating algae, but also consuming some animal material (references in Smith and Keinath 2005, Nichols 2006).

Ranking of habitat quality variables. Landscape context is the most important habitat variable, but other wetland-scale habitat variables are also critical for occupancy by leopard frogs (Table 31).

Table 29. Seasonal importance to northern and plains leopard frogs of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	**Breeding Adult and Tadpole**	**Adult Foraging (Summer and post–breeding)**	**Winter**	**Relative Range of Importance**
Natural wetland types				
Beaver pond	√	√		High
Emergent marsh	√	√		High
Playa	√	√		Medium
Riparian wetland (shrub-scrub)	√	√		Medium
Riparian wetland (herbaceous)	√	√		High
Sandbar		√		Low
Stream channel			Probably	Medium-High
Warm water slough	√	√	√	High
Wet meadow		√		High
Impoundments and other human created wetlands				
Irrigation-influenced wet meadow		√		High
Irrigation ditch		√		Low-Medium
Gravel pits	√	√	√	Low-High
Moist soil unit		√		Low-Medium
Recharge pond/Moist soil unit	√	√		Medium
Reservoir	√	√	√	Low-High
Sewage lagoon	√	√		Low-High
Stock pond	√	√		Low-High
Urban runoff ponds	√	√		Low-High

Table 30. Quality (high, medium and low) of key habitat quality variables for northern and plains leopard frogs in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	Value		
	High	Medium	Low
Absence of predatory fish and/or bullfrogs			
Breeding wetlands	Predatory fish and/or bullfrogs absent	Very few predatory fish and/or bullfrogs	Predatory fish and/or bullfrogs abundant
Dominant vegetation			
Breeding wetlands	Sedges, rushes, cattails		Dense woody vegetation
Adult foraging	Grasses and sedges		Dense woody vegetation
% emergent vegetation			
Breeding wetlands	51–90%	31-50%	10-30%
Adult foraging	30–90%		25-30% or 91-100%
Landscape context			
	All 3 habitat types within 1–2 km; space between habitat with herbaceous vegetation > 1 m; free from contaminants	All 3 habitat types within 5 km; space between partially unvegetated or with vegetation > 1 m; trace contaminants	All 3 habitat types > 5 km; space between unvegetated or with vegetation > 1 m; contaminated
% water within 8 km	> 2% other wetlands on landscape	1-2% other wetlands on landscape	< 1% other wetlands on landscape
Size of habitat			
Breeding wetlands	30–60 m diameter		
Adult foraging	Not well known		
Wintering	Large and deep enough that water does not freeze solid		
Sunlight exposure			
Breeding wetlands	Exposed enough to warm water	Mostly shaded	Fully shaded
% Total canopy cover > 2m	0-30%	31-50%	51-100%
Vegetation height			
Breeding wetlands	< 1 m	1-2 m	> 2 m
Adult foraging	15–50 cm	51–100 cm	> 1 m
Water depth			
Breeding wetlands	66–100 cm	1-2 m	10-65 cm
Adult foraging	0-10 cm	11-20 cm	21-30 cm
Wintering	> 100 cm		90-100 cm
Water quality			
Breeding wetlands	pH = 6.1-7 No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Cloudy or sheen of oil
Adult foraging	pH = 6.1-7		

Table 30, continued.

Habitat Quality Variable	Value		
	High	Medium	Low
Water quality			
Wintering	pH = 6.1-7 No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Cloudy or sheen of oil

Table 31. Importance, ranking, and EPA monitoring level of key habitat quality variables for northern and plains leopard frogs in the Lower South Platte River Basin, Colorado.

	Importance				EPA Level		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Breeding/tadpole wetlands							
Landscape context	1	√			√		
Absence of predatory fish and bullfrogs	2	√					√
Water quality	3	√					√
Water depth	4	√					√
Exposure to sunlight	5	√				√	
% emergent cover	6		√			√	√
Vegetation height	7		√				√
Size of habitat	8			√	√		
Dominant vegetation	9			√			√
Adult foraging wetlands							
Landscape context	1	√			√		
Vegetation height	2	√					√
Water depth	3	√					√
Water quality	4	√					√
% emergent cover	5		√			√	√
Dominant vegetation	6		√				√
Size of habitat	7			√	√		
Over-winter wetlands							
Landscape context	1	√			√		
Water depth	2	√					√
Water quality	3	√					√
Size of habitat	4	√			√		

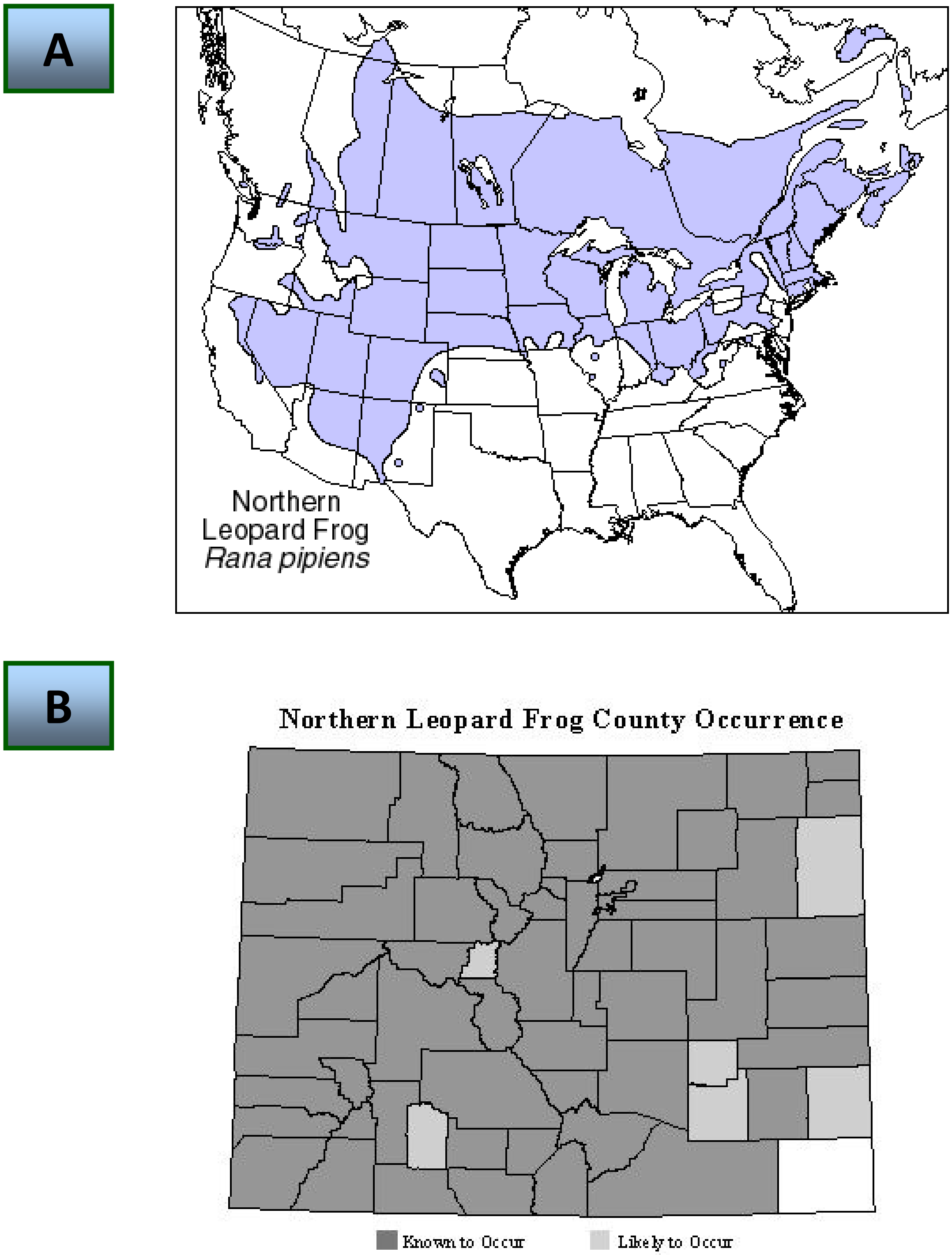

Figure 12. **Distribution of northern leopard frog**
(A) in the United States and Canada (from Idaho Herps 2008) and (B) in Colorado (from NDIS 2012).

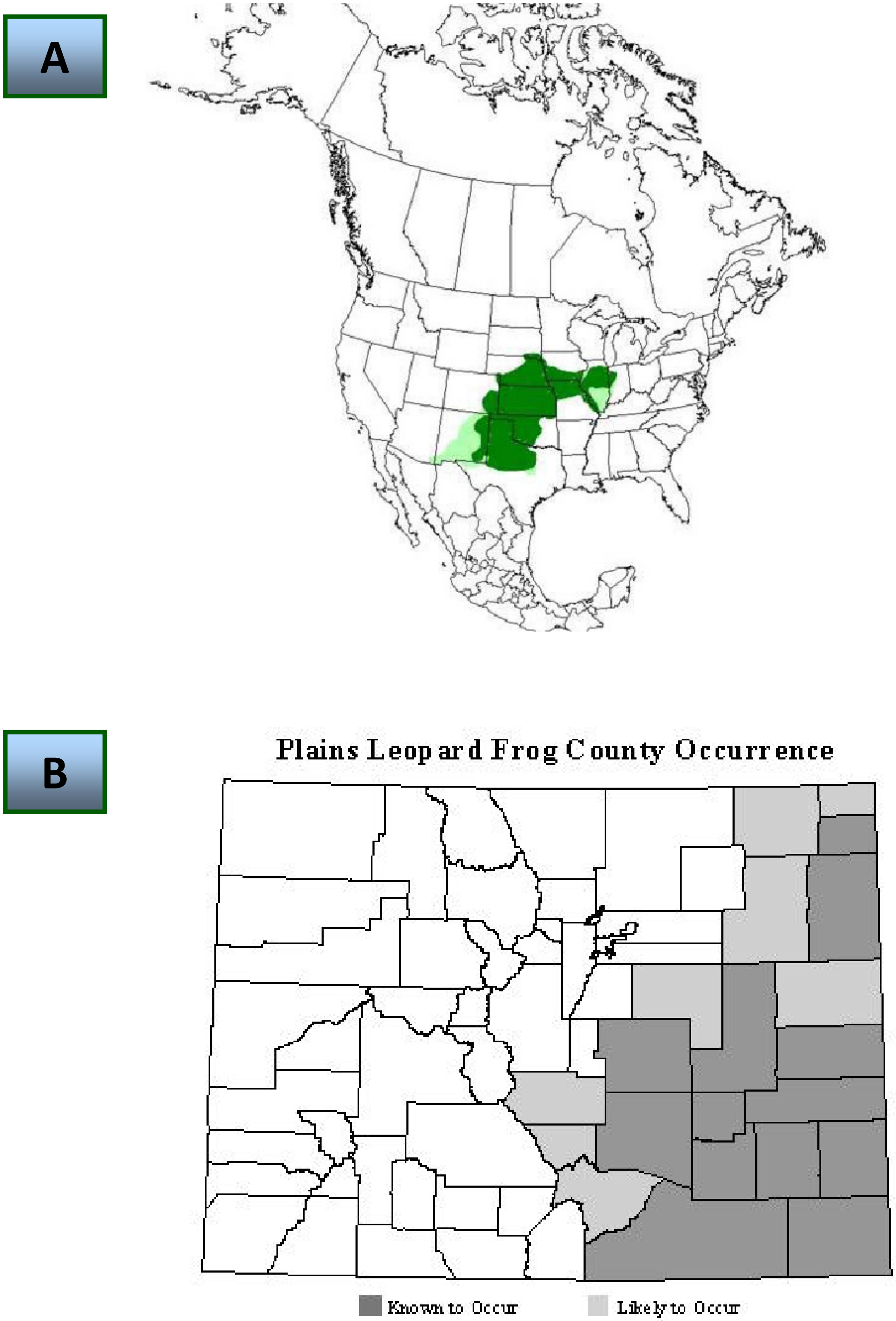

Figure 13. Distribution of plains leopard frog (A) in the United States and Canada (from Smith and Keinath 2005) and (B) in Colorado (from NDIS 2012).

3.2.8 Red-sided Garter Snake

Range, population status, conservation status. The red-sided garter snake (*Thamnophis sirtalis parietalis*), also called the common garter snake (T. Jackson, pers. comm.),[3] is found in Canada and the western United States, with a disjunct distribution in the western United States (Figure 14a). In Colorado, they are found throughout much of the LSPRB (Figure 14b) and are a species of concern. The abundance of red-sided garter snakes is mostly unknown (WGFD 2010b). Population declines of other garter snakes, such as *Thamnophis elegans*, which consume mostly amphibians, have apparently been tied to amphibian declines (Matthews et al. 2002). Because the red-sided garter snake eats primarily amphibians (Kephart 1982), it is possible that, likewise, populations of red-sided garter snakes are associated with populations of amphibians.

Wetland habitats. Garter snakes hibernate during the winter, up to seven or eight months in the more northern parts of their range (Aleksiuk 1976, Garstka et al. 1982, O'Donnell et al. 2004). While they are active, they are wetland-dependent, occupying most of the wetland habitats within the LSPRB (Table 32).

Key habitat quality variables. Surprisingly little information is available in the literature on habitat preferences of red-sided garter snakes. Therefore, much of the information contained herein was obtained by Tina Jackson, Herpetologist for Colorado Parks and Wildlife, who confirmed the paucity of information. This information is summarized in Table 33.

Ranking of habitat quality variables. The ranked importance of habitat variables for red-sided garter snakes is summarized in Table 34.

[3] The taxonomy of garter snakes and separation into subspecies based on color has been questioned because of the wide variety of color morphs in single localities (Mooi et al. 2011).

Table 32. Seasonal importance to red-sided (common) garter snakes of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	Spring Ice Thaw–mid May	Summer	Fall Sept.–Ice Formation	Winter	Relative Range of Importance
Natural wetland types					
Beaver pond	√	√	√	Absent	High
Emergent marsh	√	√	√	Absent	High
Playa	√	√	√	Absent	Low-High
Riparian wetland (shrub-scrub)	√	√	√	Absent	Med-High
Riparian wetland (herbaceous)	√	√	√	Absent	High
Sandbar	√	√	√	Absent	Low
Warm water slough	√	√	√	Absent	High
Wet meadow	√	√	√	Absent	High
Impoundments and other human created wetlands					
Irrigation-influenced wet meadow	√	√	√	Absent	High
Irrigation ditch	√	√	√	Absent	Low-Med
Gravel pits	√	√	√	Absent	Low
Moist soil unit	√	√	√	Absent	Low-Med
Recharge pond/Moist soil unit	√	√	√	Absent	Med-High
Reservoir	√	√	√	Absent	Low
Sewage lagoon	√	√	√	Absent	Low-High
Stock pond	√	√	√	Absent	Low-High
Urban runoff ponds	√	√	√	Absent	Low-High

Table 33. Quality (high, medium and low) of key habitat quality variables for red-sided (common) garter snakes in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	Value		
	High	Medium	Low
Dominant vegetation			
	Emergents-sedges-grasses- anything that provides cover		
% emergent cover			
	61-100%	41-60%	20-40%
Interspersion			
	< 1:1		
Landscape context			
	Close connection between upland hibernacula and wetlands		Landscape fragmented by unsuitable habitat
Size of habitat			
	Larger is better		
Water quality			
	pH = 6.1-7 No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Cloudy or sheen of oil

Table 34. Importance, ranking, and EPA monitoring level of key habitat quality variables for red-sided (common) garter snakes in the Lower South Platte River Basin, Colorado.

	Importance				EPA Level		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
% emergent cover	1	√					√
Landscape context	2	√			√		
Interspersion	3		√			√	√
Size of habitat	4		√		√		
Water quality	5		√				
Dominant vegetation	6			√		√	√

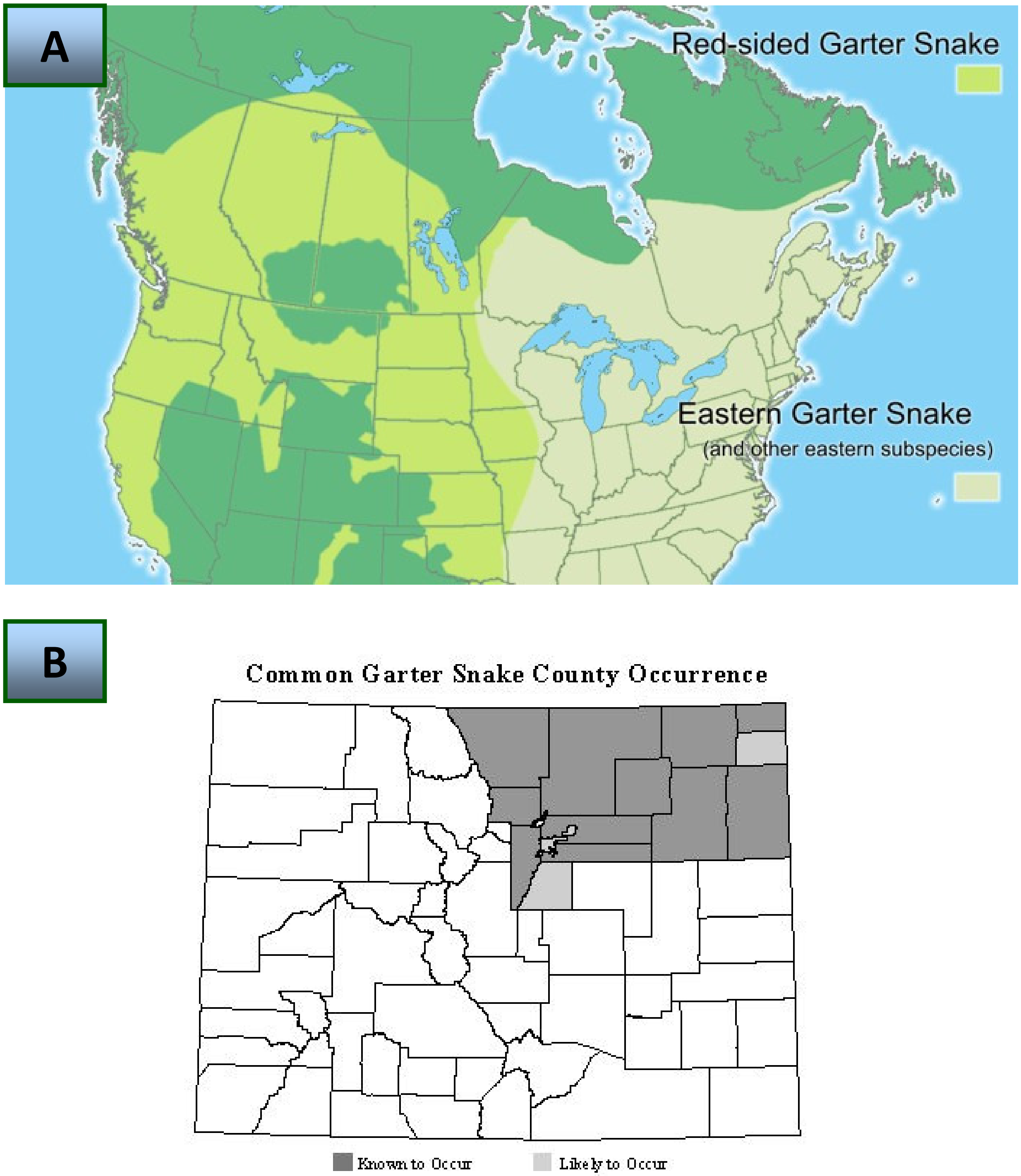

Figure 14. Distribution of red-sided (common) garter snake (A) in the United States and Canada (from Manitoba Herps Atlas 2012) and (B) in Colorado (from NDIS 2012).

3.2.9 Fish Guild

Range, population status, conservation status. The distribution of northern redbelly dace (*Phoxinus eos*) extends across the northern states from Montana to Maine and in Canada from British Columbia through Nova Scotia (Figure 15). Within Colorado, they occur almost entirely in the LSPRB (Figure 15) only in the West Plum Creek area (Nesler et al. 1997), where perhaps they have never been common (Propst and Carlson 1986). The northern redbelly dace is listed as endangered in Massachusetts (MDFW 2008), a species of concern in Montana (MNHP and MFWP 2012b), and threatened in Nebraska (AGC 2007) and South Dakota (SDGFP 2012). It is a state endangered species in Colorado (CPW 2012).

The distribution of brassy minnows (*Hybognathus hankinsoni*) extends across the northern states from Montana to western Vermont and Massachusetts and in Canada from several disjunct locations in the west to Quebec (Figure 16). The LSPRB consists of the main extent of its range in Colorado (Figure 16), except where it has been introduced into the Colorado River (Fuller and Neilson 2012). Propst and Carlson (1986) stated that brassy minnows were historically more common, and Scheurer and Fausch (2002) suggested they have declined since the 1970s. The brassy minnow is a state threatened species (CPW 2012); it is listed as vulnerable in Wyoming (WGFD 2010a) and a "potential" species of concern in Montana (MNHP and MFWP 2012a).

Wetland habitats. The wetland habitats, in addition to stream channels, that northern redbelly dace and brassy minnow occupy within the LSPRB include beaver ponds and warm water sloughs (Table 35). Additionally, brassy minnows are found in irrigation ditches.

Key habitat quality variables. The most important wetland habitat variables to the dace and minnow include dominant vegetation, landscape context, size of habitat, substrate, water depth, and water quality (Table 36).

Dominant vegetation. Northern redbelly dace inhabit areas with emergent vegetation along shorelines, and they use algal mats for spawning (Nesler et al. 1997). Stasiak (2006) found them strongly associated with abundant vegetation and woody debris, and Quist et al. (2005) found submergent vegetation to be the most important predictor for presence of brassy minnow. Similarly, brassy minnows use waters with aquatic vegetation.

Landscape context. Stasiak (2006) mentioned that a critical habitat component for northern redbelly dace is the absence of large predatory fish. The general absence of piscivorous species in beaver ponds may partly explain the dace's strong preference for beaver ponds (Schlosser and Kallemeyn 2000, Stasiak 2006). Brassy minnow persistence is very much tied to deeper pools connected with other habitats (Scheurer and Faushe 2002, Scheurer et al. 2003).

Size of habitat. Northern redbelly dace are found in off-channel habitats only within the West Plum Creek area; size varied greatly from 0.0025-0.1 ha, but all with connections to either West Plum Creek or Garber Creek (Bestgen 1989). Brassy minnows are usually found in smaller tributaries and irrigation ditches (Nesler et al. 1997).

Substrate. Northern redbelly dace prefer silt or sand substrate (Bestgen 1989), whereas brassy minnows prefer a courser gravel substrate (Nesler et al. 1997). However, Propst and Carlson (1986) mentioned that northern redbelly dace inhabit gravel-bottomed waters.

Water depth. Bestgen (1989) reported a northern redbelly dace preference of 0.25–1.3 m water depth; where they inhabited deeper ponds (> 3 m), they tended to congregate in the shallower water near shore. Scheurer et al. (2003) found that for brassy minnows, adequate pool depth varied with position on the landscape, with a water depth of 0.5 m being adequate for minnow persistence in upstream segments, but in lower reaches, minnows have only a 50% probability of persistence in pools with 0.5 m water. Pools with water depths greater than 40 cm are less likely to dry and freeze (Scheurer et al. 2003).

Water quality. Northern redbelly dace prefer clear, cool, slow-moving, well-oxygenated water (Bestgen 1989, Stasiak 2006). Brassy minnows also prefer cool, slow-moving waters and pools. Bestgen (1989) found water < 22°C in all occupied habitats, but some of the areas were thermally stratified and ranged from 18–27°C. Similarly, Stasiak (2006) reported a preference of 21–26°C.

Diet. Northern redbelly dace are omnivorous, feeding on vegetation and small invertebrates throughout the water column (Stasiak 2006). Bestgen (1989) found detritus most important. Brassy minnows are herbivorous scrapers, foraging heavily on algae (Cornell University 2012) and also diatoms (MNNP and MFWP 2012b).

Ranking of habitat quality variables. The ranked importance of habitat variables for the northern redbelly dace and brassy minnow is summarized in Table 37.

Table 35. Seasonal importance to northern redbelly dace and brassy minnow of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	**Spring Ice Thaw–mid May**	**Summer**	**Fall Sept.–Ice Formation**	**Winter**	**Relative Range of Importance**
Natural wetland types					
Beaver pond	√	√	√	√	High
Stream channel	√	√	√	√	High
Warm water slough	√	√	√	√	Low-medium
Impoundments and other human created wetlands					
Irrigation ditch (brassy minnow)		√			High

Table 36. Quality (high, medium and low) of key habitat quality variables for redbelly dace and brassy minnow in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	**Value**		
	High	**Medium**	**Low**
Predatory fish			
	Absence	Present in very low numbers	Present
Dominant vegetation			
	Algae, algal mats, submergents/emergents		
Landscape context			
	Pools connected to other habitats		
Size of habitat			
	25–1,000 m^2		
Substrate			
	Sand for dace Gravel for minnow		
Water depth (cm)			
	51-150 cm	41-50 cm	
Water quality			
	No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Cloudy or sheen of oil

Table 37. Importance, ranking, and EPA monitoring level of key habitat quality variables for redbelly dace and brassy minnow in the Lower South Platte River Basin, Colorado.

	Importance				**EPA Level**		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Predatory fish absent	1	√					√
Landscape context	2	√			√		
Water depth	3	√					√
Dominant vegetation	4	√				√	√
Water quality	5	√					√
Substrate	6	√					√
Size of habitat	7			√	√		

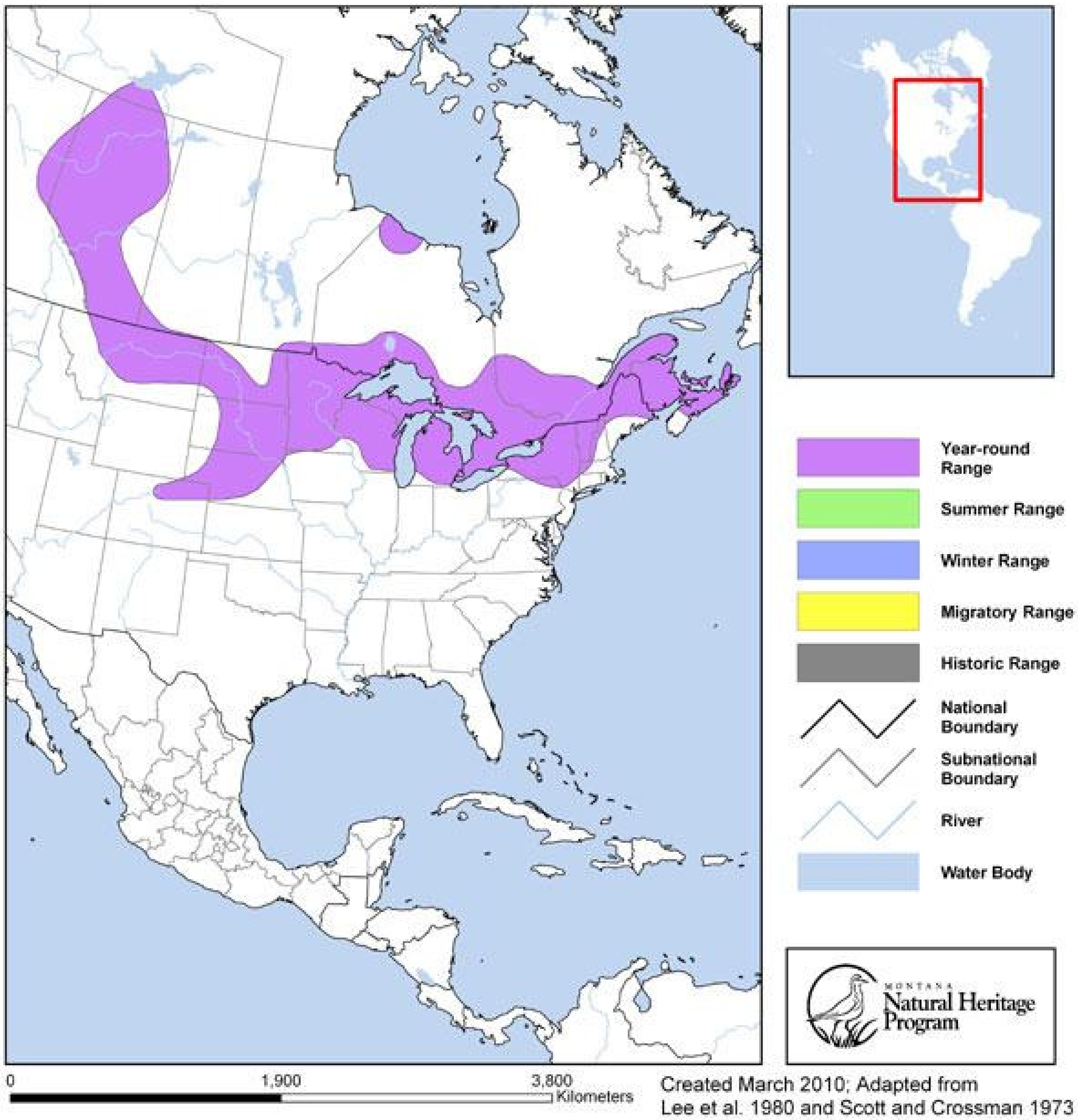

Figure 15. Distribution of northern redbelly dace from MNHP and MFWP (2012b).

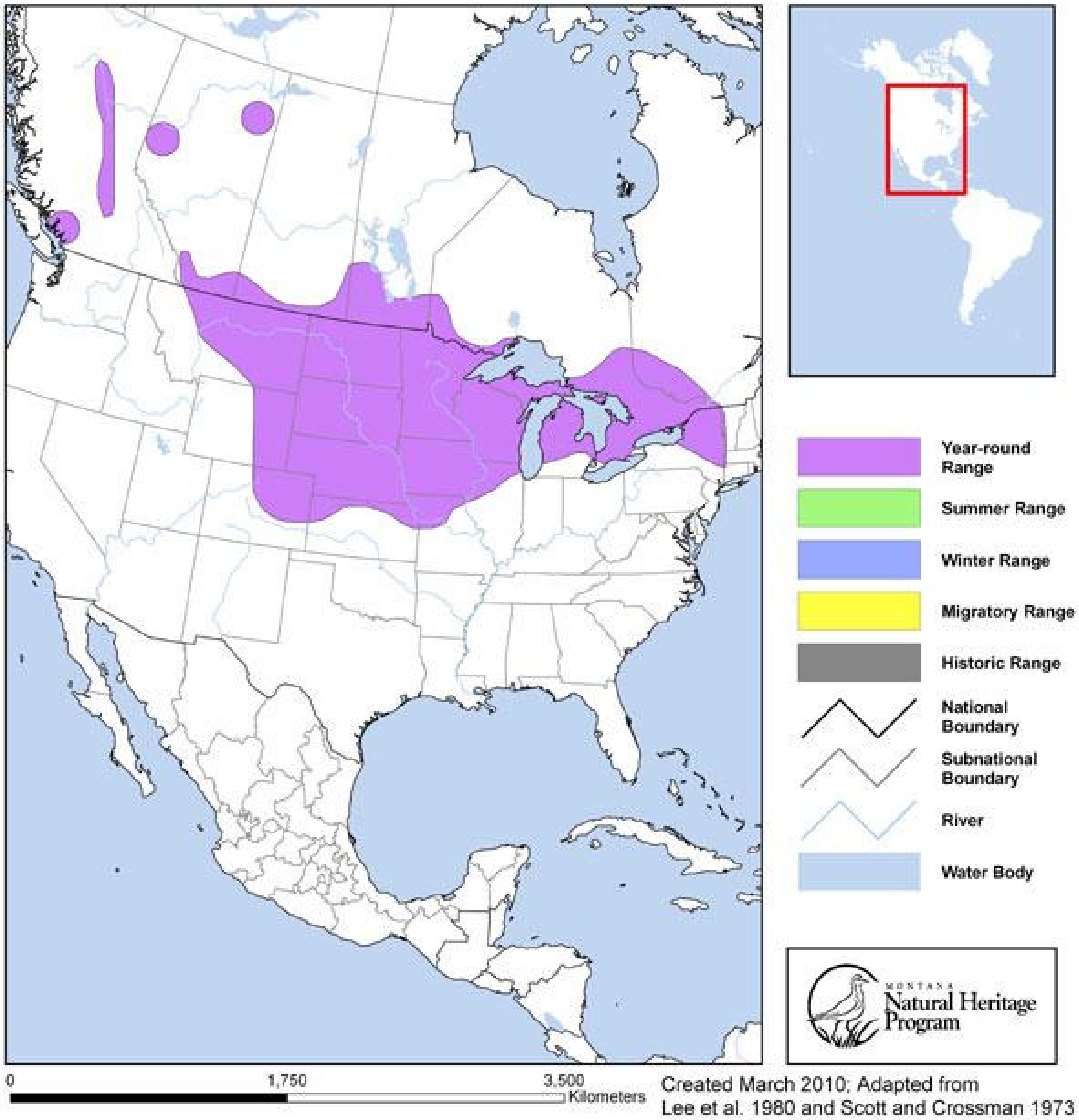

Figure 16. Distribution of brassy minnow from MNHP and MFWP (2012a).

3.2.10 River Otter

Range, population status, conservation status. Northern river otters (*Lontra canadensis*) historically ranged throughout most of the United States and Canada but were extirpated from much of their range in the west, including Colorado (CDOW 2003, Figure 17a). Reintroductions of otter to Colorado began in 1976, and they are now found in small numbers throughout most of western Colorado with a more spotty distribution in eastern Colorado (Figure 17b). They are listed as threatened in Colorado (CPW 2012) and as least concern by IUCN (Sefass and Polechla 2008).

Wetland habitats. Boyle (2006) stated that range-wide, river otters inhabit nearly every aquatic habitat. In the LSPRB, river otters are most likely to occupy beaver ponds, stream channels, and warm water sloughs (Table 38).

Key habitat quality variables. Key variables that determine habitat quality for river otters include landscape context, riparian vegetation, shore complexity, stream order/gradient, stream size, structures and debris, and water depth (Table 39).

Landscape context. Gorman et al. (2006b) reported on average, otter dens were 316 m from and 61 m higher than the closest water. Ostroff (2001 cited in Jeffress et al. 2011) found that otter occupancy was positively associated with the number of wetlands with 300 m of shoreline and the percent of wooded riparian area.

Riparian vegetation. Healthy riparian vegetation provides important cover for otters when moving on land; it also contributes to stream integrity and reduces soil erosion. Larger trees, particularly those that obscure the visual field are preferred (Crowley et al. 2012). Similarly, Jeffress et al. (2011) found that otter occupancy increased with woodland cover. Otters, at least in some populations, seem to select conifers, especially in conjunction with latrine sites (Newman and Griffin 1994, Swimley et al. 1998, Crait and Ben-David 2006, Crowley et al. 2012).

Shore complexity. In general, the greater the shore complexity of ponds and streams, the more likely shallow waters will provide habitat for fish and other prey items (Dubuc et al. 1990, Boyle 2006). Contrarily, Jeffress et al. (2011) found decreased otter occupancy with increased shoreline diversity; however, this finding may have been influenced by large reservoirs in their study area.

Stream order/gradient. Otters seem to prefer lower gradients and higher stream meandering (Melquist and Hornocker 1983, Boyle 2006). Jeffress et al. (2011) also found a strong association between otter occupancy and stream order.

Stream size. River otters prefer long stretches of stream (Dubuc et al. 1990, Boyle 2006).

Structures and debris. Habitat structure complexity is preferred by otters for denning, resting, latrines, and scent-marking. Structures contribute to complexity and can be provided by log jams, stumps and other woody debris, living trees, undercut banks, and rocks. Beaver (*Castor canadensis*) provide many of the woody structures preferred by otter; thus, river otters are often associated with beaver activity (Melquist and Hornocker 1983, Dubuc et al. 1990, Gorman et al. 2006a, Depue and Ben-David 2010). Structures close to water provide opportunities to scent mark, which is critical for their olfactory communication. These structures also provide latrine sites for otter (Newman and Griffin 1994, Swimley et al. 1998, Crait and Ben-David 2006).

Water depth. Otters prefer a diversity of water depths, from deep pools to shallower shores (Boyle 2006, Depue and Ben-David 2010). Latrine sites are associated with adjacent deep water (Swimley et al. 1998).

Diet. Throughout their range, fish comprise the majority of otters' diets; therefore, habitat suitability for otters necessarily includes habitat suitability for fish (Melquist and Hornocker 1983, Crait and Ben-David 2006, Guertin et al. 2010, Crowley et al. 2012). Otters also consume crayfish, mollusks, frogs, snakes, turtles, salamanders, birds, mammals, and fruit (Melquist and Hornocker 1983, Boyle 2006).

Ranking of habitat quality variables. Habitat quality variable are ranked in Table 40.

Table 38. Seasonal importance to river otter of wetland habitats in the Lower South Platte River Basin, Colorado.

Wetland Habitat	**Spring Ice Thaw–mid May**	**Summer**	**Fall Sept.–Ice Formation**	**Winter**	**Relative Range of Importance**
Natural wetland types					
Beaver pond	√	√	√	√	High
Stream channel	√	√	√	√	High
Warm water slough	√	√	√	√	High

Table 39. Quality (high, medium and low) of key habitat quality variables for river otter in the Lower South Platte River Basin, Colorado.

Habitat Quality Variable	Value		
	High	**Medium**	**Low**
Landscape context			
	Near beaver activity & connected with tributaries		Disconnected without beavers
Riparian vegetation			
% Total canopy cover > 2 m	51-100%	31-50%	20-30%
Height of canopy cover > 2 m	> 15 m	5-15 m	0.5-5 m
Shore complexity			
	Diverse and complex; undercut banks		
Stream order			
	> 4th order		< 4th order
Stream size			
	Longer is better; wide		narrow
Structures and debris			
	Log jams and/or beaver activity		
Water depth			
% water > 20 cm	91-100%	81-90%	40-80%

Table 40. Importance, ranking, and EPA monitoring level of key habitat quality variables for river otter in the Lower South Platte River Basin, Colorado.

		Importance			EPA Level		
Habitat Variable	**Rank No.**	**High**	**Medium**	**Low**	**1**	**2**	**3**
Landscape context	1	√			√	√	
Structures and debris	2	√					√
Riparian vegetation	3	√				√	√
Shore complexity	4	√					√
Stream size	5		√		√		
Banks	6		√				√
Stream order	7		√		√		
Water depth	8		√		√		

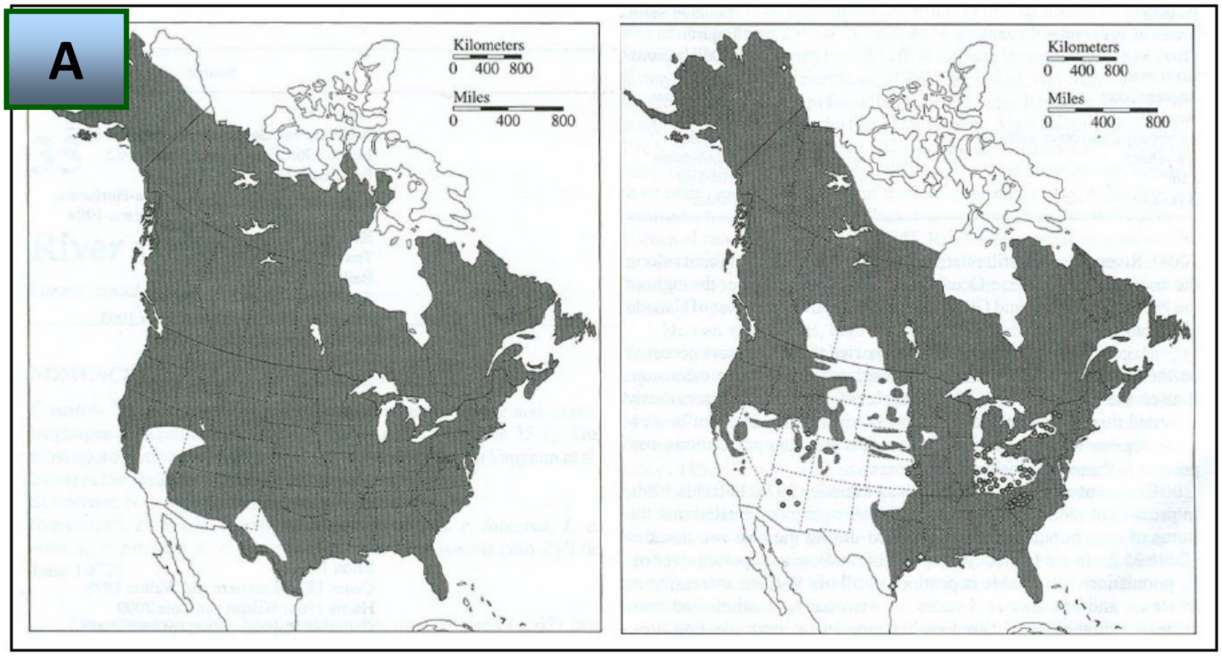

Figure 2. Historical (left) and current (right) distributions of the North American river otter. On the current distribution map, circles represent reintroduction sites. Reprinted from Melquist et al. (2003).

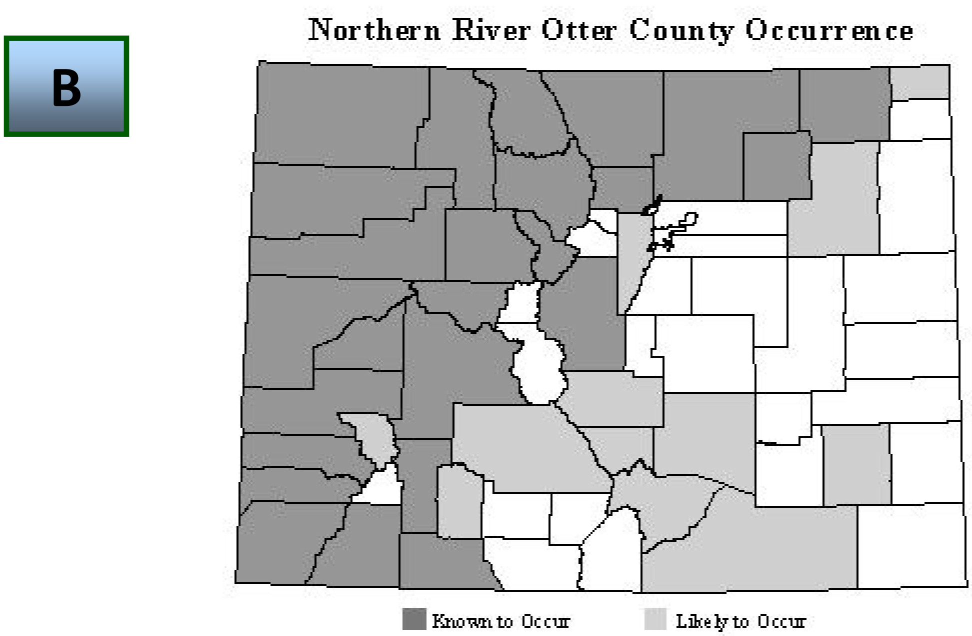

Figure 17. Distribution of river otter
(A) in the United States and Canada (Boyle 2006) and (B) in Colorado (from NDIS 2012).

3.3 Metric Protocols

3.3.1 Key Habitat Quality Variables

Not including food resources, 21 key habitat variables have been identified as either high or medium importance to the 18 priority species under consideration (Table 41). Seven of the 21 variables are important to only to the piping plover or the river otter.

Table 41. Ranked importance of key habitat variables according to the number of CPW priority wetland-dependent species that depend on each feature.

Habitat variable	Number of species with variable as moderate to high importance
Landscape context	18
Size of habitat	16
Water depth	15
Dominant vegetation type	14
Emergent cover (%)	13
Invertebrates	7
Dominant vegetation height	5
Absence of pred. fish/bullfrogs	4
Water quality*	4
Interspersion	2
Residual cover	2
Substrate	2
Sunlight exposure	2
Vegetation density	2
Open sand/gravel	1
Proximity to objects	1
Riparian vegetation (large trees)	1
Shore complexity	1
Stream banks steep	1
Stream order	1
Structures and debris	1

*Number of species directly affected. This does not take into account indirect effects, which may be applicable to other priority species.

3.3.2 Sampling Framework

Most of the key habitat variables can be measured within the existing sample framework used by CNHP. CNHP will use the 10 × 10 m plot configurations suggested by EPA (2011, Figure 18); therefore, all key habitat features that require sampling at plots or along transects should be measured using this sample design.

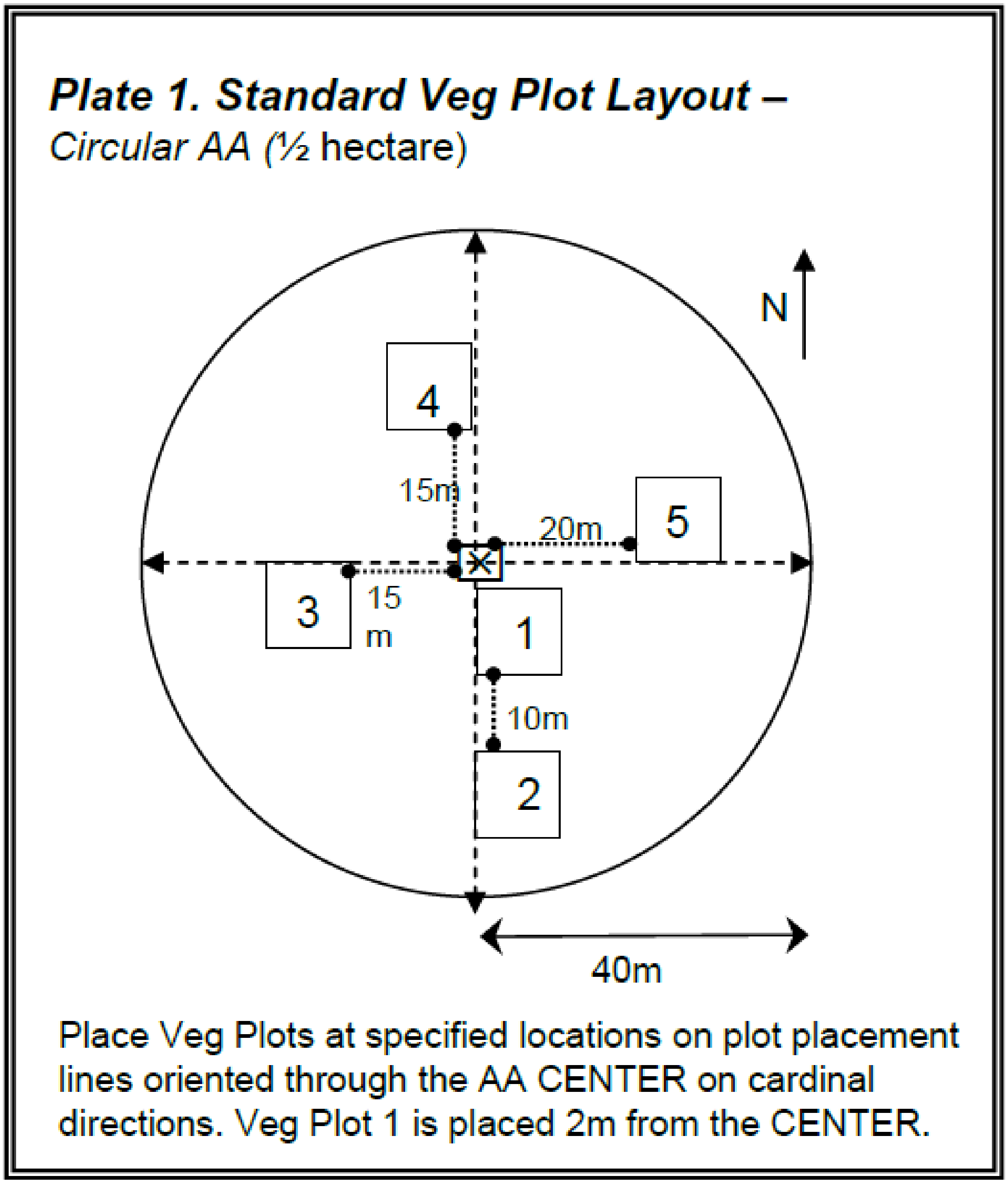

Figure 18. Diagram of one example sampling design adopted by CNHP (from EPA 2011).

3.3.3 Field Protocols for Key Habitat Quality Variables

Many of the habitat quality variables can be assessed at more than one level, depending on the depth of information needed as well as resolution and seasonal timing of aerial photography (Table 42 with more details in Appendix IV). For example, identification of dominant vegetation type can usually be accomplished with rapid assessment. However, in cases where identification to the species level is desired, evaluation of plants, flowers, or seeds in a lab may be required. Percent emergence and interspersion patterns can be assessed at all three levels, depending on resolution of aerial imagery for level 1 and/or confidence in estimations for level 2; in cases where levels 1 and 2 assessments are not adequate, a level 3 assessment may be required.

The information in Table 42 and Appendix IV provided a starting point for discussions on how to most efficiently incorporate important habitat variables for the priority wildlife species into the existing CNHP field protocol. The table and appendix are provided in this final report to document the process, not the final outcome; they have not been altered since they were provided to CNHP as required products in spring, 2011. The final field protocol, resulting from this process, is in the CNHP Final Report.

3.4 Management Practices

Prior to human settlement, particularly European settlement, fire, grazing by native ungulates, and natural climate events were the major forces that set back the natural succession of wetlands (Kantrud 1986). With fire suppression, relatively more continuous grazing, and anthropogenic global climate change, the more natural forces that once shaped conditions of wetlands have been altered. In the absence of forces interrupting natural ecological processes, wetlands tend to progress toward monotypic dense stands of hydrophytes.

Wetland managers have often relied on human-employed mechanical means of setting back succession in order to achieve the desired conditions of wetlands. This requires an adaptive management approach, which requires both a toolbox of management options and monitoring and evaluation to assess whether the actions result in the desired outcome. Recommended management practices that can be used for modifying or maintaining habitat conditions are provided in Appendix V.

Table 42. Summary of protocol recommendations. Protocols for measuring food resources are in Appendix IV.

			EPA Level		
Key Habitat Feature	**Scale of information**	**Recommendations**	**1**	**2**	**3**
Landscape context and land use	1.5, 3, and 8 km from wetland	Buffers should be constructed around wetlands in GIS at 1.5, 3, and 8 km; determine other wetlands, (number, size, type, connectivity), proximity to agriculture, adjacent land use, land ownership.	√	NA	NA
Size of habitat	Entire wetland area	Size of the wetland can be determined by using GIS polygonal measuring tools. If questionable, the size of the wetland obtained in GIS can be verified by walking around the perimeter with GIS tracks on save mode. For larger wetlands, distances across the wetland should be measured with a range finder at angles determined by a compass.	√	√	NA
Water depth	Vegetation plot	If the land manager cannot provide water depth information, water depth should be determined with a measuring stick at vegetation plots, using plots recommended by EPA (2011).	NA	√	√
Dominant vegetation	Vegetation plot	The plant community should be determined by methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011).	NA	√	√
% Emergent (or vegetative) cover	Entire wetland area	If good aerial photography is available, Level 1 would be the most ideal method because it involves quantifying rather than estimates. The Level 2 methods of CNHP will provide adequate information to access the value to wildlife. This includes estimating cover of shallow water (< 20 cm) and cover of deeper water (20–100 cm).	√	√	√
Vegetation height	Vegetation plot	Vegetation height should be estimated and placed size classes according methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011).	NA	√	√
Water quality	Vegetation plot	pH, conductivity, and temperature should be measured in the middle of the water column, using plots recommended by EPA (2011).	NA	√	NA
Interspersion patterns	Entire wetland area	Patterns of complexity should follow the CNHP protocol (Figure 2), using the best fit of diagrams or other descriptions at the wetland level, such as • Fringe (vegetation around the perimeter of the wetland with central open water) • Partially interspersed (few patches of vegetation in central portion) • Complex (vegetation interspersed in many patches) • Closed (few to no areas of open water)	√	√	√

Residual cover depth	Vegetation plot	Residual cover should be determined with a measuring stick according to methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011).	NA	NA	√
Shade/sun (light interception)	Vegetation plot or Assessment Area	Canopy, as a measure of light interception, should be measured directly with a densiometer at plots, using the sampling plot design recommended by EPA (2011). Alternatively, it can be estimated at the Assessment Area level.	NA	√	NA
% open sand or gravel area on sandbar	NA	Percent open sand or gravel area on sandbars should be measured using GIS tools; alternatively it can be determined using the same methods as percent cover (see Appendix 1).	√	NA	NA
Riparian vegetation (woody)	Assessment Area	Presence of woody vegetation should be measured according to CNHP methods: 1. Dominant canopy trees (> 5 m and > 30% cover) 2. Sub-canopy trees (> 5m but < dominant canopy height) or trees with sparse cover 3. Tall shrubs or older tree saplings (2–5 m) 4. Short shrubs or young tree saplings (0.5–2 m)	NA	√	√
Structures and debris	Entire wetland area	Presence or absence of beaver structures, log jams, and debris jams should be noted according to CNHP protocols.	NA	√	NA
Shore complexity	Assessment Area	Presence or absence of backwater sloughs and other features that increase shoreline should be noted according to CNHP protocol.	√	√	NA
Stream banks	Assessment Area	Presence or absence of undercut banks should be noted according to CNHP protocol.	NA	√	NA
Stream length	NA	Stream length should be measured with GIS tools.	√	NA	NA
Stream order	Entire wetland area	Stream order can be determined from maps detailed enough to show all tributaries.	√	NA	NA
Stream width	Entire wetland area	Stream width at bankful should be estimated according to CNHP protocol	√	√	NA

4.0 DISCUSSION

Overall, the area of NWI wetlands represents 3% of the total land in the LSPRB. The number of wetland habitats used by the priority species varied from 1–18, and the area potentially available to the priority species ranged from as little as 1,444 ha (3,567 acres) for the piping plover to 102,612 ha (253,560 acres) for the dabbling duck and frog guilds (Table 43). These figures only approximate the total area of wetlands that represent the habitats known to be used. These figures also suggest nothing about the importance or the condition of the wetlands and whether they are, in reality, occupied by the priority species. Therefore, these area figures are likely an over-estimate of functionally available habitat.

Landscape context is of high importance to all 18 priority species and is, therefore, the most important variable, followed by size of habitat, water depth, dominant vegetation type, and percent of emergent cover (Table 44). Landscape context is important to all the priority species for various reasons, including (1) species requiring several wetland conditions during different life cycles (e.g., frogs and snakes), (2) species requiring several wetland conditions for nocturnal and diurnal activities (dabbling ducks, sandhill cranes, and long-billed curlews), (3) the land use surrounding a wetland has a direct or indirect effect on water quality (affects frogs, fish, and American bittern), and (4) the landscape context affects connectivity of water (affects fish and river otter). Additionally, proximity of other wetlands affects dispersal by waterfowl of wetland plant seeds (Mueller and van der Valk 2002) and other organisms (Charalambidou and Santamaría 2005) that are important prey items. For example, Brusati et al. (2001) found that wetlands created for mitigation purposes had higher recruitment of benthos invertebrates if the wetland was close to other natural wetlands. Naugle et al. (2001) recommended conservation of wetlands on the landscape to both preserve connectivity among wetlands and strengthen the value of habitat in core-protected areas.

The priority species addressed in this report represent only a small proportion of wildlife species that actually use wetland habitat in the LSPRB, and their needs vary. In many cases, the preferred conditions of key habitat variables overlap; in other cases, there is very little overlap. In other words, unless a wetland is very extensive with myriad habitats and habitat conditions, it is unlikely to support all the priority species. Furthermore, some of the priority species are so specialized (e.g., fish, river otter, and piping plover) that they occupy only one or a few habitats that are not occupied by some of the other priority species.

Some investigators have suggested that effective management for a target species or a target guild can benefit other non-target species. When this situation occurs, the target species or guild can be used as a surrogate to predict the effects on other species and, therefore, can be useful for conservation efforts (Noss 1990). Ducks, as flagship species, have often been used to enhance and protect wetland habitat and have been promoted as surrogates for other species, which requires the assumption that what is good for ducks is necessarily good for other species. Many investigators have questioned these assumptions and value of this approach (Simberloff 1998, Lindenmayer et al. 2002). For example, Koper and Schmiegelow (2006) found in Alberta, Canada, ducks could not be used as effective surrogate species for either songbirds or shorebirds because they found no responses to habitat variables that were consistently similar among groups. Koper and Schmiegelow (2006), therefore, emphasized that these assumptions must be validated. However, the groups of species they compared are not ecologically similar. The priority species in this report also diverge ecologically, and the species most ecologically similar were already lumped into guilds (e.g., ducks, frogs, and fish). To illustrate this point and for convenience of looking at overlap among species, conditions for the key habitat variables that promote positive responses are listed in Appendix VI.

Limited management resources will inevitably always restrict monitoring of all target species; therefore, we should strive for practical efforts, based on the best available knowledge. These efforts should be validated to the extent possible through monitoring, followed with evaluation and adjustment through adaptive management approaches.

Close proximity to agricultural fields is important to ducks, sandhill cranes, and curlews, and close proximity to other wetlands is important for ducks, short-eared owls, and frogs.
All priority species, with the exception of American bitterns, seem to prefer vegetation less than 1 m, and many prefer vegetation < 60 cm, such as ducks, piping plover, long-billed curlew, short-eared owl, and adult frogs in foraging areas.

The 18 priority wetland-dependent species considered in this project require a wide array of food resources, including both plant and animal matter. While food resources, per se, are beyond the scope of field data collection for CNHP, some useful information can be gleaned from the data set. Food resources consisting of plant matter can be determined from the list of plant species and relative abundance. For food resources consisting of animal matter, some assumptions can be made. For example, Hornung and Foote (2006) suggested that the complexity and abundance of aquatic plants can be used to predict the occurrence of aquatic invertebrates; they found that biomass of herbivorous invertebrates increased with complexity of the plant community while a more simple plant community supported more predatory invertebrates.

Predators are considered major population regulators but, as with food resources, are beyond the scope of this project. However, some of the same conditions that favor priority species may also favor important predators, including some predatory priority species. For example, similar wetland conditions may attract frogs and red-sided garter snakes, as well as American bitterns that eat frogs and snakes. Introduced predators, such as bullfrogs, also may be attracted to the same wetland conditions as are the priority frog and fish guilds.

In addition to the more local wetland conditions, numerous landscape context variables and forces that extend beyond the LSPRB, such as global climate change, can affect future populations of the CPW priority species. These include, but are not limited to, precipitation, temperature, other weather events (e.g., storms and wind), urban and rural development, energy development, stream flow, floodplain modifications, as well as changes in hydrology, irrigation amounts or techniques, hunting and other recreation, agriculture or grazing, invasive plants, and resources to manage wetlands.

Table 43. Area and percent land used by Colorado Parks and Wildlife wetland-dependent priority species in decreasing order.

Species	Number of habitats used in LSPRB	Area of NWI wetlands used in LSPRB*	% of land covered by used wetlands **
Dabbling duck guild	18	102,612 ha (253,560 acres)	3.01%
Frog guild	18	102,612 ha (253,560 acres)	3.01%
Red-sided garter snake	17	68,557 ha (169,409 acres)	2.01%
Sandhill crane	7	63,938 ha (157,994 acres)	1.88%
Short-eared owl	3	40,957 ha (101,207 acres)	1.20%
Long-billed curlew	3	37,960 ha (93,801 acres)	1.11%
American bittern	6	35,166 ha (86,898 acres)	1.03%
Fish guild	3	16,272 ha (40,208 acres)	0.48%
River otter	3	13,252 ha (32,746 acres)	0.39%
Piping plover	1	1,444 ha (3,567 acres)	0.04%

*Acreage does not include warm water sloughs.
**Percent calculated by dividing the NWI acres of wetland habitat used by the total acreage in LSPRB; therefore, for species (e.g., red-sided garter snake) using upland habitat, the percent does not represent the total acreage used.

Table 44. Qualified and ranked importance of key habitat variables for 18 Colorado Parks and Wildlife wetland-dependent priority species. Variable are ranked according the number of species for which the variable is either of high or medium importance.

	Number of species according to value of variable				
Key habitat variable	High (H)	Medium (M)	Low (L)	H or M	Ranked importance
Landscape context	18	0	0	18	1
Size of habitat	6	10	2	16	2
Water depth	14	1	0	15	3
Dominant vegetation type	11	3	3	14	4
Emergent cover (%)	11	2	0	13	5
Absence of pred. fish/bullfrogs	4	0	0	4	6*
Invertebrates	0	7	0	7	6*
Water quality	4	0	0	4	6*
Dominant vegetation height	5	0	0	5	7*
Interspersion	1	1	1	2	7*
Residual cover	2	0	0	2	7*
Substrate	2	0	0	2	7*
Sunlight exposure	2	0	0	2	7*
Vegetation density	2	0	0	2	7*
Open sand/gravel	1	0	0	1	8*
Proximity to objects	1	0	0	1	8*
Riparian vegetation	1	0	0	1	8*
Shore complexity	1	0	0	1	8*
Stream banks steep	0	1	0	1	8*
Stream order	0	1	0	1	8*
Structures and debris	1	0	0	1	8*

* Tied ranks.

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6.0 APPENDICES

Appendix I. Justification for removing 16 CPW wetland-dependent priority wildlife species from the list for the Lower South Platte River Basin and justification for the original removal of piping plover and river otter, which were placed back on the list.

Boreal toad (*Bufo boreas boreas*): Boreal toads are unlikely to exist with LSPRB due to elevation preferences (CPW 2012, CHA 2012).
Lesser scaup (*Aythya affinis*): Lesser scaup constitute a very small proportion of hunting, and they are not a species of concern.
Piping plover (*Charadrius melodus*): Piping plovers are not known to breed with LSPRB (Nelson 1998c, COBBA 2012, RMBO 2012). RMBO (2012) states, "In Physiographic Area 36 in Colorado, they nest only on reservoirs in the vicinity of the Arkansas River, between Las Animas and Lamar." However, Elliott-Smith and Haig (2004) show an isolated population adjacent to and just south of LSPRB, and NDIS (2012) suggests occurrence within LSPRB. NDIS (2012) cites Andrews and Righter (1992) as their primary source for distribution. Andrews (pers. comm., 1/5/2012) stated,

> "Regarding the five species within the South Platte area: Piping Plover, Snowy Plover, and Least Tern-all would be very rare migrants-not regular or expected, just the occasional vagrant. I have seen each of the species within the area, but very seldom. I am not aware of any breeding nor would I expect any. Lewis's Woodpecker-small numbers (including breeding) in eastern Douglas Co. and Elbert Co.; otherwise a very rare wanderer. Red-naped Sapsucker-regular migrant (in small numbers) throughout in riparian and urban areas (perhaps extremely rarely in winter); I would not expect any breeding.
>
> "As an example from one of the best studied sites within the area, here are the statements we made in our checklist of Barr Lake birds (Andrews, Robert, Robert Righter, Michael Carter, Tony Leukering, and Alison Banks. 2002. *Birds of Barr Lake and Surrounding Areas, 1888 through 1999: An Annotated Checklist*. Rocky Mountain Bird Observatory Ornithological Monograph No. 1):
>
> > Snowy Plover: 6 records in April and May, and 4 records from July to October.
> > Piping Plover: 1 record in May and 4 in August
> > Least Tern: 1 record (from 1907) in early June
> > Lewis's Woodpecker: 11 records, scattered throughout the year but mostly spring and fall
> > Red-naped Sapsucker: 4 records in April and May, and 12 records in September and October."

In a follow-up, Andrews (pers. comm.., 1/11/2012) stated,

> "The sightings for Barr Lake included all published observations (from journal articles and things like DFO newsletters, etc.), specimens, and any unpublished observations we could get from people. I think they are pretty close to being complete for the 1888–1999 time period. Wetlands at Barr Lake (and probably most other reservoirs in the South Platte basin) are not suitable for these three species. For example, Barr Lake doesn't have islands, nor does it have a bare shoreline in the breeding season, and the same is true for

> most other reservoirs (Jackson, Prewitt, etc.). Riverside has an island (pelicans nest there), but I can't say why none of these of these species nest there. All three of the species (the two plovers and the tern) are too marginal for wetland quality to be much of a concern in this area. It appears as if this part of Colorado has always been marginal for these three species."

Western snowy plover (*Charadrius alexandrinus nivosus*): Western snowy plovers are not known to breed with LSPRB (Nelson 1998d, Page et al. 2009, COBBA 2013, RMBO 2012). NDIS (2012) and Andrews and Righter (1992) suggest very rare occurrences (see pers. comm. with Andrews under piping plover, above). RMBO (2012) states, "Within the Central Shortgrass Prairie in Colorado, they breed on the shores of reservoirs near the Arkansas River between La Junta and Lamar."

Least tern (*Sternula antillarum*): To the best of current knowledge, least terns do not breed within LSPRB (Thompson et al. 1997, Nelson 1998a, Sauer et al. 2011, COBBA 2013, CPW 2012, RMBO 2012). RMBO (2012) states, "In Physiographic Area 36 in Colorado, they nest only on reservoirs in the vicinity of the Arkansas River, between Las Animas and Lamar." NDIS (2012) and Andrews and Righter (1992) suggest only very rare occurrences (see pers. comm. with Andrews under piping plover, above).

Bald Eagle (*Haliaeetus leucocephalus*): Key habitat quality variables for bald eagles are not parameters of wetlands.

Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*): Hughes (1999) and Guilfoyle (2001) indicate that the range of the *occidentalis* subspecies does not overlap with LSPRB.

Lewis's woodpecker (*Melanerpes lewis*): Lewis's woodpeckers generally do not breed within LSPRB (Tobalske 1997, Sauer et al. 2011, Cornell University 2012). Kuenning (1998) reported a few confirmed breeding records in Elbert County; however, the current Colorado Breeding Bird Atlas (2007–2011) reports no Lewis's woodpeckers within LSPRB. NDIS (2012) and Andrews and Righter (1992) suggest very rare occurrences during spring and fall (see pers. comm. with Andrews under piping plover, above).

Red-naped sapsucker (*Sphyrapicus nuchalis*): Barrett (1998a), Sauer et al. (2011), and COBBA (2012) suggest no evidence of breeding within LSPRB, and Walters et al. (2002) suggest no occurrence at any time within LSPRB. NDIS (2012) shows some occurrence in Adams and Elbert Counties, but these occurrences are very unusual (Andrews, pers. comm., see above under piping plover).

Southwestern willow flycatcher (*Empidonax traillii extimus*): The range of the Federally-endangered subspecies, *extimus*, extends only into southern Colorado and does not occur within LSPRB (USFWS 2002, 2012; NDIS 2012).

Southern redbelly dace (*Phoxinus erythrogaster*): NDIS (2012) indicates absence of southern redbelly dace in LSPRB: "In Colorado, one population of southern redbelly dace has been discovered in a single tributary of the Arkansas River in Pueblo (Miller 1982). This small tributary is little more than a small spring which surfaces at the base of a hill, flows alongside a railroad track for about a half mile and then enters the Arkansas River. Single individuals of the southern redbelly dace have been previously collected in 1965 in the Arkansas River in Pueblo and Canon City (J. Seilheimer, personal communication) and by Miller (1982) in Turkey Creek in Pueblo County. It is not known for certain if this population is native to Colorado."[4]

Arkansas darter (*Etheostoma cragini*): NDIS (2012) and CPW (2012) both indicate an absence of Arkansas darters in LSPRB, and that within Colorado, they are found only within the Arkansas River drainage. NDIS (2012) states, "The Arkansas darter has a very restricted natural range. It is only found in tributaries of the Arkansas River in Colorado, Kansas, Missouri and Oklahoma. The species is on the Colorado list of threatened species. In Kansas, the fish is listed as threatened and is classified as rare and endangered in Oklahoma. In Colorado, isolated populations have been found in several spring areas adjacent to the Fountain River south of Colorado Springs and other small tributaries, Rush Creek and Big Sandy Creek, of the Arkansas River on the eastern portion of Colorado (Miller 1984). The Arkansas darter is the only darter found in the Arkansas River Drainage, and is native to Colorado (Ellis 1914)."

Plains orangethroat darter (*Etheostoma spectabile*): NDIS (2012) indicates an absence of Plains Orangethroat Darters in LSPRB: "The species is rather widespread in the central part of the United States ranging from Michigan to Tennessee south to Texas and into Colorado. In Colorado, the species is restricted to, and the only darter found in, the Republican River Basin on the eastern side of the state. The orangethroat was the second most abundant species in the Republican Basin (Cancalosi 1980)." CPW Native Aquatic Species Biologist, Boyd Wright, stated, "Plains orangethroat darter are found in the North and South Fork Republican River…they are not found in the South Platte River basin" (pers. comm.. 1/9/2011).

River otter (*Lontra canadensis*): Although shown as occurring within LSPRB, NDIS describes the range as follows: "They occur in the Colorado, Gunnison, Piedra, and Dolores rivers. Tracks and other sign of otters have also been found in the Poudre and Laramie drainages in Larimer County. " Scott Wait (CPW biologist) believes occurrence of river otters in LSPRB is "possible but unlikely" (pers. comm.. 1/9/2012). Eric Odell (CPW biologist) in a personal communication (1/9/2012), stated, "We have had reports of otters on the lower S Platte, but as you suggest, only one confirmed sighting will 'light up' the map. I would not say that the Lower South Platte is important to river otter populations in Colorado."

Dwarf shrew (*Sorex nanus*): NDIS (2012) suggests and absence of dwarf shrews in LSPRB and states, "The dwarf shrew is known from the Southern Rocky Mountains at elevations above 1,680 m (5,500 ft). Armstrong et al. (1973) reported a total of 81 dwarf shrews collected at elevations of 1,600 to 3,050 m (5,300–10,000 ft) in the Arkansas River drainage. Hoffmeister (1967) and Spencer (1975) have captured the dwarf shrew at Mesa Verde and Durango." NatureServe (2012) also suggests absence in LSPRB.

Meadow jumping mouse (*Zapus hudsonius*): Meadow jumping mice are riparian species but do not rely on riparian wetlands. They rely on scrub-shrub and logs.

Yellow mud turtle (*Kinosternon flavescens*): NDIS (2012) states, "Nebraska south to northern Mexico, west to southern Arizona (Iverson 1989); disjunct populations in Illinois, Iowa, and Missouri. Occurs in eastern Colorado in the Republican, Arkansas, and Cimarron River drainages at elevations below 5,000 feet (1,525 m)." CHA (2012) shows most occurrences of yellow mud turtles in Yuma County.

[4] Many citations for literature referenced are not provided on the NDIS website. Therefore, references within quotes from this website are not included in the Literature Cited section.

Appendix II. Wetland habitat types in Lower South Platte River Basin.

Natural wetlands

Beaver pond: impoundment created by beaver dam, usually made of mud and woody plant material.

Emergent marsh: shallow water wetland that is frequently or continuously inundated and supports herbaceous plants adapted to saturated conditions; can be isolated or along reservoirs and other water bodies.

Playa: isolated depressional wetland with distinctive wet and dry seasons, fed by precipitation and runoff.

Riparian wetland – dominated by herbaceous plants: wetland adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by herbaceous phreatophytic plants.

Riparian wetland – dominated by shrub-scrub: wetland adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by woody phreatophytic shrubs.

Sandbar: accumulation of sand and/or gravel within a river channel; often maintained by scouring action.

Stream channel: area of river confined by banks and a streambed.

Warm water slough: slowly moving shallow water adjacent to river; source originates from ground water; in winter water temperature warmer than in river and under normal conditions does not freeze during winter.

Wet meadow: grassy areas saturated at or near the surface for part of the year.

Impoundments and other human-created wetlands

Irrigation-influenced wet meadow: meadow receiving surface or subsurface irrigation waters.

Irrigation ditch/canal: excavated canal that supplies water to dry land.

Gravel pits: steep-sided excavation, usually in association with gravel mining operations; may or may not have sloped wetlands on fringe.

Moist soil unit: managed wetland with dike and water control structure; manipulated to flood intermittently or seasonally to maximize production of moist-soil annual and/or perennial herbaceous plants; sometimes planted with crops that provide seeds, vegetation, and/or roots that benefit wetland-dependent species.

Recharge pond: diked shallow water impoundment on ephemeral drainage designed to retime S. Platte River flows into Nebraska according to legal mandates.

Reservoir: impoundment used to store and regulate water for agricultural or municipal use; usually > 5 acres.

Sewage lagoon: impoundment fully contained by dikes and receiving domestic/industrial/agricultural effluent; usually near urban areas or feedlots; rectangular or square in shape

Stock pond: diked pond on ephemeral drainage in pasture or prairie; used for watering livestock; usually created by humans and < 5 acres.

Urban runoff ponds: pond that capture effluent from urban storm runoff

Appendix III. Field Key to Wetland Habitat Types in Lower South Platte River Basin. Last updated May 24, 2013.

Wildlife habitat types are small to large-scale patches on the landscape that represent important and distinct habitat zones for wildlife species. The primary divide within the key is between natural and human-created habitat types. There may be several habitat types within a wetland or riparian area, or there may only be one. To be called out as a separate habitat type within a mosaic of vegetation, each patch must be ***>0.1 ha***. Keep this criterion in mind as you read through the key. A small puddle with a few cattails does should not be classified as an emergent marsh.

1a. Wetland habitat that is predominately natural, though may be degraded or otherwise influenced by human activities.. **GO TO KEY 1: Natural Wetland Habitat Types**

1b. Wetland habitat that is created or significantly modified by human activities (e.g., impounded, excavated, diked), even if for habitat enhancement.............................. **GO TO KEY 2: Human-Created Habitat Types**

KEY 1: Natural Wetland Habitat Types

1a. Habitat not associated with flowing water bodies (e.g., small streams, large rivers, or their floodplains).... **2**

1b. Habitat associated with a flowing water body (e.g., a small stream, large river, or their floodplain) **4**

2a. Isolated depressional wetland with distinctive wet and dry seasons, fed by precipitation and runoff.. **Playa**

2b. Wetlands lacking distinctive wet and seasons. **3**

3a. Shallow water wetland that is frequently or continuously inundated and supports herbaceous plants adapted to saturated conditions. Typically a mix of open water and vegetation, but may be completely vegetated. Can be isolated or along reservoirs (in this case, the reservoir in not natural, but the marsh vegetation is naturalized along the shore).. .... **Emergent marsh**

3b. Herbaceous wetland area saturated at or near the surface for part of the year. Typically dominated by grasses or sedges.. **Wet meadow**

4a. Open water habitat (even if partially or mostly vegetated) with obvious evidence of past or current beaver activity impounding water; dam usually constructed with woody plant material and mud ....**Beaver pond**

4b. No evidence of past or current beaver activity impounding water **5**

5a. Flowing water habitat within the floodplain or within the confines of a stream or river channel. May be partially or mostly vegetated, but water still flows through or over **6**

5b. Habitat associated with or adjacent to flowing water, but does not contain flowing water except in overbanking floods. Woody vegetation on the margins of open water bodies also keys here (i.e., reservoir edges) **8**

6a. Slowly moving shallow water adjacent to river. Source originates from ground water and moves slowly toward river. There is no obvious upstream connection to the primarily river channel. Water present all year and in wither, water temperature warmer than river and typically does not freeze. Only found on the South Platte River floodplain from Greeley to the state line. Not associated with smaller streams.. ....**Warm water slough**

6b. Habitat within the confines of the ordinary high water line of a stream or river. If overly vegetated (see sand bar below), it may not be apparent that the habitat is within the ordinary high water line **7**

7a. Area of stream or river that is confined by banks and streambed. If not a primary river or stream channel, there is an obvious upstream and downstream connection to the primary channel (i.e., not a warm water slough). May be covered with water or be exposed sediment. In some cases, exposed stream or river channels may be vegetated if flow is not regular. ....**Stream or river channel**

7b. Accumulation of sand and/or gravel within a river channel, often maintained by scouring action. Generally only associated with large rivers that can transport significant volumes of sediment. Can become densely vegetated with willows and other vegetation if scouring does not occur for several years. If this is the case, the underlying sand and gravel may not be obvious. If a willow stand is immediately within the river channel, it is likely growing over a sand bar. This should be classified as a sand bar and not as riparian vegetation. .... **Sand bar**

8b. Natural shallow water wetland within the floodplain that is frequently or continuously inundated and supports herbaceous plants adapted to saturated conditions. Typically a mix of open water and vegetation, but may be completely vegetated. ....**Emergent marsh**

8b. Wetland area within the floodplain that is not frequently or continuously inundated. Vegetation may be herbaceous or woody. **9**

8a. Wetland are adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by herbaceous phreatophytic plants. ....**Riparian wetland (herbaceous)***

8b. Wetland area adjacent to stream; flooded intermittently, seasonally, or permanently; fed by water from the stream either above or below ground; dominated by woody phreatophytic shrubs. ....**Riparian wetland (shrub / forested)***

*Note: Wetland habitat features only apply to actual wetlands, not non-wetland riparian areas and cottonwood gallery forests. For non-wetland areas, use either “open mesic vegetation” for herbaceous areas and “cottonwood gallery” for wooded areas.

KEY 2: Human-Created Habitat Features

1a. Open, herbaceous meadows receiving surface or subsurface irrigation waters. Includes herbaceous meadows created through direct flood irrigation or indirect irrigation runoff, tail waters, return flow, or ditch seepage ....**Irrigation-influenced wet meadow**

1b. Not as above **2**

2a. Permanent open water. *[Not likely to be included as sample points in the Lower South Platte project due to water depth.]* **3**

2b. Seasonal open water, may be dry at any point in season depending on water management. May be partially or entirely vegetated or clear of vegetation **5**

3a. Impoundment that is fully contained by dikes and receiving domestic/industrial/agricultural effluent; usually near urban areas or feedlots; rectangular or square in shape .... **Sewage lagoon**

3b. Open water habitat that is not diked on all sides **4**

4a. Steep-sided excavation, usually within a floodplain, association with current or past gravel mining operations. May or may not have sloped wetlands on fringe. If gravel pit has been restored, sloping sides may be more gradual and vegetated. Look at the larger landscape context to determine whether a wetland likely originated as a gravel pit. *[Restored or reclaimed gravel pits may be included in the Lower South Platte project if water levels are not too high.]* .... **Gravel pit**

4b. Impoundment used to store and regulate water for agricultural or municipal use; usually > 5 acres. *[Vegetated shores around reservoirs would be classified as emergent marsh.]* .... **Reservoir**

5a. Excavated canal that supplies water to and across dry land. In some cases, it may be difficult to distinguish irrigation canals from warm water sloughs and other natural side channels, as natural channels are sometimes used to convey water and hand-dug irrigation canals can, over time, take on natural features. Look at the larger landscape context, the straightness of the channel (natural channels have more curves while ditches are straighter), and the path of water flow (natural channels follow the most direct path while ditches often cut across contours) to make an educated guess. .... **Irrigation ditch/canal**

5b. Human-created habitat without flowing water **6***

6a. Wetland designed and managed for the benefit of wildlife or for recharge to the South Platte River (wildlife habitat may be a secondary goal or not at all). *[The following habitat types represent two ends of a continuum and there is significant grey area in between. If it is clear from discussions with a landowner that the wetland being sampled is one or the other, use the specific name. If it is not clear, call the wetland a* ***managed wetland****.]* **7**

6b. Impounded or excavated open water feature (pond) designed for a variety of purposes. May or may not be vegetated. May be dry at time of sampling **8**

7a. Managed wetland with dike and water control structure; manipulated to flood intermittently or seasonally to maximize production of moist-soil annual and/or perennial herbaceous plants; sometimes planted with crops that provide seeds, vegetation, and/or roots that benefit wetland-dependent species. .... **Moist soil unit**

7b. Diked shallow water impoundment designed to retime South Platte River flows into Nebraska according to legal mandates. .... **Recharge pond**

8a. Pond designed to capture urban storm water runoff. May be vegetated or not. .... **Urban runoff pond**

8b. Pond used for fishing or other recreational purpose .... **Recreational pond**

8c. Diked pond associated with and used to water livestock .... **Stock pond**

*Note: Checking with the landowner or land manager regarding purpose and use may be required to differentiate these habitat features.

Appendix IV. Metric protocols for key habitat variables from literature.

Below are some details of how others have assessed each key habitat variable with comments and recommendations for use in the Lower South Platte River Basin. The comments and recommendations are summarized in Table 42 for convenience.

Landscape context

Level 1. Buffers should be constructed around wetlands in GIS at 1.5, 3, and 8 km. The following information within these buffers will help determine habitat quality for priority wildlife species:

1. Other wetlands
    a. Number
    b. Size
    c. Type
    d. Connectivity
2. Agricultural land; if possible distinguishing between
    a. Crops
    b. Grazing
3. Land uses (e.g., urban, industrial, energy sector, agriculture)
4. Land ownership (e.g., private, public, conservation easements)

Levels 2 and 3. Not applicable

Percent emergent cover

Level 1. With aerial photography or satellite imagery taken during the growing season, measurements of percent emergent cover will be accurate and relatively rapid. The images can be evaluated using several programs together (Rehm and Baldassarre 2007), or they can be evaluated entirely in Adobe Photoshop® (Ortega et al. 2002).

Level 2. Many investigators have used ocular estimates to describe percent of emergent cover in wetlands (Euliss and Harris 1987; Merendino et al. 1992, Ratti et al. 2001, Pearse et al. 2011). These estimates are subjective but may be less prone to large errors when the estimates are placed into categories. The following categories have been used:

Categories of percent emergent cover							References
0–1%	1–10%	10–25%	25–50%	50–75%	75–100%		Edwards and Otis 1999
<1%	1–5%	6–25%	26–50%	51–75%	76–95%	>95%	Naugle et al. 2000
							Webb et al. 2010
							Fairbairn and Dinsmore 2001
0–10%	11–25%	26–50%	51–75%	>75%			Mulhern et al. 1985

<33%	33–66%	>66%	Ritter and Savidge 1999

Level 3. Ocular estimates in sample plots ($\leq 1 \times 1$ m^2) at random points or in a systematic grids have been used by several investigators in conjunction with data collection of other variables, such as plant species (Heaven et al. 2003, DeBerry and Perry 2004).

Comments and recommendations (at the entire wetland area scale). If good aerial photography is available, Level 1 would be the most ideal method because it involves quantifying rather than estimates. The Level 2 methods of CNHP will provide adequate information to access the value to wildlife. This includes estimating cover of shallow water (< 20 cm) and cover of deeper water (20–100 cm).

Water depth

Level 1. Not applicable

Level 2. In some cases, asking the land owner or land manager about water depth may reveal ranges of water depth both within the wetland and during different times of the year.

Level 3. Below are several methods for determining water depth.
Bolduc and Afton (2004): A measuring stick was used to measure water at three random plots. “Locations of sampling stations were determined using random numbers to select distances and angles from an observation blind that fell within the pond area, up to a distance of 200 m from the blind.”
Germaine and Hays (2009): “We estimated maximum pond depth by noting high-water marks on shoreline vegetation. We measured actual pond depths by wading to pond center…”
Hornung and Foote (2006): A measuring stick was used to measure water at three plots in each wetland. “Three sub-sampling locations were established at each wetland using a stratified random design: randomly selected along a transect that ran parallel to the wetland shore and was one third the entire shoreline length.”
Rotella and Ratti (1992): “Water depth was recorded 1 m to the east, south, and west of permanent stakes in each wetland…”

Wet meadows. To measure water depth in wet meadows, Riffell et al. (2001) measured water in depressions between hummocks at a point closest to their sampling station. “Each bird-sampling transect was divided into 50-m segments. Within each segment, four habitat- sampling radii were established radiating from the center of that segment. Five sampling points were located at 10-m intervals along each of the habitat-sampling radii (total of 20 points per 50-m segment of each bird transect).”

Comments and recommendations (measured at the vegetation plot scale). If the land manager cannot provide water depth information, water depth should be determined with a measuring stick at vegetation plots, using plots recommended by EPA (2011).

Dominant vegetation

Level 1. Not applicable

Level 2.
Thorn and Zwank (1993): "Nine managed impoundments on the refuge were classified as one or more of four different plant zones: annuals (wild millets, sprangletop and smartweeds); saltgrass; alkali-three-square bulrush; and cattail-hardstem bulrush. Type and amount of the dominant plant zone within each impoundment were estimated from aerial photographs and subsequently verified by visual ground truthing."

Level 3.
Hornung and Foote (2006): "Three sub-sampling locations were established at each wetland using a stratified random design: randomly selected along a transect that ran parallel to the wetland shore and was one third the entire shoreline length…Two adjacent 1-m2 quadrats were established at each sub-sampling location, extending from the shoreline toward the center of the wetland. Aquatic plants were identified to species."
Rollo and Bolen (1969): "The vegetation immediately surrounding the playa lakes in the study areas was sampled using a modification of the "step point" method (Evans and Love 1957). Random lines of 10 paces in length and radiating at 5 pace intervals from the water's edge were used as transects to characterize the vegetation. At each step on the transects the nearest plant was tallied. The vegetation of each of three lakes was sampled with 2500 points in total. The data from each site were combined to estimated an abundance rating for each species."

Wet meadows. Riffell et al. (2001): "Each bird-sampling transect was divided into 50-m segments. Within each segment, four habitat- sampling radii were established radiating from the center of that segment. Five sampling points were located at 10-m intervals along each of the habitat-sampling radii (total of 20 points per 50-m segment of each bird transect)…. Within each frame, we recorded the presence or absence of graminoid vegetation (grass or sedge), cattail (*Typha* spp.), bulrush (*Scirpus* spp.), floating vegetation, submersed vegetation, willow (*Salix* spp.), alder (*Alnus* spp.), open water pockets, and moss."

Comments and recommendations (measured at the vegetation plot scale). The plant community should be determined by methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011). The plant community should be placed in the following cover classes: 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%.

Size of habitat

Level 1. Size of the wetland can be determined by using GIS polygonal measuring tools.

Level 2. If questionable, the size of the wetland obtained in GIS can be verified by walking around the perimeter with GIS tracks on save mode. For larger wetlands, distances across the wetland should be measured with a range finder at angles determined by a compass.

Level 3. Not applicable

Comments and recommendations (at the entire wetland area scale).

Vegetation height

Level 1. Not applicable

Level 2.
Mulhern et al. (1985): "Vegetation height was assigned to one of five classes (0–0.25 m, open water and low mat vegetation; 0 .25–0.50 m, wet meadow vegetation; 0.5–1.0 m, sedge [*Carexs* p.] and white-top grass (Scholochloafestuacaea]; 1.0–2.0 m, cattail [*Typha latifolia*]; and 2.0 m, shrubs and trees)."

Level 3.
Hines and Mitchell (1983): "A vegetation transect consisting of 20, 20 X 50-cm quadrats spaced at 1.8-m intervals was established on each artificial island after the 1973 nesting season. We recorded the height of vegetation and the canopy cover of all plants > 10 cm."
Joyner (1980): "Mean height of the peripheral terrestrial vegetation was calculated by picking 50 random locations around the perimeter of each pond. At each location, terrestrial vegetation was measured at 0.3, 1.0, and 3.0 m from the water's edge along 3- m linear transects constructed perpendicular to the shoreline."
Shaffer et al. (2006): "A transect was established lengthwise through the center of each island. Parallel transects were then established on either side of the center transect halfway between the center transect and the island shore, for a total of 3 transects…We also categorized the vegetation within 15 cm of each transect point into 1 of 10 vegetation classes (after Willms and Crawford 1989): 1) tall and dense forbs, 2) tall and dense grass, 3) short and sparse forbs, 4) short and sparse grass, 5) tall and sparse forbs, 6) tall and sparse grass, 7) short and dense forbs, 8) short and dense grass, 9) shrub, and 10) unvegetated."
Smith et al. (2004): "…we established 5 200-m transects during August of each year to determine plant species frequency and vertical vegetative cover. We used a 10- cm-diameter circular plot at each 5-m interval along the transect and… We used a profile board (Nudds 1977) 2.4 m high, and 15 cm wide, divided into 6 40-cm · 15-cm sections to determine vertical cover."
Zicus et al. (2006): "We established 3 sampling clusters along the longest straight-line diagonal across a field. We established sampling-cluster starting points at the 3 quarter-points along the diagonal, and permanently marked these with stakes. Each sampling cluster had 4 sampling points that were 20 m north, east, south, and west of a starting point. At each sampling point, we measured vegetation height"

Wet meadows. Riffell et al. (2001) measured height of vegetation in wet meadows along sampling segments (see above, under *water depth* section, for selection of sampling segments).

Comments and recommendations (measured at the vegetation plot scale). Vegetation height should be estimated and placed in size classes according to methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011). Vegetation height should be placed in the following size classes according to CNHP protocol: 1: <0.5 m 2: 0.5–1m 3: 1–2 m 4: 2–5 m 5: 5–10 m 6: 10–15 m 7: 15–20 m 8: 20–35 m 9: 35–50 m 10: >50 m.

Water quality and pH

Level 1. Not applicable.

Level 2. Merendino et al. (1992) did not find any significant differences between measurements of pH and conductivity taken directly in the field and a subset of water samples sent to a chemical laboratory.

Level 3. Not applicable.

Comments and recommendations (measured at the vegetation plot scale). pH, conductivity, and temperature should be measured in the middle of the water column, using plots recommended by EPA (2011).

Interspersion

Interspersion is a concept that describes patterns of vegetation cover and water in terms of both amount (as a ratio of cover:water) and pattern (shapes of vegetation within the wetland); both are important for some wildlife species.

Level 1. With aerial photography or satellite imagery taken during the growing season, the images can be evaluated using Adobe Photoshop® (Ortega et al. 2002, see Appendix 1).

Level 2. Many investigators have used estimates in the field to describe cover:water ratios and complexity of patterns
Mulhern et al. (1985): Mulhern et al. placed patterns into categories of (1) uniform, (2) partially interspersed, and (3) heavily interspersed.
Murkin et al. (1997): Murkin et al. described patterns as (1) little open water, (2) hemimarsh (50:50 interspersed cover:water), and (3) little vegetation.
Ratti et al. (2001): Ratti et al. described patterns as "(1) closed marsh, (2) hemimarsh, (3) marshes with central expanses of open water surrounded by wide bands of emergent cover, and (4) open marshes (>95% open water or bare soil)."

Level 3. Some investigators have worked with interspersion patterns that were manipulated in the field.
Kaminski and Prince (1981): Kaminski and Prince worked with manipulated designs of 30:70, 50:50, and 70:30.
Smith et al. (2004): Smith et al. placed manipulated interspersion ratios into categories of 25:75, 50:50, and 75:25.

Comments and recommendations (at the entire wetland area scale). Patterns of complexity should follow the CNHP protocol (Figure 2), using the best fit of diagrams or, if a pattern is not represented on the diagram, using other descriptions at the wetland level, such as

- Fringe (vegetation around the perimeter of the wetland with central open water)
- Partially interspersed (few patches of vegetation in central portion)
- Complex (vegetation interspersed in many patches)
- Closed (few to no areas of open water)

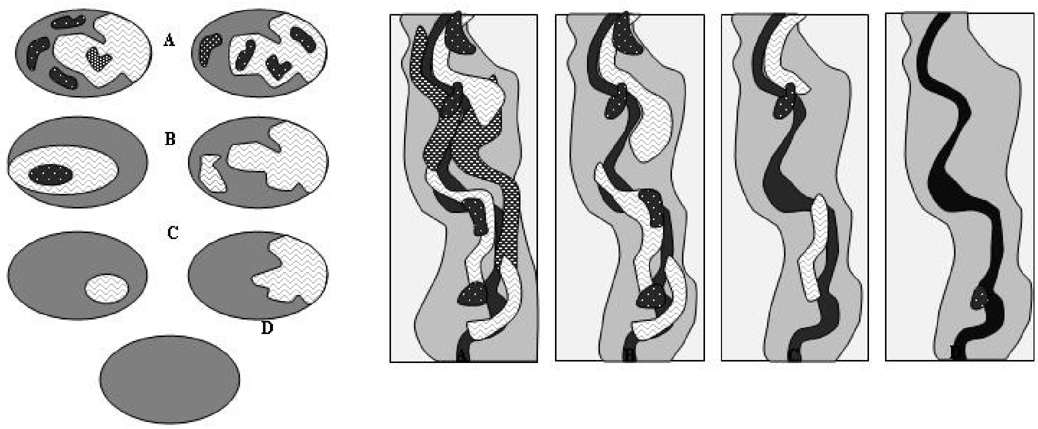

Figure 2. Diagrams used to describe interspersion patterns.

Shade/sun

Level 1. Not applicable.

Level 2. This feature helps determine if solar radiation is adequate to warm waters sufficiently for frogs eggs to develop. In smaller wetlands where large trees can shade all or most of the water, it would be useful to estimate the percent of overstory canopy covering the wetland.

Level 3. Not applicable.

Comments and recommendations (measured at the vegetation plot scale or estimated at the Assessment Area scale). Canopy, as a measure of light interception, should be measured directly with a densiometer (Nuttle 1997) at plots, using plots recommended by EPA (2011). Alternatively, it can be estimated at the Assessment Area scale.

Residual cover depth

Levels 1 and 2. Not applicable.

Level 3. Residual cover (dead vegetation from the previous year) can be measured in the same ways that vegetation height is measured (Grove et al. 2001).

Comments and recommendations (measured at vegetation plot scale). Residual cover should be determined with a measuring stick according to methods already in use by CNHP (Lemly et al. 2011), using plots recommended by EPA (2011).

Key Habitat Feature Unique to Piping Plover

Percent open sand or gravel area on sandbar

Level 1. Percent open sand or gravel area can be determined using tools in GIS.

Levels 2 and 3. Not applicable.

Comments and recommendations. Percent open sand or gravel area on sandbars should be measured using GIS tools; alternatively it can be determined using the same methods as percent cover (see Appendix 1).

Key Habitat Features Unique to River Otter

The following key habitat features are meant to be measured only in riparian areas.

Structures and debris

Level 1. Not applicable.

Level 2.
Dubuc et al. (1990): "We recorded the location and condition of each beaver house and dam encountered. Beaver impoundments were considered active if dams showed recent mudding (i.e., building or repair) and water levels were being maintained."
Swimley et al. (1998). Swimley et al. recorded presence or absence of flood debris, logs, and beaver structures within 100-m stream sections.
Newman and Griffin (1994): Newman and Griffin recorded presence or absence of beaver lodges or dens within a 5-m radius of otter latrine sites.

Level 3. Not applicable.

Comments and recommendations (at the entire wetland scale). Presence or absence of beaver structures, log jams, and debris jams should be noted according to CNHP protocols.

Riparian vegetation

Level 1. Not applicable.

Level 2.
Edwards and Otis (1999): Edwards and Otis placed patches of vegetation into height categories of (1) low 0–2 m, (2) medium 2–6 m, and (3) high > 6 m.
Level 3.
Crowley et al. (2012): Crowley et al. measured the diameter at breast height (DBH) of all trees within 5.64-m-diameter half circles.

Comments and recommendations (at the Assessment Area scale). Presence of woody vegetation should be measured according to CNHP methods:

1. Dominant canopy trees (>5 m and > 30% cover)
2. Sub-canopy trees (> 5m but < dominant canopy height) or trees with sparse cover
3. Tall shrubs or older tree saplings (2–5 m)
4. Short shrubs or young tree saplings (0.5–2 m)

Shore complexity

Level 1.
Dubuc et al. (1990): "Mean shoreline diversity was calculated by dividing the perimeter of each water-body by its total area (Hays et al. 1981:83) and averaging that value for all wetlands and deep water habitats within a watershed."
Swimley et al. (1998). Swimley et al. recorded presence or absence of backwater sloughs within 100 m-stream sections.

Level 2.
Newman and Griffin (1994): Newman and Griffin recorded river otter latrine sites as "point of land, isthmus, mouth of permanent stream, or none of the above."

Level 3. Not applicable.

Comments and recommendations (at the Assessment Area scale). Presence or absence of backwater sloughs and other features that increase shoreline should be noted according to CNHP protocol.

Stream length

Level 1. Stream length can be determined using tools in GIS.

Levels 2 and 3. Not applicable.

Comments and recommendations. Stream length should be measured with GIS tools.

Banks

Level 1. Not applicable.

Level 2.
Swimley et al. (1998). Swimley et al. recorded presence or absence of undercut banks within 100-m stream sections.

Level 3. Not applicable.

Comments and recommendations (at the Assessment Area scale). Presence or absence of undercut banks should be noted.

<u>Stream order</u>

Level 1. Stream order can be determined from maps detailed enough to show all tributaries.

Levels 2 and 3. Not applicable.

Comments and recommendations (at the entire wetland scale). Stream order should be determined from maps detailed enough to show all tributaries.

<u>Stream width</u>

Level 1. Stream width should be determined using GIS tools.

Level 2. If stream width has changed since the most recent aerial photography available, it should be measured in the field with a range finder.

Level 3. Not applicable.

Comments and recommendations (at the entire wetland scale). Stream width at bankful should be estimated according to CNHP protocol.

Protocols for optional sampling food resources in Lower South Platte River Basin

Invertebrates

Levels 1 and 2. Not applicable.

Level 3.
Many investigators have successfully used a wide variety of methods (e.g., Ashley et al. 2000, Bolduc and Afton 2004, de Szalay et al. 2003, Elmberg et al. 2003, Gray et al. 1999, EPA. 2002, Hornung and Foote, 2006, Joyner 1980, Kaminski and Prince 1981). EPA (2002) and Frederickson and Reid (1988) published thorough comparisons of protocols.

Comments and recommendations. Samples should be taken at vegetation plots, using the plot sampling design of EPA (2011). Ideally, collections would occur at least monthly, March through October.
Benthic invertebrates: A 12-cm-diameter core sampler (should be 25–30 cm long) sunk to a depth of 10 cm and sieved through a 500-µm screen will capture benthic macro-invertebrates (>0.5 mm). A 2.5-cm-diameter core sampler sunk to a depth of 2 cm and sieved through a 63-µm screen will capture benthic meiofaunal invertebrates (0.06–0.5 mm, Bolduc and Afton 2004).
Water-column invertebrates: A 500-µm mesh sweep net with a 20-cm opening, swept through a total length of 20 m with upward vertical sweeps will capture aquatic macro-invertebrates in the water column equivalent to 6 m^2 (Bolduc and Afton 2004).
Invertebrates on emergent vegetation and in wet meadows: Sweep nets (as described above) should be used to sweep vegetation in wet meadows and through emergent vegetation above the water column. To be consistent with sweeps in the water column, the total length of sweeps should be 20 m, e.g., 10 sweeps of 2 m each. In very dense emergent vegetation, such as cattails, where sweeping is not practical, invertebrates should be sampled with activity traps (de Szalay et al. 2003). Activity traps should be constructed with one-liter plastic bottles and funnels (de Szalay et al. 2003). Activity traps are typically checked 24 hours later (de Szalay et al. 2003).
Preservation: Invertebrates collected through aerial sweeping should be placed directly in jars of 95% ethanol (Joyner 1980). All material remaining in nets or sieves should be preserved in jars of 10% buffered formaldehyde and labeled with collection site and date. In the lab, before samples are identified, they should be washed according to Ashley et al. (2000), who rinsed with tap water samples in a 425-µm screen to strain out detritus and fine sediments; they separated invertebrates by floating in saturated sucrose solution, rinsed in dionized water, and stored in 70% isopropanol; alternatively 95% ethanol can be used.
Identification: Identification of invertebrates to the family level is adequate for management purposes (Fredrickson and Reid 1988). Some invertebrates might not be identified at a lower level than phylum. For example, Bolduc and Afton (2004) suggested, "Invertebrates were identified as the follows: (1) Diptera, Mollusca, and Decapoda to the family level, (2) other Insecta and Arthropoda to order, (3) Annelida, and Granuloreticulosa to class, and (4) Nematoda were not identified further." Resources for identification could include Colorado State University classrooms and/or work-study students or student volunteers.
Biomass calculations: Biomass for each classification unit or size unit should be calculated by either comparing with known values in the literature or by drying a known number of individuals

(e.g., 30 individuals) at 105° C for 24 hours (Kaminski and Prince 1981) and weighing. Biomass should be averaged from invertebrate weight unit (e.g., mg)/L per wetland per sampling round (Hornung and Foote 2006).

<u>Seeds</u>

Levels 1 and 2. Not applicable.

Level 3.
Reinecke and Hartke (2005): "Measurement of Seed Availability—During mid-October, we went to all 35 second-sample plots in each impoundment, clipped inflorescences within a 0.25-m^2 frame, and collected soil cores with a depth and diameter of 10 cm. We soaked soil cores in a 3% solution (1:32) of hydrogen peroxide (H_2O_2) for 3–5 hrs to disperse clays (Bohm 1979:117) and conducted a test to ensure the oxidizing agent H_2O_2had no effect on the mass of barnyard grass (*Echinochloa crusgalli*) seeds (K. J. Reinecke and K. M. Hartke, unpublished data). We washed samples with water over a set of 2 or 3 sieves, depending on the amount and coarseness of plant detritus. The set included a No. 5 (4 mm) or No. 10 (2 mm) sieve combined with a No. 45 (355 μm) sieve. After removing seeds from the coarse sieve(s), we dried material remaining in the No. 45 sieve. We then used a second set of 3 sieves to separate large (retained by No. 35 [500 μm] or No. 20 [850 μm] sieves) and small seeds (retained by No. 45 sieve). We removed large seeds from the first 2 sieves and determined mass (to the nearest 0.1 mg) after drying for 48 hrs at 50°C. Then, we distributed material retained by the No. 45 sieve uniformly over a numbered grid of 100 equal sized cells and drew a random subsample of 25. We used a binocular microscope to remove small seeds from the selected cells. After determining dry mass of small seeds in the subsample, we multiplied by 4 to estimate the mass of small seeds in soil cores. We calculated total mass of seeds in soil cores as the sum of the masses of large and small seeds. After airdrying plant inflorescences, we held them over the 3 sieves used to separate large and small seeds, and threshed out the seeds they contained. After drying and weighing seeds from inflorescences, we added the mass of seeds in soil cores and the mass of seeds in inflorescences to create a response variable (in kg/ha) for estimating mean seed availability."

<u>Smith et al. (2004)</u>: "We determined seed production by clipping 25 0.5 × 0.5-m quadrats in monotypic stands of moistsoil species in each playa (Haukos and Smith 1993). We separated seed and vegetation of each species in the field and then dried it in the laboratory at 40°C to a constant mass. Weighed samples of each species were converted to kg/ha and multiplied by the estimated area of each species to estimate total production of each species in each playa. We then transformed seed biomass data to duck-use days (DUD) (Reinecke et al. 1989, Haukos and Smith 1993) as an index of carrying capacity for each playa."

Comments and recommendations. Samples should be taken at vegetation plots, using the plot sampling design of EPA (2011). Ideally, collections should occur monthly May through September. Clippings from 0.5 × 0.5-m quadrats should be processed according to Smith et al. (2004), above, in situations where the seeds are uncontaminated by other materials. If the seeds need to be rinsed, the methods of Reinecke and Hartke (2005) should be used.

Submergents

Level 1. Not applicable.

Level 2.
Riffell et al. (2001) and Isola et al. (2000) recorded presence or absence within 1 × 1 m sampling frames. Heitmeyer (1986) recorded presence and taxonomy of submergent plants (*Ceratophyllum*, *Chara*, *Lemna*. *Najas*, and *Potamogeton*). Hornung and Foote (2006) measured the height of submergents. Capers (2003) counted rooted stems and identified species, and Monda and Ratti (1988) identified species within 1 × 1 m floating sampling frames.

Level 3. Not applicable.

Comments and recommendations. Information on presence or absence of submergent vegetation, along with identification, if present, should be taken at vegetation plots, using the plot sampling design of EPA (2011). Ideally, collections should occur monthly May through September.

Tubers

Levels 1 and 2. Not applicable.

Level 3.

Brasher et al. (2007): "We estimated tuber biomass by excavating soil in plots to a depth of 10 cm, but we sampled for tubers only in wetlands where we observed the growth of tuber-producing species (Table 1). We rinsed excavated soil through sieves (mesh sizes 5 [4.0 mm] and 18 [1.0 mm]) to expose and facilitate removal of tubers. We collected by hand all submerged aquatic vegetation in the water column of our plot when located in standing water. We sorted submerged aquatic vegetation to identify and retain only plant parts and species valued as food resources for ducks (Table 1). We dried seeds, tubers, and submerged aquatic vegetation to constant mass at 50° C and weighed to nearest 0.01 g."

Taylor and Smith (2005): "We sampled belowground rhizome and tuber mass along 4 permanent transects, which were randomly established on each field perpendicular to feeder canals and irrigation flow direction. Along these transects we randomly established 10 permanent paired sampling locations consisting of a 0.5-m circular exclosure (unconsumed mass) and an adjacent sampling site without an exclosure (consumed mass). After the flooding sequence was completed for each block each year, we took a 15 × 15 × 15-cm soil sample (Gutman and Watson 1980) from within the exclosure and a paired adjacent open sampling location. We washed tubers and rhizomes free of soil, separated them by species, oven-dried them to constant mass, and weighed them to the nearest 0.1 g. We termed the difference between the amount of food in the exclosure and open sample as use (i.e., consumption)."

Comments and recommendations. Samples should be taken at vegetation plots, using the plot sampling design of EPA (2011). Ideally, collections should occur monthly May through

September. Tubers should be excavated, using 15 × 15 × 15-cm soil samples (Taylor and Smith 2005). The tubers should be rinsed of soil, dried at 50° C, and weighed to the nearest 0.01 g. Tubers should be sorted from soil samples taken.

Appendix V. Recommended common management practices for changing or maintaining habitat conditions. From Gammonley et al. 2012.

Disking: It is the most intense disturbance of wetland vegetation used in managing wetlands. Disking destroys both the erect stems as well as breakup the extensive rhizome system that keeps plants alive during dry conditions. The USFWS observations show that mallards, northern pintails, white fronted geese, and Canada geese choose "managed wetlands where significant amounts of vegetation remain. Snow geese select wetlands (including disked areas) where the majority of the site is open water. http://www.fws.gov/rainwater

Excavation: The processes of removing and altering the landscape for the purpose of creating or restoring a site for wetland use. Excavation usually includes three processes. Excavation of soil and vegetation, removal and transport of unwanted materials, and deposition of these materials. When excavating in a wetland, care should be taken to minimize use of heavy machinery. Whenever possible, place heavy equipment on stabilization mats to reduce unwanted damage to the surrounding landscape. If at all possible, work when the ground is frozen and during low flow and low wind periods.

Haying: This management practice is used to manage vegetation types where ungulates refuse to graze (e.g. weed patches), or where prescribed burning is not practical (e.g. in close proximity to domestic structures). Results of haying may include, killing invasive tree seedlings, and creating firebreaks for future prescribed burns. Haying is generally delayed until after mid-July to reduce depredation of nests and nesting birds. http://www.fws.gov/rainwater

High Diversity seeding/planting: The term "high diversity seeding" includes harvesting, processing and sowing large numbers of native species in an attempt to return the plant community as close as possible to its pre-cultivation condition. Their objective is to manage uplands for warm season, grass-dominated plant communities with a diverse mix of other cool- and warm-season grasses, sedges, rushes, and broadleaf forbs. This process can be used where wet meadow plant communities are lacking in wetlands that would benefit from seeding of sedges, rushes, and wetland grasses. http://www.fws.gov/rainwater/management/reseeding.htm

Hydrologic Manipulation: Hydrologic processes that are artificially implemented to improve wetland functions. Water level manipulation may be used to increase or decrease salinity; stimulate germination and growth of moist-soil plants; decrease turbidity; increase production of invertebrates; recycle nutrients; alter the density of vegetation; control disease; and increase viable resources for target species (e.g. migratory birds). Hydrologic control can be achieved by the use of weirs (solid structures that maintain a minimum water level), dikes (impoundments), control gates, and pumps. The USFWS recommends using a cover: water ratio of about 50:50 across the entire wetland. (WPIF, date unknown).

Mechanical Control of Woody Vegetation: The means of cutting, sawing, clipping, mowing and uprooting of woody vegetation. The hand tools most commonly used for this technique are the mattock, heavy hoe and grubber. Mulching machines or tractor-mounted mowers and brush-hogs may also be used for spot cutting on larger vegetation such as willow and tamarisk.

Mowing: This management technique can be useful on small scale wetlands or artificially created wetlands (e.g. reservoirs surrounded by extensive marshes) during the winter months. At this time, water levels are typically at their lowest levels, yielding thick layers of ice. Robust emergent vegetation (e.g. cattails) can be clipped just above the ice so that spring flooding restricts the oxygen supply to the root zone. As a result, many of the plants do not resprout, allowing other emergent species to thrive (WPIF, date unknown).

Prescribed Burning: Prescribed burning in wetlands can be used to remove old vegetation; create open water areas; expose the soil profile for new germination; release nutrients that are bound in dead vegetation; remove exotic plant species; and create a mosaic of vegetation types. http://www.fws.gov/rainwater

Spraying/Chemical Treatment: The purpose is to remove undesirable plants, e.g., cattails monocultures, and invasive weeds.

Tree Removal: This management technique is primarily use on prairie wetlands (e.g. Rainwater Basin of Nebraska). In doing so, the USFWS uses tree removal around wetlands to increase the amount of upland grasslands. The North American Breeding Bird Survey reports that 70% of the 29 species characteristic of North American prairies has experienced a decline in population. A portion of that decline is attributed to the small area of remaining grassland parcels and the increasing number of trees found within the grasslands. http://www.fws.gov/rainwater

Ungulate Grazing: The purpose for grazing wetlands for [wildlife is]…to economically manage the type and abundance of plants. The USFWS strives for habitat which has abundant wetland plant seed, aquatic invertebrate substrate, and at least 50% open water when flooded one foot deep. http://fws.gov/rainwater/management/grazing.htm

Appendix VI. Conditions of habitat variables that promote positive responses by CPW priority species.

Species	Qualifiers	Value High	Medium	Low
Absence of predatory fish and/or bullfrogs				
Frogs	Breeding wetlands	Predatory fish and/or bullfrogs absent	Very few predatory fish and/or bullfrogs	Predatory fish and/or bullfrogs abundant
Fish		Absence	Present in very low numbers	Present
Dominant vegetation				
Ducks	General type	Grasses, sedges, rushes submergents, and other seed-producing plants	Herbaceous plants that provide little to no food resources for ducks	Willows and other woody shrubs
Ducks	Structure	Soft and easy to move through	Courser, more rigid, and dense	Woody or stiff and dense
Bittern		Cattails/Bulrush/Sedges/ Reed grasses/Bur-reeds	Other tall/medium emergents	Short (e.g., sedges) or no emergents
Crane	Feeding	Grasses, sedges, crops (particularly corn stubble)		Dense woody vegetation
Plover		Sparse grasses clumps preferred	Denser grasses	Woody vegetation
Curlew	Playas	Sparse, short, soft		Dense, tall, woody
Curlew	Wet meadows	Open, short grasses		Trees/high grass
Owl		Grasses	Fields with woody vegetation	Trees (but will occasionally roost in trees)
Frogs	Breeding wetlands	Sedges, rushes, cattails		Dense woody vegetation
Frogs	Adult foraging	Grasses and sedges		Dense woody vegetation
Snake		Emergents-sedges-grasses-anything that provides cover		Dense woody vegetation
Fish		Algae, algal mats, submergents/emergents		
Dominant vegetation height				
Bittern		1-2 m	0.5- < 1 m	< 0.5 m
Crane	Feeding	< 0.5 m	.05-1 m	1-2 m
Curlew		Short (< 50 cm)	Medium (50–100 cm)	Tall (1-5 m)
Owl		30–60 cm		> 60 cm

Appendix VI, continued.

Species	Qualifiers	Value High	Medium	Low
Dominant vegetation height				
Frogs	Breeding wetlands	< 1 m	1-2 m	> 2 m
Frogs	Adult foraging	15–50 cm	51–100 cm	> 1 m
% emergent/vegetation cover				
Ducks	Diurnal	21–50%	5–20%	< 5% or > 50%
Ducks	Nocturnal	61–80%	21–60%	10-20%
Ducks	Reservoirs/gravel pits	> 5%	1–5%	0%
Bittern		61–80%	31–60% or 81-100%	15–30%
Crane	Roosting	0–20%	21–40%	> 40%
Plover		0–5%	6–10%	11-20%
Curlew	Playas	0-33%	34-50%	50-70%
Owl		Close to 100%		
Frogs	Breeding wetlands	51–90%	31-50%	10-30%
Frogs	Adult foraging (herbaceous)	30–90%		25-30% or 91-100%
Garter snake		61-100%	41-60%	20-40%
Interspersion (see diagram)				
Ducks	Diurnal	C or D	B	A or E
Ducks	Nocturnal	C or D		A or B or E
Bittern		B or C or D		A or E
Crane	Roosting	A	B or C	D or E
Landscape context				
Ducks	% water within 8 km	> 2%	1-2%	< 1%
Ducks	Distance to agricultural fields, especially corn	< 8 km	8-16 km	> 16 km
Ducks	Distance to roosts (Known locations)	< 8 km	8-16 km	> 16 km
Bittern	Distance to pollution or urban area	> 200 m	150-200 m	< 150 m

Appendix VI, continued.

Species	Qualifiers	Value High	Medium	Low
Landscape context				
Crane	% water within 8 km	> 2%	1-2%	< 1%
Plover		Along river with natural flow regimes and ungrazed		Sites away from river (less successful)
Curlew	% water within 8 km	> 2%	1-2%	< 1%
Curlew	% irrigated hay pastures within 8 km	35-70%		< 35%
Curlew	% grassland within 8 km	35-70%		< 35%
Owl	% grassland within 8 km	35-70%		< 35%
Owl		Juxtaposition of large grasslands and wetlands; ungrazed		
Frogs		All 3 habitat types within 1–2 km; space between habitat with herbaceous vegetation < 1 m; free from contaminants	All 3 habitat types within 5 km; space between partially unvegetated or with vegetation < 1 m; trace contaminants	All 3 habitat types > 5 km; space between unvegetated or with vegetation < 1 m; contaminated
Frogs	% water within 8 km	> 2%	1-2%	< 1%
Snake		Close connection between upland hibernacula and wetlands		Landscape fragmented by unsuitable habitat
Fish		Pools connected to other habitats		
Otter		Near beaver activity & connected with tributaries		Disconnected without beavers
% open sand or gravel area				
Plover		Near 100% open		Less than open
Proximity to large object, e.g., rocks, logs				
Plover	Near nests	Close	More distant	Far
Curlew	Near nests	Close	More distant	Far

Appendix VI, continued.

Species	Qualifiers	Value High	Medium	Low
% Residual cover				
Bittern		41–60%	21–40% or 61-100%	10–20%
Owl	For nesting	41-60%	21-40%	10-20%
Riparian vegetation				
Otter	% Total canopy cover > 2 m	51-100%	31-50%	20-30%
Otter	Height of canopy cover > 2 m	> 15 m	5-15 m	0.5-5 m
Shore complexity				
Otter		Diverse and complex; undercut banks		
Size of habitat				
Ducks	Size of wetland: Beaver ponds,, emergent marshes, playas moist soil unit, recharge ponds	> .8 ha	.2–.8 ha	< .2 ha
Ducks	Size of wetland: reservoirs, wet meadows/riparian wetlands	> 8 ha	4–8 ha	< 4 ha
Bittern	Size of wetland	>10 ha	5–10 ha	1-5 ha
Crane roosting	Size of wetland	50–150 m from shore OR >1 ha	26–50 m from shore OR 1 ha	15-25 m from shore OR < 1 ha
Plover		The bigger the better; > 20 m wide	15–20 m wide	< 15 m wide
Curlew	Size of habitat	> 20 ha	5–20 ha	3-5 ha
Owl	Size of habitat	> 100 ha	50–100 ha	25-50 ha
Frogs	Breeding wetlands	30–60 m diameter		
Frogs	Adult foraging	Not well known		

Appendix VI, continued.

Species	Qualifiers	Value High	Medium	Low
Size of habitat				
Frogs	Wintering	Large and deep enough that water does not freeze solid		
Snake		Larger is better		
Fish		25–1,000 m^2		
Stream order				
Ducks		5^{th} or 6^{th} order	3^{rd} or 4^{th} order	1^{st} or 2^{nd} order
Otter		> 4th or lower gradients		< 4th order
Stream size				
Otter		Longer is better Wide		narrow
Structures and debris				
Otter		Log jams and/or beaver activity		
% Submergent vegetation				
Ducks		31-60%	11-30%	0-10%
Substrate				
Fish		Sand for dace Gravel for minnow		
Sunlight exposure (measured as % Total canopy cover > 2m)				
Frogs	Breeding wetlands	0-30%	31-50%	51-100%
Water depth (cm)				
Ducks		10-30 cm	31–60 cm	> 60 cm
Bittern		5-20	21-100	<5 or 100-120
Crane	Roosting	5–20 cm	20–40 cm	> 40 cm or dry
Crane	Feeding	Usually dry or shallow hummocks		
Plover		dry		
Curlew	Playas	0–16 cm	17-18 cm	> 19 cm
Curlew	Wet meadows	0 or hummocks		
Owl		0 cm	1-2 cm	3-20 cm

Appendix VI, continued.

Species	Qualifiers	Value High	Medium	Low
Water depth (cm)				
Frogs	Breeding wetlands	66–100 cm	1-2 m	10-65 cm
Frogs	Adult foraging	0-10 cm	11-20 cm	21-30 cm
Frogs	Wintering	> 100 cm		90-100 cm
Fish		51-150 cm	41-50 cm	
Otter		deeper better		Shallow
	% water > 20 cm	91-100%	81-90%	40-80%
Water quality				
Frogs		pH = 6.1-7 No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Acidic or contaminated with herbicides, pesticides, N loading Cloudy or sheen of oil
Snake		pH = 6.1-7 No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Acidic or contaminated with herbicides, pesticides, N loading Cloudy or sheen of oil
Fish		Clear, cool, slow moving No visual evidence of turbidity or other pollutants	Turbidity and/or pollutants limited to small area	Cloudy or sheen of oil