PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP or Program)
Final Statement
PRRIP Joint Whooping Crane Documents (WEST Report and Whooping Crane Habitat Synthesis Chapters) Peer Review

On September 12, 2017 at the September Quarterly Meeting, the Governance Committee (GC) approved the following motion:

The Governance Committee approves the Technical Advisory Committee (TAC) recommendation to accept the WEST Report (Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River) and the PRRIP Whooping Crane Habitat Synthesis Chapters, revised by the Executive Director's Office in response to peer review comments and TAC comments, as FINAL. These documents are approved by the Governance Committee as final with the understanding they will be used for decision-making purposes, and with the understanding the revised documents and all associated peer review documents will be made available to the public and posted on the Program web site.

The final revised WEST Report and PRRIP Whooping Crane Habitat Synthesis Chapters are attached as a unified document. **Appendix A** (also attached) includes the following documents:

- **Document #01, Acceptance Report from Louis Berger** – Report from the Program's Independent Science Review Contractor, Louis Berger, that summarizes responses from the three peer reviewers as to whether they could accept the WEST report and the habitat synthesis chapters as revised based on their comments and the EDO responses. This document includes the comment spreadsheet for both documents and the EDO responses to those comments.

- **Document #02, Responses to comments from Doug Shields** – Comments from peer reviewer Doug Shields and EDO responses that were inadvertently left out of Document #04 (see below).

- **Document #03, Responses to additional peer reviewer comments** – Before finalizing Document #01, Louis Berger shared a draft with the EDO. This document includes some specific responses to additional peer reviewer comments from Dave Baasch in the EDO, called out in yellow highlights.

- **Document #04, Initial peer review report from Louis Berger** – This is the original report from Louis Berger from December 2016 summarizing the initial results of the peer review process.

NOTE: *The EDO will seek publication of whooping crane habitat synthesis chapters 2 and 3 in early 2018 upon review and approval by the TAC and GC. The Chapter 2 manuscript will be updated with PRRIP whooping crane monitoring data through Spring 2017 and Chapter 3 will be updated to include telemetry data through Spring 2016.*

All further questions regarding the WEST Report and the Whooping Crane Habitat Synthesis Chapters, their use, and the peer review should be directed to the EDO.

Correlates of Whooping Crane Habitat Selection

And Trends in Use

in the Central Platte River, Nebraska

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Executive Summary

The Platte River Recovery and Implementation Program (PRRIP) monitors migratory habitat for the endangered whooping crane (*Grus americana*) and directs the management of land and water resources to provide benefits to this species, and ultimately improve the survival of whooping cranes during migration. The objective of this paper is to determine progress towards PRRIP's goal of providing benefits to whooping cranes by 1) analyzing in-channel habitat selection by whooping cranes in the central Platte River, a primary stopover area, and 2) assessing trends in whooping crane use of the central Platte River over time. Study results in the form of habitat characteristics associated with the highest selection ratios by whooping cranes will also help to inform future management actions by PRRIP. To this end, PRRIP researchers monitored whooping crane group use in the central Platte River with daily systematic aerial surveys during spring and fall migrations. The survey protocol outlines standardized survey methods and survey effort to facilitate consistent data collection and enable unbiased analyses of habitat selection. In-channel habitat selection from fall 2001 to spring 2013 was analyzed within the resource selection function framework utilizing penalized regression splines. Model selection determined the best fitting model among a list of a priori models containing various combinations of descriptors of habitat derived from land cover vector shapefiles, aerial imagery, and the HEC-RAS hydraulic model. There were 55 observations of unique whooping crane groups, 33 in the spring and 22 in the fall, located with the systematic aerial surveys. Each choice set extended 10 miles upstream and downstream from the use point. Unobstructed channel width, nearest forest, and nearest obstruction were the factors with the most influence on in-channel habitat selection. The impact of these variables was evident by the higher relative selection ratios at larger unobstructed channel widths, longer distances to nearest forest, and longer distances to nearest obstruction (dense vegetation), though all relationships declined after reaching a maximum and whooping crane groups were observed across a wide range of values for each of these variables. Analyses of all 176 systematic in-channel observations, and all 253 systematic and opportunistic in-channel observations were presented in appendices to the report as a comparison to the systematically obtained data.

Diurnal habitat selection from fall 2001 to spring 2013 was analyzed within the same modelling framework as in-channel habitat selection but was limited to descriptors of habitat that could be calculated for both in-channel and off-channel locations. There were 478 diurnal observations of whooping crane groups, 347 in the spring and 131 in the fall, located with the systematic aerial surveys. Each choice set extended 3 miles in all directions from the use point. Land cover, nearest disturbance and proximity to roost location were the factors with the most influence on in-channel habitat selection. The highest relative selection ratios were seen at in-channel and corn cover categories, longer distances to nearest disturbance, and shorter distances to previous night roost location.

Trends in whooping crane use of the central Platte River through time were analyzed from spring 2001 to fall 2014. To account for the documented increase in the Aransas-Wood Buffalo population of migrating cranes that could have stopped in the central Platte River during migration, two use metrics were quantified as the proportion of the population using the central Platte River and the crane use days per bird in the population. Simple linear models of trend were estimated after testing for temporal correlation in the error terms. Trends in the proportion of the population using the central Platte River were significantly increasing for the spring migration season, indicating the number of cranes that used the study area in the spring was increasing

faster than the population size. Both the fall trends and the combined spring and fall trends in the proportion of the population using the central Platte River were not significantly different from zero, i.e. no trend. Trends in the crane use days per bird in the population for the spring, fall, and combined spring and fall were not significantly different from zero, i.e. no trend. The non-significant result equates to the conclusion that the number of crane use days documented in the study area was increasing in proportion to the population size.

Table of Contents

Executive Summary i
List of Figures v
List of Tables vii
List of Appendices viii
1. Introduction 1
 Establishment of PRRIP 2
 Habitat Selection 2
 Trends in Use 3
2. In-channel Habitat Selection Methods 3
 Whooping Crane Group Observation Data 4
 Whooping Crane In-channel Habitat Selection 5
 Statistical Modeling of Aerial Survey Detection 10
3. Diurnal Habitat Selection Methods 10
 Whooping Crane Group Observation Data 11
 Whooping Crane Diurnal Habitat Selection 11
4. Trend Methods 13
 Whooping Crane Group Observation Data 13
 Aransas-Wood Buffalo Whooping Crane Population Estimates 13
 Statistical Methods 14
5. In-channel Habitat Selection Results 15
 Whooping Crane Group Observations 15
 In-channel Habitat Selection for Spring and Fall Combined 17
 Spring In-channel Habitat Selection 19
 Fall In-channel Habitat Selection 20
 Aerial Survey Detection 22
6. Diurnal Habitat Selection Results 22
 Whooping Crane Group Observations 22
 Diurnal Habitat Selection for Spring and Fall Combined 23
7. Trend Results 25
 Whooping Crane Group Observations 25
 Trends in Proportion of Population Using the central Platte River 25
 Trends in Crane Use Days per Bird in the Population 28
8. Discussion 31
 In-channel Habitat Selection 31
 Diurnal Habitat Selection 32
 Trend 32

Comparison to Previous Literature 32
9. Summary of Findings 34
10. References 35

List of Figures

Figure 1. Trend in the estimated population size of the Aransas-Wood Buffalo whooping crane population from 1938 to 2014 14

Figure 2. Spatial distribution of the in-channel systematic unique observations of whooping crane groups on the central Platte River from fall 2002 to spring 2013. 16

Figure 3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 488 feet at the mean value of nearest forest. 18

Figure 4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 523 feet at the mean value of unobstructed channel width. 18

Figure 5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 144 feet at the mean value of nearest forest 19

Figure 6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 533 feet at the mean value of nearest obstruction. 19

Figure 7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 136 feet... 20

Figure 8. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 299 feet at the mean value of total channel width. 22

Figure 9. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to total channel widths in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The lowest selection ratio value was predicted to occur at 1158 feet at the mean value of nearest obstruction 22

Figure 10. Predicted relative selection ratios for diurnal use by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest disturbance in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest value for selection ratio value was predicted to occur at 1339 feet at the mean value of other variables in the model. 24

Figure 11. Predicted relative selection ratios for diurnal use by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of proximity to roost location in the spring and fall combined. Tick marks indicate actual data (use points at y=1, choice set points at y=0). The highest selection ratio value was predicted to occur at 0 feet at the mean value of other variables in the model. 24

Figure 12. Relative abundance of land cover types for diurnal spring and fall locations of whooping crane use (left) and the choice set points (right). 24

Figure 13. Cranes using the central Platte River during spring migration and population size from 2001 to 2014. 25

Figure 14. Proportion of population using the central Platte River, spring 2001-2014. 25

Figure 15. Cranes using the central Platte River during fall migration and population size from 2001 to 2014. 27

Figure 16. Proportion of population using the central Platte River, fall 2001-2014. 27

Figure 17. Cranes using the central Platte River during spring and fall migration and population size from 2001 to 2014. 28

Figure 18. Proportion of population using the central Platte River, 2001-2014. 28

Figure 19. Cranes use days on the central Platte River during spring migration and population size from 2001 to 2014. 29

Figure 20. Crane use days on the central Platte River per bird in the population, spring 2001-2014. 29

Figure 21. Cranes use days on the central Platte River during fall migration and population size from 2001 to 2014. 30

Figure 22. Crane use days on the central Platte River per bird in the population, fall 2001-2014. 30

Figure 23. Cranes use days on the central Platte River during spring and fall migration and population size from 2001 to 2014. 31

Figure 24. Crane use days on the central Platte River per bird in the population, 2001-2014. 31

List of Tables

Table 1. Number of in-channel observations of whooping crane groups detected in the study area during PRRIP surveys and opportunistically from fall 2001 to spring 2013. Analyses presented in this report were conducted with the systematic unique data. We present analyses with all systematic in-channel observations in Appendix C, and analyses with systematic and opportunistic in-channel observations in Appendix D.. 5

Table 2. Sample size for in-channel models with 20 available locations in each choice set in addition to the location used by the whooping crane group. Observations of whooping cranes were obtained by systematic sampling through aerial surveys from fall 2001 to spring 2013 when the protocol remained consistent. 15

Table 3. Top management models for in-channel habitat use in the spring and fall, ranked by the AIC statistic. The AIC value for the null model was 847.57... 17

Table 4. Top models for in-channel habitat use in the spring and fall, ranked by the AIC statistic. The AIC value for the null model was 847.57... 19

Table 5. Top models for in-channel habitat use in the spring, ranked by AIC statistic. The AIC value for the null model was 478.66.. 20

Table 6. Top models for in-channel habitat use in the fall, ranked by AIC statistic. The AIC value for the null model was 295.74.. 21

Table 7. Top models for diurnal habitat use for both seasons combined, ranked by AIC statistic. The AIC value for the null model was 10,610.97... 23

Table 8. Observational data from the Platte River Recovery Implementation Program (PRRIP) whooping crane migrational habitat use surveys in the central Platte River, Nebraska and USFWS Aransas-Wood Buffalo Population surveys, 2001-2014. There was no PRRIP survey conducted in Spring 2003. 26

List of Appendices

A. In-channel a priori Models

B. Mirrored Histograms and Summary Statistics for Systematic Unique In-channel Whooping Crane Observations

C. Analysis of All Systematic In-channel Whooping Crane Group Observations

D. Analysis of Systematic and Opportunistic In-channel Whooping Crane Observations

E. Mirrored Histograms and Summary Statistics for Systematic Diurnal Whooping Crane Observations

1. Introduction

The whooping crane is a distinctive species found only in North America and is currently recovering its population to higher levels. It is the tallest of North American birds, standing nearly five-feet tall with a wingspan of 7-8 feet (Urbanek and Lewis 2015). Adult individuals are covered in white plumage with black primary feathers on the wings and a red face and crown, while plumage of juveniles is tinged reddish cinnamon in color (Allen 1952).

The historic population of the whooping crane was variously estimated at 500 to 1,400 individuals in 1870, with an overall range that extended from the Artic coast to central Mexico (Allen 1952). By 1941 the migratory population declined to only 16 individuals (Canadian Wildlife Service and USFWS 2005) and the species was listed as endangered in 1967 (USFWS 1986). The bulk of the population of whooping cranes today belongs to the Aransas-Wood Buffalo population, estimated at roughly 300 whooping cranes (Urbanek and Lewis 2015). Individuals in the Aransas–Wood Buffalo population are long-distance migrants that breed in Northwestern Canada and the Northern Territories. They arrive on breeding grounds in late April and individuals will typically lay two eggs between late April and early May, incubating for about a month, after which young are raised. Autumn migration begins in mid-September and most birds arrive on the wintering grounds on the Texas Gulf Coast by early to mid-December where they will remain until migrating north again in the spring (Allen 1952).

Individuals of the Aransas-Wood Buffalo population of the whooping crane migrate diurnally twice a year over the course of several weeks along a narrow corridor (approximately 200 miles wide and 2,485 miles in length) within the Central Flyway in the U.S. and Canada enroute between breeding and wintering grounds (Pearse et al. 2015). This migration corridor includes stopping points for roosting and foraging where whooping cranes will remain for one to several days to build energy reserves to complete migration (Howe 1989, Kuyt 1992, Canadian Wildlife Service and USFWS2007). At stopover sites, whooping cranes roost standing in shallow water associated with palustrine, lacustrine, or riverine wetlands. Some stopover sites in the migration corridor are used consistently and receive relatively high annual use. One of these sites, the Big Bend reach of the Platte River in central Nebraska, is the only stretch of river designated as critical whooping crane habitat under the Endangered Species Act (Armbruster 1990; Biology Workgroup 1990). Characteristics of central Platte River roost habitat have been examined and described in detail (Johnson 1981; Lingle et al. 1984; Ziewitz 1987; Faanes 1988; Faanes and Bowman 1992; Faanes et al. 1992). In early examinations of roost sites in the central Platte River, researchers identified wide, unvegetated channels and open visibility with the absence of tall trees or dense shrubs near the roost as important habitat characteristics (Johnson and Temple 1980; 1981; Johnson 1981; Ziewitz 1987; Armbruster 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004).

Characteristics of whooping crane roost habitat have been examined and described for the central Platte River in Nebraska (Johnson 1981; Lingle et al. 1984; Armbruster 1990; Faanes 1988; Faanes and Bowman 1992; Faanes et al. 1992). Several characteristics common to whooping crane riverine roost sites include shallow, wide, unvegetated channels and open visibility with the absence of tall trees or dense shrubs near the roost (Johnson and Temple 1980; USFWS 1981; Johnson 1981; Armbruster 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004). To date, however, roost characteristics and criteria have been developed based on a limited amount of quantitative information and most criteria have been derived from circumstantial roost locations that may not be representative of a typical stopover site (Armbruster 1990).

Farmer et al. (2005) reported whooping cranes selected channels with wider unobstructed channel widths at both scales they evaluated (i.e., use was not random with respect to unobstructed channel width). Past research indicates whooping cranes tend to select roost habitat with increased wetted width and area of suitable depth (Farmer et al. 2005). Unit discharge is related to flow, wetted width, and area of suitable depth in that an increase in unit discharge (increase in flow or decrease in channel width) would generally equate to an increase in wetted width and a decrease in area of suitable depth. A strong relationship between unit discharge or discharge divided by total channel width and whooping crane use was found by Biology Workgroup (1990) and Farmer et al. (2005). Additional studies are addressed in the Discussion section below.

The objective of this paper is to determine progress towards providing benefits to whooping cranes by 1) analyzing in-channel habitat selection by whooping cranes in the central Platte River, a primary stopover area, and 2) assessing trends in whooping crane use of the central Platte River over time. Inferences from this study will be influenced by fewer biases than past research on migrational habitat use by whooping cranes as the analysis is based on data from unbiased sampling using aerial surveys in a well-defined study area. Study results in the form of habitat characteristics associated with the highest selection ratios by whooping cranes will also help to inform future management actions by PRRIP.

Establishment of PRRIP

The Platte River Recovery Implementation Program (Program or PRRIP) was established as a program to manage land and water resources for whooping cranes within the central Platte River. Its origin goes back to efforts to relicense Kingsley Dam on the North Platte River in western Nebraska (PRRIP 2015). This relicensing was addressed at a time when threatened and endangered species such as the whooping crane were known to use the Platte River and the USFWS had released its 1994 Biological Opinion on Platte River operations; these factors combined to provide the potential for conflict over the Platte's vital water. Rather than engage in years of courtroom battles over limited water supplies and river species, the governors of the three basin states (Colorado, Nebraska, and Wyoming) joined with the Secretary of Interior in July 1997 to sign the "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitat along the Central Platte River, Nebraska" for the creation of PRRIP, which commenced on January 1, 2007, with its overall goal being to utilize federal and state provided land, water, and scientific monitoring and research to secure defined benefits for the whooping crane and its habitat in the central Platte River (PRRIP 2015).

Habitat Selection

For this analysis, we investigated habitat selection by whooping crane groups during migration stopovers on the central Platte River from fall 2001 to spring 2013. We fit statistical models to determine if there were habitat characteristics associated with the locations selected for use by whooping crane groups. We compared models containing different combinations of habitat descriptors to determine which were the most likely to describe selection by whooping cranes. The top models are intended to provide guidance for managing the central Platte River.

Habitat characteristics of use sites in the study area have typically been quantified using different metrics for in-channel (locations within the active channel) versus off-channel (locations outside of the active channel) use. Biologically, this equates to the assumption that whooping crane groups select for different habitat characteristics during the selection of in-channel versus off-channel use locations. This difference results in the need for two different habitat models, with the quantification of riverine metrics through hydraulic models restricted to the in-channel use locations. Here we have analyzed the in-channel habitat use locations that were observed from early morning aerial monitoring alone, while combining in-channel and off-channel habitat use for an additional study of habitat use during the diurnal time period when cranes were monitored by ground crews.

For the in-channel habitat use analysis we focused on the description of habitat metrics to facilitate application in PRRIP management. We quantified the characteristics of in-channel habitat with three basic sources of information: land cover vector shapefiles, aerial imagery, and the HEC-RAS hydraulic model. Each habitat descriptor was calculated with desktop analyses, at the time of the analysis, using consistent methods. There were no habitat descriptors measured in the field in the analysis. Our goal was to develop habitat models that could inform management using metrics that PRRIP will be able to measure and monitor.

For the diurnal habitat use analysis, we focused on descriptors of habitat metrics that could be measured for both in-channel and off-channel use locations. We quantified the characteristics of habitat with two basic sources of information: land cover vector shapefiles, and aerial imagery. As with the in-channel analysis, each habitat descriptor was quantified with desktop analyses to facilitate the development of models useful to PRRIP managers.

Trends in Use

The use of stopover habitat in the central Platte River by whooping cranes during migration has been monitored for the spring and fall seasons by PRRIP since spring 2001, with the exception of spring 2003. It is hypothesized that the incidence of whooping crane stopovers in the AHR will increase through time as PRRIP implements targeted management of land and water resources, although natural variation that will be inherent in sampled data of small populations like the whooping crane may have obscured any increases in the short-term. To evaluate this hypothesis, we investigated trends in the use of the central Platte River by groups of whooping cranes during migration stopovers on the central Platte River from spring 2001 to fall 2014.

For this analysis, we define trend as the change in the mean level of whooping crane use through time (Chatfield 2003). Consistent data collection for whooping crane group use by PRRIP in the study area is ideal for monitoring long term trends in use. Using these data, we estimated linear statistical models to determine if the mean level of use was increasing, decreasing, or not changing in the study area. Whooping crane use of the PRRIP study area was quantified in two ways: the number of cranes and the number of crane use days. This trend evaluation also accounted for the simultaneous change that has occurred in population size of whooping cranes that potentially stop on the central Platte River.

2. In-channel Habitat Selection Methods

The study area for the PRRIP monitoring program encompasses 3.5 miles on either side of the central Platte River from the junction of US Highway 283 and Interstate 80 (near Lexington, Nebraska to Chapman, Nebraska (PRRIP 2011). Aerial surveys were flown daily, weather permitting, during both migration seasons, with the spring time period spanning from March 21 to April 29, and the fall time period spanning from October 9 to November 10. Flights followed the main river channel and took place in the morning intending to locate crane groups before they departed the river to begin foraging. Return flights were scheduled after the main river channel flight and systematically surveyed upland areas and smaller side channels. Flights were flown at an elevation of 1,000 feet above ground as to not disturb whooping cranes as the plane passed over. A full description of the data collection methods can be found in the Program's Whooping Crane monitoring protocol (PRRIP 2011). All data were collected while adhering to the FWS guidelines regarding minimization or elimination of crane disturbance.

Whooping Crane Group Observation Data

The basic sample unit for this analysis was the location of a crane group within the study area. The PRRIP monitoring program compiled observations of crane groups in the study area into a dataset; the observations include those that were identified with the systematic aerial surveys, follow-up ground monitoring efforts, and opportunistically identified locations from the public and other professional biologists (Table 1). Analyses presented here only pertain to the data collected through the systematic aerial PRRIP surveys and for the first location of a crane group in the area. For example, if a crane group was identified using the channel multiple times throughout the day, or multiple days in a row, then only the first detection was included here, if it was identified with the aerial survey. We considered the first observation of a crane group as "unique", or independent, and did not include subsequent in-channel observations to ensure independence of observations. This dataset, and associated analysis, based only on observations from the aerial survey was intended to be representative of the entire study area and not biased by multiple observations of the same crane group or observations obtained by convenience sampling.

While PRRIP designed systematic aerial sampling of whooping crane use locations to ensure analyses could be conducted with data that were unbiased with respect to sampling methods, the abundance of data collected during multi-day stopovers provide an opportunity to conduct more robust analyses and evaluate the impacts of additional data on conclusions. Therefore, we conducted a second analysis of the data with all the systematically identified locations, both unique and non-unique, which can be found in Appendix C. Multiple observations of the same crane group were included. We performed a third analysis of the data with all locations in the PRRIP dataset, which is presented in Appendix D. This analysis included systematic and opportunistic sightings and multiple observations of the same crane group. The impact of the inclusion of non-unique observations in a subsequent analysis was evaluated using the same methods as for the systematic unique assessment presented here.

The use of stopover habitat by whooping cranes during migration has been monitored by the PRRIP since spring 2001, with the exception of spring 2003. By the end of 2002, the Program adopted a consistent monitoring protocol for the aerial survey methodology. Minor operating procedures were changed as a result of evaluations conducted during the early years (e.g., flight height, flight direction). Coincidently, our analysis excluded observations of crane groups during 2001 and spring of 2002 due to the lack of landcover data in 2001 and early 2002, but had the effect of removing survey data that was obtained during the years with slightly different survey methods. Analyses presented here were based on model selection with whooping crane group observations from fall 2002 to spring 2013 when the protocol remained consistent and land cover descriptors of habitat were available, while predictions and inferences from the resulting models included all observations.

Table 1. Number of in-channel observations of whooping crane groups detected in the study area during PRRIP surveys and opportunistically from fall 2001 to spring 2013. Analyses presented in this report were conducted with the systematic unique data. We present analyses with all systematic in-channel observations in Appendix C, and analyses with all systematic and opportunistic in-channel observations in Appendix D.

Year	Systematic Unique	All Systematic (Unique and Non-unique)	All Systematic And Opportunistic
2001	1	4	7
2002	4	20	22
2003	1	1	1
2004	1	2	3
2005	4	6	6
2006	4	27	28
2007	7	31	37
2008	3	5	6
2009	7	23	23
2010	8	20	21
2011	8	16	23
2012	1	7	39
2013	6	14	38
Total	55	176	253

Whooping Crane In-channel Habitat Selection

We evaluated habitat selection by whooping crane groups in the central Platte within the Resource Selection Function (RSF) estimation framework. In this model, characteristics of points (i.e., locations) used by whooping cranes were contrasted to characteristics of points available for use to the whooping crane. The relative difference in the distribution, or density, of these characteristics defines habitat selection. For example, cranes may choose to roost in a river channel of a certain depth while there are many deeper and shallower channels that they could have selected to roost. Multiple modelling paradigms were available for this estimation due to recent statistical advances which have demonstrated that spatial point process models underlie both the use-available approach and the presence-only approach (Johnson et al. 2006, Aarts et al. 2012, McDonald 2013, Warton and Aarts 2013). We chose the use-available approach for this study because of the need to handle an important factor that affects whooping crane selection in the central Platte River: changing availability.

Analyzing wildlife selection with changing availability has been a part of the RSF literature for more than 20 years (Johnson 1980, Arthur et al. 1996, McCracken et al. 1998, Manly et al. 2002, McDonald et al. 2006). Whooping crane use of the Platte River represents a unique situation in that availability of resources changes both temporally and spatially. A special case of RSF estimation, the discrete choice framework of analysis, accounts for changing availability in model estimation. By incorporating changing availability, the variability associated with the dynamic nature of riverine habitat was accounted for in the habitat selection model.

In-channel habitat available for use by whooping cranes is chiefly a function of river hydrology, adjacent and in-channel vegetation, and human disturbance. Natural snowmelt and rainfall, hydroelectric operations, and irrigation activities chiefly influence in-channel streamflow in the central Platte River. During a multi-night stopover by a whooping crane group, there can be a dramatic range in the volume of in-stream flows. As the characteristics of available habitat change temporally during a crane group stopover, so too does the definition of available habitat in this analysis.

The spatial aspect of changing habitat conditions is primarily due to the variability in geomorphic channel type throughout the 80 mile habitat reach. As an aerially migrating whooping crane group approaches the river, the options for a stopover location are presumably limited by sight to a reduced section of the study reach. We assumed that the entire length of the central Platte was not available to the migrating group, but rather the group evaluated a subsection during the selection process. We also assumed that this subsection was near the chosen use point. We acknowledge there may be exceptions to this, but we believe they are rare. Therefore, our definition of available habitat for crane groups was centered on the actual location used and changes spatially for crane groups in the area.

We have chosen the discrete choice method of RSF estimation to incorporate changing availability at temporal and spatial scales. The discrete choice model accounts for changing habitat conditions in the study area, while modeling the underlying relationships between selection and predictor variables. We handled non-linear changes in the RSF due to changing availability with penalized regression splines to approximate the functional response (Aarts et al. 2013). With the exception of mixed linear models (Hebblewhite and Merril 2008, Duchesne et al. 2010, Matthiopoulos 2011), other methods of estimating RSF's using the inhomogenous point process have not incorporated this facet of habitat selection into the statistical underpinnings of the method. It may be possible that recent advances in space-time point process models proposed by Johnson et al. (2013) may be appropriate for this type of data (Trevor Hefley, pers. Comm.), but the method does not address the incorporation of changing availability at this time.

Defining the Available Choice Set

The choice set represents a sample of points from an area that the crane group could have selected for use. This distribution is analogous to the background sample in Maxent (Phillips et al. 2006, Phillips and Dudik 2008) and the quadrature points in point process models (Warton and Shepherd 2010). In the discrete choice framework, the choice set is unique for each choice, or used location, and is linked to the choice through the likelihood terms in the model. In effect, the model allows the comparison between characteristics of each used location and the characteristics of the choice set. This pairing in the model is accomplished through the use of a strata term in the Cox model within the generalized additive model (GAM) framework using the `gam` function in the mgcv package (Wood 2014, R Core Team 2013).

For the in-channel habitat use analysis, the choice set was centered on the use location and extended 10 miles upstream and downstream from that point. We assumed the cranes could reasonably evaluate this area based on an assessment of viewsheds from 3,000 feet above ground level by PRRIP personnel, which was a reported elevation for long distance flights by telemetry-marked whooping cranes in the 1980s (Kuyt 1992). The sensitivity of results to this assumption was tested using an available area of 5 miles upstream and downstream of the use locations and we found our results were insensitive to what was defined to be available. There were 20 locations in the choice set for each use location in the model. This description of the choice set had the effect of limiting inference of the in-channel habitat model to areas within 10 miles of selected use locations, but was implemented in order to facilitate the study of habitat selection at the spatial scale of interest. The determination to use 20 locations in the choice set was determined based on a Monte Carlo simulation by PRRIP personnel. The analysis evaluated the change in the percent mean error of the average of one hydraulic metric across adjacent profiles simulated across a range of sample sizes from 2 to 200. The simulation results showed little decrease in percent mean error of the statistic after a sample size of 20 was reached.

Descriptors of In-channel Habitat

We quantified the characteristics of in-channel habitat with three basic sources of information: land cover vector shapefiles, aerial imagery, and the HEC-RAS hydraulic model. We calculated each descriptor of habitat for possible inclusion as a predictor variable in the habitat models. We calculated the metrics for both the whooping crane use point and the available points in the choice set.

We obtained land cover information from the land cover product produced for the PRRIP by USFWS-Rainwater Basin Joint Venture. This GIS product is a compilation of agriculture crop information taken from the USDA National Agricultural Statistics Service 2012 Nebraska Cropland Data Layer (CDL, Boryan et al. 2011) with field boundaries from USDA Farm Service Agency Common Land Unit (CLU). We calculated the following metrics for the analysis:

- Proportion Corn (PC)- Proportion of landcover within 3-mile radius buffer classified as corn
- Proportion Forest (PF)- Proportion of landcover within 3-mile radius buffer classified as forest
- Proportion Grassland (PG)- Proportion of landcover within 3-mile radius buffer classified as grassland
- Proportion Wet Meadow (PWM)- Proportion of landcover within 3-mile radius buffer classified as wet meadow
- Unforested Width (UFW)- Width of river corridor unobstructed by riparian forest
- Nearest Forest (NF)- Distance to nearest riparian forest. Distance larger than 1320 feet (1/4/ mile) were capped at 1320 feet.

We used aerial photographs and remote sensing data from LiDAR to determine the following metrics of channel openness for the analysis:

- Unobstructed Channel Width (UOCW)- Width of channel unobstructed by dense vegetation
- Nearest Obstruction (NO)- Distance to nearest dense vegetation.

We ran the HEC-RAS hydraulic model to predict metrics describing channel characteristics for the analysis. The Program developed the HEC-RAS model primarily using longitudinal profile surveys updated with 2009 topography, and 2005 land use conditions. The Program calibrated the model based on gaged rating curves, March 2009 inferred water surface elevation from LiDAR data, and water surface elevation measured in 2009. We calculated the following metrics for the analysis:

- Total Channel Width (TCW)- Total width of channel from left bank to right bank
- Wetted Width (WW)- Top width of wetted channel

- Proportion Wetted (PW)- Proportion of total channel width that was wetted
- Mean Depth (MD)-Mean depth of the wetted portion of the channel
- Unit Discharge (UD)- Flow (cfs) per linear foot of channel width.
- Width Depth Ratio (WDR)- Ratio of channel width to depth (WW/MD).

Data Summaries

For each descriptor of in-channel habitat, or the predictor variable, we developed mirrored histograms to graphically display the data. These figures show the distribution of the values for each variable in order to contrast the distribution for the set actually chosen by whooping cranes to the available set. For each probability histogram, the area of the bars sums to one. Although these figures display the relationship between the predictor variables and the outcome (use by whooping cranes), they simplify the assessment by combining data across the many choice sets. Despite this caveat, they are presented in Appendix B to provide a graphical precursor to understanding the statistical models of habitat use. Mean, standard deviation and coefficient of variation for each variable are in Table B.1 of Appendix B.

Candidate Model List/Model Selection

The PRRIP staff and Program Technical Advisory Committee members developed a list of 184 candidate models, each containing a different combination of covariates (predictor variables). This set of models, with the inclusion of a null model containing no covariates, composed the complete set of *a priori* models evaluated (Appendix A, Table A.1). We determined which *a priori* model was most useful in predicting habitat use with the model selection process known as the Akaike Information Criterion statistic (AIC, Burnham and Anderson 2002). The model in the *a priori* list with the lowest AIC value was considered the most parsimonious and the most likely given the data. This model was used to infer conclusions about habitat use. We also calculated the AIC weight to assist in the interpretation of the AIC rankings. The AIC weights were calculated for each model as the proportion of the relative likelihood of the model to the sum of the relative likelihoods over the complete model set. The weights express the magnitude of the difference in relative likelihood of a model, standardized to sum to 1 across all models in the candidate model list.

Management Model List

For the next step, we selected a subset of 10 of the *a priori* candidate models for the candidate management model list (Appendix A, Table A.1). We retained models from the list of 184 candidate models in this list if they contained variables that potentially could be used in management of the river by the PRRIP. PRRIP staff determined the management potential of each variable, i.e., which variables were ones they could affect physically on the ground and in relation to where whooping cranes may roost. In general, landcover variables were not included in these models, with the exception of nearest forest. We included unobstructed channel width, total channel width, and unit discharge in these models.

Functional Response to Resource Selection

We used penalized regression spline methodology to evaluate a functional response in habitat use. Resource selection models evaluate functional responses, i.e., the change in selection as a function of spatial or temporal changes in resource availability, and spline smoothers allow for non-linear effects. Smooth spline functions enabled a wide array of functional forms to be incorporated into the RSF, with the implementation of model selection determining the precise shape of the functional response. The smooth term was represented in the habitat model with a set of basis functions and associated penalties (Hastie and Tibshirani 1990, Wood 2006). The penalty was larger when the smoothing function was very "wiggly" and requires more degrees of freedom. The degrees of freedom for each smooth term was optimized for each iteration when the likelihood was maximized.

Statistical Modeling of Habitat Use/Resource Selection

Resource selection functions were developed to evaluate characteristics of whooping crane habitat selection in the central Platte River. The basic premise of resource selection modeling is that resources (which may be food items, land cover types, or any quantifiable habitat characteristic) that are important to cranes will be "used" disproportionately to the availability of those resources in the environment (Manly et al. 2002). In this analysis, we contrasted the characteristics at the used locations to characteristics at randomly selected "available" locations in the study area.

To model habitat selection, a discrete choice model (Manly et al. 2002) of resource selection was fit to the data. This model enables us to model habitat selection when the habitat that was available for use changes both temporally and spatially. The model was an exponential model of the form:

$$w(X_{ij}) = \exp(s_1(X_{1ij}) + s_2(X_{2ij}) + \cdots + s_p(X_{pij}))$$

where X_1 to X_p are habitat metrics, j indexes the units in the choice set, and i indexes the unit selected, s_1 to s_p are the smooth functions of X_1 to X_p, respectively. The smooth terms are penalized regression splines, or smooth functions of the predictor variables describing the relationship between selection and the habitat metrics. The incorporation of penalized regression splines (i.e., smooth terms) into the linear predictor of the model is analogous to the parameterization of a GAM (Wood 2006).

The use-availability likelihood was maximized using R statistical software (R Core Team 2013), specifically the `gam` function of the mgcv package within R. The mgcv package determines the smoothness of the spline, and associated degrees of freedom, through iteratively re-weighted least squares fitting of the penalized likelihood (Wood 2006). The penalty for the smoothing parameter was determined for each iteration using generalized cross validation (GCV). We determined the final model among the set of candidate models with AIC criterion.

We interpreted the relationship between covariates in the model and habitat selection through response functions (see next section) and the degrees of freedom for the smooth terms. The estimated degrees of freedom indicate the amount of smoothness, with a value of 1 equivalent to a straight line. In cases where the estimated degrees of freedom were 1, we removed the smoothing component for that covariate and fit a parametric straight line. We only present p-values indicating the significance of the smoothed terms if the null hypothesis was not rejected, because these tests are known to reject the null too often when using penalized likelihood models (Wood 2006).

Response Functions

After identifying the best fit models, we estimated the predicted relative selection ratios across the range of observed values of the covariates in the models. This analysis provided a graphical display of the modelled relationship between the predictor variables (habitat characteristics) and the response (use by whooping cranes), holding constant the effects of the other variables in the model. These plots are analogous to two-dimensional partial-regression plots. The 90% confidence intervals for the response functions are approximated using a Taylor expansion approach (Wood 2006). For models without landcover metrics, the entire dataset, including 2001 and spring of 2002 was used for prediction.

Graphical displays of response functions were combined with rug plots to show the underlying data in model fitting. Rug plots display a tick mark for each data point in the model, with used points displayed at the top (use equals 1) and the choice set displayed at the bottom of the figure (use equals 0). The displayed outcome resembles that of a shag carpet, or rug. Response functions were scaled to the maximum value of the upper limit of the 90% confidence interval (maximum equals 1) and only displayed out to the 75th percentile of the use points in order to limit the influence of values from the extreme end of the distribution (i.e., the largest values for habitat characteristics) in the interpretation of the results.

Statistical Modeling of Aerial Survey Detection

Members of the aerial survey crews used whooping crane decoys to conduct trials to measure the detection efficiency of observers on a sample of the daily aerial flights. The detection trials were intended to evaluate the probability of detecting whooping cranes during aerial surveys. Detection trials were conducted using a life-size whooping crane decoy placed in the area where an aerial survey was to be conducted. All trials were conducted using single decoys randomly placed on accessible conservation lands during 2001-2010 and all accessible land (privately owned or otherwise) during 2011-2013. We acknowledge the limitation of using single plastic decoys in lieu of a real feathered bird, possibly within a flock.

The number of decoys detected during the aerial flights was assumed to follow a binomial distribution with parameters n (the number of decoy trials) and p (the detection probability) (Reed 1996). Logistic regression models were developed to determine the influence of several factors on the probability of detection. Each descriptor of in-channel habitat (see above) was evaluated for inclusion in the model. There were a total of 197 detection trials from fall 2002 to spring 2013 in the model.

After identifying the best fit in-channel models, we evaluated each covariate for influence on the probability of detection. The covariates in the in-channel models were fit one at a time into the linear predictor of the probability of detection model to determine the significance of the linear fit. We conducted this analysis to determine if there was evidence of biased detection probabilities for whooping cranes in the study area, and if there was a need to account for this effect in the habitat analyses.

3. Diurnal Habitat Selection Methods

Analyses presented here pertain to the data collected through the systematic aerial PRRIP surveys used to document nocturnal roost locations and described above in section “Whooping Crane In-channel Habitat Selection” and all subsequent diurnal locations of crane groups documented in the study area by ground monitoring crews. Diurnal habitat use includes in-channel observations and out-of-channel observations that occurred within the study area during the day. The study area and data collection methods were described above in the in-channel habitat selection methods. The basic sample unit for this analysis was the location of a crane group within the study area. The data for this model comes from the PRRIP continuous use monitoring.

Whooping Crane Group Observation Data

Diurnal observations of crane groups in the study area were identified with the systematic aerial surveys and follow-up ground monitoring. We only included 1 roost location per crane group per day. We considered diurnal observations of a crane group independent if they were separated in time by 2.5 hours or more. This analysis was restricted to observations of crane groups that were first identified by the aerial survey. The dataset was intended to be representative of the entire study area and not biased by observations obtained by convenience sampling. This analysis excluded observations of crane groups during 2001 and spring of 2002 due to the lack of landcover data for 2001 and early 2002.

The ground monitoring effort, also called continuous use monitoring, identified locations of whooping crane group use both within the channel and outside the channel. Observers recorded the location of a crane group in the study area, including land cover type, every 10 minutes. In some cases, all observations for a crane group were in one contiguous land cover type, in other cases the crane group moved among land cover types. The continuous use monitoring dataset of these 10 minute increments was subsampled with frequency to satisfy independence assumptions, resulting in a dataset with multiple observations per crane group that were weighted by the length of time the crane group spent in the land cover type.

Whooping Crane Diurnal Habitat Selection

We evaluated habitat selection by whooping crane groups in the central Platte within the RSF estimation framework described for the in-channel habitat selection above. We used the discrete choice method of RSF estimation including penalized regression splines to approximate functional response.

<u>Defining the Available Choice Set</u>

For the diurnal habitat use analysis, the choice set was centered on the use location and extended 3 miles in all directions from that point. The habitat within the choice set area was described at a set of 1,171 points systematically spaced at 250m intervals. We assumed the cranes could reasonably evaluate this area while moving among use locations within the study area. To improve computer processing speeds during model selection, each choice set was sampled randomly to obtain a sample size of 50 for each choice set.

<u>Descriptors of Diurnal Habitat</u>

We quantified the characteristics of in-channel habitat with two basic sources of information: land cover vector shapefiles, and LiDAR. We calculated each descriptor of habitat for possible inclusion as a predictor variable in the habitat models. We calculated the metrics for both the whooping crane use point and the available points in the choice set.

We calculated the following metrics for the analysis using the land cover product generated by the USFWS-Rainwater Basin Joint Venture described above:

- Land cover type (LC)- Categories of land cover were 1) Corn, 2) Alfalfa, 3) Soybeans, 4) Wheat, 5) Channel, 6) Developed, 7) Grassland, 8) Trees, 9) Palustrine wetlands, 10) Wet meadow

We used aerial photographs and remote sensing data from LiDAR to determine the following metrics for the analysis:

- Nearest obstruction (NO)- Distance to nearest obstruction defined as trees greater than 1.5m high.

- Nearest disturbance (ND)- Distance to nearest disturbance defined as a house, town, road or railroad.

We used the crane group use location to calculate the following:

- Proximity to the roost location (PRL)- Distance to the roost location used by the crane group the previous night.

<u>Data Summaries</u>

Mirrored histograms, as described in the in-channel section, and summary statistics were made for the 3 continuous descriptors of diurnal habitat for the model selection dataset, from fall 2002 to spring 2013 (Appendix E).

<u>Candidate Model List/Model Selection</u>

The PRRIP staff and Technical Advisory Committee members developed a list of 15 candidate models, each containing a different combination of covariates (predictor variables). This set of models, with the inclusion of a null model containing no covariates, composed the complete set of *a priori* models evaluated (Appendix A, Table A.2). We determined which *a priori* model was most useful in predicting habitat use with the model selection process known as the Akaike Information Criterion statistic (AIC, Burnham and Anderson 2002). The model in the *a priori* list with the lowest AIC value was considered the most parsimonious and likely given the data and then used to infer conclusions about habitat use. AIC weights were calculated to assist in the interpretation of AIC rankings.

<u>Statistical Model</u>

We evaluated the characteristics of diurnal whooping crane habitat selection using the same statistical model described in the in-channel methods section. The functional response in habitat use was quantified using penalized regression splines in the resource selection function. Degrees of freedom for the regression splines were limited to 5 to facilitate model convergence. Predicted relative selection ratios across the range of the observed values of the covariates was estimated to facilitate model interpretation, as described above.

4. Trend Methods

Whooping Crane Group Observation Data

The study area for the PRRIP monitoring program encompasses 3.5 miles on either side of the central Platte River from the junction of US Highway 283 and Interstate 80 near Lexington, Nebraska, to Chapman, Nebraska (PRRIP 2011). Aerial surveys were flown daily, weather permitting, during both migration seasons, with the spring time period spanning from March 21 to April 29, and the fall time period spanning from October 9 to November 10. Flights followed the main river channel and took place in the morning, intended to locate crane groups before they departed the river to begin foraging. Return flights were scheduled after the main river channel flight and systematically surveyed upland areas and smaller side channels. A full description of the data collection methods can be found in the Program's Whooping Crane monitoring protocol (PRRIP 2011).

We compiled the observations of crane groups in the PRRIP monitoring program in the study area that were identified by the Program's monitoring contractor as well as opportunistic sightings that were reported by the public during the monitoring seasons. Crane groups were observed from either the air or the ground. There were a total of 25 survey seasons from spring 2001 to fall 2014, with the single exception of spring 2003.

Aransas-Wood Buffalo Whooping Crane Population Estimates

Biologists at the Aransas National Wildlife Refuge have conducted a winter aerial survey of the whooping crane population since 1950 (Stehn and Taylor 2008). In 2011, the survey methods were revisited and a new protocol was implemented to address issues of imperfect detection and expansion of the survey area (Butler et al. 2014). Despite the change in methods beginning in fall 2011, the two surveys represent the best available information on the size of the migrating population.

The population estimate of the Aransas-Wood Buffalo population, made in the winter every year at the Aransas National Wildlife Refuge in Texas and reported to PRRIP by the U.S. Fish and Wildlife Service (USFWS), has increased from 174 cranes in 2001 to 314 cranes in 2014 (Stehn and Taylor 2008, USFWS 2015). There has been an estimated increase in the size of the population of 4% per year (USFWS 2015) from 1938 to 2014 (Figure 1).

For the central Platte River use trend analysis, the population estimate for 2001 to 2011 came from the aerial survey during the time the population wintered in the Aransas, Texas area. This estimate was assumed to be for the same population that migrated across the central Platte River study area during spring migration following the survey. The fall estimate of the population from 2001 to 2011 came from the spring estimate, with documented mortality removed and the number of juveniles counted at Wood Buffalo added. For this analysis, the population estimate from fall 2011 to fall 2014 came from the sum of the winter aerial survey estimate and the number assumed to spend the winter beyond the primary survey area (USFWS 2015). The estimate from each winter survey was assumed to be for the same population that migrated across the central Platte River study area in the following spring and fall migration seasons.

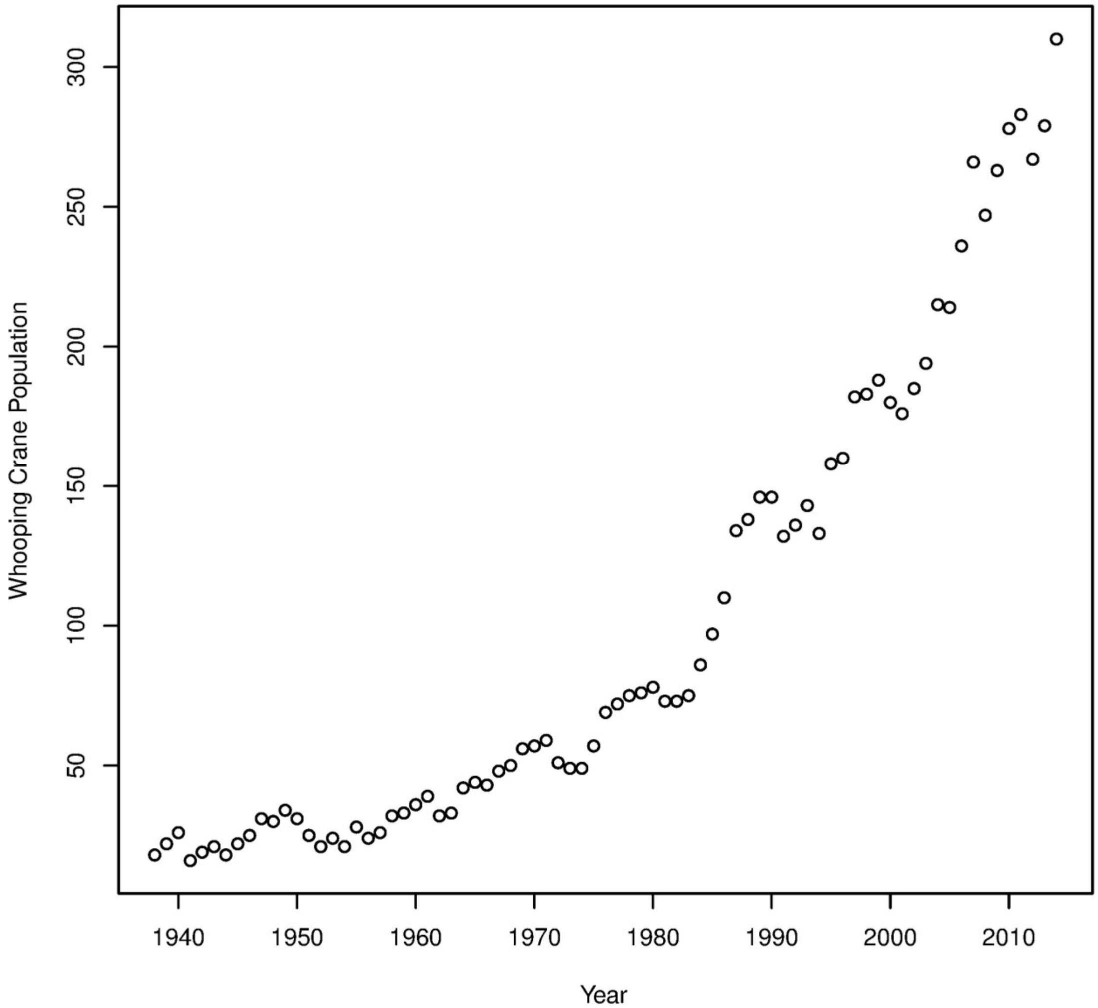


Figure 1. Trend in the estimated population size of the Aransas-Wood Buffalo whooping crane population from 1938 to 2014.

Statistical Methods

We analyzed two response metrics for the presence of trends across surveys: number of cranes and the number of crane use days. We divided each metric by the estimated size of the Aransas-Wood Buffalo population from the most recent survey, to account for the documented increase in the population of migrating cranes that could have stopped in the central Platte River. We quantified the proportion of the population using the central Platte River as the ratio of the number of cranes observed in the study area to the population size. We also quantified the crane use days per bird in the population as the ratio of the number of crane use days in the study area to the population size. We estimated trends in each metric separately for the spring and fall seasons and for both seasons combined. We used the data analysis package R to fit models (R Core Team 2013).

We developed the model structure for the trend estimation by evaluating the time series and auto-correlation functions for each response metric. We tested for correlation over time in the error terms. Based on these results, we were able to develop models assuming independent error terms (Kutner et al. 2005). Linear statistical models were fit for each metric with a continuous time covariate. We interpreted the p-value on the effect of time to determine if the trend was significantly different from zero at the alpha equal to 0.10 level of significance. We plotted the trend estimate with a 90% confidence interval.

We also estimated the Spearman rank correlation coefficient as a non-parametric estimate of the correlation between each use metric and time. This statistic evaluates the monotonic correlation and is more resistant to outliers than linear modelling. The test for a significant difference from zero was based on Spearman's rank correlation test using the exact distribution for sample sizes less than 22 (Savicky 2014). We interpreted the significance of the test statistic to identify the extent of corroboration with the significance of the linear trend estimate.

5. In-channel Habitat Selection Results

Whooping Crane Group Observations

We developed in-channel habitat selection models for the 33 spring, 22 fall, and the combined 55 spring and fall systematic and unique observations of whooping crane groups (Table 2, Figure 2). These observations span the time from fall 2001 to spring 2013. Actual sample sizes for the models were larger because of the inclusion of the data representing the choice set (Table 2).

Table 2. Sample size for in-channel models with 20 available locations in each choice set in addition to the location used by the whooping crane group. Observations of whooping cranes were obtained by systematic sampling through aerial surveys from fall 2001 to spring 2013.

Season	Number of Use Locations in Analysis	Total Number of Data Points in Analysis
Spring	33	693
Fall	22	462
Spring and Fall Combined	55	1155

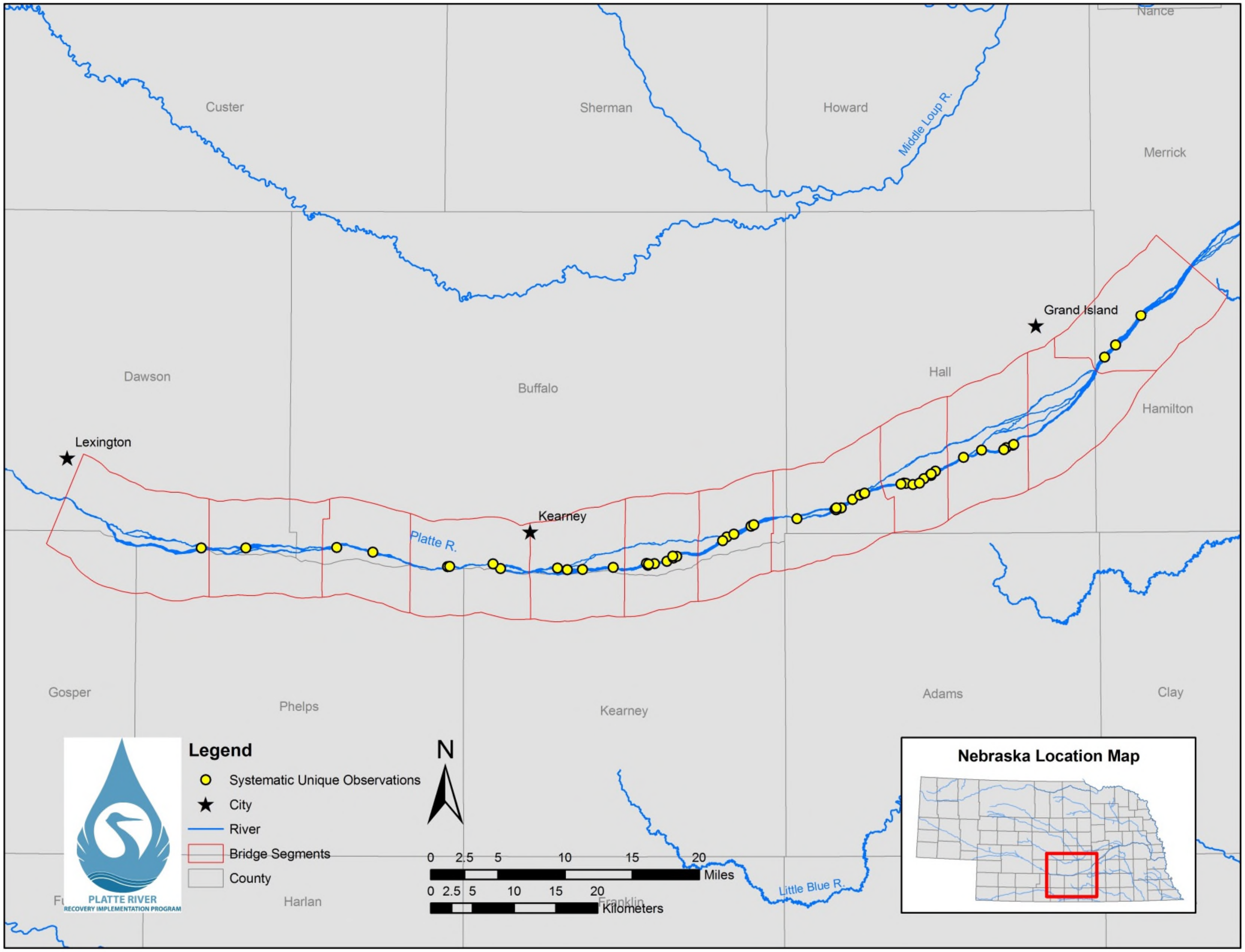


Figure 2. Spatial distribution of the in-channel systematic unique observations of whooping crane groups on the central Platte River from spring 2001 to spring 2013.

In-channel Habitat Selection for Spring and Fall Combined

Statistical modeling of habitat use indicated unobstructed channel width and nearest forest were the most important predictor variables for management purposes (Table 3). In addition, the top model exhibited a lower AIC value than an intercept only model. Additional variables in the top five models included total channel width, and unit discharge.

Table 3. Top management models for in-channel habitat use in the spring and fall, ranked by the AIC statistic. The AIC value for the null model was 847.57.

Rank	AIC value	AIC Weight	Covariates
1	826.83	0.45	UOCW + NF
2	828.45	0.20	UOCW + NF + TCW + UD
3	828.75	0.17	UOCW + NF + TCW
4	830.24	0.08	NF
5	831.93	0.04	NF + TCW + UD

* For definitions of covariates, see section in Methods titled, "Descriptors of In-channel Habitat"

The estimated smoothing spline functions for each of the variables in the top model were quadratic shapes depicting predicted selection ratios positively increasing with larger values of unobstructed channel width and nearest forest up to a point, after which declines were predicted. The model results for unobstructed channel width indicated the highest value predicted selection ratio to occur at 488 feet (Figure 3), though the relationship was not statistically significant ($p=0.0650$). Increased nearest forest was associated with a higher predicted relative selection ratios up to the highest selection ratio predicted to occur at 523 feet from the center of the channel (Figure 4). The estimated degrees of freedom for the smoothed terms were 3.47 and 3.69 for unobstructed channel width and nearest forest, respectively.

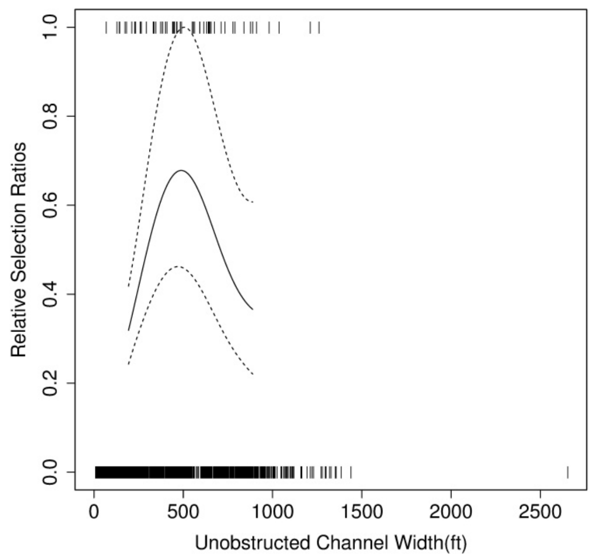


Figure 3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 488 feet at the mean value of nearest forest.

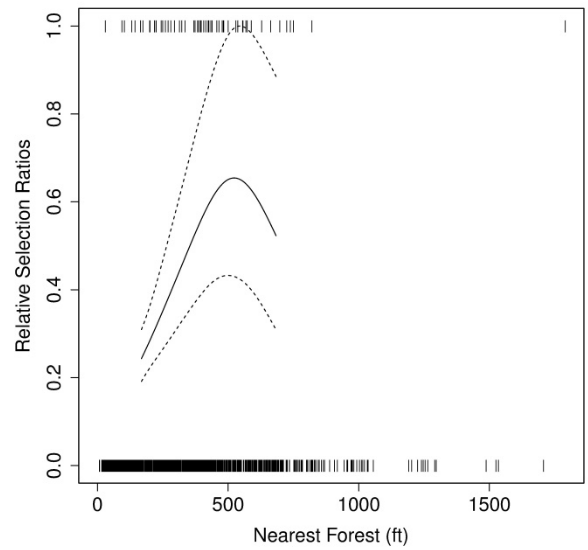


Figure 4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 523 feet at the mean value of unobstructed channel width.

Model selection for in-channel habitat use for the spring and fall observations combined, across every candidate model in the *a priori* set, indicated nearest obstruction and nearest forest were the most important predictor variables (Table 4). Nearest obstruction was present in all of the top 5 models, and nearest forest was present in four of the top five models. These models do not appear at the top of the management model list because PRRIP staff does not consider nearest obstruction to be a variable that can be managed relative to where a whooping crane selects to roost (i.e., they could roost next to a vegetated bank in a wide unobstructed channel). The top model exhibited a lower AIC value than an intercept only model. The estimated smoothing spline functions for each of the variables in the top model were quadratic shapes depicting predicted selection ratios positively increasing with larger values of nearest obstruction and nearest forest up to a point, after which declines were predicted. The model results for nearest obstruction indicated the highest predicted selection ratio to occur at 144 feet (Figure 5). Increased distance to nearest forest was associated with a higher predicted relative selection ratios up to the highest selection ratio predicted to occur at 533 feet from the center of the channel (Figure 6), though the relationship was not statistically significant (p=0.0702). The estimated degrees of freedom for the smoothed terms were 3.43 and 3.40 for nearest obstruction and nearest forest respectively.

Table 4. Top models for in-channel habitat use in the spring and fall, ranked by the AIC statistic. The AIC value for the null model was 847.57.

Rank	AIC value	AIC Weight	Covariates
1	816.22	0.08	NO + NF
2	817.33	0.04	NO + NF + TCW + UD
3	817.45	0.04	NO + NF + TCW
4	817.69	0.04	NO + UOCW
5	817.71	0.04	NO + NF + PF

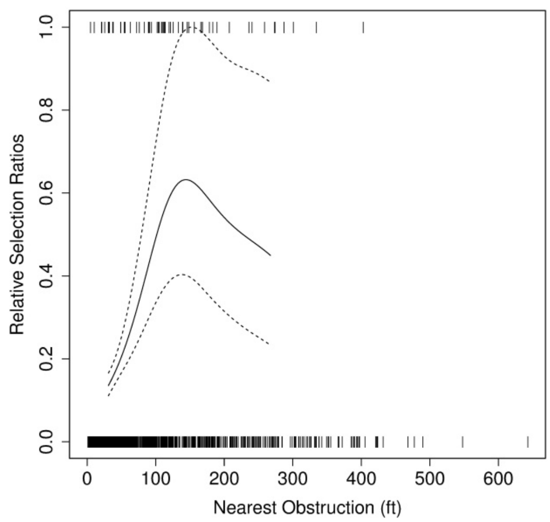


Figure 5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 144 feet at the mean value of nearest forest.

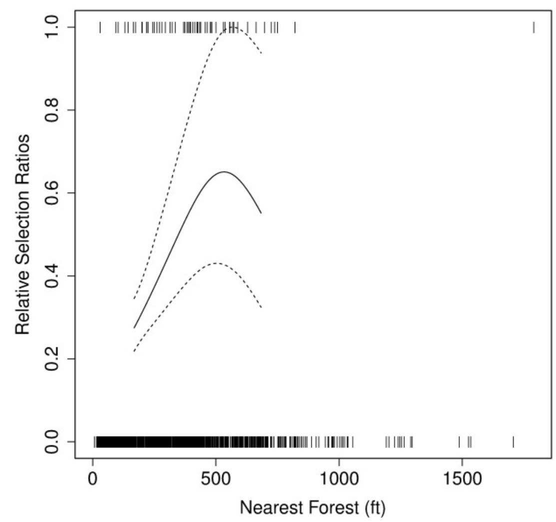


Figure 6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 533 feet at the mean value of nearest obstruction.

Spring In-channel Habitat Selection

Model selection for in-channel habitat use for the spring observations, across every candidate model in the *a priori* set, indicated nearest obstruction was the most important predictor variables (Table 5). Nearest obstruction was present in all five of the top five models. The top model exhibited a lower AIC value than an intercept only model. Additional variables in the top five models included total channel width, unit discharge, proportion forest, and nearest forest.

Table 5. Top models for in-channel habitat use in the spring, ranked by AIC statistic. The AIC value for the null model was 478.66.

Rank	AIC value	AIC Weight	Covariates
1	451.16	0.08	NO
2	451.61	0.06	NO + TWC + UD
3	452.14	0.05	NO + PF
4	452.28	0.04	NO + NF
5	452.60	0.04	NO + TCW + UFW + UD

The estimated smoothing spline function for nearest obstruction was quadratic shaped depicting predicted selection ratios positively increasing with larger values up to a point, after which declines were predicted. The model results for unobstructed channel width indicated the highest predicted selection ratio to occur at 136 feet (Figure 7). The estimated degrees of freedom for the smoothed term was 3.17.

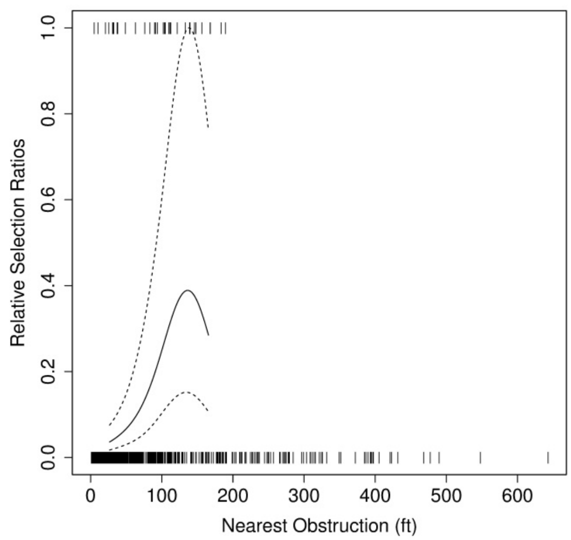


Figure 7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 136 feet.

Fall In-channel Habitat Selection

Model selection for in-channel habitat use for the fall observations, across every candidate model in the *a priori* set, indicated nearest obstruction, total channel width, nearest forest, and unit discharge were the most important predictor variables for management purposes (Table 6). The top model exhibited a lower AIC value than an intercept only model. Additional variables in the top five models included unforested width, width to depth ratio, and proportion corn.

Table 6. Top models for in-channel habitat use in the fall, ranked by AIC statistic. The AIC value for the null model was 295.74.

Rank	AIC value	AIC Weight	Covariates
1	276.90	0.05	NO + TCW
2	276.97	0.05	NO + TCW + NF
3	277.01	0.05	NO + TCW + NF + UD
4	277.08	0.05	NO + TCW + UD
5	277.70	0.03	NO + TCW + PC

The estimated smoothing spline functions for nearest obstruction was positively increasing with larger values, indicating a positive relationship between predicted relative selection ratios and nearest obstruction. The model results indicate increased nearest obstruction was associated with a higher predicted relative selection ratios with the highest value predicted to occur at 299 feet (Figure 8). Increased total channel width was associated with variable relative selection ratios with lowest predicted values to occur at 1158 feet (Figure 9). The estimated degrees of freedom for the smoothed terms were 2.18 and 4.07 for nearest obstruction and total channel width respectively.

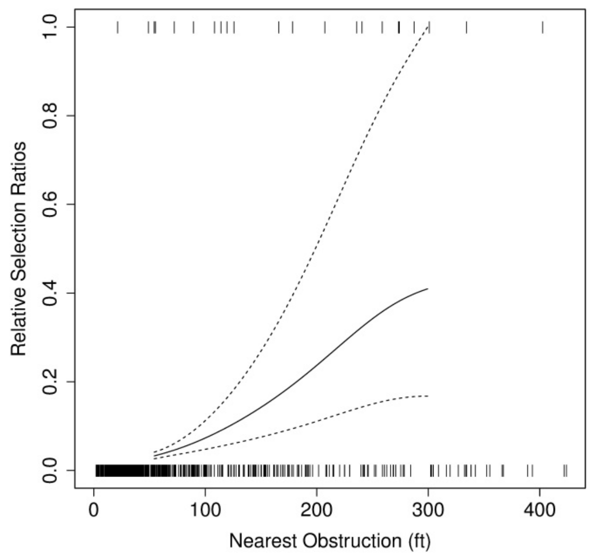


Figure 8. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest selection ratio value was predicted to occur at 299 feet at the mean value of total channel width.

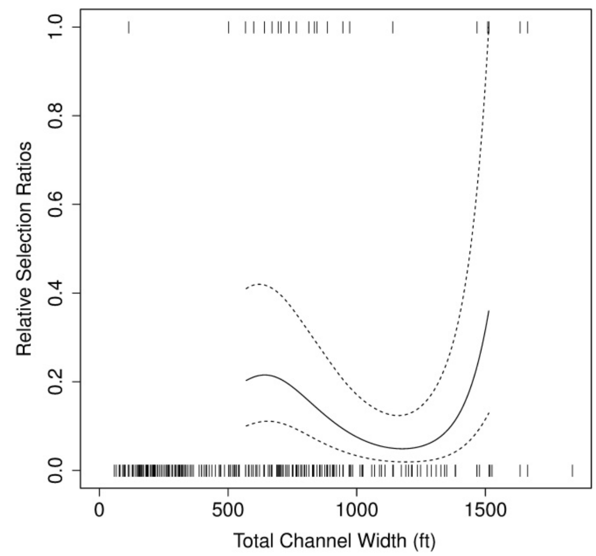


Figure 9. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to total channel widths in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The lowest selection ratio value was predicted to occur at 1158 feet at the mean value of nearest obstruction.

Aerial Survey Detection

The in-channel covariates were not found to be statistically significant predictors of detection probability. Each covariate had a non-significant linear effect. The p-value on the linear effect of unobstructed channel width was 0.2010, nearest forest was 0.1806, and nearest obstruction was 0.4148. Since covariates in the top habitat selection model were not statistically significant in the detection model, we can conclude that the imperfect detection of whooping cranes does not bias the linear predictor of the habitat selection model (Hefley et al. 2013).

6. Diurnal Habitat Selection Results

Whooping Crane Group Observations

We developed diurnal habitat selection models for the combined 478 spring and fall systematic continuous use observations of whooping crane groups. There were 347 observation in the spring and 131 observations in the fall. These observations span the time from fall 2002 to spring 2013. The actual sample size for the model was larger because of the inclusion of the data representing the choice set.

Diurnal Habitat Selection for Spring and Fall Combined

Statistical modeling of habitat use indicated the full model with all 4 covariates was most likely given the data. The full model contained the effects of nearest obstruction, nearest disturbance, proximity to roosting location and land cover (Table 7).

Table 7. Top models for diurnal habitat use for both seasons combined, ranked by AIC statistic. The AIC value for the null model was 10,610.97.

Rank	AIC value	AIC Weight	Covariates
1	8909.59	0.56	ND + NO + PRL + LC
2	8910.06	0.44	ND + PRL + LC
3	8978.51	0.00	PRL + LC
4	9218.41	0.00	NO + ND + PRL
5	9238.07	0.00	ND + PRL

The estimated smoothing spline function for nearest disturbance was increasing with larger values, indicating a positive relationship between predicted relative selection ratios and distance to nearest disturbance. The model results indicated increased distance to nearest disturbance was associated with a higher predicted relative selection ratios, with the highest value predicted to occur at 1,339 feet (Figure 10). The estimated parametric function for nearest obstruction was not statistically significant (p=0.1727). The estimated smoothing spline function for proximity to roost location was decreasing with larger values, indicating a negative relationship between predicted relative selection ratios and proximity to roost location. The model results indicate larger distances to the roost location were associated with a lower predicted relative selection ratios with the highest value predicted to occur at 0 feet (Figure 11). The estimated degrees of freedom for the smoothed terms were 3.65 and 3.95 for nearest disturbance and proximity to roost location respectively.

The model results for land cover were interpreted relative to the corn cover category. The relative selection ratio was significantly higher for the in-channel cover category relative to the corn cover category (p=0.0048; Figure 12). All remaining cover categories had lower relative selection ratio than corn cover. Relative to the corn cover category, the relative selection ratio was significantly lower for grassland cover (p<0.0001), soybean cover (p<0.0001) and wet meadow cover (p<0.0001). The cover of alfalfa was predicted to have a lower relative selection ratio than corn cover, though the result was not statistically significant (p=0.7594). The cover of wheat, cover of trees and developed areas also were predicted to have a lower relative selection ratio than corn cover, but we view this result with caution as the lack of data in these categories resulted in model estimates with extremely large standard errors.

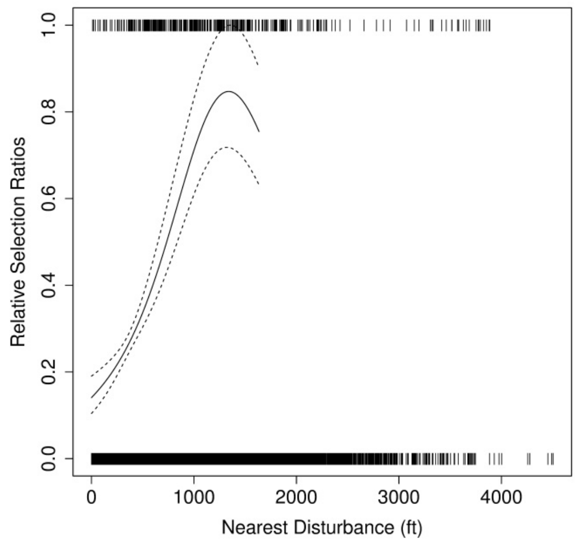


Figure 10. Predicted relative selection ratios for diurnal use by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest disturbance in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). The highest value for selection ratio value was predicted to occur at 1339 feet at the mean value of other variables in the model.

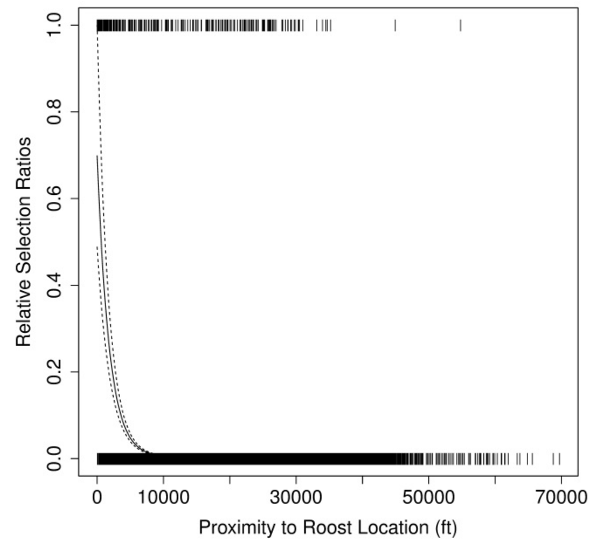
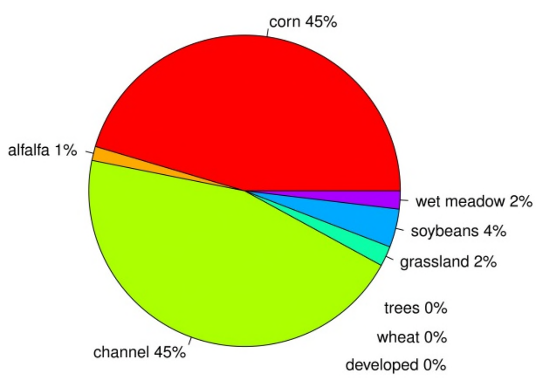


Figure 11. Predicted relative selection ratios for diurnal use by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of proximity to roost location in the spring and fall combined. Tick marks indicate actual data (use points at y=1, choice set points at y=0). The highest selection ratio value was predicted to occur at 0 feet at the mean value of other variables in the model.



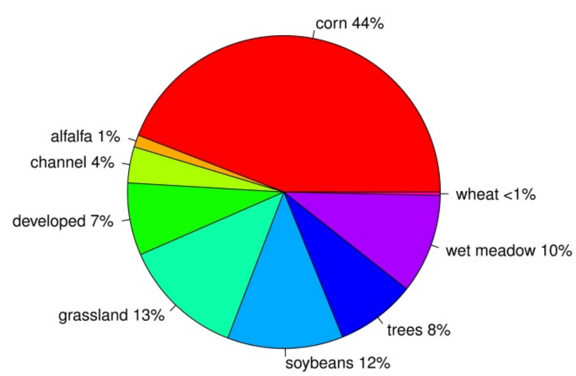


Figure 12. Relative abundance of land cover types for diurnal spring and fall locations of whooping crane use (left) and the choice set points (right).

7. Trend Results

Whooping Crane Group Observations

Observational data on whooping cranes was collected by surveyors with the PRRIP monitoring program and encompassed 13 spring migrations and 14 fall migrations for a total of 27 migration seasons (Table 8). The number of crane groups observed during a single survey season ranged from 1 to 13. The number of unique cranes ranged from 1 to 36 during a single survey season. Crane use days ranged from 1 to 121 per survey season.

Trends in Proportion of Population Using the central Platte River

<u>Spring</u>

Spring migration results showed an increase in the number of cranes using the central Platte River (Figure 13). Statistical modeling of the trend in the proportion of the whooping crane population using the central Platte River in the spring indicated a significant increase through time (Figure 14). The estimated trend was a positive 0.007 change per year (p=0.0168). The significance of the trend estimate indicated the number of unique individuals detected using the central Platte River in the spring had increased at a rate significantly faster than the size of the Aransas-Wood Buffalo population. Spearman's rank correlation statistic was 0.67 with a significant p-value of 0.0114, indicating a strong monotonic correlation between the metric and time. The autocorrelation function for these data indicated little serial correlation at a lag of 1 time period. The residuals of the model showed a slight increase in variance through time.

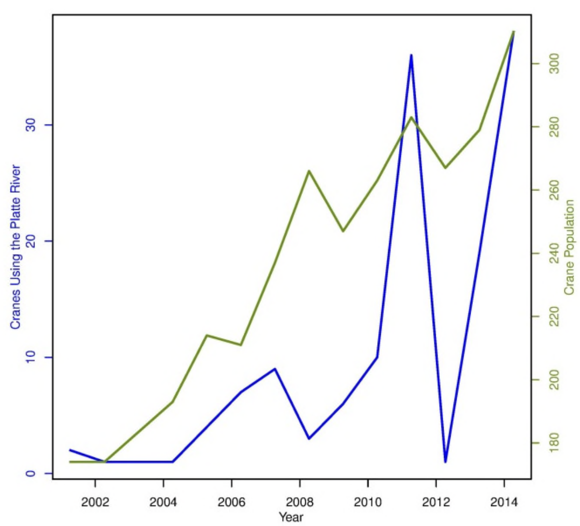


Figure 13. Cranes using the central Platte River during spring migration and population size from 2001 to 2014.

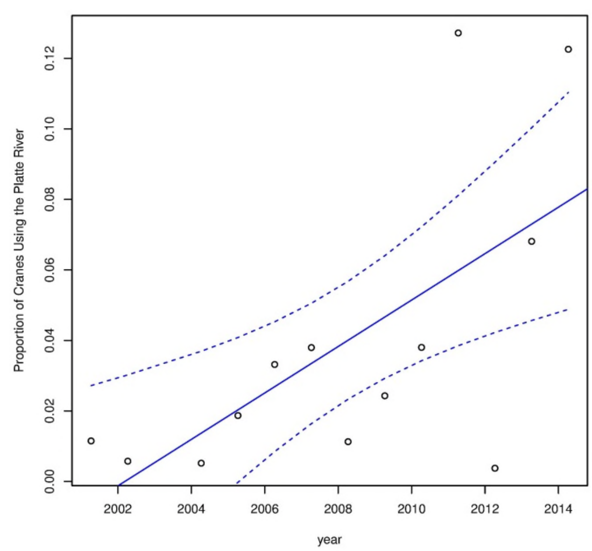


Figure 14. Proportion of population using the central Platte River, spring 2001-2014.

Table 8. Observational data from the Platte River Recovery Implementation Program (PRRIP) whooping crane migrational habitat use surveys in the central Platte River, Nebraska and USFWS Aransas-Wood Buffalo Population surveys, 2001-2014. There was no PRRIP survey conducted in Spring 2003.

	Spring						Fall					
Year	Population Size	# Crane Groups	# Unique Cranes	# Crane use days	Proportion of Population Using Platte	Number of crane use days to Population	Population Size	# Crane Groups	# Unique Cranes	# Crane use days	Proportion of Population Using Platte	Number of crane use days to Population
2001	174	2	2	8	0.01	0.05	174	1	1	2	0.01	0.01
2002	174	1	1	26	0.01	0.15	185	8	19	121	0.10	0.65
2003	184	-	-	-	-	-	194	1	1	2	0.01	0.01
2004	193	1	1	1	0.01	0.01	214	1	6	18	0.03	0.08
2005	214	3	4	13	0.02	0.06	216	1	2	4	0.01	0.02
2006	211	4	7	54	0.03	0.26	237	1	3	45	0.01	0.19
2007	237	5	9	71	0.04	0.30	266	2	10	23	0.04	0.09
2008	266	1	3	27	0.01	0.10	270	4	20	42	0.07	0.16
2009	247	4	6	42	0.02	0.17	264	4	12	44	0.05	0.17
2010	263	4	10	42	0.04	0.16	281	4	15	32	0.05	0.11
2011	283	1	36	104	0.13	0.37	267	2	6	12	0.02	0.04
2012	267	1	1	7	0.00	0.03	279	2	4	29	0.01	0.10
2013	279	10	19	48	0.07	0.17	310	2	3	8	0.01	0.03
2014	310	13	38	96	0.12	0.31	314	2	5	10	0.02	0.03

Fall

Fall migration results showed a variable number of cranes using the central Platte River (Figure 15). Statistical modeling of the trend in the proportion of the whooping crane population using the central Platte River in the fall indicated a decrease through time (Figure 16), though the trend was not significantly different from zero. The estimated trend was a negative 0.001 change per year (p=0.5940). Again, the Spearman's rank correlation statistic corroborated the results of non-significance with a correlation coefficient of 0.27 and a p-value of 0.3565 indicating the correlation coefficient was not significantly different from 0. The autocorrelation function for these data indicated little serial correlation past a lag of 1 time period. The residuals of the model showed little to no trend in pattern.

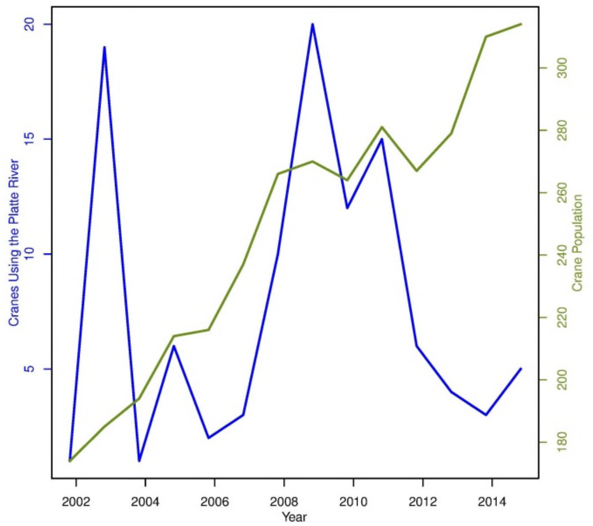


Figure 15. Cranes using the central Platte River during fall migration and population size from 2001 to 2014.

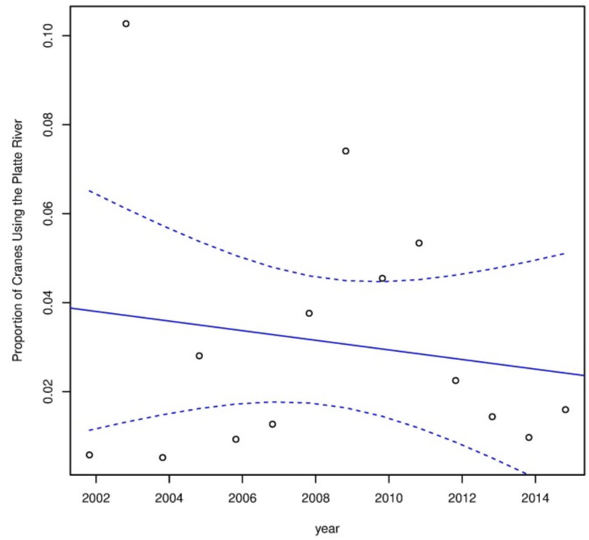


Figure 16. Proportion of population using the central Platte River, fall 2001-2014.

Combined Spring and Fall

Across both migration seasons, there was large variation in the number of cranes using the central Platte River (Figure 17). Statistical modeling of the trend in the proportion of the whooping crane population using the central Platte River indicated an increase through time (Figure 18), though the trend was not significantly different from zero. The estimated trend was a positive 0.002 change in the ratio per year (p=0.1390). The borderline significance of the trend estimate indicated the number of unique individuals detected using the central Platte River from 2001-2014 had increased at a rate that was faster than the size of the Aransas-Wood Buffalo population, though not significantly faster. Spearman's rank correlation statistic was 0.50 with a significance of 0.0076, indicating a strong monotonic correlation between the metric and time. The autocorrelation function for these data indicated little serial correlation past a lag of 1 time period. The residuals of the model showed no pattern.

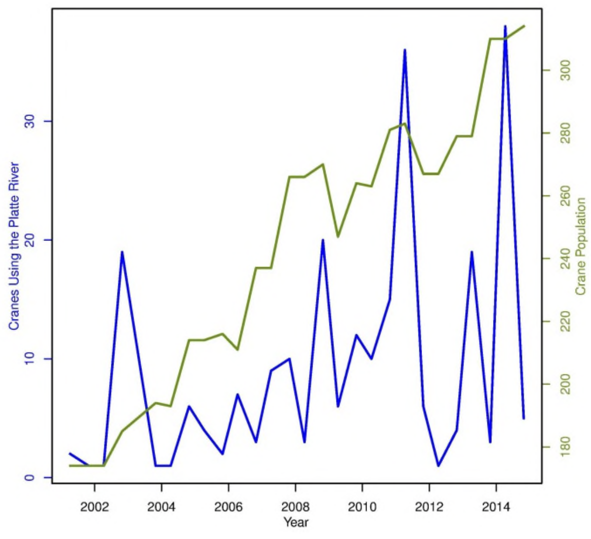


Figure 17. Cranes using the central Platte River during spring and fall migration and population size from 2001 to 2014.

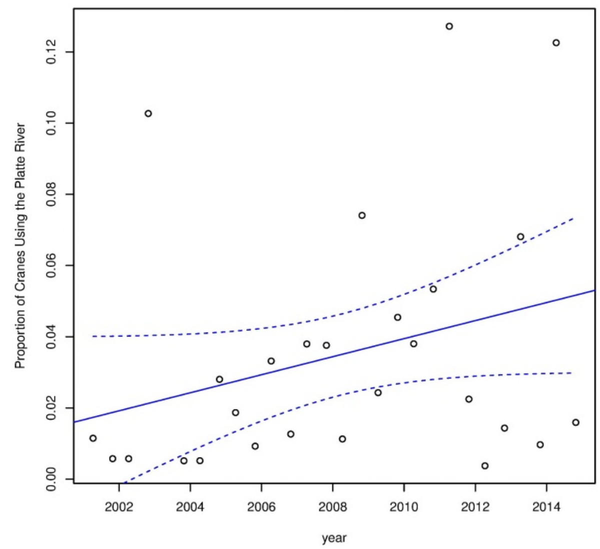


Figure 18. Proportion of population using the central Platte River, 2001-2014.

Trends in Crane Use Days per Bird in the Population

<u>Spring</u>

Spring migration results indicated an increase in the number of crane use days in the study area (Figure 19). Statistical modeling of the trend in crane use days per bird in the population in the spring indicated an increase through time (Figure 20), though the result was not significantly different from zero. The estimated trend was a positive 0.012 change in the ratio per year (p=0.1380). The borderline significance of the trend estimate indicated the number of crane use days on the central Platte River in the spring from 2001-2014 had increased at a rate that was faster than the increase in size of the Aransas-Wood Buffalo population, though not significantly faster. Spearman's rank correlation statistic was 0.56 with a significance of 0.0469, indicating a strong monotonic correlation between the metric and time. The autocorrelation function for these data indicated little serial correlation past a lag of 1 time period. The residuals of the model indicated good model fit with no discernable pattern.

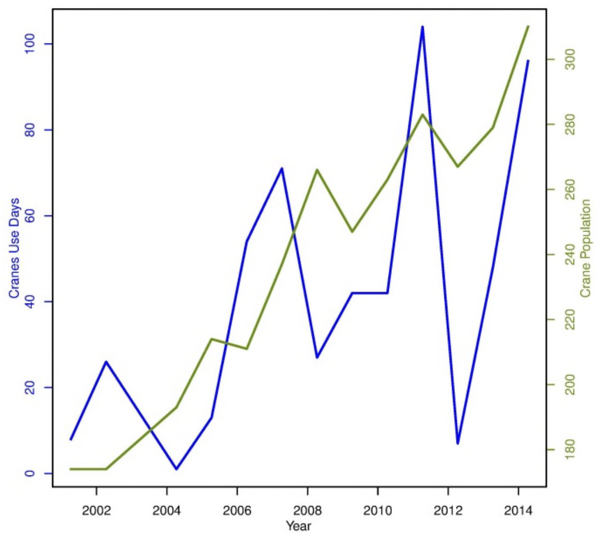


Figure 19. Cranes use days on the central Platte River during spring migration and population size from 2001 to 2014.

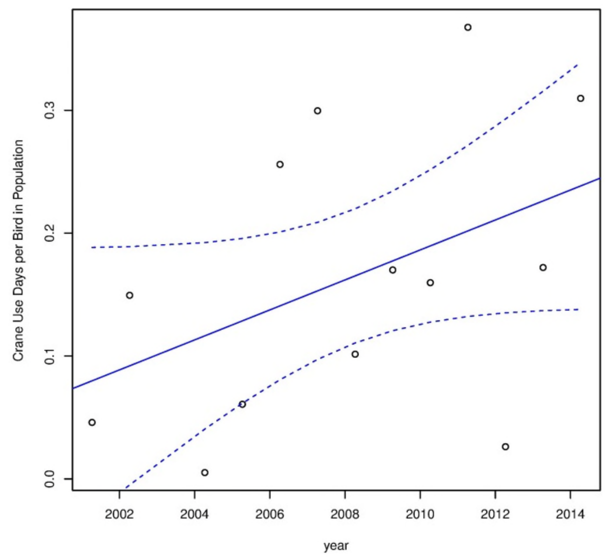
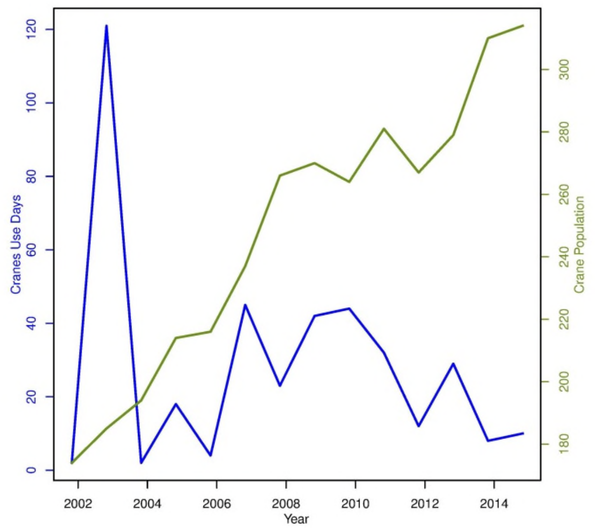


Figure 20. Crane use days on the central Platte River per bird in the population, spring 2001-2014.

Fall

Fall migration results showed a decrease in the number of crane use days in the study area (Figure 21). Statistical modeling of the trend in the crane use days per bird in the population in the fall indicated a decrease through time, though the trend was not significantly different from zero (Figure 22). The estimated trend was a negative 0.012 change in the ratio per year (p=0.2760). Again, the Spearman's rank correlation statistic corroborated the results of non-significance with a correlation coefficient of 0.09 and a p-value of 0.7591 indicating this coefficient was not significantly different from 0. The autocorrelation function for these data indicated little serial correlation past a lag of 1 time period. The residuals of the model showed little to no pattern.



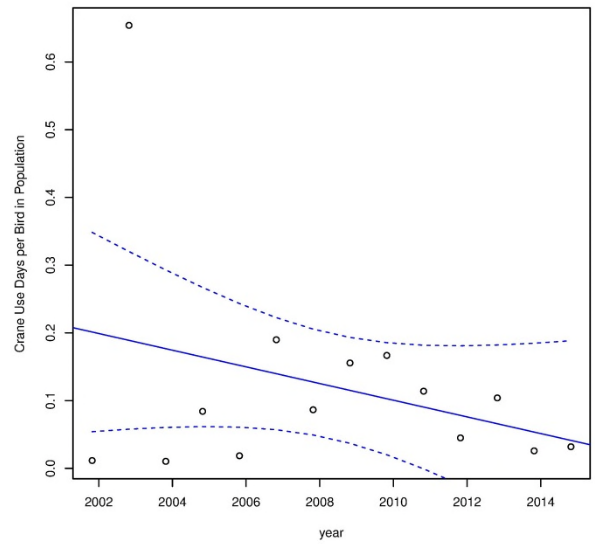


Figure 21. Cranes use days on the central Platte River during fall migration and population size from 2001 to 2014.

Figure 22. Crane use days on the central Platte River per bird in the population, fall 2001-2014.

Combined Spring and Fall

Across both migration seasons, there was large variation in the number of crane use days in the study area (Figure 23). Statistical modeling of the trend in crane use days per bird in the population indicated a decrease through time, though the trend was not significantly different from zero (Figure 24). The estimated trend was a negative 0.001 change per year (p=0.9090). Again, the Spearman's rank correlation statistic corroborated the results of non-significance with a correlation coefficient of 0.26 and a p-value of 0.1981 indicating this coefficient was not significantly different from 0. The autocorrelation function for these data indicated little serial correlation past a lag of 1 time period. The residuals of the model showed little to no pattern.

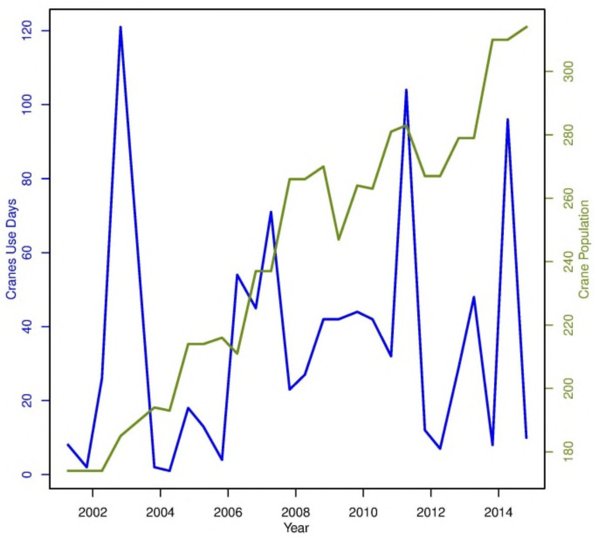


Figure 23. Cranes use days on the central Platte River during spring and fall migration and population size from 2001 to 2014.

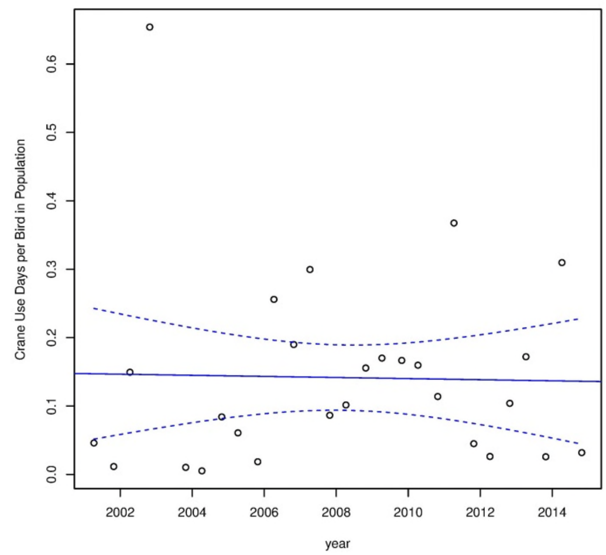


Figure 24. Crane use days on the central Platte River per bird in the population, 2001-2014.

8. Discussion

In-channel Habitat Selection

The combined spring and fall in-channel habitat models presented here relate a similar message about whooping crane habitat selection on the central Platte River. Unobstructed channel width, nearest forest, and nearest obstruction were the factors with the most influence on in-channel habitat selection. The overall top in-channel model suggested that whooping cranes were selecting in-channel habitat with large distance to nearest forest and obstruction up to a point after which the relative selection ratios declined. At the direction from PRRIP staff, the set of *a priori* management models did not contain nearest obstruction. The top management model differs from the top model for the combined spring and fall seasons. The management model suggested that whooping cranes were selecting in-channel habitat with large values of unobstructed channel width and large distances to nearest forest. Though the selection ratios for unobstructed channel width and nearest forest were maximized at 488 and 523 feet, respectively, it can be inferred based on the confidence intervals at these peaks, that widths between 275 and 745 feet for unobstructed channel width and distances between 305 and 686 feet for nearest forest would result in statistically similar selection ratios.

The spring in-channel model suggested that whooping cranes were selecting in-channel habitat with large distances to nearest obstruction, or dense vegetation. Whooping crane groups were observed across a wide range of values and it can be inferred based on the confidence intervals at the peak of 136 feet that nearest obstruction distances between 80 and 166 feet would result in statistically similar selection ratios. The fall in-channel model also suggested that whooping cranes were selecting in-channel habitat with large values of distances to nearest obstruction. Based on the confidence interval at the peak of 299 feet, nearest obstruction distances as small as 165 feet would result in statistically similar selection ratios.

In-channel and diurnal habitat selection analyses did not account for imperfect detection of whooping crane groups during the study. Although imperfect detection surely existed, it was assumed that the probability of detection was constant across each survey as a result of the consistency in survey methodology. Analyses presented here found the relationship between detection and variables in the top habitat models was not evident, and we conclude the results were unbiased with respect to detection (Hefley et al. 2013).

Diurnal Habitat Selection

The diurnal habitat model presented here indicates whooping cranes were selecting in-channel and corn cover categories that were close to the previous night roost location and did not have the possibility of disturbance in the form of houses, towns, roads, or railroads. The model results did not indicate whooping cranes show avoidance of vegetation greater than 1.5m during diurnal habitat use. Relative to the corn cover category, the relative selection was significantly lower for grassland, soybean, and wet meadow cover categories.

Trend

The study of rare or hard to detect wildlife populations consistently leads to high variance in observational use data. With 27 data points spanning 14 years from 2001 to 2014, the PRRIP dataset was highly variable, though some trends were apparent. For all trend analyses, it was assumed that the influence of imperfect detection of whooping crane groups in the survey data was consistent through the study period, as a result of the consistency in survey methodology.

The trend models presented here for the proportion of the Aransas-Wood Buffalo population using the Platte River showed a significant increase in spring migration use. The fall migration season showed a non-significant decrease in the metric through time, meaning there was no trend detected. The combined spring and fall migration season showed a non-significant increase with a p-value of 0.1390.

The trend models for the crane use days on the central Platte River during the spring migration per bird in the population also showed a non-significant increase with a p-value of 0.1380. This metric had a non-significant decline for fall and for both migration seasons combined. The positive estimate in the spring indicates the number of use days was increasing faster than the population size, while the non-significant results in fall and for the combined seasons indicated the number of crane use days in the study area was increasing in proportion to the population size.

It is unknown if the change in USFWS survey and estimation methods for determining the size of the winter whooping crane population had an impact on these results. There was not sufficient information to apply a correction factor to either the old or new population data to develop consistent estimates across the change in survey methods that occurred in 2011. It was noted that the consistent multiplicative increase in the population estimate throughout the time period did not appear to change abruptly at 2011. This consistency does lend credibility to the utility of these data across the change in methodology.

Comparison to Previous Literature

Faanes et al. (1992) describe the attributes of whooping crane roost sites on the Platte River, provided by Johnson and Temple (1980) and Johnson (1982; both articles were not available) as a channel width of at least 180 feet with most channels greater than 509 feet wide, horizontal visibility that included an "unobstructed view from bank to bank and several hundred meters upstream and downstream," overhead visibility that included no tall trees or tall/dense shrubbery, feeding sites relatively close and typically within one mile, and usually more than 1,312 feet from human developments with tall trees or banks in between. It is not clear from the summary how these attributes were derived but they are very similar to our results for unobstructed channel width (selection ratios greatest at 488 feet and distance from human disturbance (selection ratios greatest at 1,339 feet from nearest disturbance).

Armbruster (1990) presented a synthesis of information on observations of habitats used by whooping cranes and sandhill cranes in North America but notes that these studies are based on assumptions due to small sample sizes and uncertainty regarding used versus available sites. Based on these studies the author concluded that 1) a distance of at least 66 feet between a site and any potential obstruction was required for consideration as habitat, 2) optimum water depth was equal or less than 12 inches, 3) the minimum size of a wetland usable for roosting was 0.04 ha (0.1 ac), and 4) sources of disturbance such as roads affected cranes out to at least 328 feet. Of the numerous studies described, the author reported unobstructed channel widths for two roost sites on the Platte River as 1,148 feet and 1,020 feet based on Lingle et al. 1984 and 1986, which is greater than the 488 feet described in our study.

Faanes et al. (1992) compared characteristics at 19 - 23 confirmed roost sites for whooping cranes (1983-1990) in the central Platte River to 1,381 unused sites using bank-to-bank transects. The authors reported the following results: 1) water depth was shallower than average at roost sites than at unused sites (8 inches versus 12 inches, respectively); 2) channel widths at roost sites ranged from 171 feet to 1,201 feet and 19 of the 23 roosts were in channels at least 492 feet wide; and 3) the average distance to shore was similar for both roost sites and unused sites (217 feet 66.2 and 215 feet, respectively). This study was an improvement on previous work because it used statistical methods to compare characteristics of unused and selected habitats. The outcome that most of the roosts were located in channels at least 492 feet wide is similar to the conclusion of this study (greatest selection ratios was for unobstructed channels that were 488 feet wide). Also, the water depth suggested by Faanes et al. was similar to that reported by Armbruster (1990).

Austin and Richert (2001) analyzed all known observational data on whooping cranes (1,352 sightings; 1943-1999) and all known site evaluation data (1,060 observations; 1977-1999) for areas used by whooping cranes in the Aransas-Wood Buffalo migration corridor. The authors acknowledged the limitations of their study such as observer biases, variation in the distribution and interest of biologists to confirm and collect further information on crane sightings, as well as varying landscape features that may hinder crane sightings. Although the authors did not summarize observations specifically for the central Platte River location used in our study, they did note that it was obvious from mapping observations that "whooping cranes were frequently observed in this area." The authors found that whooping cranes using the Platte River tended to be single cranes or nonfamily groups. For riverine habitats such as the Platte River roosting cranes were more often recorded on unvegetated sites than vegetated sites and the width of river averaged 764 +/- 276 feet (SD) with a range of 249 feet to 1,499 feet. More than 70% of chosen riverine roosts were adjacent to woodland habitat.

For all observations, Austin and Richert (2001) found no relationship between roost site and use of the closest feeding sites, which varies from our study in which whooping cranes tended to use corn fields close to the previous night's roost. Overall whooping cranes used cropfields often and more than 60% of all sites (and more than 80% of feeding sites) were on private land. The unobstructed visibility of about half of the roost sites and two-thirds of the feeding sites was less than 0.25 mile (1,320 feet), while over two-thirds of crane observations were recorded within 0.5 mile (2,640 feet) of human development. About 78% of spring records of whooping cranes in Nebraska were located on riverine sites including the Platte River while half of the fall records in Nebraska were located on riverine sites and 11% were from lacustrine wetlands.

9. Summary of Findings

We compared characteristics of habitat from 2001 to 2013 and trends in use from 2001 to 2014 within the central Platte River for whooping cranes using systematic surveys. Our findings show:

- Roosting whooping cranes chose a range of unobstructed channel widths; selection ratios were greatest for unobstructed channels that were 488 feet wide with widths between 275 and 745 feet resulting in statistically similar selection ratios.
- Roosting whooping cranes chose a range of distances to nearest forest; selection ratios were greatest for channels that were 523 feet from the nearest forest with distances between 305 and 686 feet resulting in statistically similar selection ratios.
- The inclusion of additional non-unique in-channel observations resulted in larger optimum distances and channel widths for the majority of linear and quadratic response functions, as reported in Appendices C and D, compared to the systematic unique results in this report.
- During the day whooping cranes used cornfields that were close to the previous night's roost with no possibility of disturbance; selection ratios were greatest at 1,339 feet from the nearest disturbance (i.e., house, town, road, or railroad) with distances between 1,009 and 1,635 feet resulting in statistically similar selection ratios.
- During the day whooping cranes were significantly more likely to choose riverine habitat over corn cover, but chose corn cover significantly more than grassland, soybean, and wet meadow cover.
- Trends in use over time within the central Platte River showed a significant increase in use in the spring, a non-significant decrease in use during the fall, and a non-significant increase in use for spring and fall combined.

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Appendix A. In-Channel *a priori* Models

List of Tables

Table A.1. In-channel *a priori* model list for whooping crane habitat use created by PRRIP. The interpretation assumes an *a priori* direction (positive or negative) in the relationship between whooping crane habitat use and the covariates but actual model fit, based on data, could have been in the opposite direction.* Indicates model was in the management candidate model list…1

Table A.2. Diurnal *a priori* model list for whooping crane habitat use created by PRRIP. The interpretation assumes an *a priori* direction (positive or negative) in the relationship between whooping crane habitat use and the covariates but actual model fit, based on data, could have been in the opposite direction…………………………………………………………………….9

Table A.1. In-channel *a priori* model list for whooping crane habitat use created by PRRIP. The interpretation assumes an *a priori* direction (positive or negative) in the relationship between whooping crane habitat use and the covariates but actual model fit, based on data, could have been in the opposite direction.* Indicates model was in the management candidate model list.

Model ID	Covariates	Interpretation
1	UFW	Channels w/o trees on bank line
2*	UOCW	Wide unobstructed views
3*	TCW	Wide channels
4	NO	Wide unobstructed views
5*	NF	Channels w/o trees on bank line
6	UOCW + UFW	Wide unobstructed views w/o trees on bank line
7*	TCW + UOCW	Wide channels with wide unobstructed views
8	TCW + WW	Wide channel widths with high wetted widths
9	TCW + PW	Wide channel widths with a high proportion of the channel that is wetted
10*	TCW + UD	Wide channel widths with moderate flow volume
11	TCW + MD	Wide channel widths with moderate to shallow depths across the channel
12	TCW + WDR	Wide channel widths with moderate width-depth ratio
13	NO + UFW	Wide unobstructed views w/o trees on bank line
14*	UOCW + NF	Wide unobstructed views w/o trees on bank line
15	NO + NF	Wide unobstructed views w/o trees on bank line
16	TCW + NO	Wide channels with wide unobstructed views
17	UFW + UOCW + TCW	Wide channels with wide unobstructed views w/o trees on bank line
18*	TCW + UOCW + UD	Wide channel widths with wide unobstructed views with moderate flow volume
19	TCW + UFW + UD	Wide channel widths w/o trees on bank line with moderate flow volume
20	TCW + UOCW + WDR	Wide channel widths with wide unobstructed views with moderate width-depth ratio
21	TCW + UFW + WDR	Wide channel widths w/o trees on bank line with moderate width-depth ratio
22	TCW + NF + WDR	Wide channel widths w/o trees on bank line with moderate width-depth ratio
23*	TCW + NF + UD	Wide channel widths w/o trees on bank line with moderate flow volume
24*	NF + UOCW + TCW	Wide channels with wide unobstructed views w/o trees on bank line
25	NF + NO + TCW	Wide channels with wide unobstructed views w/o trees on bank line
26	TCW + NO + UD	Wide channel widths with wide unobstructed views with moderate flow volume
27	TCW + NO + WDR	Wide channel widths with wide unobstructed views with moderate width-depth ratio

Model ID	Covariates	Interpretation
28	UFW + NO + TCW	Wide channels with wide unobstructed views w/o trees on bank line
29	TCW + UOCW + UFW + UD	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume
30	TCW + UOCW + UFW + WDR	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio
31	TCW + UOCW + NF + WDR	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio
32*	TCW + UOCW + NF + UD	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume
33	TCW + NO + NF + WDR	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio
34	TCW + NO + NF + UD	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume
35	TCW + NO + UFW + UD	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume
36	TCW + NO + UFW + WDR	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio
37	PC	Corn nearby
38	UFW + PC	Channels w/o trees on bank line and corn nearby
39	UOCW + PC	Channels with wide unobstructed views and corn nearby
40	TCW + PC	Wide channels and corn nearby
41	NO + PC	Channels with wide unobstructed views and corn nearby
42	NF + PC	Channels w/o trees on bank line and corn nearby
43	UOCW + UFW + PC	Wide unobstructed views w/o trees on bank line and corn nearby
44	TCW + UOCW + PC	Wide channels with wide unobstructed views and corn nearby
45	TCW + WW + PC	Wide channels with high wetted widths and corn nearby
46	TCW + PW + PC	Wide channels with a high proportion of the channel that is wetted and corn nearby
47	TCW + UD + PC	Wide channels with moderate flow volume and corn nearby
48	TCW + MD + PC	Wide channels with moderate to shallow depths across the channel and corn nearby
49	TCW + WDR + PC	Wide channels with moderate width-depth ratio and corn nearby
50	TCW + NO + PC	Wide channels with wide unobstructed views and corn nearby
51	UOCW + NF + PC	Wide unobstructed views w/o trees on bank line and corn nearby
52	NO + NF + PC	Wide unobstructed views w/o trees on bank line and corn nearby
53	NO + UFW + PC	Wide unobstructed views w/o trees on bank line and corn nearby
54	TCW + UOCW + UFW + PC	Wide channels with wide unobstructed views w/o trees on bank line and corn nearby
55	TCW + UOCW + UD + PC	Wide channels with wide unobstructed views with moderate flow volume and corn nearby

Model ID	Covariates	Interpretation
56	TCW + UFW + UD + PC	Wide channel widths w/o trees on bank line with moderate flow volume and corn nearby
57	TCW + UOCW + WDR + PC	Wide channels with wide unobstructed views with moderate width-depth ratio and corn nearby
58	TCW + UFW + WDR + PC	Wide channel widths w/o trees on bank line with moderate width-depth ratio and corn nearby
59	TCW + NO + NF + PC	Wide channels with wide unobstructed views w/o trees on bank line and corn nearby
60	TCW + NO + UFW + PC	Wide channels with wide unobstructed views w/o trees on bank line and corn nearby
61	TCW + NO + UD + PC	Wide channels with wide unobstructed views with moderate flow volume and corn nearby
62	TCW + NO + WDR + PC	Wide channels with wide unobstructed views with moderate width-depth ratio and corn nearby
63	TCW + NF + WDR + PC	Wide channel widths w/o trees on bank line with moderate width-depth ratio and corn nearby
64	TCW + UOCW + NF + PC	Wide channels with wide unobstructed views w/o trees on bank line and corn nearby
65	TCW + NF + UD + PC	Wide channel widths w/o trees on bank line with moderate flow volume and corn nearby
66	TCW + UOCW + UFW + UD + PC	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and corn nearby
67	TCW + UOCW + UFW + WDR + PC	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and corn nearby
68	TCW + NO + UFW + UD + PC	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and corn nearby
69	TCW + NO + UFW + WDR + PC	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and corn nearby
70	TCW + UOCW + NF + WDR + PC	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and corn nearby
71	TCW + UOCW + NF + UD + PC	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and corn nearby
72	TCW + NO + NF + UD + PC	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and corn nearby
73	TCW + NO + NF + WDR + PC	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and corn nearby
74	PWM	Wet meadow nearby
75	UFW + PWM	Channels w/o trees on bank line and wet meadow nearby
76	UOCW + PWM	Channels with wide unobstructed views and wet meadow nearby
77	TCW + PWM	Wide channels and wet meadow nearby
78	UOCW + UFW + PWM	Wide unobstructed views w/o trees on bank line and wet meadow nearby
79	TCW + UOCW + PWM	Wide channels with wide unobstructed views and wet meadow nearby
80	TCW + UOCW + UFW + PWM	Wide channels with wide unobstructed views w/o trees on bank line and wet meadow nearby
81	TCW + WW + PWM	Wide channels with high wetted widths and wet meadow nearby

Model ID	Covariates	Interpretation
82	TCW + PW + PWM	Wide channels with a high proportion of the channel that is wetted and wet meadow nearby
83	TCW + UD + PWM	Wide channels with moderate flow volume and wet meadow nearby
84	TCW + MD + PWM	Wide channels with moderate to shallow depths across the channel and wet meadow nearby
85	TCW + WDR + PWM	Wide channels with moderate width-depth ratio and wet meadow nearby
86	TCW + UOCW + UD + PWM	Wide channels with wide unobstructed views with moderate flow volume and wet meadow nearby
87	TCW + UFW + UD + PWM	Wide channel widths w/o trees on bank line with moderate flow volume and wet meadow nearby
88	TCW + UOCW + UFW + UD + PWM	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and wet meadow nearby
89	TCW + UOCW + WDR + PWM	Wide channels with wide unobstructed views with moderate width-depth ratio and wet meadow nearby
90	TCW + UFW + WDR + PWM	Wide channel widths w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
91	TCW + UOCW + UFW + WDR + PWM	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
92	NO + PWM	Channels with wide unobstructed views and wet meadow nearby
93	NO + UFW + PWM	Wide unobstructed views w/o trees on bank line and wet meadow nearby
94	TCW + NO + PWM	Wide channels with wide unobstructed views and wet meadow nearby
95	TCW + NO + UFW + PWM	Wide channels with wide unobstructed views w/o trees on bank line and wet meadow nearby
96	TCW + NO + UD + PWM	Wide channels with wide unobstructed views with moderate flow volume and wet meadow nearby
97	TCW + NO + UFW + UD + PWM	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and wet meadow nearby
98	TCW + NO + WDR + PWM	Wide channels with wide unobstructed views with moderate width-depth ratio and wet meadow nearby
99	TCW + NO + UFW + WDR + PWM	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
100	TCW + NF + WDR + PWM	Wide channel widths w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
101	TCW + UOCW + NF + WDR + PWM	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
102	TCW + NF + UD + PWM	Wide channel widths w/o trees on bank line with moderate flow volume and wet meadow nearby
103	TCW + UOCW + NF + UD + PWM	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and wet meadow nearby
104	TCW + UOCW + NF + PWM	Wide channels with wide unobstructed views w/o trees on bank line and wet meadow nearby
105	UOCW + NF + PWM	Wide unobstructed views w/o trees on bank line and wet meadow nearby

Model ID	Covariates	Interpretation
106	NF + PWM	Channels w/o trees on bank line and wet meadow nearby
107	TCW + NO + NF + PWM	Wide channels with wide unobstructed views w/o trees on bank line and wet meadow nearby
108	TCW + NO + NF + UD + PWM	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and wet meadow nearby
109	TCW + NO + NF + WDR + PWM	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and wet meadow nearby
110	NO + NF + PWM	Wide unobstructed views w/o trees on bank line and wet meadow nearby
111	PF	Less forest nearby
112	UFW + PF	Channels w/o trees on bank line and less forest nearby
113	UOCW + PF	Channels with wide unobstructed views and less forest nearby
114	TCW + PF	Wide channels and less forest nearby
115	NF + PF	Channels w/o trees on bank line and less forest nearby
116	NO + PF	Channels with wide unobstructed views and less forest nearby
117	UOCW + UFW + PF	Wide unobstructed views w/o trees on bank line and less forest nearby
118	TCW + UOCW + PF	Wide channels with wide unobstructed views and less forest nearby
119	TCW + WW + PF	Wide channels with high wetted widths and less forest nearby
120	TCW + PW + PF	Wide channels with a high proportion of the channel that is wetted and less forest nearby
121	TCW + UD + PF	Wide channels with moderate flow volume and less forest nearby
122	TCW + MD + PF	Wide channels with moderate to shallow depths across the channel and less forest nearby
123	TCW + WDR + PF	Wide channels with moderate width-depth ratio and less forest nearby
124	NO + UFW + PF	Wide unobstructed views w/o trees on bank line and less forest nearby
125	TCW + NO + PF	Wide channels with wide unobstructed views and less forest nearby
126	UOCW + NF + PF	Wide unobstructed views w/o trees on bank line and less forest nearby
127	NO + NF + PF	Wide unobstructed views w/o trees on bank line and less forest nearby
128	TCW + UOCW + UFW + PF	Wide channels with wide unobstructed views w/o trees on bank line and less forest nearby
129	TCW + UOCW + UD + PF	Wide channels with wide unobstructed views with moderate flow volume and less forest nearby
130	TCW + UFW + UD + PF	Wide channel widths w/o trees on bank line with moderate flow volume and less forest nearby
131	TCW + UOCW + WDR + PF	Wide channels with wide unobstructed views with moderate width-depth ratio and less forest nearby
132	TCW + UFW + WDR + PF	Wide channel widths w/o trees on bank line with moderate width-depth ratio and less forest nearby
133	TCW + NO + UFW + PF	Wide channels with wide unobstructed views w/o trees on bank line and less forest nearby
134	TCW + NO + UD + PF	Wide channels with wide unobstructed views with moderate flow volume and less forest nearby

Model ID	Covariates	Interpretation
135	TCW + NO + WDR + PF	Wide channels with wide unobstructed views with moderate width-depth ratio and less forest nearby
136	TCW + NF + WDR + PF	Wide channel widths w/o trees on bank line with moderate width-depth ratio and less forest nearby
137	TCW + NF + UD + PF	Wide channel widths w/o trees on bank line with moderate flow volume and less forest nearby
138	TCW + UOCW + NF + PF	Wide channels with wide unobstructed views w/o trees on bank line and less forest nearby
139	TCW + NO + NF + PF	Wide channels with wide unobstructed views w/o trees on bank line and less forest nearby
140	TCW + UOCW + UFW + UD + PF	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and less forest nearby
141	TCW + UOCW + UFW + WDR + PF	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and less forest nearby
142	TCW + NO + UFW + UD + PF	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and less forest nearby
143	TCW + NO + UFW + WDR + PF	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and less forest nearby
144	TCW + UOCW + NF + WDR + PF	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and less forest nearby
145	TCW + UOCW + NF + UD + PF	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and less forest nearby
146	TCW + NO + NF + UD + PF	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and less forest nearby
147	TCW + NO + NF + WDR + PF	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and less forest nearby
148	PG	Grassland nearby
149	UFW + PG	Channels w/o trees on bank line and grassland nearby
150	UOCW + PG	Channels with wide unobstructed views and grassland nearby
151	TCW + PG	Wide channels and grassland nearby
152	NO + PG	Channels with wide unobstructed views and grassland nearby
153	NF + PG	Channels w/o trees on bank line and grassland nearby
154	UOCW + UFW + PG	Wide unobstructed views w/o trees on bank line and grassland nearby
155	TCW + UOCW + PG	Wide channels with wide unobstructed views and grassland nearby
156	TCW + WW + PG	Wide channels with high wetted widths and grassland nearby
157	TCW + PW + PG	Wide channels with a high proportion of the channel that is wetted and grassland nearby
158	TCW + UD + PG	Wide channels with moderate flow volume and grassland nearby
159	TCW + MD + PG	Wide channels with moderate to shallow depths across the channel and grassland nearby
160	TCW + WDR + PG	Wide channels with moderate width-depth ratio and grassland nearby

Model ID	Covariates	Interpretation
161	NO + UFW + PG	Wide unobstructed views w/o trees on bank line and grassland nearby
162	TCW + NO + PG	Wide channels with wide unobstructed views and grassland nearby
163	UOCW + NF + PG	Wide unobstructed views w/o trees on bank line and grassland nearby
164	NO + NF + PG	Wide unobstructed views w/o trees on bank line and grassland nearby
165	TCW + UOCW + UFW + PG	Wide channels with wide unobstructed views w/o trees on bank line and grassland nearby
166	TCW + UOCW + UD + PG	Wide channels with wide unobstructed views with moderate flow volume and grassland nearby
167	TCW + UFW + UD + PG	Wide channel widths w/o trees on bank line with moderate flow volume and grassland nearby
168	TCW + NO + NF + PG	Wide channels with wide unobstructed views w/o trees on bank line and grassland nearby
169	TCW + NO + UFW + PG	Wide channels with wide unobstructed views w/o trees on bank line and grassland nearby
170	TCW + NO + UD + PG	Wide channels with wide unobstructed views with moderate flow volume and grassland nearby
171	TCW + NO + WDR + PG	Wide channels with wide unobstructed views with moderate width-depth ratio and grassland nearby
172	TCW + NF + UD + PG	Wide channel widths w/o trees on bank line with moderate flow volume and grassland nearby
173	TCW + UOCW + NF + PG	Wide channels with wide unobstructed views w/o trees on bank line and grassland nearby
174	TCW + UOCW + WDR + PG	Wide channels with wide unobstructed views with moderate width-depth ratio and grassland nearby
175	TCW + UFW + WDR + PG	Wide channel widths w/o trees on bank line with moderate width-depth ratio and grassland nearby
176	TCW + NF + WDR + PG	Wide channel widths w/o trees on bank line with moderate width-depth ratio and grassland nearby
177	TCW + UOCW + UFW + UD + PG	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and grassland nearby
178	TCW + UOCW + UFW + WDR + PG	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and grassland nearby
179	TCW + NO + UFW + UD + PG	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and grassland nearby
180	TCW + NO + UFW + WDR + PG	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and grassland nearby
181	TCW + UOCW + NF + WDR + PG	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and grassland nearby
182	TCW + UOCW + NF + UD + PG	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and grassland nearby
183	TCW + NO + NF + UD + PG	Wide channels with wide unobstructed views w/o trees on bank line with moderate flow volume and grassland nearby
184	TCW + NO + NF + WDR + PG	Wide channel widths with wide unobstructed views w/o trees on bank line with moderate width-depth ratio and grassland nearby

Table A.2. Diurnal *a priori* model list for whooping crane habitat use created by PRRIP. The interpretation assumes an *a priori* direction (positive or negative) in the relationship between whooping crane habitat use and the covariates but actual model fit, based on data, could have been in the opposite direction.

Model ID	Covariates	Interpretation
1	LC	Land cover class
2	PRL	Near roost location
3	NO	Away from obstructions
4	ND	Away from disturbance features
5	NO + PRL	Away from obstructions and near roost location
6	ND + PRL	Away from disturbance features and near roost location
7	NO + ND	Away from obstructions and disturbances
8	LC + NO	Land cover class away from obstructions
9	LC + ND	Land cover class away from disturbance features
10	LC + PRL	Land cover class and near roost location
11	LC + NO + ND	Land cover class away from obstructions and disturbances
12	LC + NO + PRL	Land cover class away from obstructions and near roost location
13	LC + ND + PRL	Land cover class away from disturbance features and near roost location
14	NO + ND + PRL	Away from obstructions and disturbances and near roost location
15	LC + NO + ND + PRL	Land cover class away from obstructions and disturbances and near roost location

Appendix B. Mirrored Histograms and Summary Statistics for Systematic Unique In-Channel Whooping Crane Observations

List of Figures

Figure B.1. Histograms of nearest riparian forest (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 3

Figure B.2. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 4

Figure B.3. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 5

Figure B.4. Histograms of proportion of landcover within a 1-mile radius classified as corn at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 6

Figure B.5. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 7

Figure B.6. Histograms of total channel width from left bank to right bank (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 8

Figure B.7. Histograms of proportion of landcover within a 1-mile radius classified as forest at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 9

Figure B.8. Histograms of mean depth of the wetted channel (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below)..... 10

Figure B.9. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 11

Figure B.10. Histograms of proportion of wetted area present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 12

Figure B.11. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 13

Figure B.12. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 14

Figure B.13. Histograms of top width (feet [ft]) of wetted channel at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below). 15

Figure B.14. Histograms of width-to-depth ratio (wetted depth / mean depth) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below)..... 16

List of Tables

Table B.1. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis. Spring sample sizes were 32 for used locations and 640 for the choice sets, fall sample sizes were 21 for used locations and 420 for the choice sets. Variable abbreviations are in the methods section of the main body of the report. 1

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		Choice Sets			**Used Locations**		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
UOCW	Fall	395.09	292.44	74.02	564.09	261.98	46.44
	Spring	378.22	330.88	87.48	471.10	320.36	68.00
	Spring and Fall	384.90	316.17	82.14	507.95	299.48	58.96
NO	Fall	86.00	89.54	104.12	172.99	103.86	60.04
	Spring	77.11	96.23	124.79	91.57	51.88	56.66
	Spring and Fall	80.63	93.69	116.20	123.83	85.85	69.32
UFW	Fall	2091.46	2504.55	119.75	1896.77	1029.13	54.26
	Spring	1993.26	2244.74	112.62	1860.68	1564.23	84.07
	Spring and Fall	2032.17	2350.45	115.66	1874.98	1366.15	72.86
NF	Fall	322.66	253.97	78.71	474.58	178.04	37.52
	Spring	299.94	248.08	82.71	347.58	195.78	56.33
	Spring and Fall	308.95	250.56	81.10	397.90	197.42	49.62
TCW	Fall	735.58	413.30	56.19	929.89	414.29	44.55
	Spring	631.41	388.64	61.55	664.56	322.35	48.51
	Spring and Fall	672.69	401.65	59.71	769.69	380.95	49.49
WW	Fall	358.95	226.11	62.99	478.60	217.51	45.45
	Spring	373.44	236.59	63.35	424.02	265.83	62.69
	Spring and Fall	367.70	232.49	63.23	445.65	247.09	55.44
PW	Fall	0.56	0.27	47.97	0.57	0.26	45.48
	Spring	0.64	0.23	36.07	0.64	0.26	39.58
	Spring and Fall	0.61	0.25	41.03	0.61	0.26	41.82
MD	Fall	1.02	0.55	54.45	0.97	0.61	62.77
	Spring	1.22	0.59	48.50	1.13	0.50	43.97
	Spring and Fall	1.14	0.58	51.33	1.07	0.54	51.01
UD	Fall	1.39	1.52	109.52	1.24	1.43	115.14
	Spring	2.16	2.56	118.56	1.79	1.41	78.77
	Spring and Fall	1.85	2.24	120.83	1.57	1.43	90.92
WDR	Fall	445.60	396.75	89.04	601.52	368.11	61.20
	Spring	381.22	317.72	83.34	444.70	349.73	78.64
	Spring and Fall	406.73	352.40	86.64	506.83	361.98	71.42
PC	Fall	42.00	6.43	15.31	40.79	6.37	15.61
	Spring	40.59	7.85	19.34	40.60	7.69	18.94
	Spring and Fall	41.15	7.35	17.86	40.67	7.13	17.53
PF	Fall	7.28	1.40	19.29	7.32	1.41	19.23
	Spring	6.99	2.87	41.05	6.69	2.72	40.70
	Spring and Fall	7.10	2.40	33.80	6.94	2.30	33.10
PWM	Fall	12.23	6.84	55.94	12.53	5.85	46.70
	Spring	11.18	5.92	52.94	11.49	6.62	57.64
	Spring and Fall	11.59	6.32	54.49	11.90	6.29	52.86

		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
PG	Fall	25.37	7.04	27.74	26.38	6.40	24.27
	Spring	24.13	6.92	28.68	23.99	7.40	30.85
	Spring and Fall	24.62	6.99	28.39	24.94	7.06	28.31

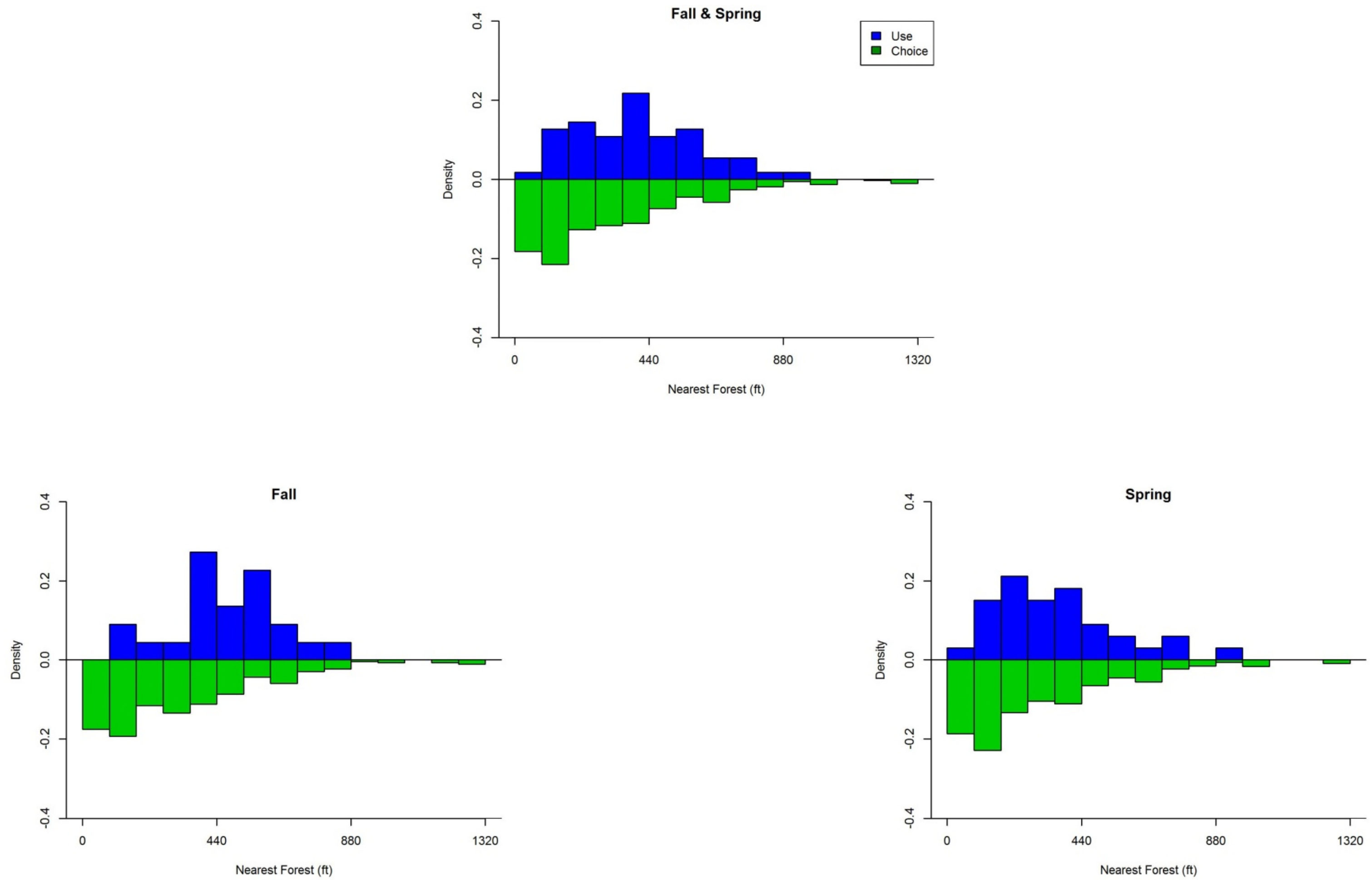


Figure B.1. Histograms of nearest riparian forest (feet [ft]) at systematic unique locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and Fall were combined (above) and shown separately (below).

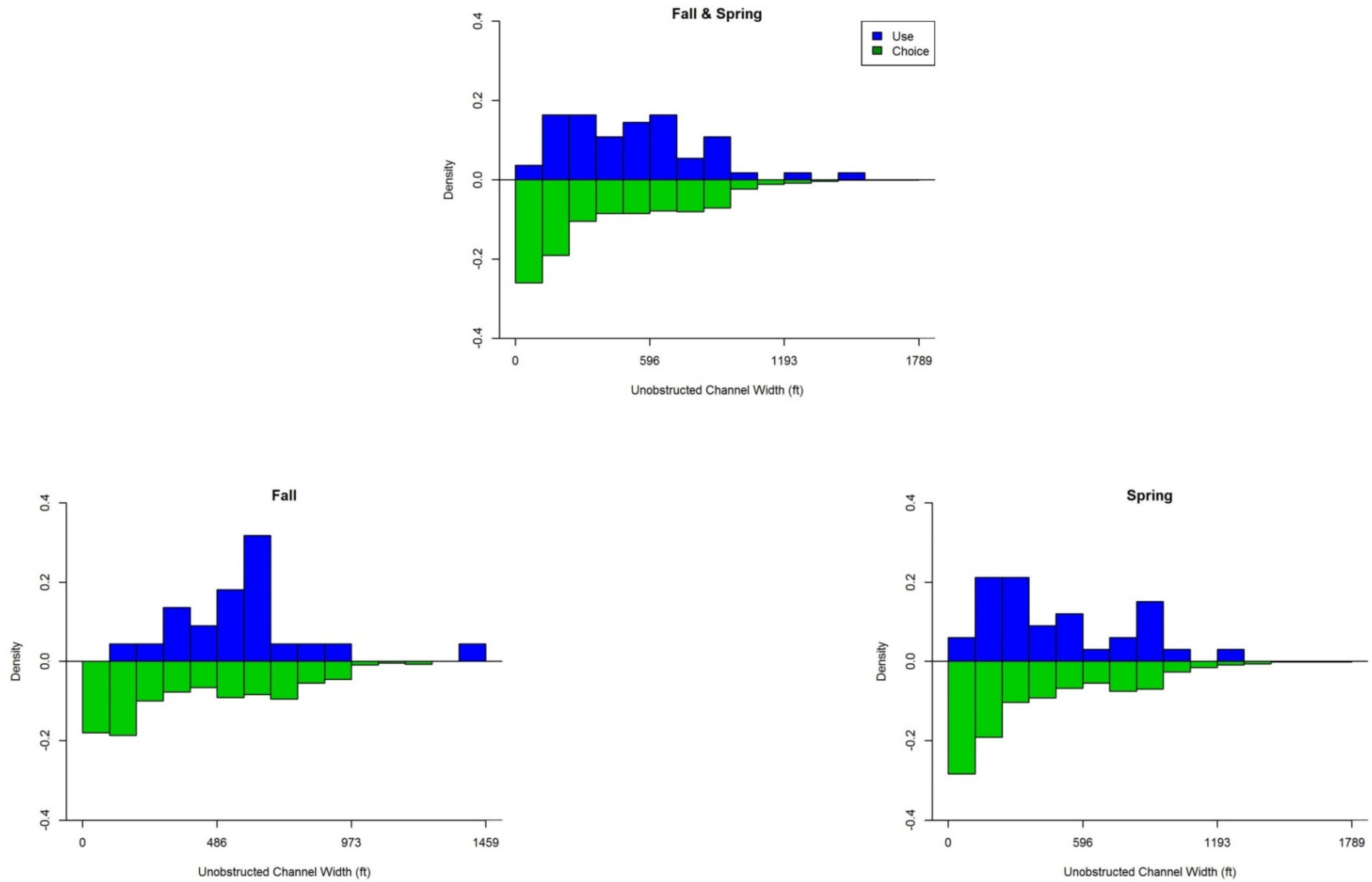


Figure B.2. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

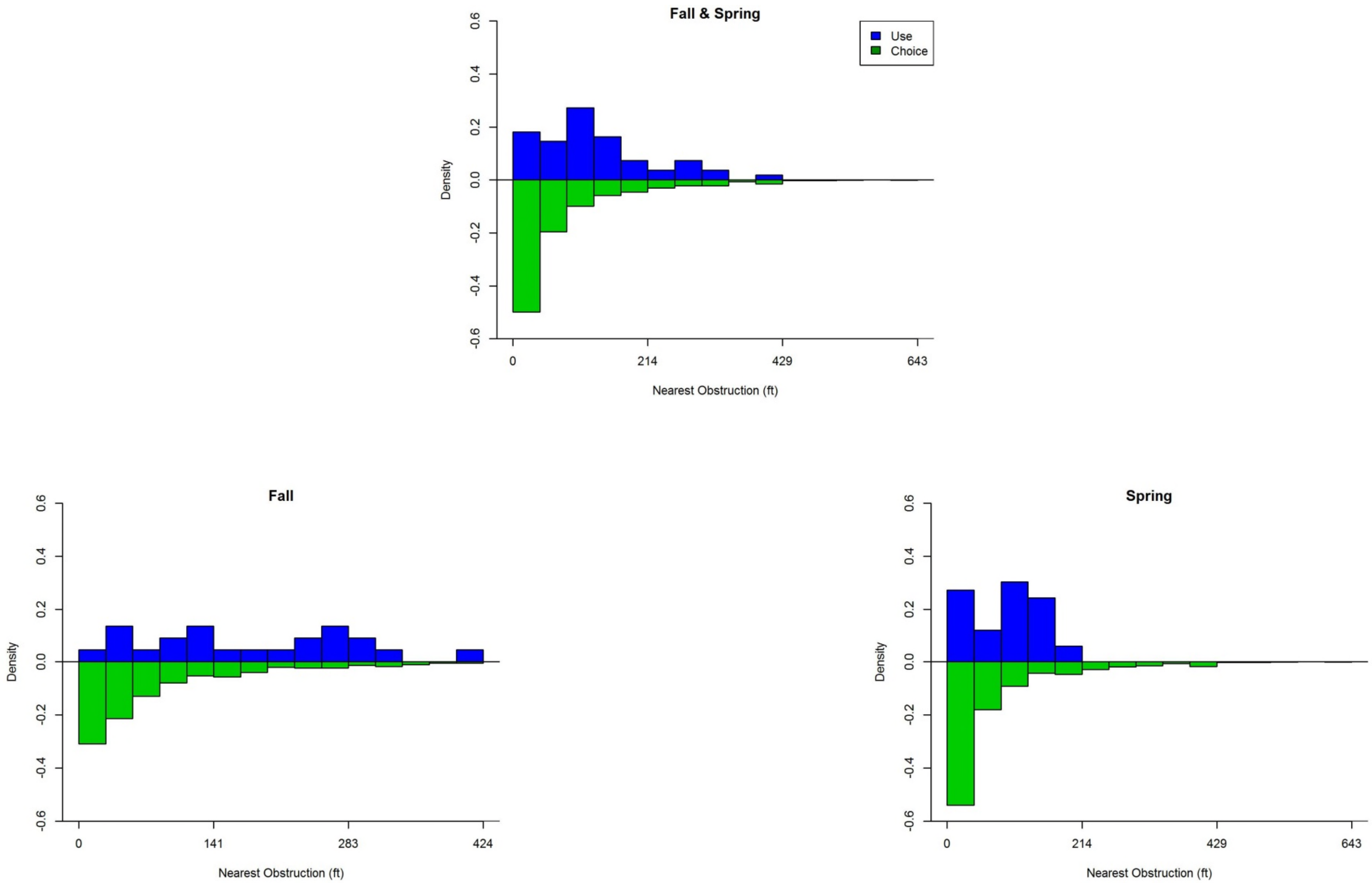


Figure B.3. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

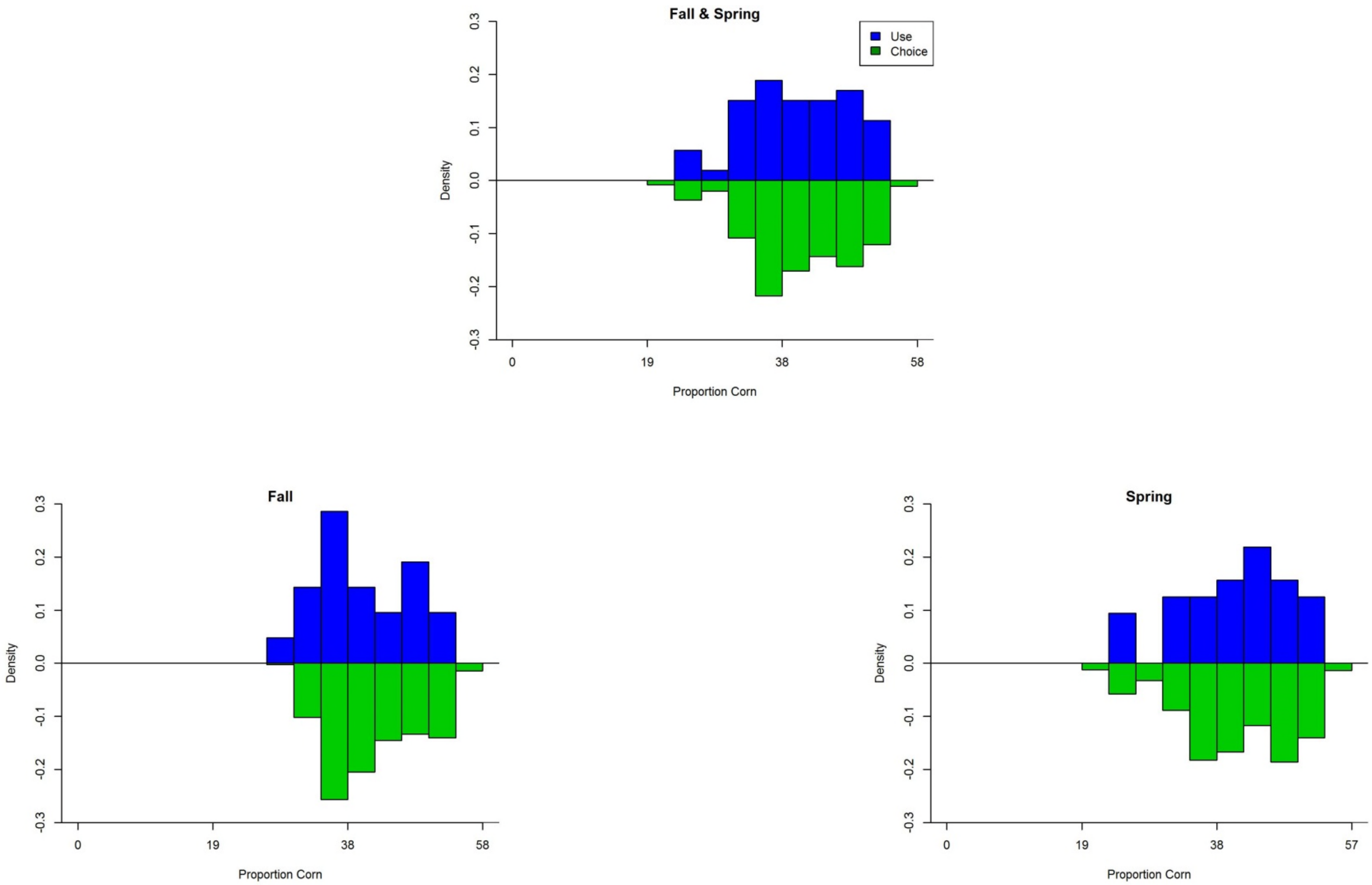


Figure B.4. Histograms of proportion of landcover within a 1-mile radius classified as corn at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

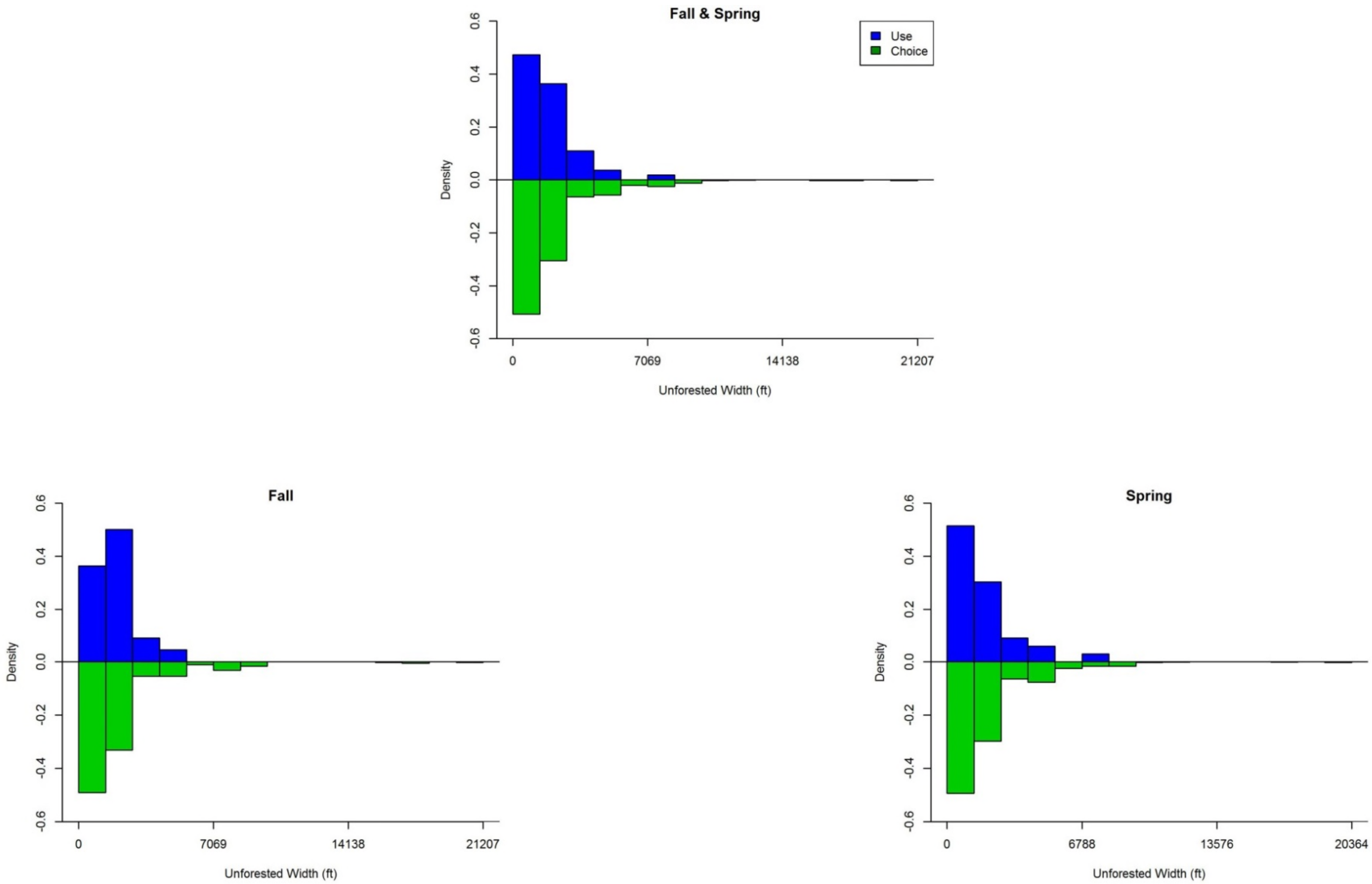


Figure B.5. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

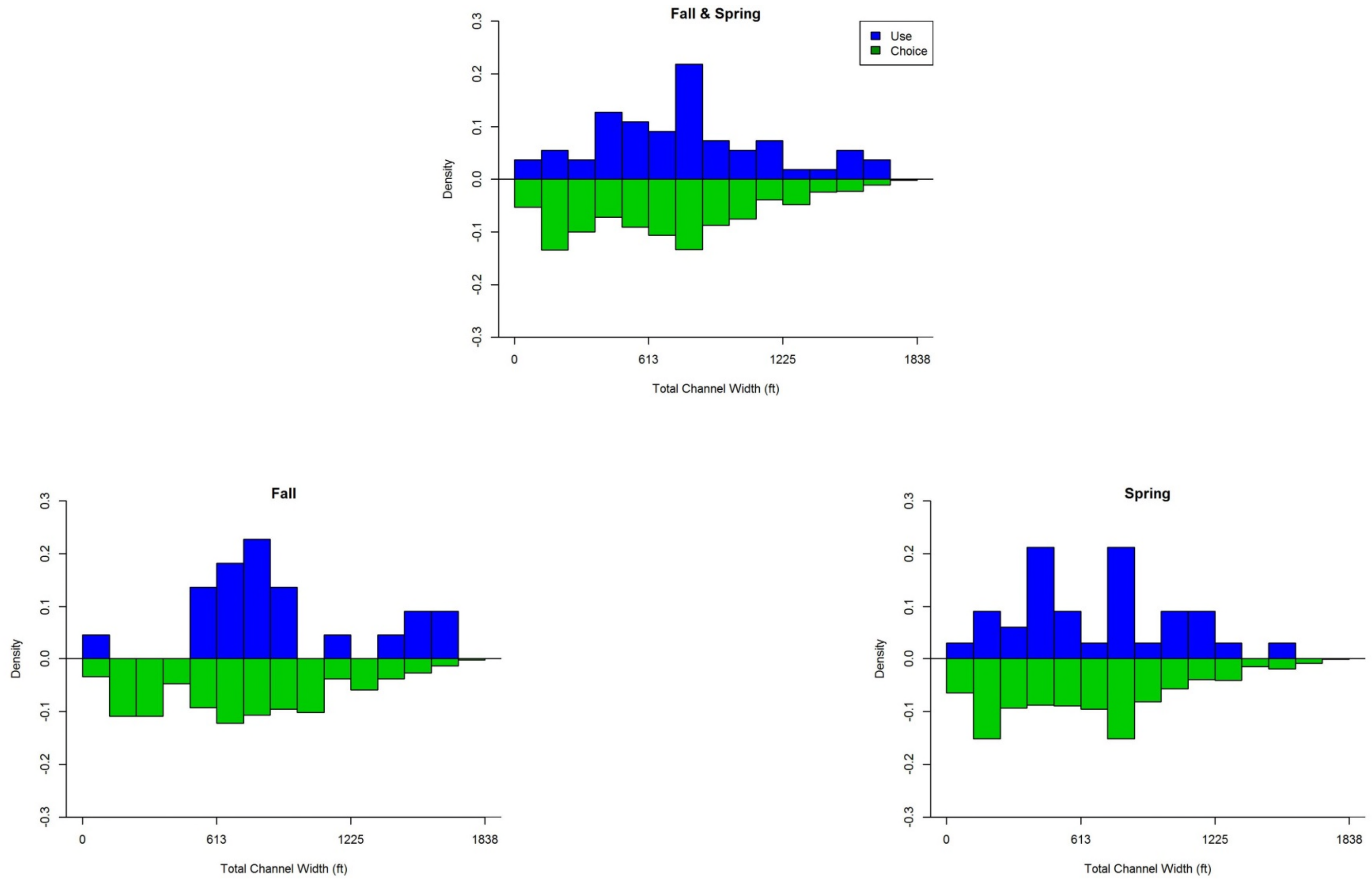


Figure B.6. Histograms of total channel width from left bank to right bank (feet [ft]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

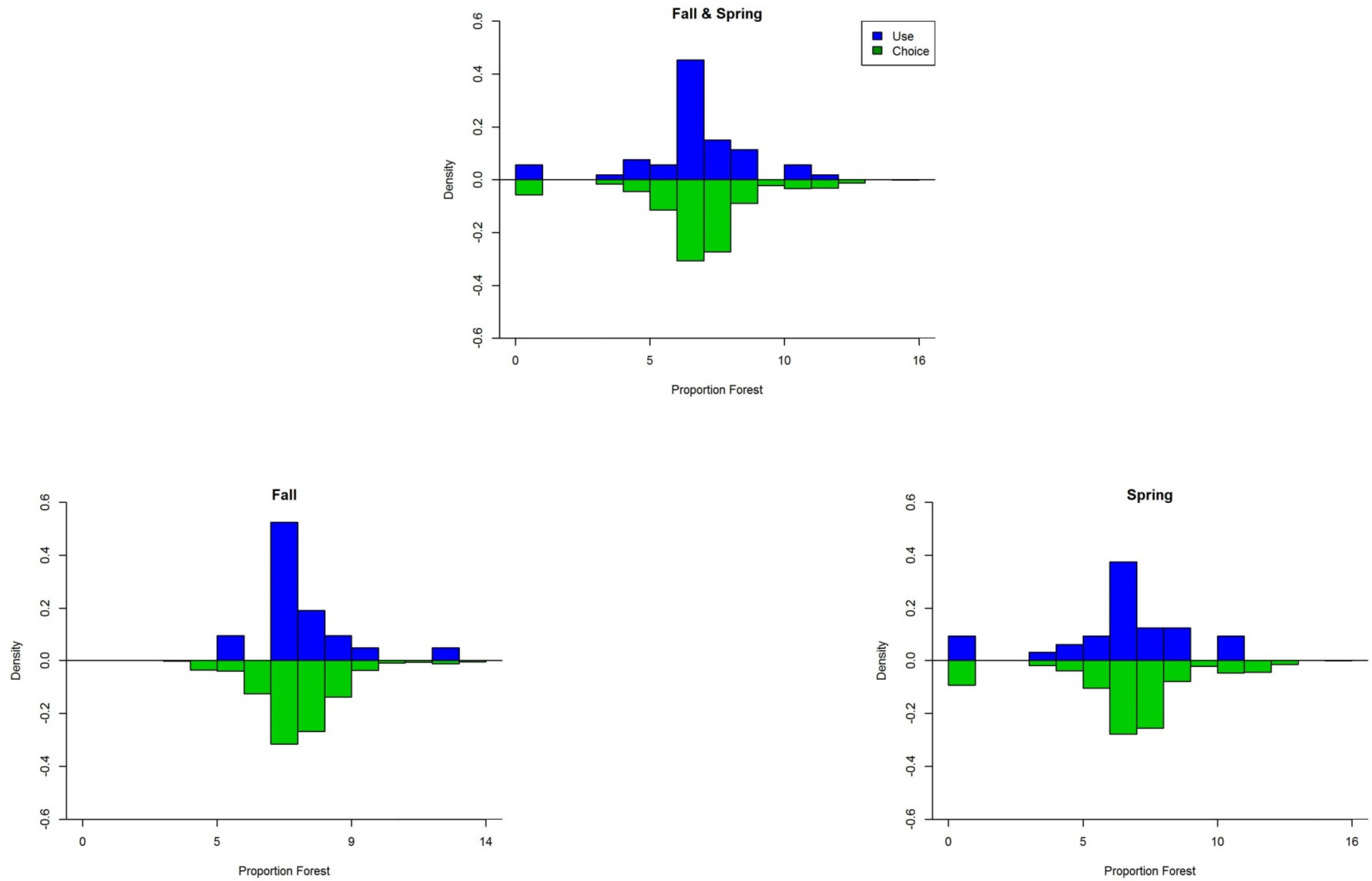


Figure B.7. Histograms of proportion of landcover within a 1-mile radius classified as forest at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

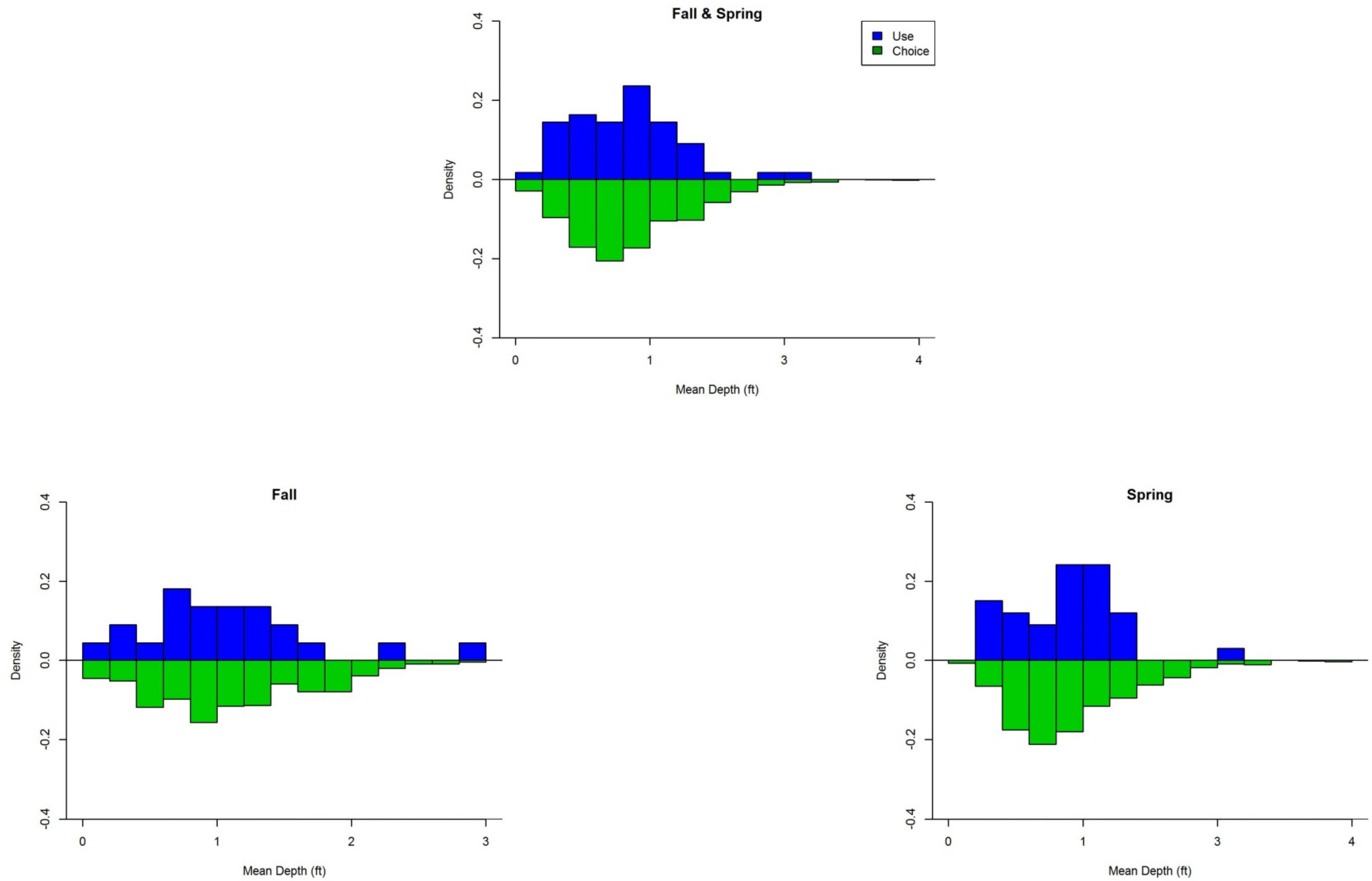


Figure B.8. Histograms of mean depth of the wetted channel (feet [ft]) at systematic unique locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and Fall were combined (above) and shown separately (below).

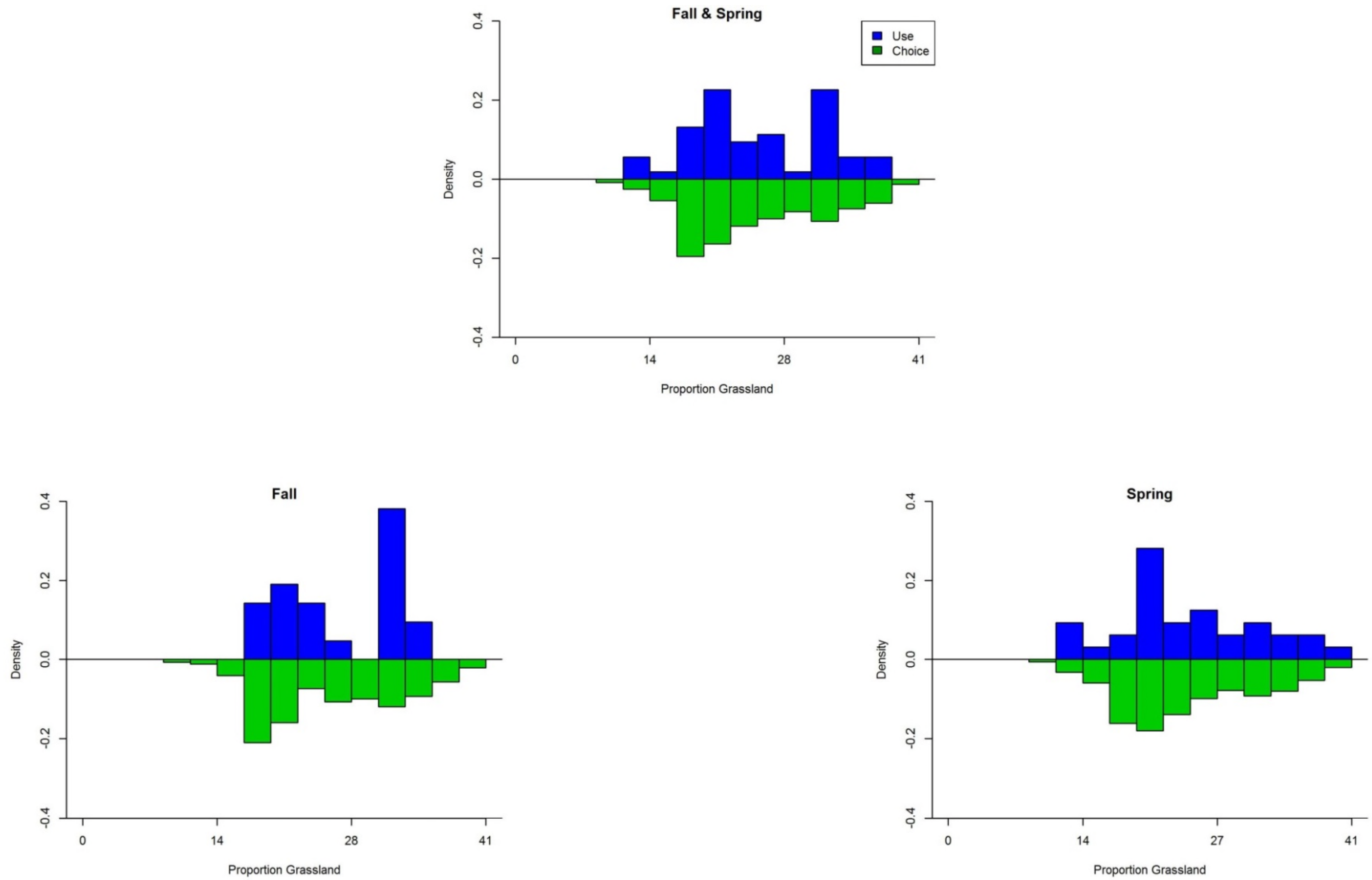


Figure B.9. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

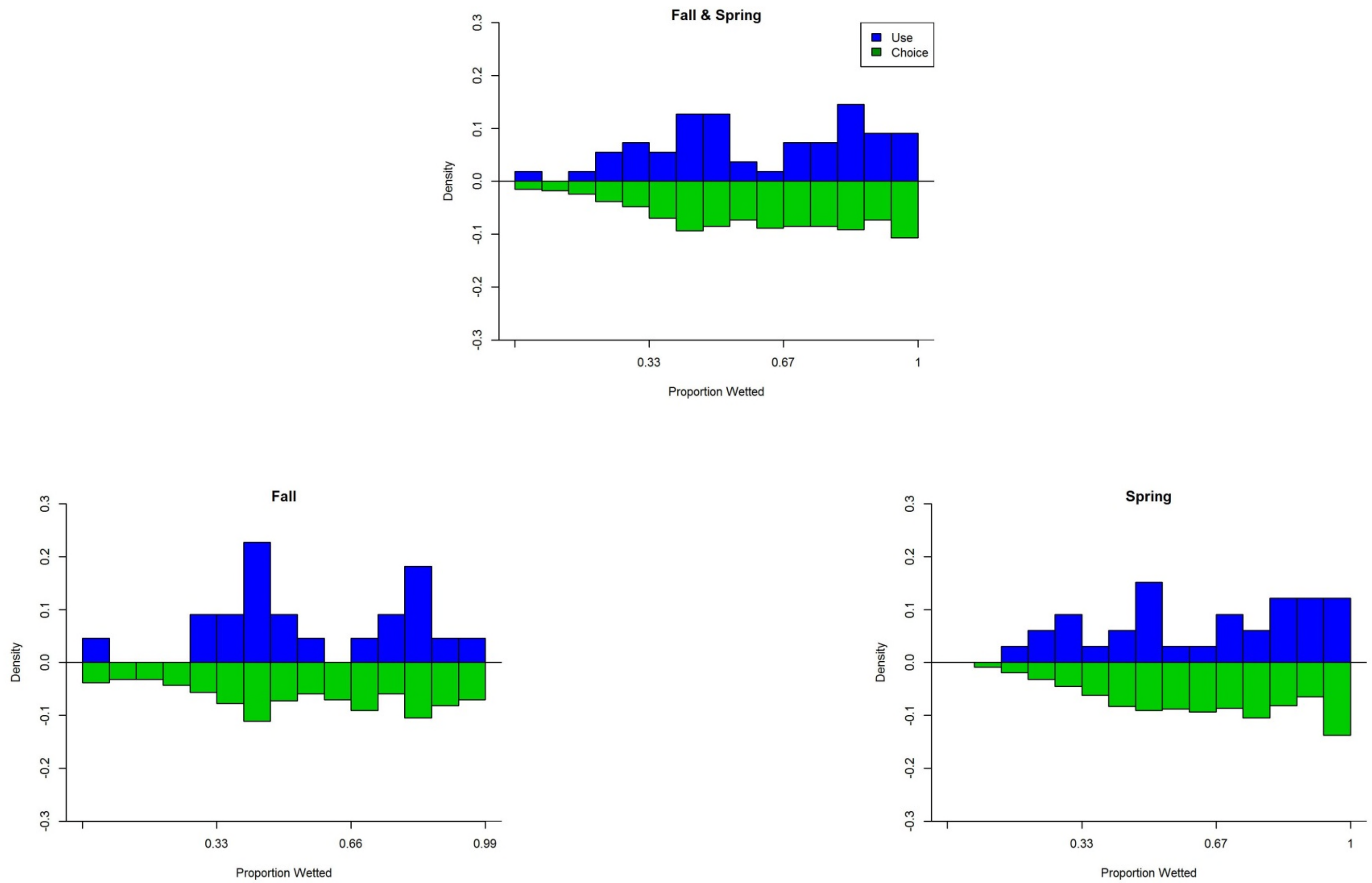
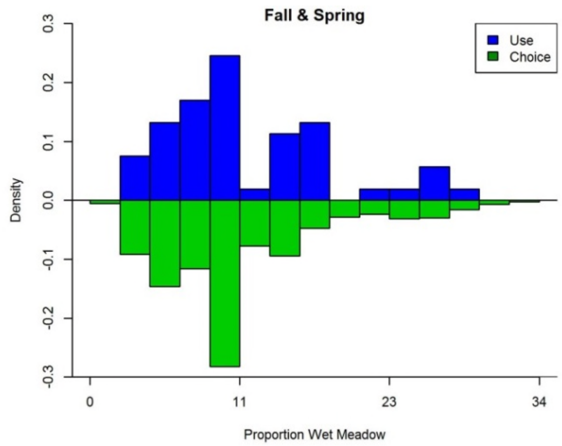
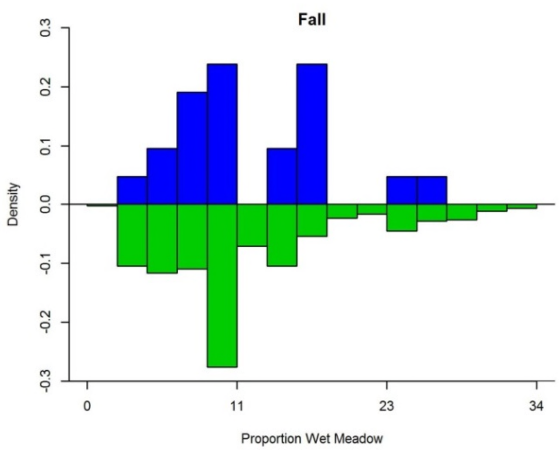


Figure B.10. Histograms of proportion of wetted area present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).





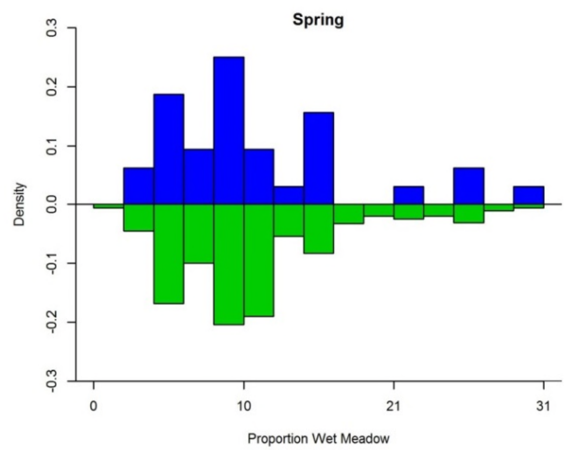


Figure B.11. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

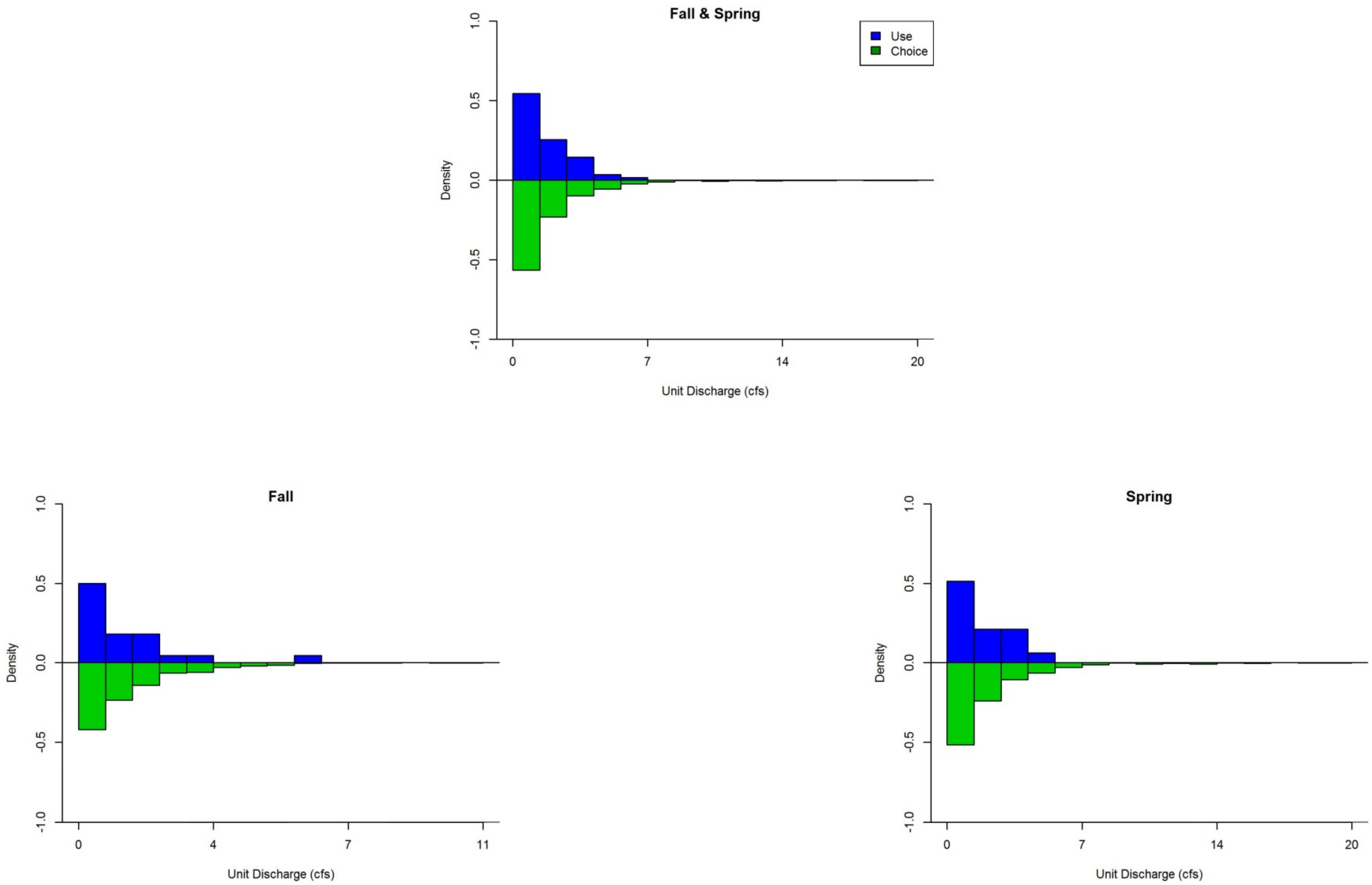


Figure B.12. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

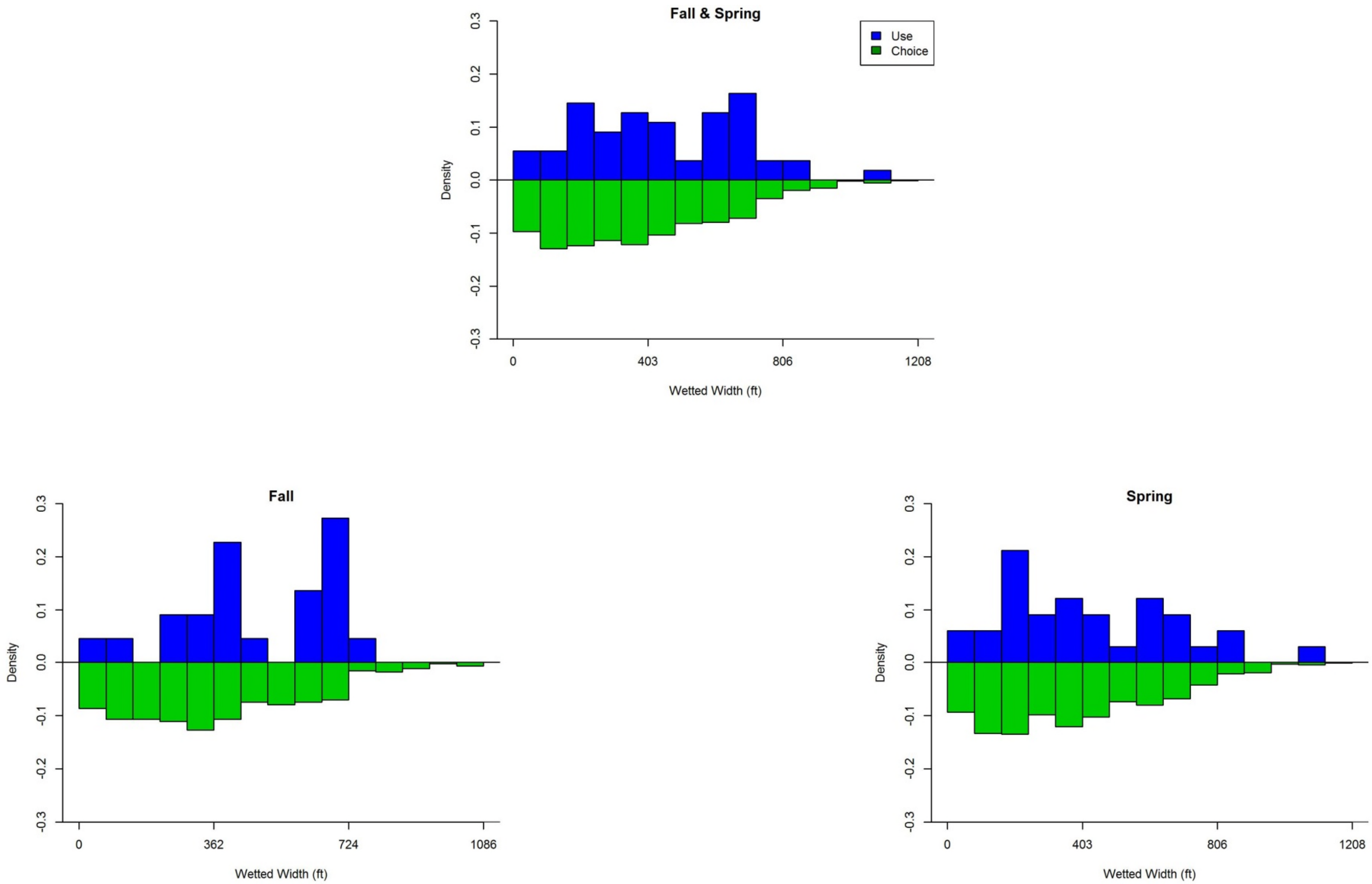


Figure B.13. Histograms of top width (feet [ft]) of wetted channel at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

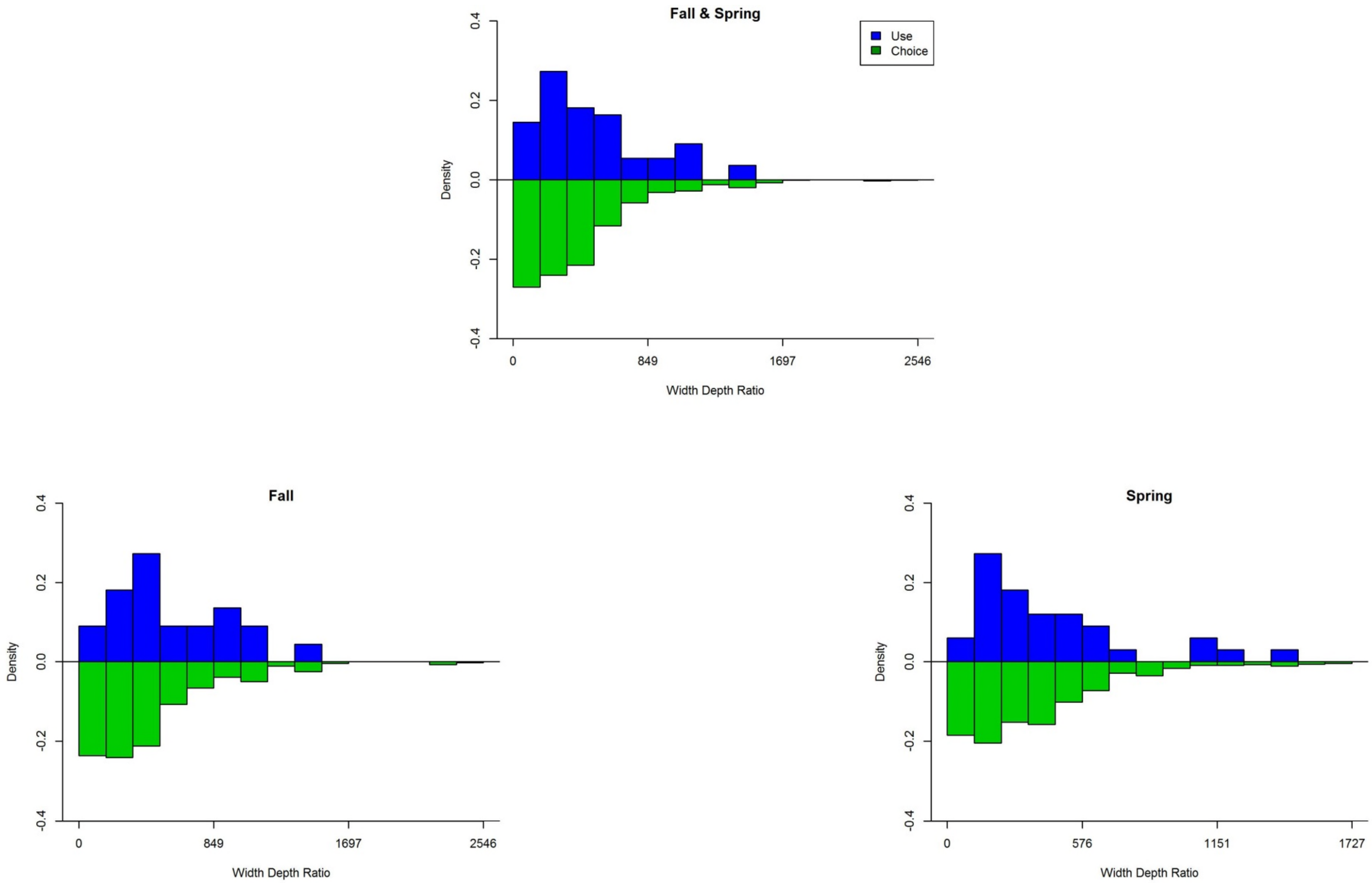


Figure B.14. Histograms of width-to-depth ratio (wetted depth / mean depth) at systematic unique locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and Fall were combined (above) and shown separately (below).

Appendix C. Analysis of All Systematic In-Channel Whooping Crane Group Observations

Table of Contents

List of Figures ii
List of Tables iv
1. Introduction 1
2. Methods 2
3. Results 2
Whooping Crane Group Observations 2
Habitat Selection for Spring and Fall Combined 2
Spring Habitat Selection 4
Fall Habitat Selection 5
4. Discussion 6
5. References 24

List of Figures

Figure C.1. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 3

Figure C.2. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 3

Figure C.3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 4

Figure C.4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 4

Figure C.5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 5

Figure C.6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 6

Figure C.7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of total channel widths in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 6

Figure C.8. Histograms of nearest riparian forest (feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 10

Figure C.9. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 11

Figure C.10. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 12

Figure C.11. Histograms of proportion of landcover within a 1-mile radius classified as corn at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 13

Figure C.12. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 14

Figure C.13. Histograms of total channel width from left bank to right bank (feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 15

Figure C.14. Histograms of proportion of landcover within a 1-mile radius classified as forest at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 16

Figure C.15. Histograms of mean depth of the wetted channel (feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below)...... 17

Figure C.16. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 18

Figure C.17. Histograms of proportion of wetted area present at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 19

Figure C.18. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 20

Figure C.19. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 21

Figure C.20. Histograms of top width (feet [ft]) of wetted channel at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 22

Figure C.21. Histograms of width depth ratio (wetted depth / mean depth) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below)...... 23

List of Tables

Table C.1. Sample size for in-channel models with 20 locations in each choice set. Observations include non-unique locations obtained by systematic sampling from fall 2001 to spring 2013..... 2

Table C.2. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis, excluding fall 2001 and spring 2002 observations. Spring sample sizes were 115 for used locations and 2300 for the choice sets, fall sample sizes were 46 for used locations and 920 for the choice sets. Variable abbreviations are in the methods section of the main body of the report. 8

1. Introduction

We reran the analysis presented in the main body of the report on a second set of data encompassing additional observations of group use by whooping cranes in the central Platte River. We conducted this analysis to incorporate every systematic observation of whooping crane groups in the central Platte River study area, in order to increase the sample size of the modelling efforts. All the observations included in this appendix were obtained through systematic sampling of the entire river corridor. The additional sightings come from multiple relocations of crane groups assumed to have been located previously in the study area, and are termed "non-unique" here. For example, a crane group identified during aerial surveys could also be observed on subsequent days during multi-day stopovers, thus providing one unique observation and one or more non-unique observations for one group of whooping cranes. In total there were an additional 96 non-unique observations detected during the spring migration and an additional 25 non-unique observations detected during the fall migration.

In general, exact identification of a migrating whooping crane group was not possible because individuals are not marked, nor do they have discernable phenotypical differences. For this reason, it was rarely known if an individual observed in the area was the same individual observed at a nearby area or even in the same area at another time. Biologists have typically used cues such as group size, group composition, timing, and location to make professional judgements regarding whooping crane groups that were seen on multiple days within a migration season. For example, biologists will generally agree that a crane group composed of two adults and one juvenile that has been observed on two consecutive days was the same group, if the sightings were within a reasonable spatial proximity.

In statistical analyses, there are important assumptions regarding the independence of the data (Breslow 1996). The treatment of non-independent data as independent data in an analysis is often called pseudo-replication (Hurlbert 1984). These assumptions directly relate to the ability of a random sample to provide unbiased inference towards a specified population. In order to have results that can be applied to the population, the data in the sample should be representative of the population of interest (Thompson 1992). When multiple observations of the same individuals are included when fitting a model, the response of interest, e.g. habitat use, can be biased by those individuals compared to other individuals that are observed only once, meaning that the habitat preferences of the individuals observed multiple times will be considered more heavily in the model than individuals observed once. In the case with migrating whooping cranes using the central Platte River, it is possible that the inclusion of non-unique sightings in an analysis is biased, as different durations of crane group stopovers can be related to the habitat encountered.

The PRRIP data collection for migrational habitat information on whooping cranes was conducted such that the professional judgements by the USFWS whooping crane coordinator regarding crane group identity were recorded, but were not inherently defined in the dataset. In other words, analyses can be conducted treating all crane groups as independent, or attributing multiple observations to repeated use of the same crane group.

The study of rare, or hard to detect, wildlife populations consistently leads to issues of pseudo-replication during the analysis. Researchers must balance the need for adequate sample size in the statistical analysis, with the perils of biasing the results with the inclusion of non-typical or non-random individuals. The results presented in the main body of the report, based only on unique or independent observations, contain less bias than results presented in this appendix. The impact of the inclusion of non-unique observations in this analysis was evaluated by fitting these data to the same models that were presented in the main body of the report.

2. Methods

For this analysis of habitat use we followed the same methods as written in the Methods section of the main body of the report. There were no changes in the definition of available habitat or the descriptors of habitat use. We did not repeat model selection but rather fit the best models identified during the analysis of the systematic unique data with all systematically collected data (i.e., unique and non-unique locations).

3. Results

Whooping Crane Group Observations

We developed in-channel habitat selection models for the 129 spring, 47 fall, and the combined 176 spring and fall systematic unique and non-unique whooping crane group observations (Table C.1). These observations span the time from fall 2001 to spring 2013. Actual sample sizes in the models were larger because of the inclusion of the data representing the choice set (Table C.1).

Table C.1. Sample size for in-channel models with 20 locations in each choice set. Observations include non-unique locations obtained by systematic sampling from fall 2001 to spring 2013.

Season	Number of Use Locations in Analysis	Total Number of Data Points in Analysis
Spring	129	2709
Fall	47	987
Spring and Fall Combined	176	3696

Habitat Selection for Spring and Fall Combined

As presented in the main body of the report, the top management model for spring and fall observations indicated unobstructed channel width and nearest forest were the most important predictor variables for management purposes. The estimated smoothing spline functions for each of these variables, when fit to all systematic data, were positively increasing with larger values of unobstructed channel width and nearest forest up to a point, after which declines were predicted. The model results indicated the highest selection ratio value was predicted to occur at 615 feet for unobstructed channel width (Figure C.1). Increased nearest forest was associated with a higher predicted selection ratios up to the highest selection ratio predicted to occur at 594 feet from the center of the channel (Figure C.2). The estimated degrees of freedom for the smoothed terms were 4.75 and 3.71 for unobstructed channel width and nearest forest respectively.

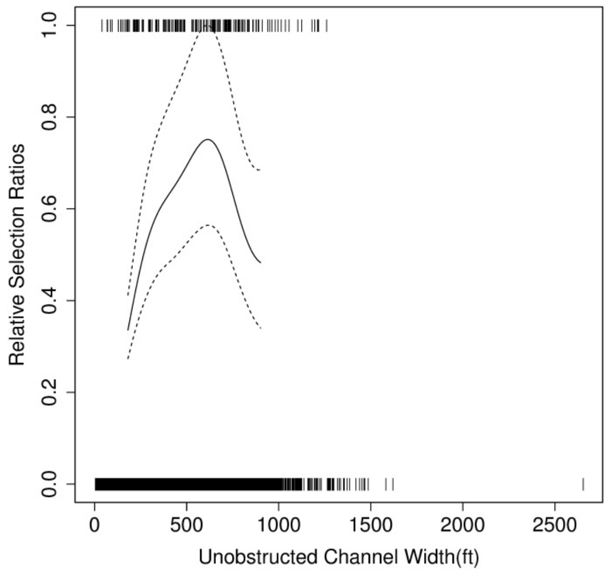


Figure C.1. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

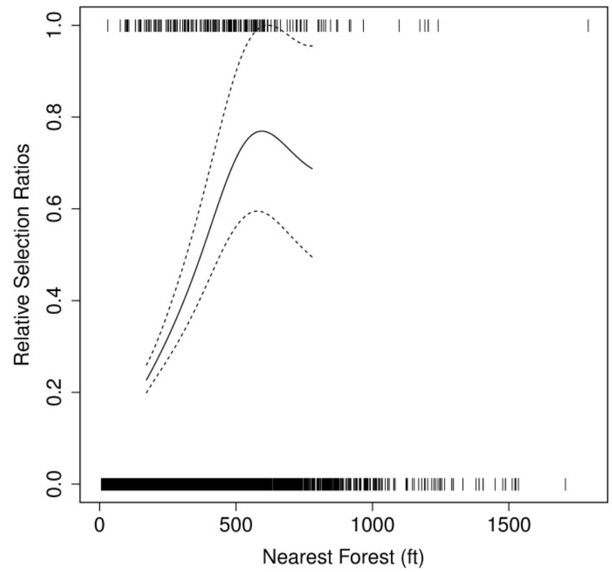


Figure C.2. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

As indicated in the main body of the report, the top model for in-channel habitat use for the spring and fall observations combined, across every candidate model in the *a priori* set, indicated nearest obstruction and nearest forest were the most important predictor variables. The estimated smoothing spline functions for each of these variables were positively increasing with larger values of nearest obstruction and nearest forest, indicating a positive relationship between predicted relative selection ratios and each variable. The model results indicate increased nearest obstruction was associated with a higher predicted relative selection ratio with the highest value predicted to occur at 261 feet (Figure C.3). Increased nearest forest was associated with a higher predicted relative selection ratio with the highest value predicted to occur at 697 feet (Figure C.4). The estimated degrees of freedom for the smoothed terms were 4.61 and 3.09 for nearest obstruction and nearest forest respectively.

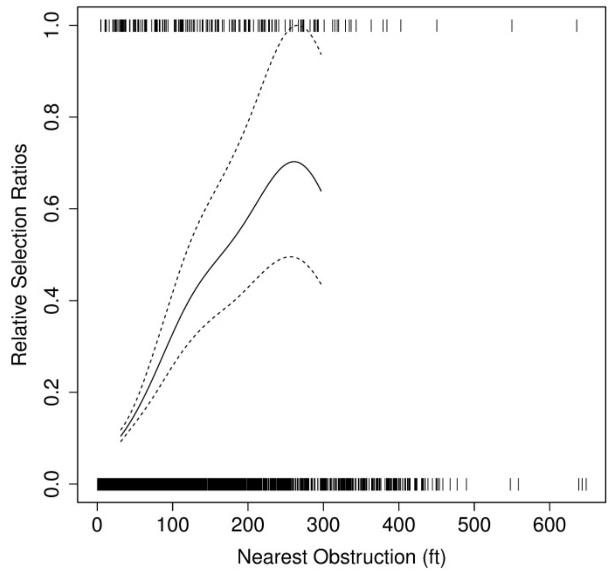


Figure C.3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

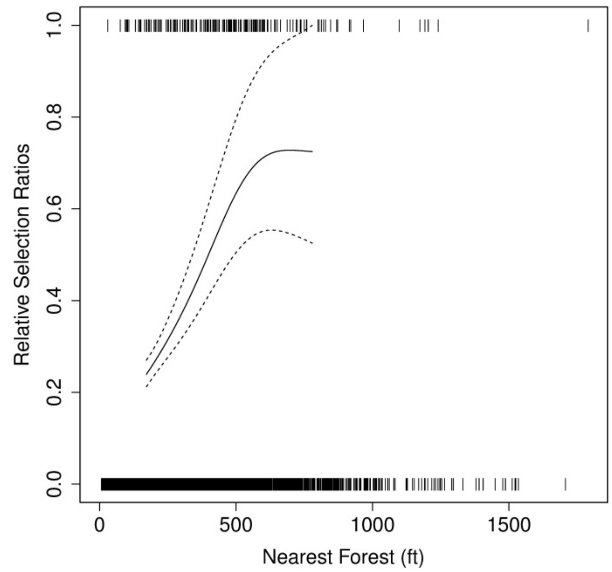


Figure C.4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring and fall combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Spring Habitat Selection

The estimated smoothing spline function for nearest obstruction was quadratic shaped depicting predicted selection ratios positively increasing with larger values up to a point, after which declines were predicted. The model results for unobstructed channel width indicated the highest selection ratio was predicted to occur at 266 feet (Figure C.5). The estimated degrees of freedom for the smoothed term was 4.47.

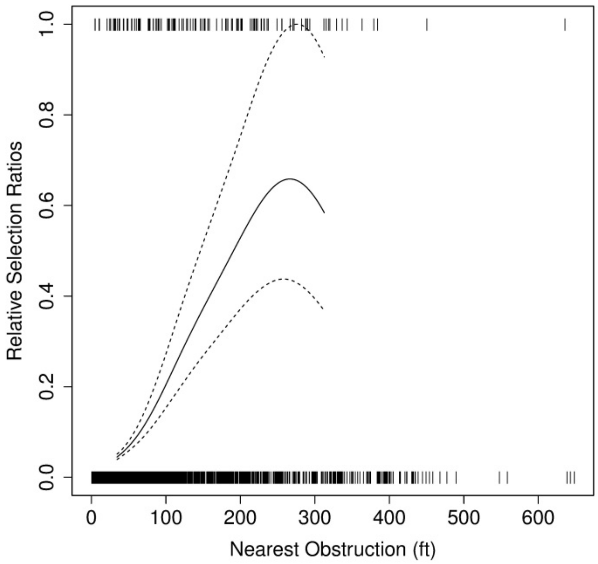


Figure C.5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Fall Habitat Selection

The parametric function for nearest obstruction was positively increasing with larger values of nearest obstruction, indicating a positive relationship between predicted relative selection ratios and nearest obstruction. The model results indicate increased nearest obstruction was associated with a higher predicted relative selection ratios with the highest value predicted to occur at 289 feet (Figure C.6). Increased total channel width was associated with variable relative selection ratios with the highest value predicted to occur at 672 feet (Figure C.7), though the relationship was not statistically significant (p=0.1290). The estimated degrees of freedom for the model terms were 1 and 3.62 for nearest obstruction and total channel width respectively.

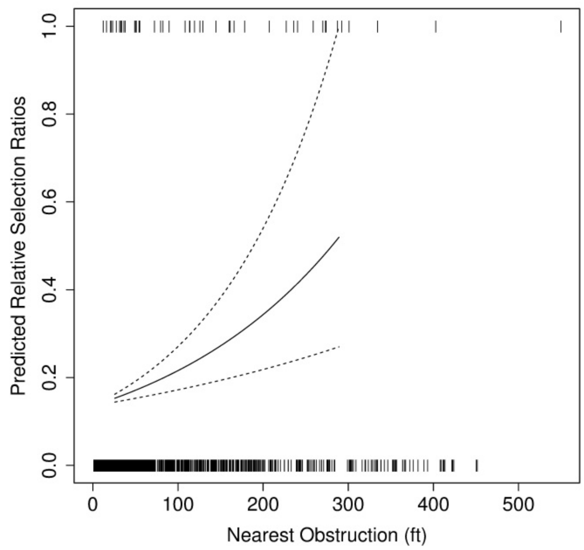


Figure C.6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

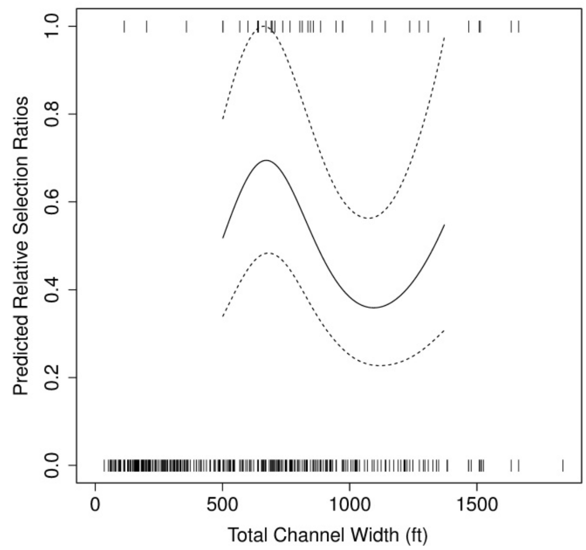


Figure C.7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of total channel widths in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Summary statistics for each variable for the used locations contrasted to the choice sets for fall 2002 to spring 2013 are in Table C.2 and graphical summaries are in Figure C.8 to Figure C.21.

4. Discussion

The in-channel habitat models presented here, with the inclusion of all unique and non-unique systematic locations, related a similar message about whooping crane habitat selection on the central Platte River compared to the results presented in the main body of the report. There were consistent modelled relationships between habitat descriptors and relative selection ratios for each season. The distances at which the curves were maximized, for the majority of linear and quadratic cases, were larger with the inclusion of the non-unique observations compared to the systematic unique results in the main body of the report.

The combined spring and fall models indicated whooping cranes selected for larger distances to nearest forest and obstruction and wider unobstructed channel widths up to a point after which the relative selection ratios declined. The selection ratios for unobstructed channel width and nearest forest in the top management model were maximized at 615 and 594 feet, respectively, it can be inferred based on the confidence intervals at these peaks that unobstructed channel widths between 315 and 799 feet and distances between 425 and 779 feet to the nearest forest would result in statistically similar selection ratios. For the top overall model, the selection ratios for nearest obstruction and nearest forest were maximized at 261 and 697 feet, respectively, based on the confidence intervals, that distances to nearest obstruction between 162 and 297 feet and distances between 432 and 779 feet to the nearest forest would result in statistically similar selection ratios.

The spring model suggested whooping cranes selected wide unobstructed views, with the maximum at 266 feet. Whooping crane groups were observed across a wide range of values and it can be inferred based on confidence intervals that nearest obstruction distances between 170 and 313 feet would result in statistically similar selection ratios.

The fall model suggested whooping cranes selected wide unobstructed views, with the maximum at 289 feet. Based on the confidence intervals at the peak, nearest obstruction distances as small as 148 feet would result in statistically similar selection ratios. Total channel width in the fall model suggested whooping cranes selected wide unobstructed views, with the maximum at 672 feet. Based on the confidence intervals at the peak, channel widths between 501 and 886 feet would result in statistically similar selection ratios.

Table C.2. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis, excluding fall 2001 and spring 2002 observations. Spring sample sizes were 115 for used locations and 2300 for the choice sets, fall sample sizes were 46 for used locations and 920 for the choice sets. Variable abbreviations are in the methods section of the main body of the report.

		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
UOCW	Fall	385.69	286.88	74.38	482.29	305.01	63.24
	Spring	365.11	326.56	89.44	552.65	295.64	53.50
	Spring and Fall	370.99	315.83	85.13	532.55	299.09	56.16
NO	Fall	87.06	93.48	107.37	138.67	116.95	84.34
	Spring	74.85	91.04	121.64	157.07	110.71	70.49
	Spring and Fall	78.34	91.90	117.31	151.81	112.47	74.09
UFW	Fall	1886.22	2073.91	109.95	2201.24	1442.50	65.53
	Spring	2045.23	2349.08	114.86	2977.81	2924.93	98.22
	Spring and Fall	1999.80	2274.68	113.75	2755.93	2608.58	94.65
NF	Fall	320.78	247.72	77.22	497.40	213.48	42.92
	Spring	298.17	244.92	82.14	447.73	264.53	59.08
	Spring and Fall	304.63	245.89	80.72	461.92	251.36	54.42
TCW	Fall	754.04	403.75	53.55	869.11	359.79	41.40
	Spring	644.34	402.61	62.48	765.92	344.29	44.95
	Spring and Fall	675.68	405.91	60.07	795.40	350.79	44.10
WW	Fall	339.78	212.87	62.65	447.52	229.15	51.20
	Spring	368.02	225.17	61.18	485.47	220.89	45.50
	Spring and Fall	359.95	222.06	61.69	474.63	223.22	47.03
PW	Fall	0.52	0.26	50.79	0.55	0.25	46.34
	Spring	0.63	0.22	35.48	0.67	0.23	34.44
	Spring and Fall	0.60	0.24	40.28	0.64	0.24	38.34
MD	Fall	0.95	0.58	60.42	0.93	0.58	62.40
	Spring	1.19	0.54	45.60	1.00	0.42	41.87
	Spring and Fall	1.12	0.56	50.13	0.98	0.47	47.92
UD	Fall	1.27	1.72	135.72	1.06	1.26	119.45
	Spring	1.85	2.00	108.06	1.53	1.19	77.55
	Spring and Fall	1.69	1.94	115.31	1.40	1.22	87.73
WDR	Fall	483.20	425.48	88.05	583.90	344.62	59.02
	Spring	387.48	326.02	84.14	581.56	365.71	62.88
	Spring and Fall	414.83	359.82	86.74	582.23	358.74	61.62
PC	Fall	42.39	6.34	14.95	42.10	6.82	16.21
	Spring	40.39	7.22	17.87	39.52	6.75	17.07
	Spring and Fall	40.96	7.03	17.17	40.26	6.85	17.01
PF	Fall	7.12	1.61	22.65	7.29	1.55	21.22
	Spring	7.22	2.33	32.27	6.61	2.25	34.03
	Spring and Fall	7.20	2.15	29.89	6.80	2.09	30.74
PWM	Fall	10.95	6.32	57.68	11.48	5.43	47.27
	Spring	12.59	6.34	50.35	14.27	7.41	51.89
	Spring and Fall	12.12	6.37	52.59	13.47	7.00	51.93

		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
PG	Fall	24.47	6.92	28.28	25.27	6.63	26.24
PG	Spring	25.79	7.15	27.73	27.13	7.20	26.53
	Spring and Fall	25.41	7.11	27.98	26.60	7.07	26.58

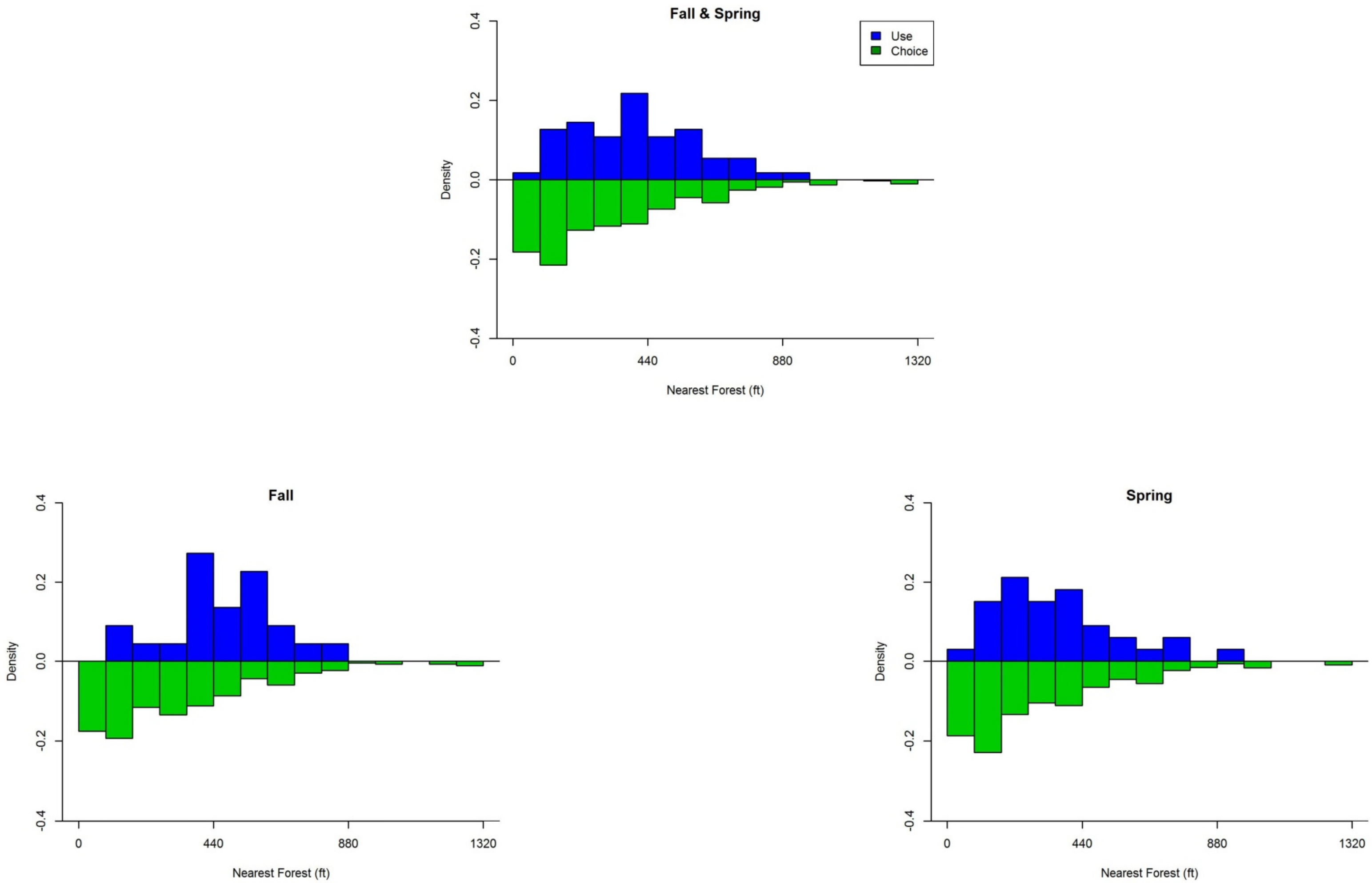


Figure C.8. Histograms of nearest riparian forest (feet [ft]) at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

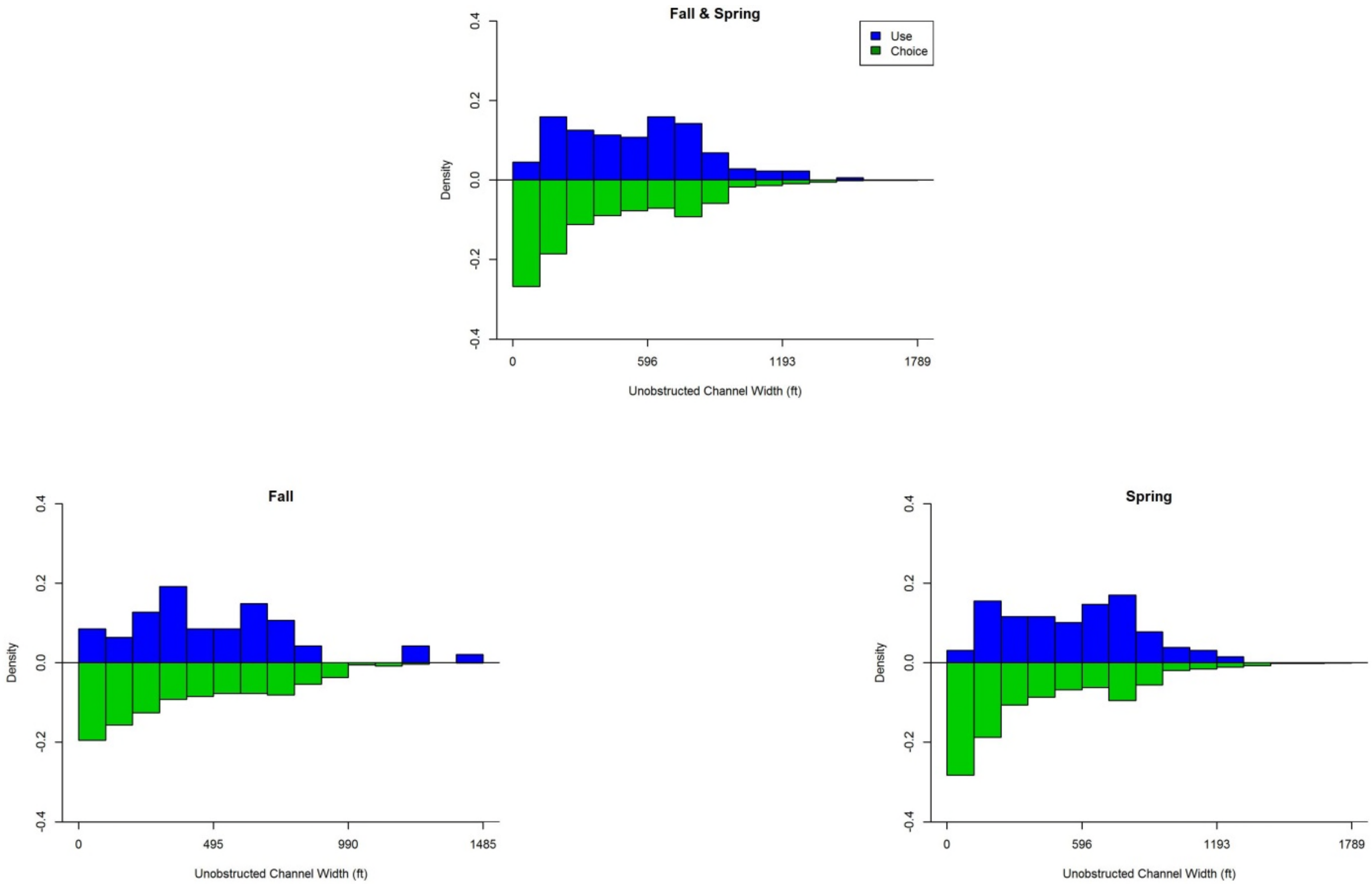


Figure C.9. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

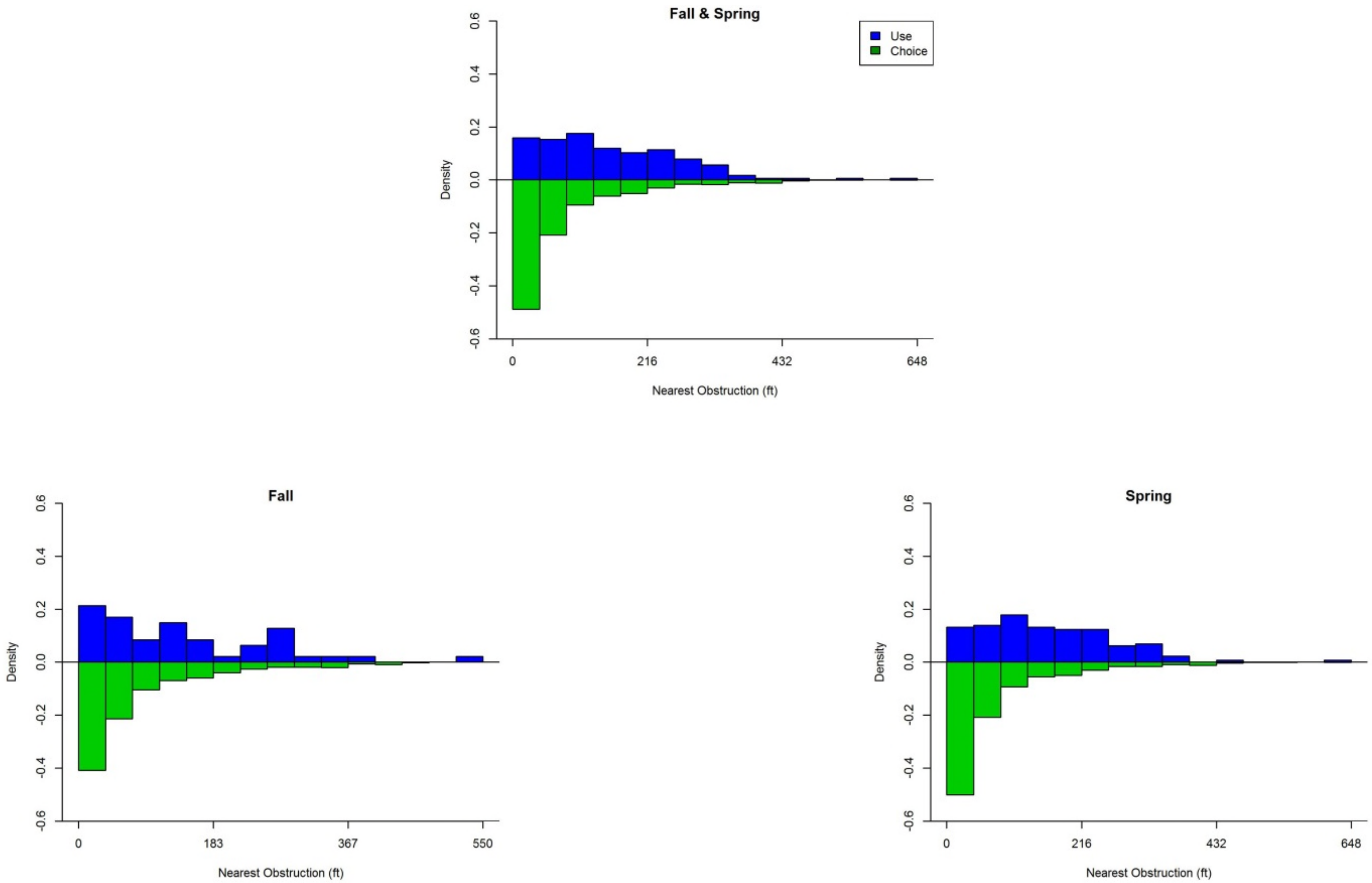


Figure C.10. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

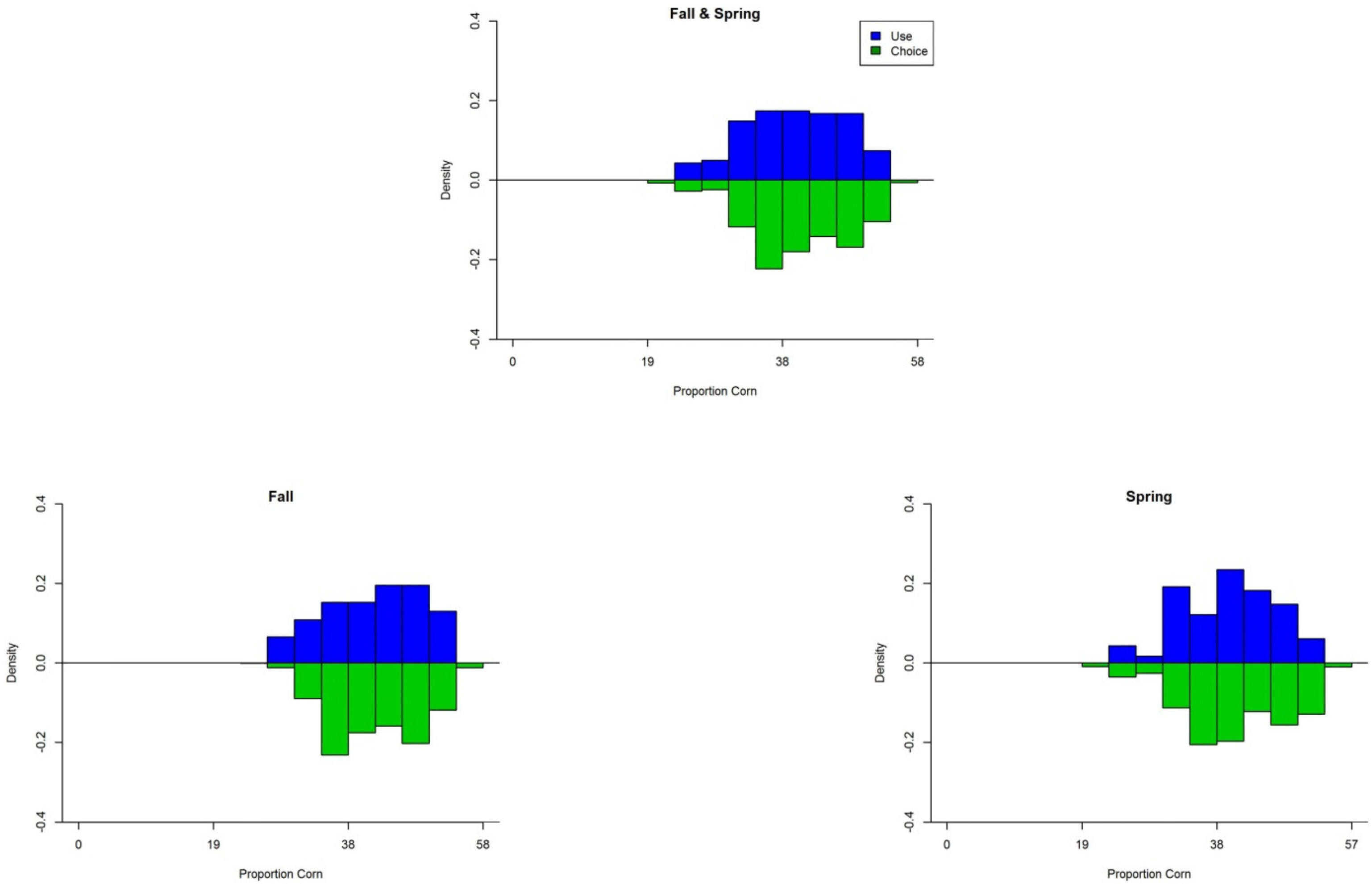


Figure C.11. Histograms of proportion of landcover within a 1-mile radius classified as corn at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

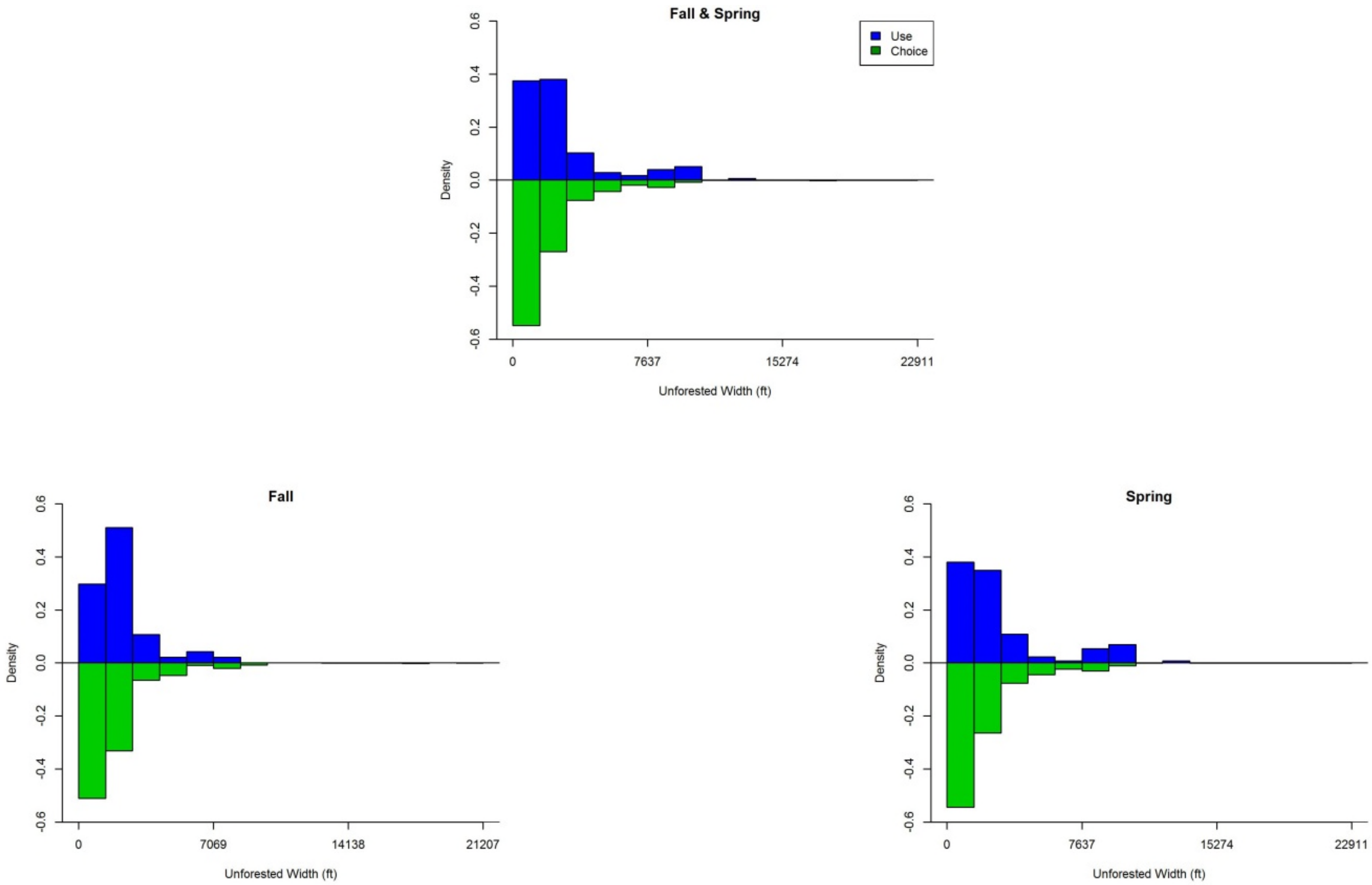


Figure C.12. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).

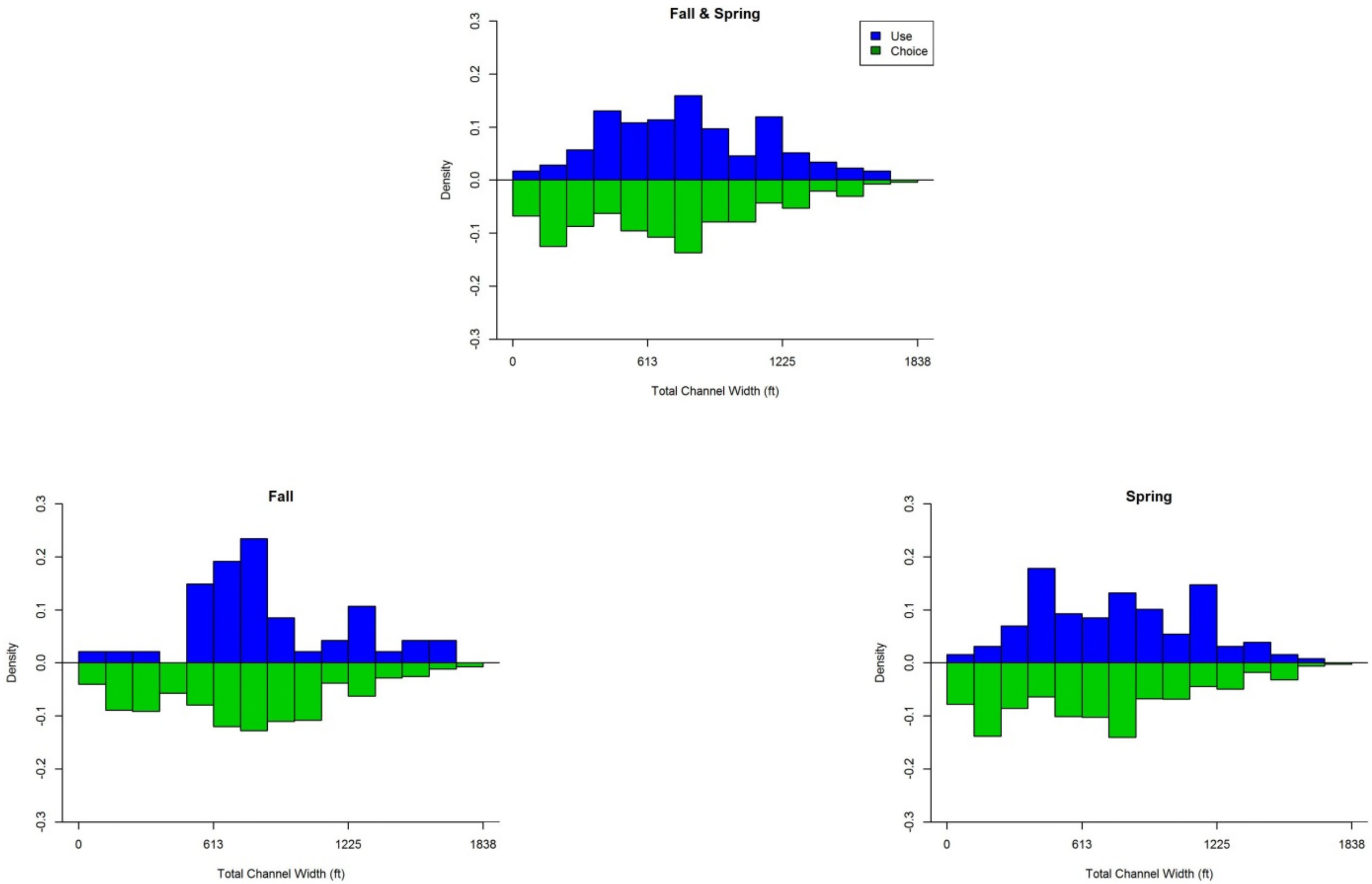


Figure C.13. Histograms of total channel width from left bank to right bank (feet [ft]) at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

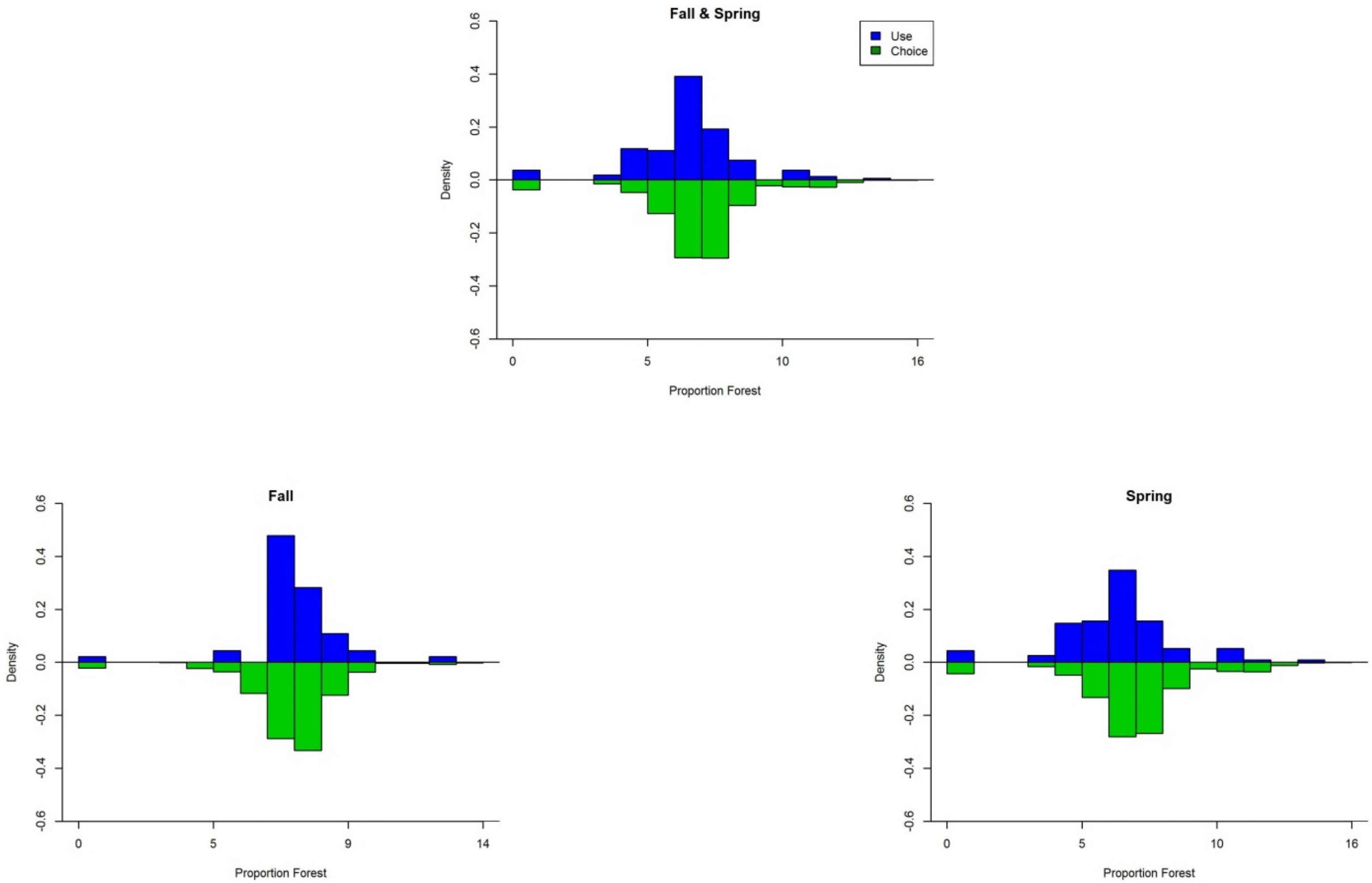


Figure C.14. Histograms of proportion of landcover within a 1-mile radius classified as forest at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

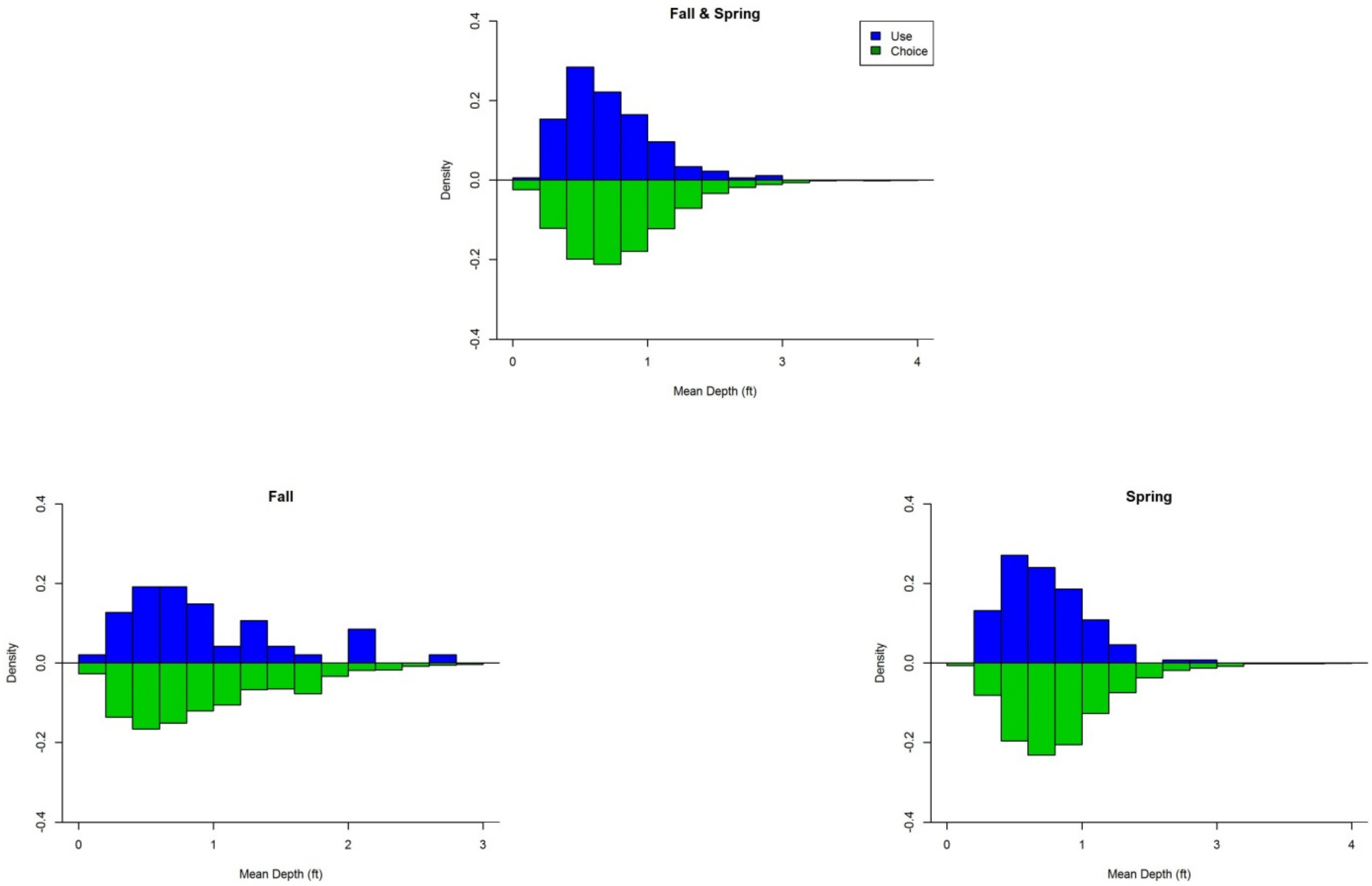


Figure C.15. Histograms of mean depth of the wetted channel (feet [ft]) at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

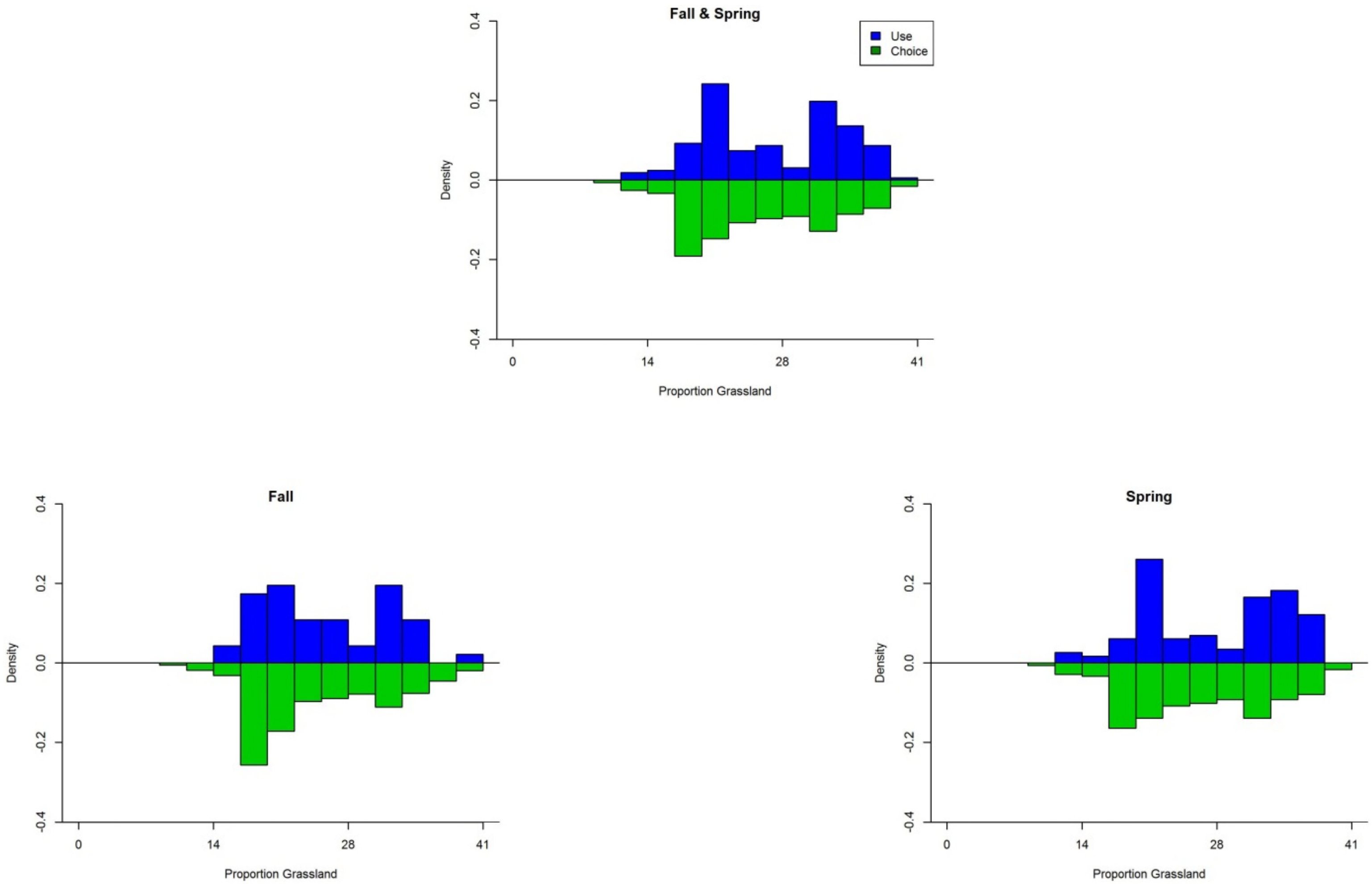


Figure C.16. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

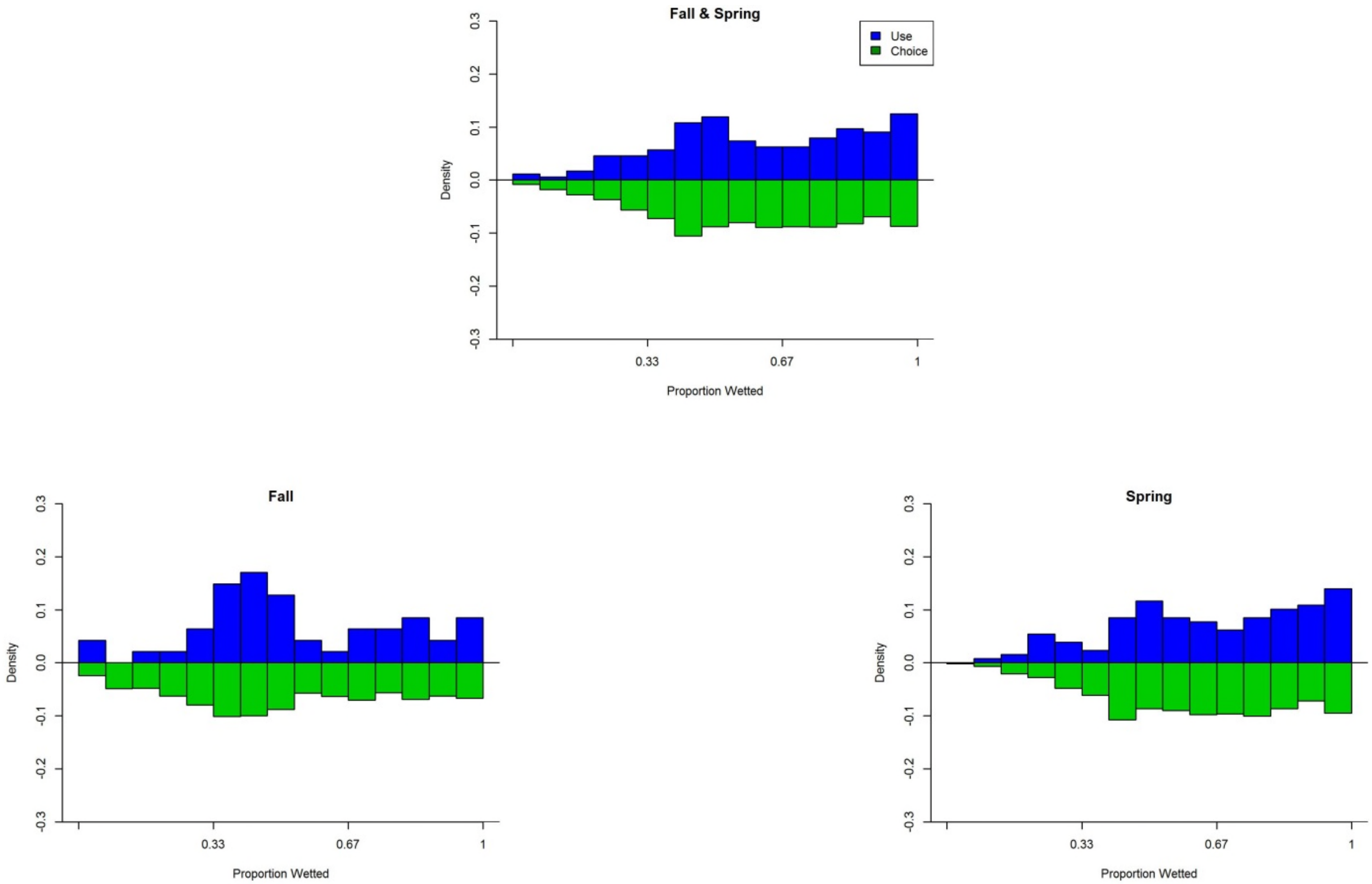


Figure C.17. Histograms of proportion of wetted area present at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

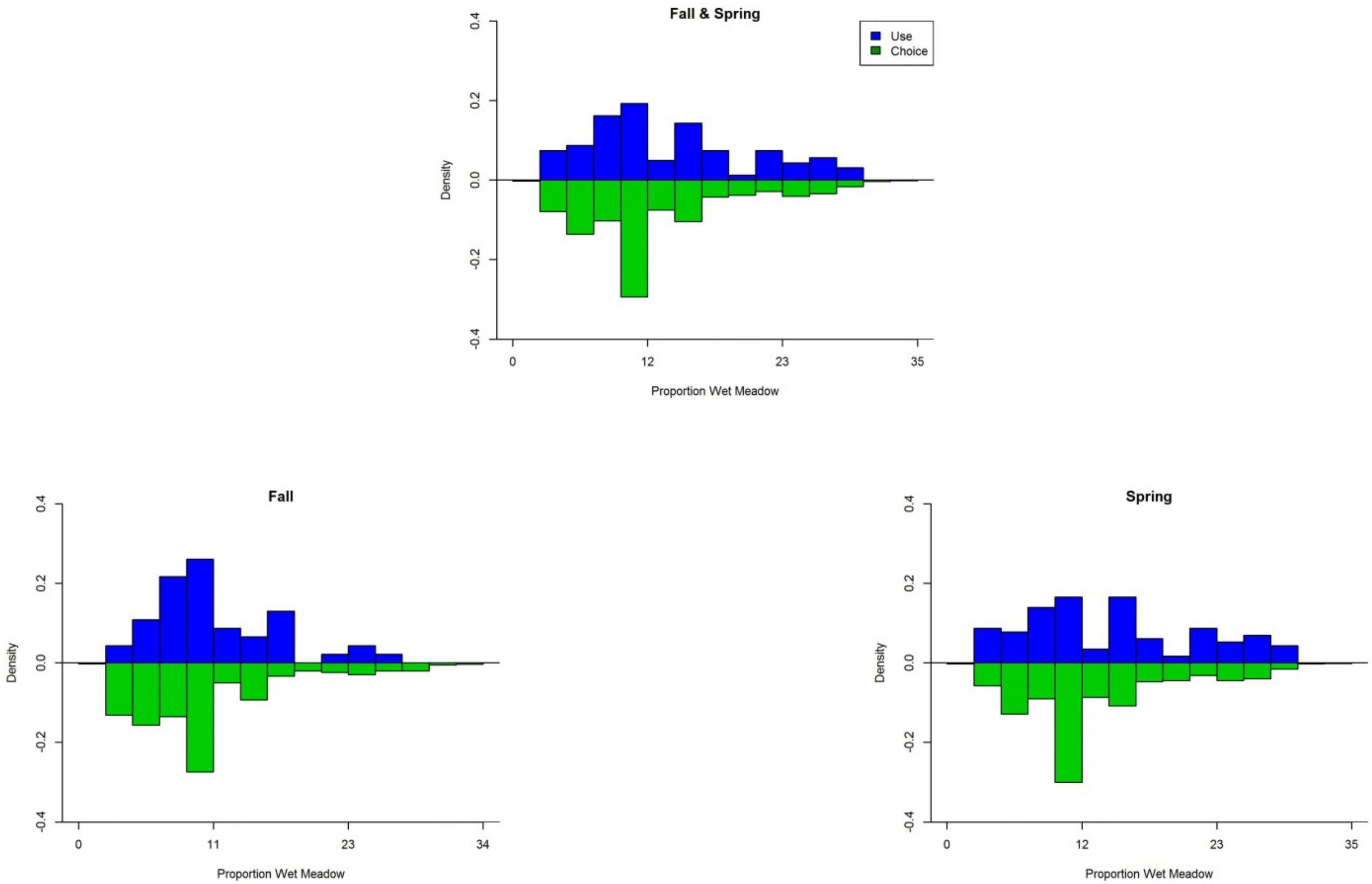


Figure C.18. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

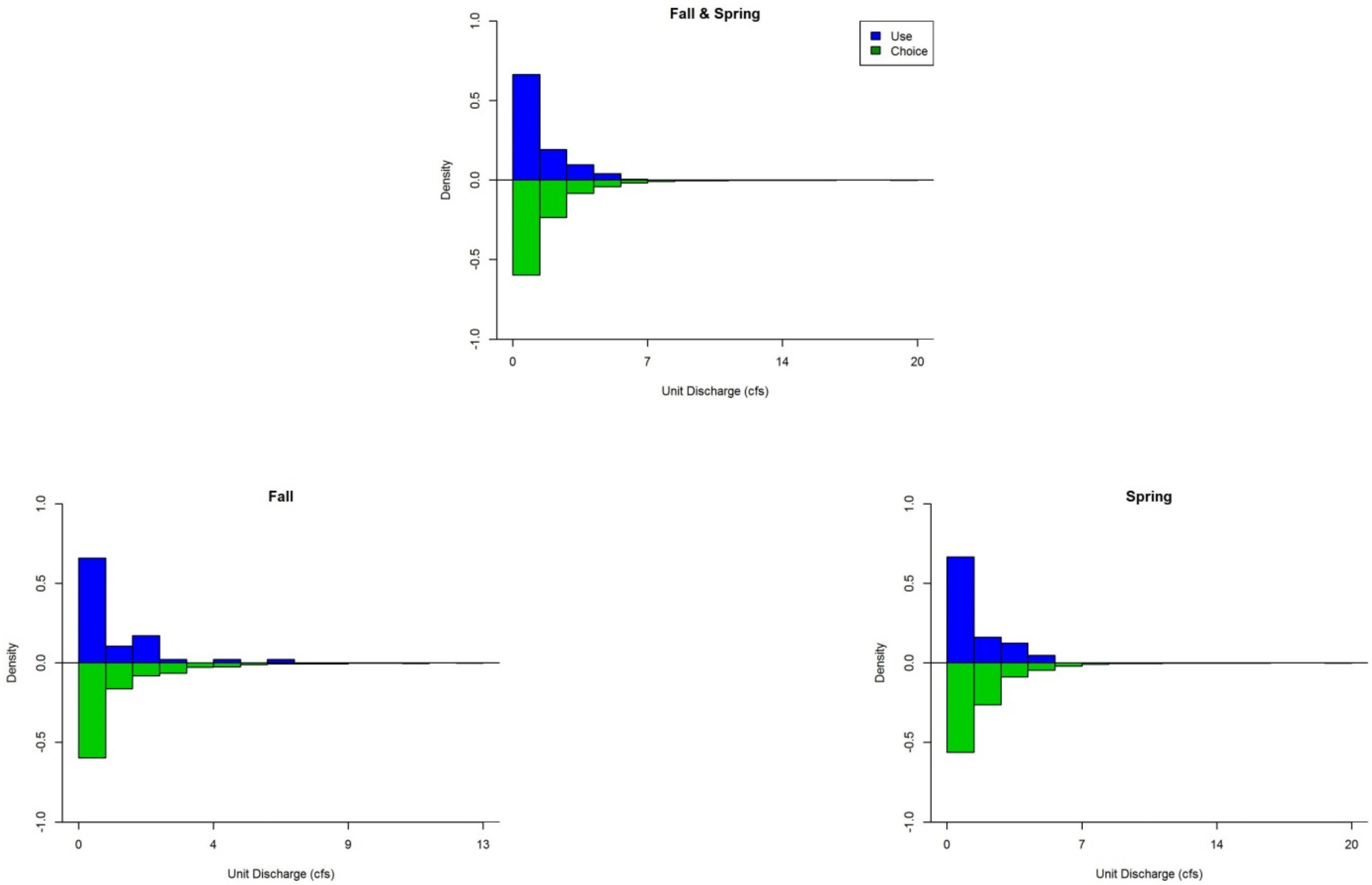


Figure C.19. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).

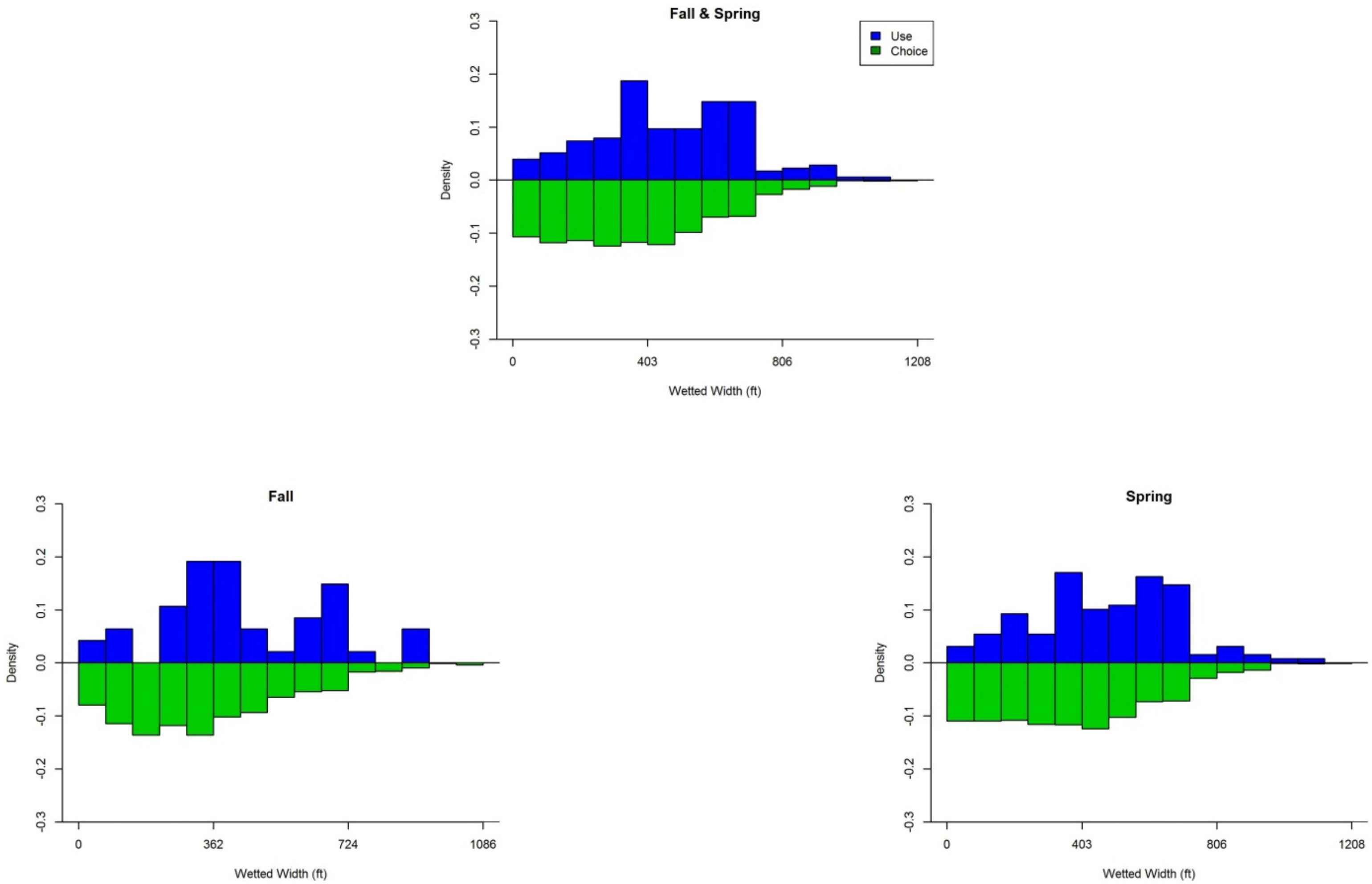


Figure C.20. Histograms of top width (feet [ft]) of wetted channel at all systematic locations of use by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).

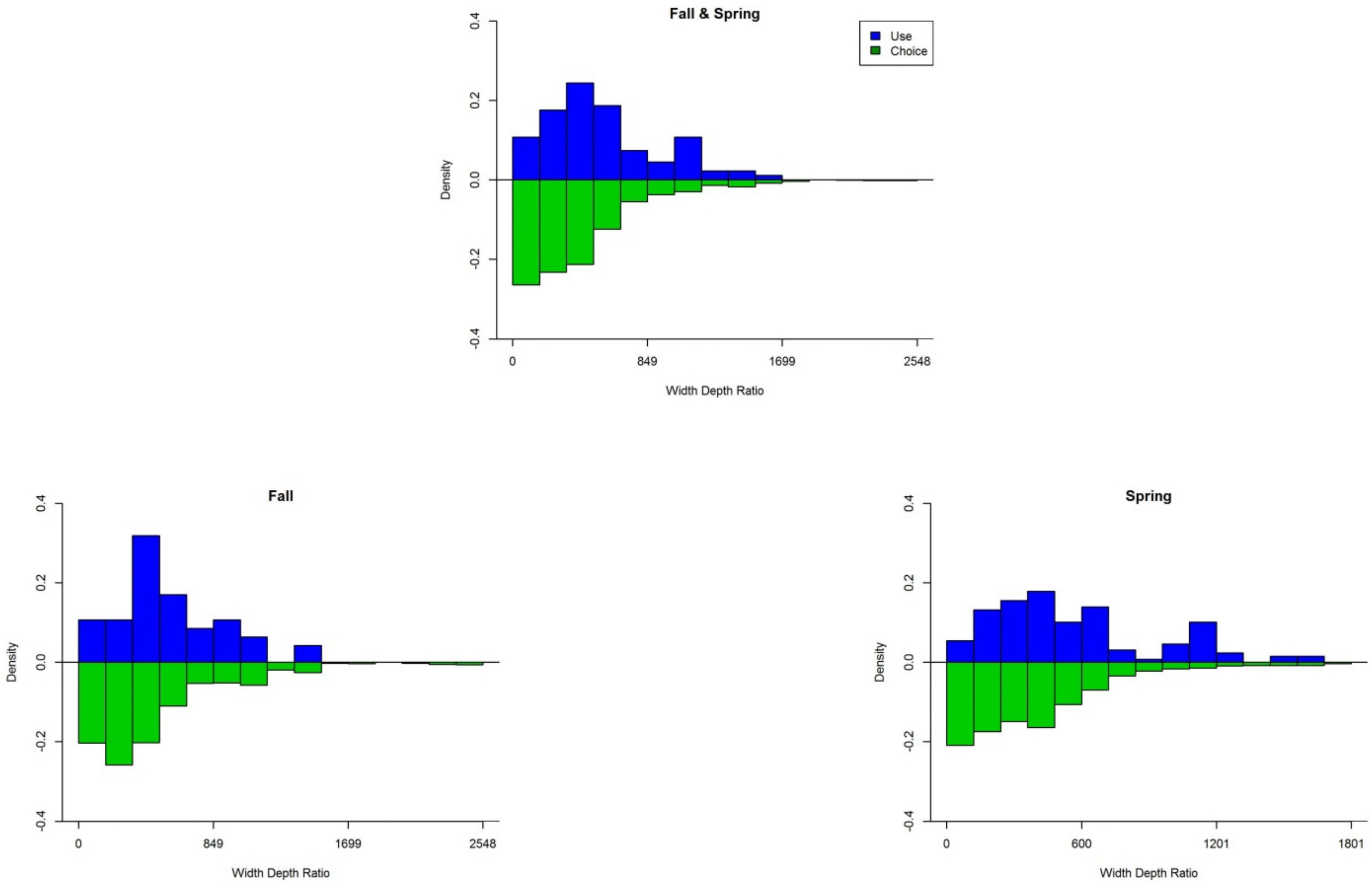


Figure C.21. Histograms of width depth ratio (wetted depth / mean depth) at all systematic locations of use by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

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Appendix D. Analysis of Systematic and Opportunistic In-Channel Whooping Crane Observations

Table of Contents

List of Figures ii
List of Tables iv
1. Introduction 1
2. Methods 1
3. Results 1
Whooping Crane Group Observations 1
Habitat Selection for Spring, Fall and Winter Combined 2
Spring Habitat Selection 4
Fall Habitat Selection 5
4. Discussion 6

List of Figures

Figure D.1. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 3

Figure D.2. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest forest in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 3

Figure D.3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 4

Figure D.4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 4

Figure D.5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 5

Figure D.6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 6

Figure D.7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of total channel width in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0). 6

Figure D.8. Histograms of nearest riparian forest (feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 10

Figure D.9. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 11

Figure D.10. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 12

Figure D.11. Histograms of proportion of landcover within a 1-mile radius classified as corn at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 13

Figure D.12. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 14

Figure D.13. Histograms of total channel width from left bank to right bank (feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 15

Figure D.14. Histograms of proportion of landcover within a 1-mile radius classified as forest at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 16

Figure D.15. Histograms of mean depth of the wetted channel (feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 17

Figure D.16. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 18

Figure D.17. Histograms of proportion of wetted area present at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 19

Figure D.18. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 20

Figure D.19. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 21

Figure D.20. Histograms of top width (feet [ft]) of wetted channel at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 22

Figure D.21. Histograms of width-to-depth ratio (wetted depth / mean depth) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below). 23

List of Tables

Table D.1. Sample size for in-channel models with 20 locations in each choice set. Observations include all locations obtained by systematic sampling or opportunistically from fall 2001 to spring 2013.. 2

Table D.2. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis, excluding fall 2001 and spring 2002 observations. Spring sample sizes were 138 for used locations and 2760 for the choice sets, fall sample sizes were 56 for used locations and 1120 for the choice sets. Winter sample sizes were 42 for used locations and 840 for the choice sets. Variable abbreviations are in the methods section of the main body of the report. 8

1. Introduction

We reran the analysis presented in the main body of the report on a third set of data. This analysis was conducted to incorporate every observation of whooping crane groups in the central Platte River during the study period, in order to increase the sample size of the modelling efforts. We included all observations obtained through systematic sampling or opportunistic reports in the analysis for this appendix. This includes groups of whooping cranes spotted during the aerial surveys, observations by on-the-ground monitors during the surveys, and any other observation reported by the public or other entities along the central Platte River. The additional sightings are from both multiple sightings of crane groups assumed to have been located previously in the study area, and any observation reported to PRRIP or USWFS. There were an additional 25 observations in the spring migration, an additional 10 observations in the fall migration, and an additional 42 observations in the winter.

As mentioned in the introduction to Appendix C, the inclusion of multiple observations of crane groups in the sample can bias the response of interest, i.e. habitat selection. The results that have been presented in the main body of the report, based only on unique or independent observations, contain less sampling bias than results presented in this appendix. The impact of including non-unique and opportunistic observations in this analysis was evaluated by fitting these data to the same models that were presented in the main body of the report.

2. Methods

For this analysis of habitat use we followed the same methods as written in the Methods section of the main body of the report. There were no changes in the definition of available habitat or the descriptors of habitat use. We did not repeat model selection but fit the best models identified during the analysis of the systematic unique data.

3. Results

Whooping Crane Group Observations

We developed models of in-channel habitat selection for the 154 spring, 57 fall, and the combined 253 spring, fall, and winter observations of whooping crane groups (Table D.1). These observations span the time from fall 2001 to spring 2013. Actual sample sizes in the models were larger because of the inclusion of the data representing the choice set (Table D.1).

Table D.1. Sample size for in-channel models with 20 locations in each choice set. Observations include all locations obtained by systematic sampling or opportunistically from fall 2001 to spring 2013.

Season	Number of Use Locations in Analysis	Total Number of Data Points in Analysis
Spring	154	3243
Fall	57	1197
All Seasons Combined [A]	253	5313

[A]Includes 42 winter use locations each with a choice set of 20 locations.

Habitat Selection for Spring, Fall and Winter Combined

As presented in the main body of the report, the top model for spring and fall observations indicated unobstructed channel width and nearest forest were the most important predictor variables for management purposes. The estimated smoothing spline functions for unobstructed channel width when fit to all data, initially increased with larger widths, and then decreased before continuing to increase with larger widths. The model results indicated the highest selection ratio value was predicted to occur at 1,052 feet for unobstructed channel width (Figure D.1). The estimated smoothing spline function for nearest forest was positively increasing with larger values of nearest forest up to a point, after which declines were predicted. Increased nearest forest was associated with higher predicted selection ratios up to the highest selection ratio predicted to occur at 547 feet from the center of the channel (Figure D.2). The estimated degrees of freedom for the smoothed terms were 6.15 and 5.11 for unobstructed channel width and nearest forest respectively.

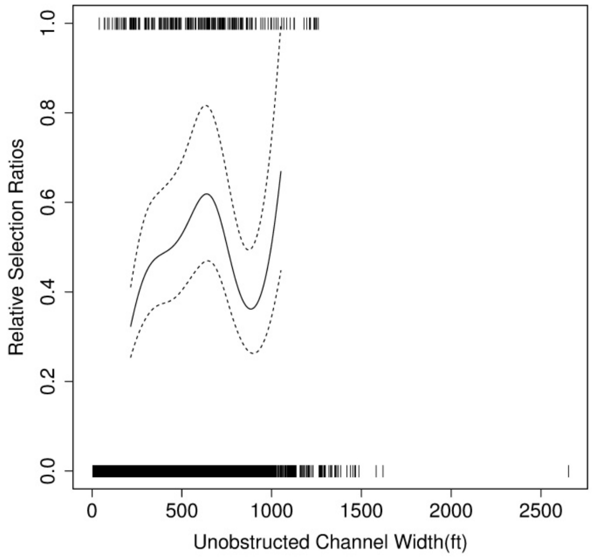


Figure D.1. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of unobstructed channel widths in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

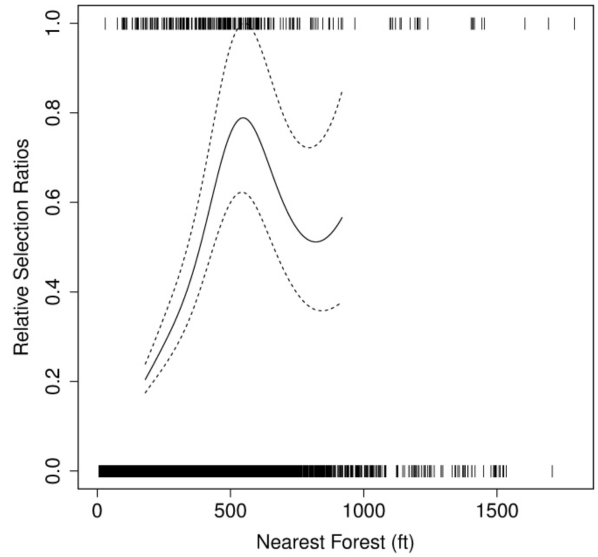


Figure D.2. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest forest in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

As indicated in the main body of the report, the top model for in-channel habitat use for the spring and fall observations combined, across every candidate model in the *a priori* set, indicated nearest obstruction and nearest forest were the most important predictor variables. The estimated smoothing spline functions for each of these variables were positively increasing with larger values of nearest obstruction and nearest forest, indicating a positive relationship between predicted relative in-channel selection ratios and each variable. The model results indicate increased nearest obstruction was associated with higher predicted relative selection ratios with the highest value predicted to occur at 260 feet (Figure D.3). Increased nearest forest was associated with higher predicted relative in-channel selection ratios with the highest value predicted to occur at 919 feet (Figure D.4). The estimated degrees of freedom for the smoothed terms were 5.42 and 3.94 for nearest obstruction and nearest forest respectively.

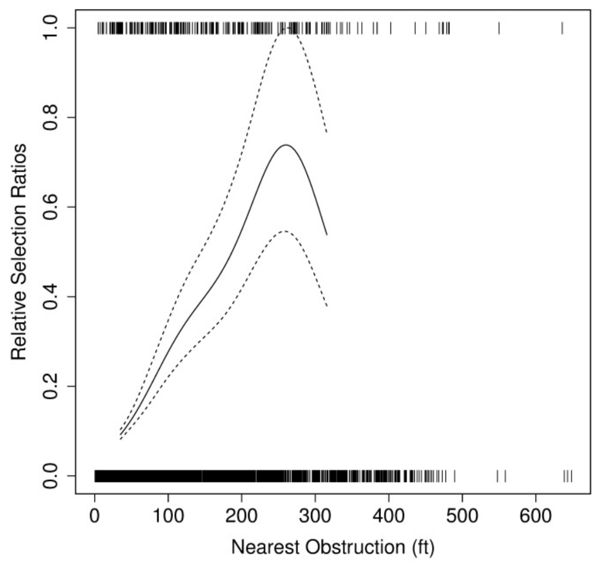


Figure D.3. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

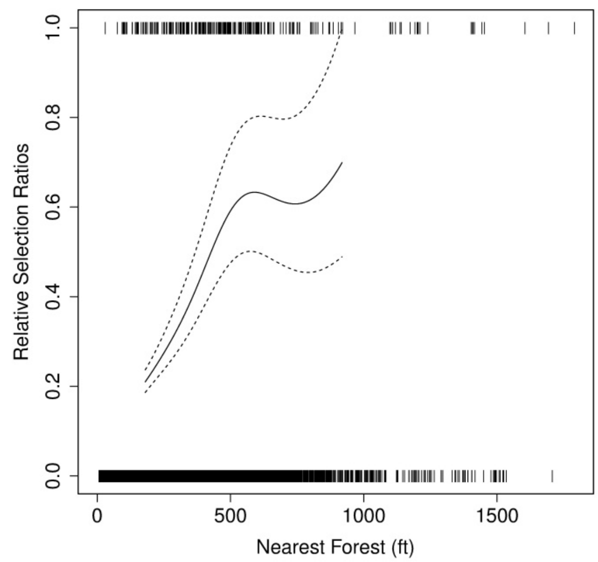


Figure D.4. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest forest in the spring, fall, and winter combined. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Spring Habitat Selection

The estimated smoothing spline function for nearest obstruction was quadratic shaped depicting predicted selection ratios positively increasing with larger values up to a point, after which declines were predicted. The model results for nearest obstruction indicated the highest predicted selection ratio occured at 258 feet (Figure D.5). The estimated degrees of freedom for the smoothed term was 4.80.

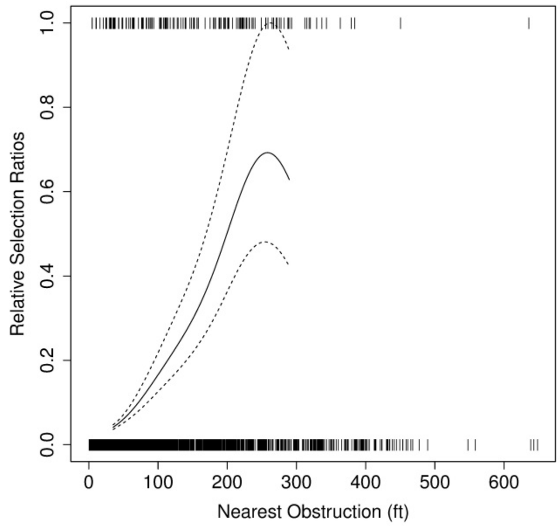


Figure D.5. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of distances to nearest obstruction in the spring. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Fall Habitat Selection

The parametric function for nearest obstruction was positively increasing with larger values of nearest obstruction, indicating a positive relationship between predicted relative selection ratios and nearest obstruction. The model results indicate increased nearest obstruction was associated with a higher predicted relative selection ratios with the highest value predicted to occur at 279 feet (Figure D.6). Increased total channel width was associated with variable relative selection ratios with the highest predicted values to occur at 689 feet (Figure D.7). The estimated degrees of freedom for the model terms were 1 and 4.27 for nearest obstruction and total channel width respectively.

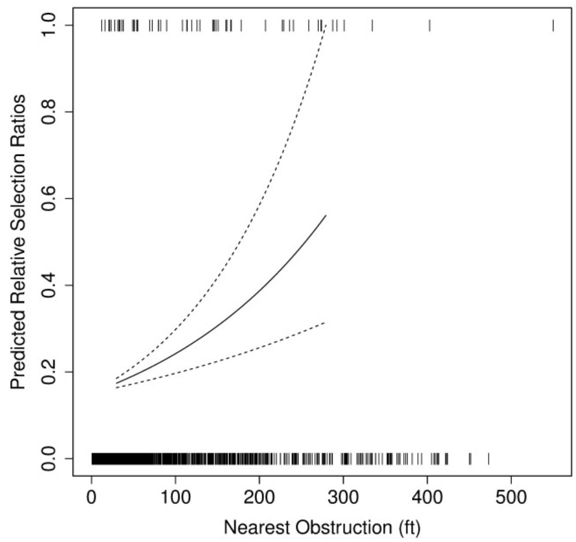


Figure D.6. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of nearest obstruction in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

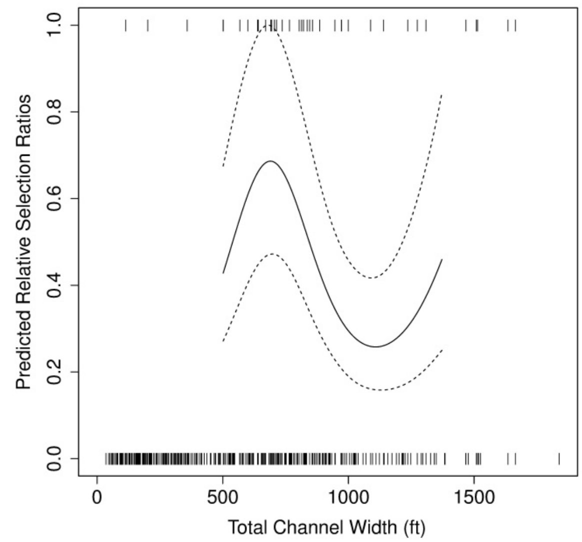


Figure D.7. Predicted relative in-channel selection ratios by groups of whooping cranes in the central Platte River, with 90% confidence intervals, across the range of total channel width in the fall. Tick marks indicate actual data (use points are above at y=1, choice set points are below at y=0).

Summary statistics for each variable for the used locations contrasted to the choice sets for fall 2002 to spring 2013 are in Table D.2 and graphical summaries are in Figure D.8 to Figure D.21.

4. Discussion

The in-channel habitat models presented here, with the inclusion of all systematic locations and opportunistic locations, relate a similar message about whooping crane habitat selection on the central Platte River as the analysis in the main report and the analysis with systematic locations presented in Appendix C. There were consistent modelled relationships between habitat descriptors and relative selection ratios for each season. The distances at which the response curves were maximized, for the majority of linear and quadratic cases, were larger with the inclusion of the non-unique and opportunistic observations compared to the systematic unique results in the main body of the report.

The combined spring and fall models indicated whooping cranes selected for larger distances to nearest forest and obstruction and wider unobstructed channel widths up to a point after which the relative selection ratios generally declined. The selection ratios for unobstructed channel width and nearest forest in the top management model were maximized at 1,052 and 547 feet, respectively, it can be inferred based on the confidence intervals at these peaks that unobstructed channel widths greater than 305 feet and distances between 436 and 682 feet to the nearest forest would result in statistically similar selection ratios. For the top overall model, the selection ratios for nearest obstruction and nearest forest were maximized at 260 and 919 feet, respectively, based on the confidence intervals, that distances to nearest obstruction between 199 and 314 feet and distances to the nearest forest greater than 420 feet would result in statistically similar selection ratios.

The spring model suggested whooping cranes selected wide unobstructed views, with the maximum at 258 feet. Whooping crane groups were observed across a wide range of values and it can be inferred based on confidence intervals that nearest obstruction distances between 195 and 290 feet would result in statistically similar selection ratios.

The fall model suggested whooping cranes selected wide unobstructed views, with the maximum at 279 feet. Based on the confidence intervals at the peak, nearest obstruction distances as small as 156 feet would result in statistically similar selection ratios. Total channel width in the fall model suggested whooping cranes selected wide unobstructed views, with the maximum at 689 feet. Based on the confidence intervals at the peak, channel widths between 524 and 860 feet would result in statistically similar selection ratios.

Table D.2. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis, excluding fall 2001 and spring 2002 observations. Spring sample sizes were 138 for used locations and 2760 for the choice sets, fall sample sizes were 56 for used locations and 1120 for the choice sets. Winter sample sizes were 42 for used locations and 840 for the choice sets. Variable abbreviations are in the methods section of the main body of the report.

		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
UOCW	Spring	369.00	323.86	87.77	593.36	309.98	52.24
	Fall	385.79	286.13	74.17	489.39	291.48	59.56
	Winter	379.86	280.12	73.74	743.43	360.14	48.44
	All Seasons	374.91	307.80	82.10	595.39	324.23	54.46
NO	Spring	75.24	89.76	119.29	159.60	108.01	67.68
	Fall	86.19	92.89	107.77	140.00	109.41	78.15
	Winter	81.41	84.06	103.26	245.61	136.21	55.46
	All Seasons	78.94	89.63	113.55	170.26	118.91	69.84
UFW	Spring	2045.92	2349.44	114.83	2940.87	2802.81	95.31
	Fall	1878.53	1994.15	106.15	2607.81	1775.44	68.08
	Winter	2377.97	2609.37	109.73	3731.98	2099.94	56.27
	All Seasons	2065.30	2325.22	112.59	3002.63	2494.25	83.07
NF	Spring	297.09	244.69	82.36	463.74	277.50	59.84
	Fall	314.26	246.96	78.58	495.04	198.02	40.00
	Winter	329.80	283.31	85.91	716.99	405.28	56.53
	All Seasons	306.98	252.78	82.34	516.24	302.75	58.64
TCW	Spring	641.05	401.14	62.58	786.11	348.77	44.37
	Fall	738.36	403.23	54.61	867.02	347.41	40.07
	Winter	624.77	416.95	66.74	965.44	352.93	36.56
	All Seasons	661.24	406.73	61.51	837.22	354.37	42.33
WW	Spring	374.41	227.96	60.88	511.85	236.45	46.19
	Fall	326.74	212.43	65.02	418.27	229.60	54.89
	Winter	372.48	247.48	66.44	640.01	283.95	44.37
	All Seasons	362.76	228.86	63.09	512.45	253.02	49.37
PW	Spring	0.64	0.22	34.59	0.69	0.22	32.56
	Fall	0.50	0.26	52.05	0.51	0.26	51.34
	Winter	0.65	0.22	33.86	0.70	0.23	33.47
	All Seasons	0.61	0.24	39.22	0.65	0.25	38.05
MD	Spring	1.23	0.56	45.68	1.01	0.43	42.08
	Fall	0.93	0.59	63.74	0.89	0.60	66.67
	Winter	1.27	0.58	46.07	1.01	0.58	57.68
	All Seasons	1.17	0.59	50.48	0.98	0.50	50.88
UD	Spring	2.02	2.11	104.75	1.66	1.50	90.37
	Fall	1.22	1.71	140.08	1.00	1.25	124.86
	Winter	2.30	2.87	124.55	1.66	2.35	140.97
	All Seasons	1.88	2.22	117.96	1.50	1.65	109.59
WDR	Spring	381.20	318.33	83.51	600.53	362.97	60.44
	Fall	481.75	426.13	88.45	565.73	325.00	57.45
	Winter	390.92	369.30	94.47	728.13	330.97	45.45
WDR	All Seasons	406.79	358.21	88.06	614.98	351.61	57.17

		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
PC	Spring	40.37	6.98	17.30	39.51	6.46	16.35
	Fall	42.24	6.36	15.06	42.30	7.24	17.11
	Winter	41.27	5.02	12.17	40.29	4.16	10.31
	All Seasons	40.97	6.57	16.04	40.31	6.40	15.87
PF	Spring	7.26	2.21	30.46	6.56	2.14	32.53
	Fall	7.07	1.81	25.55	7.17	1.80	25.04
	Winter	7.17	1.45	20.27	6.05	1.56	25.82
	All Seasons	7.20	2.00	27.83	6.62	1.99	30.12
PWM	Spring	13.12	6.56	49.98	15.27	7.75	50.74
	Fall	10.87	6.40	58.91	11.60	6.12	52.76
	Winter	16.22	7.16	44.13	21.68	7.92	36.51
	All Seasons	13.13	6.85	52.12	15.54	8.07	51.95
PG	Spring	25.99	7.14	27.48	27.65	7.23	26.16
	Fall	24.24	6.98	28.81	24.95	7.08	28.38
	Winter	27.27	6.52	23.92	31.08	6.56	21.10
	All Seasons	25.80	7.07	27.39	27.62	7.32	26.50

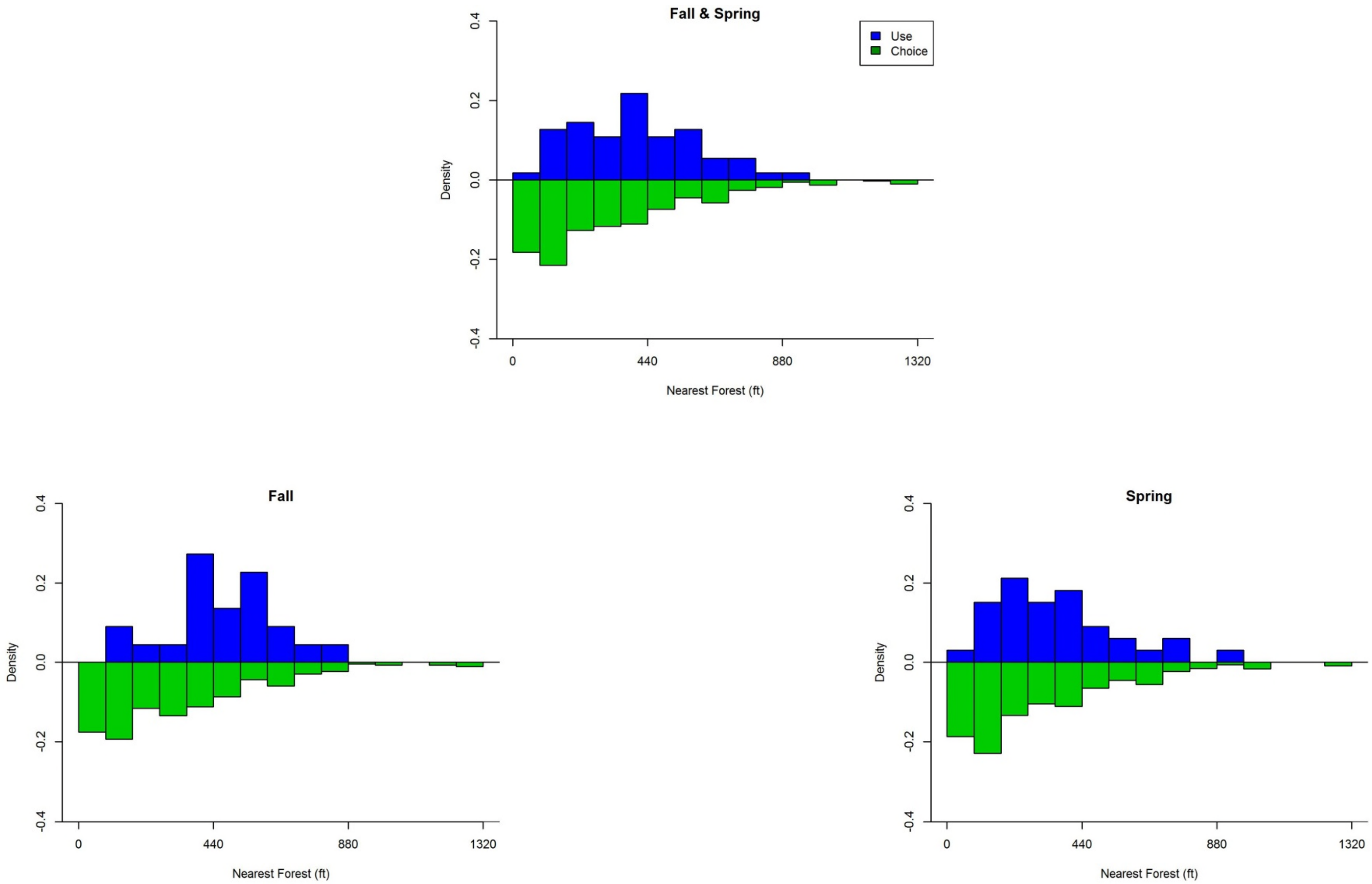


Figure D.8. Histograms of nearest riparian forest (feet [ft]) at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

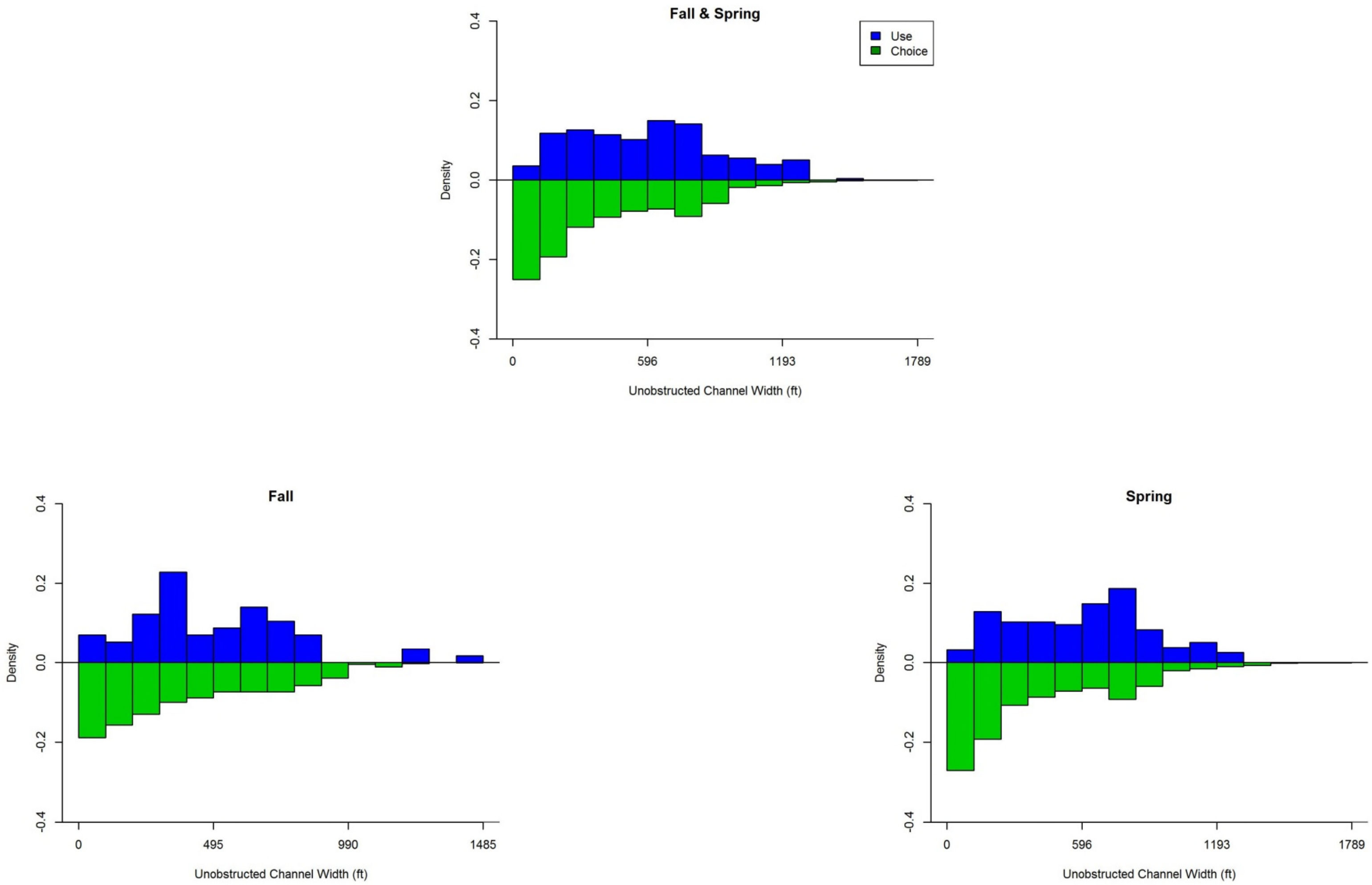


Figure D.9. Histograms of width (feet [ft]) of channel unobstructed by dense vegetation at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

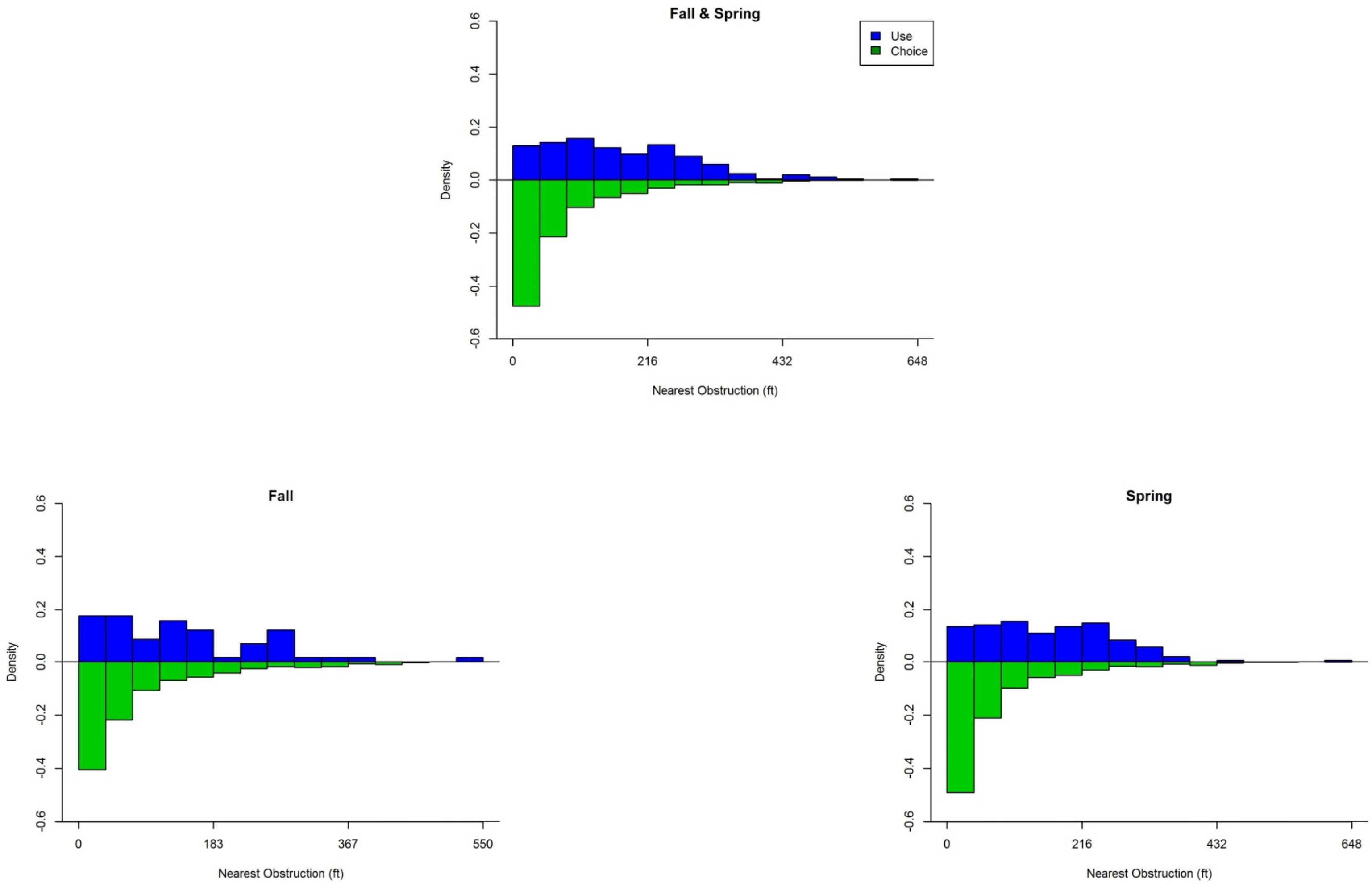


Figure D.10. Histograms of nearest obstruction (i.e., distance to nearest dense vegetation; feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).

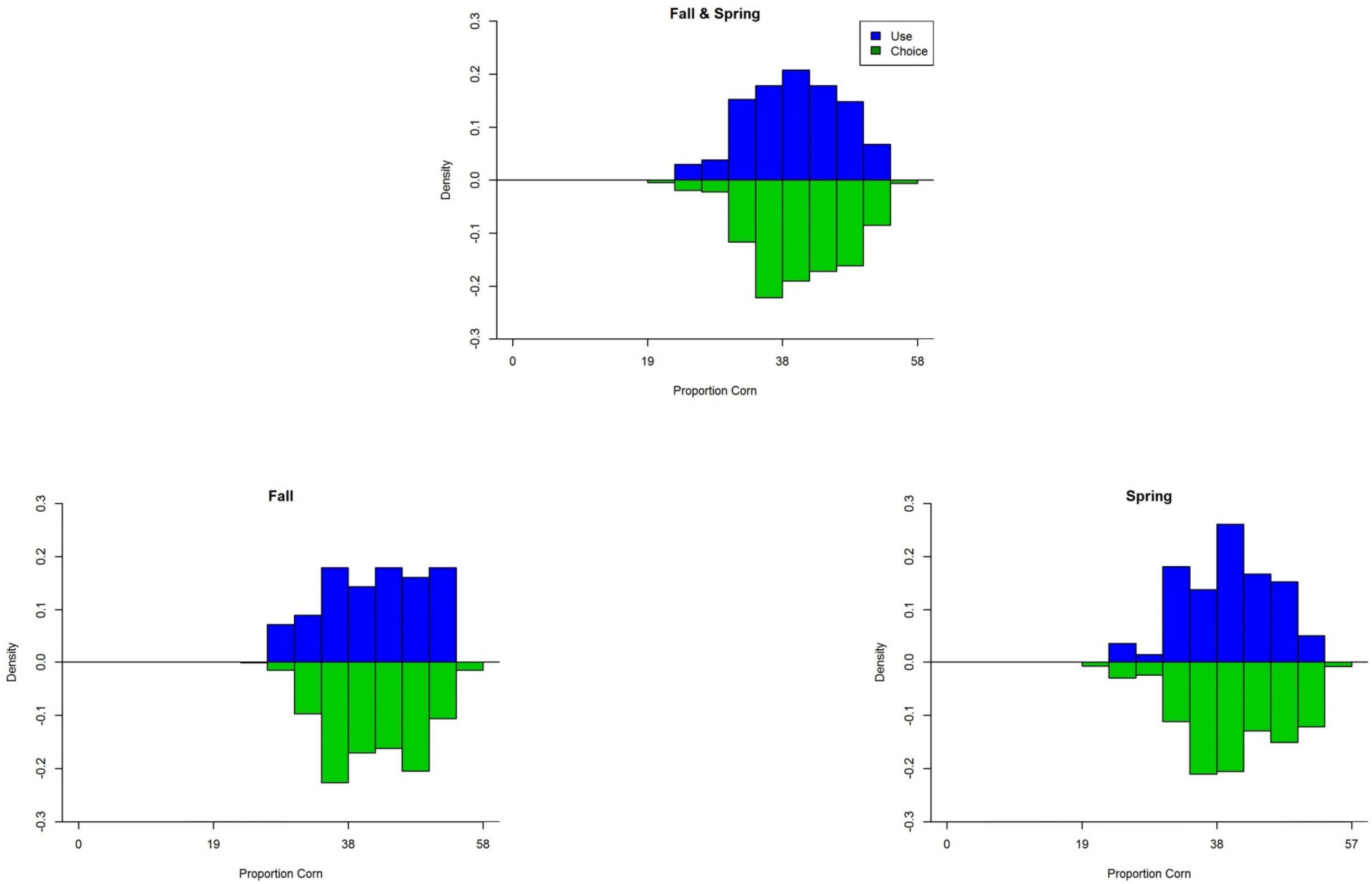
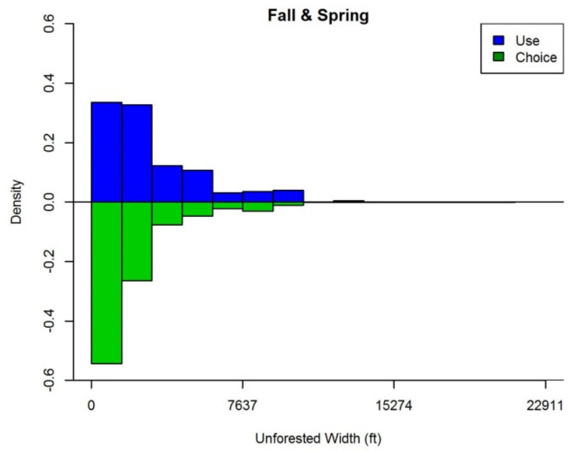
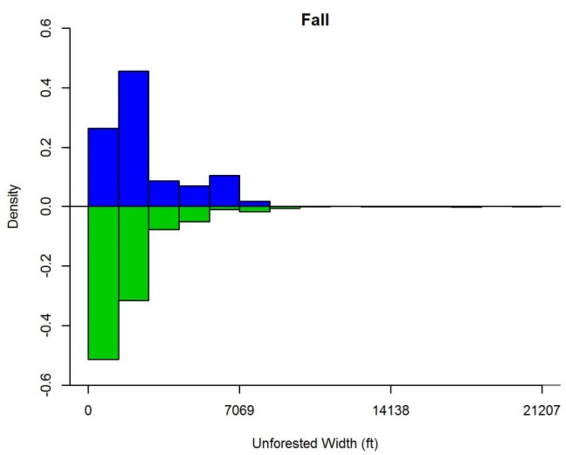


Figure D.11. Histograms of proportion of landcover within a 1-mile radius classified as corn at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).





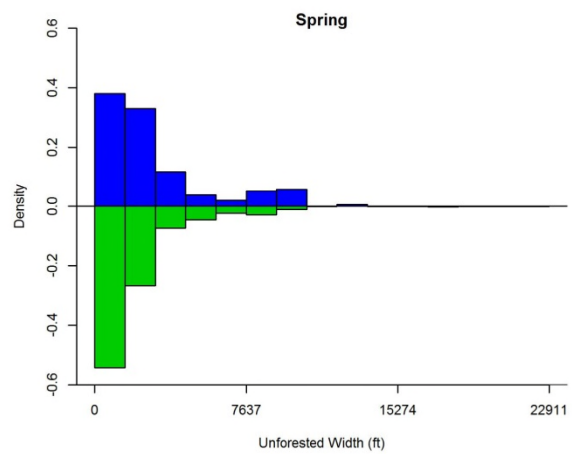


Figure D.12. Histograms of width of river corridor not obstructed by riparian forest (feet [ft]) at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

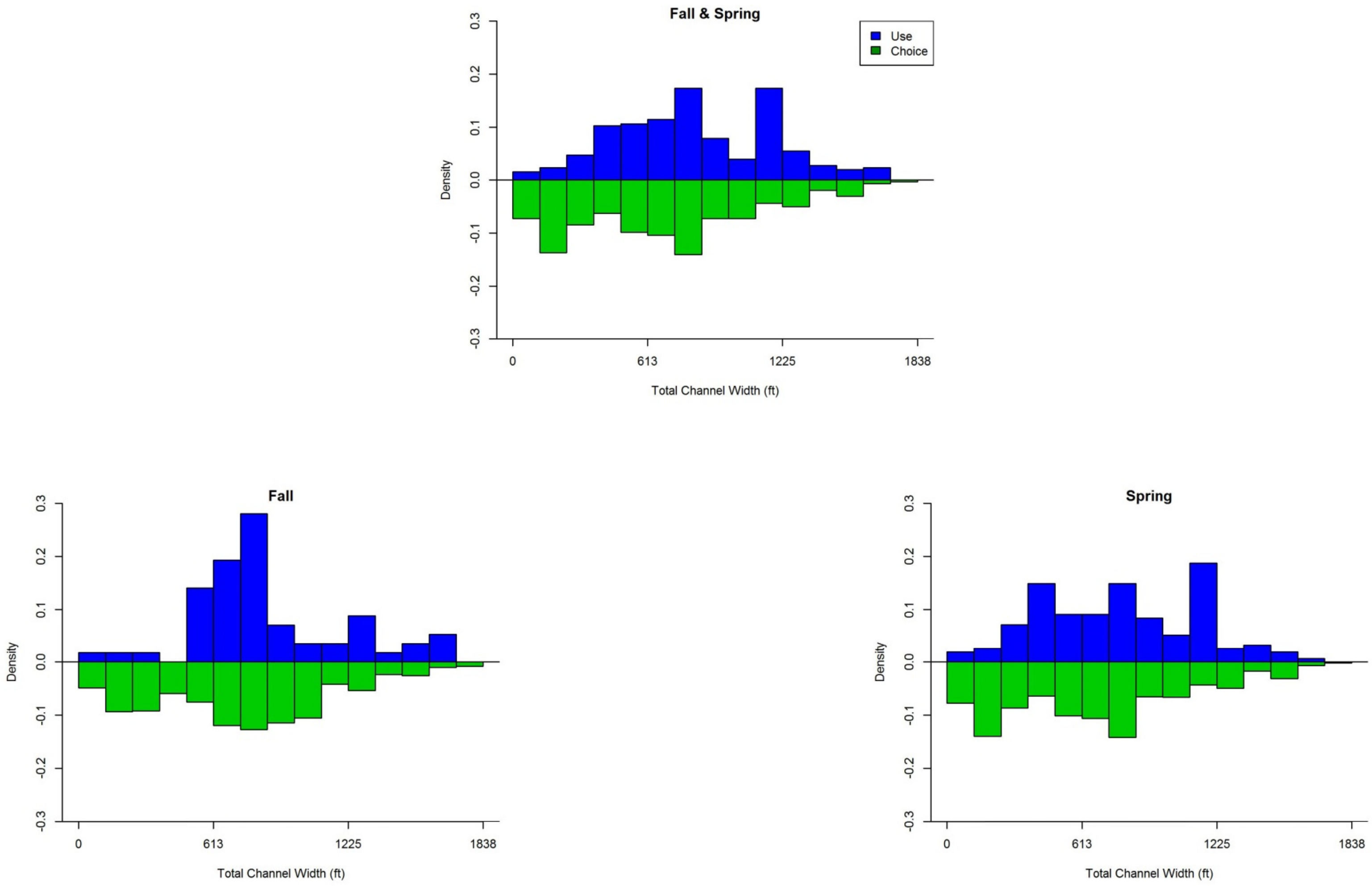


Figure D.13. Histograms of total channel width from left bank to right bank (feet [ft]) at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).

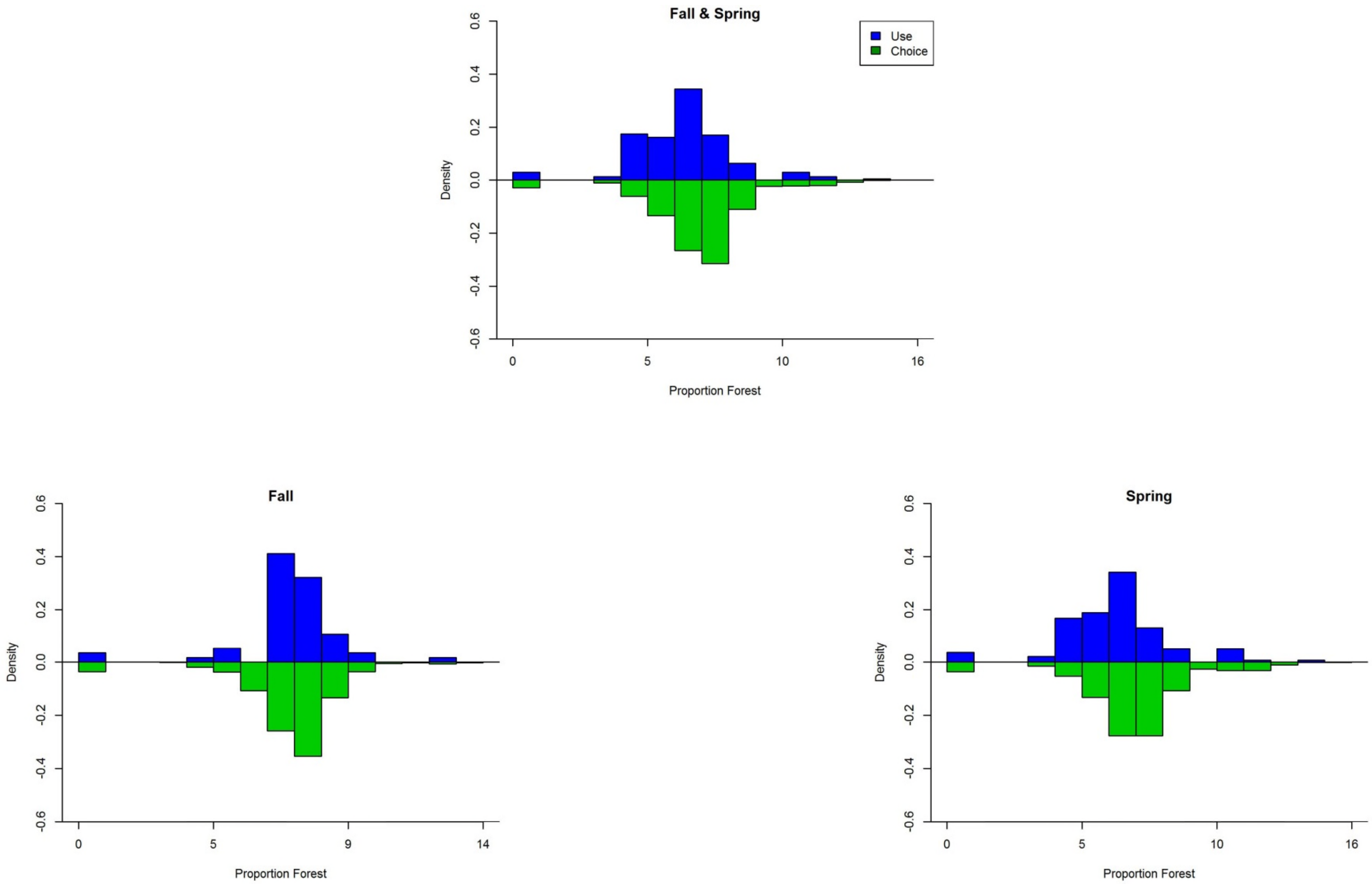
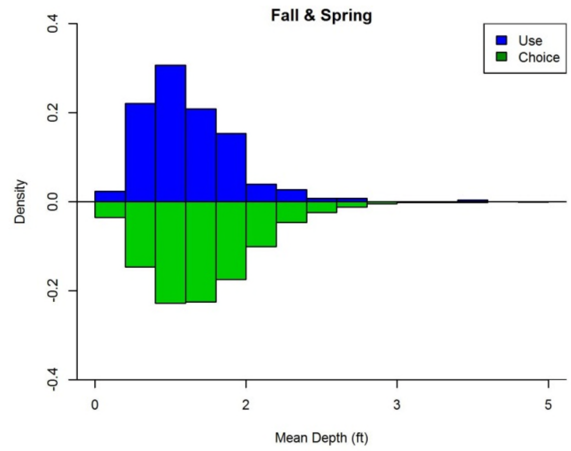
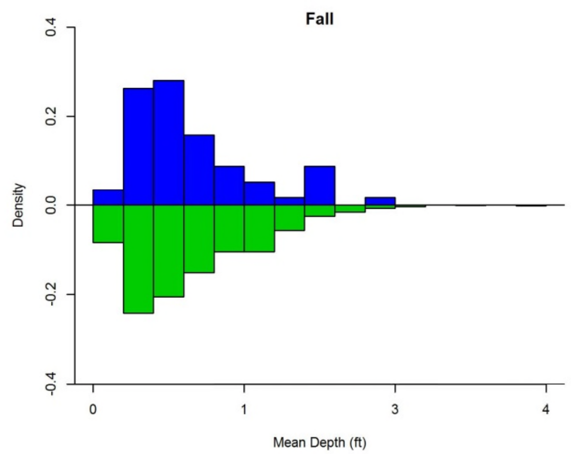


Figure D.14. Histograms of proportion of landcover within a 1-mile radius classified as forest at systematic and opportunistic locations used by a whooping crane group (“Use” in blue) and the choice set of locations (“Choice” in green). Spring and fall were combined (above) and shown separately (below).





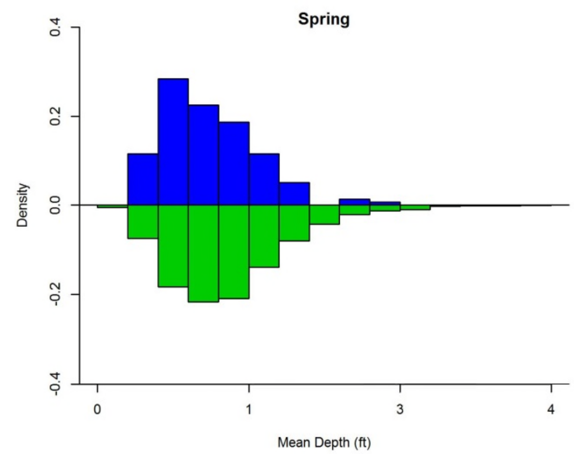
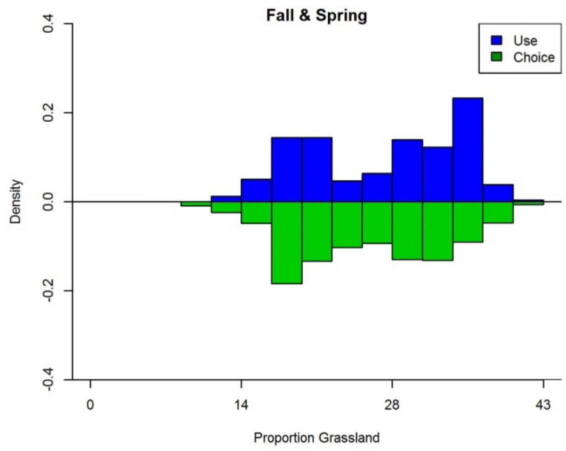
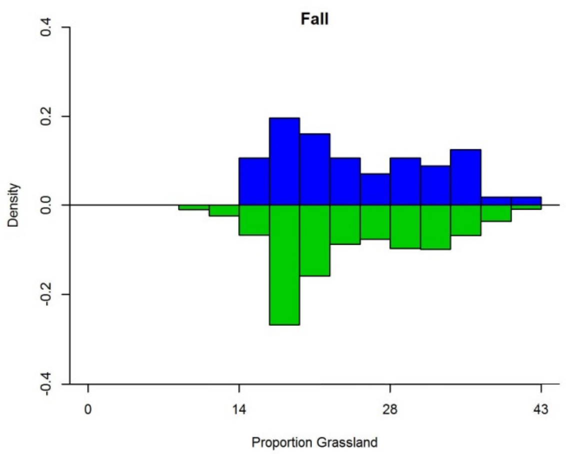


Figure D.15. Histograms of mean depth of the wetted channel (feet [ft]) at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).





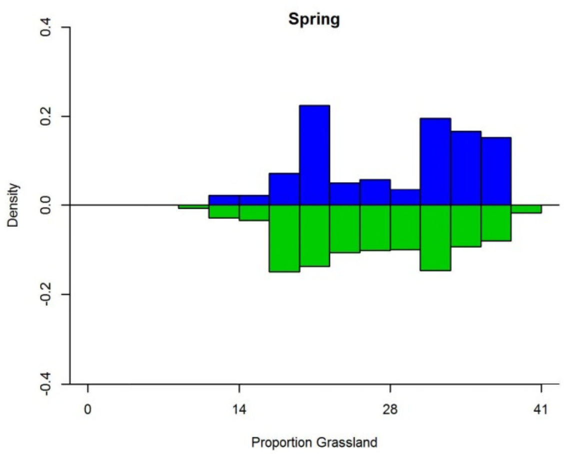


Figure D.16. Histograms of proportion of landcover within a 1-mile radius classified as grassland present at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

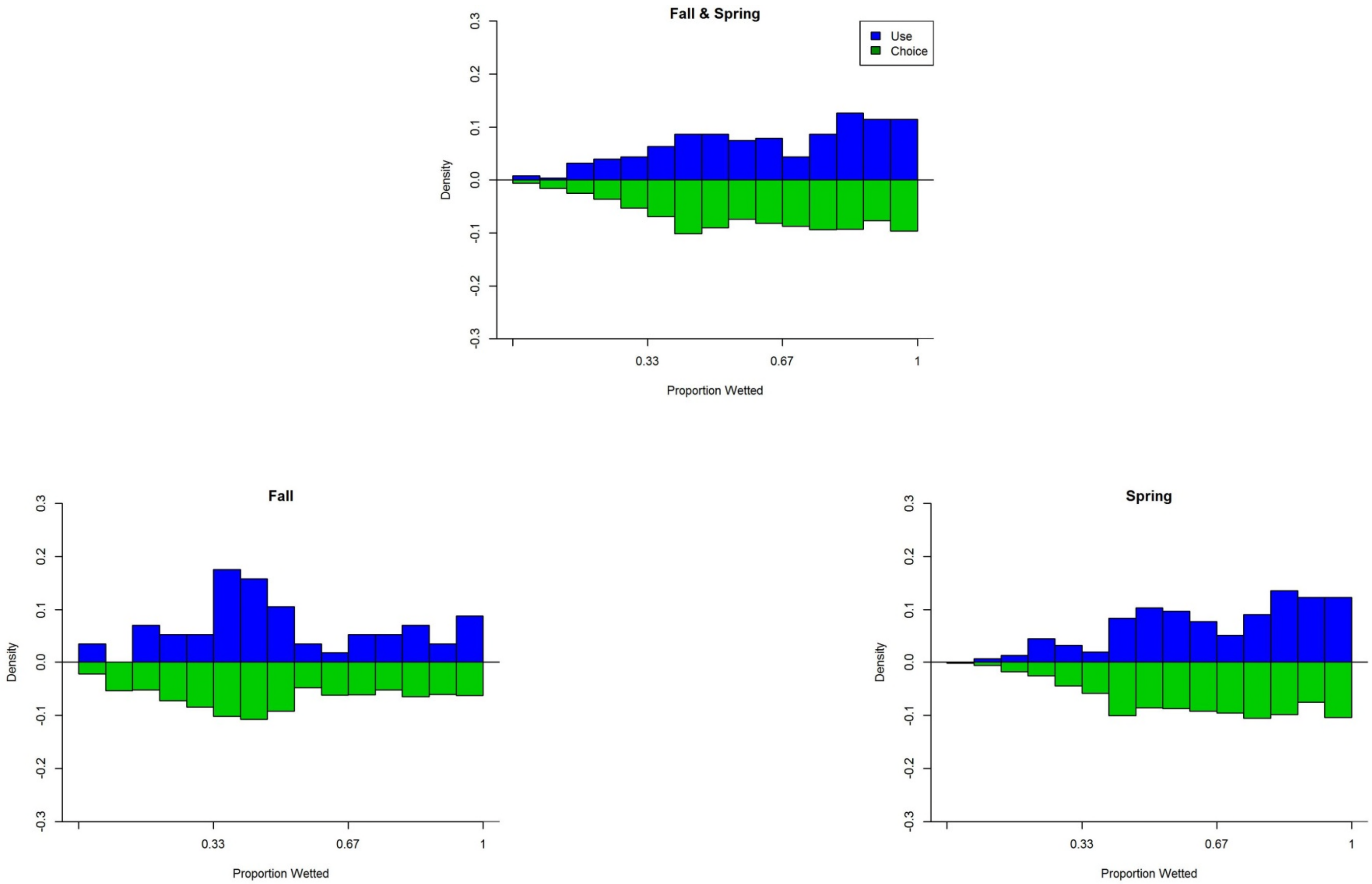


Figure D.17. Histograms of proportion of wetted area present at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

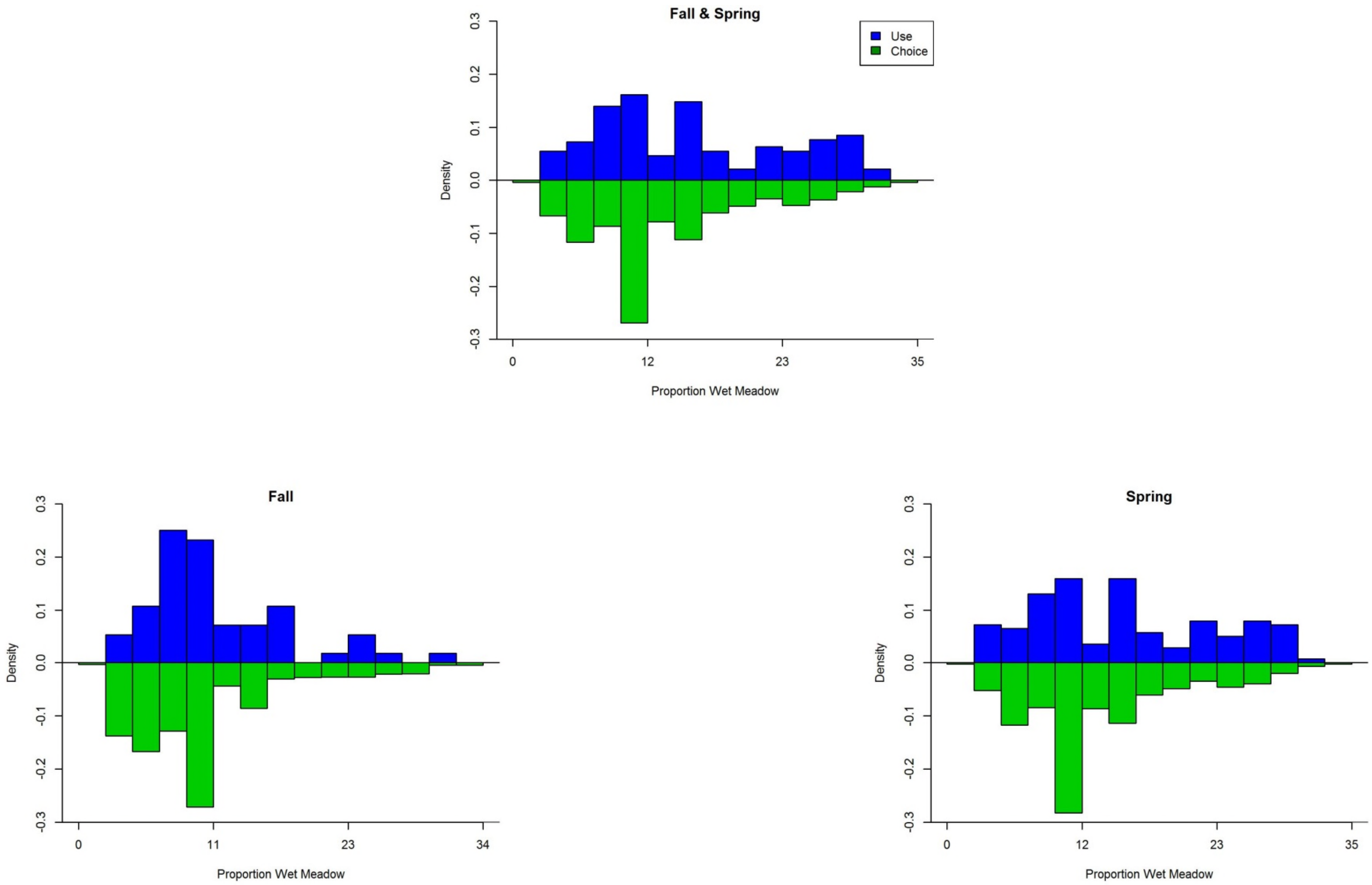


Figure D.18. Histograms of proportion of landcover within a 1-mile radius classified as wet meadow present at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

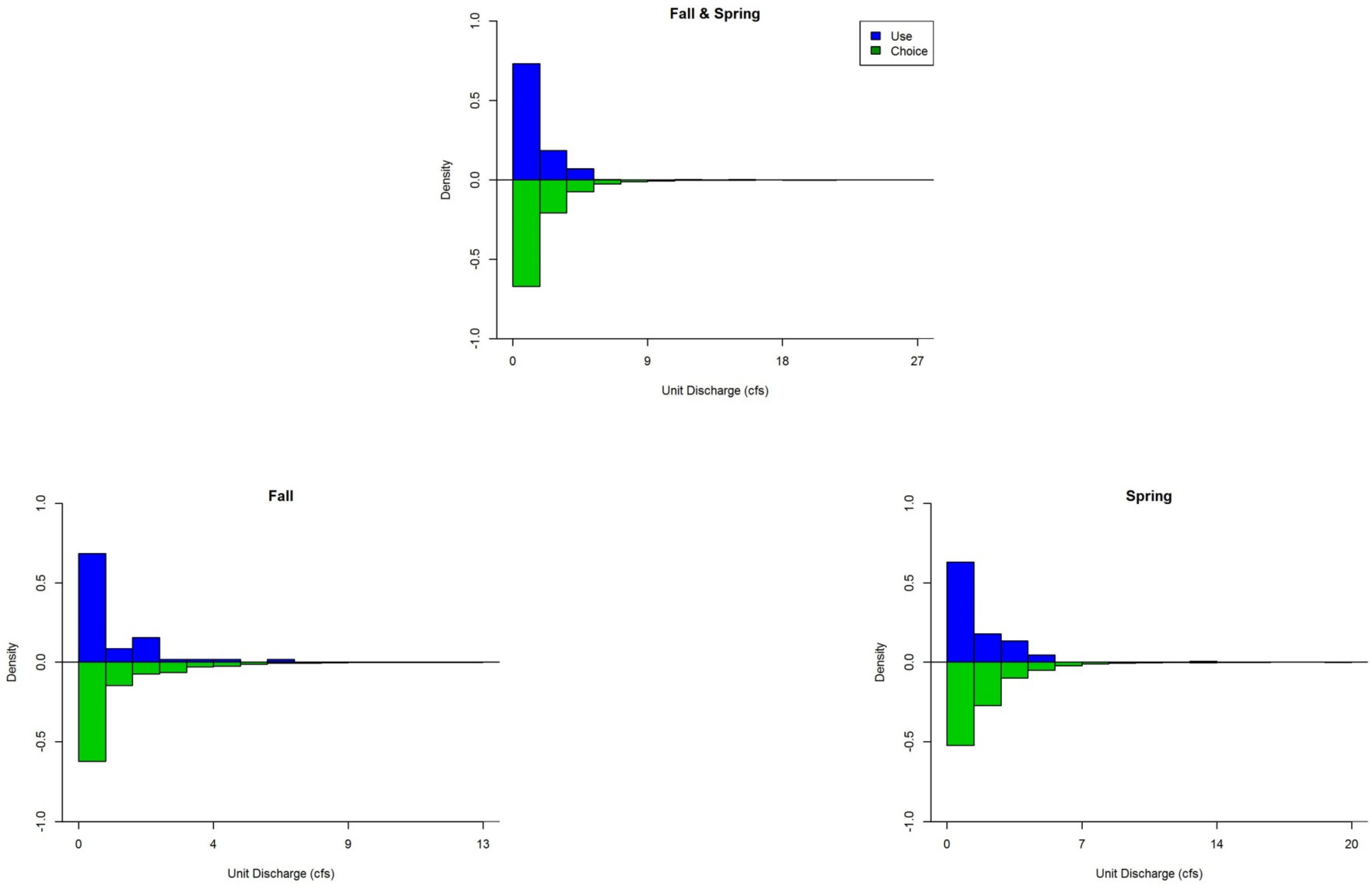


Figure D.19. Histograms of unit discharge (flow per linear foot of channel width; cubic feet per second [cfs]) at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

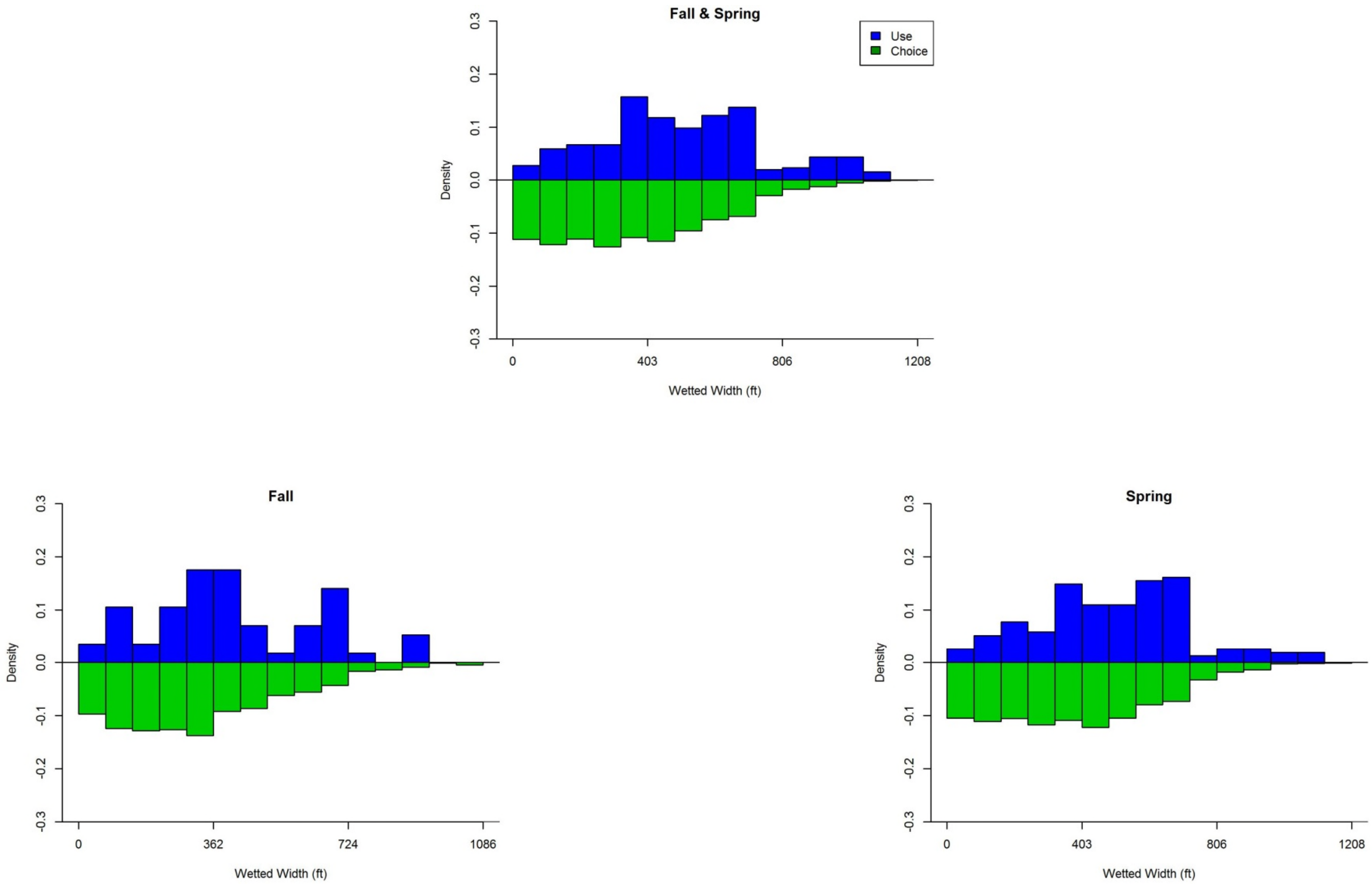


Figure D.20. Histograms of top width (feet [ft]) of wetted channel at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

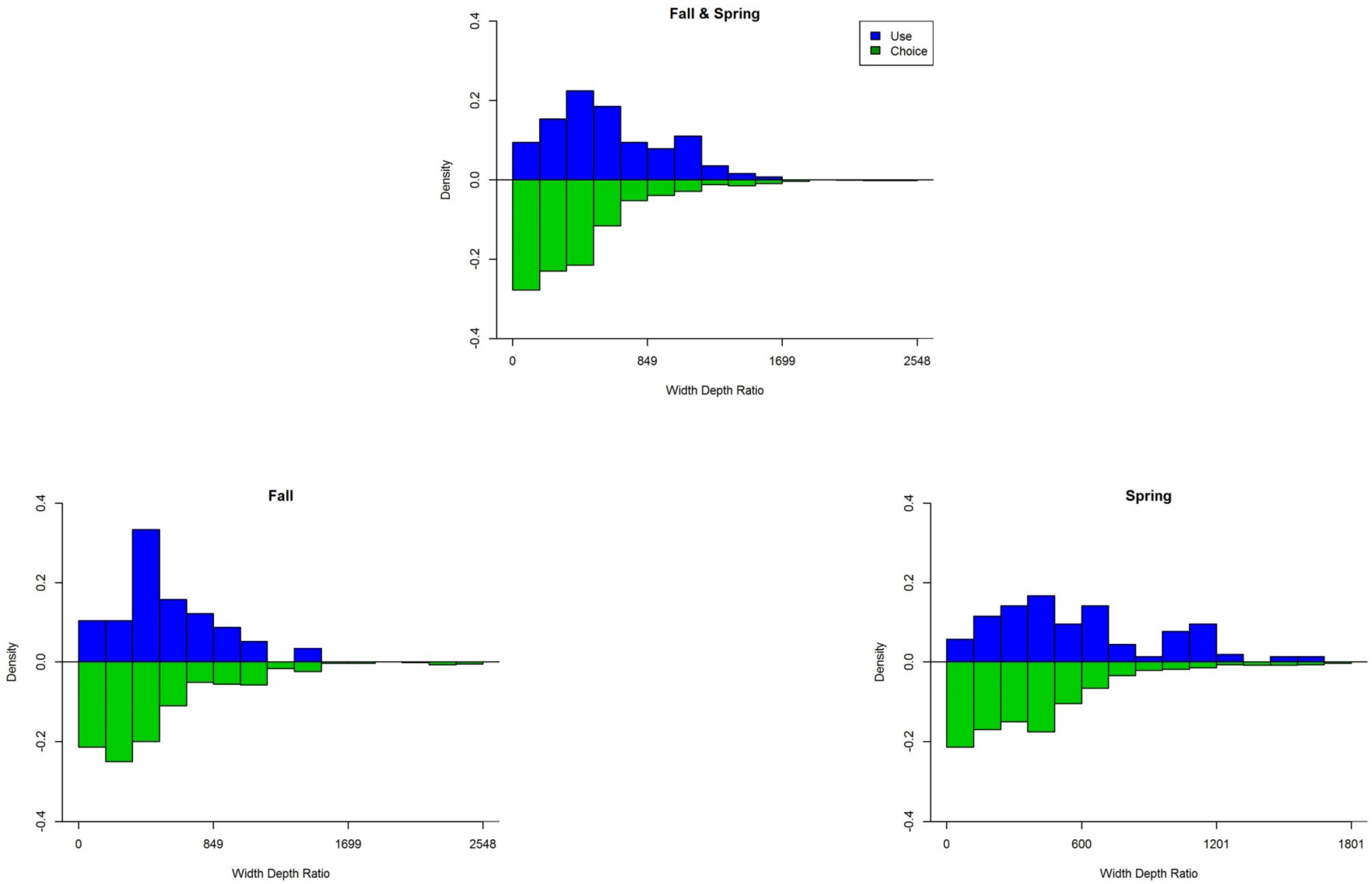


Figure D.21. Histograms of width-to-depth ratio (wetted depth / mean depth) at systematic and opportunistic locations used by a whooping crane group ("Use" in blue) and the choice set of locations ("Choice" in green). Spring and fall were combined (above) and shown separately (below).

Appendix E. Mirrored Histograms and Summary Statistics for Systematic Diurnal Whooping Crane Observations

List of Figures

Figure E.1. Histogram of nearest disturbance (feet [ft]) for diurnal locations used by whooping crane groups in the spring and fall (“Use” in blue) and the choice set of locations (“Choice” in green). 2

Figure E.2. Histogram of nearest obstruction (feet [ft]) for diurnal locations used by whooping crane groups in the spring and fall (“Use” in blue) and the choice set of locations (“Choice” in green). 2

Figure E.3. Histogram of proximity to roost location (feet [ft]) for diurnal locations used by whooping crane groups in the spring and fall (“Use” in blue) and the choice set of locations (“Choice” in green). 3

List of Tables

Table E.1. Mean, standard deviation (SD), and coefficient of variation (CV) for each variable in the analysis. Spring sample sizes were 347 for used locations and 17,350 for the choice sets, fall sample sizes were 131 for used locations and 6,550 for the choice sets. Variable abbreviations are in the methods section of the main body of the report. 1

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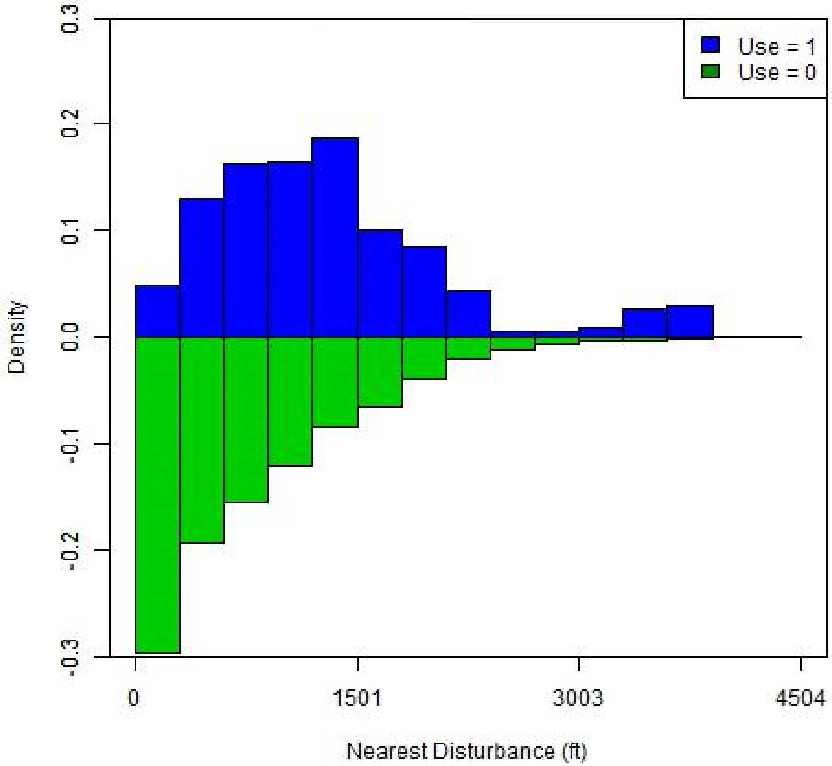
		Choice Sets			Used Locations		
Variable	**Season**	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
PRL	Fall	11961.88	5659.54	47.31	4182.58	5777.99	138.14
	Spring	16547.67	9710.95	58.68	10758.30	11274.53	104.80
	Spring and Fall	15290.89	9023.21	59.01	8956.17	10484.48	117.06
NO	Fall	615.00	587.73	95.57	405.31	275.85	68.06
	Spring	1265.88	1717.82	135.70	1068.04	1272.68	119.16
	Spring and Fall	1087.50	1523.51	140.09	886.41	1132.78	127.79
ND	Fall	772.42	675.08	87.40	1461.70	813.17	55.63
	Spring	783.50	681.54	86.99	1240.99	817.85	65.90
	Spring and Fall	780.46	679.78	87.10	1301.48	821.65	63.13



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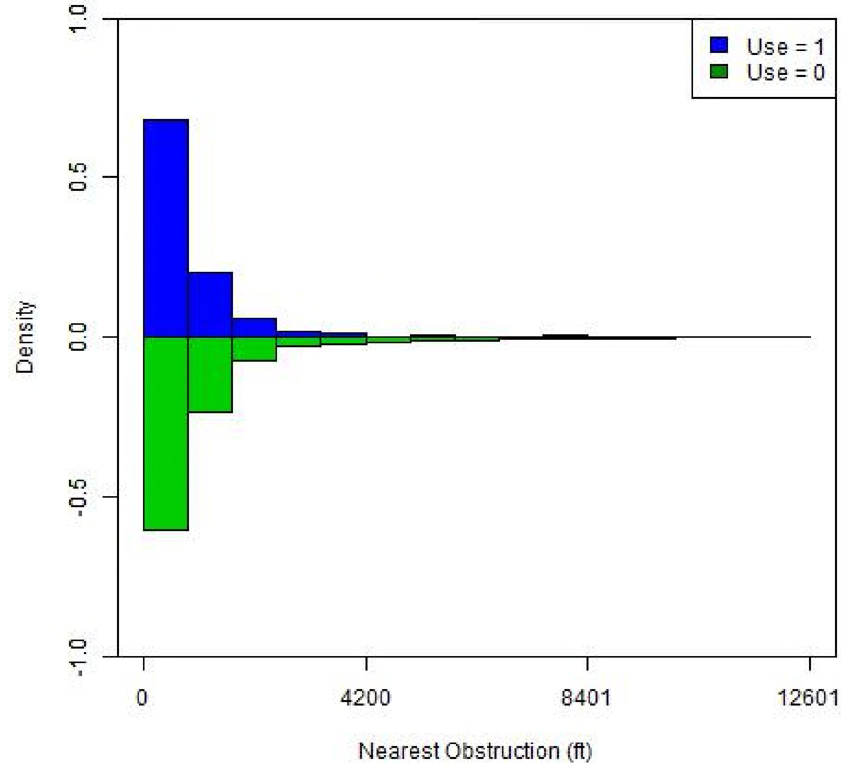

Figure E.2. Histogram of nearest obstruction (feet [ft]) for diurnal locations used by whooping crane groups in the spring and fall ("Use" in blue) and the choice set of locations ("Choice" in green).

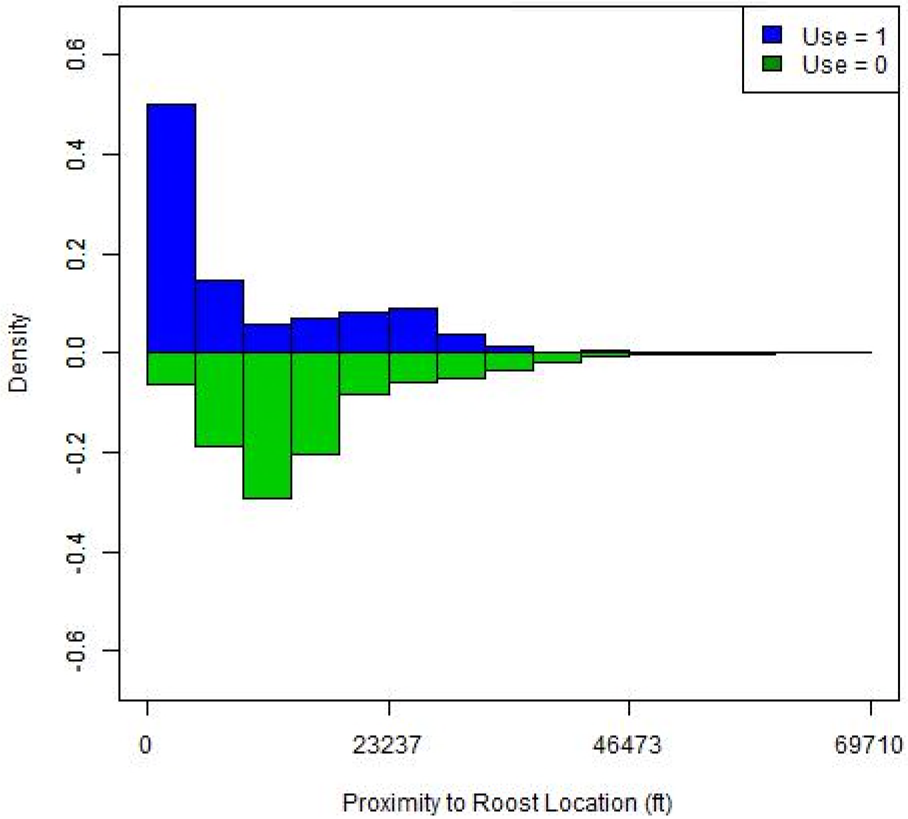

Figure E.3. Histogram of proximity to roost location (feet [ft]) for diurnal locations used by whooping crane groups in the spring and fall ("Use" in blue) and the choice set of locations ("Choice" in green).

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Data Synthesis Compilation

Whooping Crane (*Grus americana*) Habitat Synthesis Chapters

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Prepared by staff of the Executive Director's Office for the Governance Committee of the Platte River Recovery Implementation Program

August 15, 2017

PREFACE

This document was prepared by the Executive Director's Office (EDO) of the Platte River Recovery Implementation Program ("Program" or "PRRIP"). The information and analyses presented herein are focused solely on informing the use of Program land, water, and fiscal resources to achieve one of the Program's management objectives: contribute to the survival of whooping cranes by increasing habitat suitability and thus use of the Associated Habitat Reach (AHR) along the central Platte River in Nebraska. The Program has invested nine years in implementation of an adaptive management program to reduce uncertainties about proposed management strategies and learn about river and species responses to management actions. During that time, the Program has implemented management actions, collected a large body of physical and species response data, and developed modeling and analysis tools to aid in the interpretation and synthesis of data.

Implementation of the Program's AMP has proceeded with the understanding that management uncertainties, expressed as hypotheses and summarized as Big Questions, encompass complex physical and ecological responses to limited treatments that occur within a larger ecosystem that cannot be controlled by the Program. The lack of experimental control and complexity of response precludes the sort of controlled experimental setting necessary to cleanly follow the strong inference path of testing alternative hypotheses by devising crucial experiments (Platt 1964). Instead, adaptive management in the Platte River ecosystem must rely on a combination of monitoring of physical and biological response to management treatments, predictive modeling, and retrospective analyses (Walters 1997). The Program has pursued all three of these approaches, producing multiple lines of evidence across a range of spatial and temporal scales. These lines of evidence indicate implementation of the Program's Flow-Sediment-

Mechanical (FSM) management strategy, particularly the flow component, may not achieve the stated management objective and sub-objectives for whooping cranes; contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR.

This document is a compilation of four topical chapters with unique objectives and analyses that generally build on one another. Each of the chapters, which are intended to be useful as independent documents, include background information on the Program and thus may contain redundant content. Chapter 1 was developed to provide background and context to the discussions in the subsequent chapters. It provides a brief overview of whooping crane life history and occurrence within the AHR, a summary of previous investigations of habitat selection by whooping cranes along the Platte River, changes in river morphology that sparked regulatory intervention through the Endangered Species Act, and the competing management strategies the Program is implementing through an adaptive management framework. Chapters 2 and 3 focus specifically on whooping riverine habitat selection and suitability within the AHR and throughout the North-central Great Plains, respectively. Chapter 4 focuses on assumptions of priority hypotheses related to the beneficial effects of the FSM strategy on channel width measures and thus whooping crane habitat suitability, use of the Platte River, and survival during migration. Finally, a brief Summary of Key Findings has been added in order to combine and distill the most important conclusions of each chapter for Program decision makers.

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Platt, J. R. 1964. Strong inference. Science, 146(3642), 347-353.

Walters, C. 1997 Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology, 1(2), 1.

CHAPTER 1 – History and Context: The Path to Adaptive Management of Whooping Crane Habitat in the Central Platte River

Abstract

Observations of whooping crane use of the central Platte River is reviewed in relation to changes in hydrology and channel morphology over historical timeframes. The first observations of whooping cranes in the Associated Habitat Reach of the central Platte River date to the early 1800s. By the 1930s and 1940s river hydrology was altered by irrigation infrastructure and the channel actively narrowed in response to changing flow, sediment, and disturbance regimes. The loss of roosting habitat and whooping crane resources (forage) along the Platte River are hypothesized to be associated with the ongoing changes in the magnitude of channel forming flows and sediment transport. It is believed whooping crane survival during migration is negatively impacted by reductions in unobstructed channel width and unforested width along the Platte River. Adaptive management at a large scale is being used to test two management strategies to maintain suitable stopover habitat within the Associated Habitat Reach and thus to contribute to the survival of whooping cranes during migration.

Introduction

The Platte River Recovery Implementation Program (Program or PRRIP) is responsible for implementing certain aspects of the endangered whooping crane recovery plan. More specifically, the Program's Adaptive Management Plan (AMP) management objective is to improve survival of whooping cranes during migration through increased use of the Associated Habitat Reach (AHR) of the Platte River in central Nebraska (PRRIP 2006a). This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).

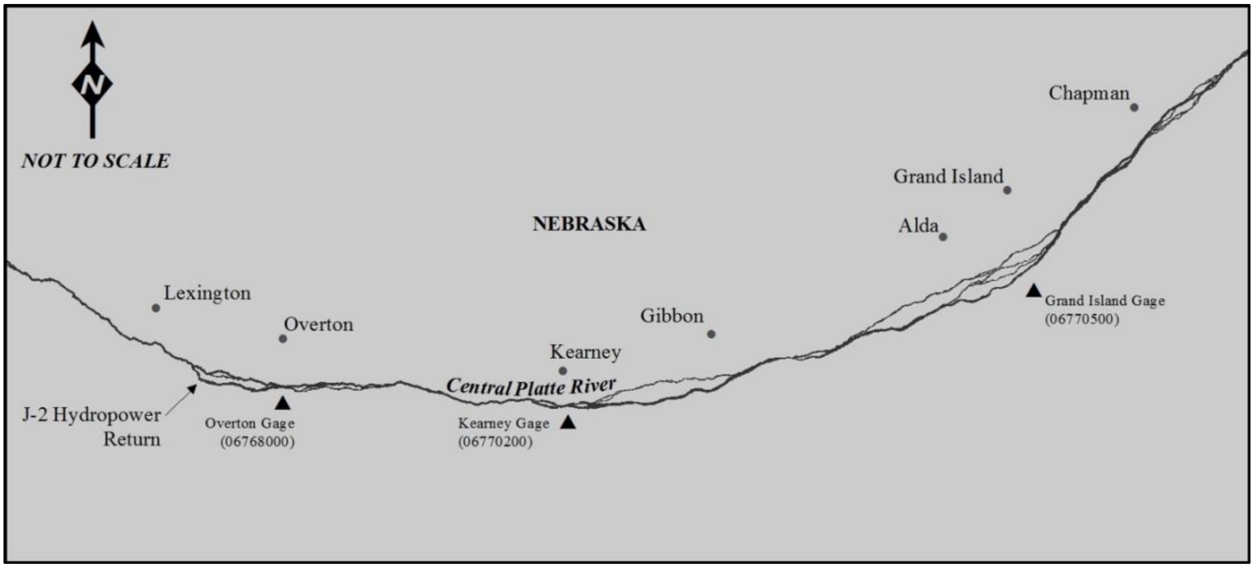

Figure 1. Associated Habitat Reach (AHR) of the central Platte River in Nebraska extending from Lexington downstream to Chapman.

The Program has invested nine years implementing an adaptive management program to test strategies for increasing whooping crane use of the AHR. Subsequent chapters of this document present analysis and interpretation of modeling, research, and monitoring efforts to date. The objective of this introductory chapter is to provide a brief overview of the large body of relevant Platte River literature and outline regulatory actions that led to the formulation of the Program. The chapter begins with a review of whooping crane monitoring and research in the AHR. Changes in hydrology and channel characteristics over historical timeframes are then explored. Finally, the rationale for regulatory intervention on behalf of the species is discussed and related to two management paradigms being evaluated by the Program.

Whooping Crane Life History

Whooping cranes are the tallest of North American birds and stand nearly five-feet tall. Their wingspan measures between seven and eight feet. Males weigh about 16 pounds and females about 14 pounds. Whooping cranes are a long-lived species that have been observed in the wild at an age >25 years. Adults are snowy white except for black primary feathers on the wings and a bare red face and crown. Immature cranes are a reddish cinnamon color that results in a mottled appearance as the white feather bases extend. The juvenile plumage is gradually replaced through the winter months and becomes predominantly white by the following spring as the dark red crown and face appear. Yearlings achieve the typical adult appearance by late in their second summer or fall. Whooping cranes are considered sub-adults and generally do not produce fertile eggs until they are 4 years old.

The whooping crane population, variously estimated at 500 to 1,400 individuals in 1870, declined to only 16 individuals in the migratory population by 1941 as a consequence of hunting and specimen collection, human disturbance, and conversion of the primary nesting habitat to hay, pastureland, and grain production (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2007). The whooping crane was listed as endangered on March 11, 1967 (USFWS 1986). The historic range of the whooping crane once extended from the Arctic coast south to central Mexico, and from Utah east to New Jersey, into South Carolina, Georgia, and Florida. The historic breeding range once extended across the north-central United States and in the Canadian provinces, Manitoba, Saskatchewan, and Alberta. Currently the main threat to whooping cranes in the wild is the potential of a hurricane or contaminant spill destroying their wintering habitat on the Texas coast.

The Aransas – Wood Buffalo population of whooping cranes are long-distance migrants that breed in and around Wood Buffalo National Park located in Northwestern Canada and the Northern Territories and winter in and around Aransas National Wildlife Refuge (ANWR) located along the Gulf Coast of Texas. The migration route is well defined and a vast majority of all observations occur within a 200-mile wide corridor through Alberta, Saskatchewan, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas (Figure 2; Pearse et al. 2015). Whooping cranes are diurnal migrants, use traditional migration staging areas, and during migration utilize stopover sites to rest and build energy reserves to complete migration (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2007). Although a variety of habitats are used during migration, a wetland is nearly always associated with a stopover site. At stopover sites, whooping cranes roost standing in shallow water associated with palustrine, lacustrine, or riverine wetlands. Whooping cranes are omnivorous feeders that forage on many items including mollusks, crustaceans, minnows, reptiles, amphibians, invertebrates, small mammals, small birds, berries, live oak, agricultural grains, and plant tubers located in wetlands, grasslands, and agricultural fields.

Whooping cranes migrate singly, in pairs, in family groups, or in small flocks and sometimes accompany sandhill cranes. Spring migration is preceded by mating behaviors such as dancing, unison calling, and frequent flying. Family groups and pairs are the first to leave the ANWR in late-March to mid-April. Whooping cranes are monogamous and form life-long pair bonds but will re-mate following the death of a mate (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2007). Whooping cranes return to the same breeding territory in Wood Buffalo National Park in April and nest in the same general area each year (Whooping Crane

Tracking Partnership unpublished data). The nesting area in Wood Buffalo National Park is a poorly drained region interspersed with numerous potholes. Bulrush is the dominant emergent in the potholes used for nesting. Adult whooping cranes construct nests of bulrush and lay one to three eggs (usually two) in late April and early May. The incubation period is about 29 to 31 days. Whooping cranes will renest if the first clutch is lost or destroyed before mid-incubation. Both sexes share incubation and brood-rearing duties. Despite the fact that most pairs lay two eggs, sibling rivalry usually results in only one chick reaching fledging age. Only one-fourth of chicks that hatch survive to reach the wintering grounds.

Figure 2. Dotted line delineates the migration corridor of whooping cranes, including breeding areas in Wood Buffalo National Park and wintering areas near Aransas National Wildlife Refuge.

Autumn migration begins in mid-September and most birds arrive on the wintering grounds on the Texas Gulf Coast by early to mid-December. On the wintering grounds, pairs and family groups occupy and defend territories. Sub-adults and unpaired adult whooping cranes form loose flocks that use the same habitat, but remain outside of occupied territories where they first wintered (Stehn and Prieto). Sub-adults tend to winter in the area where they were raised their first year and paired cranes often locate their first winter territories near their parents' winter territory.

Whooping crane observations on or along the Platte River

Historical records of whooping occurrence on or along the Platte River from 1820–2014 were compiled or recorded by Swenk, Black, Brooking, Allen, USFWS, NGPC, Ross Lock, and Hastings Museum and have been summarized by Tom Pitts (1985), the Biological Work Group (1990), and the Executive Director's Office of the Program (Figure 3). It is important to note detection of whooping cranes along the central Platte River increased substantially beginning in 2001 with the implementation of systematic surveys of the AHR and that survey methodologies at Aransas National Wildlife Refuge were modified in 2011. Population estimates were obtained from the United States Fish and Wildlife Service (USFWS), the Whooping Crane Recovery Team, and the Whooping Crane Studbook and were compiled by Betsy Didrickson of the International Crane Foundation and the USFWS.

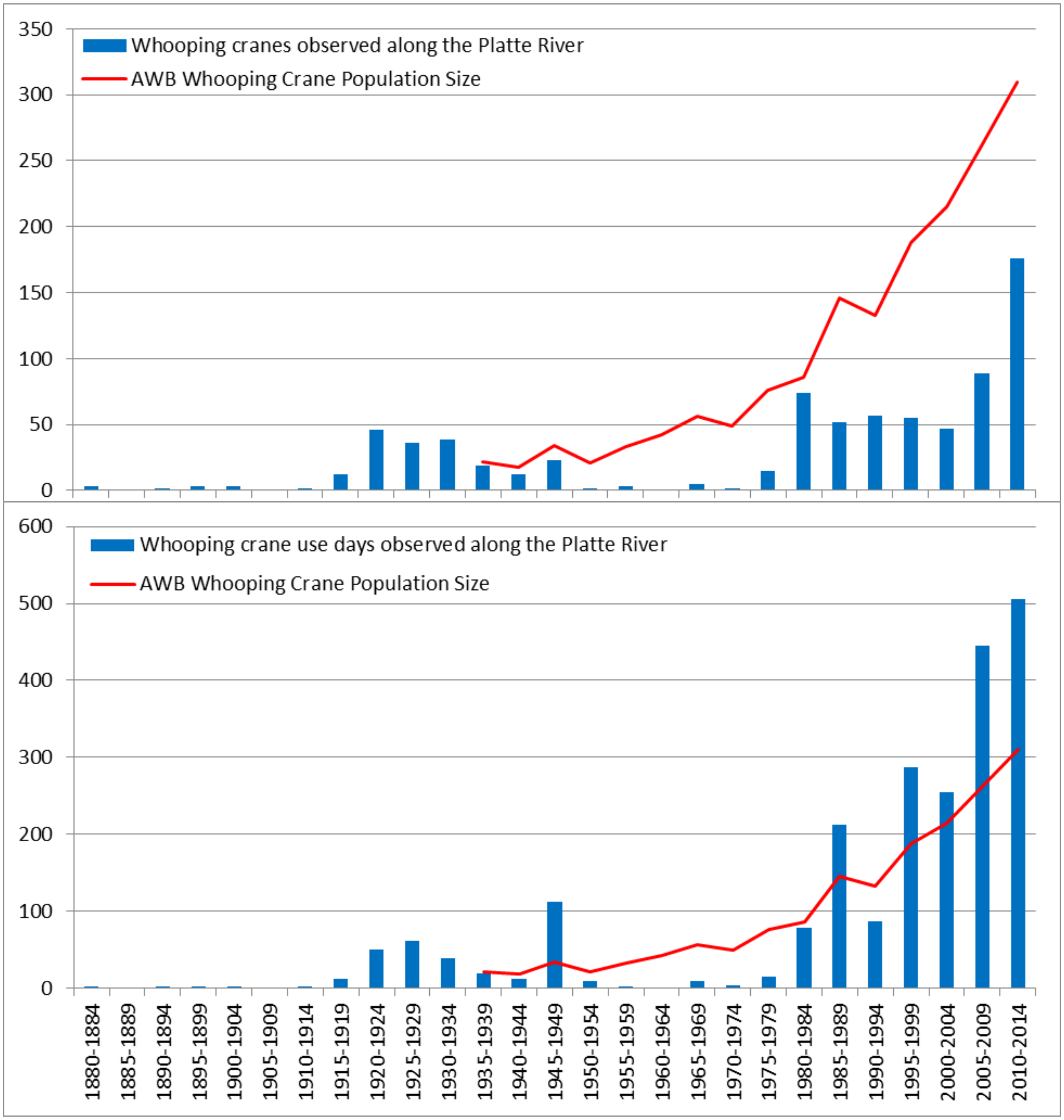

Figure 3. Numbers of whooping cranes (top bar plot) and whooping crane use days (bottom bar plot) reported on or near the Platte River in 5-year blocks of time, 1880-2014. The red line represents the numbers of whooping cranes counted in the Aransas-Wood Buffalo population at the end of each 5-year interval, 1939-2014. Monitoring effort on the Platte River changed substantially beginning in 2001 when systematic surveys of the Program Associated Habitat Area were initiated. It should also be noted that Allen (1952) and Pitts (1985) concluded the increase in observations along the Platte River during the 1920's was likely due to misidentification of whooping cranes.

Platte River habitat selection investigations

Characteristics of whooping crane roost habitat have been examined and described for the central Platte River in Nebraska (Johnson 1981; Lingle et al. 1984; Armbruster 1990; Faanes 1988; Faanes and Bowman 1992; Faanes et al. 1992). Several characteristics common to whooping crane riverine roost sites include shallow, wide, unvegetated channels and open visibility with the absence of tall trees or dense shrubs near the roost (Johnson and Temple 1980; U.S. Fish and Wildlife Service 1981; Johnson 1981; Armbruster 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004). Ziewitz (1987) described whooping roosting habitat suitability using several parameters including unobstructed channel width. In this assessment, unobstructed channels ≤500 ft wide were assigned a minimum suitability value while unobstructed channel widths ≥1,150 ft were assigned a maximum suitability value. Table 1 of the Program's land plan infers whooping crane habitat suitability and use are maximized at UOCW of 1,150 ft (PRRIP 2006b). Shenk and Armbruster (1986) reported unobstructed channel widths 246 ft were unsuitable roosting habitat for whooping crane and roost habitat was optimized at unobstructed channel widths of 1,312 ft. Similarly, the USFWS (1986) reports whooping roosting habitat is optimized at unobstructed channel widths ≥1,158 ft and channels with unobstructed widths <500 ft were deemed unsuitable roosting habitat. Contrary to these reports, Austin and Richert (2005) found unobstructed channel widths at riverine roost sites averaged 764 ft and Johnson (1981) described optimal riverine roost habitat as being any channel with an unobstructed width ≥509 ft. Pitts (1985) even went so far as to report whooping crane selection of stopover habitat occurs at random. To date, however, roost characteristics and criteria have been developed based on a limited amount of quantitative information and most criteria have been derived from circumstantial roost locations that may not be representative of a typical stopover site (Armbruster 1990).

Changes in Associated Habitat Reach hydrology over historical timeframes

Water development in the Platte River basin began in the mid-1800s as settlers migrated to the region in search of gold and to homestead after the federal government opened the basin for settlement. The Platte River is now heavily developed with over seven thousand diversion rights and seven million acre-feet of storage (Figure 4; Simons & Associates Inc. 2000). Platte River discharge records begin in 1895, fifteen years before the completion of Pathfinder Dam, the first major agricultural storage project in the basin. Mean annual discharge and the magnitude of the mean annual peak discharge in the contemporary river are less than 40% of what was observed during the brief period of record prior to reservoir construction (Table 1; Stroup et al. 2006).

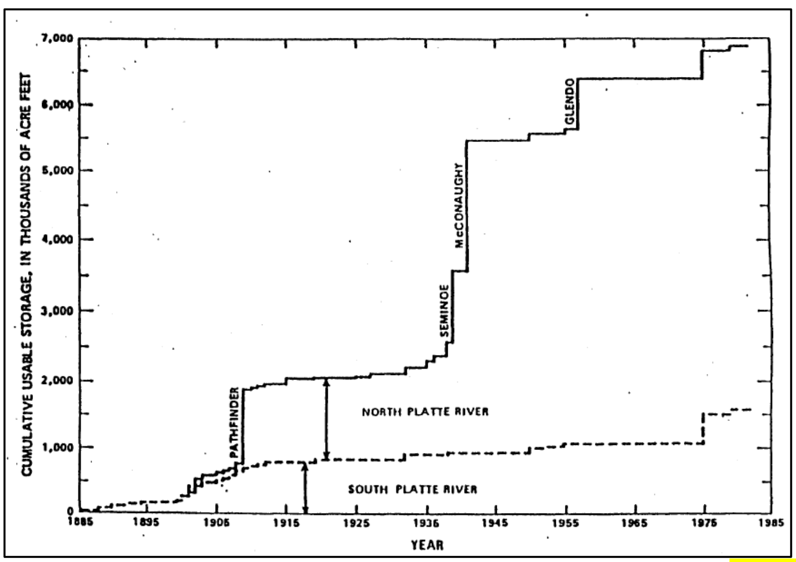

Figure 4. Cumulative usable storage in reservoirs in the Platte River basin (Simons and Associates Inc. 2000).

Table 1. Mean annual discharge and mean annual peak discharge at Overton gage adapted from Stroup et al. (2006).

	1895-1909	1910-1927	1928-1941	1942-1958	1959-1974	1975-1998	1999-2013
Mean Annual Discharge (cfs)	4,584	4,323	1,845	1,223	1,636	1,938	1,232
Mean Annual Peak Discharge (cfs)	20,725	18,218	11,548	6,685	7,301	7,176	5,056

Changes in Associated Habitat Reach sediment transport over historical timeframes

There is little bed material or sediment transport data available for the historical AHR. Simons and Associates Inc. (2000) generated a crude predevelopment sediment transport estimate of approximately 7.8 million tons per year based on a flow/sediment regression analysis and an estimate of sediment trapping in North Platte River reservoirs. Murphy et al. (2004) estimated much lower predevelopment sediment loads on the order of one to two million tons per year using a range of sediment discharge equations and discharge records from the period of 1895-1909. As indicated by the differences in these estimates, there is a high degree of uncertainty related to sediment loads in the historical AHR. Contemporary sediment load estimates are less variable and generally range from 400,000 – 1 million tons per year (Simons and Associates Inc. 2000, Murphy et al. 2004).

One of the most significant changes in sediment dynamics from predevelopment conditions is a sediment deficit in the upper half of the AHR due to clear water hydropower returns at the Johnson 2 (J-2) Return structure on the south channel downstream of Lexington, NE (Figure 5). An average of approximately 73% of Platte River flow is diverted at the Tri-County Diversion Dam downstream of North Platte and returns to the river at the J-2 Return where it constitutes approximately 47% of river flows (Murphy et al. 2004). Once diverted at North Platte, flow travels through several off-line reservoirs where almost all of the sediment is trapped. Accordingly, return flows at the J-2 Return structure are sediment-starved resulting in a sediment deficit (hungry water) below the return.

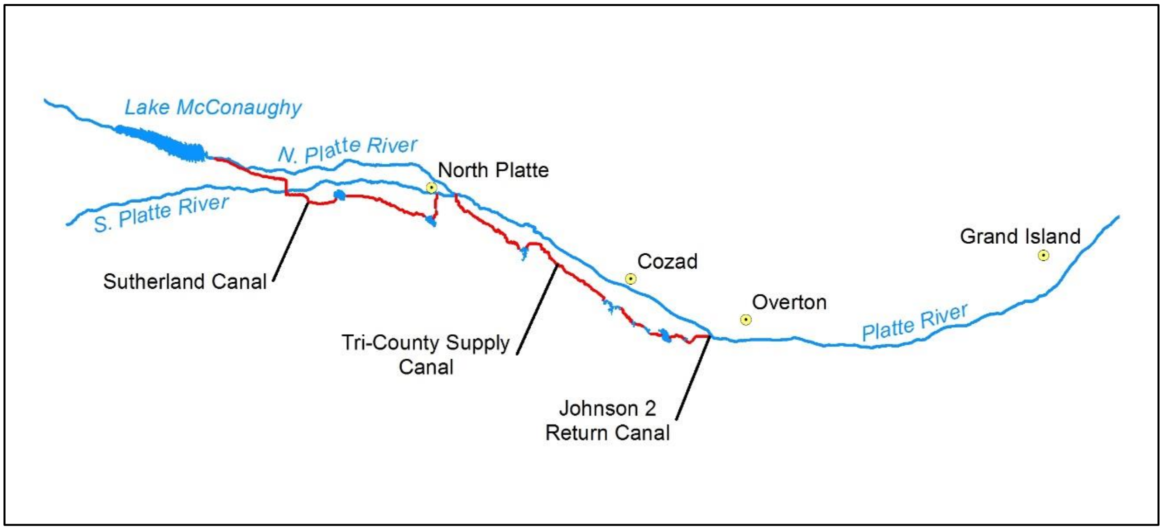

Figure 5. Map of Lake McConaughy, Tri-County Supply Canal and J-2 Return Canal. Figure reproduced from Murphy et al. (2004).

Changes in Associated Habitat Reach channel morphology over historical timeframes

The reduction in AHR active channel width (unvegetated width between permanently vegetated left and right banks) over historical timeframes through expansion of woody vegetation was first quantified by Williams (1978) and has been expanded upon in several subsequent analyses (Eschner et al. 1983, Currier et al. 1985, Peake et al. 1985, O'Brien and Currier 1987, Lyons and Randle 1988, Sidle et al. 1989, Johnson 1994, Simons and Associates 2000, Parsons 2003, Murphy et al. 2004, Schumm 2005, Horn et al. 2012). With the exception of Parsons (2003), which asserted no width change from 1930 to 1998, investigators have generally concluded the AHR experienced a significant width reduction as a result of the expansion of cottonwood forest into the channel. The change is evident in comparisons of aerial photography (Figure 6).

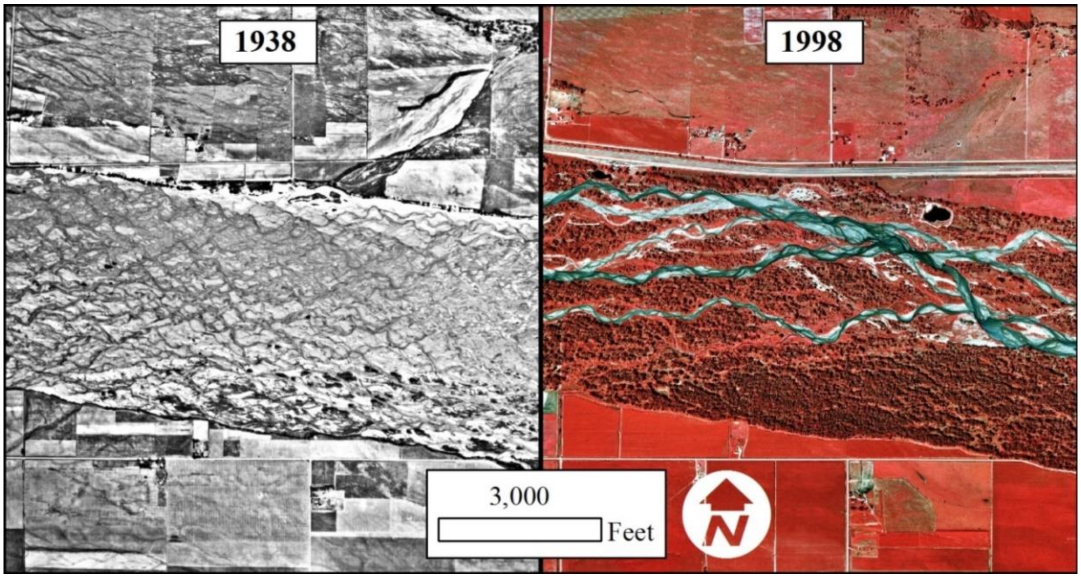

Figure 6. Comparison of 1938 and 1998 aerial photographs of the Associated Habitat Reach at River Mile 218 in the Odessa to Kearney bridge segment. Much of the 1998 channel area is occupied by riparian cottonwood forest.

The surveyed bank-to-bank or total width of the channel in the 1860s excluding large permanent islands was highly variable and averaged 3,800 ft (Figure 7). The proportion of the total width of the historical channel that was unvegetated is not known but has been estimated to be on the order of 90% (Johnson 1994). At the earliest aerial photography collection in 1938, unvegetated channel width averaged 2,600 ft. By 1998, average unvegetated width was 900 ft. Johnson (1994) evaluated the rate of change in active channel width in the AHR from 1938 to 1988 and found the majority of narrowing occurred during the 1940s and 1950s with channel area stabilizing by the 1980s (Figure 8).

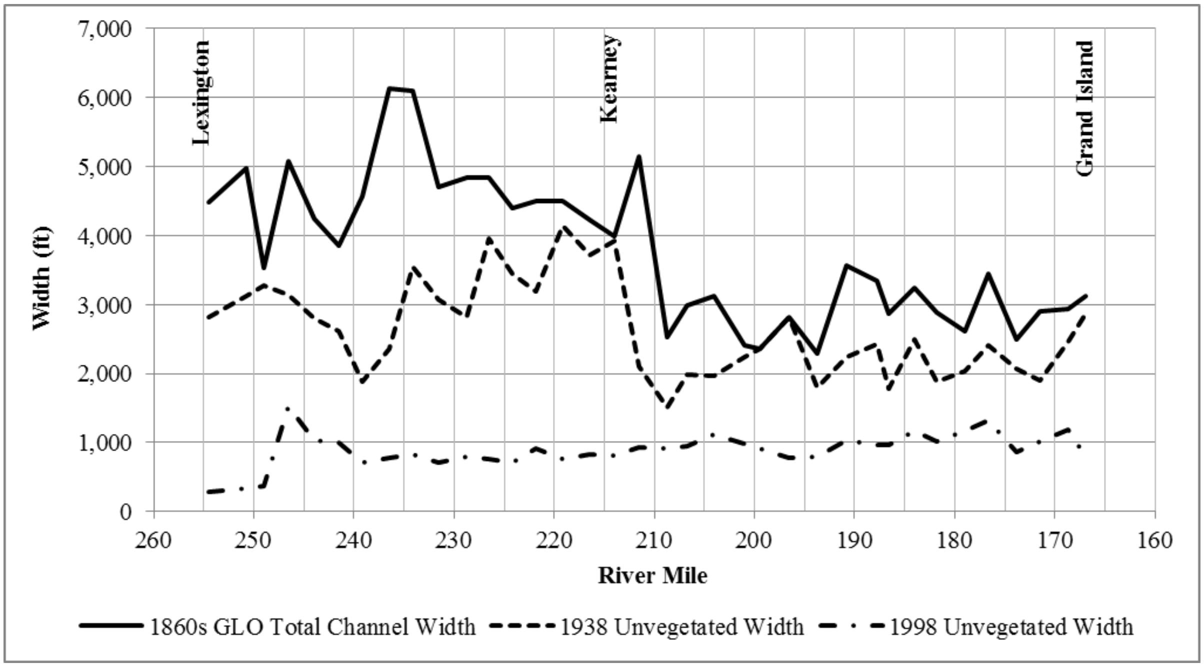

Figure 7. Total channel width in the Associated Habitat Reach from the 1860s General Land Office (GLO) survey, total unvegetated width in 1938 aerial photographs and total unvegetated width in 1998 aerial photographs.

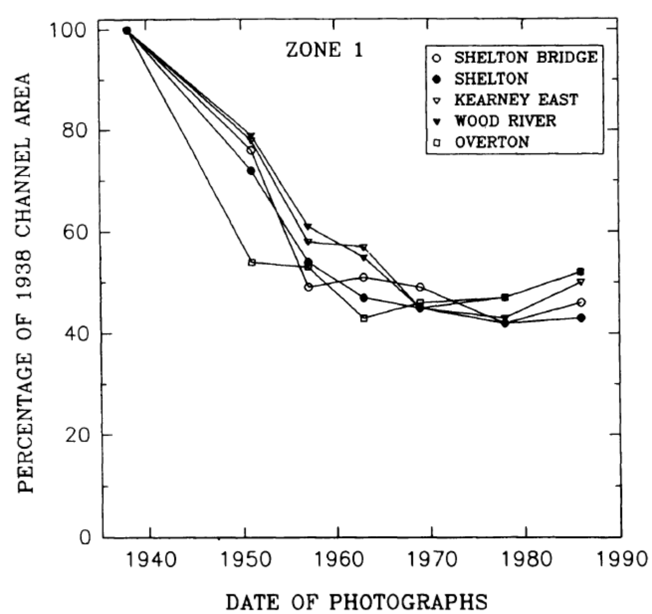

FIG. 8. Changes in active channel area in Zone 1 reaches from 1938 through 1986. Starting channel area in 1938 was set equal to 1.

Figure 8. Change in active channel area in the upper half of the Associated Habitat Reach 1938-1988 from aerial photography (Johnson 1994).

The drivers of woody vegetation expansion were explored in many of the channel width analyses with investigators generally concluding the change was due to alterations in hydrology caused by water development in the basin. Alternative hypotheses of the specific mechanisms of narrowing include:

1) a reduction of peak flow magnitude and associated ability to scour vegetation (Williams 1978, O'Brien and Currier 1987, Murphy et al. 2004),
2) a reduction in flow during the cottonwood germination period leading to increased recruitment (Johnson 1994, Simons and Associates 2000), and
3) a decrease in desiccation mortality of seedlings in summer as the river transitioned from ephemeral to perennial due to irrigation return flows (Schumm 2005).

Although changes in AHR channel width have been widely studied and debated, sandbar characteristics in the historical river are not well documented. Several investigations include brief descriptions of sandbars and islands recorded by travelers in the 19th Century (Eschner et al. 1983, Simons and Associates 2000, Murphy et al. 2004). The most descriptive observation of bedforms was contained in Mattes (1969) who reproduced a quote from a Mr. Evens in 1848 describing the Platte River near Kearney as "running over a vast level bed of sand and mica… continually changing into short offsets like the shingled roof of a house..." Other travelers generally characterized the bed of the river as being comprised of innumerable sandbars continually shifting and moving downstream (James 1823, Mattes 1969).

The first detailed characterization of AHR sandbar morphology was provided by Ore (1964) who classified Platte River bedforms as transverse bars. Further attempts to characterize sandbar morphology identified dominant bedforms as transverse/linguoid bars (Smith 1971, Blodgett and Stanley 1980), macroforms (Crowley 1981 and 1983), or a combination of both types (Horn et al. 2012). The historical accounts of Platte River bedforms appear to agree well with contemporary descriptions of transverse/linguoid bars.

Regulatory intervention in the Platte River Basin through the Endangered Species Act

In 1981, the USFWS deduced the most likely factors resulting in decreased whooping crane use of the Platte River between 1950 and 1980 were decreased unobstructed channel width, growth of woody vegetation along the bank lines, and increased human activity along the Platte River (USFWS 1981). The USFWS concluded additional diversions were likely to cause further habitat degradation and threaten the welfare of whooping cranes. As such, the USFWS determined whooping crane habitat along the central Platte River was threatened by upstream impoundments and diversions that reduce the magnitude of the annual spring runoff credited with historically creating and maintaining open-channel roosting habitat and for sustaining suitable bottomland (wet meadow) habitat deemed to be essential for foraging (USFWS 2006). The following excerpt from the Biological Opinion for the Platte River Recovery Implementation Program (USFWS 2006) provides the rationale for USFWS conclusions about the effects of upstream water development on whooping crane habitat in the AHR.

> *"<u>Open Channel Roosting Habitat</u>*
>
> *During the past century, channel habitat in the 170-mile long reach that lies within the whooping crane migration corridor has been transformed from a very wide and braided sandy channel to anabranched channels and heavily forested floodplain. Historical accounts of the Platte River place its width between 0.75- and 3 miles. Actual measurements by Bonneville in 1837 was a 1.25-mile width 25*

miles downstream of Fort Kearney, and a 1.0-mile width that was measured, by the explorer Fremont in 1845, downstream from the confluence of the North Platte and South Platte rivers (Currier et al. 1985).

Encroachment of woody vegetation into the former wide expanse of the river bed is described by Williams (1978), Eschner et al. (1983), Peake et al. (1985), Johnson (1990, 1994, and 1996), McDonald and Sidle (1992), Currier et al. (1985), and Currier (1995 and 1996a), Simons and Associates (2001), Murphy et al. (2004), and summarized by Sidle et al. (1989) and the EIS (Department of the Interior 2006). Within the Lexington to Chapman reach alone, Sidle et al. (1989) estimated that by the early 1980s the channel area had been reduced by 73 percent with the greatest reductions in the critical habitat reach from Lexington to Shelton (RM 196 to 250) (Figure VI-A6).

Currier et al. (1985) estimated that 70 percent of the open channel and 90 percent of the habitat value had been lost. Habitat loss and the threat of the Platte River whooping crane resources are related to the ongoing deterioration of forming processes (i.e., changes in the magnitude of channel forming flows and sediment transport) as described above. Further information on channel changes and loss of open channel discussed in 'Status of the Platte River Ecosystem' (Chapter VI, Section A) apply to the critical habitat reach.

Downstream of Lexington, the channel degradation described in the Status of the Platte River Ecosystem (Environment Baseline section, part A) of this biological opinion affects both channel roosting habitat and wet meadow foraging *habitat. No major tributary inflows or outflows occur below the J-2 Return and river flow patterns at Overton and Grand Island are generally similar, yet channel habitat losses are not uniform within the reach. Sediment-free J-2 Return discharges increase the downstream sediment transport to rates that are about twice the indicated amount supplied in to the habitat reach at Lexington (Randle and Samad 2003). Channel surveys indicate that much of the difference in the amount of sediment transported is from erosion of the channel bed.*

Channel bed degradation extends downstream from the J-2 Return near Lexington. The length of river reach undergoing degradation is not precisely determinable with existing data, but appears to be at least 20 miles and perhaps as much as 40 miles of a recent 15- year interval (Murphy et al. 1998, Holburn et al. 2006).

Channel bed erosion is a factor that adversely affects open channel roosting habitat by entrenching the channel and concentrating flow and increasing water depth and velocity. Channel downcutting has left high islands, banks, and benches at higher elevations and provide a surface for vegetation growth. Though the affects of this process on habitat vary somewhat among river reaches, the confining and down-cutting of the river channel between high banks has contributed to substantial decreases in horizontal visibility, open channel, and wetted channel area, and to changes from braided to anabranched river plan form.

The area of open, wide channels is not entirely eliminated in the critical habitat reach, but it is substantially reduced in amount and quality (Figure VI-B6).

Consequently, whooping crane use of the river channel for roosting is substantially limited from Lexington (RM 251) to the vicinity of Fort Kearny State Recreation Area (RM 210) (Fort Kearney lies in bridge segment 8 of Table IV-B2). Portions of the river in bridge segment 7 and 10 are maintained as open channel habitat by private non-government organizations.

Quantitatively, loss of whooping crane roosting habitat due to channel degradation is greatest in the upstream reaches. For example, between 1985 and 2000 near Overton, changes in channel morphology (i.e., channel downcutting and narrowing) virtually eliminated whooping crane roost habitat in a segment of the critical habitat reach near Overton (Figure VI-B7).

Changes in river morphology may have a controlling affect on the hydrologic relationship between the river and subirrigated meadows and wetland components of the adjoining bottomland grasslands. Platte River channel morphology must be improved and maintained in order to provide the wide channels suitable as roosting habitat and to restore and maintain wet meadows where cranes feed and rest.

<u>*Hydrocycling*</u>

Flows of the Platte River during spring and fall whooping crane migration seasons are composed in part of water diverted into CNPPID's system and returned at the upstream end of the central Platte River habitat area near Lexington. Returns at the J-2 Return and flows remaining in the south river depend in part on the *releases from Lake McConaughy and inflows from the South Platte River. Releases depend in turn on available water supplies in the basin.*

During low water supply conditions, discharges from the J-2 Return are variable. Based on operational descriptions, Hydrocycling may occur when flows reaching the Johnson No. 2 power station are less than 1.300 to 1.400 cfs, and must occur when flows reaching the Johnson No.2 power station are less than 1,050 cfs because of the risk of cavitation damage (CNPPID 2005). During low flow years, Hydrocycling may occur during whooping crane spring and fall migration periods.

The magnitude of the change in river stage attenuates downstream. Changes in river stage may range from imperceptible to a few inches (at RM 206 and 207) to more than 2 feet (RM 243-244) during Hydrocycling. The potential adverse effects of current Hydrocycling operations on whooping cranes may be occurring in a limited portion of the J-2 to Kearney reach of the river where wide channels occur, and most specifically in the segment of wide channels maintained as crane habitat.

Though migrating whooping cranes may use the Platte River at various times of day and are observed to retreat from fields to Platte River roosts during severe weather, the primary concern is the potential effects on nocturnal roosts. Whooping cranes stand in shallow (usually <0.7-foot) slow-moving water to roost. The current Hydrocycling operations may affect cranes in several ways, including the potential to flush the birds from their roosts at night, cause restless roosting behavior, and potentially increase exposure to predators (pers. comm., Gary Krapu

2006). Collision with utility lines is a principal known cause of direct injury and mortality to migrating whooping cranes (USFWS 1994g, Ward and Anderson 1992, Stehn and Wassenich 2006), and of sandhill crane injury and mortality along the Platte River (USFWS 1984g, Ward and Anderson 1992). Discussions are currently underway with CNPPID to develop and agreement on modified Hydrocycling operations to avoid or minimize effects to listed species and program benefits."

As indicated in the excerpt, a decline in AHR whooping crane habitat suitability has been inferred from the body of evidence documenting a significant change in Platte River hydrology and a morphological reduction in unvegetated AHR channel width over historical timeframes. Within this context, the USFWS began issuing jeopardy opinions for water projects that could further affect the hydrology of the AHR. These jeopardy opinions prompted the states of Wyoming, Colorado, and Nebraska and the Department of the Interior to enter into a Cooperative Agreement in 1997 for the purpose of negotiating a program to conserve threatened and endangered species habitat in the AHR while accommodating certain ongoing water development activities in the basin. Through the negotiation process, it became apparent that uncertainty and disagreements about species habitat requirements and appropriate management strategies were making it difficult to reach agreement on a program. Resolution was achieved through the development of an Adaptive Management Plan (PRRIP 2006a) that treats these disagreements as uncertainties related to two competing management strategies.

Competing Management Paradigms

The Program's two competing management strategies reflect different paths to achieving the objective of improving survival of whooping cranes during migration. The first strategy is the

Mechanical Creation and Maintenance (MCM) approach. This approach focuses on mechanical creation and maintenance of both in- and off-channel habitats for the whooping cranes including channel widening through management activities such as in-channel and bank line vegetation removal, the acquisition and restoration of off-channel wetland habitat, and the construction and preservation of wet meadow habitat. Various entities have created, maintained, and monitored whooping crane stopover habitat use in the AHR since 2001. Accordingly, there is little uncertainty about the ability to mechanically create and maintain wide open channels for whooping cranes. Instead, the uncertainties pertain to characteristics that influence selection of in- and off-channel habitats and the most economical means of creating and maintaining that habitat (PRRIP 2006a).

The second strategy is the Flow-Sediment-Mechanical (FSM) approach. This approach is water-centric with a focus on restoring channel width, improving sediment supply, and increasing annual peak flow magnitudes to increase the braided channel morphology and maintain unobstructed channel width. The FSM strategy is rooted in the view that, prior to the onset of water development and channel narrowing, the historical AHR once provided stopover habitat conditions critical for whooping crane survival and that the contemporary Platte River is insufficient to provide the population this critical resource. As discussed previously, there is a large body of evidence documenting AHR channel narrowing over historical timeframes with the most significant changes occurring during the period of 1940-1970 (Johnson 1994).

Chapters 2 and 3 provide an overview of whooping crane riverine habitat selection along the central Platte River and throughout the North-central Great Plains, respectively. Chapter 4 explores the validity of the assumption the FSM management strategy can create and maintain habitat conditions suitable for whooping crane use as identified in chapters 2 and 3 and preludes into a discussion on the potential implications for the Program's ability to create and maintain whooping crane roosting habitat using short-duration high flows.

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CHAPTER 2 – Whooping Crane Use of Riverine Stopover Sites along the Central Platte River, Nebraska

Abstract

The "Big Bend" reach of the central Platte River has been identified as critical habitat for the survival of the endangered whooping crane (*Grus americana*). Management intervention is now underway to rehabilitate habitat form and function on the central Platte River to increase use and thereby contribute to the survival of whooping cranes. The goal of our analysis was to develop habitat selection models that could be used to direct management activities along the central Platte River. As such, we focused our analysis on habitat metrics the Platte River Recovery Implementation Program (Program) has the ability influence to some degree. This includes channel characteristics such as total channel width, the width of channel unobstructed by dense vegetation, and distance of forest from the channel. Through the U.S. Fish and Wildlife Service's Environmental Account, the Program also has access to water that, through timed releases, can be used to influence flow-related metrics like wetted width and unit discharge (flow volume per linear foot of wetted channel). We developed *a priori* set of models to evaluate the influence these various metrics on the probability of whooping crane use and found the width of channel unobstructed by dense vegetation and distance to the nearest forest were the best predictors of whooping crane use. We were unable to establish evidence of a strong relationship between use and flow metrics, total channel width or unforested channel width. Our findings indicate the Program has the potential to influence whooping crane use of the central Platte River through removal of in-channel vegetation to increase unobstructed width in narrow (<450 ft) channels and through removal of trees within areas where the distance to nearest forest from the center of the channel is <500 ft.

Introduction

The Platte River Recovery Implementation Program (Program or PRRIP) is responsible for implementing certain aspects of the endangered whooping crane (*Grus americana*) recovery plan. More specifically, the Program's management objective is to contribute to the survival of the whooping crane during migration by increasing and maintaining migratory stopover habitat in the Associated Habitat Reach (AHR) of the Platte River in central Nebraska. This ninety-mile reach extends from Lexington, NE downstream to Chapman, NE and includes the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1).

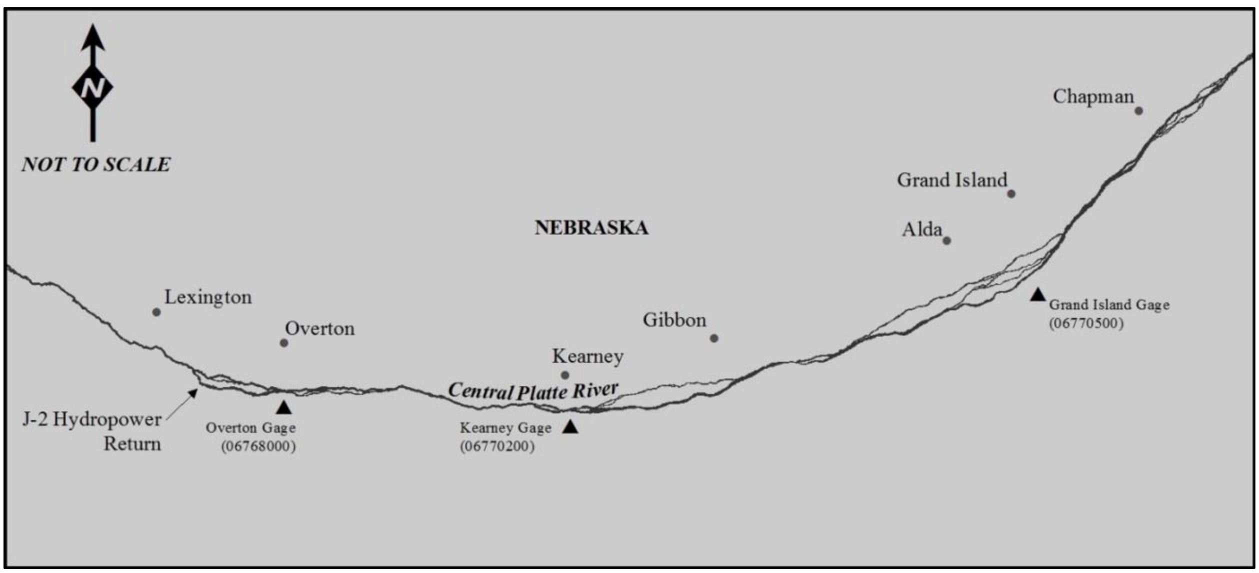

Figure 1. Associated Habitat Reach of the central Platte River extending from Lexington downstream to Chapman, NE.

During the First Increment of the Program (2007-2019), stakeholders committed to working toward this management objective by acquiring and managing 10,000 acres of land and 130,000-150,000 acre-feet of water to benefit whooping crane and other target species. However, there has been significant disagreement about species' habitat requirements and the appropriate strategy for managing the Program's land and water resources (Freeman 2010). In order to reach consensus for Program implementation, stakeholders agreed to treat disagreements as uncertainties to be evaluated within an adaptive management framework. The result is an Adaptive Management Plan (AMP) designed to test priority hypotheses including several associated with whooping crane responses to management actions designed to influence river form and improve habitat suitability (PRRIP 2006).

The whooping crane was listed as a federally endangered species in March 1967, and portions of the central Platte River were designated as critical habitat under the Endangered Species Act in May 1978 (U.S. Fish and Wildlife Service 1978). The National Research Council (2004) supported this critical habitat designation and concluded that current habitat conditions along the central Platte River adversely affect the likelihood of survival and recovery of the whooping crane population. Whooping crane stopovers occur throughout the migration corridor and last from one to several days during migrations that can last several weeks. Possible impacts of water and land development in the migration path has led to concern about the quality and quantity of stopover habitat for roosting and foraging. Along the central Platte River, flowing portions of riverine habitat have by far the highest incidence of stopover use for whooping cranes (Austin and Richert 2001; National Research Council 2004).

Evaluations of habitat characteristics at roost locations along the central Platte River date to the early 1980s (Johnson and Temple 1980; U.S. Fish and Wildlife Service 1981; Johnson 1981; Pitts 1985; Shenk and Armbruster 1986; U.S. Fish and Wildlife Service 1986; Ziewitz 1987; Armbruster 1990; Biology Workgroup 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004; Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005, Farmer et al. 2005). These analyses were focused on evaluations of hydrologic and geomorphic metrics assumed to be important for whooping crane habitat selection including unobstructed channel widths, distance to obstruction (i.e., nearest forest), view widths, flow, wetted width, suitable depth, etc. These analyses were typically developed based on a limited amount of quantitative information and most criteria were derived from circumstantial roost locations that may not be representative of a typical stopover site (Armbruster 1990). As a consequence, the results and conclusions 1) reflect the investigators assumptions about the habitat metrics that were important for whooping crane roost site selection and 2) may not be representative of typical stopover sites.

The objective of this analysis is to investigate riverine habitat selection by whooping cranes using methods that allow us to 1) identify habitat metrics that are both important for whooping crane use and that can be influenced through management activities and 2) do so in a manner that addresses changes in habitat through time and the biases associated with evaluation of circumstantial or opportunistic roost locations. This was accomplished through evaluation of channel and flow habitat characteristics at systematically detected whooping crane group stopover locations (fall 2001 – spring 2013) within a use-available resource selection function (RSF) estimation framework. A total of 16 *a priori* models were evaluated and ranked to identify the habitat metrics that appear to most strongly influence whooping crane roost location.

Methods

Our study area, the Associated Habitat Reach (AHR), encompasses the Platte River channel and a 3.5-mile buffer adjacent to the channel from the junction of US Highway 283 and Interstate 80 (near Lexington, Nebraska) downstream to Chapman, Nebraska (PRRIP 2011). Systematic whooping crane use data was collected during the spring and fall migration periods per the Program's whooping crane monitoring protocol (PRRIP 2011). Aerial surveys were flown daily during migration seasons, with the spring monitoring period spanning from March 21 to April 29, and the fall monitoring period spanning from October 9 to November 10. Flights followed the main river channel and took place at dawn to locate crane groups before they departed the river to begin foraging at off-channel sites. Return flights occurred after the river survey was completed and systematically surveyed upland areas and smaller side channels.

Whooping Crane Group Observation Data

Whooping crane habitat use within the AHR has been monitored since 2001. The basic sample unit for this analysis was a crane group (≥1 whooping crane). Per the Program's systematic monitoring protocol, crane groups were identified as being detected systematically during daily monitoring flights. Consequently, this dataset, and associated analyses, was unbiased with respect to the unequal monitoring effort associated with reports of observations by the public. The first observation of a crane group was identified as being unique with subsequent observations identified as repeat observations. For example, when crane groups were observed multiple days in a row, only the first observation was considered to be unique (independent).

The model selection process only utilized the unique (first) location for crane groups located systematically during implementation of the monitoring protocol (n=55). These observations are referred to as systematic unique observations. We also performed a supplementary analysis using the best model based on systematic unique observations using all systematically collected observations (n=176). This supplemental analysis substantially increased the number of observations in the analysis.

Parameterization of the A Priori Model Set

We quantified the characteristics of in-channel riverine habitat with two basic sources of information: aerial imagery and a HEC-RAS hydraulic model. We used aerial photographs and remote sensing data from LiDAR to determine the following metrics of channel openness for the analysis (Figure 2):

- Unobstructed Channel Width (UOCW) - Width of channel unobstructed by dense vegetation
- Nearest Forest (NF) - Distance to nearest riparian forest. Distance larger than 1,320 feet (1/4/ mile) were capped at 1,320 feet.
- Unforested Channel Width (UFCW) - Width of channel unobstructed by riparian forest

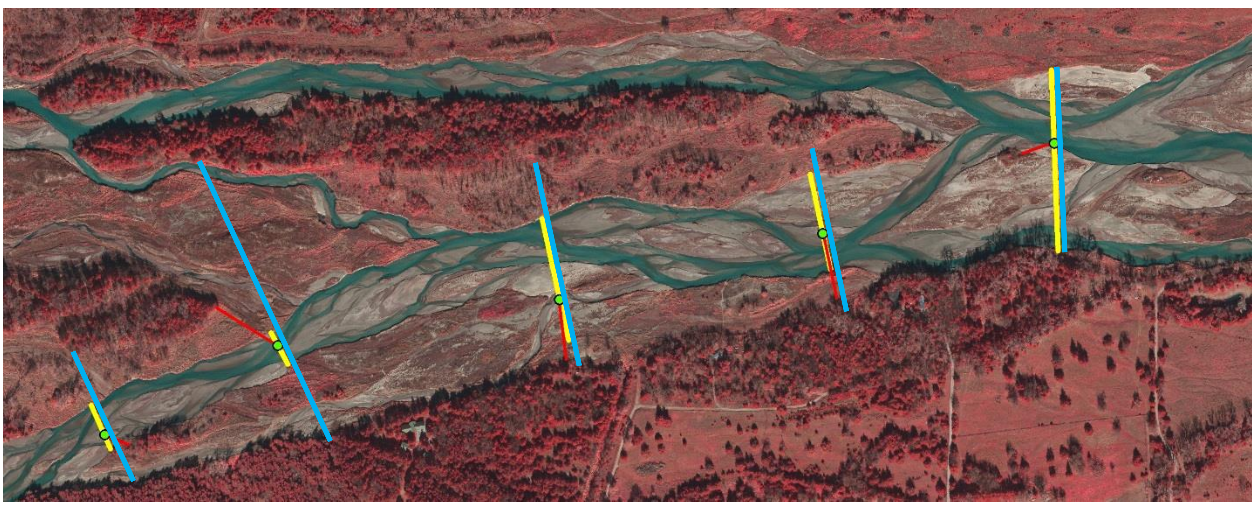

Figure 2. Example of how Unobstructed Channel Width (UOCW; yellow lines), Nearest Forest (NF; red lines) and Unforested Channel Width (UFCW; blue lines) were measured at whooping crane use and available locations.

We ran the Program's system scale HEC-RAS hydraulic model using the mean daily discharge at the nearest stream gage on the date of each whooping crane group observation to calculate following metrics that describe flow-related channel characteristics:

- Total Channel Width (TCW) - Total width of channel from left bank to right bank
- Unit Discharge (UD) - Flow (cfs) per linear foot of wetted channel width.
- Discharge divided by Total Channel Width (DIS) - Flow (cfs) per linear foot of total channel width (TCW).

HEC-RAS model geometry was developed primarily using 2009 LiDAR topography supplemented with 2009 surveyed channel transects and longitudinal profile surveys. Model roughness values were based on 2005 land use dataset. The model was calibrated based on gage rating curves, March 2009 inferred water surface elevation from LiDAR data, and 2009 surveyed water surface elevation. Each descriptor of habitat was tested for possible inclusion as a predictor variable in the habitat selection models.

Whooping Crane In-channel Riverine Habitat Selection

Habitat metrics were calculated for each whooping crane group use location and at the 20 corresponding randomly selected in-channel available points within 10 miles upstream and downstream of the use location. Sixteen a priori candidate models, including a null model, were developed based on the habitat variables described above (Table 1). No metrics were included together in a model if substantial correlation ($r \geq 0.50$) was present (Appendix I).

The habitat selection analysis was conducted within a resource selection function (RSF) estimation framework (Manly et al. 2002). In this model, characteristics of points used by whooping crane groups were contrasted to characteristics of points defined to be available for use by the whooping crane group. The relative difference in the distribution, or density, of these characteristics defines habitat selection. Multiple modelling paradigms were available for this estimation, with recent statistical advances demonstrating spatial point process models are underlying both the use-available approach and the presence-only approach (Johnson et al. 2006, Aarts et al. 2012, McDonald 2013, Warton and Aarts 2013). The use-available approach was chosen for this study because of the presence of existing literature for the handling of an important factor affecting whooping crane selection in AHR – changing availability.

Table 1. In-channel Riverine *a priori* model list evaluated for whooping crane roosting habitat use. The interpretation assumes an *a priori* direction (positive or negative) in the relationship between whooping crane habitat use and metrics, but actual model fit, based on data, could have been in the opposite direction.

Model	*A priori* Models	Interpretation
1	NULL	Habitat selection is random
2	UOCW	Select channels with views unobstructed by dense vegetation or wooded islands.
3	TCW	Select channels with increased distance from right to left bank including vegetated and wooded islands.
4	NF	Select channels with increased ‘openness’ which includes areas without trees located nearby in any direction.
5	UFCW	Select channels with wide unforested widths.
6	UOCW+NF	Select channels with views unobstructed by dense vegetation or wooded islands and with increased ‘openness’ which includes areas without trees located nearby in any direction.
7	TCW+UOCW	Select channels with views unobstructed by dense vegetation or wooded islands and increased distance from right to left bank that can include vegetated and wooded islands.
8	TCW+UD	Select channels with increased distance from right to left bank including vegetated and wooded islands during times when the amount of flow (cfs) per unit of wetted channel width (ft) provides suitable conditions for use.
9	TCW+DIS	Select channels with increased distance from right to left bank including vegetated and wooded islands during times when the amount of flow (cfs) per unit of total channel width (ft) provides suitable conditions for use.
10	TCW+UOCW+UD	Select channels with increased distance from right to left bank that can include vegetated and wooded islands and views unobstructed by dense vegetation or wooded islands during times when the amount of flow (cfs) per unit of channel wetted width (ft) provides suitable conditions for use.
11	TCW+UOCW+DIS	Select channels with increased distance from right to left bank that can include vegetated and wooded islands and views unobstructed by dense vegetation or wooded islands during times when the amount of flow (cfs) per unit of total channel width (ft) provides suitable conditions for use.

Model	*A priori* Models	Interpretation
12	TCW+NF+UOCW	Select channels with increased distance from right to left bank including vegetated and wooded islands, with increased 'openness' which includes areas without trees located nearby in any direction, and with views unobstructed by dense vegetation or wooded islands.
13	TCW+NF+UD	Select channels with increased distance from right to left bank including vegetated and wooded islands, with increased 'openness' which includes areas without trees located nearby in any direction during times when the amount of flow (cfs) per unit of channel wetted width (ft) provides suitable conditions for use.
14	TCW+NF+DIS	Select channels with increased distance from right to left bank including vegetated and wooded islands, with increased 'openness' which includes areas without trees located nearby in any direction during times when the amount of flow (cfs) per unit of total channel width (ft) provides suitable conditions for use.
15	TCW+UOCW+NF+UD	Select channels with increased distance from right to left bank including vegetated and wooded islands, with views unobstructed by dense vegetation or wooded islands, with increased 'openness' which includes areas without trees located nearby in any direction during times when the amount of flow (cfs) per unit of channel wetted width (ft) provides suitable conditions for use.
16	TCW+UOCW+NF+DIS	Select channels with increased distance from right to left bank including vegetated and wooded islands, with views unobstructed by dense vegetation or wooded islands, with increased 'openness' which includes areas without trees located nearby in any direction during times when the amount of flow (cfs) per unit of total channel width (ft) provides suitable conditions for use.

Wildlife habitat selection studies with changing availability has received much attention over the last few decades (Johnson 1980, Arthur et al. 1996, McCracken et al. 1998, Manly et al. 2002, McDonald et al. 2006). Whooping crane use of the Platte River represents a unique situation in that availability of resources change on both spatial and temporal scales. The spatial aspect of changing habitat conditions is chiefly due to the variability in channel morphology throughout the 90-mile AHR and the temporal component is associated with changes in channel form through time. We chose the discrete choice method of RSF estimation to incorporate changing availability at temporal and spatial scales. The discrete choice model accounts for changing habitat conditions in the study area, while modeling the underlying relationships between selection and predictor variables (McDonald et al. 2006). Non-linear changes in the RSF due to changing availability were handled with penalized regression splines to approximate the functional response (Aarts et al. 2013). With the exception of mixed linear models (Hebblewhite and Merrill 2008, Duchesne et al. 2010, Matthiopoulos et al. 2011), other methods of estimating RSF's using the inhomogeneous point process have not incorporated this facet of habitat selection into the statistical underpinnings of the method. It is possible that recent advances in space-time point process models proposed by (Johnson et al. 2013) may be appropriate for this type of data, but the incorporation of changing availability has not been addressed at this time.

Defining the Available Choice Set

The choice set represents a sample of points from an area the crane group could have selected for use. This distribution set is analogous to the background sample in Maxent (Phillips et al. 2006, Phillips and Dudik 2008) and the integration points in point process models (Hefley et al. 2015). In the discrete choice framework, the choice set is unique for each choice, or used location, and is linked to the choice through the likelihood terms in the model. In effect, the model allows the comparison between characteristics of each used location and the characteristics of the choice set. This pairing in the model is accomplished through the use of strata in the gam function (R Core Team, 2016).

As an aerially migrating whooping crane group approaches the river it cannot visually see the entire 90-mile AHR. Consequently, the choice set for each stopover location were necessarily limited to a subsection of the AHR. For the purposes of this analysis, we limited the choice set to a 20-mile reach of river centered on the use location and extending 10 miles upstream and downstream from that point. This decision was based on an aerial evaluation of viewsheds from 3,000 ft above ground level, which was a reported elevation for long distance flights by telemetry-marked whooping cranes in the 1980s (Kuyt 1992) as well as a commonly observed migration elevation during an ongoing telemetry study (PRRIP unpublished data). At 3,000 ft above ground, only large features like bridge crossings were readily discernable at distances >10 miles from the flight location without supplemental magnification.

Functional Response to Resource Selection

We used penalized regression spline methodology to evaluate a functional response in habitat use. Resource selection models evaluate functional responses (i.e., change in selection as a function of spatial or temporal changes in resource availability) and spline smoothers allow for non-linear effects. Smooth spline functions enabled a wide array of functional forms to be incorporated into the RSF, with the implementation of model selection determining the precise shape of the functional response. The smooth term in the habitat model likelihood is represented with a set of basic functions and associated penalties (Hastie and Tibshirani 1990, Wood 2006). The penalty is larger when the smoothing function is very "wiggly" and requires more degrees of freedom. The degrees of freedom for each smooth term is optimized for each iteration when the likelihood is maximized.

Statistical Modeling of Habitat Use/Resource Selection

Resource selection functions were developed to evaluate characteristics of whooping crane group habitat selection in the central Platte River. The basic premise of resource selection modeling is that resources (any quantifiable habitat characteristic) that are important to cranes will be "used" disproportionately to the availability of those resources in the environment (Manly et al. 2002). In our analyses, the characteristics at the used locations were contrasted to characteristics at randomly selected "available" locations in the study area.

To model habitat selection, a discrete choice model of resource selection was fit to the dataset. This model facilitates modeling habitat selection when the habitat that was available for use changes both temporally and spatially. The model evaluates a weighted relative selection ratio with a multinomial logit form expressed as:

$$w\left(X_{ij}\right) = \exp(s_1(X_{1ij}) + s_2(X_{2ij}) + \cdots + s_p(X_{pij}))$$

where X_1 to X_p are habitat metrics, j indexes the units in the choice set, and i indexes the unit selected, s_1 to s_p are the smooth functions of X_1 to X_p, respectively. Relative selection ratios were weighted against the maximum value of the upper confidence interval so that the highest value was one. The smooth terms are penalized regression splines, or smooth functions of the predictor variables describing the relationship between selection and the habitat metrics. The incorporation of penalized regression splines (i.e. smooth terms) into the linear predictor of the model is analogous to the parameterization of a generalized additive model (Wood 2006).

The use-availability likelihood was maximized using R statistical software (R Core Team 2016) through RStudio (RStudio Team 2016), specifically with the gam function of the mgcv package under a Restricted Maximum Likelihood Estimated Cox Proportional Hazards model. The mgcv package determines the smoothness of the spline, and associated degrees of freedom, through iteratively re-weighted least squares fitting of the penalized likelihood (Wood 2006). The penalty for the smoothing parameters is determined at each iteration using generalized cross validation. Final model determination among the set of candidate models was obtained using Akaike's Information Criterion (AIC).

Interpretation of the relationship between metrics in the model and habitat selection was through response functions and the degrees of freedom for the smooth terms. The estimated degrees of freedom indicate the amount of smoothness, with a value of 1 equivalent to a straight line. In cases where the estimated degrees of freedom were 1, we removed the smoothing component for that covariate and fit a parametric straight line. Due to a small sample size of systematic unique whooping crane group observations (n=55), we limited the potential degrees of freedom for regression splines to less than 4 for all variables.

Response Functions

After identifying the best fit models, we estimated the predicted relative selection ratio across the range of observed values of the metrics in the models. This analysis provided a graphical display of the modeled relationship between the predictor variables and the response, holding the effects of the other variables in the model constant at the mean.

Graphical displays of response functions were combined with rug plots to show the underlying data in model fitting. Rug plots display a tick mark for each data point in the model, with used points displayed at the top (use equals 1) and the choice set displayed at the bottom of the figure (available equals 0). Response functions were scaled to the largest predicted value (maximum equals 1) and predictor variables were displayed with 90% confidence intervals from the 10th to the 90th percentiles to limit the influence of extreme values on the interpretation of results.

Data Summary

We included the mean and standard deviation of each metric included in the *a priori* model set to provide basic summary statistics for each descriptor of whooping crane habitat. For each predictor variable in the top-ranked in-channel riverine habitat selection model, we developed mirrored histograms to graphically display the distribution of the values for each variable in order to contrast the distributions of the used set and available set of data. For each distributional density histogram, the area of the bars sums to one. Although these figures display the relationship between the predictor variables and the outcome (use by whooping crane groups), they simplify the assessment by combining data across the many choice sets. Despite this caveat, they are presented to provide a graphical precursor to understanding the statistical models of habitat use.

Results

Whooping Crane Habitat Selection based on Systematic Unique Observations

In-channel riverine habitat selection models were developed for the 55 spring and fall systematic and unique whooping crane group observations and the associated 1,100 available points. Mirrored histograms were provided to graphically display the data for each predictor variable in the top- ranked habitat selection model (Figures 3 and 4). These figures show the distribution of the values for each variable in order to contrast the distribution of use and available data. We also provided basic summary statistics for all metrics included in our *a priori* set of models in Table 2.

Statistical modeling of habitat use indicated UOCW and NF were the most important predictors of whooping selection of in-channel riverine habitat (Table 3). The relative selection ratio was maximized at an UOCW of 460 ft, but relative selection ratios were statistically similar for UOCW's ranging from 278 to 889 ft (Figure 5). The relative selection ratio was maximized at a distance of 512 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 257 to 684 ft from the nearest forest (Figure 6). The estimated degrees of freedom for the smoothed terms were 3.213 for UOCW and 3.178 for NF.

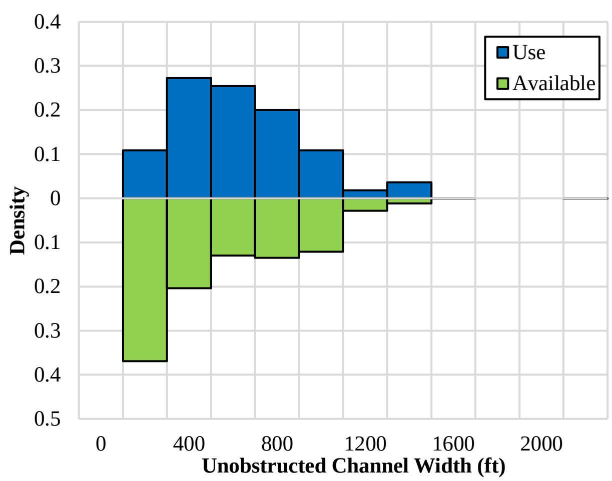

Figure 3. Mirrored histogram to graphically display the distribution of values for unobstructed channel width in order to contrast measurements collected at whooping crane roost locations (blue bars) and choice set or 'available' (green bars) locations. The area of the bars for stopover and available locations each sum to one.

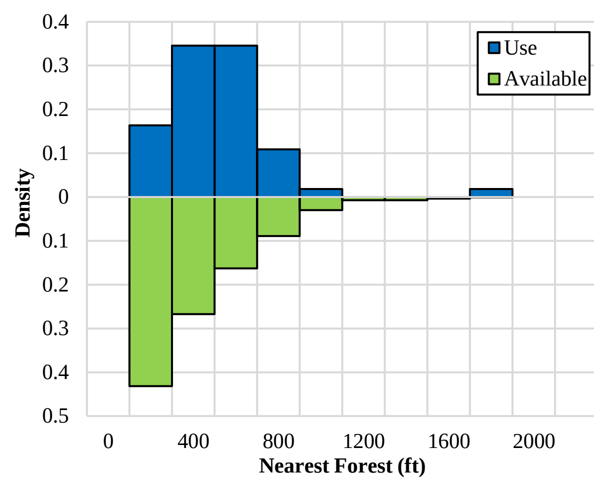

Figure 4. Mirrored histogram to graphically display the distribution of values for distance to nearest forest along a line running perpendicular to the channel in order to contrast measurements collected at whooping crane roost locations (blue bars) and choice set or 'available' (green bars) locations. The area of the bars for stopover and available locations each sum to one.

Table 2. Mean and standard deviation (in parenthesis) of metrics included in the *a priori* models for whooping crane group in-channel riverine roost location habitat selection analyses. The mean and standard deviation are provided for spring, fall, and a combination of spring and fall whooping use locations.

Covariate	Abbreviation	Units	Spring Mean (SD)	Fall Mean (SD)	Combined Mean (SD)
Unobstructed Channel Width	UOCW	Feet	485 (270)	579 (286)	523 (278)
Unforested Channel Width	UFCW	Feet	857 (370)	1,133 (374)	967 (393)
Total Channel Width	TCW	Feet	690 (350)	919 (407)	782 (387)
Nearest Forest	NF	Feet	386 (308)	470 (175)	419 (265)
Unit Discharge	UD	cfs/foot	2.64 (1.46)	1.75 (1.58)	2.28 (1.56)
Discharge/TCW	DIS	cfs/foot	1.77 (1.39)	1.22 (1.39)	1.55 (1.41)

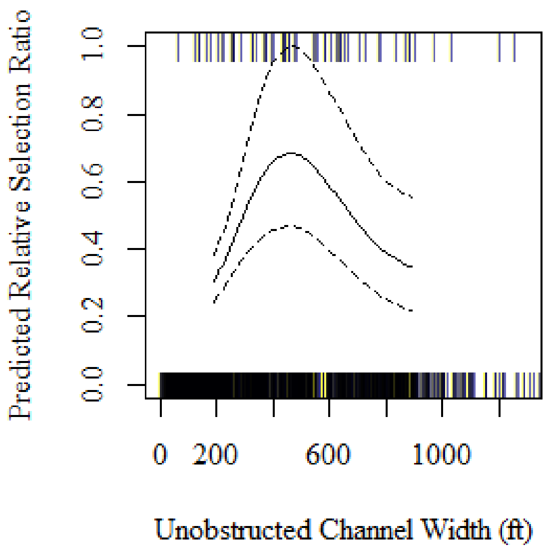

Figure 5. Predicted relative selection ratio for the top ranked RSF model, with 90% confidence intervals, of unobstructed channel widths (UOCW). Tick marks indicate actual data (use points are presented at y=1 and available points are presented at y=0). Data is displayed from the 10th to the 90th percentile of use locations.

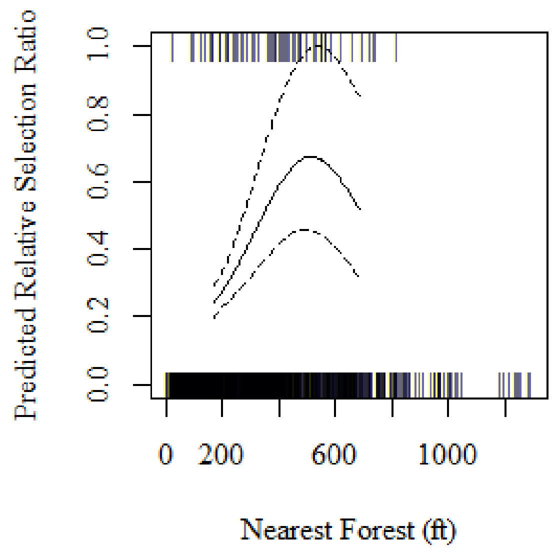

Figure 6. Predicted relative selection ratio for the top ranked RSF model, with 90% confidence intervals, of distances to nearest forest. Tick marks indicate actual data (use points are presented at y=1 and available points are presented at y=0). Data is displayed from the 10th to the 90th percentile of use locations.

Table 3. In-channel riverine habitat use model selection for whooping crane group stopover sites on the central Platte River.

Model	Metrics	df	AIC	ΔAIC	weight
6	UOCW+NF	61.35	859.25	0.00	0.49
12	TCW +UOCW+NF	62.33	861.12	1.87	0.19
15	TCW+UOCW+NF+UD	63.33	861.44	2.18	0.16
16	TCW+UOCW+NF+DIS	63.32	863.14	3.89	0.07
4	NF	57.73	864.85	5.60	0.03
2	UOCW	57.85	866.31	7.05	0.01
5	UFCW	57.78	866.98	7.73	0.01
13	TCW+NF+UD	59.72	867.03	7.77	0.01
7	TCW+UOCW	58.83	867.62	8.37	0.01
10	TCW+UOCW+UD	59.83	867.73	8.47	0.01
14	TCW+NF+DIS	59.71	868.56	9.31	0.00
11	TCW+UOCW+DIS	59.83	869.55	10.30	0.00
8	TCW+UD	56.00	881.35	22.10	0.00
3	TCW	55.00	881.93	22.68	0.00
9	TCW+DIS	56.00	882.63	23.38	0.00
1	NULL	54.00	883.70	24.45	0.00

Whooping Crane Group Habitat Selection based on all Systematic Observations

The top-ranked habitat selection model that included UOCW and NF, was used to analyze the 176 systematically collected whooping crane group observations identified during aerial surveys (2001 – 2013) as well as the associated 3,520 available points. The 176-systematic whooping crane group observations included the 55 unique locations in the Program's systematic monitoring data as well as 121 subsequent observations of the 55 whooping crane groups observed during aerial surveys. UOCW at use locations averaged 547 ft (SD = 290 ft; median = 547 ft) while UOCW at available locations averaged 310 ft (median = 246 ft). NF at use locations averaged 467 ft (SD = 262 ft; median = 445 ft) while NF at available locations averaged 391 ft (median = 294 ft). Model results indicate UOCW and NF relationships were similar to results of models derived from the systematic unique dataset. An increasing trend was observed from low to intermediate values of UOCW and NF, but relative selection ratios did not differ greatly from intermediate to high values because of the uncertainty in point estimates. The relative selection ratio was maximized at an UOCW of 618 ft, but relative selection ratios were statistically similar for UOCW's ranging from 239 to 901 ft. Similarly, the relative selection ratio was maximized at 595 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 368 to 779 ft.

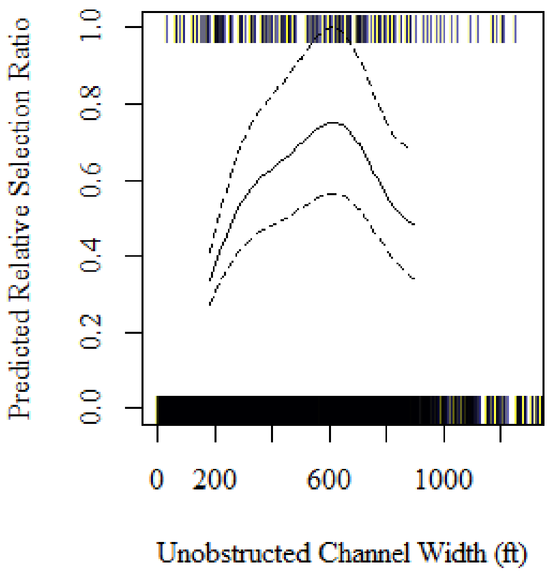

Figure 7. Predicted relative selection ratio for the top ranked RSF model evaluated with all systematic observations (n = 176), of unobstructed channel width (UOCW). Tick marks indicate actual data (use points are presented at y=1 and available points are presented at y=0). Data is displayed from the 10th to the 90th percentile of use locations with 90% confidence intervals.

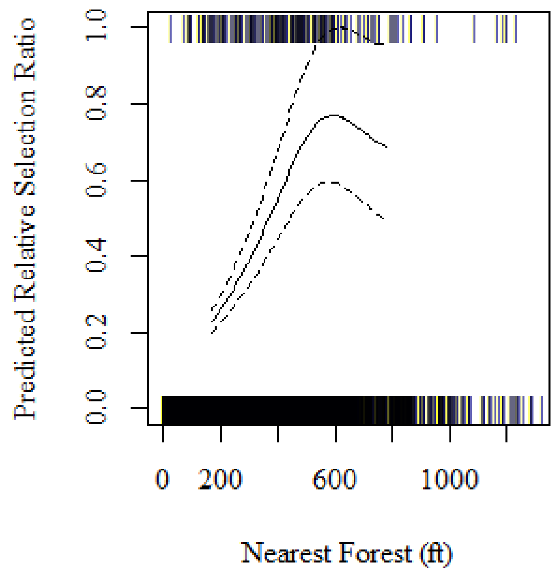

Figure 8. Predicted relative selection ratio for the top ranked RSF model evaluated with all systematic observations (n = 176), of nearest forest (NF). Tick marks indicate actual data (use points are presented at y=1 and available points are presented at y=0). Data is displayed from the 10th to the 90th percentile of use locations with 90% confidence intervals.

Discussion

The use of systematic aerial surveys to detect stopovers of whooping cranes over the course of 13 years provided 55 systematic unique locations and a total of 176 systematically collected stopover locations and allowed an evaluation of whooping crane use of riverine habitat throughout the AHR. Evaluations of riverine roost site habitat characteristics along the central Platte River have largely been focused on geomorphic and, more recently, hydrologic metrics including unobstructed channel width, distance to obstruction (e.g., nearest forest), wetted width, area of suitable depth, and flow (Biology Workgroup 1990; Farmer et al. 2005). Of these, wetted width and area of suitable depth are highly dependent on instantaneous flow and change continuously while, without intervention, other metrics generally change over longer periods of time (i.e., years). Given the relative stability of geomorphic features, we were able to obtain good estimates of UOCW, TCW, and NF remotely. However, the variability in hydrologic metrics such as area of suitable depth and wetted width required us to use hydraulic modeling to calculate the more stable and estimable metrics including unit discharge (UD) and discharge divided by total channel width (DIS).

Unit discharge (UD) is calculated as total discharge divided by the wetted width of the active channel. Selection for increasing UD would generally equate to an increase in wetted width and depth. We similarly evaluated discharge divided by total channel width (DIS), which related flow to total channel width. This covariate was included as total channel width can more readily be managed than the wetted width of the channel at a specific discharge. Given the Pearson correlation between these metrics ($r > 0.90$), including UD or DIS in our analysis was equivalent to testing both of these metrics at once.

Previous studies on the central Platte River assumed whooping cranes select roost locations based on flow-related habitat metrics similar to wetted width and proportion of the channel that is suitably shallow for roosting (Biology Workgroup 1990; Farmer et al. 2005). Our analysis did not identify a strong relationship between flow-related metrics and whooping crane use location. A model containing unit discharge was within 3 AIC units of the top model, but more parsimonious models had better explanatory ability and assumed the effect of unit discharge was negligible. Instead, we found the strongest relationship between metrics of channel openness (UOCW and NF) and roost location with crane groups generally selecting sites that were more "open" than narrowest channels that are present in the AHR. However, it should be noted that our analysis only addresses the influence of flow (on a given day) in roost location choice. It does not address the relationship between flow and a cranes' decision to use or not use riverine habitat. Such an analysis would need to include absence data which would require us to know flow conditions when whooping crane groups chose not to use the AHR. That data is not available.

The lack of a strong relationship between flow metrics and whooping crane selection of a specific roost location can be interpreted two ways: 1) flow is not important in whooping crane selection of roost locations, or 2) sufficient areas of suitable depth and wetted area were equally available and adequate at use and available locations on use days. Given water is almost always associated with whooping crane roost locations (Austin and Richert 2005), it is likely that sufficient areas of suitable depth and wetted area were available at use and available locations, reducing the importance of flow-habitat metrics in roost site selection. A crane group comprised of four to six adults will roost in an area that is generally less than 50 ft by 50 ft. Under most flow and channel configuration combination, there is much more suitably shallow water (<0.8 ft) roosting habitat than is required to accommodate the crane group sizes observed in the AHR.

Though increased UOCW and NF were important predictors of whooping crane group roost site selection, we were unable to establish a strong relationship between UFCW or TCW and whooping crane use. Though TCW and UFCW were included in models within 8 AIC units of the top model, our top model was more parsimonious and explained habitat selection as well as or better which indicates the effect of TCW and UFCW were negligible. Failure to find a strong relationship between TCW or UFCW and whooping crane use is likely related to the fact wider, unmanaged channels on the central Platte River are generally split by one or more densely vegetated or wooded islands which reduces their suitability as whooping crane roosting habitat.

Horizontal visibility has long been viewed as an important aspect for defining optimum and secure habitat for whooping crane roosts (Shenk and Armbruster 1986; Armbruster 1990; Farmer et al. 2005). Our results support that characterization as unobstructed channel width (UOCW) and distance to nearest forest (NF) were found to be important predictors of whooping crane group roost site selection. With regards to distance to nearest forest, we found whooping cranes were disproportionately using sites with distance to nearest forest between 500–550 ft. From a management perspective, our results indicate UOCWs ≥450 ft and unforested corridor widths ≥1,000 ft represent highly suitable habitat for roosting sites for whooping cranes along the central Platte River.

Characteristics of whooping crane roost habitat have been examined and described for the central Platte River in Nebraska (Johnson 1981; Lingle et al. 1984; Armbruster 1990; Faanes 1988; Faanes and Bowman 1992; Faanes et al. 1992). Several characteristics common to whooping crane riverine roost sites include shallow, wide, unvegetated channels and open visibility with the absence of tall trees or dense shrubs near the roost (Johnson and Temple 1980; U.S. Fish and Wildlife Service 1981; Johnson 1981; Armbruster 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004). To date, however, roost characteristics and criteria have been developed based on a limited amount of quantitative information and most criteria have been derived from circumstantial roost locations that may not be representative of a typical stopover site (Armbruster 1990).

Shenk and Armbruster (1986) reported unobstructed channel widths 246 ft were unsuitable roosting habitat for whooping crane and roost habitat was optimized at unobstructed channel widths of 1,312 ft; however, these estimates were based on the opinion of participants of a workshop rather than an analysis of data. Similarly, the USFWS (1986) reports whooping roosting habitat is optimized at unobstructed channel widths ≥1,158 ft and channels with unobstructed widths <500 ft were deemed unsuitable roosting habitat; however, again these measures were not based on an analysis of data. Farmer et al. (2005) reported whooping cranes selected channels with wider unobstructed channel widths at both scales they evaluated. Our results corroborated their finding in that unobstructed channel width influenced stopover site selection by whooping cranes; however, we found the relationship was nonlinear and that habitat suitability was maximized when UOCW was ≥460 ft.

Johnson (1981) described optimal riverine roost habitat as being any channel with an unobstructed width ≥509 ft, which is similar to our findings. Austin and Richert (2001) found river widths at stopover roost locations distributed throughout the migration corridor ranged from 249 ft to 1,499 ft and averaged 764 ft. Though river widths reported by Austin and Richert (2001) are wider than unobstructed channel widths we observed within the AHR, discrepancies in these measures could simply be an artifact of biases in the observational data or how each metric was measured (i.e., river width may not be comparable to unobstructed channel width).

We used data collected systematically along the central Platte River during 2001-2013 to evaluate riverine habitat selection within the AHR. The goal of our analysis was to develop habitat models to be used to inform and direct management activities the Program is able to implement. We were unable to establish a relationship between whooping crane use and flow metrics or total channel width, but rather found unobstructed channel width and distance to the nearest forest were good predictors of whooping crane use. Our findings indicate the Program would have the potential to influence whooping crane use of the central Platte River through increasing unobstructed channel widths that are <450ft and mechanically removing trees within areas where the unforested corridor width is <1,000ft.

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Appendix I. Pearson correlation coefficients for whooping crane group in-channel riverine habitat selection in the central Platte River.

Habitat Metric	1	2	3	4	5	6
1- Unobstructed Channel Width	1.00	0.47	0.35	0.48	-0.11	-0.06
2- Unforested Channel Width		1.00	0.62	0.47	-0.16	-0.18
3- Total Channel Width			1.00	0.36	-0.24	-0.32
4- Nearest Forest				1.00	-0.12	-0.10
5- Unit Discharge					1.00	0.92
6- Discharge Divided by Total Channel Width						1.00

CHAPTER 3 – Whooping Crane Use of Riverine Stopover Sites within the North-central Great Plains, USA

Abstract

Although whooping cranes are known to use riverine roost sites throughout the migration corridor, few studies have attempted to evaluate habitat selection at riverine roost sites across multiple river systems. An important aspect of whooping crane roosts along their migration route is the amount of unobstructed visibility provided by stopover sites. Whooping cranes have been reported to select stopover locations based on the security offered by the site. One such form of security offered by riverine sites is the presence of water surrounding the roost. Another factor that is generally believed to enhance site security is wide open views not obstructed by dense, tall vegetation or wooded areas. The goal of our analysis was to develop habitat models that could be used to direct management activities along the central Platte River. As such, we focused our analysis on two metrics, unobstructed channel width (UOCW) and distance to nearest forest (NF), that the Platte River Recovery Implementation Program has the ability to influence. We used telemetry data obtained from a sample of 38 birds of all ages over the course of five years to provide an unbiased evaluation of whooping crane use of riverine habitat throughout the migration corridor. We evaluated the influence of UOCW and NF on whooping crane selection of riverine habitat throughout the North-central Great Plains in the United States. Our results indicate UOCW has the most influence on riverine habitat selection and the highest relative selection ratios occurred when UOCW was ≥668 ft; however, we found there is a fairly wide range of uncertainty in this estimate.

Introduction

Each year, the Aransas–Wood Buffalo (AWB) population of whooping cranes undertake a 5,000-mile round-trip migration from the breeding area in and near Wood Buffalo National Park in Northern Canada to the wintering area in and around Aransas National Wildlife Area on the gulf coast of Texas. The migration route is well defined and the vast majority of observations occur within a 200-mile wide corridor through Alberta, Saskatchewan, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. During migration, whooping cranes utilize stopover sites to rest and build energy reserves to complete migration. Although a variety of habitats are used during migration, water is nearly always associated with a stopover site (Pearse et al. 2016). At stopover sites, whooping cranes typically roost standing in shallow water associated with palustrine or lacustrine wetlands and river channels.

Some stopover sites in the migration corridor are used consistently and receive relatively high annual use. One of these sites, the Big Bend reach of the central Platte River in Nebraska, is the only stretch of river designated as critical whooping crane habitat under the Endangered Species Act (Armbruster 1990; Biology Workgroup 1990). Characteristics of central Platte River roost habitat have been examined and described in detail (Johnson 1981; Lingle et al. 1984; Ziewitz 1987; Faanes 1988; Faanes and Bowman 1992; Faanes et al. 1992). Early examinations of roost sites in the central Platte River identified wide, unvegetated channels and open visibility with the absence of tall trees or dense shrubs near the roost as important habitat characteristics (Johnson and Temple 1980; U.S. Fish and Wildlife Service 1981; Johnson 1981; Ziewitz 1987; Armbruster 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004). Recent Program analyses of central Platte River whooping crane use locations during the period of 2001-

2013 found the width of channel unobstructed by dense vegetation and the distance to nearest forest to be the best predictors of whooping crane use (Chapter 2). Ziewitz (1987) described whooping crane roosting habitat suitability using several parameters including unobstructed channel width. In this assessment, unobstructed channels ≤500 ft wide were assigned a minimum suitability value while unobstructed channel widths ≥1,150 ft were assigned a maximum suitability value. Table 1 of the Program's land plan infers whooping crane habitat suitability and use are maximized at 1,150 ft (PRRIP 2006). Contrary to Ziewitz (1987) and Table 1 of the Program's Land Plan (PRRIP 2006), Austin and Richert (2005) reported unobstructed channel widths at riverine roost sites averaged 764 ft and Johnson (1981) described optimal riverine roost habitat as being any channel with an unobstructed width ≥509 ft. Pitts (1985) even went so far as to report whooping crane selection of stopover habitat occurs at random.

Although whooping cranes are known to use riverine roost sites throughout the migration corridor, few studies have attempted to evaluate selection of riverine roost sites across multiple river systems (Stahlecker 1997; Austin and Richert 2005). The objective of this investigation is to assess if and how unobstructed channel width and distance to nearest forest influence whooping crane selection of riverine habitat throughout the North-central Great Plains in the United States. Results of this investigation provide a line of evidence regarding the importance of these habitat metrics in whooping crane roost site selection as well as an opportunity to compare habitat use along the central Platte River to riverine use throughout the migration corridor.

Methods

Our study area included the migration corridor for the Aransas-Wood Buffalo population within North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma (Figure 2; Pearse et al. 2015). Locational data (henceforth, telemetry data) generated from 68 GPS-marked whooping cranes (2010-2014) was filtered to only include stopover (use) locations that occurred in riverine habitat (wetted channels) within the study area. The data was further filtered to only include a single location recorded during the first night of the stopover per whooping crane per stopover site (i.e., multi-day stopovers were only included in the analysis once). When >1 radio-marked whooping crane was present at a stopover at the same time, we included a use location for each bird present at the stopover site. We defined stopover sites as sites used as a roost for ≥1 night.

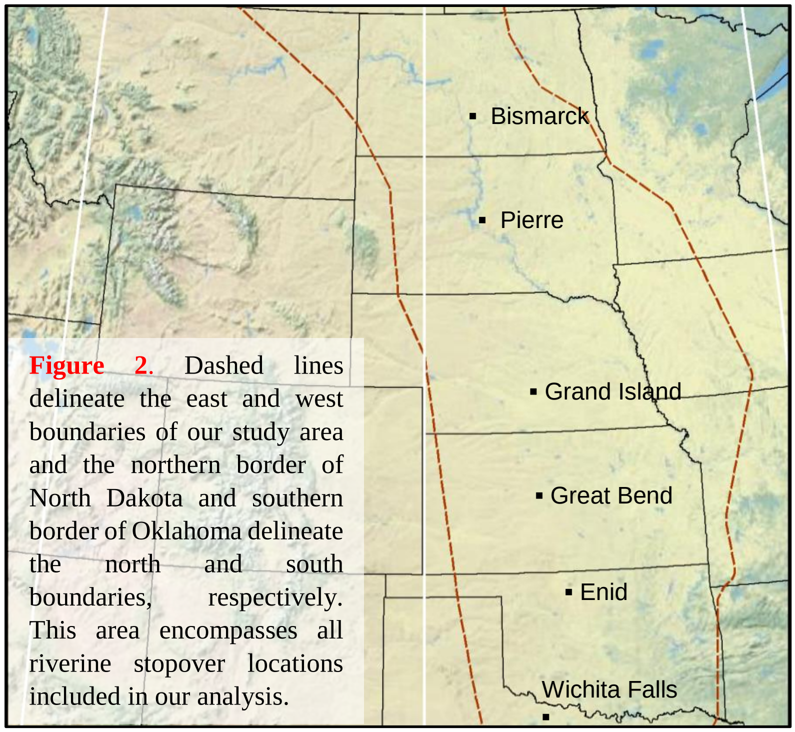

Figure 2. Dashed lines delineate the east and west boundaries of our study area and the northern border of North Dakota and southern border of Oklahoma delineate the north and south boundaries, respectively. This area encompasses all riverine stopover locations included in our analysis.

Defining the Choice Set

Habitat metrics were calculated for each whooping crane use location and at the 20 corresponding randomly selected in-channel available points within 10 miles upstream and downstream of the use location. It was assumed the cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft above ground level by Program personnel, which was a reported elevation for long distance flights by telemetry-marked whooping cranes in the 1980s (Kuyt 1992) as well as a commonly observed migration elevation during an ongoing telemetry study (unpublished data). Hawth's Tools (Jenness 2011) was used to generate the 20 available locations per stopover location within each river segment. The points were stratified so each stopover location was paired with 20 available locations in the same river segment as the stopover location.

Parameterization of the A priori Model set

A GIS and USDA-NRCS Geospatial Imagery Data was used to delineate the unobstructed width of the channel along a line running perpendicular to the channel and through each stopover and available location. Unobstructed channel width (UOCW) was defined as the width of channel lacking dense vegetation as observed in USDA-NRCS Geospatial Imagery Data collected closest to the season use occurred. When channels were segmented by a densely-vegetated island, UOCW was delineated based on the channel segment nearest the stopover or available location. Distance to nearest forest (NF) was defined as the distance from the use or available location to the nearest forested area. Distance to nearest forest was truncated at 1,320 ft (1/4 mile) when no forested area was located within a quarter mile of the use or available location.

A list of 3 candidate models was developed, each containing a different combination of habitat metrics. This set of models, with the inclusion of a null model containing no habitat metrics, composed the complete set of *a priori* models evaluated (Table 1). The model selection process determined which *a priori* model was most parsimonious and useful in predicting habitat use with the Akaike Information Criterion statistic (AIC, Burnham and Anderson 2002). The most parsimonious *a priori* model with a ΔAIC <2.0 was considered the best model to infer conclusions about habitat selection (Burnham and Anderson 2002).

Mirrored histograms were prepared for each predictor to graphically display the data (Figures 4 and 5). These figures show the distribution of the values for each habitat metric in order to contrast this distribution for the stopover sites to the available sites. For each probability histogram, the area of the bars sums to one. Although these figures display the relationship between the predictor variables and the outcome (use by whooping cranes), they simplify the assessment by combining data across the many choice sets.

Statistical Modeling of Habitat Use/Selection

Methods and procedures used to model habitat selection throughout the North-central Great Plains were identical to those presented in Chapter 2.

Results

The use of telemetry data obtained from a sample of 38 birds of all ages over the course of five years provided 150 independent stopover locations. Measurements at these 150, riverine stopover (‘use’) locations and 3,000 available locations were obtained and incorporated into the habitat selection analysis. Though variable, mean UOCW and NF were wider at stopover locations than available locations for each metric (Table 3). Median UOCW was 548 ft at stopover and 462 ft at available locations. Median NF was 244 ft at stopover and 200 ft at available locations.

Table 1. *A priori* model set tested in the use-availability habitat selection analysis.

Covariate	Definition of Model Terms
Null	No covariates (habitat selection is random)
UOCW	Unobstructed channel width
NF	Distance to nearest forest maximized at 1,320 ft
UOCW+NF	Unobstructed channel width plus minimum distance to nearest forest maximized at 1,320 ft

Table 2. Models used in our habitat selection analysis ranked by AIC statistic. See Table 1 for a description of the metrics.

Rank	Covariates	AIC	ΔAIC
1	s(UOCW)	2685.3	0.0
2	s(UOCW) + s(NF)	2685.4	0.1
3	s(NF)	2704.8	19.5
4	NULL	2714.5	29.3

Table 3. Mean unobstructed channel widths (UOCW) and distance to nearest forest (NF) for all stopover and available locations. Standard deviations are provided in parentheses. See Table 1 for a description of metrics.

Metric	Mean Width (ft) at Stopover Locations (SD)	Mean Width (ft) at Available Locations (SD)
UOCW	663 (543)	639 (689)
NF	297 (222)	290 (339)

Statistical modeling of habitat selection indicated UOCW was an important predictor of whooping crane riverine habitat selection (Table 2). Predicted relative selection ratios increased with UOCW and was maximized at 668 ft (Figure 6); however, there is uncertainty in the point estimate and relative selection ratios were statistically similar for UOCW's ranging from 402 to 1,211 ft (Figure 6). Predicted relative selection ratios also increased with NF and was maximized at 492 ft when UOCW was maximized at 647 ft; however, NF was not included in the top, and more parsimonious model, and relative selection ratios were statistically similar for a wide range of values for NF (Figure 7).

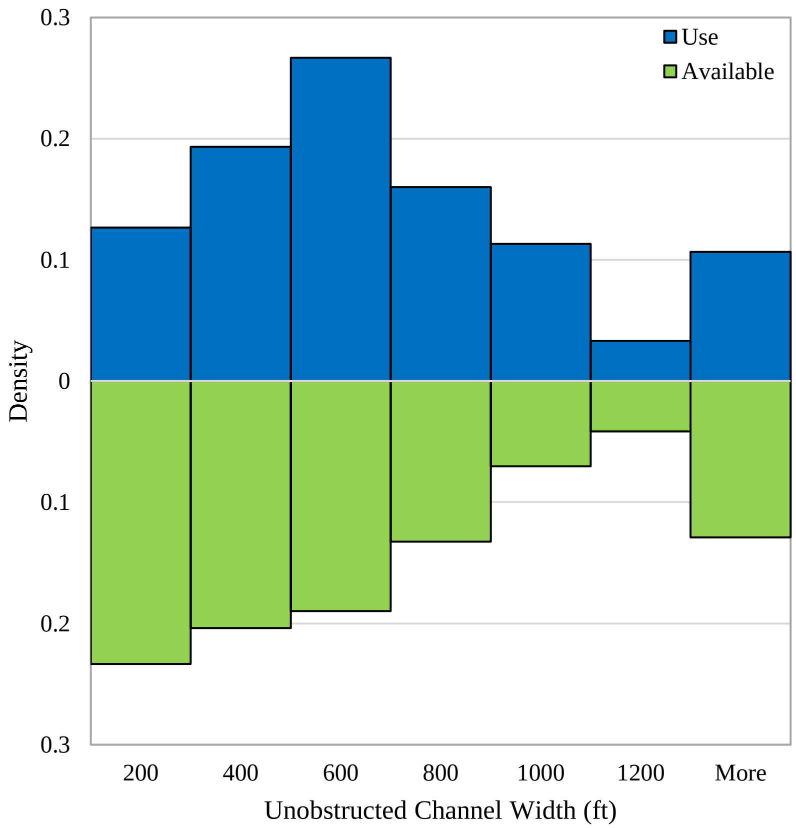

Figure 4. Mirrored histogram to graphically display the distribution of values for unobstructed channel width (UOCW) in order to contrast measurements collected at stopover (blue bars) and available (green bars) locations. The area of the bars for stopover and available locations each sum to one.

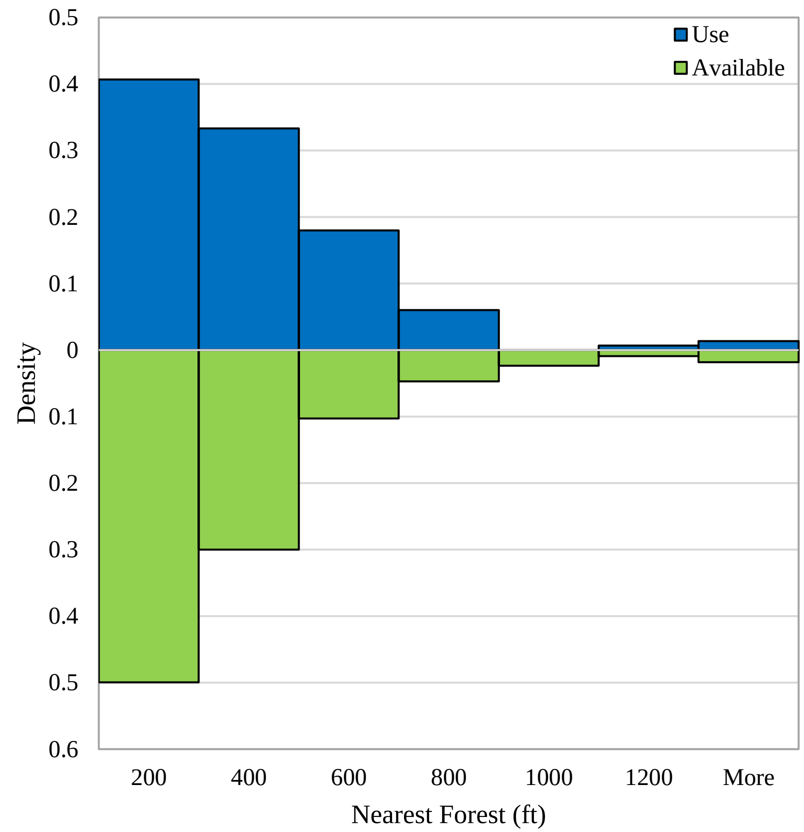

Figure 5. Mirrored histogram to graphically display the distribution of values for distance to nearest forest (NF) in order to contrast measurements collected at stopover (blue bars) and available (green bars) locations. The area of the bars for stopover and available locations each sum to one.

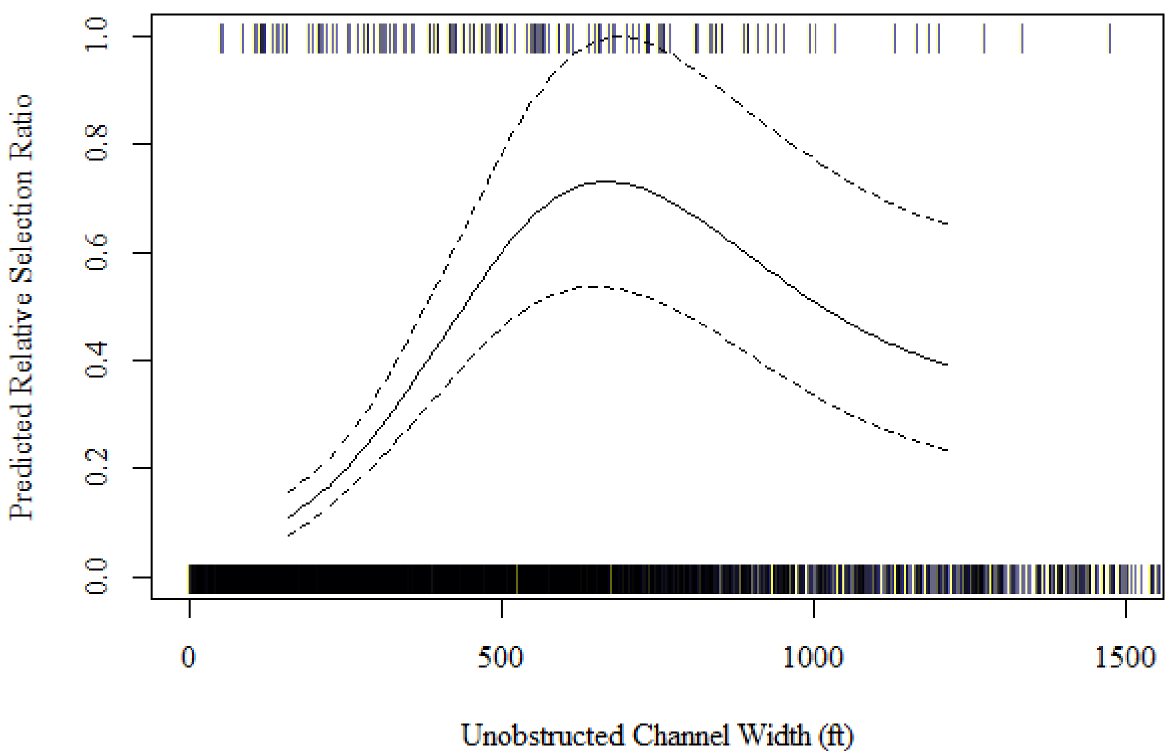

Figure 6. Predicted relative selection ratio, with 90% confidence intervals, across the range of unobstructed channel widths (UOCW). The response function was scaled to the largest predicted value was 1 and is only displayed between the 10th and 90th percentile of the stopover locations in order to limit the influence of values from the ***extreme*** ends of the distribution on the interpretation of the results. The selection ratio is maximized when unobstructed channel width is ≥668ft. Tick marks display actual data (use locations are plotted at y=1 available locations are plotted at y=0).

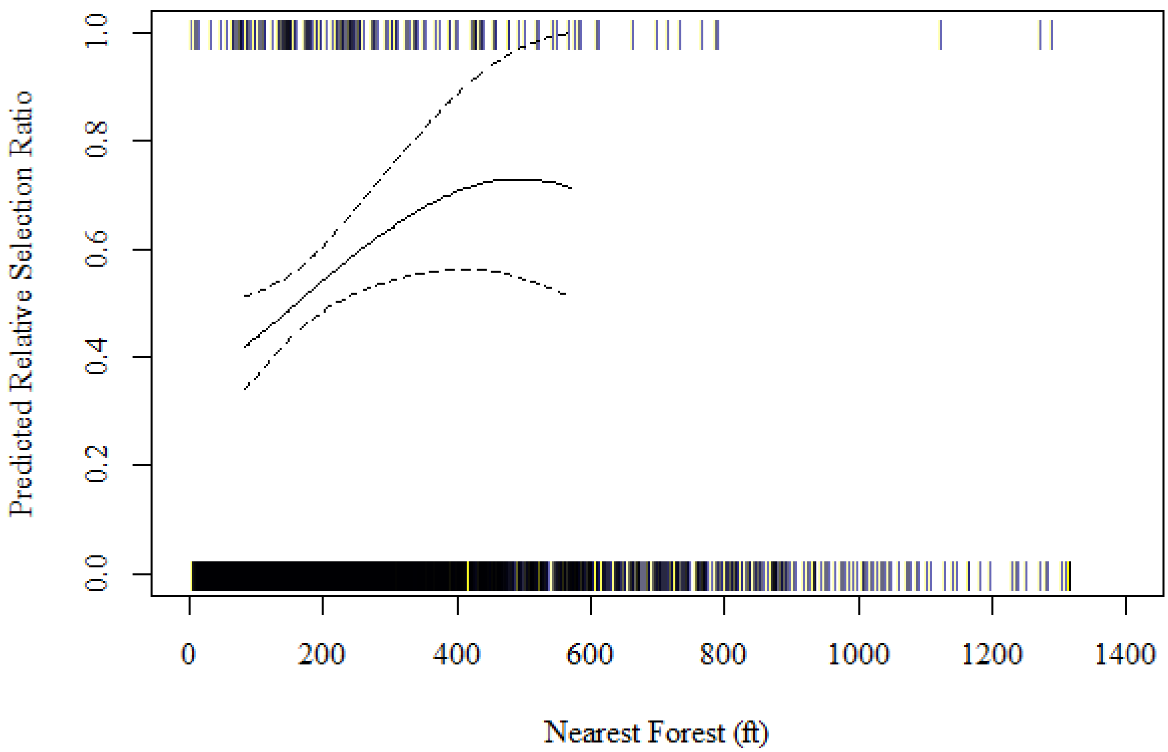

Figure 7. Predicted relative selection ratios with 90% confidence intervals from the second-ranked, and less parsimonious model, across the range of distances to nearest forest. The response function was scaled so the largest predicted value was 1 and is only displayed between the 10th and 90th percentile of the stopover locations in order to limit the influence of values from the ***extreme*** ends of the distribution on the interpretation of the results. The selection ratio is maximized when NF is ≥492ft and unobstructed channel width is ≥647ft. Tick marks indicate actual data (use locations are at y=1, available locations are at y=0).

Discussion

Several studies have characterized habitat use by whooping cranes using the U.S. Fish and Wildlife Service's opportunistic sightings database (Austin and Richert 2005; Faanes et al. 1992; Belaire et al. 2013; Hefley et al. 2015). These characterizations, however, are influenced by sampling bias, detection bias, and location error (Hefley et al. 2015). The use of telemetry data obtained from a sample of 38 birds of all ages over the course of five years provided 150 independent stopover locations and allowed access to a substantial set of unbiased data to evaluate whooping crane use of riverine habitat throughout the migration corridor.

An important aspect of the ecology of whooping cranes using roosts along their migration route is the amount of unobstructed visibility provided by stopover sites. Whooping cranes select stopover locations based on the security offered by the site (Ward and Anderson 1987). One such form of security offered by riverine sites is the presence of water surrounding the roost. Water provides a sense of security and enables whooping cranes to hear potential predators as they approach (Ward and Anderson 1987). While we did not examine presence of water at each use site, we assumed surface water was available during stopovers within riverine habitats. Another factor generally believed to enhance site security is wide open views not obstructed by dense, tall vegetation or wooded areas. Riverine habitat provides this security with the presence of wide unobstructed widths.

Whooping crane riverine roost sites and day-use sites tend to consistently lack tall vegetation in close proximity to the site (Austin and Richert 2005). Johnson and Temple (1980) reported that throughout the whooping crane's range, unobstructed bank to bank visibility at riverine roost sites was at least 656 ft. Lingle et al. (1984) reported that a Platte River roost site near Prosser, Nebraska, had an unobstructed bank to bank distance of 1,145 ft. Estimates derived by a Biology Ad Hoc Workgroup suggested habitat selection was optimized at unobstructed channel widths of 1,312 ft (Shenk and Armbruster 1986). Subsequent analyses of unobstructed channel width at whooping crane roosts through the spring 1987 migration period ranged from 699 ft to 1,207 ft (U.S. Fish & Wildlife Service, unpublished data). Although we did observe stopovers occurring in unobstructed channels of these widths, >50% of stopovers along the migration route were in channels with unobstructed widths that were <548 ft. Lingle et al. (1986) suggested whooping cranes choose the widest available sites. However, our results indicate whooping cranes use channels with moderately wide unobstructed channel widths at least as much as channels with very wide unobstructed channel widths, suggesting moderate unobstructed channel widths have a similar habitat value as very wide unobstructed channel widths.

Whooping crane stopover locations were located in channels with unobstructed widths ranging from 53 to 3,191 ft and averaged 663 ft (median = 548 ft). Johnson and Temple (1980) proposed a minimum suitability criterion for channel width of 180 ft. The narrowest observed unobstructed channel width at stopover locations within the migration corridor was 53 ft, which is much narrower than their recommendation. Similarly, Austin and Richert (2005) found river widths at stopover roost locations ranged from 249 ft to 1,499 ft and averaged 764 ft. Our telemetry data results are similar to the 712-foot mean unobstructed channel width observed at roost sites on the Platte River (Faanes et al. 1992) and corroborate findings of Johnson (1982) in that >60% of stopover locations were in channels with an unobstructed width >451 ft. However, results of our resource selection analysis suggest unobstructed channel widths as low as 400 ft statistically can be as favorable to whooping cranes as well.

Whooping cranes roosting in the Platte River have been noted to select sites with broad channels free of woody vegetation and with adequate horizontal and overhead visibility (U.S. Fish and Wildlife Service 1981). However, it has also been reported that banks and vegetation that form a visual obstruction may actually enhance their security, as long as they are not too close to the cranes (Faanes et al. 1992). Austin and Richert (2005) reported >70% of roost sites were adjacent to woodland habitat. To some degree the results of this study support both of these positions. For use locations, the median distance to nearest forest was 244 ft (range = 7 ft –1,292 ft), but we were not able to establish a strong relationship between whooping crane habitat selection and increased distance to nearest forest.

Relative selection ratios of whooping crane use along the central Platte River for systematic, unique observations of whooping cranes was highest in channels with unobstructed channel widths ≥450 ft and distances to nearest forest from the center of the channel ≥500 ft, but substantial uncertainty surrounds those estimates (Chapter 2). When considering whooping crane use of riverine habitat between the borders of Canada and Texas, relative selection ratios were statistically similar for unobstructed channel widths and distance to nearest forest as they were for the central Platte River; however, distance to nearest forest was not included in the most parsimonious, top-ranked model in this chapter and thus was not considered to have a substantial influence on selection. Both analyses had high amounts of uncertainty associated with modeling habitat use, leading to somewhat indistinguishable habitat use differences from intermediate to high values for each habitat metric. Accounting for uncertainties and use location information, it appears whooping cranes select channels that are moderately wide, but not necessarily the widest stretch of river available. Given results of analyses described in Chapters 2 and 3, it appears maintaining unobstructed channel widths of ≥600 ft and unforested corridor widths of ≥1,000 ft would result in highly favorable whooping crane riverine roosting habitat.

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CHAPTER 4 – Central Platte River Unvegetated Width Relations to Hydrology, Channel Morphology and Management Actions: Implications for a Water-centric Management Strategy

Abstract

The Flow-Sediment-Mechanical (FSM) approach is one of two management strategies presented in the Platte River Recovery Implementation Program’s (Program) Adaptive Management Plan (AMP) to create and maintain suitable riverine habitat for whooping cranes. The Program’s FSM management strategy consists of sediment augmentation, mechanical vegetation clearing and channel widening, and short duration high flow (SDHF) releases of 5,000 – 8,000 cfs for three days in two out of three years to increase the unvegetated width of the main channel and, by extension, maintain suitable habitat for whooping crane use. We examined the influence of a range of hydrologic and physical metrics on total unvegetated channel width (TUCW) and maximum unobstructed channel width (MUOCW) during the period of 2007–2015 and applied those findings to assess the performance of the FSM management strategy. A strong positive relationship was identified between peak flows and TUCW and MUOCW in the AHR. However, peak discharge magnitude and durations that create highly favorable whooping crane roosting habitat are much greater than SDHF releases, as currently envisioned. Our analysis also indicates channel disking in combination with herbicide application would be effective in creating and maintaining highly favorable MUOCWs for whooping cranes in all but the very driest years.

Introduction

The Platte River Recovery Implementation Program’s (Program or PRRIP) whooping crane management objective is to contribute to improved whooping crane survival during migration. The primary management sub-objective is to increase the availability of whooping crane migration habitat along the Associated Habitat Reach (AHR) of the central Platte River that extends approximately 90 miles from Lexington, NE downstream to Chapman, NE. Performance indicators include area of suitable roosting habitat, area of suitable foraging habitat, proportion of the population using the AHR during each migration season, and the number of days cranes use the AHR (crane use days) during each migration season (PRRIP 2006).

Whooping Crane Habitat Suitability and Use

The Program's whooping crane management objectives and indicators focus on habitat and use metrics (as opposed to population) due to the small proportion of the whooping crane population that uses the AHR in any given year and the limited amount of time individual birds spend in the area (~two to three days on average). Generally, 5–10% (range 0.9–7.4%) are detected during the Program's monitoring seasons annually; however, up to ~20% of the population has been detected systematically or opportunistically within a 1-year timespan (FWS 2017). Investigations of whooping habitat use along the central Platte River have been ongoing since the late 1970s and have focused on a range of hydrologic and geomorphic metrics including unobstructed channel widths, distance to obstruction (i.e., nearest forest), view widths, flow, wetted width, suitable depth, etc. (Johnson and Temple 1980; U.S. Fish and Wildlife Service 1981; Johnson 1981; Armbruster 1990; Biology Workgroup 1990; Faanes et al. 1992; Austin and Richert 2001; National Research Council 2004; Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005, Farmer et al. 2005).

In 2015, Program monitoring and satellite telemetry data were used to perform whooping crane habitat selection analyses in the AHR (Chapter 2) and at riverine stopover sites throughout the migration corridor (Chapter 3). Those investigations, which included a variety of hydrologic and geomorphic habitat metrics, suggest riverine habitat use by whooping cranes increases with increasing width of channel unobstructed by dense vegetation (UOCW) and increasing distance to forest. Systematic AHR monitoring indicates the probability of whooping crane habitat selection of the central Platte River is greatest when UOCW exceeds approximately 450 ft and unforested corridor width exceeds 1,000 ft (Chapter 2). Migration corridor-wide telemetry data indicates the habitat selection of riverine habitat is greatest when UOCW exceeds approximately 650 ft and unforested corridor width exceeds 1,000 ft (Chapter 3).

It is important to note that many definitions for channel width have been used in past reports. For example, channel width has been defined as the width of channel from outer bank to outer bank (Faanes et al. 1992; Shenk and Armbruster 1986), water edge to water edge (Shenk and Armbruster 1986), unforested channel width (USFWS 1987; Ziewitz 1992), unobstructed channel width in 4 cardinal directions (Faanes 1992), unobstructed width of channel (Lingle et al. 1984 and 1986; Shenk and Armbruster 1986; Biology Workgroup 1990; Johnson and Temple 1980), and generically as river width (Austin and Richert 2005). The Program habitat selection analysis in Chapter 2 included metrics that described total bank-to-bank width, wetted width, width of channel unobstructed by dense vegetation (UOCW), and unforested width of the channel. However, only UOCW and distance to nearest forest (NF) were found to be important predictors of whooping crane use.

Program Management Actions to Improve Whooping Crane Habitat Suitability

The Flow-Sediment-Mechanical (FSM) approach is one of two management strategies presented in the Program's Adaptive Management Plan (AMP) to create and maintain suitable riverine habitat for whooping cranes. Proposed actions include: (1) vegetation clearing and channel widening (Mechanical), (2) partially offsetting the average annual sediment deficit of approximately 150,000 tons in the west half of the AHR through augmentation of sand (Sediment), and (3) implementation of short-duration high flows (SDHF) of 5,000 – 8,000 cfs for three days (Flow) in two out of three years to scour vegetation and maintain wide unobstructed channels.

These management actions are hypothesized to be sufficient to increase the unvegetated width of the main channel (Figure 1) and, by extension, increase channel suitability for whooping crane use. The mechanical component of the FSM management strategy has been employed in the AHR by various conservation organizations since the 1980s. Sand augmentation (sediment component) has been ongoing at varying levels since 2006. Implementation of SDHF releases has been limited by flow conveyance issues upstream of the AHR, but natural high flow events during the period of 2007–2014 have provided natural peak flows in excess of what the Program could produce at full FSM implementation. Each component of the FSM is discussed in greater detail in the following sections.

Mechanical

Overall, various organizations perform conservation on more than 30,000 acres for various species within the AHR, which encompasses approximately 47% of the channel within the ninety-mile reach. These organizations have been clearing in-channel vegetation and widening channels since the 1980s in an effort to increase channel width and prevent woody vegetation from establishing in the channel. Since Program inception in 2007, mechanical in-channel vegetation control efforts have included disking to clear islands and bank line disking and other mechanical actions to widen channels. These actions have been implemented by the USFWS Partners for Fish and Wildlife, The Crane Trust, The Nature Conservancy, Audubon Society, Nebraska Public Power District (NPPD), Central Nebraska Public Power and Irrigation District (CNPPID), and the

Program. Mechanical channel maintenance activities are ongoing in nine out of 12 bridge segments in the AHR (Table 1).

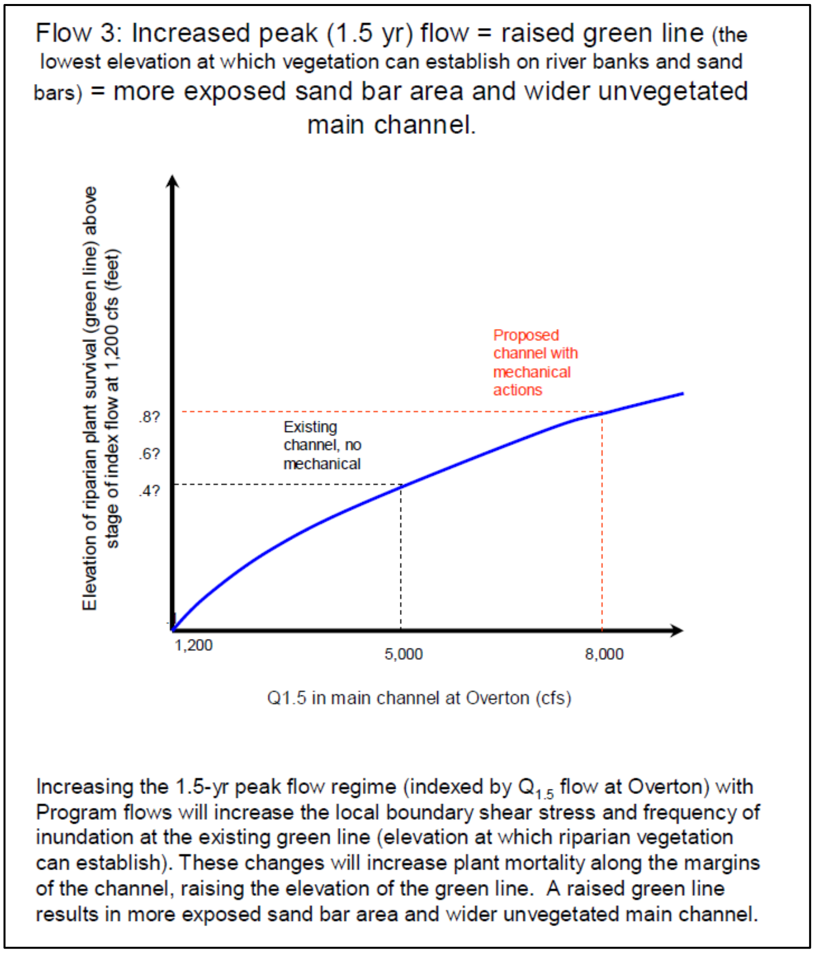


Figure 1. Program priority hypothesis Flow 3 which hypothesizes flows of 5,000 to 8,000 cfs (X-axis) will increase the green line (i.e., elevation at which riparian vegetation can establish; Y-axis) resulting in an increase the unvegetated width of the main channel.

Though not originally included in the FSM management strategy, reach-wide herbicide application has also become an important tool to eradicate and/or control the spread of common reed (*Phragmites australis)* during the period of 2008–2014. The spraying program has included aerial and ground application of herbicide to all common reed infestations detected in the channel

(Craig 2011). In excess of 15,000 acres have been sprayed in the AHR since the initiation of control efforts.

Table 1. Mechanical management actions undertaken by various entities since Program inception in 2007.

Bridge Segment	Length Managed (mi)	Mechanical Management Actions
Lexington to Overton	9.0	Vegetation removal from banks and islands, channel disking
Overton to Elm Creek	4.0	Vegetation removal from banks and islands, island leveling, channel widening, channel disking
Elm Creek to Odessa	4.0	Vegetation removal from banks and islands, island leveling, channel disking
Odessa to Kearney	0.0	
Kearney to Minden	4.7	Vegetation removal from banks and islands, channel disking
Minden to Gibbon	5.5	Vegetation removal from banks and islands, island leveling, channel disking
Gibbon to Shelton	1.7	Vegetation removal from banks and islands, channel disking
Shelton to Wood River	2.5	Vegetation removal from banks and islands, channel disking
Wood River to Alda	4.0	Vegetation removal from islands, island leveling, channel disking
Alda to Hwy 281	6.5	Vegetation removal from banks and islands, channel disking
Hwy 281 to Hwy 34	0.0	
Hwy 34 to Chapman	0.0	
TOTAL	41.9	

Sediment

The sediment component of the FSM strategy involves mechanical sand augmentation at the upstream end of the AHR to offset a sediment deficit from clear water hydropower returns at the J-2 return facility near Lexington, NE (Figure 2). The average annual sediment deficit is greatest in the south channel of the river immediately downstream of the J-2 Return. The deficit decreases in the downstream direction. There are no major tributary inputs of sediment in the AHR. Accordingly, the deficit is made up primarily through erosion of channel bed and bank materials in the south channel downstream of the return (Holburn et al. 2006; Murphy et al. 2006; HDR Engineering Inc. 2011).

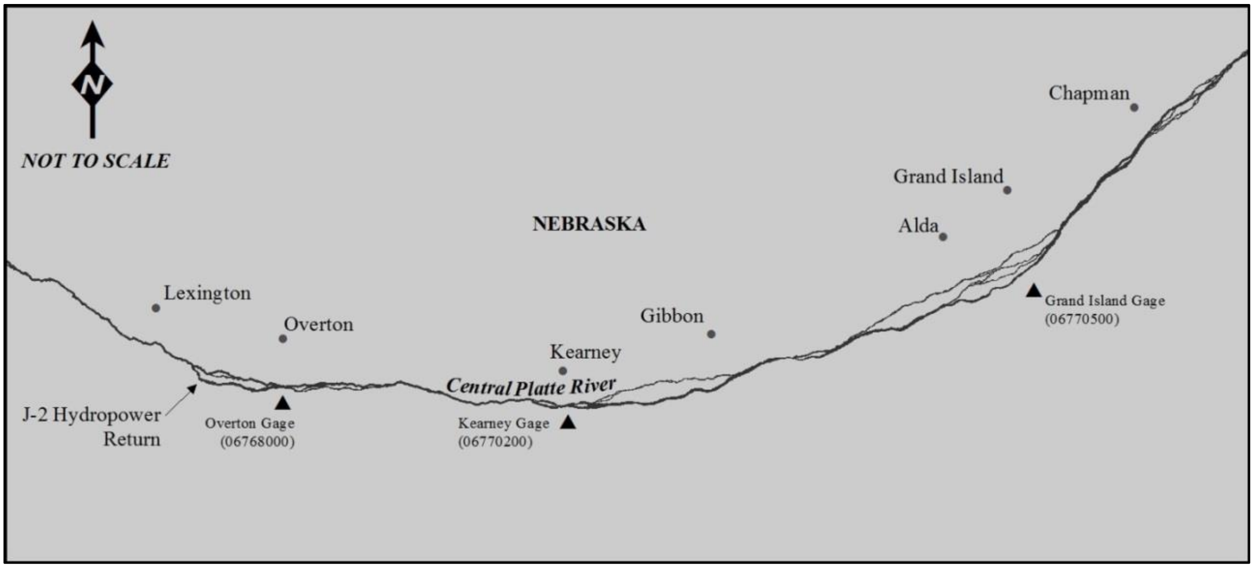


Figure 2. Associated Habitat Reach of the central Platte River extending from Lexington downstream to Chapman, NE. Locations of stream gages used in the analyses are included as well.

Sediment augmentation efforts began in 2006 as part of channel widening activities by NPPD at the Cottonwood Ranch property in the Overton to Elm Creek bridge segment. The Program has since expanded those efforts to include the addition of a second augmentation site upstream of the Overton Bridge (Table 2).

Table 2. Total annual discharge, sediment load, and sediment augmentation by water year. Sediment loads from Program system-scale geomorphology monitoring.

Water Year*	Total Annual Discharge at Overton (Acre-ft)	Sediment Augmented (tons)	Total Sediment Load at Overton (tons)	Total Sediment Load at Kearney (tons)	Total Sediment Load at Shelton (tons)	Total Sediment Load at Grand Island (tons)
2006	272,032	15,570	--	--	--	--
2007	569,912	21,875	--	--	--	--
2008	525,025	42,500	--	--	--	--
2009	585,994	50,000	200,000	207,300	214,900	281,500
2010	1,377,665	50,000	613,000	730,000	719,000	877,000
2011	2,691,194	50,000	1,424,000	1,728,000	1,467,000	2,011,000
2012	1,247,736	0	567,000	641,000	495,000	713,000
2013	638,733	182,000	255,200	268,700	165,700	209,700

* 2014 and 2015 data not available

The Program began conducting annual system-scale geomorphology and vegetation monitoring in 2009. Analysis of transect survey and sediment transport measurement data for the period of 2009–2013 strongly indicates the portion of the reach upstream from Kearney was degradational during that period, with an average annual sand deficit in the range of 100,000 tons (Tetra Tech Inc. 2014). Tetra Tech Inc. (2014) considered both survey and model results and concluded the portion of the reach downstream from Kearney was most likely aggradational. However, given potentially contradictory lines of evidence, Tetra Tech Inc. (2014) indicated this conclusion was only weakly supported by the data.

Flow

The primary physical process driver of the FSM management strategy is the implementation of short-duration high flows (SDHF) of 5,000 – 8,000 cfs for three days on a near annual basis. Implementation of SDHF is intended to increase the magnitude of peak flows (indexed by the $Q_{1.5}$ flow; the peak flow exceeded in two out of three years) from approximately 4,000 cfs to 5,000 – 8,000 cfs. Total release volumes on the order of 50,000 – 75,000 acre-ft are necessary to achieve full SDHF magnitude and duration due to reservoir release ramping constraints and flow attenuation.

Persistent channel conveyance constraints upstream of the AHR limit the Program's ability to generate flow release magnitudes in the 5,000 – 8,000 cfs range. As such, the Program has not had the ability to fully implement an SDHF magnitude release through the AHR. However, the easing of basin drought and subsequent river discharge recovery coincident with Program implementation since 2007 provided natural high flows of similar magnitude and greater duration than contemplated in the AMP. During the first nine years of Program implementation (2007–2015), mean annual discharge more than doubled, and the three-day mean annual peak discharge at Grand Island exceeded 5,000 cfs in seven out of nine years and 8,000 cfs in five out of nine years (Table 3; Figure 3). Overall, the shift in basin hydrology resulted in a nine-year period (2007–2015) with peak flow frequency, magnitude, and duration that substantially exceeded what could have been achieved under full FSM implementation during 2000–2006.

Table 3. 2007–2015 median discharge during the growing season (cfs) and annual peak flow event magnitudes (cfs), durations and volumes (acre-ft) at Grand Island (USGS Gage 06770500) in relation to the Short-Duration High Flow management action performance criteria.

Year	Median Discharge during Growing Season (cfs)	Average Daily Peak Discharge (cfs)	3-Day Mean Peak Discharge (cfs)	Days >5,000 cfs	Days >8,000 cfs	Total Event Volume (acre-feet)*
SDHF	NA	NA	5,000 – 8,000	3	0	50,000 – 75,000
2007	1,045	5,312	5,543	3	0	84,813
2008	903	12,472	10,900	13	5	253,012
2009	479	3,379	3,180	0	0	24,258
2010	2,243	8,498	8,540	17	6	535,319
2011	5,468	9,474	9,883	81	16	3,287,603
2012	238	3,300	3,183	0	0	332,310
2013	218	11,313	9,167	9	6	245,871
2014	943	7,342	7,263	6	0	181,269
2015	3,030	16,100	15,666	50	42	1,245,818

*Cumulative flow volume for consecutive days of discharge greater than 2,000 cfs.

Analysis Objectives

Overall, the scale of flow, sediment, and mechanical management actions and natural analogs during 2007–2015 have been sufficient to allow the Program to effectively explore vegetation response. The whooping crane resource selection analyses indicate the width of channel unobstructed by dense vegetation (UOCW) is an important predictor of whooping crane use. Accordingly, the maximum UOCW (MUOCW) at any given location within AHR channel is an important vegetation metric representing whooping crane habitat suitability. Another potentially important vegetation response metric is the total unvegetated width of the channel (TUCW). This is because the relationship between vegetation and physical processes and Program management actions will likely be more easily identified when evaluating all unvegetated segments across all channels as it eliminates the randomness associated with the spatial distribution of vegetated islands within the channel.

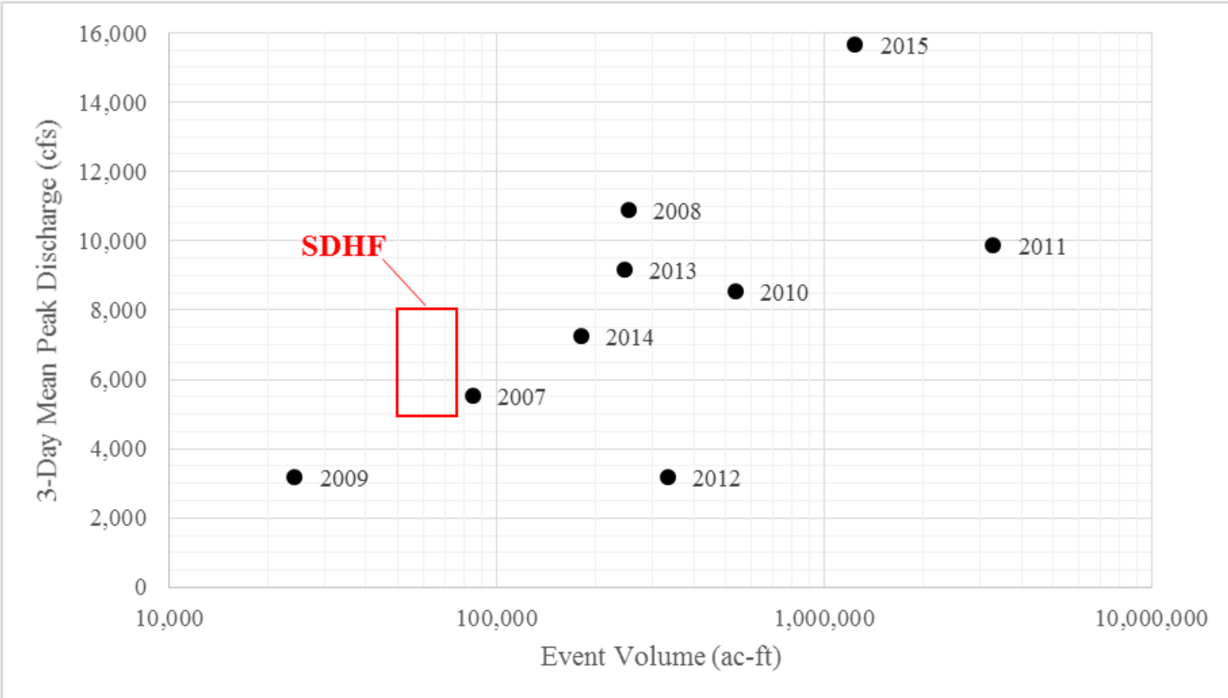


Figure 3. 2007–2015 three-day mean peak discharge (cfs) and event volume (acre-ft) at Grand Island (USGS Gage 06770500) in relation to the range of Short-Duration High Flow magnitudes and volumes. Event volumes are cumulative volumes from concurrent days during annual peak flow events when discharge exceeded 2,000 cfs.

Accordingly, the objectives of this analysis include 1) quantification of annual AHR TUCW and MUOCW through the First Increment of the Program (2007–2019), 2) evaluation of the relationship between TUCW and MUOCW in the AHR, 3) identification and quantification of management actions, hydrologic (flow) conditions, and physical conditions that influence annual TUCW and MUOCW in the AHR, and 4) application of analysis results to predict the ability of the FSM management strategy to create and maintain UOCWs that are highly suitable for whooping crane use.

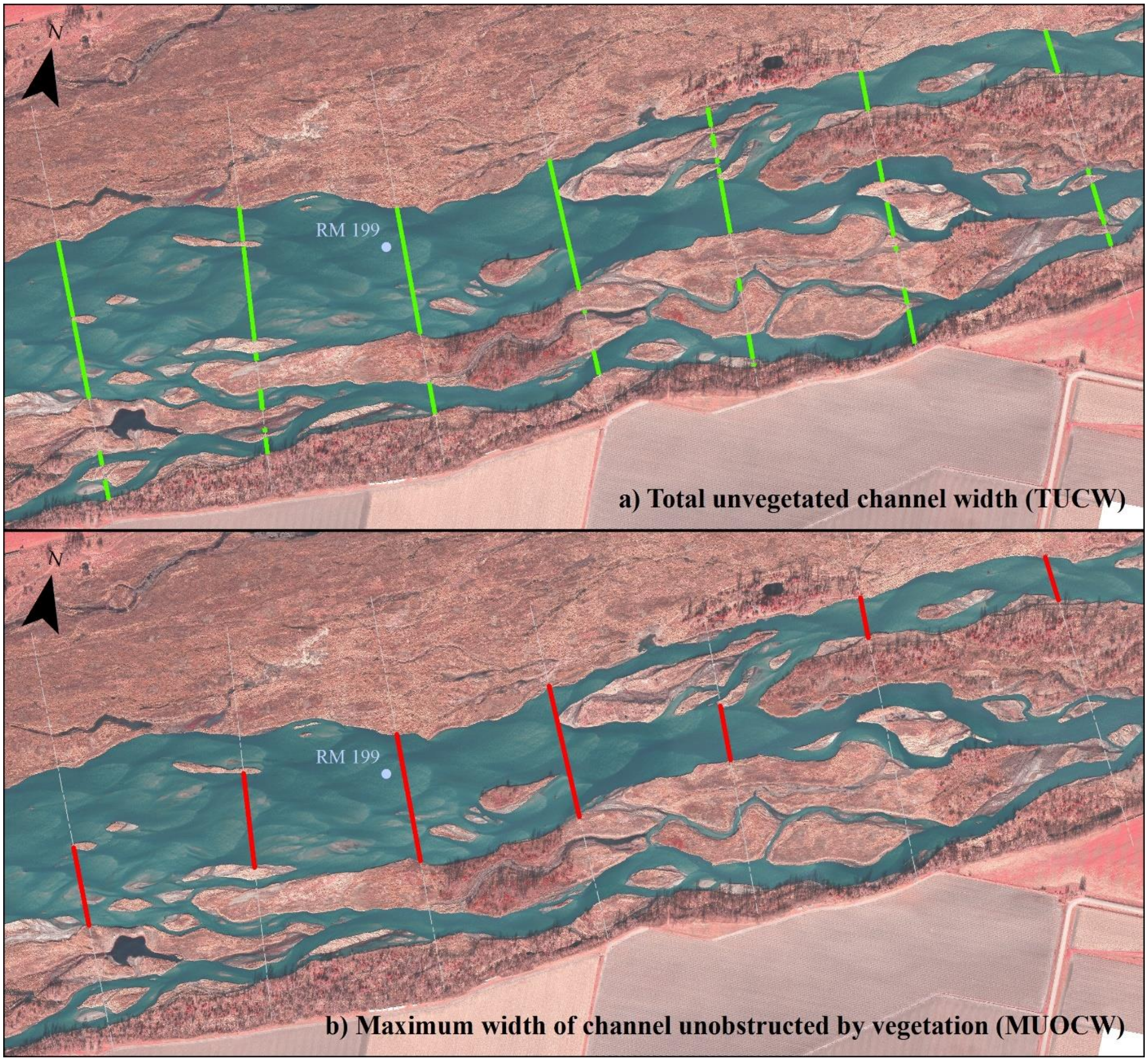
Methods

Study Area

The AHR is a ninety-mile reach extending from Lexington, NE downstream to Chapman, NE and encompasses the Platte River channel and off-channel habitats within three and one half miles of the river (Figure 1). The study reach for this analysis focuses solely on the 84 miles of channel extending downstream from the Overton bridge to Chapman. The short reach between Lexington, NE and the Overton, NE was excluded due to the presence of the J-2 hydropower return. Natural river flows are largely confined to the north channel, and hydropower return flows are confined to the south channel in this reach, making it difficult to interpret relationships between hydrology and physical process relationships in this portion of the AHR.

Measurement of Total Unvegetated Width and Maximum Unobstructed Channel Width

We used summer or fall aerial imagery collected annually during periods of low flow to photo-interpret TUCW and MUOCW throughout the AHR during the period of 2007–2015. Unvegetated width metrics were delineated at a scale of 1" = 200' along 436 pre-defined transects using ESRI ArcMAP Geographic Information System (GIS) software. Photo-interpretation of unvegetated width metrics was determined to provide acceptable measurement accuracy based on previous comparisons of field-measured and photo-interpreted unvegetated width measurements in the AHR (Werbylo et al. 2016). Transects were oriented perpendicular to flow and spaced at 1,000 ft intervals along the channel throughout the study area and encompassed all channels in split flow reaches. Figure 4 provides examples of TUCW and MUOCW width delineations.



1563
1564 **Figure 4.** Examples of total unvegetated channel width (TUCW; a) and maximum width of
1565 channel unobstructed by vegetation (MUOCW; b) delineations near River Mile 199.

1566
1567 *Model Metrics and Statistical Analyses*

1568 A number of investigators have attempted to identify the management, hydrologic, and
1569 geomorphic factors that influence channel width in the AHR. Most investigations evaluate those
1570 factors within the context of changes in unvegetated channel width during the period following
1571 water resources development in the basin (Williams 1978; O'Brien and Currier 1987; Johnson

1994; Simons and Associates Inc. 2000; Murphy et al. 2004; Schumm 2005). Several of the investigators identified peak flows as the controlling factor in channel width (Williams 1978; O'Brien and Currier 1987; Murphy et al. 2004). Although peak flow metrics of interest had varying return intervals and durations identified by different investigators, these differences were generally not discussed. Investigators also typically cited a secondary effect of reduction in sediment supply/transport. Others have identified mean June flows (Johnson 1994; Simons and Associates Inc. 2000), summer flows (Schumm 2005), slight differences in channel slope (Schumm 2005) and differences in bed material grain size (Murphy et al. 2004) as potentially controlling or at least influencing unvegetated channel width in the AHR. In addition, investigators have discussed the role of woody and/or scour resistant vegetation in limiting the ability of the AHR to widen in response to changes in hydrology (Tal et al. 2004). This phenomenon has been described as the vegetation ratchet effect because the channel is free to narrow through vegetation encroachment, but has limited ability to re-widen once bars and banks are stabilized by woody or other scour-resistant vegetation.

A total of 11 primary hydrologic, geomorphic, and management variables were identified based on our review of the literature, proposed FSM management actions, and our knowledge of ongoing activities in the AHR (Table 4). We performed 2 multiple quantile linear regression analyses to identify and quantify effect sizes of these variables on TUCW and MUOCW in the AHR during the period of 2007–2015.

Table 4. Hydrologic, geomorphic and management variables included in the robust regression analyses for total unvegetated channel width (TUCW) and unobstructed channel width (MUOCW) for the period of 2007–2015. Units of measurement (Units) and description of data acquisition (Description) are included for each metric.

Metric	Type	Units	Description
Peak Discharge	Hydrologic	Cubic feet per second (cfs)	Mean daily discharge records were obtained from www.water.usgs.gov for the three United States Geological Survey (USGS) stream gages located in the AHR (Figure 1). Annual hydrologic metrics were calculated for each transect by linear interpolation from the nearest gage. Mean annual peak discharges were identified for 1, 3, 5, 10, 20, 30, 40, 50, and 60 day durations.
Peak Discharge + Previous Year Peak Effect	Hydrologic	Cubic feet per second (cfs)	Mean annual peak discharge + a percentage of peak discharge from previous year. Metric intended to identify peak discharge effects across multiple years. Previous year peak effects included 0%, 20%, 40%, 60%, 80%, and 100% of previous year peak discharge.
Minimum Discharge	Hydrologic	Cubic feet per second (cfs)	Mean annual minimum discharge events were identified for 10, 20, 30, and 40 day durations.
Mean June Discharge	Hydrologic	Cubic feet per second (cfs)	Mean daily discharge during the month of June.
Mean Growing Season Discharge	Hydrologic	Cubic feet per second (cfs)	Mean daily discharge during the portion of the year when vegetation is actively germinating and growing in the channel. Growing season is defined as 15-April through 15-August.
Wetted Width at Bankfull Discharge	Geomorphic	Feet (ft)	Wetted width of the channel at bankfull discharge. Metric included to represent "vegetation ratchet" control on width adjustment potential. Widths were delineated from June 2011 aerial imagery, which was flown at near bankfull discharge. Areas of shallow overbank flow were omitted.
Median Grain Size	Geomorphic	Millimeter (mm)	Average of median bed and bar material grain size during the period of 2009-2014 at Program pure panel anchor point locations. Transect grain size was identified based on nearest anchor point.
Channel Slope	Geomorphic	Dimensionless	Mean channel slope for 1-mile reach centered on each transect. Slopes calculated from 2009 longitudinal profile of the AHR.
River Mile	Geomorphic	Mile (mi)	General metric included to represent general effect of declining sediment deficit from west to east.
Annual Disking	Management	Categorical	Annual delineations of disking and herbicide application were used to classify transects in GIS as to whether or not these management actions were applied. If any portion of a transect was intersected by the disking polygon, the transect was considered disked. If any portion of a transect was intersected by a herbicide polygon, the transect was considered to be treated with herbicide.
Annual Herbicide	Management	Categorical	

Transects were subset spatially to utilize every fifth transect location to minimize autocorrelation. We used quantile regression analysis because our dataset contained heterogeneous variances and obvious bias due to unmeasured variables, which made traditional least squares linear regression inappropriate (Rosenbaum 1995, Terrell et al. 1996, Cade et al. 1999, Cade 2003). Quantile regression provides a more comprehensive view of variable relationships by estimating multiple rates of change (i.e., slopes) throughout the distribution of the response variable (Koenker and Bassett 1978).

Due to the high number of possible covariate combinations, especially due to uncertainty of best peak and minimum flow durations to predict TUCW and MUOCW, we utilized Akaike's Information Criterion (AIC) and quantile regression goodness of fit for a given quantile (R^1) in a five-step model selection process. Interpretation of quantile regression goodness of fit was developed to be analogous to interpretation of least squares regression coefficient of determination (Koenker and Machado 1999). Similar multi-step AIC model selection efforts have been observed in ecological modeling efforts (Baasch et al. 2010, McGowan et al. 2011, Catlin et al. 2015). A full description for the TUCW model selection process and tables for the MUOCW quantile linear regression processes are included in Appendices I and II. The model selection steps and goodness of fit measurements were analyzed where the quantile value (τ) was 0.5 and no covariates were included together in models if absolute spearman correlation was ≥ 0.5. We utilized this multi-step selection process to: 1) identify the most important hydrologic variables, 2) identify the duration of hydrologic variables that best explain each response, 3) identify the most important non-hydrologic variables, and 4) produce final models with both hydrologic and non-hydrologic variables that best explain and accurately predict TUCW and MUOCW at transect locations in the

AHR. Model coefficient confidence intervals were produced with an inverted rank test (Koenker 1994) and the 0.05 and 0.95 response quantiles were used to produce 90% prediction intervals to evaluate whooping crane habitat suitability described in the subsequent section.

Application of the Final MUOCW Model to Evaluate the FSM Management Strategy

The final MUOCW model was used to assess the potential performance of the FSM management strategy at a hypothetical habitat complex location given observed hydrology during the period of 1998–2015. The habitat complex was assumed to have a main channel bankfull width of 1,000 ft and a median bed material grain size of 0.9 mm. Annual MUOCW was first calculated given observed hydrology during the period of 1998–2015 at the Overton stream gage (06768000). Observed hydrology was then altered to add a series of SDHF events of 8,000 cfs for three days in approximately two out of three years. MUOCWs predicted under full SDHF implementation were compared to those predicted given observed hydrology to assess the ability of SDHF releases to increase MUOCW and maintain UOCWs that are highly suitable for whooping crane use.

Results

Total Unvegetated Channel Widths (TUCW) and Unobstructed Channel Widths (MUOCW)

TUCW and MUOCW followed similar trend patterns from 2007–2015. The lowest average values for each width measurement were observed in 2007 and the highest was in 2015 (Table 5). From 2008–2014, MUOCW mean and median values were observed to have little variation, with the greatest yearly difference of 110 ft for mean and 89 ft for median observations. Likewise, from 2008–2014, TUCW mean and median values were observed to have little variation, with the greatest yearly difference of 219 ft for mean and 222 ft for median observations (Table 5).

Table 5. Observed total unvegetated channel widths (TUCW) and unobstructed channel widths (MUOCW) by river mile, 2007–2015.

Year	Mean TUCW(ft)	Median TUCW(ft)	Mean MUOCW(ft)	Median MUOCW(ft)
2007	572	558	300	260
2008	720	729	443	383
2009	650	642	373	341
2010	661	653	409	347
2011	869	864	481	430
2012	695	692	454	394
2013	722	720	483	421
2014	716	710	431	373
2015	1,054	1,027	625	575

Spatially, both TUCW and MUOCW were highly variable but generally increased with decreasing river mile (i.e., in a downstream direction). Both width metrics also increased from 2007–2015 at almost all locations within the AHR (Figure 6). However, the magnitude of width increases varied based on river segment. For example, the UOCW increase from river mile 170 to 180 was far less than what was observed from river mile 160 to 170 (Figure 6).

Relationship between TUCW and MUOCW

The relationship between TUCW and MUOCW for all transects in all analysis years is presented in Figure 7. In general, MUOCW increased with increasing TUCW, but there were few cases when the entire unvegetated width of the channel was consolidated into a single segment (MUOCW = TUCW). This indicates that under existing hydrologic, geomorphic, and management conditions, the channels of the AHR tend to contain either densely vegetated sandbars or be split by permanent islands. Accordingly, it is not appropriate to interpret MUOCW as being equivalent to TUCW or other metrics intended to describe the total width of AHR channels.

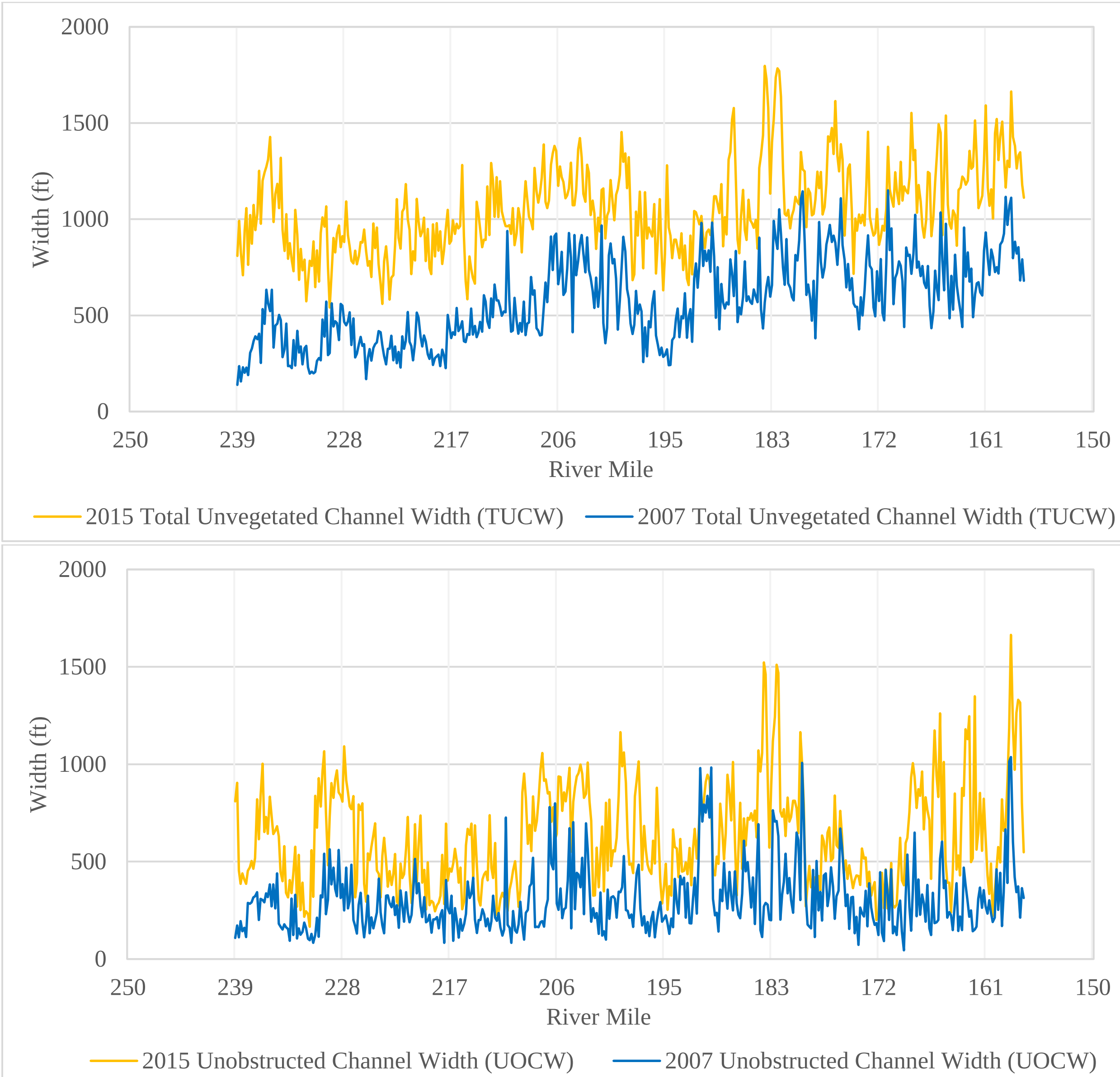


Figure 6. Observed total unvegetated channel widths (TUCW) and unobstructed channel widths (MUOCW) by river mile for analysis years 2007 and 2015.

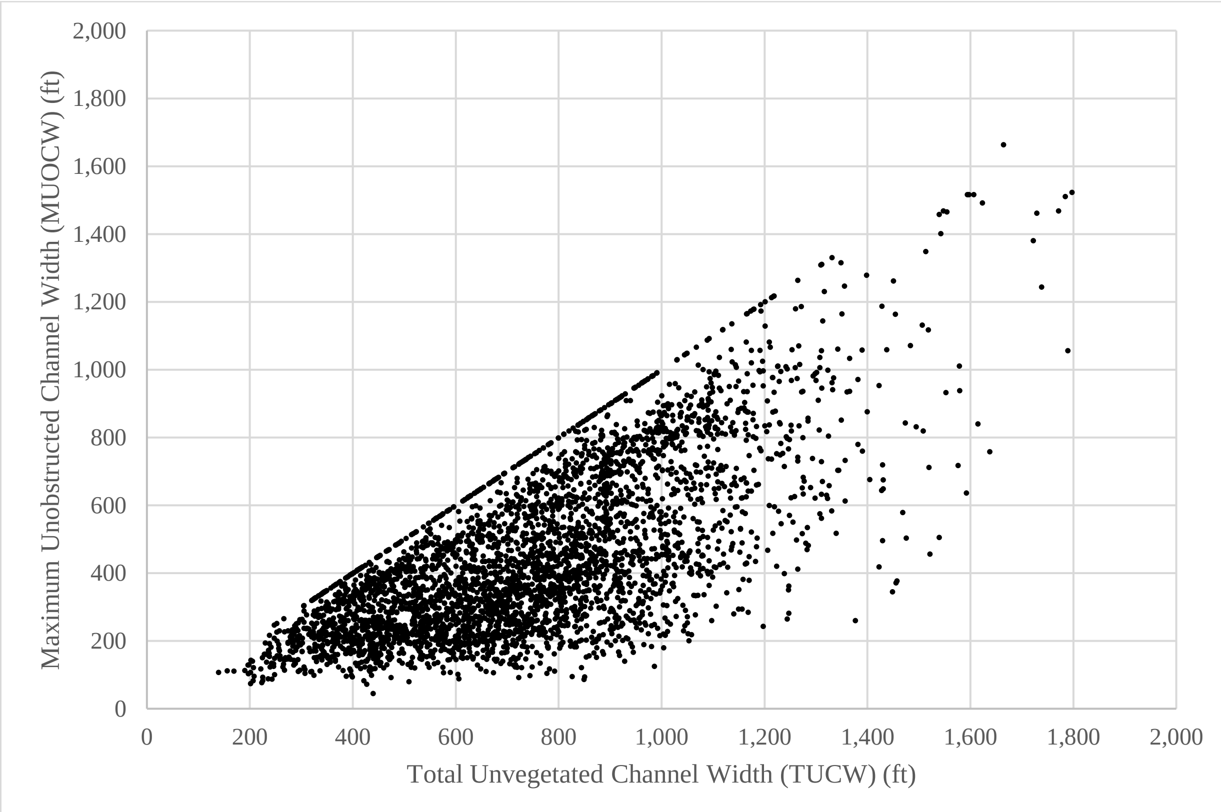


Figure 7. Relationship between total unvegetated channel width (TUCW) and maximum unobstructed channel width (MUOCW) for all transects, 2007–2015.

Quantile Regression Analysis – Metrics Found to Influence Total Unvegetated Channel Width

A summary of important annual flow, geomorphic and management variable values in relation to mean TUCW and MUOCW are presented in Table 6. Forty-day peak discharge ranged from 2,010 cfs to 12,486 cfs and generally occurred between early May and early July (Figure 8). Wetted width ranged from 603 ft to 1,717 ft. Disking was somewhat variable during the analysis period, ranging from a low of 0% of transects being disked in 2011 to a high of 41% of transects in 2007 in the AHR. The proportion of transects sprayed was low in 2007 and 2008, prior to the commencement of large-scale phragmites spraying efforts. At full-scale implementation, up to 83% of transects were sprayed in a single year.

Table 6. Summary of important AHR flow, geomorphic and management metric values from 2007 to 2015 in relation to mean total unvegetated channel width (TUCW) and unobstructed channel width (MUOCW) from 2007 to 2015.

Year	40 Day Peak Discharge (cfs)	Bankfull Wetted Width (ft)[1]	Median Grain Size (mm)[2]	% of Transects Disked	% of Transects Sprayed	TUCW (ft)	MUOCW (ft)
2007	2,010			33%	0%	558	300
2008	3,825			41%	5%	729	443
2009	2,112			10%	13%	642	373
2010	5,171			5%	77%	653	409
2011	8,171	1,044	0.93	0%	44%	864	481
2012	2,922			9%	81%	692	454
2013	3,661			11%	71%	720	483
2014	2,943			18%	74%	710	431
2015	12,486			0%	83%	1,027	625

[1] Bankfull width measurements were derived from 2011 aerial imagery.
[2] Median grain size was calculated as the average of measurements from 2009–2014. We assumed bankfull width and median grain size were relatively stable at individual transects from 2007–2015.

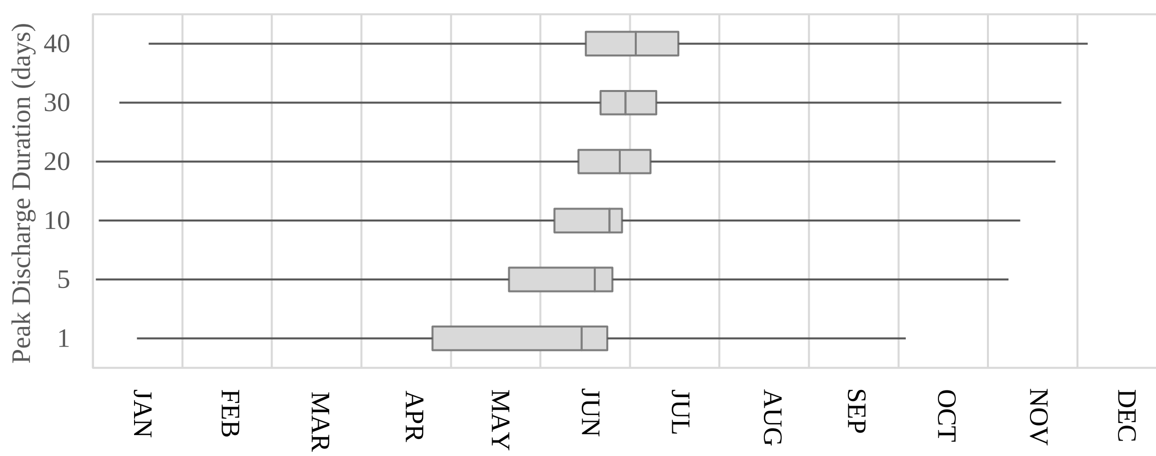


Figure 8. Distribution of peak discharge dates from the Overton, Kearney, Grand Island and Duncan gauges from 2007 to 2015. Median values are presented, along with the lower and upper quartiles. Minimum and maximum values are presented as bars.

We found TUCW was best explained by 40-day duration peak discharge, disking, herbicide application, and wetted width of the channel at bankfull discharge (Appendix I Table I-5; Table 7); all of which were incorporated in one of two models that carried substantial model weight (w > 0.40). AIC values indicate our top model was ~436 AIC units lower than a model only including 40-day peak discharge and wetted width and ~850 AIC unit lower than the null model. All variables had a positive effect on TUCW from 2007–2015. The formula of the top model to explain TUCW at the 0.5 quantile (τ = 0.5) was noted as:

$$TUCW = 199.41 + 0.04 * 40\ Day\ Peak + 136.14 * Disking + 33.52 * Herbicide + 0.32 * Wetted\ Width \quad 1.1$$

where "40 Day Peak" refers to mean 40-day duration peak discharge, "Herbicide" and "Disking" were categorical variables based on whether or not herbicide or disking were applied within the previous year, and "Wetted Width" was a measure of the wetted width of all channel segments at bankfull discharge.

Besides the effects of 40-day peak discharge, beta values generally increased from low to high quantiles of TUCW. For instance, at the 0.05 quantile, disking increased TUCW by 53 ft and herbicide increased TUCW by 19 ft on average. At the 0.95 quantile, disking increased TUCW by 201 ft and herbicide increased TUCW by 81 ft on average (Table 7).

Table 7. Multiple quantile regression beta estimates of the top model from the total unobstructed channel width (TUCW) model selection process.

Quantile	Intercept	40-Day Peak	Disking	Herbicide	Wetted Width
0.05	-23.75	0.04	52.82	18.91	0.29
0.10	50.20	0.04	90.89	23.51	0.26
0.25	119.41	0.04	111.09	31.66	0.28
0.50	199.11	0.04	136.14	33.52	0.32
0.75	298.30	0.04	122.13	22.46	0.37
0.90	364.56	0.03	127.74	69.97	0.44
0.95	379.53	0.03	201.28	81.17	0.49

Based on the results of our top quantile regression model at the 0.5 quantile, for each 1,000 cfs increase in 40-day peak discharge, on average, we would expect a 38 ft (95% CI = 10 – 59 ft) increase in TUCW annually, when no disking or herbicide treatment was applied and wetted width at bankfull discharge was held at its median value (Figure 9). When transects were disked, on average, TUCW was 136 ft (95% CI = 103 – 164 ft) wider than at transects where no disking occurred within the previous year. When transects were disked and herbicide was applied, on average, TUCW was 170 ft (95% CI = 113 – 223 ft) wider than transects where no other management actions occurred in the previous year. For each 100 ft increase in wetted width at bankfull discharge, on average, we would expect a 32 ft (95% CI = 29 – 36 ft) increase in TUCW annually (Figure 10).

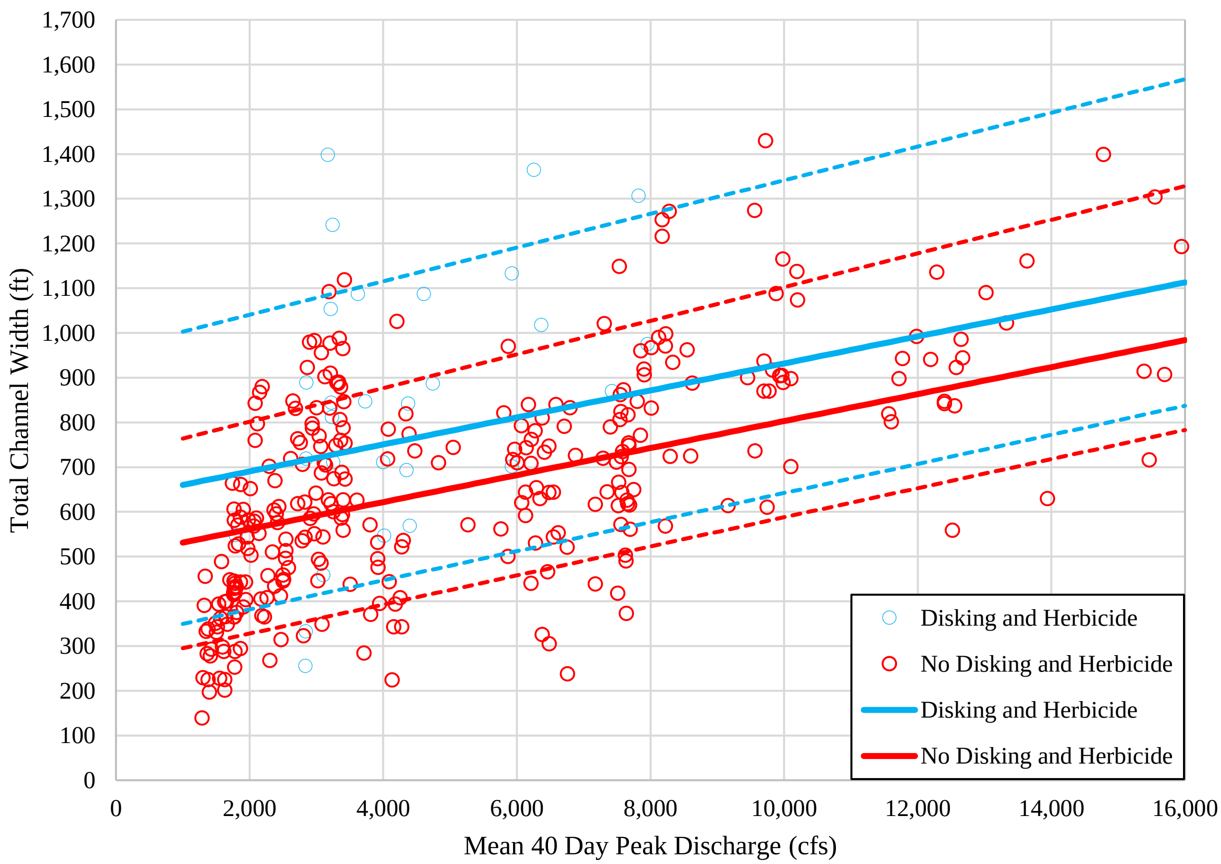


Figure 9. Predicted relationships of total unvegetated channel width (TUCW) to 40-day peak discharge at transects in the AHR with (blue) or without (red) management actions from 2007–2015. Dashed lines represent 90% quantile regression prediction intervals and points display the subset of measured TUCWs at transects used in quantile regression analyses. Points represent

transects where no management actions (red), disking only (dark blue), or disking and herbicide (blue) occurred.

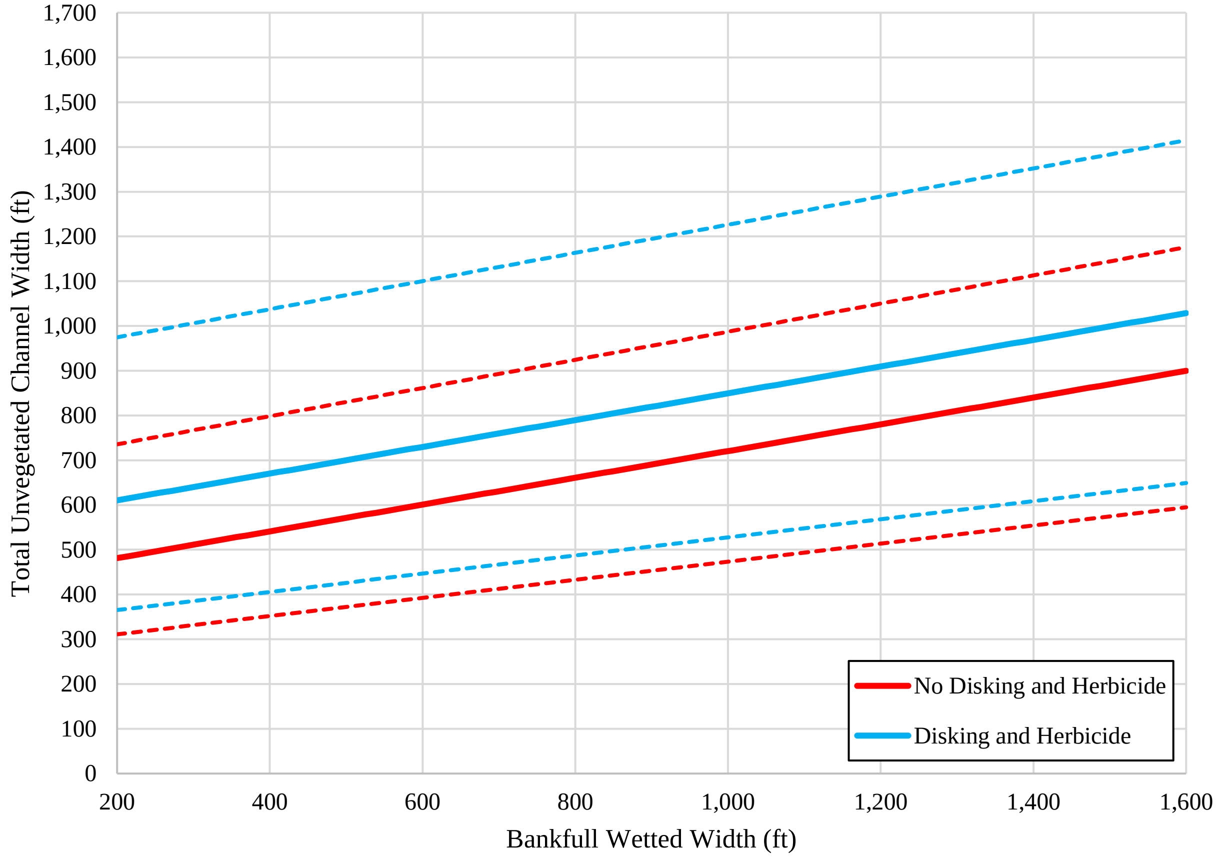


Figure 10. Predicted relationships of total unvegetated channel width to wetted width at transects in the AHR with (blue) or without (red) management actions from 2007–2015. Dashed lines represent 90% quantile regression prediction intervals.

We used several methods to assess the accuracy of the top model we identified through AIC model selection. First, we compared observed and predicted TUCW at each transect for each year. Utilizing the TUCW linear model and betas previously stated at the 0.5 quantile, 45% of TUCW predictions were within 100 ft and 76% of predictions were within 200 ft of actual values observed from 2007–2015. Overestimating TUCW was of special concern since narrower than predicted TUCW potentially have more negative consequences for whooping crane habitat suitability than underestimations. Twenty-nine percent of TUCW predictions were overestimated by more than 100 ft and only 11% were overestimated by more than 200 ft.

We also compared mean observed and predicted TUCW for all transects in each year (Table 8) and compared observed and predicted widths for each AHR bridge segment across all years (Table 9). Only two years, 2007 and 2010, were found to contain mean errors >10% of actual values. When observing errors by bridge segment, four of the eleven bridge segments contain mean errors >10% of actual values, but no mean errors exceeded 17% (Table 8).

Table 8. Comparison of mean observed and predicted total unvegetated channel width (TUCW) in AHR for the period of 2007-2015 using a 0.5 quantile regression. Parentheses indicated 90% quantile regression prediction intervals.

Year	Observed Mean TUCW (ft)	Predicted Mean TUCW (ft)	Mean Error (ft)	Mean Error as % of Observed TUCW
2007	572	670 (401 - 947)	99 (-171 - 375)	17 (-30 - 66)
2008	720	777 (495 - 1059)	56 (-225 - 339)	8 (-31 - 47)
2009	650	608 (365 - 870)	-42 (-285 - 221)	-6 (-44 - 34)
2010	661	740 (502 - 1029)	79 (-159 - 367)	12 (-24 - 56)
2011	869	811 (570 - 1071)	-58 (-299 - 202)	-7 (-34 - 23)
2012	695	640 (404 - 941)	-55 (-291 - 246)	-8 (-42 - 35)
2013	722	751 (506 - 1041)	29 (-216 - 319)	4 (-30 - 44)
2014	716	716 (467 - 1017)	-1 (-249 - 301)	0 (-35 - 42)
2015	1054	991 (746 - 1266)	-63 (-309 - 211)	-6 (-29 - 20)

Table 9. Comparison of mean observed and predicted total unvegetated channel width (TUCW) by bridge segment for the period of 2007–2015 using a 0.5 quantile regression. Parentheses indicated 90% quantile regression prediction intervals.

Bridge Segment	Observed TUCW (ft)	Predicted TUCW (ft)	Error (ft)	Error as % of Observed TUCW
Overton - Elm Creek	590	575 (362 - 826)	-15 (-229 - 236)	3 (-39 - 40)
Elm Creek - Odessa	572	550 (334 - 815)	-22 (-238 - 242)	4 (-42 - 42)
Odessa - Kearney	500	525 (334 - 767)	24 (-167 - 266)	5 (-33 - 53)
Kearney - Minden	638	583 (374 - 837)	-56 (-264 - 198)	9 (-41 - 31)
Minden - Gibbon	864	732 (469 - 1033)	-132 (-395 - 169)	15 (-46 - 20)
Gibbon - Shelton	880	775 (506 - 1078)	-105 (-373 - 198)	12 (-42 - 23)
Shelton - Wood River	620	723 (485 - 988)	103 (-135 - 367)	17 (-22 - 59)
Wood River - Alda	780	835 (557 - 1142)	54 (-223 - 362)	7 (-29 - 46)
Alda - Hwy 281	972	939 (631 - 1266)	-33 (-341 - 294)	3 (-35 - 30)
Hwy 281 - Hwy 34	872	911 (632 - 1208)	39 (-240 - 335)	4 (-28 - 38)
Hwy 34 - Chapman	834	926 (650 - 1221)	92 (-185 - 387)	11 (-22 - 46)

Quantile Regression Analysis – Metrics Found to Influence Maximum Unobstructed Channel Width

We found MUOCW was best explained by 40-day duration peak discharge and wetted width of the main channel (Appendix II Table II-4) and were incorporated in the only model with a model weight >0.10 ($w = 0.83$). Disking, herbicide application, and median grain size were also included in the top model explaining MUOCW. AIC values indicated our top model which included disking, herbicide application and median grain size was ~45 AIC units lower than a model that only included 40-day peak discharge and wetted width and ~451 AIC unit lower than the null model. All variables had a positive effect on MUOCW from 2007–2015 except median grain size, which exhibited a negative relationship. The formula of the top model used to explain MUOCW at the 0.5 quantile ($\tau = 0.5$) was noted as:

$$UOCW = 191.64 + 0.02 * 40\ Day\ Peak + 122.22 * Disked + 24.11 * Herbicide + 0.18 * Main\ Channel\ Wetted\ Width - 95.09 * Median\ Grain\ Size \quad 2.1$$

where "40 Day Peak" refers to mean 40-day duration peak discharge, "Herbicide" and "Disking" were categorical variables based on whether or not herbicide or disking were applied within the previous year, "Main Channel Wetted Width" refers only to the main channel and not the total wetted width of all channels at bankfull discharge, and "Median Grain Size" refers to the median size of the substrate.

Besides the effects of 40-day peak discharge and median grain size, other beta values generally increased from low to high quantiles. For example, at the 0.05 quantile, disking increased MUOCW by 23 ft and herbicide increased MUOCW by 18 ft on average. At the 0.95 quantile, on average, disking increased TUCW by 172 ft and herbicide increased TUCW by 43 ft (Table 10).

Table 10. Multiple quantile regression beta estimates of the top model from the unobstructed channel width (MUOCW) model selection process.

Quantile	Intercept	40 Day Peak	Disking	Herbicide	Main Channel Wetted Width	Median Grain Size
0.05	58.48	0.01	22.86	18.16	0.04	14.09
0.10	145.96	0.01	28.12	22.76	0.04	-37.61
0.25	205.11	0.01	116.65	31.90	0.09	-92.59
0.50	191.64	0.02	122.22	24.11	0.18	-95.09
0.75	226.44	0.02	165.15	50.55	0.37	-132.01
0.90	67.08	0.02	142.63	35.26	0.64	-10.75
0.95	360.90	0.01	171.76	43.07	0.66	-212.90

Based on the results of our top quantile regression model at the 0.5 quantile, for each 1,000 cfs increase in 40-day peak discharge, on average, we would expect a 20 ft (95% CI = 16 – 24 ft) annual increase in MUOCW, when no disking or herbicide treatment was applied and other variables were held at their median values (Figure 12). For each 100 ft increase in bankfull wetted width of the main channel, on average, we would expect an 18 ft (95% CI = 14 – 23 ft) increase in MUOCW (Figure 13). When transects were disked, on average, MUOCW was 122 ft (95% CI

= 85 – 163 ft) wider than transects where no disking occurred within the previous year. When both disking and herbicide were applied, on average, we found transects were 146 ft (95% CI = 91 – 217 ft) wider than transects where no management actions occurred in the previous year. We also found as median grain size decreased, MUOCW increased (Figure 14). For each 0.1 mm decrease in median grain size, on average, MUOCW increased by 10 ft (95% CI = 2 – 19 ft).

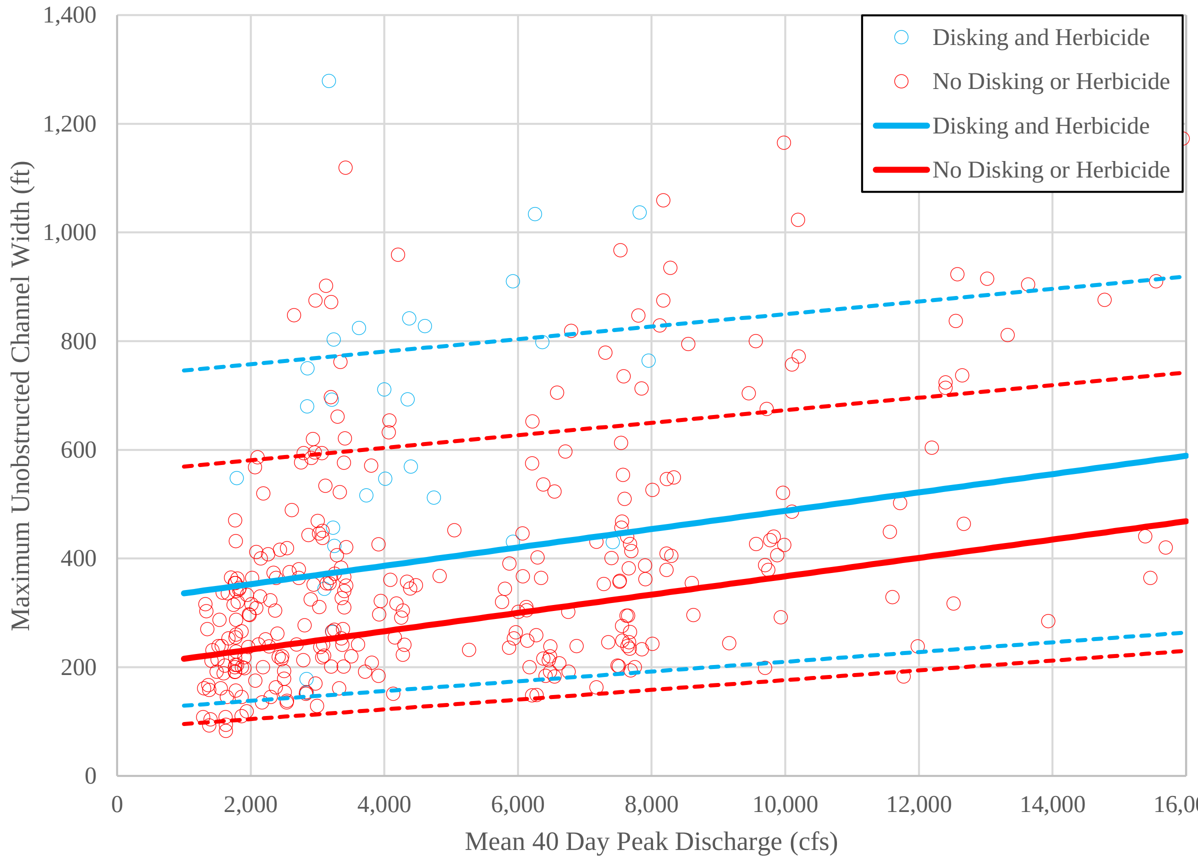
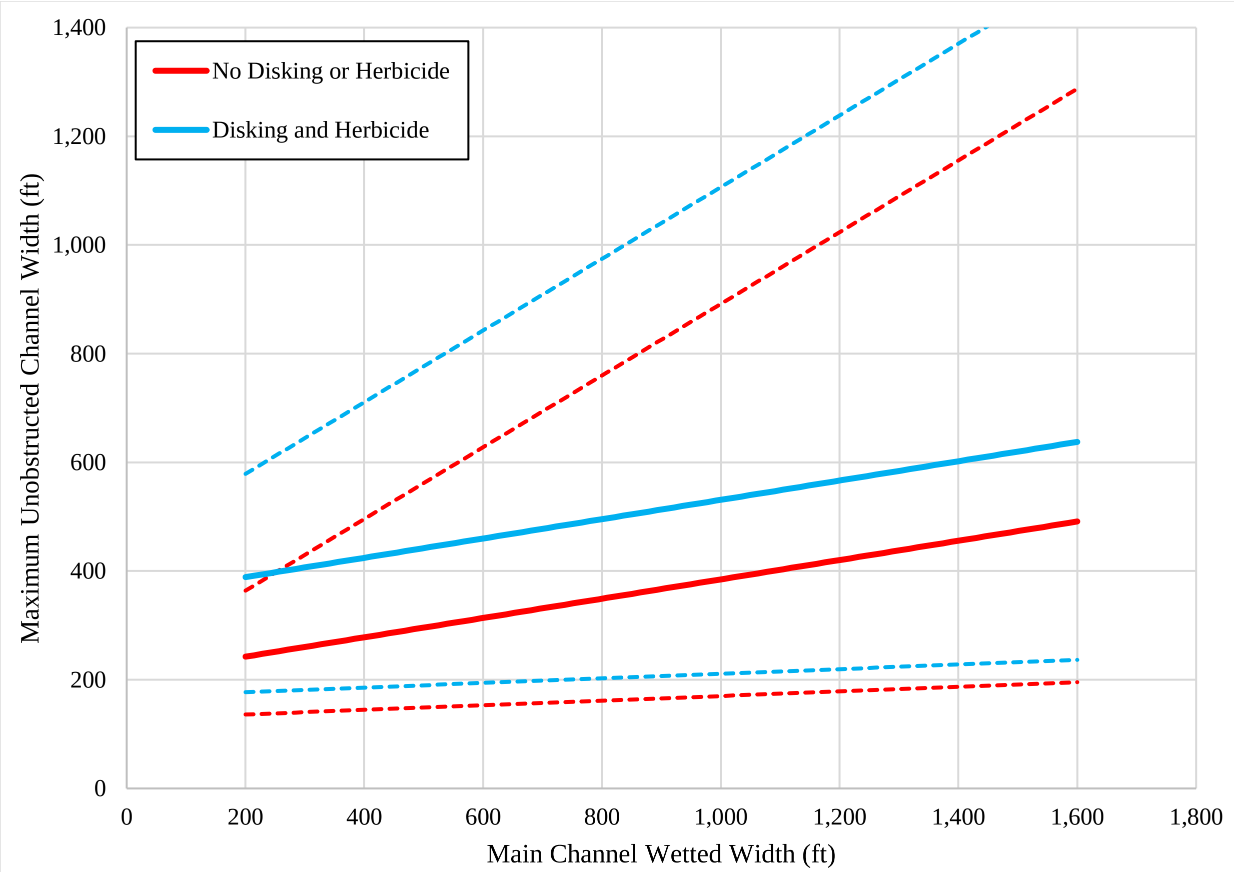


Figure 12. Predicted relationships of maximum unobstructed channel width (MUOCW) to 40-day peak discharge at transects with (blue) or without (red) management actions in the AHR from 2007–2015. Dashed lines represent 90% quantile regression prediction intervals and points display the subset of measured UOCWs at transects used in robust regression analyses. Points represent transects where no management actions (red), disking only (dark blue), or disking and herbicide (blue) occurred.



1792
1793 Figure 13. Predicted relationship between maximum unobstructed channel width and main channel
1794 wetted width at transects with (blue) or without (red) management actions in the AHR from 2007–
1795 2015. Dashed lines represent 90% quantile regression prediction intervals.

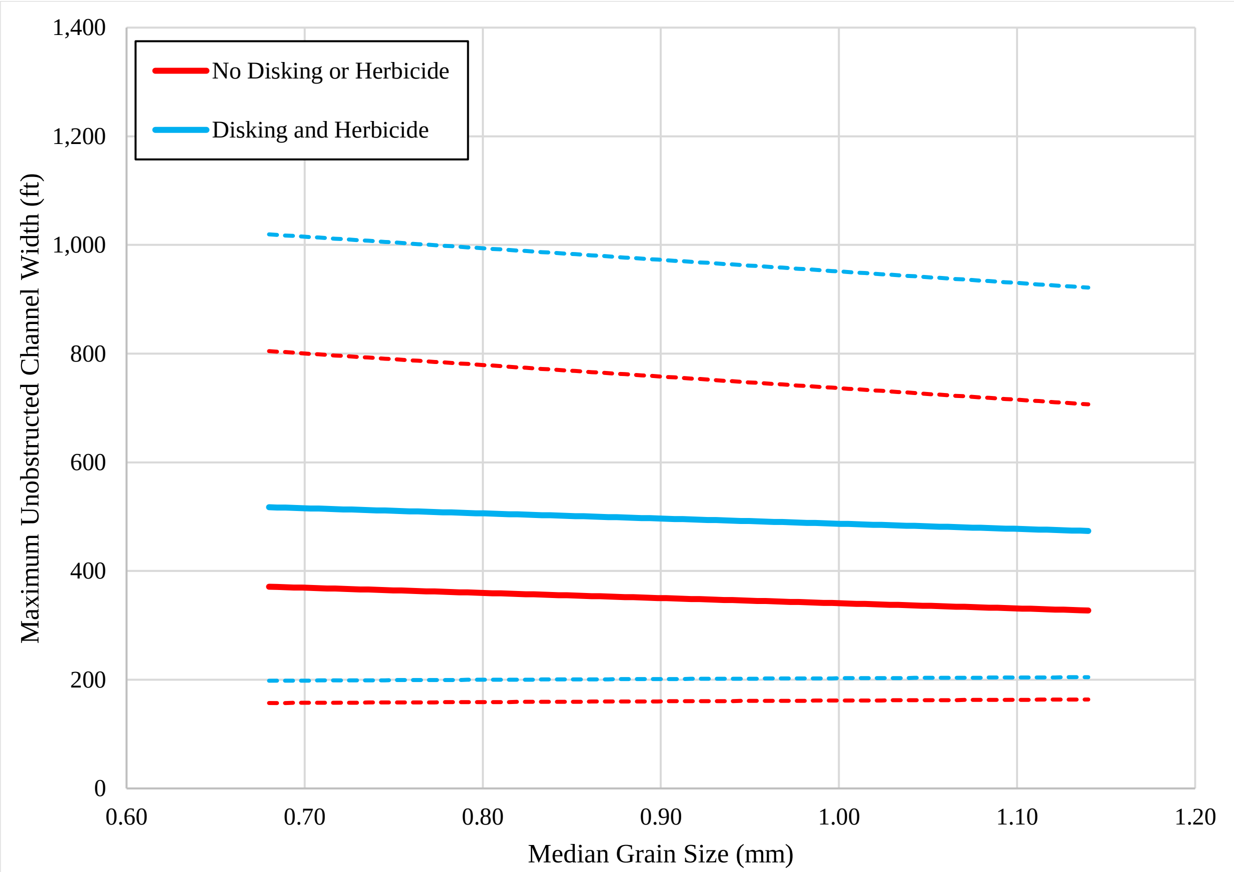


Figure 14. Predicted relationship between maximum unobstructed channel width and median grain size at transects with (blue) or without (red) management actions in the AHR from 2007–2015. Dashed lines represent 90% quantile regression prediction intervals.

We incorporated several measurements to validate the accuracy of the top MUOCW model we identified through the AIC model selection process. Utilizing the MUOCW linear model and betas previously stated for the 0.5 quantile, 39% of MUOCW predictions were within 100 ft and 69% were within 200 ft of actual values observed from 2007–2015. Once again, overestimating MUOCW was of special concern since narrower than predicted MUOCW potentially have more negative consequences for whooping crane habitat suitability than underestimations. Only 37% percent of MUOCW predictions were overestimated by more than 100 ft and 10% were overestimated by more than 200 ft.

We also compared mean observed and predicted MUOCW for all transects within the AHR in each year (Table 9) and compared observed and predicted widths for each bridge segment across all years (Table 10). Eight of the nine years assessed were found to contain mean prediction errors <20% of actual values (Table 9). Seven of the eleven bridge segments in the AHR were found to contain mean prediction errors <20% of actual values (Table 10).

In addition, we performed a Monte Carlo analysis using Oracle Crystal Ball software to assess the sensitivity of predicted MUOCW to the observed distributions of the variables contained in the top model. Appropriate distributional assumptions were determined by Oracle Crystal Ball and fit to observed data for each model variable and a total of 100,000 random simulations were run to calculate sensitivity associated with each variable based on contribution to variance. Overall, 40-day mean peak had the greatest impact on MUOCW and contributed 42.7% of the variance in predicted MUOCWs, disking contributed 32.8%, bankfull wetted width contributed 22.0%, median bed material grain size contributed -1.3% and herbicide contributed 1.1% (Appendix III).

Table 11. Comparison of mean observed and predicted maximum unobstructed channel width (MUOCW) in the AHR for the period of 2007–2015 using a 0.5 quantile regression. Values in parentheses represent 90% quantile regression prediction intervals.

Year	Observed MUOCW (ft)	Predicted MUOCW (ft)	Error (ft)	Error as % of Observed MUOCW
2007	300	354 (152 - 802)	54 (-148 - 501)	18 (-49 - 167)
2008	443	426 (183 - 883)	-17 (-260 - 440)	4 (-59 - 99)
2009	373	305 (140 - 747)	-68 (-234 - 374)	18 (-63 - 100)
2010	409	397 (189 - 854)	-12 (-220 - 445)	3 (-54 - 109)
2011	481	432 (206 - 894)	-49 (-275 - 413)	10 (-57 - 86)
2012	454	338 (159 - 786)	-116 (-295 - 332)	26 (-65 - 73)
2013	483	406 (190 - 864)	-77 (-293 - 380)	16 (-61 - 79)
2014	431	389 (179 - 843)	-42 (-252 - 412)	10 (-59 - 96)
2015	625	552 (265 - 1033)	-73 (-360 - 408)	12 (-58-65)

Table 12. Comparison of mean observed and predicted unobstructed channel width (UOCW) by bridge segment for the period of 2007-2015 using a 0.5 quantile regression. Values in parentheses represent 90% quantile regression prediction intervals.

Bridge Segment	Observed MUOCW (ft)	Predicted MUOCW (ft)	Error (ft)	Error as % of Observed
Overton - Elm Creek	324	156 (397 - 711)	-73 (-241 - 314)	18 (-61 - 79)
Elm Creek - Odessa	338	158 (444 - 697)	-106 (-286 - 253)	24 (-64 - 57)
Odessa - Kearney	307	155 (334 - 666)	-26 (-179 - 332)	8 (-54 - 99)
Kearney - Minden	328	161 (312 - 717)	15 (-152 - 405)	5 (-49 - 130)
Minden - Gibbon	400	178 (583 - 857)	-183 (-405 - 274)	31 (-69 - 47)
Gibbon - Shelton	414	185 (528 - 891)	-114 (-343 - 363)	22 (-65 - 69)
Shelton - Wood River	385	182 (415 - 831)	-30 (-233 - 416)	7 (-56 - 100)
Wood River - Alda	449	200 (502 - 938)	-52 (-302 - 436)	10 (-60 - 87)
Alda - Hwy 281	489	211 (604 - 1029)	-115 (-393 - 425)	19 (-65 - 70)
Hwy 281 - Hwy 34	466	212 (360 - 991)	106 (-148 - 631)	30 (-41 - 175)
Hwy 34 - Chapman	468	215 (457 - 1002)	11 (-242 - 545)	2 (-53 - 119)

Analysis of SDHF Performance

Simulated SDHF releases were added to observed mean daily flows for the period of 1998–2015 (Figure 18) to evaluate the predicted increase in channel width under full SDHF implementation. The modified flow series included ten SDHF releases. Simulated SDHF releases were added to the flow record during the month of April in two out of three years during dry periods. SDHF releases were not added in wet years or the years immediately following the two highest discharge years (1999 and 2011). Specifically, SDHF implementation was added in the years of 1998, 2001, 2002, 2004, 2005, and 2007. The SDHF hydrograph in all cases included two to three days of up-ramping flows, three days at a discharge of 8,000 cfs and two to three days of down-ramping flows following the peak. Ramping duration depended on observed discharge with longer ramping duration under low discharge conditions. SDHF volumes ranged from 26,000 to 68,000 acre-ft. Predicted increases of TUCW and MUOCW values at the 0.05, 0.50, and 0.95

response quantiles with and without SDHF releases (assuming a main channel bankfull wetted width of 1,000 ft, herbicide treatment, and no disking) are presented in Table 13. Implementation of an SDHF release in a given year is predicted to increase TUCW by 0 – 26 ft and MUOCW by 0 – 14 ft depending on baseline river discharge at the time of the release. The greatest increases in TUCW and MUOCW are predicted to occur when baseline river discharge is low.

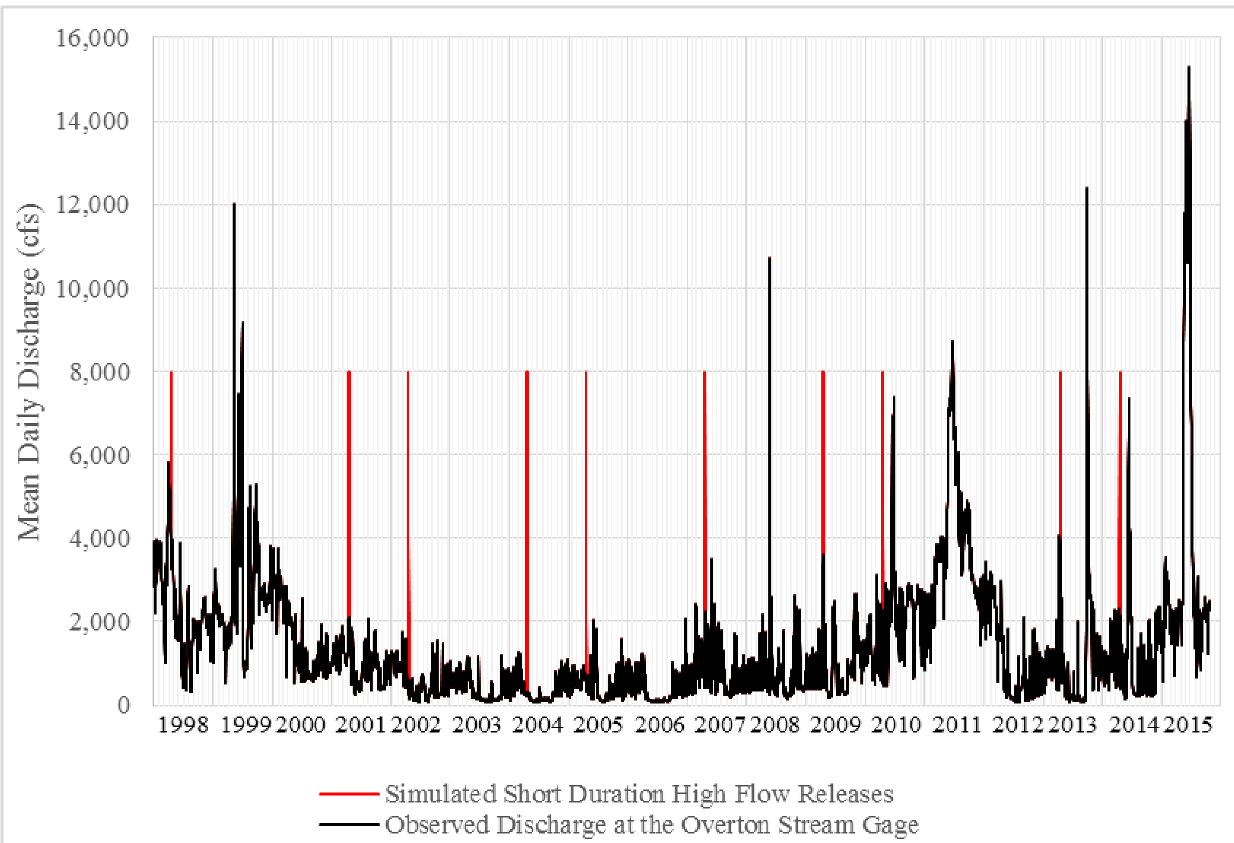


Figure 18. Observed hydrology at the USGS Overton Stream Gage (06768000) and simulated short duration high flow events of 8,000 cfs for three days in approximately two out of three years.

Table 13. Predicted increases in maximum unobstructed channel width (MUOCW) and total unvegetated channel width (TUCW) at specified quantiles (τ) with implementing a short duration high flow (SDHF) during 1998, 2001, 2002, 2004, 2005, and 2007 on the central Platte River, Nebraska.

	Δ MUOCW (ft)			Δ TUCW (ft)		
Year	τ (0.05)	τ (0.50)	τ (0.95)	τ (0.05)	τ (0.50)	τ (0.95)
1998	4	7	5	13	13	11
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	7	13	9	24	23	20
2002	7	13	9	24	23	21
2003	0	0	0	0	0	0
2004	5	9	6	17	17	15
2005	7	12	9	24	23	20
2006	0	0	0	0	0	0
2007	7	14	9	26	25	22
2008	0	0	0	0	0	0
2009	0	0	0	0	0	0
2010	0	0	0	0	0	0
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0

Discussion

The Program's FSM management strategy consists of sediment augmentation to offset the sediment deficit due to clear water hydropower returns, mechanical vegetation clearing and channel widening, and SDHF releases in approximately two out of three years to increase and maintain the width of channel free from vegetation. This investigation provides insights about the beneficial effects of each of these management actions in maintaining TUCW and more specifically, MUOCWs that are highly suitable for whooping crane roosting habitat.

This investigation included an indirect evaluation of sediment through inclusion of median grain size. Differences in median grain size through the AHR may be an indicator of sediment balance with coarser grain sizes in deficit reaches due to winnowing of bed material. However, differences in grain size may also be attributable to differences in local sediment transport capacity as a result of variability in channel width. Overall, median grain size was found to be correlated with maximum unobstructed channel width, with a predicted 10-foot increase in MUOCW for every 0.1 mm decrease in median bed material grain size. However, it is difficult to assess whether sediment supply is influencing width or width is influencing grain size. Overall, uncertainty in causation versus correlation may not be that important, as MUOCW appears to be somewhat insensitive to median grain size which only accounted for 1.3% of the variance in predicted MUOCWs (Appendix IV).

Program priority hypothesis Flow 3 postulates peak flow magnitude is a major driver in maximum unobstructed channel width. Specifically, increasing peak flow magnitude (metric is $Q_{1.5}$) is hypothesized to increase the vegetation-free width of the main channel in the AHR (Figure 13). Quantile regression analyses in this investigation strongly support the assertion of a positive relationship between peak flow magnitude and TUCW and MUOCW in the AHR. Overall, 40-day mean peak discharge accounted for 42.7% of the variance in predicted MUOCWs. The analyses, however, do not support the assertion that increasing peak flow magnitude through SDHF releases of 5,000 – 8,000 cfs for three days in two out of three years will produce substantive increases in the vegetation-free width of the channel. Maximum increases in TUCW of 26 ft and MUOCW of 14 ft are predicted. This is due to the very short duration and low volume of SDHF releases in relation to the 40-day peak discharge duration that is the best hydrologic predictor of TUCW and

MUOCW in the AHR. The difference in peak-volume relationships between observed natural peak flow events and SDHF is apparent in Figure 3.

Overall, these analyses strongly indicate peak flows significantly influence TUCW and MUOCW in the AHR, but SDHF releases, as currently envisioned, would likely not be effective in managing MUOCW to create and/or maintain suitable whooping crane habitat. SDHF is predicted to produce maximum increases in MUOCW of approximately 14 ft, which is a minimal effect during very dry periods when mean MUOCW is on the order of 100 ft narrower than the low end of the 500 – 700 ft range of highly-favorable UOCWs for whooping crane use (Chapters 2 and 3). During wetter years when baseline MUOCW is closer to the lower end of the suitable range, the much greater duration of the natural peak flow events appears to eclipse the limited effect of an SDHF.

Although it appears likely that SDHF releases will not be a viable management tool, disking in combination with herbicide application likely will. The predicted effect of channel disking and spraying is an increase of well over 100 ft in MUOCW across most of its distribution. The major limitation of disking, however, is the lack of a system-scale beneficial effect. The Program can utilize disking to effectively manage MUOCW at Program habitat complexes, but cannot utilize disking on other conservation or private lands without landowner agreements.

This investigation also highlights the uncertainties that are introduced when exploring the relationship between physical process and species habitat metrics. The quantile regression analysis results indicated a strong relationship between TUCW and hydrologic, geomorphic, and management variables with the top model explaining on the order of 42% of the variability in the data. However, when evaluating the relationship for MUOCW, which is primarily a habitat suitability metric for whooping cranes, the top model only explained 15% of the variability in the data. Uncertainty around predicted maximum unobstructed channel widths is evident in the 95% prediction intervals displayed in Figures 11 to 13. This loss of predictive ability occurs because the spatial distribution of vegetated bars and/or islands within the channel exerts a strong control on MUOCW. This is evident in Figure 4, where TUCW is somewhat consistent across all transects but MUOCW is highly variable depending on the location of vegetated bars within the channel.

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Appendix I. Total Unvegetated Channel Width (TUCW) robust linear regression model selection results from a 5-step process, including a full description of procedures, which were also utilized for both MUOCW modeling efforts.

In the first step, we determined the duration of peak discharge that best explained total unvegetated channel width by comparing AIC values of univariate robust regression models of 1, 3, 5, 10, 20, 30, 40, 50, and 60-day mean peak discharge durations. Three and 5 day durations coincide with SDHF flow duration management strategies. Duration covariates in models with a ΔAIC value ≤2.0 were passed along to the second modeling step. Based on AIC values, 40-day peak discharge duration was passed along to the second modeling step (Table I-1).

Table I-1. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection of peak discharge duration influence on total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to model selection step 1.

Peak Discharge Duration	AIC	ΔAIC	Likelihood	AIC_w	R^1
40 Days	10617.94	0.00	1.00	1.00	0.23
20 Days	10802.49	184.56	0.00	0.00	0.14
30 Days	10805.79	187.86	0.00	0.00	0.14
10 Days	10814.78	196.84	0.00	0.00	0.13
5 Days	10815.04	197.10	0.00	0.00	0.13
50 Days	10816.53	198.59	0.00	0.00	0.13
60 Days	10827.03	209.09	0.00	0.00	0.12
3 Days	10834.24	216.31	0.00	0.00	0.12
1 Day	10856.39	238.46	0.00	0.00	0.11
Null	11032.35	414.42	0.00	0.00	0.00

Second, we combined the best annual duration model covariates and mean peak flows from the previous year over the same duration. Forty-day duration peak discharge was combined previous the previous year's peak discharge. Combinations were made with 0 to 100% of peak flow from the previous year at intervals of 20%. We hypothesized a lag effect of peak flows would carry over to the current year and this step would help us determine how important previous year peak flow was to total unvegetated channel width. Important combined previous and current year duration variables, in models with a ΔAIC value ≤2.0, were passed along to the fourth modeling step, which, in part, compared all hydrologic variables for ability to explain total unvegetated channel width (Tables I-2, I-4a). Based on AIC values, 40 Day peak discharge with 0% discharge from the previous year was passed along to the fourth modeling step.

Table I-2. Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of current and previous year 40-day peak discharge influence on total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to model selection step 2.

Current and Previous Year Peak Discharge	AIC	ΔAIC	Likelihood	AICw	R^1
40 days with 0% Last Year	10617.94	0.00	1.00	1.00	0.23
40 days with 40% Last Year	10791.17	173.23	0.00	0.00	0.14
40 days with 60% Last Year	10792.17	174.23	0.00	0.00	0.14
40 days with 20% Last Year	10796.25	178.31	0.00	0.00	0.14
40 days with 80% Last Year	10796.78	178.84	0.00	0.00	0.14
40 days with 100% Last Year	10803.70	185.76	0.00	0.00	0.14
Null	10937.86	371.44	0.00	0.00	0.00

Third, we performed the same procedure from step 2 for mean minimum discharge for 10, 20, 30, and 40 day durations. A step to add a lag effect of minimum discharge was not included due to little influence of low flows from previous year compared to high flows on total unvegetated channel width. Important minimum duration variables, in models with a ΔAIC value ≤2.0, were passed along to the fourth modeling step (Table I-3).

Table I-3. Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of mean minimum discharge 40-day peak discharge influence on total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to model selection step 3.

Mean Minimum Discharge Duration	AIC	ΔAIC	Likelihood	AICw	R^1
40 Days	10971.39	0.00	1.00	0.96	0.04
20 Days	10978.07	6.68	0.04	0.03	0.04
30 Days	10982.23	10.84	0.00	0.00	0.03
50 Days	11006.31	34.92	0.00	0.00	0.02
Null	11032.35	60.96	0.00	0.00	0.00

In our fourth model selection step, we tried to identify to best hydrological and non-hydrological variables. All hydrological variables, including those from the best peak and minimum flow models, were compared by modeling total unvegetated channel width in univariate models (Table I-4a). We then performed the same procedure for all non-hydrological variables (Table I-4b). Covariates in important univariate models (ΔAIC≤2.0) were then passed to the final modeling step. We also included several other non-hydrological variables which have been hypothesized to have an importance in explaining total unvegetated channel width when utilized as an additive effect with 40-day duration peak discharge. For example, we hypothesize disked transects would have wider total unvegetated channel widths than non-disked transects given the same peak discharge duration and flow.

Table I-4a. Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of hydrologic variables on total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to model selection step 4.

Hydrological AIC table	AIC	ΔAIC	Likelihoo	AICw	R^1
40-Day Peak Discharge	10617.9	0.00	1.00	1.00	0.23
Mean June Discharge	10847.4	229.53	0.00	0.00	0.11
Mean Growing Season	10864.1	246.23	0.00	0.00	0.10
Null	10937.8	319.92	0.00	0.00	0.00
30-Day Minimum Discharge	10971.3	353.45	0.00	0.00	0.04

Table I-4b: Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of non-hydrologic variables on total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to model selection step 4.

Non-Hydrological AIC table	AIC	ΔAIC	Likelihood	AICw	R[1]
Wetted Width	10618.72	0.00	1.00	1.00	0.23
Mile	10772.12	153.40	0.00	0.00	0.15
Median Grain Size	10817.11	198.39	0.00	0.00	0.13
Herbicide	11006.73	388.00	0.00	0.00	0.02
Channel Consolidation	11016.53	397.80	0.00	0.00	0.01
Disking	11023.32	404.60	0.00	0.00	0.01
Channel Slope	11025.99	407.26	0.00	0.00	0.01
Null	11032.35	413.63	0.00	0.00	0.00

Finally, we used the best identified hydrologic and non-hydrologic variables, 40-day peak discharge with 0% of last year's flow and wetted width, along with other geomorphic and management variables to develop a suite of models to explain total unvegetated channel width observed from 2007 to 2015 (Table I-5). We included variables in final models with seemingly little explanatory power based on AIC values reported in step four. These included variables that were hypothesized to explain trends in total unvegetated channel width not captured by wetted width and 40-day peak discharge. For example, disking was included in the final modeling step due to the hypothesis disked transects generally had wider total unvegetated channel width than non-disked channels regardless of wetted width or 40-day peak discharge value.

Table I-5. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection results of annual total unvegetated channel width in the Associated Habitat Reach (AHR), 2007–2015.

Non-Hydrological AIC table	AIC	ΔAIC	Likelihood	AICw	R[1]
40-Day Peak + Disking + Herbicide + Wetted Width	10181.85	0.00	1.00	0.56	0.42
40-Day Peak + Disking + Wetted Width	10182.35	0.50	0.78	0.44	0.42
40-Day Peak + Disking + Herbicide + Median Grain Size	10441.50	259.65	0.00	0.00	0.32
40-Day Peak + Disking + Median Grain Size	10445.46	263.61	0.00	0.00	0.32
40-Day Peak + Disking + Herbicide + River Mile	10446.75	264.89	0.00	0.00	0.32
40-Day Peak + Disking + Mile	10454.41	272.56	0.00	0.00	0.31
40-Day Peak	10617.94	436.08	0.00	0.00	0.23
Null	11032.35	850.50	0.00	0.00	0.00

[1]Null model tests the hypothesis that unobstructed channel width remained constant from 2007-2015.

Appendix II. Maximum Unobstructed Channel Width (MUOCW) robust linear regression model selection results from multi-step process.

Table II-1. Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of peak discharge duration influence on unobstructed channel width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to unobstructed channel width model selection step 1.

Peak Discharge Duration	AIC	ΔAIC	Likelihood	AICw	R^1
40 Days	10694.6	0.00	1.00	1.00	0.08
20 Days	10723.8	29.20	0.00	0.00	0.06
30 Days	10724.8	30.15	0.00	0.00	0.06
10 Days	10726.9	32.27	0.00	0.00	0.06
5 Days	10734.8	40.21	0.00	0.00	0.06
50 Days	10735.6	41.01	0.00	0.00	0.06
60 Days	10738.4	43.73	0.00	0.00	0.06
3 Days	10743.2	48.56	0.00	0.00	0.05
1 Day	10759.4	64.77	0.00	0.00	0.04
Null	10825.1	130.51	0.00	0.00	0.00

Table II-2. Akaike's Information Criterion (AIC), quantile regression (τ = 0.5) model selection of current and previous year 40-day peak discharge influence on unobstructed channel width (UOCW) in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to UOCW model selection step 2.

Previous Year Discharge	AIC	ΔAIC	Likelihood	AICw	R^1
40-Day Peak with 0% Last Year	10694.64	0.00	1.00	1.00	0.08
40-Day Peak with 60% Last Year	10720.06	25.42	0.00	0.00	0.07
40-Day Peak with 40% Last Year	10720.16	25.52	0.00	0.00	0.07
40-Day Peak with 80% Last Year	10722.88	28.24	0.00	0.00	0.06
40-Day Peak with 20% Last Year	10723.58	28.94	0.00	0.00	0.06
40-Day Peak with 100% Last Year	10727.13	32.49	0.00	0.00	0.06
Null	10825.15	130.51	0.00	0.00	0.00

Table II-3. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection of mean minimum discharge 40-day peak discharge influence on unobstructed channel width (MUOCW) in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to MUOCW model selection step 3.

Mean Minimum Discharge Duration	AIC	ΔAIC	Likelihood	AICw	R^1
30 Days	10805.11	0.00	1.00	0.38	0.01
20 Days	10805.24	0.12	0.94	0.36	0.01
10 Days	10805.91	0.80	0.67	0.25	0.01
40 Days	10812.55	7.44	0.02	0.01	0.01
Null	10825.15	20.03	0.00	0.00	0.00

Table II-4a. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection of hydrologic variables on unobstructed channel width (UOCW) width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to UOCW model selection step 4a.

Hydrological AIC table	AIC	ΔAIC	Likelihood	AICw	R^1
40-Day Peak Discharge	10694.64	0.00	1.00	1.00	0.08
Mean June Discharge	10766.91	72.27	0.00	0.00	0.04
Mean Growing Season Discharge	10780.44	85.80	0.00	0.00	0.03
30-Day Minimum Discharge	10805.11	110.47	0.00	0.00	0.01
Null	10825.15	130.51	0.00	0.00	0.00

Table II-4b. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection of non-hydrologic variables on unobstructed channel width (UOCW) width in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to UOCW model selection step 4b.

Non-Hydrological AIC table	AIC	ΔAIC	Likelihood	AICw	R^1
Main Channel Wetted Width	10738.56	0.00	1.00	1.00	0.05
Median Grain Size	10755.30	16.74	0.00	0.00	0.04
MILE	10771.16	32.60	0.00	0.00	0.04
Disking	10789.43	50.86	0.00	0.00	0.02
Herbicide	10809.12	70.56	0.00	0.00	0.01
Channel Slope	10820.28	81.72	0.00	0.00	0.00
Channel Consolidation	10825.67	87.11	0.00	0.00	0.00
Null	10825.15	86.58	0.00	0.00	0.00

Table II-5. Akaike's Information Criterion (AIC), quantile regression ($\tau = 0.5$) model selection results of annual maximum unobstructed channel width (MUOCW) in the Associated Habitat Reach (AHR), 2007–2015. Results correspond to MUOCW model selection step 5.

Combined Models	AIC	ΔAIC	Likelihood	AICw	R^1
40-Day Peak + Main Channel Wetted Width + Disking + Herbicide + Median Grain Size	10581.75	0.00	1.00	0.69	0.15
40-Day Peak + Main Channel Wetted Width + Disking + Median Grain Size	10584.56	2.81	0.25	0.17	0.15
40-Day Peak + Main Channel Wetted Width + Disking + River Mile + Herbicide	10585.73	3.99	0.14	0.09	0.15
40-Day Peak + Main Channel Wetted Width + Disking + River Mile	10588.51	6.76	0.03	0.02	0.14
40-Day Peak + Main Channel Wetted Width + Disking	10588.73	6.98	0.03	0.02	0.14
40-Day Peak + Main Channel Wetted Width	10627.11	45.36	0.00	0.00	0.12
Null	11032.35	450.60	0.00	0.00	0.00

Appendix III. Oracle Crystal Ball Monte Carlo simulation results for top MUOCW Quantile regression model at the 0.5 quantile. Variable distributions are presented in figures III-1:5 and figure III-6 displays the sensitivity analysis results.

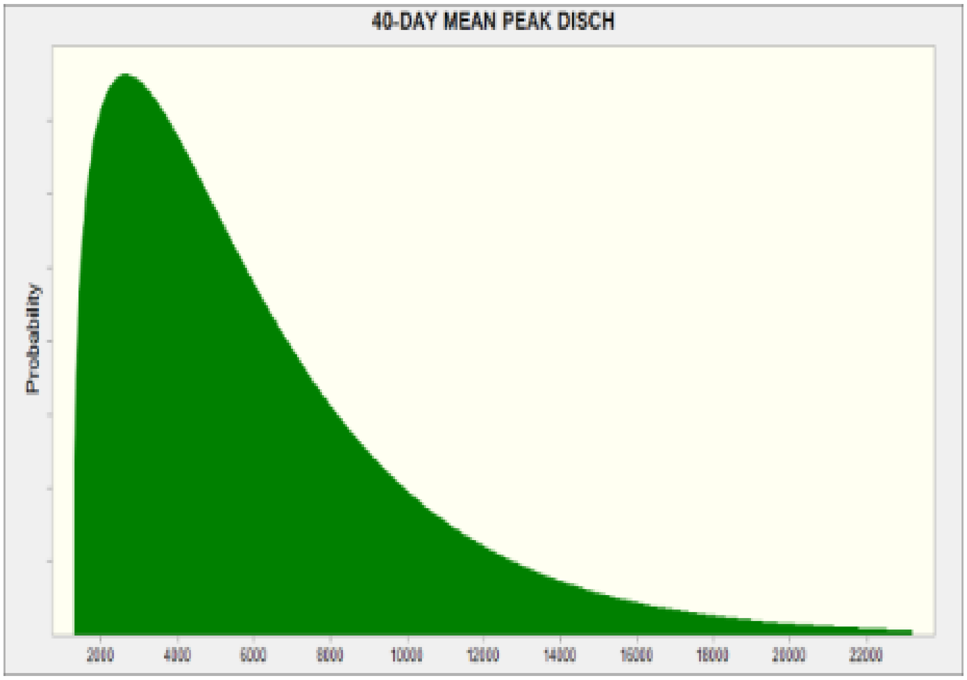


Figure III-1. Gamma distribution fitted to the predictor variable "40-day peak" for use in a sensitivity analysis through Monte Carlo simulation.

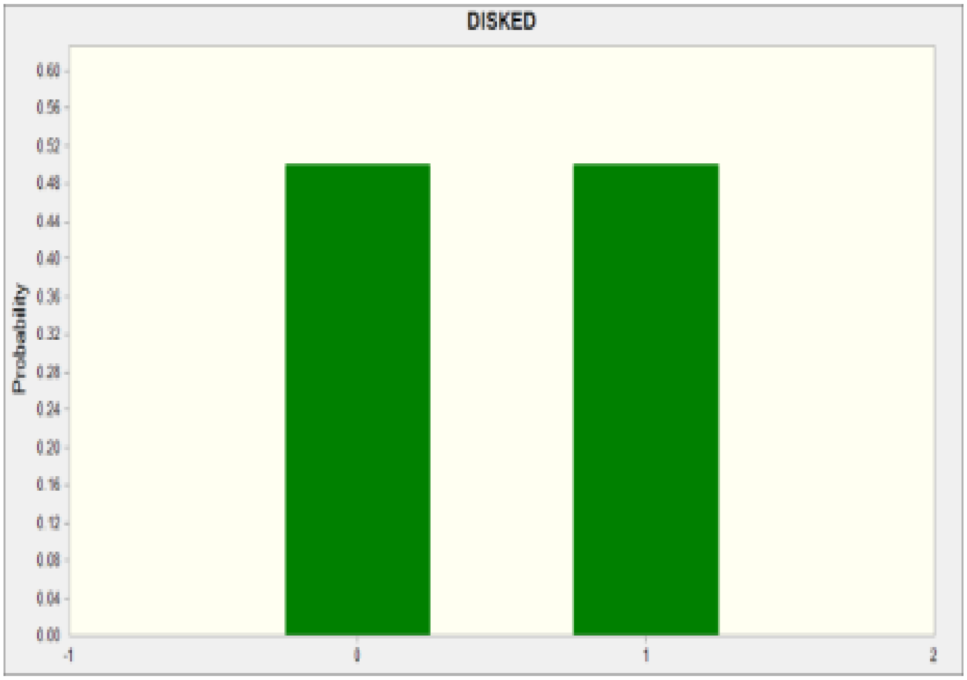


Figure III-2. Uniform distribution fitted to the binary predictor variable "Disking" for use in a sensitivity analysis through Monte Carlo simulation.

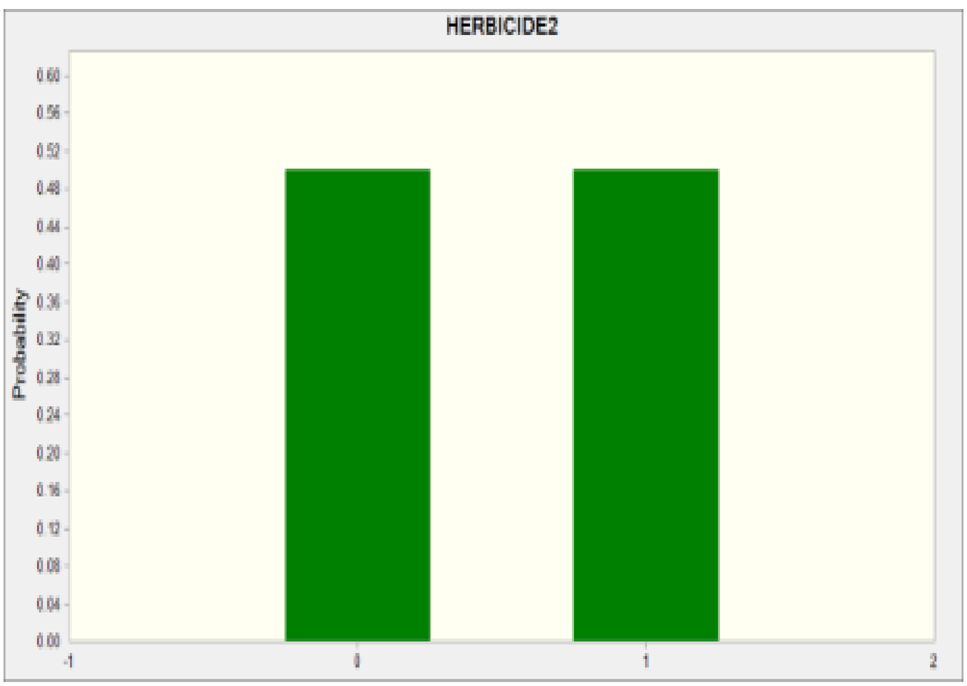


Figure III-3. Uniform distribution fitted to the binary predictor variable "Herbicide" for use in a sensitivity analysis through Monte Carlo simulation.

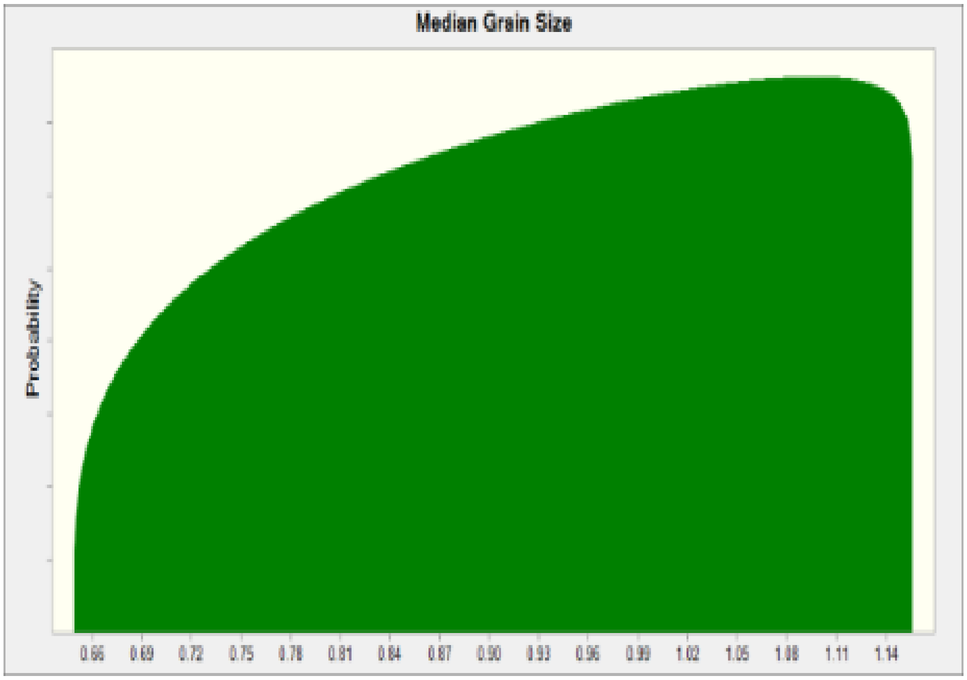


Figure III-4. Beta distribution fitted to the binary predictor variable “Median Grain Size” for use in a sensitivity analysis through Monte Carlo simulation.

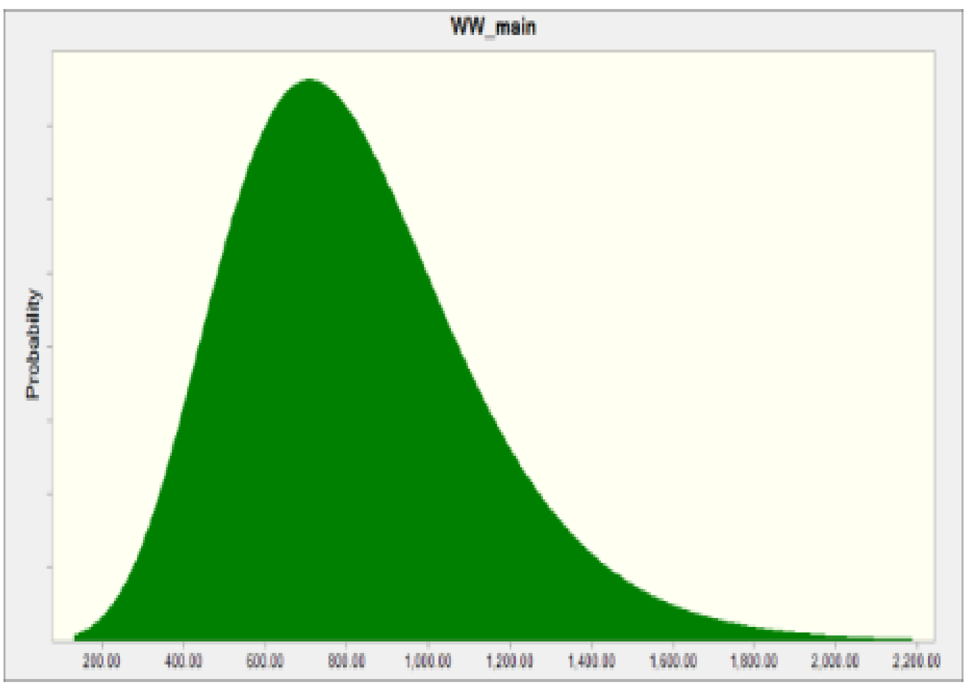
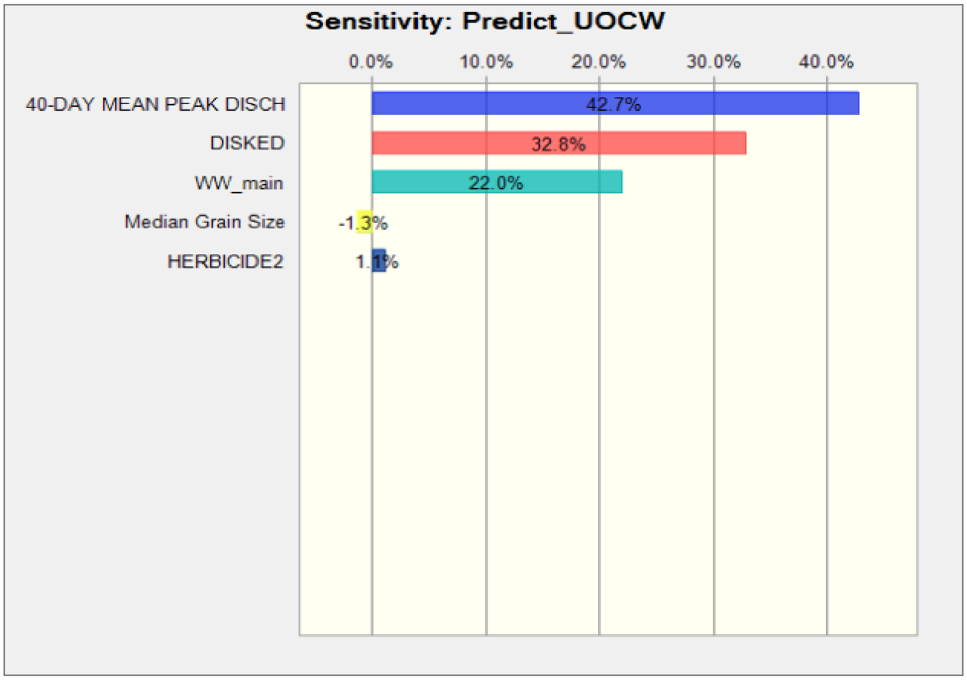


Figure III-5. Lognormal distribution fitted to the binary predictor variable “Main Channel Wetted Width” for use in a sensitivity analysis through Monte Carlo simulation.



2133
2134 **Figure III-6**. Monte Carlo simulation sensitivity results for the response variable "Maximum
2135 Unobstructed Channel Width".

SUMMARY OF KEY FINDINGS

To date, the Platte River Recovery Implementation Program (Program) has invested nine years implementing an Adaptive Management Plan (AMP) to evaluate, in part, the Program's ability to contribute to the survival of whooping cranes during migration through increased habitat suitability and use of the Associated Habitat Reach (AHR). During this time, enough progress has been made to allow us to address critical uncertainties and assess the performance of the Flow-Sediment-Mechanical (FSM) management strategy. In short, given the results of our weight of evidence approach outlined in Chapters 1-4, the Executive Director's Office (EDO) of the Program concludes implementation of the FSM strategy will not create or maintain suitable in-channel roosting habitat for whooping cranes. A narrative of key findings follows.

We used data collected systematically along the central Platte River during 2001-2013 to evaluate riverine habitat selection within the AHR. The goal of our analysis was to develop habitat models to be used to inform and direct management activities the Program is able to implement. We were unable to establish a relationship between whooping crane use and flow metrics or total channel width, but rather found unobstructed channel width and distance to the nearest forest were good predictors of whooping crane use. Our findings indicate the Program would have the potential to influence whooping crane use of the central Platte River through increasing unobstructed channel widths that are <500ft and mechanically removing trees within areas where the unforested corridor width is <1,000ft.

We also used telemetry data obtained over the course of five years, 2010-2014, to provide an unbiased evaluation of whooping crane use of riverine habitat throughout the migration corridor. Based on findings in Chapter 2, we evaluated the influence of unobstructed channel width and distance to nearest forest on whooping crane selection of riverine habitat throughout the North-central Great Plains in the United States. Our results indicate probability of selection for unobstructed channel width was maximized around 650 ft and unforested corridor width was maximized around 1,000ft. Based on results of Chapters 2 and 3, the Program informally accepted unobstructed channel widths of at least 600 ft and unforested corridor widths of at least 1,000 ft as highly favorable whooping crane riverine roosting habitat and as management objectives for whooping crane habitat at the Program's Pawnee complex between Odessa and Kearney, Nebraska.

As a final step, we used annual delineations of total channel width and maximum unobstructed channel width throughout the AHR to evaluate several flow and mechanical management alternatives hypothesized to create and maintain whooping crane roosting habitat. Results of our quantile regression analyses indicate a positive relationship between unobstructed channel width and disking and peak discharge. Our results also indicate disking and flows substantially exceeding the magnitude and duration of a Short-Duration High Flow (SDHF) release are the only management activities able to create and maintain 600 ft unobstructed channel widths believed to be favorable for whooping crane roosting habitat.

Implementation of SDHF releases, the physical process driver of the FSM management strategy, is hypothesized to produce suitable riverine roosting habitat for whooping cranes within the AHR. However, natural high flow events in 2007, 2008, 2010, 2011, 2013, and 2014 all exceeded minimum SDHF magnitude and duration and only with the extreme high flow event occurring in 2015 did average unobstructed channel width exceed 600 ft. As such, our weight of evidence approach leads us to conclude implementation of the FSM management strategy will not create or maintain favorable whooping crane riverine roosting habitat. Mechanical creation and maintenance of in-channel roosting habitat in the AHR, however, is ongoing and evaluations of use of these habitats are forthcoming.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
APPENDIX A
Joint Whooping Crane Documents Final Peer Review Package

Appendix Contents:

- **Document #01, Acceptance Report from Louis Berger –** Report from the Program's Independent Science Review Contractor, Louis Berger, that summarizes responses from the three peer reviewers as to whether they could accept the WEST report and the habitat synthesis chapters as revised based on their comments and the EDO responses. This document includes the comment spreadsheet for both documents and the EDO responses to those comments.

- **Document #02, Responses to comments from Doug Shields –** Comments from peer reviewer Doug Shields and EDO responses that were inadvertently left out of Document #04 (see below).

- **Document #03, Responses to additional peer reviewer comments –** Before finalizing Document #01, Louis Berger shared a draft with the EDO. This document includes some specific responses to additional peer reviewer comments from Dave Baasch in the EDO, called out in yellow highlights.

- **Document #04, Initial peer review report from Louis Berger –** This is the original report from Louis Berger from December 2016 summarizing the initial results of the peer review process.

ACCEPTANCE DOCUMENTATION

Platte River Recovery Implementation Program
Data Synthesis Compilation, Whooping Crane (Grus americana) Habitat Synthesis Chapters and Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River, Nebraska

Introduction

This report documents the acceptance of the following two reports prepared for the Platte River Recovery Implementation Program (PPRIP) concerning Whooping Crane Habitat by the assigned peer review panel:

- Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River, Nebraska, prepared by Western Ecosystem Technology, Inc. (hereafter, "WEST report"). The WEST report is a data analysis report that includes multiple analyses of the Program's whooping crane monitoring data that was collected within the Associated Habitat Reach (AHR), 2002–2013.

- Combined set of four whooping crane "habitat synthesis chapters" related to the habitat of and use by the whooping crane on the central Platte River prepared by the Executive Director's Office (EDO) of the PRRIP (hereafter "synthesis chapters").

Peer Review Summary Report

Three panel members were selected to conduct an independent desktop peer review between August 9, 2016, and October 31, 2016. Panel members submitted their concerns to general and chapter-specific questions provided to them; rated both the WEST report and synthesis chapters in five different categories; provided overall recommendations and specific comments on the text of chapters, by page and line number. Panel members were asked to provide their recommendation to either accept the WEST Report and synthesis chapters, accept with revisions, or deem the reports unacceptable. All three panel members recommended that the WEST report and synthesis chapters be accepted with revisions.

Louis Berger prepared a Summary Report and compiled the specific comments into a spreadsheet, organized by WEST Report and Synthesis Chapters, providing chapter, page and line numbers (if applicable). The Summary Report provided an overview of the formal, independent, external scientific peer review, including the panel member's ratings and recommendations. The Summary Report and comment spreadsheet were submitted to PRRIP in December 2016 for review and response.

Headwaters Corporation reviewed the Summary Report and comment spreadsheet. Based on the recommendations, both documents were modified and a spreadsheet created (**Exhibit 1**) to describe the modifications made and to obtain feedback on the changes from the reviewers and ultimately final acceptance of both documents.

Acceptability Review

Panel members were asked to review the modified document, particularly the items where they had indicated changes were necessary before the two documents would be "acceptable" and indicate their acceptance of the final documents on the spreadsheet (Exhibit 1) or other written format. The following provides a brief summary of each reviewer's response regarding the modifications. Individual responses are documented in Exhibits 1 or 2.

Brian Cade, PhD, Bio Statistician

Dr. Cade was pleased with how the authors responded and incorporated all major statistical modifications suggested, including the suggested word changes to "relative selection". Headwaters was notified of Dr. Cade's additional suggested edit to a heading in Table 13 (Synthesis Chapters) from "changes in mean" to "quantiles". Based on his email, both reports are acceptable. See **Exhibit 2** for a copy of his email response.

Elizabeth Smith, PhD, Whooping Crane Biologist

Dr. Smith provided response on the spreadsheet (**Exhibit 1**) and indicated by email that she did not find anything that would entail any lengthy revision. All changes were accepted on both reports; however, she did provide additional clarification/comments on the synthesis chapters that did not fall under the accept category, which are highlighted in bold in **Exhibit 1** Synthesis Chapters.

Doug Shields, Jr., PhD, Hydraulic Engineer

Dr. Shields stated there still should be evidence in the documents of integration of efforts to manage for Whooping Crane with those directed at the other species of concern such as sturgeon, least tern, piping plover. Shields noted that his comments (Question # 9, Page 20 of Summary Report) were not addressed concerning findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), Kui et al. (2014), Diehl et al. (2016), Manners et al. (2015) and Edmaier et al. (2015). He also provides additional comment regarding the management models. A copy of his initial response is provided in **Exhibit 2**. PRRIP prepared an additional response to Dr. Shields comments (**Exhibit 3**). Dr. Sheilds acknowledged the responses and states that from his perspective they are minimally satisfactory. He understands the points made in the response about the long time frame involved in the AM cycle; and encourages program administrators to devise a more nimble approach for incorporating breaking research and new scientific learning into project management.

Conclusion

Dr. Cade and Dr. Smith accepted both documents as modified; however additional comments were provided as presented in Exhibits 1 and 2. Dr. Shields accepted both documents “pro forma.” His comments are provided in Exhibits 2 and Exhibit 3.

EXHIBIT 1 (Comment Spreadsheet)

WEST REPORT	**Page 1 - 11**
SYNTHESIS CHAPTERS	**Page 12 - 19**

PANEL MEMBER COMMENT SPREADSHEET Platte River						
Comment ID #	**Chapter or Section**	**Page #**	**Reviewer**	**Comment**	**Issues to Address for making report Acceptable**	**PRRIP Response**
				WEST REPORT		
1	General		Shields	Please allow a few observations that do not clearly fall under any question below. I realize some of my comments here are well outside the general purview of the PRRIP. The documents for review describe long-term, expensive efforts to provide adequate habitat for a small subset (5-10%) of the small surviving population of a single species for, "~two to three days on average," and range from, "one to several days," twice a year. The western migratory population is estimated to be about 300 individuals (Chapter 1, Figure 3), so we are talking about 15-30 animals using a 90-mile-long reach of the Platte for less than 7 days per year, total. Perhaps the numbers are even smaller, as Table 8 of the WEST report shows an average of 11 and 8 animals, or 4% and 3% of the population, using the AHR in Spring and Fall, respectively for the period 2001-2014.		Noted. 19 cranes/200 in the population= ~10% where as 19 cranes/300 in the population = ~6% thus the stated range of 5-10% use of the Platte River on an annual basis.
2	General		Shields	These ~7 days of annual use (2 to 3 days in Spring and 2 to 3 days in Fall) are spread over several weeks in the Spring and in the Fall. Such an intense focus on lightly-used habitat for a single species seems illogical. In my view the ESA process misplaces emphasis on species rather than habitat. A focus on restoring the properties and characteristics of the ecosystem, more specifically habitat and associated processes that create and sustain habitats, would potentially benefit a wider range of species and lead to better long-term outcomes than attempting to precisely target the preferences of a single species.		Noted
3	General		Shields	I am aware that the PRRIP is also addressing issues associated with least tern, piping plover and pallid sturgeon. However, the documents covered by this review are completely silent about those species. In particular, I think it would be valuable to discuss management activities that potentially benefit all four targeted species or, more to the point, activities that produce pre-impact habitats and processes.		Noted
4	General		Shields	The small size of the studied population and their transient presence in the AHR creates an extremely difficult problem when trying to produce defensible scientific results. I appreciate the dedication and effort of the teams involved in this work, but clear-cut, objective conclusions are hard to obtain. The resource selection documented by the systematic monitoring, if it is perfectly accurate, shows the habitat preferences of members of a depleted population acting in a degraded and stressed system. In a system more similar to the one that existed in the nineteenth century, selection behavior might have been different.		Noted

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
5	General		Shields	The difference between spring and fall population fraction use trends (e.g., Figures 18 and 22) was not explained. No hypotheses were presented or tested regarding this phenomenon.	X	No Program hypothesis about use exists that separates spring and fall migration. That is why results include trends in annual use as it is hypothesized that whooping crane use will increase as the Program implements more management activities (i.e., through time). However, the data exhibited large variation by season which warranted looking at the seasons separately.
6	General		Shields	The terms “in-channel,” “off-channel,” and “diurnal” are all used as descriptors of the words “use,” or “habitat,” without definition.	X	Definitions added.
7	General		Shields	It is not at all clear what is meant by, “subsequent diurnal locations of crane groups,” in the first paragraph under “diurnal habitat selection methods.” Diurnal is defined as, “of, or during the day,” or “daily.” Did not the systematic aerial PRRIP surveys occur in daytime?		Clarification added.
8	General		Smith	Reorganize report (See Smith comments in Appendix A-12 to A-24)	**X - Accept, hopefully suggestions will be helpful at that time**	The report will be reorganized as necessary for a publication.
9	Exec Sum	p. 7-8	Smith	Clearly state the objective of the study in the Executive Summary (p. 7, para. 1, line 1) and in the Introduction (p. 8, para. 1, line 10)	X - Accept	Stated
10	General		Smith	Add a “Summary of Findings” section to the report to provide concise review of the main results of the study that can be used to convey this information to managers and decision makers. Key points should center on: 1) a more informative Introduction that provides the historical context of this endangered species and its linkage and dependence on this altered riverine ecosystem; 2) reviewing previous research that sets the stage for understanding the monitoring and assessment challenges; and, comparing those results with results of this report to assess the current approach and results in this report 3) discussing continuing challenges and dilemma of designing monitoring programs that provide data appropriate for use in the questions being asked and make recommendations for improving the monitoring program; 4) processing these results into tangible management strategies that achieve the Program objectives.	X - Accept	Information has been added to provide historical context and previous research. We do not feel it is appropriate to discuss monitoring program challenges in the contect of this analysis, other than the acknowledgements made when analying non-systematic data. The PRRIP's Governance Committee determines the 'tangible management strategies' so it was our goal to analyze and report on the data so they have the information to do so.
11	General		Smith	Provide a brief overview of the Whooping Crane including the following: a. Description and life history b. Reasons for population decline and Endangered status c. Importance of migratory corridor for the Aransas-Wood Buffalo population, with emphasis on central Platte River, including critical habitat designation Suggested citations provided in Smith comments (A-12 to A-24)	X - Accept	Information has been added to provide life history, declines, migration.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
12	General		Smith	Provide a brief literature review of previous studies that identified need for management criteria and habitat evaluations a. History of change in this region b. Establishment of PRRIP c. Overview of contribution of previous studies d. Management needs within PRRIP that are to be addressed by this study	X - Accept	Information has been added to provide research context.
13	1.0 Introduction	p. 7	Smith	Within the Introduction, present an overview of historical observational databases and the advantage of aerial versus ground surveys, and using unique and non-unique data points.	X - Accept	Beyond the scope of this report, we did not perform a review or comparison of databases It is just a clarification of how you decided which data to use
14	1.0 Introduction	p. 7	Smith	Within the introduction justify the inclusion of 2nd and 3rd approaches as either appendices or including in the main report in the Introduction. Provide more details about the value of including 2nd and 3rd approaches in the Methods to accompany Table 1 (p. 11)	X - Accept	Added text describing the additional work to look at "impacts" (see comments for #42 and #43)
15	2. In-Channel Habitat Selection Methods	p 11 p. 12	Cade	Availability definition is not unreasonable (subsection of river 10 miles upstream and 10 miles downstream viewable from flight trajectory) given there are many possible ways to define resource availability. However, the flight trajectory towards the Platte R. itself may be selection for specific sections of the river with desirable characteristics, i.e., some constraint on choices may already have been made. So while it is not unreasonable to restrict availability the way you have done such that it is local (±10 miles from used location) and changing for every roost site, it would be equally reasonable to assume that this large migratory bird could have gone anywhere on the migration trajectory across the Platte R. in Nebraska and, thus, the entire stretch of river was available to any crane for initial roosting. Clearly, this definition of availability could completely change the results of the RSF analysis. Would it be informative to consider estimating an RSF this way where availability was defined by the larger scale and considered the same for all cranes within a year? If this demonstrated similar selection patterns as the more local/changing availability scale, would it strengthen interpretations?		There is little scientific evidence of site fidelity from migration to migration or year to year, which would indicate the birds are not establishing their tragectory based on their memory of a specific location on the Platte River. Furthermore, limiting the area defined to be available as the 90 mile reach that is surveyed does not seem justifiable as the east and west end of the study area are abitrary with respect to the migration corridor for whooping cranes. Using telemetry data, as was done in Chapter 3, is more appropriate for the broader scope described here.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
16	2. In-Channel Habitat Selection Methods	p12	Shields	I do not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. The justification given for analyzing a 10-mile long reach for in-channel habitat is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft. above ground level." No data are provided regarding the flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable ("…an assessment of viewsheds from 3,000 ft. above ground level by PRRIP personnel…"). How sensitive are your findings to the 10-mile assumption? Would an assumed available reach length 5 miles for the choice set produce a different outcome? Further since the land cover variables encompass conditions within a 3-mile radius of an analyzed point, the actual distance from the selection point to the boundary of the choice set could exceed five miles. I assume that monitoring flights were conducted in such a way that the overflying aircraft did not modify crane behavior, but it would be good to read an assurance to that effect.	X	Additional analyses conducted and text added that describes the sensitivity of our results to the area considered available. A citation was also included that describes the elevation whooping cranes migrate at (3,000 ft above ground level). Monitoring flights do not influence where whooping cranes are sighted at and they have not been observed responding to the plane; text added. The available locations for off-channel habitat selection analyses were within a 3-mile buffer around each use location so the maximum distance an available location could be from a use location would be 3 miles.
17	2. In-Channel Habitat Selection Methods	p. 12	Cade	Pairing of use site with available sites (20 points) in discrete choice logistic regression GAM using a strata option in mgcv package. Could they provide example R code for some of the model estimates? I do not see a strata argument in mgcv(). Is this perhaps something that is associated with the cox proportional hazards family option (proportional hazards models often being used to estimate discrete choice models) in gam()? I think you need to define the model more clearly with respect to how it was actually estimated in the gam() function of mgcv package, including model form, family used, link function, other arguments like strata, etc. Of course, providing some of the code in an Appendix would also help clarify this.		The strata term used in coxph() can also be used in gam when the family = cox.ph(); text added. For exmple: gam(time1 ~ strata(bout) + s(covar), family = cox.ph(), method = "REML", data = dataframe, weight = event1). Code will be provided in a digital repository upon publication.
18	2. In-Channel Habitat Selection Methods	p. 12	Cade	The conclusions drawn from the resource selection analyses are reasonable as far as they go. The partial regression plots for individual predictor variables in the generalized additive model (GAM) are informative. However, I believe that they can provide more useful interpretations by incorporating information on intervals of values associate with the predictor variables (e.g., unobstructed channel widths 200-700 feet) that are consistent with the sampling variation (90% confidence intervals) of the highest relative selection ratios. I provide more details on this issue under [question] 5.		Range of values statistically similar to the maximum relative probability of selection added to the text.
19	2. In-Channel Habitat Selection Methods	p. 13	Cade	How is dense vegetation defined in "distance to nearest dense vegetation"?		Dense vegetation was identified in aerial imagery and was interpreted as areas where bare sand was not exposed within the vegetation.
20	2. In-Channel Habitat Selection Methods	p. 13	Shields	"We ran the Program HEC-RAS" should be "We ran HEC-RAS"		Change made

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
21	2. In-Channel Habitat Selection Methods	p. 13	Cade	It seems like it would be useful to examine the correlation structure (potential multicollinearity in the models) among these unobstructed widths and channel width measures that are going to be used as predictor variables. This might suggest some simpler model forms and certainly would aid interpretation.		Correlation between variables were tested and all variables in the top models were determined to be uncorrelated (i.e., R^2 <0.48).
22	2. In-Channel Habitat Selection Methods	p. 14	Cade	Use of term “relative probabilities of use”. They are not really probabilities. Page 14: The resource selection function w(X) is an exponential function not a logit function, where w(X) is scaled on the interval [0, +□). Does the discrete choice multinomial logit mode used to estimate coefficients involve the same steps as with other RSF models where an estimated intercept from a logistic regression model is excluded from the exponential form of the RSF (similar to McDonald 2013)? Should be reworded for clarity.	X	Yes, they are ratios of ratios. There is no intercept, it is an exponential model. Changes made to text.
23	2. In-Channel Habitat Selection Methods	p. 15	Cade	It is not clear how the use of P-values for significance of smoothed terms if null hypothesis was rejected is useful. Perhaps I’m misinterpreting something here.		The statement… "we ONLY presented p-values when the null was not rejected …." is there to note that we are NOT presenting p-values when the null was rejected. We are not presenting p-values when the null was rejected "because these tests are known to reject the null too often when using penalized likelihood models ". So we "trust" the p-value when it is large, but not when it is small.
24	2. In-Channel Habitat Selection Methods	p. 15	Cade	In Response Functions, Wording is not reasonable – predicted “relative probability of selection”. These are ratios of proportions from an exponential RSF that by definition are scaled [0, +□). They are not probabilities. You can scale the relative selection ratios to [0, 1] as done here but that still does not make them probabilities. In fact, you could scale them from [0, to any positive number you want] and their interpretation is still the same as they only have meaning with respect to each other in the same model. A w(X) = 0.8 indicates a relative selection ratio 4× greater than a relative selection ratio of w(X) = 0.2. But similarly a w(X) = 4.8 indicates a relative selection ratio 4× greater than a relative selection ratio of w(X) = 1.2 on a different scale. The interpretation is with respect to other w(X) within a model. I suggest just using the term “relative selection ratios”. I think it is especially important to keep this distinction because it becomes easy to confuse the rescaled relative selection ratios on [0, 1] as if they were actual probabilities estimated from a logistic regression model. They are not probabilities. Would have to change wording in all relevant figure labels (e.g., Figures 3, 4, 5, 6, 7, 8, 9, etc.). I recognize that many people including McDonald (2013) have used the term “relative probabilities of selection” but I think it is misleading and potentially confusing to use the word “probability” in this terminology, especially after McDonald (2013) did such an excellent job clarifying that these ratio of ratios are not scaled on [0, 1].	X	Changed to "relative selection ratios" in text.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
25	2. In-Channel Habitat Selection Methods	p. 15	Cade	It is not clear that 90% confidence intervals for estimated relative selection ratios can really be approximated using a Taylor series expansion approach because the estimates come from a multinomial logistic regression model but the RSF uses these in an exponential functional form that excludes the intercept. If these were simple logistic regression estimates carried forward to exponential RSF, I don't believe there is a simple analytical formula to compute standard errors (or confidence intervals) for predicted w(X). It is not obvious to me whether this same constraint applies to the discrete choice multinomial logit model used but it seems likely. With a conventional RSF modeling approach I would have simulated these by sampling from the multivariate normal distribution associated with the logistic regression estimates and their covariances (including the intercept) say m = 10,000 times, and for each sample compute the exponential RSF (that excludes the intercept), and then compute confidence intervals from the sampling distribution of that exponential RSF based on the m = 10,000 estimates. More details on your Taylor series expansion approach should be provided to justify its credibility. I note that in Chapters 2 and 3 of the Synthesis document that bootstrapping is employed for estimating these confidence intervals.	X	Chapters 2 and 3 did not use bootstrapping, but used the same approach. The predictions/se are from the gam package and do not use the intercept in the predicitions (can ouptut se for each term). See page 240 in Wood 2006 (type="terms").
26	2. In-Channel Habitat Selection Methods	p. 15	Cade	It is not clear why you would want to constrain the response functions to eliminate just the extremely large (upper 25th percentile) values of habitat characteristics. You could just as easily justify eliminating the extremely small (lower 25th percentile) values of habitat characteristics. Or more reasonably, do not eliminate any of them. It is possible that it is more extreme values that are especially important, although admittedly the statistical model will have less precise selection ratios for the extremes. This needs to be handled differently than currently done. I realize that some of the estimated CI may get extreme at more extreme values of the predictor variables, so perhaps you would have to limit graphs to 10th to 90th percentiles rather than the entire range	X	The report has been changed to show the predictions from 10 to 90%iles for consistency with chapter 2. We limited the view of the graphs to aid in interpretation. The were not "constrained" in the sense that the values changed whether we displayed the entire extent of the range of x, or a portion. We did not limit the lower end of the range of x becasue we do not see extreme values occuing at the lower end of the range, likely due to the sufficient amount of data there. The sparsity of the data at the upper end of the range, combined with the spline fitting approach, caused these values to have very large influence. We wanted to use a consistent cut-off value in the display of these relationships despite the influence varying by model, covariate, dataset, etc. Including the entire form of the regression spline across the range of x would very likely confuse the reader and cause undue criticism of this modelling approach.
27	3. Diurnal Habitat Selection Methods	p.16	Cade	Diurnal habitat selection methods. Same comments from above would apply as they used similar models	X	See responses above
28	4. Trend Methods	p. 19	Shields	"For the central Platter River" should be "For the central Platte River"		Change made

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
29	4. Trend Methods	p. 19	Cade	Why not plot the trend estimate with a 95% CI to correspond with the P = 0.05 level of significance corresponding to your hypothesis test of zero trend? Seems unnecessarily inconsistent. In general there are very few observations (n = 32 for spring, n = 21 for fall, and n = 53 combined) for estimating a very complex logit model. It is the sample size of the smallest group, crane use locations, that impacts the precision of these logit models. As many of the models considered (Table A.1) have up to 4 predictor variables included with multiple degrees of freedom (df) potentially used for each due to the spline fitting, it seems unlikely that many of these more highly parameterized models could be estimated well with such a small sample of used locations. And that won't necessarily be reflected entirely in AIC statistics.		The alpha should have been 0.10 in the text; change made. We agree with the sparsity of data when split by season, but the analyses were conducted at PRRIP's request, but were not emphasized in the report. The precision (or lack thereof) of these models is evident by the width of the CI on the splines.
30	5. In-channel Habitat Selection Results; USFWS and EDO letters	p. 22 Table 3	Shields	Lines 131-170 of the USFWS comments and EDO responses discuss how UD was computed. Line 150 states that UD is based on "total channel width," which "remains relatively constant at a location through time." Furthermore, TCW includes islands, so dividing discharge by TCW yields a result that is not even accurate for mean UD. Given these facts, the development of unit discharge (UD) values based on 2009 flows and channel topography for use in the analysis is troubling. The average unit discharge for a cross section is discharge divided by flow width (not channel width). (I believe the report uses the expression "wetted width" in a way equivalent to my use of "flow width.") Cranes likely do not respond to average UD, however. So the UD of importance in evaluating habitat is the local UD occurring at the time and place where the birds are roosting. Local UD is the product of local depth and local velocity. Local depth likely varies across a substantial range in time and space in the AHR of the Platte, so computation of cross-section average UD based on 2009 surveys is unlikely to yield much information about the availability of habitat with <0.7-foot depth. The aforementioned EDO response explains the difficulty of obtaining representative UD values, and it would seem that at least some field measurements are needed to validate the UD values used in the analysis. Are the values used in the analysis actually representative of those occurring when habitat selection was made? The report is unclear regarding the discharge values that were used to compute UD. Ideally, the discharge that occurred on the date when the cranes made their habitat selection is the discharge that should be used. Perhaps the way that UD was determined contributes to its lack of influence in the top models for in-channel habitat use (e.g., Table 3).	X	UD was recalculated and defined as 'Flow per linear foot of wetted channel width". Discharge on the date selection was made was used in this calculation. Field verification would be difficult or impossible to conduct. However, UD is most certainly highly if not perfectly correlated with the amount of shallow water habitat as when UD decreases, so does depth.
31	5. In-channel Habitat Selection Results	Figure 5 p. 23-25	Cade	You could provide some additional verbiage to help interpret these partial regression plots. For example, with respect to Figure 5 you could indicate that at 138 feet of distance to nearest obstruction (at mean distance to nearest forest) the relative selection ratio (approx. 0.60) for roost sites is 6× greater than the relative selection ratio (0.1) at 50 feet of distance (or whatever the correct measure is that corresponds to 0.1 selection ratio) to nearest obstruction. The advantage of this is that it helps set the context for using the relative selection ratios to compare with each other within a model. Could even provide these interpretation for all predictor variables from say their 25th to 75th percentiles of values, i.e., describe the change in relative selection ratios across the central 50% of observations (or any	X	This appraoch to interpretation will be considered and likely included when a manuscript is drafted.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
32	5. In-channel Habitat Selection Results	Figure 3 p. 23-25	Cade	These partial regression plots need to be interpreted with respect to the confidence intervals on the relative selection ratios. There seems to be an undue focus on where the point estimates of the relative selection ratios maximize (e.g., Figure 3). Given the lack of precision in these relative selection ratio estimates as indicated by their very wide CI, it would be more appropriate to interpret the values of the predictor variables (e.g., unobstructed channel width in Figure 3) associated with intervals consistent with intervals for highest relative selection ratios. For example, unobstructed channel widths of approximately 200-700 feet all seem consistent with 90% CI for highest relative selection ratios, i.e., the 90% CI for any estimated relative selection ratio at 200 to 700 feet (approximately based on graphic, this can be refined more precisely with the estimates) all overlap with intervals for the highest value estimated at 509 feet. So really the relative selection ratio estimates cannot be claimed to be substantially different for any unobstructed channel widths between 200 and 700 feet based on your estimated sampling variation defined by the 90% CI. This interpretation issue is akin to the problem of separation of distributions in regression models (see for example, Xin and Nelson. 2003. Separation among distributions related by linear regression. American	X	Updated discussion to include this appraoch to interpretation and will likely include when a manuscript is drafted. The report has limited interpretation, more will be added for a manuscript.
33	5. In-channel Habitat Selection Results	Table 4 p. 24	Shields	I am puzzled by the statement, “Nearest obstruction and nearest forest were present in all five of the top five models. These models do not appear at the top of the management model list because PRRIP staff does not consider nearest obstruction to be a variable useful for management.” Mechanical removal of trees is one of the key management actions described! However, it would seem that there should be a high correlation between NO and NF and between NO and UOCW. The report does not comment on this, either. The diurnal data indicate preferential selection of cornfields relative to grassland, soybean and wet meadow. Has any consideration been given to potential hazards to WC posed by herbicides, insecticides or less than optimal forage found in cornfields relative to more natural habitats?		Clarification added. While NO and NF may appear to be manageable through vegetation removal, we can't control if the bird chooses to land next to a bankline that would be considered an obstruction. Potential hazards associated with selection of cornfields is beyond the scope of this Report and potentially beyond the scope of the PRRIP.
34	6. Diurnal Habitat Selection Results	Figure 11 p. 30	Cade	Does it make sense that diurnal selection should be maximized at zero distance from roosts? I wonder if you might need to be taking logs of roost location differences.		Zero distance is essentailly a roost location, and some of the roost locations are in this dataset because the birds foraged or remained in the river during the day which is not uncommon. Those observations essentially 'anchored' the spline at zero.
35	7. Trend Results	31-33	Cade	How do you know the number of “unique” individual cranes?		Cranes were monitored throughout the day so typically it was known if the crane group migrated or spent multiple days in the study area.
36	7. Trend Results	p. 31-33	Smith	In Results, add summary results of 2nd and 3rd approaches and reference tables and figures that are located in appendices; for example, identify the variables within the top models.	X - Accept	Included a summary statement, did not duplicate figures in main report.
37	8. Discussion	p. 37	Smith	Compare the results among three approaches more fully in the Discussion, for example, the differences of model results and the importance of these finding to achieve the objectives of the study.	X - Accept	The additional analyses were requested by stakeholders to allow them to be able to compare biases. They are not meant to be the focus of the report.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
38	8. Discussion	p. 37	Smith	Since conclusions are limited in all sections of this report, I suggest providing recommendations of use of these approaches in Summary of Findings	X - Accept	Added a summary of findings. Interpretation has been intentionally left for the PRRIP and other stakeholders. Interpretation will be written for published manuscripts.
39	8. Discussion	p. 37	Cade	It might be worth discussing the correlation (multicollinearity) between nearest obstruction predictor variable that was not used in the management models and unobstructed channel width predictor variable that was used in both best and management models. How much of variation in nearest obstruction is related to variation in unobstructed channel width?		The correlation was 0.55 or 0.57, depending on the dataset.
40	8. Discussion	p. 37	Smith	Currently, the discussion section within this report does not provide any comparisons with previous work and would be strengthened by this inclusion. I am providing notes for each paper to provide what I believe to be pertinent points and arranged the papers in chronological order to assist in the overview suggested in Question 2, Suggested Revision 2.c. (See Smith comments in Appendix A-12 to A-24)	X - Accept	Changes made.
41	8. Discussion	P. 38	Shields	How certain are you that birds spotted in early morning were in locations where they had roosted the previous night? "Flights….took place in the early morning intending to locate crane groups before they departed the river to begin foraging." Note that the question I am asking goes beyond error in detecting presence of a group (page 38, "imperfect detection")		Opportunistic evening and morning observations and telemetry data indicate whooping cranes do not generally move large distances during the night, though it is possible under special scenarios I suppose (i.e., predator disturbance).
42	App C-E	Appendix	Cade	I wonder if there is a more effective strategy for analyzing the additional data from the systematic and opportunistic samples. Rather than using this data to select among candidate models with different combinations of predictor variables, why not just use this additional data in the models that were already selected as best for your most unbiased analyses in the main body of the report (the first records on crane roosts from systematic surveys). Then you might be able to look and see how well the additional data supports or does not support the best unbiased estimates. For example, it could be that if all the spring crane roosts were used with the model that used nearest obstruction (Table 5, and Figure 7) that the estimated response function would be very similar, though perhaps with narrower confidence intervals because of the increased sample size. This would be encouraging. Or they might yield very different responses which would be discouraging but could be explained both by real different patterns or biases in the sample (and you can't distinguish these two possibilities). But the current approach of reselecting candidate models allows you to consider more complex models simply because the combined data sets have larger sample sizes.		Change made. Systematic unique observations used to select the best model and all systematic data was evaluated with that model in Appendix. Report implies we did the additional analyses to "evaluate impacts", but the interpreation of differences in results is not extensive.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
43	App C and D	Appendix	Smith	To improve the importance of information in Appendices C and D, please provide the following information in the Methods: 1) Whooping Crane Group Observation Data (p. 10, para. 1, line 1) a. summarize the explanation given in Appendix C (paragraphs 3-6) at the beginning of this paragraph, b. provide justification of why these analyses are beneficial in the report, then c. introduce this sentence with "Therefore, we conducted…"	X - Accept	The focus of appendicies C and D changed with the reviewer comment #42. Since this was never a part of the origianl analysis objective, we did not focus too much on using the results to infer biases. One can imply that conclusion, but again most interpretation is left for the PRRIP, at the PRRIPs request. Presented the idea on page 4 and a sneak peak in the introduction right after the 2 objectives are stated.
44	9. References	p. 38	Smith	Inconsistent use of issue number in journal citations. Standardize use of issue number and correct as necessary Aarts… 2013 - unnecessary comma after Brasseur Remove comma Aarts ... 2013 - no period at end of reference Insert period Arthur - no and before last author Insert and Boryan - wrong format for author names- place junior authors' initials before last name Boryan – unnecessary comma after authors remove comma Brei and Bishop – not in text Use or remove Brei et al 2002 – not in text Use or remove Burnham and Anderson – unnecessary space between author initials Remove spaces Burnham and Anderson - Extra space after date Remove space Butler et al. – unnecessary space between author initials Remove space Gesch – not in text - Use or remove Gesch – Unnecessary commas around date Remove commas around date Gesch et al. - Period missing after date insert period after date Gesch et al. – not in text Use or remove Gesch et al. - Unnecessary commas around date remove commas around date Gesch et al. - Period missing after date insert period after date Hefley et al. – unnecessary semicolon after volume number remove semicolon Jin et al. – not in text Use or remove Jin et al. - wrong format for author names place junior authors' initials before last name Jin et al. – unnecessary comma after Journal name remove comma after journal name Jin et al. – unnecessary spaces around hyphen remove spaces around hyphen Johnson et al. 2006 - unnecessary space between author initials. Remove spaces	X - Accept	Changes made (did not remove comma after Brasseur).

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
45	9. References	p. 38	Smith	Johnson et al. 2006 – missing period at end of reference Insert period Johnson et al. 2013 - wrong format for author names place junior authors' initials before last name Kutner et al. - wrong format for author names place junior authors' initials before last name Manly 1997 – not in text Use or remove Manly 2001 – not in text Use or remove McCullaugh and Nelder – unclear why FRS is included Complete or remove Melvin and Temple 1982 – not in text Use or remove PRRIP 2010 – unnecessary spaces around date Remove spaces PRRIP 2015b – unnecessary "b" Remove b Rawlings et al. 1998 – not in text Use or remove Rawlings et al. 1998 – unnecessary space between author initials Remove spaces Warton and Aarts 2013 – missing in References Insert reference		Changes made.
46	9. References	p. 38	Shields	In reference list, but not cited in paper 1. Jin et al 2013 2. Manly 1997 3. Manly 2001 4. McCullough and Nelder 1989 5. Brei and Bishop 2008 6. Brei and Bishop 2009 7. Gesch 2007 8. Gesch et al 2002 9. Melvin and Temple 1982 10. Rawlings et al 1998 11. PRRIP 2010 12. Reed 1996		Changes made.

PANEL MEMBER COMMENT SPREADSHEET
Platte River Recovery Implementation Program
Data Synthesis Compilation, Whooping Crane (Grus americana) Habitat Synthesis Chapters

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
1	Overall		Shields	The synthesis chapters do provide evidence that higher flows, disking and herbicide application increase whooping crane stopover habitat, particularly when all three occur together. I do note that the increase in mean UOCW due to SDHF releases alone is essentially negligible, but it is important to note that the WC do not react to mean conditions along the AHR. Instead, they need some minimum level of habitat availability. Figure 15 shows that a 40-day peak discharge of 1,000 cfs is associated with a ~25% probability that a managed transect will have a UOCW > 600 ft. A three-day SDHF of 8,000 cfs requires 45,000 ac-ft. above a base flow of 500 cfs (or 26,000 to 68,000 ac-ft., lines 495-496), while a 40-day flow of 1,000 cfs requires 40,000 ac-ft. above a baseflow of 500 cfs, so a 40-day flow would be attainable with current water allocation. If 25% of the AHR provided UOCW > 600 ft., would that represent an improvement over current conditions? Over projected future conditions? Would it be biologically significant with respect to WC habitat availability?		The objective of this analysis was to evaluate the performance of the FSM management strategy, which includes SDHF, a specific flow management action. As the reviewer notes, the predicted increase in UOCW due to SDHF is negligible. IE, if channels are unsuitably narrow, SDHF will not substantially improve UOCW, if channels are already suitably wide, the incremental benefit of SDHF is unnecessary. Once the Program has completed its formal assessment of SDHF (last step in adaptive management cycle) we will adjust flow-management through development and testing of new flow-management hypotheses.
2	Overall		Smith	Suggested Revisions: provide a more comprehensive evaluation for Program decisions and promotion of policy by: 1) Incorporating more discussion in each section relating to the interpretation of results that address components of both MCM and FSM; 2) Providing more information about locations of conserved/managed areas as part of MCM management potential; 3) Providing more discussion of MCM strategy effectiveness in Chapters 2 and 4;	X - Accept	The objective of this analysis was to evaluate the performance of the FSM management strategy, which includes SDHF, a specific flow management action. Evaluation of the performance of the MCM management strategy was outside of the scope of this investigation.
3	Overall		Smith	Suggested revisions throughout the report: 1) Standardize between standard and metric, or give both throughout report 2) Standardize spacing between number and measurement (e.g., 10ft vs 10 ft.) among chapters 3) Correct spelling of Richert from Reichert throughout report 4) Correct PRRIP from Program for citing program reports throughout this report	X - Accept	Changes made
4	Chapter 1	Figure 3	Shields	Size and status of WC population. The statement that the AHR is used by 5-10% of the WC migratory population (Chapter 4, line 32) may be at variance with the blue bars of Figure 3 of Chapter 1, which Figure badly needs a legend. The top half of this figure shows whooping crane numbers of ~175 for 2010-2014. If this is 175 individuals per year, then 175 >>30. If it is 175 individuals for the entire period 2010-2014, then 175/5 = 35 ~ 30. Line 235 of Chapter 1 states that WC use of the Platte River declined between 1950 and 1980, but Figure 3 shows an increase during this period.		Legend added to figure which clarifies the confusion expressed in this comment. Lately, 5-10% has been the typical annual use of the AHR, but use has ranged from <1% to nearly 15%. Red line represents the population size and blue bars represent wc use during each 5-year period. Use of the Platte River (blue bars) between 1950 and 1980 was nearly 0, but the population size (red line) increased during this time period.
5	Chapter 1	21	Smith	(Program 2006a) referenced in Literature Cited as PRRIP 2006a. Correct to PRRIP 2006a, standardize throughout report (also p. 8, line 134, p. 19, line 361, etc.)	X - Accept	Change made
6	Chapter 1	28	Shields	"Nine years implementing"--see line 7 of preface		Change made
7	Chapter 1	51	Smith	Correct Latest edition of this reference to 2007	**Page 6, line 16 - Latest publication of recovery plan is 2007, you cite it correctly on page 7 on line 9 and 21**	Unsure what is wanted here???
8	Chapter 1	59	Smith	State 200-mile wide corridor. Actually less, as cited in Tacha et al. 2010 and substantiated by Pearse et al. 2015; also cite Pearse et al. for Figure 2 map, since same as in this publication	X - Accept	Figure 2 shows the migration corridor developed based on observations collected during the recent telemetry study. The corridor ranges from ~300-500 miles wide, however, a majority of use occurs within the central 200-mile wide area as stated. Tacha et al. 2010 reported 95% of use locations were located within a 170-mile wide corridor which is similar to our report.
9	Chapter 1	75	Shields/ Smith	"ANR" should be "ANWR"	X - Accept	Change made
10	Chapter 1	Fig 2	Smith	Standardize scale to Km or mi throughout	X - Accept	Change will be made for publication.
11	Chapter 1	103	Smith	Most birds arrive by early-mid December, not mid-November (Butler et al. 2014...winter abundance). Dorect to early-mid December.	X - Accept	Change made
12	Chapter 1	106	Smith	Generalized statement of sub-adults near natal area of first winter, Correct to relate actually form loose flocks and travel outside defended territories where they first wintered (Stehn and Prieto 2010)	X - Accept	Change made
13	Chapter 1	111	Smith	Pitts (1985) incomplete citation; delete if not available.	**Provide information relating you have on file at your business location**	We have a copy of the report, but it has never been published.
14	Chapter 1	124	Shields	After “monitoring effort "insert “on the Platte River"		Change made
15	Chapter 1	138	Smith	insert feet follow metric 1,150	X - Accept	Change made

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
16	Chapter 1	140	Shields	"maximized at 1,150…" should be "maximized at UOCW of 1,150…"		Change made
17	Chapter 1	160	Smith	Expand explanation of percentage changes throughout the period in Table 1	X - Accept	Explanation provided in the literature cited in the caption (Stroup et al. 2006)
18	Chapter 1	199	Shields	"no width change" between what dates?		Dates added.
19	Chapter 1	270	Smith	Add Peake et al. 1985 to Literature Cited	X - Accept	Change made
20	Chapter 1	273	Smith	EIS 2006 cited as Department of Interior in Literature Cited (determine correct citation)	X - Accept	Change made
21	Chapter 1	274	Smith	no date of citation in text after Sidle et al. (correct)	X - Accept	Change made
22	Chapter 1	288	Shields	between the J-2 Return and….. something left out after "and"		Correction made
23	Chapter 1	326	Shields	"thought" should be" though"		Change made
24	Chapter 1	329	Shields	should be illustrated with a map		Unclear what is wanted???
25	Chapter 1	334	Shields	define hydrocycling		Change not made
26	Chapter 1	380	Smith	Reichert misspelled through document (Correct to Richert)	X - Accept	Change made
27	Chapter 1	410	Smith	No space between page numbers	X - Accept	Change made
28	Chapter 1	433	Smith	Replace semicolon with comma after first author name	X - Accept	Change made
29	Chapter 1	440	Smith	Place period after year (not comma)	X - Accept	Change made
30	Chapter 1	443	Smith	Not cited as PRRIP in text (correct throughout)	X - Accept	Change made
31	Chapter 1	448	smith	Not cited as PRRIP in text (correct throughout)	X - Accept	Change made
32	Chapter 1	470	Smith	Incomplete citation (add source)	USFWS 2006 biological opinion reference, source info missing (see above citation that cites location, and pages)	Unclear what is wanted here, source is the USFWS???
33	Chapter 1	General	Smith	Suggested revision: Add conclusion statements for Chapters 2 and 3 in Chapter 1	X - Accept	Noted
34	Chapter 1	General	Smith	The conclusion given within Chapter 1 and reiterated in Chapter 4 states that the implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy, particularly the flow component, may not achieve the stated management objective and sub-objectives for whooping crane and "contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR". If this strategy were the only one identified in the Adaptive Management Plan, the objective of the project would be simple to evaluate. What is unclear is why both alternatives were not the intended focus of evaluation in this report.	**Please insert explanation in text**	The Program's Adaptive Management Plan is focused on implementation and testing of the FSM management strategy. Thus we focused on that management strategy.
35	Chapter 1 References	399	Shields	In paper, but not in reference list 1. Allen 1952 2. Randal and Samad 2003 In paper, but not in reference list		Change made
36	Chapter 2	11	Shields	"the ability of to alter" should be "alteration of"		Change made
37	Chapter2	72	Shields	remove parenthesis		Change made
38	Chapter 2	91	Shields	Comma before quotation marks		Unsure what is wanted here???
39	Chapter 2	111	Smith	Capitilize Priori in subtitle	X - Accept	Change made
40	Chapter 2	175-185	Shields	Please refer to Chapter 2, lines [175-185] and Chapter 3, lines 94-100. I do not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. Line 165 states that it was assumed that the area evaluated was "centered on the use location and extended 10 miles upstream and downstream from that point." It is unclear if the evaluated area is 10 or 20 miles long in total, but line 169 implies that was assumed to be 10 miles. The justification given is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft. above ground level." No data are provided regarding the flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable. How sensitive are your findings to the 10-mile assumption? Would an assumed available reach length 5 miles for the choice set produce a different outcome? I assume that monitoring flights were conducted in such a way that the overflying aircraft did not modify crane behavior, but it would be good to read an assurance to that effect.	X	Text and citation added. An additional analysis was conducted which indicated results were not sensitive to distance considered available. In the chapter 2 analysis, the relative selection ratio was maximized at an intermediate UOCW of 466 ft, but the 90% confidence interval overlapped the relative selection ratios and were statistically similar for UOCW's ranging from 234 to 889 ft and at an intermediate NF of 538 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 257 to 684 ft from the nearest forest. In the within 5-mile availability anaylsis, UOCW was maximized at 467 ft, but the 90% confidence interval overlapped the relative selection ratios and were statistically similar for UOCW's ranging from 228 to 889 ft and at an intermediate NF of 517 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 257 to 684 ft from the nearest forest.
41	Chapter 2	94-101	Shields	Apparent contradictions between these three phrases "with the exception of spring 2003," "excluded crane group observations during 2001", "AHR, spring 2001-spring 2013," and line 52. please clarify.		Further clarification added
42	Chapter 2	106	Shields	Need to make comma after "River" a semicolon		Change made
43	Chapter 2	53-54	Shields	States that "riverine habitat has by far the highest incidence of stopover use by whooping cranes." Exactly what is meant by riverine habitat? Are floodplains riverine? Backwaters? Islands? Sporadically connected wetlands?		Clarification added.

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				HABITAT SYNTHESIS CHAPTERS		
44	Chapter 2	70-72	Shields	Chapter 2, lines [70-72] states that, "the monitoring protocol encompasses 3.5 miles on either side of the central Platte River…" So what use was made of observations of cranes within this seven-mile-wide (3.5 x 2) band?		Analyses only included observations within the river.
45	Chapter 2	112-113	Shields	"characteristics of in-channel habitat." What other habitat types were included in the 7-mile + channel width-wide corridor? Why were they excluded?		Analyses were focused only on riverine habitat selection.
46	Chapter 2	114	Smith	one particular key component in the analyses involved the Unobstructed Open Channel Width (UOCW) metric bears discussion. In Chapter 1, an excellent overview of the literature comparing the optimum UOCW results from several studies (p. 11). Given the importance of this metric in the report's model results, it would be beneficial to discuss in this section, and/or in the succeeding chapters why this variability might occur. In addition, it appears that UOCW is measured differently within this study which may affect results in Chapter 2 compared with Chapter 4. Also, a new metric, Total Unobstructed Channel Width (TUCW) was introduced in Chapter 4 research design and analyses. Suggested Revision: 1) Review the method descriptions and discern if the difference only appears within the figures and not in the definitions, Fig. 2 (Chapter 2, p. 33) as possibly multiple lines across the channel, while only measured once within the channel in the approach depicted in Fig. 6 (Chapter 4, p. 82). 2) Address the differences when defined in Chapter 4, including the use of the new metric (TUCW) if it differs from UOCW in Chapter 2.	X - Accept	Changes made
47	Chapter 2	122	Shields	"updated" should be "supplemented"		Change made
48	Chapter 2	123	Shields	"gaged" should be " gage"		Change made
49	Chapter 2	134	Cade	I think a more defensible statement about what the RSF analyses in Chapters 2 and 3 indicate with regards to important roost site conditions to maintain for whooping cranes can be made by focusing interpretations more on intervals of values (e.g., unobstructed channel widths) that are consistent with intervals of highest relative selection ratios (90% CI). See Cade response to Question 8 or individual comments Appendix A-1 to A-6.	X	Uncertainty around points estimates of habitat selection was included in results and described in the discussion sections of chapters 2 and 3.
50	Chapter 2	135	Shields	there are two number 5's in Table 1		Change made
51	Chapter 2	141	Shields	"geomorphic channel type" should be " channel morphology "		text revised
52	Chapter 2	155	Shields	"This distribution" should be "distribution set"		Changes made
53	Chapter 2	188-202	Shields	The description of statistical methods is heavily weighted with jargon. No definition is provided for the left hand side of the equation, w(Xij), or Xij for that matter. Is it the probability that the ith unit in the jth choice set is selected for use by a crane flock?		Included description of relative selection ratio and specificed other components more directly.
54	Chapter 2	256	Shields	Table 2 unit discharge units are ft^2/s/ft., not feet		Change made
55	Chapter 2	270	Smith	Insert the word "crane" after whooping	X - Accept	Change made
56	Chapter 2	271	Cade	Wording "indicating a parsimonious selection of covariates" seems unnecessarily obtuse. All the comparisons of the delta AIC between the top model and the null, intercept only model indicates is exactly the same thing as the hypothesis test that all the regression coefficients are zero – at least one coefficient is not zero. This same statement is used repeatedly in the Correlates of Whooping Crane Habitat Selection document too.	X	Edited model selection text in chapters 2 and 3
57	Chapter 2	189 -203	Cade	Figures 5 and 6. Interesting that relative selection ratios drop as both unobstructed channel width and distance to nearest forest get too large. Any interpretations to offer? One could argue that the sampling variation is so great for these decreasing estimates of selection ratios at the larger distances (spread of 90% CI) that there is no strong evidence that there really is a decline from their peak at intermediate distances. Again, I would argue as above that this really needs to be interpreted in terms of an interval of predictor values that is consistent with an interval of values for the highest relative selection ratios. I could also argue that your GAM model suggests that a simpler piecewise linear spline that allowed an increasing slope at shorter distances, with one knot where selection ratios are maximum at intermediate distances, followed by another slope that would probably be only slightly declining at higher distances. This would require fewer edf and probably provide a more parsimonious interpretation of the data pattern.	X	Intrepretations of habitat selection ratios were included and mostly focused on the uncertainty around point estimates as opposed to exact point estimates of habitat relationships based on GAM models. GAM models were also re-run to limit spline degrees of freedom.
58	Chapter 2	189-203	Cade	What is the correlation structure between unobstructed channel width and distance to nearest forest? I'm guessing that there is some strong linearity for some range of values (the smaller distances) and that for larger values the correlation pattern then gets stranger. Here I note that the restricted plotting of partial estimates is not made to <75th percentile of used locations so a more complete picture of the estimated relationship is provided than in the Correlates of Whooping Crane Habitat Selection document.		Very little correlation is observed throughout the different quantiles of the unobstructed channel width and distance to forest range. We evaluated correlatation within the the 0-0.25, 0.25-0.50,0.5-0.75, and 0.75-1.0 quantiles of unobstructed channel width and nearest forest and found correlation at use locations did not exceed r = 0.36 in any given comparison and has an overall correlation of 0.48. To limit the over influences of data extremes, we limited our habitat relationship predictions (predicted relative selection ratio plots) to data between the 10th and 90th percentile.
59	Chapter 2	292	Shields	"crane use" should have a comma after it		Change not made
60	Chapter 2	296	Cade	Line 296: What does it mean that results with the n = 75 observations were "but slightly higher than results ….."?		Wording was changed as to not imply direction of relationship and provide more emphasis on estimate uncertainties.
61	Chapter 2	297-298	Cade	Lines 297-298: The statement that higher relative selection ratios when UOCW was ≥522 feet and NF was ≥549 feet is not consistent with the model estimated with n = 55 because you actually had declining resource selection ratios at higher distances. Is this really what you meant to say?		Wording was changed to show the highest value of the point estimates of each relative selection ratio in light of the uncertainty of the estimates.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
62	Chapter 2	302	Shields	"465ft)" should have a comma after it		Change made
63	Chapter 2	321	Shields	after "width" insert "(UOCW)" and after "forest" insert "NF"		Change made
64	Chapter 2	321	Smith	In Chapter 2, authors explained how the metrics wetted area and suitable depth within the channel would improve habitat suitability for whooping cranes. However, they were unable to quantify those metrics and used unit discharge as a proxy, which was a measure of flow and channel width, which did not score high in the top four models, a result that was counter to previous studies (p. 47, line 321). They do state that "it may not be appropriate to assume flow metrics are not important to selection of habitat by whooping cranes. Instead, it appears area of suitable depth and wetted width surrounding areas selected by whooping cranes were equally available and potentially adequate at flows observed during times of whooping crane use". Given that the main purpose of this report involves determining if SDHF regimes were adequate to maintain habitat suitability, it appears this last statement may be unfounded, and potentially erroneous. Suggested revisions: 1) Provide a more detailed discussion on the results of the other studies 2) Suggest an alternative approach generating necessary data for future studies, given the importance of this hydrologic metric.	X - Accept	Change made
65	Chapter 2	330	Shields	after "data" there should be a comma		Change not made
66	Chapter 2 References		Shields	In paper, but not in reference list 1. Freeman 2010 2. Phillips et al 2006 3. Phillips and Dudik 4. Manly 1997 In paper, but not in reference list		Citations added
67	Chapter 2	348-349	Cade	The math related to your logic to get to 279 feet from the bank line of a 488 foot wide channel is not immediately recognizable. This should be stated explicitly so that it is obvious that you are subtracting half of 488 from 523 feet.		Additional information added
68	Chapter 3	4	Smith	No mention of purpose of the chapter, Program objectives. Begin with a similar, perhaps condensed version, of Program information at beginning of Abstract; see Chapter 2, Abstract, p. 28 lines 4-16	X - Accept	Additional information added
69	Chapter 3	13	Smith	List number of samples. Insert "at 158 stopover sites" after habitats	X - Accept	Unsure what is wanted here…cant find the word 'habitats' on page 13??? Not able to locate either
70	Chapter 3	13	Smith	No mention of connection to Chapter 2 results, where decision to use UOCW and NF in models. Provide connection to report objectives; Insert "Based on the results of Chapter 2…"	X - Accept	Change made
71	Chapter 3	17	Shields	Chapter 3 indicates that, "selection probability was maximized….when distance to the nearest forest from the edge of the channel…..was > 190 ft." I am concerned that management measures based on this finding would lead to clearing riparian zones. Did it matter what was growing along the unforested channel margins? Would cropland and wetlands or wet meadows have the same effect on selection probability?		Noted
72	Chapter 3	64	Shields	"whooping roosting habitat" should be "whooping crane roosting habitat"		Change made
73	Various: Chapter 1 Chapter 3 Chapter 3 Chapter 3	 68; 255 45-46 178; 204 69-72	Shields	Habitats other than shallow open water are also important part of stopover habitat suitability. Chapter 1, line [68}, states, "a wetland is nearly always associated with a stopover site." Line [255} mentions, "….suitable bottomland (wet meadow) habitat deemed to be essential for foraging." Lines 305-305 mention the importance of, "wet meadows where cranes feed and rest." Chapter 3 lines 45-46 states, "At stopover sites, whooping cranes typically roost standing in shallow water associated with palustrine or lacustrine wetlands and river channels…." In apparent contradiction to these statements, Chapter 3, line 178 notes that both, "roost sites and day-use sites tend to consistently lack vegetation." But line 204 notes reports by Austin and Reichert (2005) that, "70% of roost sites were adjacent to woodland habitat." Despite the apparent importance of wetlands in WC stopover resting and foraging, the overall approach and data presented in these chapters are largely agnostic with respect to wetlands. Is the entire effort directed at riverine roost habitat? If that is clearly stated or justified in the documents, I did not see it. Although observations of whooping cranes used to build the datasets used for the analysis were all daytime observations, when presumably cranes would use the non-roosting habitats such as wetlands, no mention of wetlands or variables or metrics to describe wetland proximity to roost sites are presented. Lines 69-72 note that, "Flights took place in the morning intending to located crane groups before they departed the river to begin foraging at off-channel sites," but how successful were you in deciding what time in the morning that would be? Further, the same passage continues with the statement that return flights took place later and, "systematically surveyed upland areas and smaller side channels." So if you found a crane group in a wetland or field how was that observation handled? Is that part of your data set? Why or why not?		Noted. The analyses presented in Chapters 2 and 3 are intentionally focused on 'riverine habitat selection' and thus off-channel and wetland locations were not included in these chapters (See the WEST Report for these addional analyses). All flights were initiated 30 minutes before sunrise to give the best opportunity of observing cranes roosting on the river, however, we have no information as to the roost location for crane groups that potentially could have left the river prior to the observers detecting them.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
74	Chapter 3	87-88	Shields	Further, lines 87-88 of Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat…." Exactly what is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel? Chapter 3, lines 104-105 notes that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." It seems to me that this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.		Clarification added. The study was focused on WC use of riverine habitat so wetland use locations were not included. We delineated all channels throughout the Great Plains that were used by WC and generated random points within the channel as was done in Chapter 2.
75	Chapter 3	91-93	Shields	Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat…." Exactly what is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel? Chapter 3, lines 104-105 notes that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." It seems to me that this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.		Duplicate comment. See response to previous comment.
76	Chapter 3	93-96	Shields	It is not clear how bird movement during a multi-day stopover was handled when assigning a single location for the "stopover site" (e.g., Chapter 3, lines 89-91).		Clarification added
77	Chapter 3	91	Smith	No reference for Figure 2 (Pearse et. al 2015)	X - Accept	Citation added
78	Chapter 3	94	Shields	location should have a comma after it		Change made
79	Chapter3	115	Shields	"was defined in Chapter 3" should be "is defined in this chapter"		Change made
80	Chapter 3	117	Shields	"throughout migration" should be "other than"		Unclear, change not made
81	Chapter 3	118	Shields	"corridor are not available except for within" should be "were not available"		Change made
82	Chapter 3	133	Shields	Show and explain definition for NF in a figure like 2-2.		Figure not included because we delineated all channels within the Great Plains and generated random locations within the channel and delineated metrics exactly as was done in Chapter 2.
83	Chapter 3	148	Smith	No measurement for values in Table 2. Insert " ft.: in both columns.	X - Accept	Change made
84	Chapter 3	162	Cade	Again, I would eliminate the terms "relative probability of use". They are not probabilities scaled on [0, 1]. They are relative selection ratios that you've chosen to scale to [0, 1]. See my additional explanations in my review of the Correlates of Whooping Crane Habitat Selection document. I note that n = 158 roost locations is a much more suitable sample size for estimating these spline functions than the n = 55 in Chapter 2. The decreasing selection ratios with increasing distance to nearest forest from 200 to 425 feet and then increasing selection ratios with increases above 425 feet needs some serious interpretation. And again, as discussed in my review of the Correlates of Whooping Crane Habitat Selection document, all the interpretations of partial effects need to really be done with respect to the confidence intervals of the relative selection ratios rather than focusing on just the point estimates. Doing this would indicate that the data and statistical models suggest a much wider range of channel widths as having indistinguishable relative selection ratios.	X	As in chapter 2, a revision of terminology was conducted and reflected that these habitat relationships are scaled to 1 and not the same as stating a probability of use. Intrepetation of the habitat selection results was revised to reflect the amount of uncertainty of point estimates and how positive/negative relationships are indistinguiable at intermediate to large values of unobstructed channel width. The relationship is more clear cut now that we delineated channels throughout the migration corridor, generated random locations within the channel, calculated metrics as was done in Chapter 2, and re-ran the analyses.
85	Chapter 3	183-205	Cade	But an interesting aspect of this discussion that is not made is that the data actually shows cranes make less use of the widest unobstructed channel widths and distances to nearest forest that were available, and primarily focus roosts more on intermediate distances (Figures 5 and 6). Reconciling this would seem to be important in arguing about how critical wide open channel areas are to cranes. Is it possible that those widest, open channels actually end up having water depths that are too shallow to provide the security from predators that conceptually they might be seeking? Or something else?	X	The discussion section points out how we are not able to capture some of the detailed aspects of roost sites for this analysis such as water details at a site. We included language indicating cranes appear to select for more intermediate UOCWs. However, we limited our specific inference about very wide channels having less use by cranes because of the uncertainty around points estimates of the relative selection ratios.
86	Chapter 3	201	Smith	Discuss water presence, but did not measure or analyze that in this chapter. Insert "While we did not examine presence of water at each use site, we assumed that surface water was available in a riverine site"?	X - Accept	Change made
87	Chapter 3	212	Shields	"telemetry" should be "Our telemetry"		Change made
88	Chapter 3	225-265	Smith	The point concerning UOCW in Chapter 3 states that the variability of this metric was among different river systems within the migratory corridor (p. 66, lines 225-265). The explanation that these other rivers are typically wider than the AHR at Platte River are not founded on any results provided in the chapter .I believe this would elevate the value of the chapter findings as a potential publication of merit, as well as providing information on the importance of these multiple stopover sites throughout the Great Plains for migrating whooping cranes.	**See Below**	Noted

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				HABITAT SYNTHESIS CHAPTERS		
89	Chapter 3	General	Smith	Suggested revisions: 1) Provide a location map or text description of river systems (or alternatively, basins) used during this study 2) Discuss potential effects bird age, group, or experience may affect habitat choice (e.g., in telemetry juveniles in fall migration, locations are chosen by experienced parents, most likely on their >5th migration) 3) Characterize the general weather conditions throughout the study in terms of potential water availability (drought index, for example)	**X - Introducing new study sites without locations doesn't make sense, particularly when it is discussed that river widths are less at Platte than "other sites; drought affects water availability, and may affact where cranes land in a river system; if this information will be published, may want to consider addressing this**	All river systems within the study area that experienced use were included in our analysis so no map or further description added. All ages of birds were tracked so our sample was representative of what the population selected as a whole. Locations included in our study represent locations selected by crane groups (≥1 crane) rather than individuals. Not sure what the value of reporting indices such as the drought index given it seems unlikely such metrics would effect selection of various widths of river channel???
90	Chapter 3 references	248	Shields	In paper, but not in reference list 1. Freeman 2010 2. Austin Reichert 2001? Maybe a mistake?		Citations added
91	Chapter 3	280	Smith	Correct misspelling to "Currier"	X - Accept	Change made
92	Chapter 4	12	Smith	Define UOCW and relate to previous chapters	X - Accept	Change made
93	Chapter 4	12	Smith	Define TUCW and relate to previous chapters	X - Accept	Change made
94	Chapter 4	15	Smith	Define AHR	X - Accept	Change made
95	Chapter 4	45	Smith	Acronym NF not defined	X - Accept	Change made
96	Chapter 4	48	Shields	"UOCW reaches" should be "UOCW exceeds"		Change made
97	Chapter 4	48	Shields	"unforested corridor width reaches" should be "unforested corridor width exceeds"		Change made
98	Chapter 4	48	Smith	Use NF acronym	X - Accept	Change made
99	Chapter 4	48	Shields	"UOCW reaches 739ft" should be "UOCW exceeds 739ft"		Change made
100	Chapter 4	48	Shields	"unforested corridor width reaches" should be "unforested corridor width exceeds"		Change made
101	Chapter 4	49	Shields	"1,119ft" insert "(Chapter 3) before the period"		Change made
102	Chapter 4	66	Shields	"Number 2 offsetting" should be inserted "Partially offsetting"		change made
103	Chapter 4	76	Shields	"AHR but natural high flow" should have "AHR, but natural high flow"		Change made
104	Chapter 4	80	Cade/Smith	Figure 1: I can't see any green line that is referenced in the caption.	**Either change wording in figure, or remove phrase "green line"**	Green line is a geomorphic term indicating the lowest elevation vegetation establishes in the channel
105	Chapter 4	Figure 1	Smith	Font size not standardized in figure; unclear what "?" means in y axis	X - Accept	Figure description enhanced.
106	Chapter 4	87	Smith	Insert 90-mi reach (when referring to overall length)	X - Accept	Change made
107	Chapter 4	93	Smith	Insert "National Audubon Society"	X - Accept	Change made
108	Chapter 4	101	Smith	Capitalize genus name	X - Accept	Change made
109	Chapter 4	146	Shields	"mean discharge more than doubled and " should be "mean discharge more than doubled, and"		Change made
110	Chapter 4	Fig 2	Smith	Map not to scale (correct)	**It seems that a map in a publication such as this would format maps with scale**	Do not understand this comment. No change made.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
111	Chapter 4	Fig 3	Smith	Correct x axis title (Total Volume)	**Total Event Volume was listed in Table 3 for x-axis, use same in Fig. 3**	Do not understand this comment. No change made.
112	Chapter 4	164	Shields	"TUCW" should be spelled and defined, and present figure 4 here		Defined but did not move figure location.
113	Chapter 4	176	Shields	"First Increment of the Program" should be defined		Change made
114	Chapter 4	178	Shields	"estimates for maintenance of 400-800" should be "estimates for maintenance should be 400-800 ft."		Change made
115	Chapter4	186	Shields	"focuses solely on the 84-miles" should be "focuses solely on 84 miles"		Change made
116	Chapter 4	189	Shields	"Largely confined to the north channel and hydropower" should be "largely confined to the north channel, and hydropower"		Change made
117	Chapter 4	190	Shields	"south channel in this reach making it difficult" should be "south channel in this reach, making it difficult"		Change made
118		198	Smith	"insert hyphen (photo-interpreted)	X - Accept	Change made
119	Chapter 4	199	Smith	Vague citation (provide more reference)	X - Accept	Study has been published. Change made.
120	Chapter 4	226-228	Cade	The terminology "multiple" rather than "multivariate" regression is more appropriate as the former typically implies multiple predictor variables whereas the latter implies multiple response variables. Robust regressions is defined later.	X	Change made
121	Chapter 4	229-230	Cade	It seems like quantile regression could perhaps be better employed here to evaluate unobstructed channel widths while treating this measure as a continuous variable, avoiding creating the arbitrary binomial breaks at 400, 500, 600, 700, or 800 feet.		Agreed, analysis was updated to a quantile regression and a logistic regression method was omitted.
122	Chapter 4	236-243	Cade	Quantile regression where you estimate an interval of quantiles could have perhaps more easily been used here. Quantile regression estimates for those quantiles less than the extreme values will be little influenced by the extreme values. Furthermore, the quantile regression estimates could easily be used to provide a prediction interval (e.g., 80% prediction interval based on 0.10 and 0.90 quantile estimates) without making any distributional assumptions. Cade and Noon (2003) provides a concise introduction and Koenker (2005) is the definitive text on quantile regression.		Analysis was updated to a quantile regression
123	Chapter 4	236	Smith	Not sure if term eliminate is appropriate (suggest - reduce)	X - Accept	Change not made. It does elimnate the effect of island randomness.
124	Chapter 4	246	Smith	Hyphen missing (five-step)	X - Accept	Change made
125	Chapter 4	288	Shields	"with increasing TUCW but" should be "with increasing TUCW, but"		Change made
126	Chapter 4	304	Shields	"At full-scale implementation, up to 83%" should be "At full-scale implementation be 83%"		Change not made. At full scale implementation, spraying effort varies based on phrag occurance.
127	Chapter 4	338	Cade	Should this be 48 feet (0.48 × 100)?	X	Change made
128	Chapter 4	339	Smith	Results for herbicide only missing (add information)	X - Accept no change, just interested in individual and paired management options	Change not made, herbicide only relationships were not important to visualize for mangement reasons. Conclusions about herbicide effectiveness on channel widths responses can be determined from other parts of the results section.
129	Chapter 4	342	Smith	Insert "other" between "no" and "management"	X - Accept	Change made
130	Chapter 4 Figures 9-14	347-419	Cade	Figures 9, 10, 11, 12, 13, 14: Are these really 95% confidence intervals on the predicted means? I would expect the confidence intervals to have the typical bow tie shape with decreased interval lengths near the mean of the predictor variable and wider interval lengths at more extreme predictor values. These are parallel lines. I'm wondering if these really are 95% prediction intervals for a single new observation. This should be checked.	X - Accept	The updated analysis with quantile regression does not have this issue and is similar to comment ID 122
131	Chapter 4	409	Smith	Disking and herbicide (blue) missing in legend (add)	X - Accept	Changes made
132	Chapter 4	360-378; 424-435	Cade	These comparisons make the common mistake of thinking that the mean regression estimated should be close to all observations in a system where there is considerable variability. It would be more informative to look at the prediction interval lengths (for a single new observation), say for 95% prediction intervals, and then see what proportion of observations are outside that interval (is it more than 5%). The point estimate of the predictions from the estimated mean regression model should not really be the focus for determining the suitability of the model estimates. The intervals associated with the predictions are more relevant.		Changes made to reflect prediction and not confidence intervals.
133	Chapter 4	362	Shields	"betas previously stated" --betas should be defined		Specific language was added the address betas values and tables were added presenting beta values across the distribution of response variables.
134	Chapter 4	398	Cade	Should that be 20 feet (0.02 × 1000)?	X	Beta values are based on per unit changes in the predictor variable. So, a one unit change in 40 Day peak corresponds to a 0.02 ft increase in TUCW, but a 1000 unit increase in 40 day peak corresponds to a 20 ft increase in TUCW.
135	Chapter 4	401	Cade	Should that be 19 feet (0.19 × 100)?	X	Beta values are based on a per unit increase in the predictor variables.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
136	Chapter 4	404	Smith	Add results for disking only	**Why show results in Figure 12 for disking only if you don't intend to evaluate them?**	Change not made because a disking only relationships would only add complexity and confusion to overall results
137	Chapter 4	415	Shields	"Dischargemain" should be "Discharge"		Change made
138	Chapter 4	436	Cade	Some statement about what the Monte Carlo random sampling was across should be made here. There are many ways to conduct Monte Carlo simulations	X	Added more specific language about monte carlo simulation to obtain variable sensitivity.
139	Chapter 4	449-469	Cade	Again, I think if quantile regression had been used for the modeling of UOCW and TUCW, that the proportion of the probability distribution being modeled by the covariates exceeding some selected values (400, 500, 600, 700, and 800 feet) would have been easily determined without these logistic regressions.		Analysis was updated to a quantile regression
140	Chapter 4	497	Smith	Insert space between value and measure	X - Accept	Change made
141	Chapter 4	510	Smith	The discussion in Chapter 4 could be expanded when describing the constraints from upstream management to provide flow releases of 5,000-8,000 cfs. It may be helpful to understand how effective those short-duration high flows as designated in the AMP affect shallow water roost conditions within the channel to ensure suitable habitat conditions for whooping cranes in the AHR during migration periods. Suggested revision: 1) Include discussion in Chapter 4 that acknowledges any benefits derived from SDHF improving habitat suitability; 2) Provide any recommendations on the flows necessary to achieve the AMP objective based on reported analyses.	X - Accept	Chapter 4 does explicitly state the benefits derived from SDHF in relation to increased UOCW. There are no other whooping crane-related SDHF benefits that are relevant to the Program. We did not add flow recommendations as they will be developed through the Program's AM process.
142	Chapter 4	525	Shields	"may not be that important as UOCW" should be "may not be that important, as UOCW"		Change made
143	Chapter 4	527	Shields	In paper, but not in reference list 1. Murphy et al 2001		Change made
144	App III	120	Smith	TUCW not defined in Table Caption	X - Accept	Change made
145	App IV	142	Cade	Oracle Crystal Ball Monte Carlo Simulations: There is too little detail provided to determine whether this simulation analysis is accomplishing anything of merit. For example, why assign the particular probability distribution functions to the various predictor variables, e.g., gamma for peak discharge, beta for median grain size, etc.?		Added statement that distributions were fit to the observed data.
146	EDO Memo	124	Cade	WEST and the EDO are correct to be cautious about using model averaging. The comment suggests that the Trust was suggesting model averaging regression coefficients into a "best" model. There has never been good theoretical or empirical evidence that model averaging individual regression coefficients ever achieves anything useful in terms of addressing model uncertainty in a multimodel inferential context. Indeed, Cade (2015. Model averaging and muddled multimodel inferences. Ecology 96: 2370-2382) and Banner and Higgs (2016. Considerations for assessing model averaging of regression coefficients. Ecological Applications, In press) have presented a fairly thorough indictment of simple model averaging of regression coefficients. Furthermore, model averaging individual regression coefficients for the spline terms in the GAM used here would seem to be even more nonsensical. It still might be useful to model average the predicted responses across the multiple models to address model uncertainty in the predictions, but this in no way results in a calculation that is equated to a "best" model.		Model averaging was not performed in these chapters as we are hesitant to include such information that may further complicate management decision for the Program and its partners.
FOOTNOTE				Some references to page numbers by Reviewers have been modified to reflect the September 29, 2016 document.		

EXHIBIT 2 – Reviewer Documentation

From:	Cade, Brian
To:	Kenner, Mary A.
Subject:	Re: PRRIP Whooping Crane Peer Review Response to Comments
Date:	Monday, June 26, 2017 1:52:21 PM
Attachments:	image001.png image002.png image003.png

External

Mary and Tom: I looked over the revised documents and Excel spread sheet of the responses to the reviews. I am quite pleased with the how the authors responded and incorporated changes per my suggested statistical modifications. Given the statistical expertise that resides at WEST, I was happy to see that the authors incorporated all the major statistical modifications that I suggested including the suggested wording changes to "relative selection ratios". I did note that in Chapter 4 of the Synthesis document that the heading in Table 13 says "change in mean ..." when what are really now provided are estimated quantiles. The wording here, and perhaps elsewhere, in this chapter might need to be checked to make sure the headings correctly reflect the new shift to estimating quantiles (quantile regression) rather than means. This is a rather minor editorial fix.

Thank you for the opportunity to see how the authors have responded to our reviews.

Brian

Brian S. Cade, PhD

U. S. Geological Survey
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email: cadeb@usgs.gov
tel: 970 226-9326

On Wed, Jun 21, 2017 at 2:29 PM, Kenner, Mary A. <mkenner@louisberger.com> wrote:

> Greetings,
>
> Headwaters Corporation has prepared responses to your comments on the Platte River Recovery implementation Program whooping crane peer review documents (WEST report and synthesis chapters) and would like to obtain feedback. They have requested we ask each of you to review the modified documents and indicate in some manner if the modifications are acceptable. They would like to close the loop and request each panel member take a look at their responses, particularly those items you indicated were necessary to change before the two documents would be “acceptable.”.

While your contracts for the peer reviews ran out in February, the work of taking a last look and rendering a verdict is something that was in the original contract.

Below are listed the documents that are contained in the attached pdf file:

1) Louis Berger Peer Review Summary Report.

2) An Excel file with Headwaters specific responses to each peer review comment. The file includes a tab for the synthesis chapters and a tab for the WEST report. In both cases, Headwaters added a column that includes an "X" for comments that needed to be addressed to obtain your acceptance of the final documents. The Excel files contain a column for you to make notes.

3) The revised WEST report.

4) The revised synthesis chapters.

Please note all of the documents have been combined into one PDF document. You can click on each individual document shown as an icon on the left hand side labeled 01, 02, 03, or 04. Once selected you can use the icon "open file" at the top right hand corner to open that individual report or excel file.

We would like to have your response back by July 21st so we can prepare a 1-2 page summary report of your responses to their modifications. Please communicate to us your reaction to the revised documents and whether we can now say the documents are acceptable or not.

Please let Tom or I know if you have any questions.

Mary Kenner

Project Analyst | Planning, Facilities, and Resource Management

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Mary Kenner
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From:	Doug Shields
To:	Kenner, Mary A.
Cc:	Cade, Brian; Elizabeth Smith; St Clair, Thomas
Subject:	Re: PRRIP Whooping Crane Peer Review Response to Comments
Date:	Tuesday, July 25, 2017 10:33:25 AM
Attachments:	image001.png image003.png image002.png

External

Thank you for your forbearance in allowing me to delay my response until today.

I still feel there should be evidence in your documents of integration of efforts for manage for WC with those directed at the other species of concern such as sturgeon, least tern, piping plover....my comment on this was simply "noted."

I am sorry, but I do not see my main comment, which was as follows, addressed. Maybe I just overlooked the response.

Shields noted there is no mention of *Bankhead et al. (2016)* since Bankhead's work was sponsored by the PRRIP and must have been available to the author. He strongly recommended that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), *Kui et* al. (2014), Diehl et al. (2016), Manners et al. (2015) and *Edmaier et al. (2015).* See Shields additional comments bulleted below:

• The work by *Bankhead et al. (2016)* indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

• Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

• *Corenblitt et al. (2015)* is a very general review paper that you might consider. There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River *(e.g., Fotherby 2009*). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

• Johnson (1994) is cited, but were his findings fully utilized? Johnson presents several management recommendations that include flow timing as well as flow magnitude, and his recommendations are linked closely to biological processes.

I also do not see that a management model should not include conversion of forest to wetland or wet meadow or some other type of management. See below with my final comment on the extreme right.

I am puzzled by the statement, "Nearest obstruction and nearest forest were present in all five of the top five models. These models do not appear at the top of the management model list because PRRIP staff does not consider nearest obstruction to be a variable useful for management." Mechanical removal of trees is one of the key management actions described! However, it would seem that there should be a high correlation between NO and NF and between NO and UOCW. The report does not comment on this, either. The diurnal data indicate preferential selection of cornfields relative to grassland, soybean and wet meadow. Has any consideration been given to potential hazards to WC posed by herbicides, insecticides or less than optimal forage found in cornfields relative to more natural habitats?	Clarification added. While NO and NF may appear to be manageable through vegetation removal, we can't control if the bird chooses to land next to a bankline that would be considered an obstruction. Potential hazards associated with selection of cornfields is beyond the scope of this Report and potentially beyond the scope of the PRRIP.	I cannot figure out what you mean by controlling a bird landing near a bankline considered an obstruction. You can control forest. Furthermore, I am suggesting that replacement of cornfields with more natural habitat might be a valid management action, particularly if cornfields pose an indirect hazard due to pesticides, etc.

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University, MS 38677

On Wed, Jun 21, 2017 at 3:29 PM, Kenner, Mary A. <mkenner@louisberger.com> wrote:

Greetings,

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We would like to have your response back by July 21st so we can prepare a 1-2 page summary report of your responses to their modifications. Please communicate to us your reaction to the revised documents and whether we can now say the documents are acceptable or not.

Please let Tom or I know if you have any questions.

Mary Kenner

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EXHIBIT 3 – Response to Dr. Shields Comments

PRRIP EDO Responses to Peer Review Comments from Shields:

Shields noted there is no mention of *Bankhead et al. (2016)* since Bankhead's work was sponsored by the PRRIP and must have been available to the author. He strongly recommended that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), *Kui et* al. (2014), Diehl et al. (2016), Manners et al. (2015) and *Edmaier et al. (2015)*. See Shields additional comments bulleted below:

- The work by *Bankhead et al. (2016)* indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

- Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

- *Corenblitt et al. (2015)* is a very general review paper that you might consider. There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River *(e.g., Fotherby 2009*). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

- Johnson (1994) is cited, but were his findings fully utilized? Johnson presents several management recommendations that include flow timing as well as flow magnitude, and his recommendations are linked closely to biological processes.

Regarding the use of an empirical versus simulation approach: *PRRIP implementation is proceeding under an adaptive management (AM) framework. Simulation modeling (SED-VEG model) was used to develop the Short-Duration High Flow management action described in Chapter 4. This work was conducted in the mid-2000s (problem assessment and design steps of AM). The Program began implementation and monitoring of management actions in 2007 (implementation and monitoring steps of AM). The empirical analyses in Chapter 4 reflect 1) an evaluation of the apparent effectiveness of Program management actions and 2) and broader evaluation of the physical process relationships that appear to be driving the occurrence of in-channel vegetation. Based on the Chapter 4 analyses, we have very low confidence that SDHF can create and/or maintain suitably-wide unvegetated channel widths, indicating that we need to adjust our management.*

Once the Program has formally acknowledged that we need to adjust our management actions, we will start back through another loop of AM cycle. Our first task will be to develop new (and better) simulation models to help inform new management actions. These tools will be calibrated and validated using the *empirical data collected since 2007. In fact, we have recently submitted a joint grant proposal with the Bureau of Reclamation to refine their integrated two-dimensional hydrodynamic and vegetation model (SRH-2DV) for use in the central Platte River. We have also applied various two-dimensional sediment transport models but have generally found that they do not adequately capture geomorphic adjustments in a braided river environment.*

Regarding the Bankhead et al. research: *That research was not discussed in Chapter 4 for two reasons. First, the Program has already embraced and adjusted management actions based on their findings. Specifically, the Program recognizes that flow is not competent to remove phragmites and has implemented a large-scale phragmites spraying program. All in-channel infestations are treated with herbicide annually either by helicopter or airboat. Second, the Chapter 4 analysis reflects physical process relationships under this active-treatment paradigm. IE, the Chapter 4 analysis reflects what actually happened in the reach under this active-spraying paradigm.*

Regarding sediment-vegetation relationships: *We are continuing to refine our understanding of sediment transport in the central Platte River. However, spatial and temporal variability in sediment flux has generally been so great as to mask our ability to identify trends and relationships in most of the reach with the exception of the short segment directly below the clear-water return at the upper end of the reach.*

Regarding evaluation of alternative management actions: *We are anticipating using new simulation tools to evaluate a suite of potential future flow management alternatives, including those recommended by Johnson. This will proceed as a new AM cycle.*

Regarding the statement that a management model should not include conversion of a forest to wetland or wet meadow or some other type of management: *This is a values statement and is beyond the scope of the data synthesis chapters, which focused on what habitats whooping cranes used (Chapters 1-3 and West Report) and how Program management actions and natural events influence in-channel vegetation (Chapter 4).*

From:	Doug Shields
To:	Kenner, Mary A.
Subject:	Re: PRRIP Whooping Crane Peer Review Response to Comments
Date:	Tuesday, August 08, 2017 9:34:19 AM
Attachments:	image002.png image003.png image001.png

External

Mary,

I remain mystified regarding the way my main comment was handled--I do not understand why the last document you sent was not included in the larger documents providing responses to all comments.

Pro forma, by way of this email to you I am stating that the responses have been acknowledged and are minimally satisfactory. I understand the points made in the response about the long time frame involved in the AM cycle; I encourage program administrators to devise a more nimble approach for incorporating breaking research into project management.

sincerely,

d

Doug Shields, Jr., Ph.D., P.E., D.WRE

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University, MS 38677

On Mon, Aug 7, 2017 at 5:09 PM, Kenner, Mary A. <mkenner@louisberger.com> wrote:

Doug,

There was some miscommunication on these comments, but PRRIP EDO prepared a response (attached) based on your comments provided in the Summary Report.

Please let us know if this response is satisfactory.

If so, please send an email for the record stating your acceptance of both the West Report and Synthesis Chapters based on the modified document and this additional 8/2/17 response.

Thanks.

Mary

Mary Kenner

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Country

From: Doug Shields [mailto:doug2shields@gmail.com]
Sent: Monday, July 31, 2017 2:18 PM
To: Kenner, Mary A. <mkenner@louisberger.com>; St Clair, Thomas <gtstclair@louisberger.com>

Subject: Re: PRRIP Whooping Crane Peer Review Response to Comments

External

Ms. Kenner,

I do not wish to be difficult. I do see where my comment is presented in the draft summary report on page 20. I do not see anywhere in the comments/responses spreadsheet where this comment is addressed, or even mentioned.

I also could not locate any modification to the reports to address this comment. Please tell me if I am wrong!!

Thank you for your patience.

sincerely,

d

Doug Shields, Jr., Ph.D., P.E., D.WRE

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On Thu, Jul 27, 2017 at 3:42 PM, Kenner, Mary A. <mkenner@louisberger.com> wrote:

Doug, thank you for your response. Can you please confirm (by email response) if the changes made in the modified document are acceptable.

We will incorporate your additional comments (below) into our final report. I did double check to see if your" Bankhead et. al" comment was included in the original summary report submitted and it was-- as part of your answer to question #9, page 20.

Let us know if you have any questions or concerns.

Mary

From: Doug Shields [mailto:doug2shields@gmail.com]
Sent: Tuesday, July 25, 2017 10:33 AM
To: Kenner, Mary A. <mkenner@louisberger.com>
Cc: Cade, Brian <cadeb@usgs.gov>; Elizabeth Smith <esmith@savingcranes.org>; St Clair, Thomas <gtstclair@louisberger.com>
Subject: Re: PRRIP Whooping Crane Peer Review Response to Comments

External

Thank you for your forbearance in allowing me to delay my response until today.

I still feel there should be evidence in your documents of integration of efforts for manage for WC with those directed at the other species of concern such as sturgeon, least tern, piping plover....my comment on this was simply "noted."

I am sorry, but I do not see my main comment, which was as follows, addressed. Maybe I just overlooked the response.

Shields noted there is no mention of *Bankhead et al. (2016)* since Bankhead's work was sponsored by the PRRIP and must have been available to the author. He strongly recommended that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), *Kui et* al. (2014), Diehl et al. (2016), Manners et al. (2015) and *Edmaier et al. (2015).* See Shields additional comments bulleted below:

• The work by *Bankhead et al. (2016)* indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

• Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

• *Corenblitt et al. (2015)* is a very general review paper that you might consider. There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River *(e.g., Fotherby 2009*). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

• Johnson (1994) is cited, but were his findings fully utilized? Johnson presents several management recommendations that include flow timing as well as flow magnitude, and his recommendations are linked closely to biological processes.

I also do not see that a management model should not include conversion of forest to wetland or wet meadow or some other type of management. See below with my final comment on the extreme right.

I am puzzled by the statement, "Nearest obstruction and nearest forest were present in all five of the top five models. These models do not appear at the top of the management model list because PRRIP staff does not consider nearest obstruction to be a variable useful for management." Mechanical removal of trees is one of the key management actions described! However, it would seem that there should be a high correlation between NO and NF and between NO and UOCW. The report does not comment on this, either. The diurnal data indicate preferential selection of cornfields relative to grassland, soybean and wet meadow. Has any consideration been given to potential hazards to WC posed by herbicides, insecticides or less than optimal forage found in cornfields relative to more natural habitats?	Clarification added. While NO and NF may appear to be manageable through vegetation removal, we can't control if the bird chooses to land next to a bankline that would be considered an obstruction. Potential hazards associated with selection of cornfields is beyond the scope of this Report and potentially beyond the scope of the PRRIP.	I cannot figure out what you mean by controlling a bird landing near a bankline considered an obstruction. You can control forest. Furthermore, I am suggesting that replacement of cornfields with more natural habitat might be a valid management action, particularly if cornfields pose an indirect hazard due to pesticides, etc.

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On Wed, Jun 21, 2017 at 3:29 PM, Kenner, Mary A. <mkenner@louisberger.com> wrote:

Greetings,

Headwaters Corporation has prepared responses to your comments on the Platte River Recovery implementation Program whooping crane peer review documents (WEST report and synthesis chapters) and would like to obtain feedback. They have requested we ask each of you to review the modified documents and indicate in some manner if the modifications are acceptable. They would like to close the loop and request each panel member take a look at their responses, particularly those items you indicated were necessary to change before the two documents would be "acceptable.".

While your contracts for the peer reviews ran out in February, the work of taking a last look and rendering a verdict is something that was in the original contract.

Below are listed the documents that are contained in the attached pdf file:

1) Louis Berger Peer Review Summary Report.

2) An Excel file with Headwaters specific responses to each peer review comment. The file includes a tab for the synthesis chapters and a tab for the WEST report. In both cases, Headwaters added a column that includes an "X" for comments that needed to be addressed to obtain your acceptance of the final documents. The Excel files contain a column for you to make notes.

3) The revised WEST report.

4) The revised synthesis chapters.

Please note all of the documents have been combined into one PDF document. You can click on each individual document shown as an icon on the left hand side labeled 01, 02, 03, or 04. Once selected you can use the icon "open file" at the top right hand corner to open that individual report or excel file.

We would like to have your response back by July 21st so we can prepare a 1-2 page summary report of your responses to their modifications. Please communicate to us your reaction to the revised documents and whether we can now say the documents are acceptable or not.

Please let Tom or I know if you have any questions.

Mary Kenner

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Country

PRRIP EDO Responses to Peer Review Comments from Shields:

Shields noted there is no mention of *Bankhead et al. (2016)* since Bankhead's work was sponsored by the PRRIP and must have been available to the author. He strongly recommended that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), *Kui et* al. (2014), Diehl et al. (2016), Manners et al. (2015) and *Edmaier et al. (2015).* See Shields additional comments bulleted below:

- The work by *Bankhead et al. (2016)* indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

- Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

- *Corenblitt et al. (2015)* is a very general review paper that you might consider. There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River *(e.g., Fotherby 2009*). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

- Johnson (1994) is cited, but were his findings fully utilized? Johnson presents several management recommendations that include flow timing as well as flow magnitude, and his recommendations are linked closely to biological processes.

Regarding the use of an empirical versus simulation approach: *PRRIP implementation is proceeding under an adaptive management (AM) framework. Simulation modeling (SED-VEG model) was used to develop the Short-Duration High Flow management action described in Chapter 4. This work was conducted in the mid-2000s (problem assessment and design steps of AM). The Program began implementation and monitoring of management actions in 2007 (implementation and monitoring steps of AM). The empirical analyses in Chapter 4 reflect 1) an evaluation of the apparent effectiveness of Program management actions and 2) and broader evaluation of the physical process relationships that appear to be driving the occurrence of in-channel vegetation. Based on the Chapter 4 analyses, we have very low confidence that SDHF can create and/or maintain suitably-wide unvegetated channel widths, indicating that we need to adjust our management.*

Once the Program has formally acknowledged that we need to adjust our management actions, we will start back through another loop of AM cycle. Our first task will be to develop new (and better) simulation models to help inform new management actions. These tools will be calibrated and validated using the *empirical data collected since 2007. In fact, we have recently submitted a joint grant proposal with the Bureau of Reclamation to refine their integrated two-dimensional hydrodynamic and vegetation model (SRH-2DV) for use in the central Platte River. We have also applied various two-dimensional sediment transport models but have generally found that they do not adequately capture geomorphic adjustments in a braided river environment.*

Regarding the Bankhead et al. research: *That research was not discussed in Chapter 4 for two reasons. First, the Program has already embraced and adjusted management actions based on their findings. Specifically, the Program recognizes that flow is not competent to remove phragmites and has implemented a large-scale phragmites spraying program. All in-channel infestations are treated with herbicide annually either by helicopter or airboat. Second, the Chapter 4 analysis reflects physical process relationships under this active-treatment paradigm. IE, the Chapter 4 analysis reflects what actually happened in the reach under this active-spraying paradigm.*

Regarding sediment-vegetation relationships: *We are continuing to refine our understanding of sediment transport in the central Platte River. However, spatial and temporal variability in sediment flux has generally been so great as to mask our ability to identify trends and relationships in most of the reach with the exception of the short segment directly below the clear-water return at the upper end of the reach.*

Regarding evaluation of alternative management actions: *We are anticipating using new simulation tools to evaluate a suite of potential future flow management alternatives, including those recommended by Johnson. This will proceed as a new AM cycle.*

Regarding the statement that a management model should not include conversion of a forest to wetland or wet meadow or some other type of management: *This is a values statement and is beyond the scope of the data synthesis chapters, which focused on what habitats whooping cranes used (Chapters 1-3 and West Report) and how Program management actions and natural events influence in-channel vegetation (Chapter 4).*

PANEL MEMBER COMMENT SPREADSHEET
Platte River Recovery Implementation Program
Data Synthesis Compilation, Whooping Crane (Grus americana) Habitat Synthesis Chapters

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
1	Overall		Shields	The synthesis chapters do provide evidence that higher flows, disking and herbicide application increase whooping crane stopover habitat, particularly when all three occur together. I do note that the increase in mean UOCW due to SDHF releases alone is essentially negligible, but it is important to note that the WC do not react to mean conditions along the AHR. Instead, they need some minimum level of habitat availability. Figure 15 shows that a 40-day peak discharge of 1,000 cfs is associated with a ~25% probability that a managed transect will have a UOCW > 600 ft. A three-day SDHF of 8,000 cfs requires 45,000 ac-ft. above a base flow of 500 cfs (or 26,000 to 68,000 ac-ft., lines 495-496), while a 40-day flow of 1,000 cfs requires 40,000 ac-ft. above a baseflow of 500 cfs, so a 40-day flow would be attainable with current water allocation. If 25% of the AHR provided UOCW > 600 ft., would that represent an improvement over current conditions? Over projected future conditions? Would it be biologically significant with respect to WC habitat availability?		The objective of this analysis was to evaluate the performance of the FSM management strategy, which includes SDHF, a specific flow management action. As the reviewer notes, the predicted increase in UOCW due to SDHF is negligible. IE, if channels are unsuitably narrow, SDHF will not substantially improve UOCW, if channels are already suitably wide, the incremental benefit of SDHF is unnecessary. Once the Program has completed its formal assessment of SDHF (last step in adaptive management cycle) we will adjust flow-management through development and testing of new flow-management hypotheses.
2	Overall		Smith	Suggested Revisions: provide a more comprehensive evaluation for Program decisions and promotion of policy by: 1) Incorporating more discussion in each section relating to the interpretation of results that address components of both MCM and FSM; 2) Providing more information about locations of conserved/managed areas as part of MCM management potential; 3) Providing more discussion of MCM strategy effectiveness in Chapters 2 and 4;	X - Accept	The objective of this analysis was to evaluate the performance of the FSM management strategy, which includes SDHF, a specific flow management action. Evaluation of the performance of the MCM management strategy was outside of the scope of this investigation.
3	Overall		Smith	Suggested revisions throughout the report: 1) Standardize between standard and metric, or give both throughout report 2) Standardize spacing between number and measurement (e.g., 10ft vs 10 ft.) among chapters 3) Correct spelling of Richert from Reichert throughout report 4) Correct PRRIP from Program for citing program reports throughout this report	X - Accept	Changes made
4	Chapter 1	Figure 3	Shields	Size and status of WC population. The statement that the AHR is used by 5-10% of the WC migratory population (Chapter 4, line 32) may be at variance with the blue bars of Figure 3 of Chapter 1, which Figure badly needs a legend. The top half of this figure shows whooping crane numbers of ~175 for 2010-2014. If this is 175 individuals per year, then 175 >>30. If it is 175 individuals for the entire period 2010-2014, then 175/5 = 35 ~ 30. Line 235 of Chapter 1 states that WC use of the Platte River declined between 1950 and 1980, but Figure 3 shows an increase during this period.		Legend added to figure which clarifies the confusion expressed in this comment. Lately, 5-10% has been the typical annual use of the AHR, but use has ranged from <1% to nearly 15%. Red line represents the population size and blue bars represent wc use during each 5-year period. Use of the Platte River (blue bars) between 1950 and 1980 was nearly 0, but the population size (red line) increased during this time period.
5	Chapter 1	21	Smith	(Program 2006a) referenced in Literature Cited as PRRIP 2006a. Correct to PRRIP 2006a, standardize throughout report (also p. 8, line 134, p. 19, line 361, etc.)	X - Accept	Change made
6	Chapter 1	28	Shields	"Nine years implementing"--see line 7 of preface		Change made
7	Chapter 1	51	Smith	Correct Latest edition of this reference to 2007	**Page 6, line 16 - Latest publication o recovery plan is 2007, you cite it correctly on page 7 on line 9 and 21**	Unsure what is wanted here???
8	Chapter 1	59	Smith	State 200-mile wide corridor. Actually less, as cited in Tacha et al. 2010 and substantiated by Pearse et al. 2015; also cite Pearse et al. for Figure 2 map, since same as in this publication	X - Accept	Figure 2 shows the migration corridor developed based on observations collected during the recent telemetry study. The corridor ranges from ~300-500 miles wide, however, a majority of use occurs within the central 200-mile wide area as stated. Tacha et al. 2010 reported 95% of use locations were located within a 170-mile wide corridor which is similar to our report.
9	Chapter 1	75	Shields/ Smith	"ANR" should be "ANWR"	X - Accept	Change made
10	Chapter 1	Fig 2	Smith	Standardize scale to Km or mi throughout	X - Accept	Change will be made for publication.
11	Chapter 1	103	Smith	Most birds arrive by early-mid December, not mid-November (Butler et al. 2014...winter abundance). Dorect to early-mid December.	X - Accept	Change made
12	Chapter 1	106	Smith	Generalized statement of sub-adults near natal area of first winter, Correct to relate actually form loose flocks and travel outside defended territories where they first wintered (Stehn and Prieto 2010)	X - Accept	Change made
13	Chapter 1	111	Smith	Pitts (1985) incomplete citation; delete if not available.	**Provide informati relating you have file at your business location**	have a copy of the report, but it has never been published.
14	Chapter 1	124	Shields	After "monitoring effort "insert "on the Platte River"		Change made
15	Chapter 1	138	Smith	insert feet follow metric 1,150	X - Accept	Change made

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
16	Chapter 1	140	Shields	"maximized at 1,150…" should be "maximized at UOCW of 1,150…"		Change made
17	Chapter 1	160	Smith	Expand explanation of percentage changes throughout the period in Table 1	X - Accept	Explanation provided in the literature cited in the caption (Stroup et al. 2006)
18	Chapter 1	199	Shields	"no width change" between what dates?		Dates added.
19	Chapter 1	270	Smith	Add Peake et al. 1985 to Literature Cited	X - Accept	Change made
20	Chapter 1	273	Smith	EIS 2006 cited as Department of Interior in Literature Cited (determine correct citation)	X - Accept	Change made
21	Chapter 1	274	Smith	no date of citation in text after Sidle et al. (correct)	X - Accept	Change made
22	Chapter 1	288	Shields	between the J-2 Return and….. something left out after "and"		Correction made
23	Chapter 1	326	Shields	"thought" should be" though"		Change made
24	Chapter 1	329	Shields	should be illustrated with a map		Unclear what is wanted???
25	Chapter 1	334	Shields	define hydrocycling		Change not made
26	Chapter 1	380	Smith	Reichert misspelled through document (Correct to Richert)	X - Accept	Change made
27	Chapter 1	410	Smith	No space between page numbers	X - Accept	Change made
28	Chapter 1	433	Smith	Replace semicolon with comma after first author name	X - Accept	Change made
29	Chapter 1	440	Smith	Place period after year (not comma)	X - Accept	Change made
30	Chapter 1	443	Smith	Not cited as PRRIP in text (correct throughout)	X - Accept	Change made
31	Chapter 1	448	smith	Not cited as PRRIP in text (correct throughout)	X - Accept	Change made
32	Chapter 1	470	Smith	Incomplete citation (add source)	USFWS 2006 biological opinion reference, source info missing (see above citation that cites location, and pages)	Unclear what is wanted here, source is the USFWS???
33	Chapter 1	General	Smith	Suggested revision: Add conclusion statements for Chapters 2 and 3 in Chapter 1	X - Accept	Noted
34	Chapter 1	General	Smith	The conclusion given within Chapter 1 and reiterated in Chapter 4 states that the implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy, particularly the flow component, may not achieve the stated management objective and sub-objectives for whooping crane and "contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR". If this strategy were the only one identified in the Adaptive Management Plan, the objective of the project would be simple to evaluate. What is unclear is why both alternatives were not the intended focus of evaluation in this report.	**Please insert explanation in text**	The Program's Adaptive Management Plan is focused on implementation and testing of the FSM management strategy. Thus we focused on that management strategy.
35	Chapter 1 References	399	Shields	In paper, but not in reference list 1. Allen 1952 2. Randal and Samad 2003 In paper, but not in reference list		Change made
36	Chapter 2	11	Shields	"the ability of to alter" should be "alteration of"		Change made
37	Chapter2	72	Shields	remove parenthesis		Change made
38	Chapter 2	91	Shields	Comma before quotation marks		Unsure what is wanted here???
39	Chapter 2	111	Smith	Capitilize Priori in subtitle	X - Accept	Change made
40	Chapter 2	175-185	Shields	Please refer to Chapter 2, lines [175-185] and Chapter 3, lines 94-100. I do not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. Line 165 states that it was assumed that the area evaluated was "centered on the use location and extended 10 miles upstream and downstream from that point." It is unclear if the evaluated area is 10 or 20 miles long in total, but line 169 implies that was assumed to be 10 miles. The justification given is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft. above ground level." No data are provided regarding the flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable. How sensitive are your findings to the 10-mile assumption? Would an assumed available reach length 5 miles for the choice set produce a different outcome? I assume that monitoring flights were conducted in such a way that the overflying aircraft did not modify crane behavior, but it would be good to read an assurance to that effect.	X	Text and citation added. An additional analysis was conducted which indicated results were not sensitive to distance considered available. In the chapter 2 analysis, the relative selection ratio was maximized at an intermediate UOCW of 466 ft, but the 90% confidence interval overlapped the relative selection ratios and were statistically similar for UOCW's ranging from 234 to 889 ft and at an intermediate NF of 538 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 257 to 684 ft from the nearest forest. In the within 5-mile availability anaylsis, UOCW was maximized at 467 ft, but the 90% confidence interval overlapped the relative selection ratios and were statistically similar for UOCW's ranging from 228 to 889 ft and at an intermediate NF of 517 ft from the nearest forest, but relative selection ratios were statistically similar for distances ranging from 257 to 684 ft from the nearest forest.
41	Chapter 2	94-101	Shields	Apparent contradictions between these three phrases "with the exception of spring 2003," "excluded crane group observations during 2001", "AHR, spring 2001-spring 2013," and line 52. please clarify.		Further clarification added
42	Chapter 2	106	Shields	Need to make comma after "River" a semicolon		Change made
43	Chapter 2	53-54	Shields	States that "riverine habitat has by far the highest incidence of stopover use by whooping cranes." Exactly what is meant by riverine habitat? Are floodplains riverine? Backwaters? Islands? Sporadically connected wetlands?		Clarification added.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
44	Chapter 2	70-72	Shields	Chapter 2, lines [70-72] states that, "the monitoring protocol encompasses 3.5 miles on either side of the central Platte River…" So what use was made of observations of cranes within this seven-mile-wide (3.5 x 2) band?		Analyses only included observations within the river.
45	Chapter 2	112-113	Shields	"characteristics of in-channel habitat." What other habitat types were included in the 7-mile + channel width-wide corridor? Why were they excluded?		Analyses were focused only on riverine habitat selection.
46	Chapter 2	114	Smith	one particular key component in the analyses involved the Unobstructed Open Channel Width (UOCW) metric bears discussion. In Chapter 1, an excellent overview of the literature comparing the optimum UOCW results from several studies (p. 11). Given the importance of this metric in the report's model results, it would be beneficial to discuss in this section, and/or in the succeeding chapters why this variability might occur. In addition, it appears that UOCW is measured differently within this study which may affect results in Chapter 2 compared with Chapter 4. Also, a new metric, Total Unobstructed Channel Width (TUCW) was introduced in Chapter 4 research design and analyses. Suggested Revision: 1) Review the method descriptions and discern if the difference only appears within the figures and not in the definitions, Fig. 2 (Chapter 2, p. 33) as possibly multiple lines across the channel, while only measured once within the channel in the approach depicted in Fig. 6 (Chapter 4, p. 82). 2) Address the differences when defined in Chapter 4, including the use of the new metric (TUCW) if it differs from UOCW in Chapter 2.	X - Accept	Changes made
47	Chapter 2	122	Shields	"updated" should be "supplemented"		Change made
48	Chapter 2	123	Shields	"gaged" should be " gage"		Change made
49	Chapter 2	134	Cade	I think a more defensible statement about what the RSF analyses in Chapters 2 and 3 indicate with regards to important roost site conditions to maintain for whooping cranes can be made by focusing interpretations more on intervals of values (e.g., unobstructed channel widths) that are consistent with intervals of highest relative selection ratios (90% CI). See Cade response to Question 8 or individual comments Appendix A-1 to A-6.	X	Uncertainty around points estimates of habitat selection was included in results and described in the discussion sections of chapters 2 and 3.
50	Chapter 2	135	Shields	there are two number 5's in Table 1		Change made
51	Chapter 2	141	Shields	"geomorphic channel type" should be " channel morphology "		text revised
52	Chapter 2	155	Shields	"This distribution" should be "distribution set"		Changes made
53	Chapter 2	188-202	Shields	The description of statistical methods is heavily weighted with jargon. No definition is provided for the left hand side of the equation, w(Xij), or Xij for that matter. Is it the probability that the ith unit in the jth choice set is selected for use by a crane flock?		Included description of relative selection ratio and specificed other components more directly.
54	Chapter 2	256	Shields	Table 2 unit discharge units are $ft^2/s/ft.$, not feet		Change made
55	Chapter 2	270	Smith	Insert the word "crane" after whooping	X - Accept	Change made
56	Chapter 2	271	Cade	Wording "indicating a parsimonious selection of covariates" seems unnecessarily obtuse. All the comparisons of the delta AIC between the top model and the null, intercept only model indicates is exactly the same thing as the hypothesis test that all the regression coefficients are zero – at least one coefficient is not zero. This same statement is used repeatedly in the Correlates of Whooping Crane Habitat Selection document too.	X	Edited model selection text in chapters 2 and 3
57	Chapter 2	189 -203	Cade	Figures 5 and 6. Interesting that relative selection ratios drop as both unobstructed channel width and distance to nearest forest get too large. Any interpretations to offer? One could argue that the sampling variation is so great for these decreasing estimates of selection ratios at the larger distances (spread of 90% CI) that there is no strong evidence that there really is a decline from their peak at intermediate distances. Again, I would argue as above that this really needs to be interpreted in terms of an interval of predictor values that is consistent with an interval of values for the highest relative selection ratios. I could also argue that your GAM model suggests that a simpler piecewise linear spline that allowed an increasing slope at shorter distances, with one knot where selection ratios are maximum at intermediate distances, followed by another slope that would probably be only slightly declining at higher distances. This would require fewer edf and probably provide a more parsimonious interpretation of the data pattern.	X	Intrepretations of habitat selection ratios were included and mostly focused on the uncertainty around point estimates as opposed to exact point estimates of habitat relationships based on GAM models. GAM models were also re-run to limit spline degrees of freedom.
58	Chapter 2	189-203	Cade	What is the correlation structure between unobstructed channel width and distance to nearest forest? I'm guessing that there is some strong linearity for some range of values (the smaller distances) and that for larger values the correlation pattern then gets stranger. Here I note that the restricted plotting of partial estimates is not made to <75th percentile of used locations so a more complete picture of the estimated relationship is provided than in the Correlates of Whooping Crane Habitat Selection document.		Very little correlation is observed throughout the different quantiles of the unobstructed channel width and distance to forest range. We evaluated correlation within the the 0-0.25, 0.25-0.50,0.5-0.75, and 0.75-1.0 quantiles of unobstructed channel width and nearest forest and found correlation at use locations did not exceed r = 0.36 in any given comparison and has an overall correlation of 0.48. To limit the over influences of data extremes, we limited our habitat relationship predictions (predicted relative selection ratio plots) to data between the 10th and 90th percentile.
59	Chapter 2	292	Shields	"crane use" should have a comma after it		Change not made
60	Chapter 2	296	Cade	Line 296: What does it mean that results with the n = 75 observations were "but slightly higher than results ….."?		Wording was changed as to not imply direction of relationship and provide more emphasis on estimate uncertainties.
61	Chapter 2	297-298	Cade	Lines 297-298: The statement that higher relative selection ratios when UOCW was ≥522 feet and NF was ≥549 feet is not consistent with the model estimated with n = 55 because you actually had declining resource selection ratios at higher distances. Is this really what you meant to say?		Wording was changed to show the highest value of the point estimates of each relative selection ratio in light of the uncertainty of the estimates.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
62	Chapter 2	302	Shields	"465ft)" should have a comma after it		Change made
63	Chapter 2	321	Shields	after "width" insert "(UOCW)" and after "forest" insert "NF"		Change made
64	Chapter 2	321	Smith	In Chapter 2, authors explained how the metrics wetted area and suitable depth within the channel would improve habitat suitability for whooping cranes. However, they were unable to quantify those metrics and used unit discharge as a proxy, which was a measure of flow and channel width, which did not score high in the top four models, a result that was counter to previous studies (p. 47, line 321). They do state that "it may not be appropriate to assume flow metrics are not important to selection of habitat by whooping cranes. Instead, it appears area of suitable depth and wetted width surrounding areas selected by whooping cranes were equally available and potentially adequate at flows observed during times of whooping crane use". Given that the main purpose of this report involves determining if SDHF regimes were adequate to maintain habitat suitability, it appears this last statement may be unfounded, and potentially erroneous. Suggested revisions: 1) Provide a more detailed discussion on the results of the other studies 2) Suggest an alternative approach generating necessary data for future studies, given the importance of this hydrologic metric.	X - Accept	Change made
65	Chapter 2	330	Shields	after "data" there should be a comma		Change not made
66	Chapter 2 References		Shields	In paper, but not in reference list 1. Freeman 2010 2. Phillips et al 2006 3. Phillips and Dudik 4. Manly 1997 In paper, but not in reference list		Citations added
67	Chapter 2	348-349	Cade	The math related to your logic to get to 279 feet from the bank line of a 488 foot wide channel is not immediately recognizable. This should be stated explicitly so that it is obvious that you are subtracting half of 488 from 523 feet.		Additional information added
68	Chapter 3	4	Smith	No mention of purpose of the chapter, Program objectives. Begin with a similar, perhaps condensed version, of Program information at beginning of Abstract; see Chapter 2, Abstract, p. 28 lines 4-16	X - Accept	Additional information added
69	Chapter 3	13	Smith	List number of samples. Insert "at 158 stopover sites" after habitats	X - Accept	Unsure what is wanted here…cant find the word 'habitats' on page 13??? Not able to locate either
70	Chapter 3	13	Smith	No mention of connection to Chapter 2 results, where decision to use UOCW and NF in models. Provide connection to report objectives; Insert "Based on the results of Chapter 2…"	X - Accept	Change made
71	Chapter 3	17	Shields	Chapter 3 indicates that, "selection probability was maximized….when distance to the nearest forest from the edge of the channel…..was > 190 ft." I am concerned that management measures based on this finding would lead to clearing riparian zones. Did it matter what was growing along the unforested channel margins? Would cropland and wetlands or wet meadows have the same effect on selection probability?		Noted
72	Chapter 3	64	Shields	"whooping roosting habitat" should be "whooping crane roosting habitat"		Change made
73	Various: Chapter 1 Chapter 3 Chapter 3 Chapter 3	68; 255 45-46 178; 204 69-72	Shields	<u>Habitats other than shallow open water are also important part of stopover habitat suitability.</u> Chapter 1, line [68}, states, "a wetland is nearly always associated with a stopover site." Line [255} mentions, "….suitable bottomland (wet meadow) habitat deemed to be essential for foraging." Lines 305-305 mention the importance of, "wet meadows where cranes feed and rest." Chapter 3 lines 45-46 states, "At stopover sites, whooping cranes typically roost standing in shallow water associated with palustrine or lacustrine wetlands and river channels…." In apparent contradiction to these statements, Chapter 3, line 178 notes that both, "roost sites and day-use sites tend to consistently lack vegetation." But line 204 notes reports by Austin and Reichert (2005) that, "70% of roost sites were adjacent to woodland habitat." Despite the apparent importance of wetlands in WC stopover resting and foraging, the overall approach and data presented in these chapters are largely agnostic with respect to wetlands. Is the entire effort directed at riverine roost habitat? If that is clearly stated or justified in the documents, I did not see it. Although observations of whooping cranes used to build the datasets used for the analysis were all daytime observations, when presumably cranes would use the non-roosting habitats such as wetlands, no mention of wetlands or variables or metrics to describe wetland proximity to roost sites are presented. Lines 69-72 note that, "Flights took place in the morning intending to located crane groups before they departed the river to begin foraging at off-channel sites," but how successful were you in deciding what time in the morning that would be? Further, the same passage continues with the statement that return flights took place later and, "systematically surveyed upland areas and smaller side channels." So if you found a crane group in a wetland or field how was that observation handled? Is that part of your data set? Why or why not?		Noted. The analyses presented in Chapters 2 and 3 are intentionally focused on 'riverine habitat selection' and thus off-channel and wetland locations were not included in these chapters (See the WEST Report for these addional analyses). All flights were initiated 30 minutes before sunrise to give the best opportunity of observing cranes roosting on the river, however, we have no information as to the roost location for crane groups that potentially could have left the river prior to the observers detecting them.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
74	Chapter 3	87-88	Shields	Further, lines 87-88 of Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat…." Exactly what is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel? Chapter 3, lines 104-105 notes that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." It seems to me that this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.		Clarification added. The study was focused on WC use of riverine habitat so wetland use locations were not included. We delineated all channels throughout the Great Plains that were used by WC and generated random points within the channel as was done in Chapter 2.
75	Chapter 3	91-93	Shields	Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat…." Exactly what is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel? Chapter 3, lines 104-105 notes that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." It seems to me that this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.		Duplicate comment. See response to previous comment.
76	Chapter 3	93-96	Shields	It is not clear how bird movement during a multi-day stopover was handled when assigning a single location for the "stopover site" (e.g., Chapter 3, lines 89-91).		Clarification added
77	Chapter 3	91	Smith	No reference for Figure 2 (Pearse et. al 2015)	X - Accept	Citation added
78	Chapter 3	94	Shields	location should have a comma after it		Change made
79	Chapter3	115	Shields	"was defined in Chapter 3" should be "is defined in this chapter"		Change made
80	Chapter 3	117	Shields	"throughout migration" should be "other than"		Unclear, change not made
81	Chapter 3	118	Shields	"corridor are not available except for within" should be "were not available"		Change made
82	Chapter 3	133	Shields	Show and explain definition for NF in a figure like 2-2.		Figure not included because we delineated all channels within the Great Plains and generated random locations within the channel and delineated metrics exactly as was done in Chapter 2.
83	Chapter 3	148	Smith	No measurement for values in Table 2. Insert " ft.: in both columns.	X - Accept	Change made
84	Chapter 3	162	Cade	Again, I would eliminate the terms "relative probability of use". They are not probabilities scaled on [0, 1]. They are relative selection ratios that you've chosen to scale to [0, 1]. See my additional explanations in my review of the Correlates of Whooping Crane Habitat Selection document. I note that n = 158 roost locations is a much more suitable sample size for estimating these spline functions than the n = 55 in Chapter 2. The decreasing selection ratios with increasing distance to nearest forest from 200 to 425 feet and then increasing selection ratios with increases above 425 feet needs some serious interpretation. And again, as discussed in my review of the Correlates of Whooping Crane Habitat Selection document, all the interpretations of partial effects need to really be done with respect to the confidence intervals of the relative selection ratios rather than focusing on just the point estimates. Doing this would indicate that the data and statistical models suggest a much wider range of channel widths as having indistinguishable relative selection ratios.	X	As in chapter 2, a revision of terminology was conducted and reflected that these habitat relationships are scaled to 1 and not the same as stating a probability of use. Intrepretation of the habitat selection results was revised to reflect the amount of uncertainty of point estimates and how positive/negative relationships are indistinguishable at intermediate to large values of unobstructed channel width. The relationship is more clear cut now that we delineated channels throughout the migration corridor, generated random locations within the channel, calculated metrics as was done in Chapter 2, and re-ran the analyses.
85	Chapter 3	183-205	Cade	But an interesting aspect of this discussion that is not made is that the data actually shows cranes make less use of the widest unobstructed channel widths and distances to nearest forest that were available, and primarily focus roosts more on intermediate distances (Figures 5 and 6). Reconciling this would seem to be important in arguing about how critical wide open channel areas are to cranes. Is it possible that those widest, open channels actually end up having water depths that are too shallow to provide the security from predators that conceptually they might be seeking? Or something else?	X	The discussion section points out how we are not able to capture some of the detailed aspects of roost sites for this analysis such as water details at a site. We included language indicating cranes appear to select for more intermediate UOCWs. However, we limited our specific inference about very wide channels having less use by cranes because of the uncertainty around points estimates of the relative selection ratios.
86	Chapter 3	201	Smith	Discuss water presence, but did not measure or analyze that in this chapter. Insert "While we did not examine presence of water at each use site, we assumed that surface water was available in a riverine site"?	X - Accept	Change made
87	Chapter 3	212	Shields	"telemetry" should be "Our telemetry"		Change made
88	Chapter 3	225-265	Smith	The point concerning UOCW in Chapter 3 states that the variability of this metric was among different river systems within the migratory corridor (p. 66, lines 225-265). The explanation that these other rivers are typically wider than the AHR at Platte River are not founded on any results provided in the chapter .I believe this would elevate the value of the chapter findings as a potential publication of merit, as well as providing information on the importance of these multiple stopover sites throughout the Great Plains for migrating whooping cranes.	**See Below**	Noted

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
89	Chapter 3	General	Smith	Suggested revisions: 1) Provide a location map or text description of river systems (or alternatively, basins) used during this study 2) Discuss potential effects bird age, group, or experience may affect habitat choice (e.g., in telemetry juveniles in fall migration, locations are chosen by experienced parents, most likely on their >5th migration) 3) Characterize the general weather conditions throughout the study in terms of potential water availability (drought index, for example)	**X - Introducing new study sites without locations doesn't make sense, particularly when it is discussed that river widths are less at Platte than "other sites; drought affects water availability, and may affect where cranes land in a river system; if this information will be published, may want to consider addressing this**	All river systems within the study area that experienced use were included in our analysis so no map or further description added. All ages of birds were tracked so our sample was representative of what the population selected as a whole. Locations included in our study represent locations selected by crane groups (≥1 crane) rather than individuals. Not sure what the value of reporting indices such as the drought index given it seems unlikely such metrics would effect selection of various widths of river channel???
90	Chapter 3 references	248	Shields	In paper, but not in reference list 1. Freeman 2010 2. Austin Reichert 2001? Maybe a mistake?		Citations added
91	Chapter 3	280	Smith	Correct misspelling to "Currier"	X - Accept	Change made
92	Chapter 4	12	Smith	Define UOCW and relate to previous chapters	X - Accept	Change made
93	Chapter 4	12	Smith	Define TUCW and relate to previous chapters	X - Accept	Change made
94	Chapter 4	15	Smith	Define AHR	X - Accept	Change made
95	Chapter 4	45	Smith	Acronym NF not defined	X - Accept	Change made
96	Chapter 4	48	Shields	"UOCW reaches" should be "UOCW exceeds"		Change made
97	Chapter 4	48	Shields	"unforested corridor width reaches" should be "unforested corridor width exceeds"		Change made
98	Chapter 4	48	Smith	Use NF acronym	X - Accept	Change made
99	Chapter 4	48	Shields	"UOCW reaches 739ft" should be "UOCW exceeds 739ft"		Change made
100	Chapter 4	48	Shields	"unforested corridor width reaches" should be "unforested corridor width exceeds"		Change made
101	Chapter 4	49	Shields	"1,119ft" insert "(Chapter 3) before the period"		Change made
102	Chapter 4	66	Shields	"Number 2 offsetting" should be inserted "Partially offsetting"		change made
103	Chapter 4	76	Shields	"AHR but natural high flow" should have "AHR, but natural high flow"		Change made
104	Chapter 4	80	Cade/Smith	Figure 1: I can't see any green line that is referenced in the caption.	**Either change wording in figure, or remove phrase "green line"**	Green line is a geomorphic term indicating the lowest elevation vegetation establishes in the channel
105	Chapter 4	Figure 1	Smith	Font size not standardized in figure; unclear what "?" means in y axis	X - Accept	Figure description enhanced.
106	Chapter 4	87	Smith	Insert 90-mi reach (when referring to overall length)	X - Accept	Change made
107	Chapter 4	93	Smith	Insert "National Audubon Society"	X - Accept	Change made
108	Chapter 4	101	Smith	Capitalize genus name	X - Accept	Change made
109	Chapter 4	146	Shields	"mean discharge more than doubled and " should be "mean discharge more than doubled, and"		Change made
110	Chapter 4	Fig 2	Smith	Map not to scale (correct)	**It seems that a m in a publication su as this would form maps with scale**	Do not understand this comment. No change made.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
111	Chapter 4	Fig 3	Smith	Correct x axis title (Total Volume)	**Total Event Volume was listed in Table 3 for x-axis, use [illegible] in Fig. 3**	Do not understand this comment. No change made.
112	Chapter 4	164	Shields	"TUCW" should be spelled and defined, and present figure 4 here		Defined but did not move figure location.
113	Chapter 4	176	Shields	"First Increment of the Program" should be defined		Change made
114	Chapter 4	178	Shields	"estimates for maintenance of 400-800" should be "estimates for maintenance should be 400-800 ft."		Change made
115	Chapter4	186	Shields	"focuses solely on the 84-miles" should be "focuses solely on 84 miles"		Change made
116	Chapter 4	189	Shields	"Largely confined to the north channel and hydropower" should be "largely confined to the north channel, and hydropower"		Change made
117	Chapter 4	190	Shields	"south channel in this reach making it difficult" should be "south channel in this reach, making it difficult"		Change made
118		198	Smith	"insert hyphen (photo-interpreted)	X - Accept	Change made
119	Chapter 4	199	Smith	Vague citation (provide more reference)	X - Accept	Study has been published. Change made.
120	Chapter 4	226-228	Cade	The terminology “multiple” rather than “multivariate” regression is more appropriate as the former typically implies multiple predictor variables whereas the latter implies multiple response variables. Robust regressions is defined later.	X	Change made
121	Chapter 4	229-230	Cade	It seems like quantile regression could perhaps be better employed here to evaluate unobstructed channel widths while treating this measure as a continuous variable, avoiding creating the arbitrary binomial breaks at 400, 500, 600, 700, or 800 feet.		Agreed, analysis was updated to a quantile regression and a logistic regression method was omitted.
122	Chapter 4	236-243	Cade	Quantile regression where you estimate an interval of quantiles could have perhaps more easily been used here. Quantile regression estimates for those quantiles less than the extreme values will be little influenced by the extreme values. Furthermore, the quantile regression estimates could easily be used to provide a prediction interval (e.g., 80% prediction interval based on 0.10 and 0.90 quantile estimates) without making any distributional assumptions. Cade and Noon (2003) provides a concise introduction and Koenker (2005) is the definitive text on quantile regression.		Analysis was updated to a quantile regression
123	Chapter 4	236	Smith	Not sure if term eliminate is appropriate (suggest - reduce)	X - Accept	Change not made. It does elimnate the effect of island randomness.
124	Chapter 4	246	Smith	Hyphen missing (five-step)	X - Accept	Change made
125	Chapter 4	288	Shields	"with increasing TUCW but" should be "with increasing TUCW, but"		Change made
126	Chapter 4	304	Shields	"At full-scale implementation, up to 83%" should be "At full-scale implementation be 83%"		Change not made. At full scale implementation, spraying effort varies based on phrag occurance.
127	Chapter 4	338	Cade	Should this be 48 feet (0.48 × 100)?	X	Change made
128	Chapter 4	339	Smith	Results for herbicide only missing (add information)	X - Accept no change, just interested in individual and paired management options	Change not made, herbicide only relationships were not important to visualize for mangement reasons. Conclusions about herbicide effectiveness on channel widths responses can be determined from other parts of the results section.
129	Chapter 4	342	Smith	Insert "other" between "no" and "management"	X - Accept	Change made
130	Chapter 4 Figures 9-14	347-419	Cade	Figures 9, 10, 11, 12, 13, 14: Are these really 95% confidence intervals on the predicted means? I would expect the confidence intervals to have the typical bow tie shape with decreased interval lengths near the mean of the predictor variable and wider interval lengths at more extreme predictor values. These are parallel lines. I’m wondering if these really are 95% prediction intervals for a single new observation. This should be checked.	X - Accept	The updated analysis with quantile regression does not have this issue and is similar to comment ID 122
131	Chapter 4	409	Smith	Disking and herbicide (blue) missing in legend (add)	X - Accept	Changes made
132	Chapter 4	360-378; 424-435	Cade	These comparisons make the common mistake of thinking that the mean regression estimated should be close to all observations in a system where there is considerable variability. It would be more informative to look at the prediction interval lengths (for a single new observation), say for 95% prediction intervals, and then see what proportion of observations are outside that interval (is it more than 5%). The point estimate of the predictions from the estimated mean regression model should not really be the focus for determining the suitability of the model estimates. The intervals associated with the predictions are more relevant.		Changes made to reflect prediction and not confidence intervals.
133	Chapter 4	362	Shields	"betas previously stated" --betas should be defined		Specific language was added the address betas values and tables were added presenting beta values across the distribution of response variables.
134	Chapter 4	398	Cade	Should that be 20 feet (0.02 × 1000)?	X	Beta values are based on per unit changes in the predictor variable. So, a one unit change in 40 Day peak corresponds to a 0.02 ft increase in TUCW, but a 1000 unit increase in 40 day peak corresponds to a 20 ft increase in TUCW.
135	Chapter 4	401	Cade	Should that be 19 feet (0.19 × 100)?	X	Beta values are based on a per unit increase in the predictor variables.

Comment ID #	Chapter or Section	Page #	Reviewer	Comment	Issues to Address for making report Acceptable	PRRIP Response
				HABITAT SYNTHESIS CHAPTERS		
136	Chapter 4	404	Smith	Add results for disking only	**Why show results in Figure 12 for disking only if you don't intend to evaluate them?**	Change not made because a disking only relationships would only add complexity and confusion to overall results
137	Chapter 4	415	Shields	"Dischargemain" should be "Discharge"		Change made
138	Chapter 4	436	Cade	Some statement about what the Monte Carlo random sampling was across should be made here. There are many ways to conduct Monte Carlo simulations	X	Added more specific language about monte carlo simulation to obtain variable sensitivity.
139	Chapter 4	449-469	Cade	Again, I think if quantile regression had been used for the modeling of UOCW and TUCW, that the proportion of the probability distribution being modeled by the covariates exceeding some selected values (400, 500, 600, 700, and 800 feet) would have been easily determined without these logistic regressions.		Analysis was updated to a quantile regression
140	Chapter 4	497	Smith	Insert space between value and measure	X - Accept	Change made
141	Chapter 4	510	Smith	The discussion in Chapter 4 could be expanded when describing the constraints from upstream management to provide flow releases of 5,000-8,000 cfs. It may be helpful to understand how effective those short-duration high flows as designated in the AMP affect shallow water roost conditions within the channel to ensure suitable habitat conditions for whooping cranes in the AHR during migration periods. Suggested revision: 1) Include discussion in Chapter 4 that acknowledges any benefits derived from SDHF improving habitat suitability; 2) Provide any recommendations on the flows necessary to achieve the AMP objective based on reported analyses.	X - Accept	Chapter 4 does explicitly state the benefits derived from SDHF in relation to increased UOCW. There are no other whooping crane-related SDHF benefits that are relevant to the Program. We did not add flow recommendations as they will be developed through the Program's AM process.
142	Chapter 4	525	Shields	"may not be that important as UOCW" should be "may not be that important, as UOCW"		Change made
143	Chapter 4	527	Shields	In paper, but not in reference list 1. Murphy et al 2001		Change made
144	App III	120	Smith	TUCW not defined in Table Caption	X - Accept	Change made
145	App IV	142	Cade	Oracle Crystal Ball Monte Carlo Simulations: There is too little detail provided to determine whether this simulation analysis is accomplishing anything of merit. For example, why assign the particular probability distribution functions to the various predictor variables, e.g., gamma for peak discharge, beta for median grain size, etc.?		Added statement that distributions were fit to the observed data.
146	EDO Memo	124	Cade	WEST and the EDO are correct to be cautious about using model averaging. The comment suggests that the Trust was suggesting model averaging regression coefficients into a “best” model. There has never been good theoretical or empirical evidence that model averaging individual regression coefficients ever achieves anything useful in terms of addressing model uncertainty in a multimodel inferential context. Indeed, Cade (2015. Model averaging and muddled multimodel inferences. Ecology 96: 2370-2382) and Banner and Higgs (2016. Considerations for assessing model averaging of regression coefficients. Ecological Applications, In press) have presented a fairly thorough indictment of simple model averaging of regression coefficients. Furthermore, model averaging individual regression coefficients for the spline terms in the GAM used here would seem to be even more nonsensical. It still might be useful to model average the predicted responses across the multiple models to address model uncertainty in the predictions, but this in no way results in a calculation that is equated to a “best” model.		Model averaging was not performed in these chapters as we are hesitant to include such information that may further complicate management decision for the Program and its partners.
FOOTNOTE				Some references to page numbers by Reviewers have been modified to reflect the September 29, 2016 document.		

Peer Review of Platte River Recovery Implementation Program Data Synthesis Compilation, Whooping Crane (Grus americana) Habitat Synthesis Chapters

and

Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River, Nebraska

DRAFT SUMMARY REPORT

December 2016

Louis Berger

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1.0 INTRODUCTION ... 1

1.1 Background ... 1
1.2 Purpose and Scope of Peer Review ... 1

1.2.1 General Questions for WEST Report ... 2
1.2.2 Chapter-Specific Questions for Whooping Crane Habitat Synthesis Chapters ... 2

2.0 Peer Review Process ... 3

2.1 Selection of Reviewers ... 3
2.2 Document Review and Report Development ... 4

3.0 RESULTS ... 5

3.1 Responses to Questions – WEST REPORT ... 5

3.1.1 Rating System – WEST Report ... 12
3.1.2 Acceptance – WEST Report ... 13

3.2 Responses to Questions – WHOOPING CRANE HABITAT SYNTHESIS CHAPTERS ... 14

3.2.1 Rating System – Habitat Synthesis Chapters ... 30
3.2.2 Acceptance – Habitat Synthesis Chapters ... 30

3.3 Other Specific Comments ... 31

4.0 References ... 32
5.0 Appendices ... 33

1.0 INTRODUCTION

This summary report provides an overview of a formal, independent, external scientific peer review conducted for the Platte River Recovery Implementation Program ("Program" or "PRRIP") as a joint review involving two separate but related documents. The first document titled "Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River, Nebraska" was prepared for the Program by Western Ecosystem Technology, Inc. (hereafter, "WEST report") using Program data. The second document is a combined set of four whooping crane "habitat synthesis chapters" related to the habitat of and use by the whooping crane on the central Platte River prepared by the Executive Director's Office (EDO) of the PRRIP.

1.1 Background

The WEST report is a data analysis report that includes multiple analyses of the Program's whooping crane monitoring data that was collected within the Associated Habitat Reach (AHR), 2002–2013. The WEST report includes analyses of multiple subsets of data in order to assess the influence of opportunistic sightings and multiple sightings of individual crane groups on model results; however, primary conclusions were based upon analyses that only included systematic observations of unique crane groups. In-channel habitat use analyses were focused on habitat metrics useful for providing Program decision makers information needed to direct habitat management activities. Diurnal habitat use analyses were focused on descriptors of habitat metrics that could be measured at both in-channel and off-channel use and available locations. The report also includes analyses of trends in whooping crane use of the AHR.

The information and analyses presented in the habitat synthesis chapters focus solely on informing the use of Program land, water, and fiscal resources to achieve one of the Program's management objectives: contribute to the survival of whooping cranes during migration through the Associated Habitat Reach (AHR) along the central Platte River. The AHR consists of a 90-mile reach of the Platte River in central Nebraska from Lexington to Chapman, Nebraska. The Program spent the last eight years implementing an Adaptive Management Plan (AMP) to reduce uncertainties about proposed management strategies and gain new knowledge about river and species responses to management actions. During that time, the Program implemented management actions, collected a large body of physical and species response data, and developed modeling and analysis tools to aid in data interpretation and synthesis.

1.2 Purpose and Scope of Peer Review

The purpose of this review is to provide a formal, independent, external scientific peer review of the information presented in the WEST Report and synthesis chapters. Reviewers were charged with evaluating the scientific merit of both documents' technical analyses and conclusions, ensuring that any scientific uncertainties are clearly identified and characterized and that the potential implications of the uncertainties for the technical conclusions drawn are clear. Specifically, the PRRIP requested that reviewers consider and respond to the questions listed below, at a minimum, in their reviews.

1.2.1 General Questions for WEST Report

1. Does the WEST report adequately address the overall objective, which is analyze Program data to provide insight into whooping crane habitat selection and use?

2. Do the authors of the WEST report draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

3. Are there any seminal peer-reviewed scientific papers that the WEST report omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

5. Are the statistical methods used in the WEST report valid and current, and are the associated results presented in manner useful to decision makers for the Program?

6. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the WEST report and then discussed in the results and conclusion sections?

1.2.2 Chapter-Specific Questions for Whooping Crane Habitat Synthesis Chapters

7. Does the combined set of whooping crane habitat synthesis chapters adequately address the overall objective, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for whooping cranes?

8. Do the authors of the whooping crane habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

9. Are there any seminal peer-reviewed scientific papers that the whooping crane habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

10. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?
11. Are the statistical methods used in the combined set of whooping crane habitat synthesis chapters valid and current, and are the associated results presented in manner useful to decision makers for the Program?
12. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the whooping crane habitat synthesis chapters and then discussed in the results and conclusion sections?

2.0 PEER REVIEW PROCESS

Louis Berger was retained by the PRRIP to facilitate the peer review process. Louis Berger' responsibilities in the peer review process included 11 steps:

1. Develop a clear understanding of the required expertise of each position;
2. Conduct a search for potential candidates;
3. Contact prospective candidates to screen for criteria and conflict of interest;
4. Obtain CVs/resumes, biographical sketch forms, and signed "no-conflict-of-interest" statements from all candidates;
5. Compile a summary report describing recruitment process and candidate qualifications;
6. Communicate with reviewers regarding the selection process;
7. Discuss the scope and charge with the EDO;
8. Participate in an organizational conference call with the reviewers;
9. Distribute materials and commence review;
10. Compile all peer review comments into a spreadsheet and summarize in a summary report; and
11. Submit spreadsheet and summary report to the EDO and facilitate communication between the EDO and reviewers regarding any clarification needed to understand review comments and allow authors to prepare appropriate responses.

2.1 Selection of Reviewers

Louis Berger focused its recruitment efforts on individuals with experience in areas of expertise may include ecological statistics, biostatistics, whooping crane (crane) ecology, geomorphology, hydrology, riparian ecology, river ecology, and adaptive management.

In August 2016, Louis Berger submitted a recruitment report to the Program that summarized the qualifications of 12 candidate reviewers. In August 2016, the Program's Governance Committee selected three reviewers from that list. The review panel comprised the following individuals (see Appendix C for biographical sketches):

- Brian S. Cade ("Cade"), PhD, Fort Collins Science Center, US Geological Survey (Bio Statistician)
- Elizabeth Smith ("Smith"), PhD, International Crane Foundation (Whooping Crane Biologist)
- Doug Shields, Jr., ("Shields") PhD, Shields Engineering, LLC (Hydraulic Engineer)

2.2 Document Review and Report Development

Following final approval of the three reviewers, Louis Berger initiated the review by distributing the files to the reviewers, including: the WEST correlates document and habitat synthesis chapters to be reviewed; the scope of work and schedule for the peer review; files of all references cited in the chapters; and the Program's Adaptive Management Plan. Files were distributed via Louis Berger's FTP site. Louis Berger staff held a kickoff call with three reviewers in August 2016 to discuss the scope of work, expectations with regard to technical content of deliverables, review priorities, schedule, and to answer any questions posed by panel members.

Reviewers conducted their independent desktop reviews between August 9, 2016, and October 31, 2016. Louis Berger contacted reviewers individually to obtain clarification on some aspects of their formal review reports. Reviewers submitted the following deliverables:

1. Responses to the general and chapter-specific questions listed in Section 1.2;
2. Ratings of the WEST report and synthesis chapters in five different categories, as well as an overall recommendation for acceptance; and
3. Specific comments on the text of chapters, by line number (see comment spreadsheet).

Upon receipt of the deliverables from each panel member, Louis Berger compiled the specific comments into a spreadsheet, organized by WEST Report and Synthesis Chapters, providing chapter, page and line numbers (if applicable), which was submitted to the PRRIP as a separate deliverable. Louis Berger summarized reviewer responses to questions for both the WEST Report and Whooping Crane Habitat Synthesis Chapters in this summary report, which also includes their ratings and recommendations. For clarity and continuity, many of the specific comments captured in the spreadsheet are duplicated under reviewers' responses to questions. Individual reviewer comments are included as Appendix A (WEST Report) and Appendix B (Habitat Synthesis Chapters). As described in the PRRIP Peer Review Guidelines, reviewers choose to have their review comments attributed.

3.0 RESULTS

Below are summaries of the individual reviewers' responses to the six (6) WEST Report (Section 3.1) and six (6) chapter-specific questions (Section 3.2) posed by the PRRIP. These summaries are not intended to be comprehensive or redundant, but rather they attempt to capture an overview of the reviewers' primary comments and identify any common themes. Although there were a few common themes, in most cases reviewer comments differed significantly from one another, reflecting their varied backgrounds and areas of expertise. Not only did they differ, but in several cases comments were contrary to one another. For the reviewers' full comments, see Appendices A & B. The comment spreadsheet was created to capture comments, recommendations, and editorial suggestions by chapter, page, and line (if applicable). Recommendations relating to acceptability of the report are also summarized in Section 3.3.

3.1 Responses to Questions – WEST REPORT

Below are brief summaries of the individual reviewers' responses to the six (6) general questions posed by the PRRIP. This section is not intended to be a comprehensive summary or to be redundant with the individual comments, but rather attempts to capture some of the primary comments in each reviewer's response to the individual questions, as well as any themes that emerged or issues that were raised by more than one reviewer independently. See Appendix A for the reviewers' full comments and the comment spreadsheet.

1. **Does the WEST report adequately address the overall objective, which is analyze Program data to provide insight into whooping crane habitat selection and use?**

All three reviewers (**Cade, Shields, and Smith)** indicated that the overall objective was addressed.

Cade stated that the fundamental challenge of interpreting crane roost site selection for wider, unvegetated, and unobstructed channels given the highly variable selection among cranes and changing spatial and temporal availability of channel characteristics are met with report analyses. Cade's review can be found in Appendix A-1 to A-6.

Smith indicated while the report provides the context and analyses needed to address the objective stated, no mention is made specifically within the report. She recommended minor reorganization and provided a fairly comprehensive literature review with references that could be included to upgrade the completeness of the report. See Smith's review in Appendix A-15 to A-28 and the comment spreadsheet. Her comprehensive literature review is intended to be used to more completely introduce the target species; discuss conservation challenges of whooping crane recovery pertinent to the central Platte River ecosystem; and included key studies that have variously addressed historical location databases, habitat evaluations, and development of metric criteria to guide management and restoration efforts. Smith felt these recommendations would strengthen the contribution to management of whooping crane migration habitat along the central Platte River.

While **Shields** appreciated the dedication and effort of the teams involved in this work, he stated that clear-cut, objective conclusions are hard to obtain. The small size of the studied population and their transient presence in the AHR creates an extremely difficult problem when trying to produce defensible scientific results. In his view the ESA process misplaces emphasis on species rather than habitat. A focus on restoring the properties and characteristics of the ecosystem, more specifically habitat and associated processes that create and sustain habitats, would potentially benefit a wider range of species and lead to better long-term outcomes than attempting to precisely target the preferences of a single species. He did not find adequate justification for the assumptions made about the process whooping cranes use to selected habitat, as further discussed in response to questions below. Shields also asked why the difference between spring and fall population fraction use trends (e.g., Figures 18 and 22) was not explained. No hypotheses were presented or tested regarding this phenomenon. Shields' review can be found in Appendix A-7 to A-14.

2. **Do the authors of the WEST report draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and specifics of each situation.**

Overall **Cade and Smith** felt the WEST report drew reasonable conclusions. **Shields** did not find adequate justification for assumptions made about the process of whooping crane use to select habitat and questioned the validity of unit discharge values used in analysis for both the WEST Report and Habitat Synthesis chapters.

Cade indicated that the conclusions drawn from the resource selection analyses are reasonable and analyses on trends in use of the Platte River by the whooping crane population seem useful, reasonably analyzed and interpreted. While the partial regression plots for individual predictor variables in the generalized additive model (GAM) are informative, more useful interpretations could be provided by incorporating information on intervals of values associate with the predictor variables (e.g., unobstructed channel widths 200-700 feet) that are consistent with the sampling variation (90% confidence intervals) of the highest relative selection ratios. Additional details from Cade on this issue are provided under Question No. 5 response below.

Smith stated the research questions and evaluations were strong and well executed in the main body of the text and in associated appendices, but felt the report does not introduce sufficient information about the target species, or previous studies and does not adequately address the study's objective in the specificity needed to make management decisions. She recommended inclusion of additional information to create a stand-alone report and strengthen conclusions provided by the results. Citations for this additional information are provided in Smith's detailed comments starting in Appendix A-12.

1) Provide a brief overview of the Whooping Crane including the following:
    a. Description and life history
    b. Reasons for population decline and Endangered status
    c. Importance of migratory corridor for the Aransas-Wood Buffalo population, with emphasis on central Platte River, including critical habitat designation

2) Provide a brief literature review of previous studies that identified need for management criteria and habitat evaluations
    a. History of change in this region
    b. Establishment of PRRIP
    c. Overview of contribution of previous studies
    d. Management needs within PRRIP that are to be addressed by this study.

In his review**, Shields** made several statements and posed questions *(italics*) regarding the justification for the assumptions made about the process whooping cranes use to select habitat. See his detailed response in Appendix A-7 to A-14.

- *"How sensitive are your findings to the 10-mile assumption?"*
  The justification given for analyzing a 10-mile long reach for in-channel habitat is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft. above ground level." No data are provided regarding the flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable.

- *Would an assumed available reach length 5 miles for the choice set produce a different outcome?*
  Since the land cover variables encompass conditions within a 3-mile radius of an analyzed point, the actual distance from the selection point to the boundary of the choice set could exceed five miles.

- *Shields assumed that monitoring flights were conducted in such a way as the overlying aircraft did not modify crane behavior*. He suggested providing an assurance to that effect.

- *How certain are you that birds spotted in early morning were in locations where they had roosted the previous night?* Shields noted that this question goes beyond the error in detecting presence of a group (top of page 38, "imperfect detection").

- *Are the values used in the analysis actually representative of those occurring when habitat selection was made?* Shields provided discussion concerning crane response to local flow conditions, not average conditions. He questioned the development of unit discharge (UD) values based on 2009 flows and channel topography for use in the analysis rather than a using a local UD occurring at the time and place where the birds are roosting. Local UD is the product of local depth and local velocity. Local depth likely varies across a substantial range in time and space in the AHR of the Platte, so computation of cross-section average UD based on 2009 surveys is unlikely to yield much information about the availability of habitat with <0.7-foot depth. The EDO response explains the difficulty of obtaining representative UD values, and it would seem that at least some field measurements are needed to validate the UD values used in the analysis.

- As shown in Figure 4-11 extracted from Brunner (2010) HEC-RAS allows computation of local depth and velocity. HEC-RAS simulations with discharges for the days cranes were spotted and recently surveyed cross sections could be used to obtain more representative UD values than the methodology presented in these documents.

- *The report is unclear regarding the discharge values that were used to compute UD*. Ideally, the discharge that occurred on the date when the cranes made their habitat selection is the discharge that should be used. Perhaps the way that UD was determined contributes to its lack of influence in the top models for in-channel habitat use (e.g., Table 3).

3. Are there any seminal peer-reviewed scientific papers that the WEST report omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

Cade and Shields are not as familiar with the literature of this subject area (avian resource selection) covered by the WEST report.

Smith noted the challenge that any scientific paper has faced when linking whooping crane use of migration habitat at the central Platte River, or any other location within the Aransas-Wood Buffalo population range, is the paucity of data. However, management and policy decisions have been implemented to proactively protect, restore, and maintain sufficient quantity and quality of habitat within the migratory corridor to promote its recovery of this species. Research that has been published to date can serve as an important contribution to the WEST report, and serve as an appropriate comparison to the results provided in the WEST report. In addition, the methods employed in this research design are intended to produce results that are more statistically defensible than previous studies.

Smith provided an extensive review of technical papers (arranged in chronological order) including pertinent points to assist the authors in providing a more comprehensive overview as suggested in response to Question 2 above and her suggested revision 2.c. See Smith's individual response to the WEST Report in Appendix A-14 to A-28.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Cade stated the relationship described above was addressed adequately. **Shields and Smith** provided very different responses to address this question.

Shields was puzzled by the statement, *"Nearest obstruction and nearest forest were present in all five of the top five models. These models do not appear at the top of the management model list because <u>PRRIP staff does not consider nearest obstruction to be a variable useful for management</u>." Shields commented that m*echanical removal of trees is one of the key management actions described! Furthermore, it would seem that there should be a high correlation between NO and NF and between NO and UOCW. The report does not provide comment.

Shields noted that the diurnal data indicate preferential selection of cornfields relative to grassland, soybean and wet meadow. He questioned whether any consideration has been given to potential hazards to whooping cranes posed by herbicides, insecticides or less than optimal forage found in cornfields relative to more natural habitats.

Smith acknowledged both the time and effort PRRIP has invested in developing statistically defensible metrics to guide the management actions and the challenge to ask system-wide questions and reply with a detailed, quantifiable approach. Smith's suggested revisions (below) were developed to help answer this key question concerning relationships. The authors should consider addressing the question above to describe the outcomes of the report in a Summary of Key Findings section. Smith suggested key points could center on:

1) a more informative Introduction that provides the historical context of this endangered species and its linkage and dependence on this altered riverine ecosystem;

2) reviewing previous research that sets the stage for understanding the monitoring and assessment challenges; and, comparing those results with results of this report to assess the current approach and results in this report;

3) discussing continuing challenges and dilemma of designing monitoring programs that provide data appropriate for use in the questions being asked and make recommendations for improving the monitoring program; and

4) processing these results into tangible management strategies that achieve the Program objectives.

5. Are the statistical methods used in the WEST report valid and current, and are the associated results presented in manner useful to decision makers for the Program?

Shields did not comment on this question due to limited experience and expertise in the resource selection function type of analysis presented in the report.

Cade provided several comments and suggestions on resource selection function and habitat selection results in the report, as follows. For detailed comments, suggestions, and examples from Cade, see Appendix A-1 to A-6.

- The resource selection function analyses based on the discrete choice multinomial logistic regression model seem very current and reasonable. However, there are a few definitional and interpretation issues that could be improved: 1) use of the term "relative probabilities of use," and 2) "relative probability of selection". Cade stated that the resource selection function $w(X)$ is an exponential function not a logit function, where $w(X)$ is scaled on the interval $[0, +\infty)$. They are ratios from an exponential RSF that by definition are scaled $[0, +\infty)$. These are ratios of proportions from an exponential RSF that by definition are scaled $[0, +\infty)$. They are not probabilities. Cade suggested using the term "relative selection ratios." You can scale the relative selection ratios to [0, 1] as done here but that still does not make them probabilities. In fact, you could scale them from [0, to any positive number you want] and their interpretation is still the same as they only have meaning with respect to each other in the same model. Wording would also need to be changed in all relevant figures.

- It is not clear that 90% confidence intervals for estimated relative selection ratios can really be approximated using a Taylor series expansion approach because the estimates come from a multinomial logistic regression model but the RSF uses these in an exponential functional form that excludes the intercept. He doesn't believe there is a simple analytical formula to compute standard errors (or confidence intervals) for predicted $w(X)$ and it is not obvious whether this same constraint applies to the discrete choice multinomial logit model used but it seems likely. More details on the Taylor series expansion approach should be provided to justify its credibility.

- Why were response functions constrained to eliminate just the extremely large (upper 25th percentile) values of habitat characteristics when eliminating the extremely small (lower 25th percentile) values of habitat characteristics could be justified; or more reasonably, not eliminating any of them. Cade suggested reevaluating how this was done, realizing that some of the estimated confidence intervals may get extreme at more extreme values of the predictor variables, which would necessitate limiting graphs to 10th to 90th percentiles rather than the entire range.

- Additional language should be added to help interpret the partial regression plots with respect to the confidence intervals, setting the context for using the relative selection ratios to compare with each other within a model. There seems to be an undue focus on where the point estimates of the relative selection ratios maximize. Given the lack of precision in these relative selection ratio estimates as indicated by their very wide CI, it would be more appropriate to interpret the values of the predictor variables (e.g., unobstructed channel width in Figure 3) associated with intervals consistent with intervals for highest relative selection ratios.

Smith stated that using the Resource Selection Function is a preferred method to identify which resources (often landscape features serve as a proxy for those resources) drive species distributions in selective habitats. RSF can be interpreted as being proportional to expected density of observations (Aarts et al. 2012), and thus provides useful metrics to use in evaluating the study area. The approach used in these analyses is used widely in contemporary, published literature investigating similar research and adaptive management questions. In most cases, detailed information was provided for methods in the report and appendices.

Smith further stated the report addresses three components of whooping crane habitat selection and use of the central Platte River in Nebraska. The in-channel habitat selection evaluates criteria necessary for roost habitats, diurnal habitat selection evaluates foraging habitat, and the spatial relationships tested between the two areas to satisfy migratory needs in both fall and spring seasons. The format and presentation of results is clear and easily compared in text and associated figures and tables, and also used in appendices. Smith provided suggestions to improve the importance of information in Appendices C and D (See Smith review Appendix A-12 to A-23 or comment spreadsheet.

6. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the WEST report and then discussed in the results and conclusion section?

Cade stated that the WEST report does try to address some potential biases in detection of cranes from the aerial surveys. In addition, the focus of primary resource selection analyses are on the least biased observations, first sightings of roost locations from the systematic aerial surveys. Other crane observations are incorporated in secondary analyses that largely mimic their primary analysis (but see his suggestion above about an alternative strategy for these secondary analyses).

Shields noted the following statement *"For the diurnal habitat use analysis, the choice set was centered on the use location and extended 3 miles in all directions from that point. The habitat within the choice set area was described at a set 1,171 points systematically spaced at 250m intervals."* He posed the question, "Was this convention followed even when the use location was on the edge of the study area?: If the use location was on the very edge of the study area, then the choice set would extend up to 3 miles outside the study area.

Shields also questioned potential errors in computing the value of PRL unless observers could ensure that the correct previous night's roost location was used, or if there could be confusion between crane groups, or failure to detect one group. As stated previously, his question goes beyond error in detecting presence of a group (page 38, "imperfect detection").

Smith indicated that the authors address the potential biases regarding the use of data collected within the PRRIP monitoring program that included systematic aerial PRRIP surveys, ground monitoring following surveys, as well as opportunistic sighting from public and professional biologists. The in-channel section only presents the systematic unique data results. It appears that a previous draft of the report may have included the analyses from all systematic unique, systematic unique and non-unique, and all systematic and opportunistic analyses, since Appendices C and D provide detailed methods and results.

She recommended more justification and inclusion of key findings in the main body of the report since the authors believe the information is valuable to the overall study. It is important to address the pros and cons (potential bias versus information gained) of including all three analyses, particularly what each provides in terms of informing future management and policy decisions pertinent to this Program.

Smith suggested the following revisions to the introduction, methods, results, and conclusions report would provide history, justification, and contribution of the appendices.

1) Within the Introduction, present an overview of historical observational databases and the advantage of aerial versus ground surveys, and using unique and non-unique data points.

2) Within the Introduction, justify the inclusion of 2nd and 3rd approaches as either appendices or including in the main report in the Introduction.

3) Provide more details about the value of including 2nd and 3rd approaches in the Methods to accompany Table 1.

4) In Results, add summary results of 2nd and 3rd approaches and reference tables and figures that are located in appendices; for example, identify the variables within the top models.

5) Compare the results among three approaches more fully in the Discussion, for example, the differences of model results and the importance of these finding to achieve the objectives of the study.

6) Since conclusions are limited in all sections of this report, provide recommendations of use of these approaches in Summary of Findings.

3.1.1 Rating System – WEST Report

Reviewers rated the WEST Report using a rating system provided by the Program where 1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor. Table 3-1 summarizes each reviewer's ratings.

Table 3-1. Reviewers' comprehensive ratings of the WEST Report by category.

Category	Cade	Shields	Smith
Scientific soundness	2	2	2
Degree to which conclusions are supported by the data	2	3	3
Organization and clarity	1	4	2
Cohesiveness and clarity	2	2	2
Conciseness	1	2	1
Important to objectives of the Program	2	2	1

3.1.2 Acceptance – WEST Report

Reviewers were asked to provide their recommendation to either accept the WEST Report, accept with revisions, or deem the report unacceptable. All three reviewers recommended that the WEST report be accepted with revisions. Recommended revisions were provided by individual reviewer as part of report acceptance. The majority of recommended revisions were incorporated as part of the reviewer's response to the questions in Section 3.1 (1-6). Therefore, reference to the specific question number is provided to avoid redundancy in comments.

Shields stated that revisions should address questions regarding validity of unit discharge values used in analysis, the spatial range of evaluation used by cranes when selecting stopover locations, and the differences between spring and fall results (see response to Questions #1 and #2 above).

Cade indicated the need to address use of the terms "relative probabilities of use and "relative probability of selection"; provide more details on the Taylor series expansion approach; reevaluate confidence intervals, and constraints on response functions and diurnal habitat selection methods. He provided additional comments and examples for partial regression plots in the Habitat Selection Results (see response to Question 5). He indicated these partial regression plots need to be interpreted with respect to the confidence intervals on the relative selection ratios. He suggested there seems to be an undue focus on where the point estimates of the relative selection ratios maximize.

Smith recommended reorganizing the report (see response to Question #1 comments A-12). She provided several corrections needed to eliminate inconsistencies between citations in the text (missing references in text and Reference section) and formatting within the Reference sections.

3.2 Responses to Questions – WHOOPING CRANE HABITAT SYNTHESIS CHAPTERS

Summaries of the individual reviewers' responses to the six (6) Whooping Crane Habitat Synthesis Chapter questions posed by the PRRIP are provided below. This section attempts to capture some of the primary comments or themes that emerged in each reviewer's response to the individual questions and is not intended to be a comprehensive summary or to be redundant with the individual comments. For the reviewers' full comments see Appendix B and the comment spreadsheet.

7. Does the combined set of whooping crane habitat synthesis chapters adequately address the overall objective, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for whooping cranes?

Cade stated the challenge of interpreting the dynamics of wide, unvegetated (unobstructed) channels in the Platte River with respect to the roosting requirements of whooping cranes that exhibit considerable flexibility in their habitat selection are reasonably met but could be improved as discussed further in his responses to questions below.

Shields noted that the chapters provide evidence that higher flows, disking, and herbicide application increase whooping crane stopover habitat, particularly when all three occur together. He provides the following discussion and additional questions: The increase in <u>mean</u> UOCW due to SDHF releases alone is essentially negligible, but it is important to note that the WC do not react to <u>mean</u> conditions along the AHR. Instead, they need some minimum level of habitat availability. Figure 15 shows that a 40-day peak discharge of 1,000 cfs is associated with a ~25% probability that a managed transect will have a UOCW $\geq$ 600 ft. A three-day SDHF of 8,000 cfs requires 45,000 ac-ft above a base flow of 500 cfs (or 26,000 to 68,000 ac-ft, lines 495-496), while a 40-day flow of 1,000 cfs requires 40,000 ac-ft above a baseflow of 500 cfs, so a 40-day flow would be attainable with current water allocation. If 25% of the AHR provided UOCW $\geq$ 600 ft, would that represent an improvement over current conditions? Over projected future conditions? Would it be biologically significant with respect to WC habitat availability?

Smith indicated that the four chapters provide the context and analyses needed to address the objective to "contribute to the survival of whooping cranes by increasing habitat suitability and thus use of the Associated Habitat Reach (AHR) along the central Platte River in Nebraska" (p. 2, lines 5-7). The conclusion given within Chapter 1 and reiterated in Chapter 4 states that the implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy, particularly the flow component, may not achieve the stated management objective and sub-objectives for whooping crane and "contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR". If this strategy were the only one identified in the Adaptive Management Plan, the objective of the project would be simple to evaluate. What is unclear is why both alternatives were not the intended focus of evaluation in this report.

Smith stated on p. 23, lines 375-387 there are “two competing management strategies to achieve the objective of improving survival of WHCR during migration: 1) Mechanical Creation and Maintenance (MCM) approach and 2) flow-sediment-mechanical (FSM) approach.” Within the research design and statistical analyses of Chapter 2, several physical metrics (serving to assess habitat suitability) metrics were tested in conjunction with few flow metrics. Whereas, in Chapter 4, flow metrics were tested with areas where management practices were employed (disking, herbicide) and potentially enhancing the habitat suitability. The only metric missing involves measurement evaluating “manageable lands” via the acquisition of properties to facilitate the ability for more management to occur, thus also improving habitat suitability at a broader scale for migrating whooping cranes. In Chapter 4, the limitation is defined as “The major limitation of disking is the lack of a system-scale beneficial effect. The Program can utilize disking to effectively manage UOCW at Program habitat complexes, but cannot utilize disking to manage UOCW on other conservation or private lands without landowner agreements” (p. 108, 553-555).

Smith further stated the following revisions should be made to provide a more comprehensive evaluation for Program decisions and promotion of policy:

1) Incorporating more discussion in each section relating to the interpretation of results that address components of both MCM and FSM;
2) Providing more information about locations of conserved/managed areas as part of MCM management potential; and
3) Providing more discussion of MCM strategy effectiveness in Chapters 2 and 4.

8. Do the authors of the whooping crane habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

Cade, Shields, and Smith provided extensive discussion concerning conclusions drawn and assumptions made in habitat selection and habitat variables; each focusing on specific topics related to their individual areas of expertise. Refer to detailed discussion for each reviewer in Appendix B.

Cade stated the relationships and interpretations are reasonable, but suggested a more defensible statement about what the RSF analyses in Chapters 2 and 3 indicate with regards to important roost site conditions to maintain for whooping cranes can be made by focusing interpretations more on intervals of values (e.g., unobstructed channel widths) that are consistent with intervals of highest relative selection ratios (90% CI). See Cade’s additional comments below:

- As mentioned below under response to question (11) and the review of the WEST report the variation in relative selection ratios as estimated by the 90% confidence intervals suggest that a much greater range of the predictor variable values (e.g., unobstructed channel width) are consistent with the highest selection ratios. This requires less focus on the point estimates of the partial regression plots and more emphasis on the confidence intervals around those estimates. For example, the 90% confidence intervals in Figures 5 and 6 above line 285 suggest that the highest relative selection ratios are largely indistinguishable for all unobstructed channel widths >200 ft (Fig. 5) or nearest forest >200 ft (Fig. 6) based on the overlap of their 90% confidence intervals for the relative selection ratios with the 90% confidence intervals for the relative selection ratios associated with the maximum point estimate.

- Such an interpretation is completely consistent with the raw observations of the crane roost use, where few cranes actually use the greatest unobstructed channel widths or greatest distances to nearest forest that are available, mostly concentrate use at intermediate values, and never completely avoid using narrower unobstructed channel widths or shorter distances to nearest forest (Figs. 5 and 6). This implies that the relative selection ratios as equating to something that whooping cranes require is very tenuous except perhaps in a statement reflecting a large interval of values. This perhaps may be a distressing interpretation for crane biologists but certainly suggests that there may be much wider targets of desired characteristic for roost sites for management actions to focus on. Furthermore, it suggests that the small increases in unvegetated or unobstructed channel widths that are predicted to occur from increases in 40-day mean peak discharges (Chapter 4, Table 11) have little likelihood of improving crane roosting habitat given the wide intervals of values that they use. The predictions simulated in Chapter 4, Table 11 provide small increases (0-12 ft) in unobstructed channel widths for channels that are already wide enough to have relative selection ratios consistent with the highest relative selection ratios estimated by the model (based on overlap of 90% CI). To actually provide more suitable roosting habitat for whooping cranes consistent with the RSF model (Figure 5, Chapter 2) will require that channel widths are increased on channels with much smaller widths, e.g., increase a 150 ft wide unobstructed channel width to a 350 ft wide unobstructed channel width. The RSF model suggests that given the wide variation (90% CI) of selection ratios for optimal selection, that changing unobstructed channel widths for channels with unobstructed widths >200 ft will have minimal impact on relative selection ratios.

Shields did not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. The following bullets provides a summary of Shield's discussion with specific *questions* concerning the relationship between habitat selection and habitat variable. For detailed comments, see Shields review Appendix B-7 to B-22.

- It is not clear how bird movement during a multi-day stopover was handled when assigning a single location for the "stopover site" (e.g., Chapter 3, lines 89-91).

- No definition is provided for the left hand side of the equation, w(Xij), or Xij Is it the probability that the ith unit in the jth choice set is selected for use by a crane flock? Please refer to Chapter 2, lines 188-202.

- Habitats other than shallow open water are also an important part of stopover habitat suitability as referenced in the Chapters. (See Shields Comments B-7-B-22).

- Despite the apparent importance of wetlands in WC stopover resting and foraging, the overall approach and data presented in these chapters are largely agnostic with respect to wetlands. Is the entire effort directed at riverine roost habitat? It was not apparent in the chapters.

- Although observations of whooping cranes used to build the datasets used for the analysis were all daytime observations, when presumably cranes would use the non-roosting habitats such as wetlands, no mention of wetlands or variables or metrics to describe wetland proximity to roost sites are presented.

- How were observation of a crane group within a wetland or field handled; part of your data set? Please provide explanation.

- Lines 87-88 of Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat. What is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel?

- Chapter 3, lines 104-105 state that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." Shields found this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.

- Chapter 2, lines 103-104 mention, "characteristics of in-channel habitat." What other habitat types were included in the 7-mile + channel width-wide corridor? Why were they excluded?

- Chapter 2, lines 48-50 state that "riverine habitat has by far the highest incidence of stopover use by whooping cranes." Are floodplains riverine? Backwaters? Islands? Sporadically connected wetlands?

- Chapter 2, lines 65-67 state that, "the monitoring protocol encompasses 3.5 miles on either side of the central Platte River…" So what use was made of observations of cranes within this seven-mile-wide (3.5 x 2) band?

- Chapter 3 indicates that, "selection probability was maximized….when distance to the nearest forest from the edge of the channel…..was > 190 ft." I am concerned that management measures based on this finding would lead to clearing riparian zones. Did it matter what was growing along the unforested channel margins? Would cropland and wetlands or wet meadows have the same effect on selection probability?

- Chapter 4, lines 23-25 mention that area of suitable foraging habitat is a performance indicator, but no mention of data collected to evaluate this indicator is provided.

Smith found the research questions and evaluations were strong and well executed in Chapters 2, 3 and 4. However, more discussion of findings and conclusions would be helpful, particularly since so much analyses and results were provided. Smith provided the following discussion/recommendations:

- Chapter 1 (p.2, line 23) no conclusion statements for Chapters 2 and 3 are given (that address habitat characteristics and MCM), before reaching conclusion on Chapter 4 FSM approach.

- Chapter 2, authors explained how the metrics wetted area and suitable depth within the channel would improve habitat suitability for whooping cranes. However, they were unable to quantify those metrics and used unit discharge as a proxy, which was a measure of flow and channel width, which did not score high in the top four models, a result that was counter to previous studies (p. 47, line 321).

- They do state that "it may not be appropriate to assume flow metrics are not important to selection of habitat by whooping cranes. Instead, it appears area of suitable depth and wetted width surrounding areas selected by whooping cranes were equally available and potentially adequate at flows observed during times of whooping crane use". Given that the main purpose of this report involves determining if SDHF regimes were adequate to maintain habitat suitability, it appears this last statement may be unfounded, and potentially erroneous.

- Chapter 1 suggested revisions:
    - Provide a more detailed discussion on the results of the other studies.
    - Suggest an alternative approach generating necessary data for future studies, given the importance of this hydrologic metric.

- Chapter 3, while the evaluation of whooping crane habitat selection is expanded to a broader spatial scale to encompass the north-central Great Plains, no locations were given even at the river system level. Along this line, the point concerning UOCW in Chapter 3 states that the variability of this metric was among different river systems within the migratory corridor (p. 66, lines 225-265). The explanation that these other rivers are typically wider than the AHR at Platte River are not founded on any results provided in the chapter.

- Whooping Crane data used in this research were provided by a telemetry study intended to evaluate migration corridor dimensions and habitat use. However, these 68 birds were of varying ages (juveniles, subadults, adults), groups (families, pairs, subadult flocks), and evolving migration experience through the time of the study (5 years). In addition, weather conditions can additionally affect habitat availability; however, weather conditions during the study period were not introduced as a metric, or as a descriptor of habitat suitability. They should be considered as affecting the results.

- Chapter 3 suggested revisions:
  - Provide a location map or text description of river systems (or alternatively, basins) used during this study
  - Discuss potential effects bird age, group, or experience may affect habitat choice (e.g., in telemetry juveniles in fall migration, locations are chosen by experienced parents, most likely on their >5th migration)
  - Characterize the general weather conditions throughout the study in terms of potential water availability (drought index, for example)

- Chapter 4, the overarching objective of evaluating the FSM management strategy is explored and evaluated in the context of providing hydrologic conditions necessary to maintain river channel conditions conducive to suitable whooping crane habitat on the AHR of the Platte. The discussion in Chapter 4 could be expanded when describing the constraints from upstream management to provide flow releases of 5,000-8,000 cfs. It may be helpful to understand how effective those short-duration high flows as designated in the AMP affect shallow water roost conditions within the channel to ensure suitable habitat conditions for whooping cranes in the AHR during migration periods.

- Chapter 4 suggested revisions:
  - Include discussion in Chapter 4 that acknowledges any benefits derived from SDHF improving habitat suitability.
  - Provide any recommendations on the flows necessary to achieve the AMP objective based on reported analyses.

9. **Are there any seminal peer-reviewed scientific papers that the whooping crane habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.**

Cade has not kept up on all the literature, but indicated there were no obvious deficiencies. However, he provided the following citations that could potentially have relevant information:

- Richert, A.L.D. 1999. Multiple scale analysis of whooping crane habitat in Nebraska. Ph.D dissertation, Univ. Nebraska.

- Currier, P.J. 1997. Woody vegetation expansion and continuing declines in open channel habitat on the Platte River in Nebraska. In Urbanek and Stahlecker eds. Proceedings of the Seventh North American Crane Workshop, 1996 Jan 10-13, Biloxi, Mississippi. Grand Island, NE: North American Crane Working Group. Pp 141-152.

Shields noted there is no mention of *Bankhead et al. (2016)* since Bankhead's work was sponsored by the PRRIP and must have been available to the author. He strongly recommended that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), *Kui et* al. (2014), Diehl et al. (2016), Manners et al. (2015) and *Edmaier et al. (2015).* See Shields additional comments bulleted below:

- The work by *Bankhead et al. (2016)* indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

- Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

- *Corenblitt et al. (2015)* is a very general review paper that you might consider. There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River *(e.g., Fotherby 2009*). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

- Johnson (1994) is cited, but were his findings fully utilized? Johnson presents several management recommendations that include <u>flow timing as well as flow magnitude</u>, and his recommendations are linked closely to biological processes.

Smith did not find that the conclusions were contrary to other scientific work in the literature; however, she stated this field is not well-developed. The authors should consider publishing in peer-reviewed journals to encourage such discussion at a broader level. A debate does exist regarding the appropriate maintenance and recovery of shallow, braided river systems when hydrologic pulses are severely altered. She recommended incorporating more information from these publications into the chapters and provides some key citations below for consideration at the discretion of the authors.

Geomorphology, alternate views of braided river processes

- Faanes, C.A. 1992. Factors influencing the future of Whooping Crane habitat on the Platte River in Nebraska. 1988 North American Crane Workshop:101-109.

- Farnsworth, J.M., J.F. Kenny, and C.B. Smith. 2015. Comment on "Progressive abandonment and planform changes of the central Platte River in Nebraska, central USA, over historical timeframes. Geomorphology 250, 437-439.

- Gurnell, A.M., W. Bertoldi, and D. Corenbilt. 2012. Changing river channels: the roles of hydrological processes, plants and pioneer fluvial landforms in humid temperate, mixed load, gravel bed rivers. Earth-Science Reviews. 111,129-141.

- Horn, J.D., C. Fielding, and R.M. Joeckel. 2015. Progressive abandonment and planform changes of the central Platte River in Nebraska, central USA, over historical timeframe. Papers in the Earth and Atmospheric Sciences. Paper 317.

- Kinzel, P.J. 2008. River channel topographic surveys collected prior to and following elevated flows in the central Platte River, Nebraska, spring 2008. US Geological Survey Data Series 380, 10 p.

- Pfeiffer, K. and P. Currier, P. 1992. An adaptive approach to channel management on the Platte River. 1988 North American Crane Workshop. 9,151-154.

- O'Brien, J.S. and P.J. Currier. 1987. Channel morphology, channel maintenance, and riparian vegetation changes in the Big Bend reach of the Platte River in Nebraska. Platte River Trust, Grand Island, Nebraska. 49 p.

- Piégay, H., G. Grant, F. Nakamura and N. Trustrum. 2009. Braided river management: from assessment of river behaviour to improved sustainable development. Braided Rivers: Process, Deposits, Ecology and Management, Sambrook Smith GH, Best, JL, Bristow, CS, & Petts, GE (Eds), pp.257-276.

- Smith, C.B. 2011. Adaptive management on the central Platte River – science, engineering, and decision analysis to assist in the recovery of four species. Journal of Environmental Management 92:1414-1419. FSM alternative

See separate comment spreadsheet for suggested revisions/corrections within each of the chapters to eliminate inconsistencies between citations in the text and those within the cited literature.

10. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

Cade referenced his response to Question No. 8 about what the RSF analyses in Chapters 2 and 3 indicate with regards to maintaining important roost site conditions for whooping cranes.

Shields provided extensive discussion on several topics relating to the relationship between management actions, species habitat and species response. See Shields' detailed review in Appendix B-7 to B-27. A bulleted summary is provided below:

- Relationship between NF in Chapter 2 and "nearest forest" in Chapter 3 is very confusing. A couple of diagrams/sketches, one showing a plan view and the other a cross section or two, would greatly facilitate understanding here and alongside lines 222-225 of Chapter 3.

- Better maps are needed throughout the synthesis chapters, as follows:
  - Figure 1 in chapter 1 should show the limits of the AHR and label features such as the "north channel" and the "south channel."
  - A regional map showing North and South Platte and major reservoirs, diversions and returns is also needed.
  - Figure 2 in Chapter 4, the locations of all management actions (disking, spraying, sediment augmentation) are needed as well as a location for Shelton, NE, which is featured in Table 2. Why is sediment load lower at Shelton than at Kearney or Grand Island?

- Has the role of discharge in regulating habitat availability been fully addressed? For example, line 142, chapter 2 notes that, "the temporal component [of changing habitat conditions] is associated with changes in channel form through time." It would seem that the regression analysis shows that key habitat characteristics (e.g., UOCW) vary from year to year based on the magnitude and duration of high flows, not just "changes in channel form."

- The presentation in Figure 1 in Chapter 4 is confusing. The associated text (lines 68-70) mentions SDHF of 5,000-8,000 cfs for three days in two out of three years. No basis is given for selecting this discharge or duration.

- Lines 71-72 says that the three proposed actions are “hypothesized to be sufficient to increase the unvegetated width of the main channel,” and refer to Figure 1. Figure 1 shows a hypothetical relationship between the 1.5-year return interval discharge and the elevation of riparian plants along the river margins relative to the stage for a discharge of 1,200 cfs.

- Is 1,200 cfs the current Q1.5?

- Figure 1 contains no information about proposed actions 1 and 2 (mechanical actions and sediment augmentation), except the two dashed lines, red and blue are labeled “with mechanical actions” and “no mechanical,” respectively.

- Figure 1 contains no information about the relationship between the “green line” elevation and channel width (and the term “green line” is confusing and had me looking for green lines in the figure).

- Figure 1 contains no information about flow duration.

- Can any data be added to Figure 1 to support the hypothesis? Such as, what is the relationship between the elevation of riparian plants and the most recent three years’ peak flows?

- Does hydrocycling (line 308-337) have the potential to perturb the findings regarding the relationships between habitat and crane use? If so, the topic should be explored and term defined. If not, this section should be deleted since it is a distraction.
- Terminology is confusing in referring to the maximum 40-day duration discharge as the “peak.” In Shields experience, “peak” is used to refer to the single maximum discharge in a time series. In a series of daily mean discharges, it would be the highest daily mean. In a series of “instantaneous discharges” (values measured by USGS at 15-min intervals), it would be the highest 15-min value. Typically peaks occur at the peak of an event hydrograph.

- The quantity referred to as the “40-day peak” in these chapters would be called the annual maximum 40-day mean following the example of Richter et al. (1996). Alternatively, this quantity might be referred to as the maximum 40-day discharge volume.

- It is noted (Chapter 4, lines 278-279) that “40 day peak discharge….generally occurred between early May and early July,” but the figure cited has quartiles that span almost the entire year. And how were dates assigned to 40-day-long events?

- Figure 8 of Chapter 4 “40-day peak.” What date within the 40 days is used to create this plot? How are data from the four gages combined to produce the plot?

- Confusing statement in lines 76-78 of Chapter 4 that, "Implementation of SDHF releases has been limited by flow conveyance issues upstream of the AHR but natural high flow events during the period of 2007-2014 have provided natural peak flows in excess of what the Program could produce at full FSM implementation." How were the natural flows conveyed by the channel? Did the natural flows cause unacceptable flooding?

- Johnson (1994) suggested management options involve flow timing as well as flow magnitude, whereas most of the analysis presented in the chapters focuses only on the magnitude and duration (e.g., 40-day peak) without regard to when these flows occur. Johnson ties his recommendations to biological processes dependent on river stages and flows (recruitment and seedling mortality), but the PRIP synthesis is largely silent on the process linkage between flow and key parameters of WC habitat: NF, UOCW, TCW, and TUCW.

- The mean June discharge is listed as one of the variables included in the robust regression in Chapter 4, Table 4, but this variable is only mentioned again in the appendix. These scatter plots consider only global means for the entire reach and do not account for the influence of other variables such as disking or spraying.

- Based on Johnson (1994) recommendations an argument could be made that a series of years with adequate June flows, or a series of 3 years out of 4 with adequate flows should have a different effect on UOCW and TUCW than an isolated high flow year. However, the regression analysis presented in Chapter 4 does not consider the influence of flows in preceding years.

- The robust models consist of linear combinations of the independent variables, and there are no interaction terms (such as discharge x disking, for example). Clearly, the synergistic and continued effects of all three components in the FSM approach is important, as reported in Bankhead et al. (2016).

- Chapter 4 presents an "Analysis of SDHF Performance" in which the effects of adding an SDHF "during April in two out of three years" during dry periods is assessed. No biological or ecological reason is given for staging these releases in April is given, but if the predicted impacts on TCW and UOCW are based on the robust regression results presented earlier in the chapter, the timing of the release is irrelevant since the only way the SDHF enters the equation is through its effect on 40-day peak. The explanation of where these predicted TCW and UOCW values came from is weak. Please contrast this approach with Johnson's findings about effects of June flows and winter flows.

Smith stated the report provided the necessary information to substantiate justification of the project, methods of approach, and results. The discussion within each chapter was brief, yet informative; the summary of findings provided the comprehensive points. Summary of Findings section articulates the results and conclusions of the study very well and is provides a format easy to understand and convey to managers. Her specific and editorial recommendations are provided in Appendix B-28 to B-38 and in the comment spreadsheet.

11. Are the statistical methods used in the combined set of whooping crane habitat synthesis chapters valid and current, and are associated results presented in manner useful to decision makers for the Program?

Cade indicated the statistical analyses and interpretations are reasonable as far as they go, but could be interpreted more effectively.

Shields has limited experience and expertise in the resource selection function type of analysis presented in the whooping crane synthesis chapters but did provide some discussion and questions on the statistical analysis, as summarized in the following bullets:

- Was preliminary analysis of autocorrelation used to determine that only every fifth transect would be used in regressions (line 236, chapter 4)? Clearly, fluvial systems display varying levels of upstream/downstream linkage, so the independence of adjacent observations is a concern in performing regression analysis.

- The top model for TUCW presented in lines 334-341 of Chapter 4, is a linear combination of the independent variables, but how actually independent are the effects of these variables? For example, if you disk a transect prior to the 40 day period when the maximum discharge occurs, wouldn't you expect more scour and removal of sediment and perhaps additional erosion of vegetation compared to a transect that was not disked prior to the high flow? Line 335 suggests a relationship between flow and TUCW, "when no disking or herbicide treatment was applied," and I see how the equation can be used to produce that result, but isn't there an interaction between flow, disking and herbicide that produces a synergistic effect on TUCW?

- The chapters contain many references to "disking" and "mechanical tree removal," (are these two synonymous?) as actions distinct from sediment augmentation, but lines 117-118 of Chapter 4 allude to sediment augmentation conducted as part of, "channel widening activities." Four of the rows in Table 1 of Chapter 4 mention, "island leveling," but it is not clear how this action entered the robust regression analysis, if at all. Has consideration been given to using bar grading as a method to combine removal of vegetation and sediment augmentation?

- Why are no data points plotted in Chapter 4, Figure 10?

- According to Bankhead et al. (2016), infestations of Phragmites are the most difficult to control. They spread throughout the system rapidly and are relatively insensitive to high flows. Lines 99-

104 note the importance of herbicide spraying as a control measure for this species. Lines 553 notes that disking is limited to specific areas. Why isn't spraying similarly limited? Why can spraying be applied more broadly than disking?

- Lines 34-38 of the summary of key findings mentions only SDHF and disking; spraying herbicide is not mentioned. I understand that the statistical analysis showed that spraying only explained about 3% of the variation in UOCW (line 441), but the top equation does include spraying (and see $P = 0.01$, line 459). Further, spraying evidently may be applied on a broader spatial scale than disking (although the chapters do not explain why), and it is needed to combat the highly flow-resistant Phragmites.

Smith indicated that using the Resource Selection Function is a preferred method to identify which resources (often landscape features serve as a proxy for those resources) drive species distributions in selective habitats. RSF can be interpreted as being proportional to expected density of observations (Aarts et al. 2012), and thus provides useful metrics to use in evaluating the study area. The approach used in these analyses is used widely in contemporary, published literature investigating similar research and adaptive management questions. In most cases, detailed information was provided for methods in each chapter; additional information was provided in associated appendices.

She found very few weak points in the report; however, one particular key component in the analyses involved the Unobstructed Open Channel Width (UOCW) metric bears discussion. In Chapter 1, an excellent overview of the literature comparing the optimum UOCW results from several studies (p. 11). Given the importance of this metric in the report's model results, it would be beneficial to discuss in this section, and/or in the succeeding chapters why this variability might occur. In addition, it appears that UOCW is measured differently within this study which may affect results in Chapter 2 compared with Chapter 4. Also, a new metric, Total Unobstructed Channel Width (TUCW) was introduced in Chapter 4 research design and analyses. Her suggested revisions, include:

- Review the method descriptions and discern if the difference only appears within the figures and not in the definitions, Fig. 2 (Chapter 2, p. 33) as possibly multiple lines across the channel, while only measured once within the channel in the approach depicted in Fig. 6 (Chapter 4, p. 82).

- Address the differences when defined in Chapter 4, including the use of the new metric (TUCW) if it differs from UOCW in Chapter 2.

12. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the whooping care habitat synthesis chapters and then discussed in the results and conclusion sections?

Cade stated that an adequate effort has been made at exploring potential biases that cannot be completely eliminated.

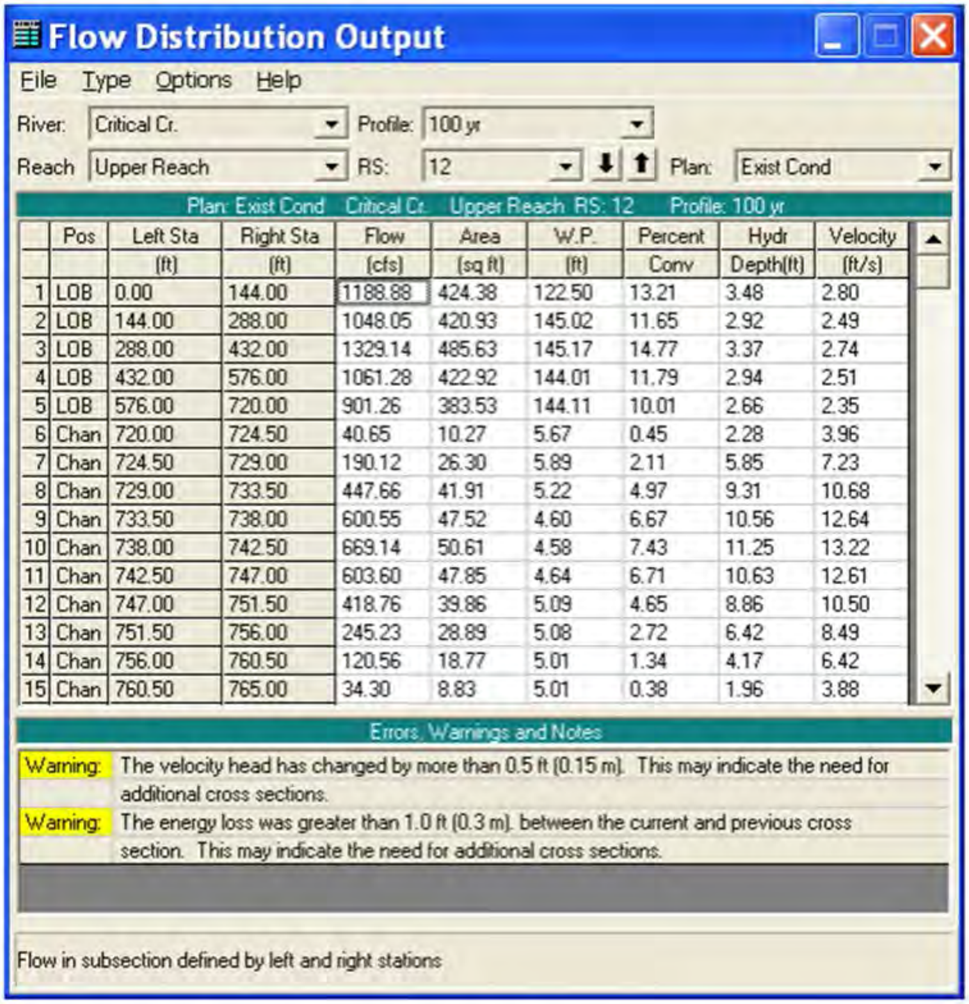
Shields' discussion for Chapter 2 (lines 276-277) noted that, "wetted width and area of suitable depth are highly dependent on instantaneous flow and change continuously…" Given this fact, the development of unit discharge (UD) values for use in the analysis is troubling (Chapter 2, lines 120-122). He provided the following comments concerning unit discharge (UD) (similar response found in Question 2 of the WEST Report):

- Line 349, Chapter 1 quotes from the Biological Opinion, "Whooping cranes stand in shallow (usually <0.7-foot) slow-moving water to roost." No range of current velocity is provided, but local unit discharge is the product of local depth and local velocity. The average unit discharge for a cross section is discharge divided by flow width (not channel width). The report uses the expression "wetted width" in a way equivalent to Shields' use of "flow width.") Cranes likely do not respond to cross-section average UD, however. They respond to local UD. So the UD of importance in evaluating habitat is the local UD occurring at the time and place where the birds are roosting. Line 168 of the USFWS comments/EDO response indicates that the area used is typically < 50 ft. x 50 ft. Local depth likely varies across a substantial range in time and space in the AHR of the Platte, so computation of cross-section average UD based on 2009 surveys is unlikely to yield much information about the availability of habitat with <0.7-foot depth when selection was made.

- Lines 131-170 of the USFWS comments and EDO responses discuss how UD was computed. Line 150 states that UD is based on "total channel width," which remains relatively constant at a location through time. Further TCW includes islands, so dividing discharge by TCW yields a result that is not even accurate for cross-section average UD.

- The aforementioned EDO response explains the difficulty of obtaining representative UD values, but it would seem that at least some field measurements are needed to validate the UD values used in the analysis. Are the values used in the analysis actually representative of those occurring when habitat selection was made?

- As shown in the Figure extracted from Brunner (2010) below, HEC-RAS allows computation of local depth and velocity. Therefore HEC-RAS simulations could be used to obtain more representative UD values than the methodology presented in these documents, given discharges contemporary with crane stopovers and recent cross section or bathymetric surveys.



	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)
1	LOB	0.00	144.00	1188.88	424.38	122.50	13.21	3.48	2.80
2	LOB	144.00	288.00	1048.05	420.93	145.02	11.65	2.92	2.49
3	LOB	288.00	432.00	1329.14	485.63	145.17	14.77	3.37	2.74
4	LOB	432.00	576.00	1061.28	422.92	144.01	11.79	2.94	2.51
5	LOB	576.00	720.00	901.26	383.53	144.11	10.01	2.66	2.35
6	Chan	720.00	724.50	40.65	10.27	5.67	0.45	2.28	3.96
7	Chan	724.50	729.00	190.12	26.30	5.89	2.11	5.85	7.23
8	Chan	729.00	733.50	447.66	41.91	5.22	4.97	9.31	10.68
9	Chan	733.50	738.00	600.55	47.52	4.60	6.67	10.56	12.64
10	Chan	738.00	742.50	669.14	50.61	4.58	7.43	11.25	13.22
11	Chan	742.50	747.00	603.60	47.85	4.64	6.71	10.63	12.61
12	Chan	747.00	751.50	418.76	39.86	5.09	4.65	8.86	10.50
13	Chan	751.50	756.00	245.23	28.89	5.08	2.72	6.42	8.49
14	Chan	756.00	760.50	120.56	18.77	5.01	1.34	4.17	6.42
15	Chan	760.50	765.00	34.30	8.83	5.01	0.38	1.96	3.88

Figure 4-11 Output for the Flow Distribution Option.

- The report is unclear regarding the discharge values that were used to compute UD. Ideally, the discharge that occurred on the date when the cranes made their habitat selection is the discharge that should be used.

- Perhaps the way that UD was determined contributes to its lack of influence in the top models for in-channel habitat use (e.g., Table 6, Chapter 2 and lines 291-292). Of course, it is troubling that UD was not used as an a priori model as the other key variables were used for models 1-5, Table 1, Chapter 2. (Note that there are two model 5's in this table).

- Further, it is interesting that HEC-RAS was used for TCW determination (Chapter 2, lines 120-122). He could not find a definition for TCW in any of the Chapters. There is a definition for "Wetted Width at Bankfull Discharge" in Table 4, Chapter 2, and it is, "Wetted width of the channel at bankfull discharge. Metric included to represent 'vegetation ratchet' control on width adjustment potential.

Widths were delineated from June 2011 aerial imagery, which was flown at near bankfull discharge. Areas of shallow overbank flow were omitted."

- [Shields] prefers to define bankfull width is as a geometric property of a given cross section and it may or may not relate to a specific return interval discharge. As shown in the figure below, bankfull width is the straight line distance between the bank tops, which are determined as pronounced inflection points marking the limit of the floodplain flat. When one top bank is higher than another, the width is determined by drawing a line from the low bank top to the point where it intersects the opposite bank. In a braided or anastomosing channel such as the Platte, the bankfull width should be measured between the extreme outer banks and encompass intervening islands and bars. So the "total channel width" in these chapters would more accurately be termed bankfull width, in my opinion.

- It is not clear how "bankfull discharge" was determined for use in HEC-RAS for finding "bankfull wetted width," or what all this has to do with the TCW values used in the regression analysis. If the June 2011 discharge occurring when aerial imagery was flown was adopted as bankfull discharge, I am curious to know the magnitude and return interval of that discharge. Which gage records were used to determine the discharge for HEC-RAS runs to compute width?

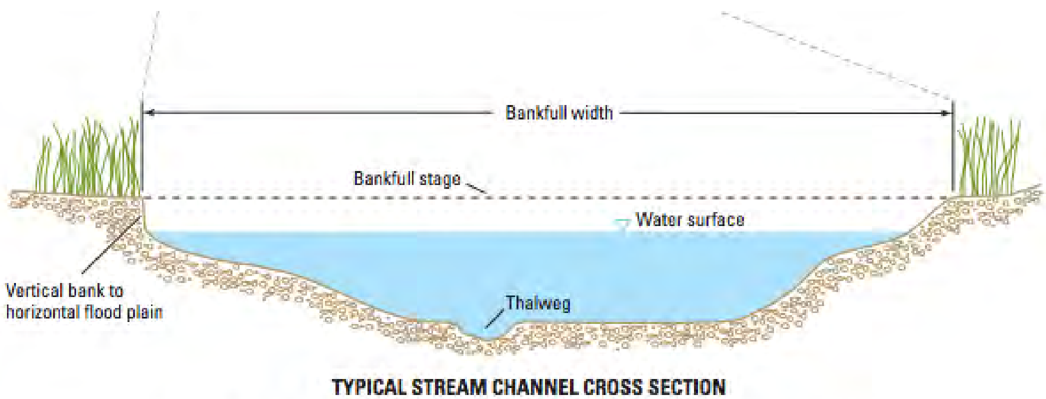


Figure 2. Typical channel reach and cross section for measurement of channel features.

- Shields found confusion among the treatments of width in Chapters 2, 3, and 4. Specifically, the discussion for Chapter 2 (lines 322-323) states, "……we were unable to establish a strong relationship between UFCW or TCW and whooping crane use." However, Chapter 4 (lines 45-47) states that probability of WC use, "…is maximized when….unforested corridor width reaches 1,011 ft…" I found no text, tabular information, or figure showing the effect of UFCW in Chapter 2.

- Further confusion ensues due to apparent contradiction between line 301 and Table 6 of chapter 4. The former states that, "Wetted width ranged from 603 ft to 1,717 ft," while the latter presents only a global mean value of 1,044 ft based on 2011 aerial imagery. Why are annual mean widths not presented in Table 6 as for the other variables? What widths were used to develop Figure 10? Were all widths used in the analysis from 2011? Similar comments apply to Figure 11.

- Measured or model-produced numerical data are needed to support statements about spatial trends in sediment deficit in lines 108-113 of Chapter 4. If the deficit, “is made up…in the south channel downstream of the return,” then are additional sediments added in the deficit region or above or below this deficit zone?

Smith stated that potential bias in both sampling bias and detection bias was discussed in Chapter 4 (p. 64, line 178) in relation to the US Fish and Wildlife Service’s Whooping Crane opportunistic sighting database. One pertinent paper was cited in regard to this specific database in the report. In addition location error was mentioned with regard to this database. Potential errors in measurement data using GIS platforms were also identified within the report. The reviewers were provided with an amended report on October 10, 2016, in which a series of memos and reply memos were included that discussed how these bias and errors may affect the results of the study, or affected data collected for the purpose of use in the analyses. She was not prepared to delve into any more detail than was discussed in these memos.

3.2.1 Rating System – Habitat Synthesis Chapters

Reviewers rated the set of chapters using a rating system provided by the Program where 1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor. Table 3-2 summarizes each reviewer’s ratings:

Table 3-2. Reviewers’ comprehensive ratings of the synthesis, chapters by category.

Category	Cade	Shields	Smith
Scientific soundness	2	3	2
Degree to which conclusions are supported by the data	2	4	2
Organization and clarity	1	5	2
Cohesiveness of conclusions	2	4	1
Conciseness	1	4	1
Important to objectives of the Program	2	2	1

3.2.2 Acceptance – Habitat Synthesis Chapters

Reviewers were asked to provide their recommendation to either accept the WEST Report and synthesis chapters, accept them with revisions, or deem them unacceptable. All three reviewers recommended that the chapters be accepted with revisions. The following sections provide recommended revisions as part of report acceptance.

Shields stated that the chapters are acceptable only if the recently published process-based research cited above (Bankhead et al. 2016, Bankhead and Simon in review, and similar papers) can be fully exploited to inform results, concerns stated above regarding UD values used in the analysis can be addressed, and synergistic, interactive effects among management measures (flow, sediment, mechanical) can be fully considered. Also, the synthesis should provide evidence that the Program is taking an ecosystem-based view of managing the AHR that considers all listed species as well as others.

Cade identified several important statistical issues to be addressed for making the report acceptable, as discussed in detail in Appendix B-1 to B-6.

Smith provided the following recommended revisions:

- Chapter 1: Add conclusion statements for Chapters 2 and 3.
- Chapter 3: Provide a more detailed discussion on the results of the other studies. Suggest an alternative approach generating necessary data for future studies, given the importance of this hydrologic metric.
- Chapter 4: Provide a location map or text description of river systems (or alternatively, basins) used during this study. Discuss potential effects bird age, group, or experience may affect habitat choice (e.g., in telemetry juveniles in fall migration, locations are chosen by experienced parents, most likely on their >5th migration). Characterize the general weather conditions throughout the study in terms of potential water availability (drought index, for example).
- Chapter 4: Include discussion in Chapter 4 that acknowledges any benefits derived from SDHF improving habitat suitability;
- Provide any recommendations on the flows necessary to achieve the AMP objective based on reported analyses.

3.3 Other Specific Comments

Louis Berger compiled the reviewers' comments into a spreadsheet, organized by report (WEST or Habitat Synthesis Chapters), chapter, page or line number (if applicable) and reviewer name, and specific comment. This spreadsheet will be used by the PRRIP in preparing responses to the comments. A column was added to indicate by an "X" which comments are recommended for acceptance of that particular report. In several cases, the reviewers referenced their specific comments or suggested revisions within the responses to the questions. The individual responses can be found in Appendix A (WEST Report) or Appendix B (Habitat Synthesis Chapters).

4.0 REFERENCES

The following references were cited in Section 3.0 above. The citations for other references recommended by the reviewers are included in their individual comments in Appendix A and B.

- Bankhead, N. L., Thomas, R. E., and Simon, A. 2016. A combined field, laboratory and numerical study of the forces applied to, and the potential for removal of, bar top vegetation in a braided river. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.3997.

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5.0 APPENDICES

Appendix A: Individual Reviewer Comments – WEST Report
Appendix B: Individual Reviewer Comments – Habitat Synthesis Chapters
Appendix C: Reviewer Biographical Sketches

APPENDIX A
INDIVIDUAL REVIEWER COMMENTS – WEST REPORT

Cade	A-1 to A-6
Shields	A-7 to A-14
Smith	A-15 to A-28

Review of WEST report for PRRIP: Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River, Nebraska (draft dated 16 February 2016).

Reviewed by Brian S. Cade, Fort Collins Science Center, USGS, October 2016.

(1) *Does the WEST report adequately address the overall objective, which is to analyze Program data to provide insight into whooping crane habitat selection and use?*

The WEST report provides a useful analysis of new data on temporal trends in use of the Platte River by whooping cranes and selection of riverine roosting habitat as well as a synthesis of other whooping crane roost habitat selection data that is applicable to the PRRIP. The fundamental challenge of interpreting crane roost site selection for wider, unvegetated, and unobstructed channels given the highly variable selection among cranes and changing spatial and temporal availability of channel characteristics are met with their analyses. Their use of a less biased sample of whooping crane observations based on systematic aerial surveys is commendable.

(2) *Do the authors of the WEST report draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.*

The conclusions drawn from the resource selection analyses are reasonable as far as they go. The partial regression plots for individual predictor variables in the generalized additive model (GAM) are informative. However, I believe that they can provide more useful interpretations by incorporating information on intervals of values associate with the predictor variables (e.g., unobstructed channel widths 200-700 feet) that are consistent with the sampling variation (90% confidence intervals) of the highest relative selection ratios. I provide more details on this issue under (5) below.

The analyses on trends in use of the Platte River by the whooping crane population seem useful, reasonably analyzed and interpreted.

(3) *Are there any seminal peer-reviewed scientific papers that the WEST report omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.*

I have not tried to keep up with the whooping crane literature but I do not know of any obvious important literature that they have missed. The Farmer et al. (2005) report might have some relevant information that is worth relating to their results, but that is done in the Synthesis document.

(4) *Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and reference materials help to verify and or validate this relationship?*

Yes, I think the WEST report has addressed these as adequately as anyone has.

(5) *Are the statistical methods used in the WEST report valid and current, and are the associated results presented in a manner useful to decision makers for the Program?*

The resource selection function analyses based on the discrete choice multinomial logistic regression model seem very current and reasonable. However, there are a few definitional and interpretation issues that could be improved. I highlight the more critical issues to address first and then discuss additional issues that might be worth exploring but are less critical to address.

Important issues to address for making report acceptable

Use of term "relative probabilities of use". They are not really probabilities.

Page 14: The resource selection function $w(X)$ is an exponential function not a logit function, where $w(X)$ is scaled on the interval $[0, +\infty)$. Does the discrete choice multinomial logit model used to estimate coefficients involve the same steps as with other RSF models where an estimated intercept from a logistic regression model is excluded from the exponential form of the RSF (similar to McDonald 2013)? Should be reworded for clarity.

Page 15: In Response Functions, Wording is not reasonable – predicted "relative probability of selection". These are ratios of proportions from an exponential RSF that by definition are scaled $[0, +\infty)$. They are not probabilities. You can scale the relative selection ratios to [0, 1] as done here but that still does not make them probabilities. In fact, you could scale them from [0, to any positive number you want] and their interpretation is still the same as they only have meaning with respect to each other in the same model. A $w(X) = 0.8$ indicates a relative selection ratio 4× greater than a relative selection ratio of $w(X) = 0.2$. But similarly a $w(X) = 4.8$ indicates a relative selection ratio 4× greater than a relative selection ratio of $w(X) = 1.2$ on a different scale. The interpretation is with respect to other $w(X)$ within a model. I suggest just using the term "relative selection ratios". I think it is especially important to keep this distinction because it becomes easy to confuse the rescaled relative selection ratios on [0, 1] as if they were actual probabilities estimated from a logistic regression model. They are not probabilities. Would have to change wording in all relevant figure labels (e.g., Figures 3, 4, 5, 6, 7, 8, 9, etc.). I recognize that many people including McDonald (2013) have used the term "relative probabilities of selection" but I think it is misleading and potentially confusing to use the word "probability" in this terminology, especially after McDonald (2013) did such an excellent job clarifying that these ratio of ratios are not scaled on [0, 1].

Page 15: It is not clear that 90% confidence intervals for estimated relative selection ratios can really be approximated using a Taylor series expansion approach because the estimates come from a multinomial logistic regression model but the RSF uses these in an exponential functional form that excludes the intercept. If these were simple logistic regression estimates carried forward to exponential RSF, I don't believe there is a simple analytical formula to compute standard errors (or confidence intervals) for predicted $w(X)$. It is not obvious to me whether this same constraint applies to the discrete choice multinomial logit model used but it seems likely. With a conventional RSF modeling approach I would have simulated these by sampling from the multivariate normal distribution associated with the logistic regression estimates and their covariances (including the intercept) say m = 10,000 times, and for each sample compute the exponential RSF (that excludes the intercept), and then compute confidence intervals from the sampling distribution of that exponential RSF based on the m = 10,000 estimates. More details on your Taylor series expansion approach should be provided to justify its credibility. I note that in Chapters 2 and 3 of the Synthesis document that bootstrapping is employed for estimating these confidence intervals.

It is not clear why you would want to constrain the response functions to eliminate just the extremely large (upper 25th percentile) values of habitat characteristics. You could just as easily justify eliminating the extremely small (lower 25th percentile) values of habitat characteristics. Or more reasonably, do not eliminate any of them. It is possible that it is more extreme values that are especially important, although admittedly the statistical model will have less precise selection ratios for the extremes. This needs to be handled differently than currently done. I realize that some of the estimated CI may get extreme at more extreme values of the predictor variables, so perhaps you would have to limit graphs to 10th to 90th percentiles rather than the entire range.

Page 16: Diurnal habitat selection methods. Same comments from above would apply as they used similar models.

Habitat selection Results

Results Page 23-25: You could provide some additional verbiage to help interpret these partial regression plots. For example, with respect to Figure 5 you could indicate that at 138 feet of distance to nearest obstruction (at mean distance to nearest forest) the relative selection ratio (approx. 0.60) for roost sites is 6× greater than the relative selection ratio (0.1) at 50 feet of distance (or whatever the correct measure is that corresponds to 0.1 selection ratio) to nearest obstruction. The advantage of this is that it helps set the context for using the relative selection ratios to compare with each other within a model. Could even provide these interpretation for all predictor variables from say their 25th to 75th percentiles of values, i.e., describe the change in relative selection ratios across the central 50% of observations (or any other interval that makes sense).

But really these partial regression plots need to be interpreted with respect to the confidence intervals on the relative selection ratios. There seems to be an undue focus on where the point estimates of the relative selection ratios maximize (e.g., Figure 3). For example, unobstructed channel widths of approximately 200-700 feet all seem consistent with 90% CI for highest relative selection ratios, i.e., the 90% CI for any estimated relative selection ratio at 200 to 700 feet (approximately based on graphic, this can be refined more precisely with the estimates) all overlap with intervals for the highest value estimated at 509 feet. So really the relative selection ratio estimates cannot be claimed to be substantially different for any unobstructed channel widths between 200 and 700 feet based on your estimated sampling variation defined by the 90% CI. This interpretation issue is akin to the problem of separation of distributions in regression models (see for example, Xie and Nelson. 2003. Separation among distributions related by linear regression. American Statistician 57: 33-36.).

Other less critical issues that could be addressed

Page 11: Availability definition is not unreasonable (subsection of river 10 miles upstream and 10 miles downstream viewable from flight trajectory) given there are many possible ways to define resource availability. However, the flight trajectory towards the Platte R. itself may be selection for specific sections of the river with desirable characteristics, i.e., some constraint on choices may already have been made. So while it is not unreasonable to restrict availability the way you have done such that it is local (±10 miles from used location) and changing for every roost site, it would be equally reasonable to assume that this large migratory bird could have gone anywhere on the migration trajectory across the Platte R. in Nebraska and, thus, the entire stretch of river was available to any crane for initial roosting. Clearly, this definition of availability could completely change the results of the RSF analysis. Would it be informative to consider estimating an RSF this way where availability was defined by the larger scale and considered the same for all cranes within a year? If this demonstrated similar selection patterns as the more local/changing availability scale, would it strengthen interpretations?

Pairing of use site with available sites (20 points) in discrete choice logistic regression GAM using a strata option in mgcv package. Could they provide example R code for some of the model estimates? I do not see a strata argument in mgcv(). Is this perhaps something that is associated with the cox proportional hazards family option (proportional hazards models often being used to estimate discrete choice models) in gam()? I think you need to define the model more clearly with respect to how it was actually estimated in the gam() function of mgcv package, including model form, family used, link function, other arguments like strata, etc. Of course, providing some of the code in an Appendix would also help clarify this.

Predictor variables (page 13):
How is dense vegetation defined in "distance to nearest dense vegetation"?

It seems like it would be useful to examine the correlation structure (potential multicollinearity in the models) among these unobstructed widths and channel width measures that are going to be used as predictor variables. This might suggest some simpler model forms and certainly would aid interpretation.

Page 15: It is not clear how the use of P-values for significance of smoothed terms if null hypothesis was rejected is useful. Perhaps I'm misinterpreting something here.

Page 19: Trend estimates. Why not plot the trend estimate with a 95% CI to correspond with the P = 0.05 level of significance corresponding to your hypothesis test of zero trend? Seems unnecessarily inconsistent.

In general there are very few observations (*n* = 32 for spring, *n* = 21 for fall, and *n* = 53 combined) for estimating a very complex logit model. It is the sample size of the smallest group, crane use locations, that impacts the precision of these logit models. As many of the models considered (Table A.1) have up to 4 predictor variables included with multiple degrees of freedom (df) potentially used for each due to the spline fitting, it seems unlikely that many of these more highly parameterized models could be estimated well with such a small sample of used locations. And that won't necessarily be reflected entirely in AIC statistics.

Page 30, Figure 11: Does it make sense that diurnal selection should be maximized at zero distance from roosts? I wonder if you might need to be taking logs of roost location differences.

<u>Trend Results</u>

Pages 31-33: How do you know the number of "unique" individual cranes?

<u>Discussion</u>

Page 37: It might be worth discussing the correlation (multicollinearity) between nearest obstruction predictor variable that was not used in the management models and unobstructed channel width predictor variable that was used in both best and management models. How much of variation in nearest obstruction is related to variation in unobstructed channel width?

Supplementary Material – Additional analyses in Appendices C - E

I wonder if there is a more effective strategy for analyzing the additional data from the systematic and opportunistic samples. Rather than using this data to select among candidate models with different combinations of predictor variables, why not just use this additional data in the models that were already selected as best for your most unbiased analyses in the main body of the report (the first records on crane roosts from systematic surveys). Then you might be able to look and see how well the additional data supports or does not support the best unbiased estimates. For example, it could be that if all the spring crane roosts were used with the model that used nearest obstruction (Table 5, and Figure 7) that the estimated response function would be very similar, though perhaps with narrower confidence intervals because of the increased sample size. This would be encouraging. Or they might yield very different responses which would be discouraging but could be explained both by real different patterns or biases in the sample (and you can't distinguish these two possibilities). But the current approach of reselecting candidate models allows you to consider more complex models simply because the combined data sets have larger sample sizes.

(6) *Are potential biases, errors, or uncertainties considered within the methods sections of the WEST report and then discussed in the results and conclusions sections?*

The WEST report does try to address some potential biases in detection of cranes from the aerial surveys. In addition, they focus their primary resource selection analyses on the least biased observations, first sightings of roost locations from the systematic aerial surveys. Other crane observations are incorporated in secondary analyses that largely mimic their primary analysis (but see my suggestion above about an alternative strategy for these secondary analyses).

RATING (1 = excellent, 2 = very good, 3 = good, 4 = fair, 5 = poor)

Scientific soundness	2
Degree to which conclusions are supported by the data	2
Organization and clarity	1
Cohesiveness of conclusions	2
Conciseness	1
Importance to objectives of the Program	2

RECOMMENDATION

Accept	
Accept after revision	X
Unacceptable	

PRRIP review—WEST Report and Habitat selection synthesis chapters

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Table of Contents

General observations 3

WEST Report 4

General Questions 4

RATING 8

Category Rating 8

Recommendation 8

Editorial Comments 9

Habitat Synthesis Chapters 10

General Questions 10

RATING 22

Category Rating 22

Recommendation 22

Editorial Comments 23

Works cited 27

General observations

Please allow a few observations that do not clearly fall under any question below. I realize some of my comments here are well outside the general purview of the PRRIP. The documents for review describe long-term, expensive efforts to provide adequate habitat for a small subset (5-10%) of the small surviving population of a single species for, "~two to three days on average," and range from, "one to several days," twice a year. The western migratory population is estimated to be about 300 individuals (Chapter 1, Figure 3), so we are talking about 15-30 animals using a 90-mile-long reach of the Platte for less than 7 days per year, total. Perhaps the numbers are even smaller, as Table 8 of the WEST report shows an average of 11 and 8 animals, or 4% and 3% of the population, using the AHR in Spring and Fall, respectively for the period 2001-2014.

These ~7 days of annual use (2 to 3 days in Spring and 2 to 3 days in Fall) are spread over several weeks in the Spring and in the Fall. Such an intense focus on lightly-used habitat for a single species seems illogical. In my view the ESA process misplaces emphasis on species rather than habitat. A focus on restoring the properties and characteristics of the ecosystem, more specifically habitat and associated processes that create and sustain habitats, would potentially benefit a wider range of species and lead to better long-term outcomes than attempting to precisely target the preferences of a single species.

I am aware that the PRRIP is also addressing issues associated with least tern, piping plover and pallid sturgeon. However, the documents covered by this review are completely silent about those species. In particular, I think it would be valuable to discuss management activities that potentially benefit all four targeted species or, more to the point, activities that produce pre-impact habitats and processes.

Second, the small size of the studied population and their transient presence in the AHR creates an extremely difficult problem when trying to produce defensible scientific results. I appreciate the dedication and effort of the teams involved in this work, but clear-cut, objective conclusions are hard to obtain. The resource selection documented by the systematic monitoring, if it is perfectly accurate, shows the habitat preferences of members of a depleted population acting in a degraded and stressed system. In a system more similar to the one that existed in the nineteenth century, selection behavior might have been different.

WEST Report

General Questions

1. Does the WEST report adequately address the overall objective, which is analyze Program data to provide insight into whooping crane habitat selection and use?

   Yes. However, the difference between spring and fall population fraction use trends (e.g., Figures 18 and 22) was not explained. No hypotheses were presented or tested regarding this phenomenon.

   The terms "in-channel," "off-channel," and "diurnal" are all used as descriptors of the words "use," or "habitat," without definition.

   It is not at all clear what is meant by, "<u>subsequent</u> diurnal locations of crane groups," in the first paragraph under "diurnal habitat selection methods." Diurnal is defined as, "of, or during the day," or "daily." Did not the systematic aerial PRRIP surveys occur in daytime?

2. Do the authors of the WEST report draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and specifics of each situation.

   <u>Do we know how cranes select stopover locations</u>?
   I do not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. The justification given for analyzing a 10-mile long reach for in-channel habitat is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft. above ground level." No data are provided regarding the flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable ("…an assessment of viewsheds from 3,000 ft. above ground level by PRRIP personnel…"). How sensitive are your findings to the 10-mile assumption? Would an assumed available reach length 5 miles for the choice set produce a different outcome? Further since the land cover variables encompass conditions within a 3-mile radius of an analyzed point, the actual distance from the selection point to the boundary of the choice set could exceed five miles.

   I assume that monitoring flights were conducted in such a way that the overflying aircraft did not modify crane behavior, but it would be good to read an assurance to that effect.

   How certain are you that birds spotted in early morning were in locations where they had roosted the previous night? "Flights….took place in the early morning <u>intending</u> to locate crane groups before they departed the river to begin foraging." Note that the question I am asking goes beyond error in detecting presence of a group (page 38, "imperfect detection").

Cranes respond to local flow conditions, not average conditions

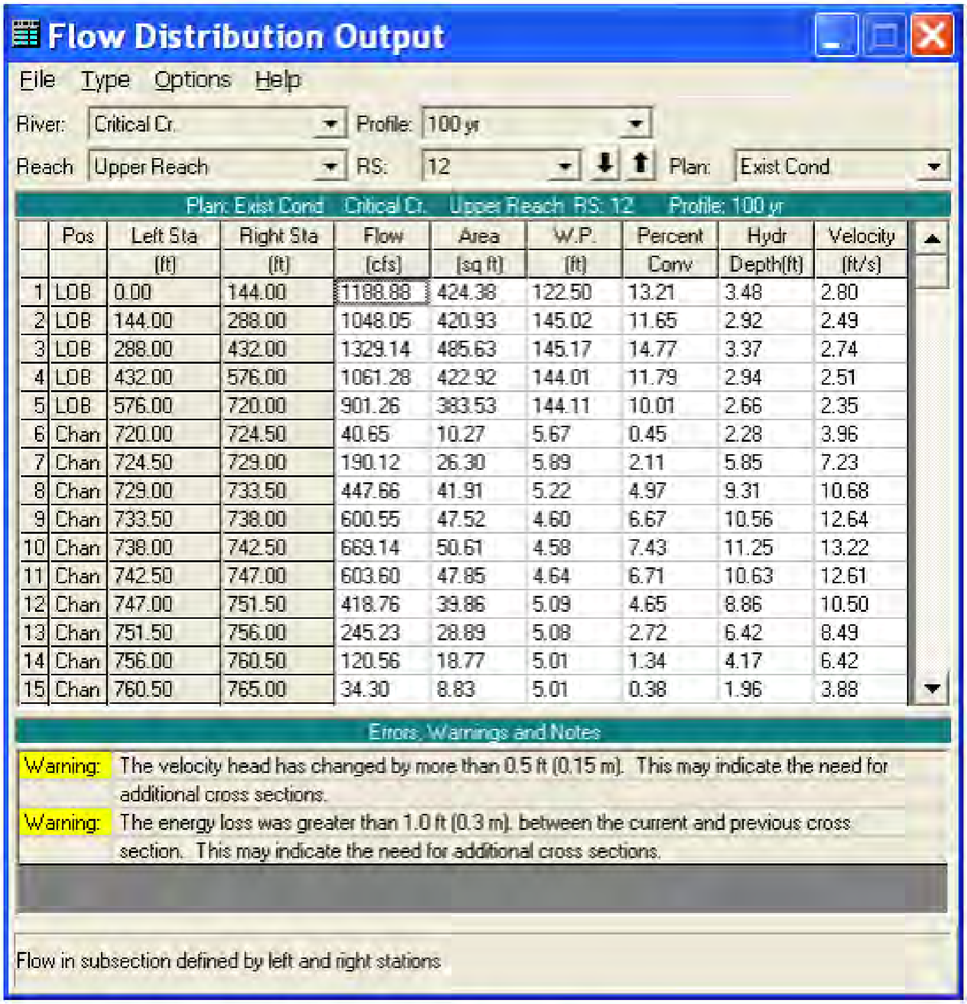
The report notes the temporal and spatial variation in habitat availability. "During a multi-night stopover…there can be a dramatic range in the volume of in-stream flows." Crane groups select a roosting location generally < 50 ft x 50 ft (USFWS comments/EDO response).

Lines 131-170 of the USFWS comments and EDO responses discuss how UD was computed. Line 150 states that UD is based on "total channel width," which "remains relatively constant at a location through time." Furthermore, TCW includes islands, so dividing discharge by TCW yields a result that is not even accurate for mean UD.

Given these facts, the development of unit discharge (UD) values based on 2009 flows and channel topography for use in the analysis is troubling. The average unit discharge for a cross section is discharge divided by flow width (**not** channel width). (I believe the report uses the expression "wetted width" in a way equivalent to my use of "flow width.") Cranes likely do not respond to average UD, however. So the UD of importance in evaluating habitat is the local UD occurring at the time and place where the birds are roosting. Local UD is the product of local depth and local velocity. Local depth likely varies across a substantial range in time and space in the AHR of the Platte, so computation of cross-section average UD based on 2009 surveys is unlikely to yield much information about the availability of habitat with <0.7-foot depth.

The aforementioned EDO response explains the difficulty of obtaining representative UD values, and it would seem that at least some field measurements are needed to validate the UD values used in the analysis. Are the values used in the analysis actually representative of those occurring when habitat selection was made?

As shown in the Figure extracted from Brunner (2010) below, HEC-RAS allows computation of local depth and velocity. HEC RAS simulations with discharges for the days cranes were spotted and recently surveyed cross sections could be used to obtain more representative UD values than the methodology presented in these documents.



	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)
1	LOB	0.00	144.00	1188.88	424.38	122.50	13.21	3.48	2.80
2	LOB	144.00	288.00	1048.05	420.93	145.02	11.65	2.92	2.49
3	LOB	288.00	432.00	1329.14	485.63	145.17	14.77	3.37	2.74
4	LOB	432.00	576.00	1061.28	422.92	144.01	11.79	2.94	2.51
5	LOB	576.00	720.00	901.26	383.53	144.11	10.01	2.66	2.35
6	Chan	720.00	724.50	40.65	10.27	5.67	0.45	2.28	3.96
7	Chan	724.50	729.00	190.12	26.30	5.89	2.11	5.85	7.23
8	Chan	729.00	733.50	447.66	41.91	5.22	4.97	9.31	10.68
9	Chan	733.50	738.00	600.55	47.52	4.60	6.67	10.56	12.64
10	Chan	738.00	742.50	669.14	50.61	4.58	7.43	11.25	13.22
11	Chan	742.50	747.00	603.60	47.85	4.64	6.71	10.63	12.61
12	Chan	747.00	751.50	418.76	39.86	5.09	4.65	8.86	10.50
13	Chan	751.50	756.00	245.23	28.89	5.08	2.72	6.42	8.49
14	Chan	756.00	760.50	120.56	18.77	5.01	1.34	4.17	6.42
15	Chan	760.50	765.00	34.30	8.83	5.01	0.38	1.96	3.88

Figure 4-11 Output for the Flow Distribution Option.

The report is unclear regarding the discharge values that were used to compute UD. Ideally, the discharge that occurred on the date when the cranes made their habitat selection is the discharge that should be used.

Perhaps the way that UD was determined contributes to its lack of influence in the top models for in-channel habitat use (e.g., Table 3).

3. Are there any <u>seminal</u> peer-reviewed scientific papers that the WEST report omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

   I am not familiar with the literature in the subject area (avian resource selection) covered by the WEST report. I do have some suggestions in my review comments for Synthesis Chapter 4.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

   I am puzzled by the statement, *"Nearest obstruction and nearest forest were present in all five of the top five models. These models do not appear at the top of the management model list because PRRIP staff does not consider nearest obstruction to be a variable useful for management."*

   Mechanical removal of trees is one of the key management actions described! However, it would seem that there should be a high correlation between NO and NF and between NO and UOCW. The report does not comment on this, either.

   The diurnal data indicate preferential selection of cornfields relative to grassland, soybean and wet meadow. Has any consideration been given to potential hazards to WC posed by herbicides, insecticides or less than optimal forage found in cornfields relative to more natural habitats?

5. Are the statistical methods used in the WEST report valid and current, and are the associated results presented in manner useful to decision makers for the Program?

   I have limited experience and expertise in the resource selection function type of analysis presented here.

6. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the WEST report and then discussed in the results and conclusion section?

   The statement is made that, *"For the diurnal habitat use analysis, the choice set was centered on the use location and extended 3 miles in all directions from that point. The habitat within the choice set area was described at a set 1,171 points systematically spaced at 250m intervals."*

   Was this convention followed even when the use location was on the edge of the study area? If the use location was on the very edge of the study area, then the choice set would extend up to 3 miles outside the study area.

   How did you ensure that you used the correct previous night roost location when computing the value for PRL? Could you have confused crane groups, or failed to detect one? Note that the question I am asking goes beyond error in detecting presence of a group (page 38, "imperfect detection").

RATING

1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor

Category Rating

Scientific soundness __2____

Degree to which conclusions are supported by the data ___3___

Organization and clarity ___4___

Cohesiveness of conclusions _2_____

Conciseness ___2___

Important to objectives of the Program _2_____

Recommendation

Accept ______

Accept with revisions ___X___ . Revision should especially address questions above regarding validity of unit discharge values used in analysis, range of evaluation used by cranes when selecting stopover locations, and the differences between Spring and Fall results.

Unacceptable ______

Correlates of Whooping Crane Habitat Selection and Trends in Use (WEST Report)

RATING:

Please score each aspect of this manuscript using the following rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

Scientific soundness	2
Degree to which conclusions are supported by the data	3
Organization and clarity	2
Cohesiveness of conclusions	2
Conciseness	1
Importance to objectives of the Program	1

(For use by internal review panel only

RECOMMENDATION	(check one)
Accept	
Accept after revision	Yes
Unacceptable	

Reviewer Responses to General Questions for the WEST report (Correlates of Whooping Crane Habitat Selection and Trends in Use)

1. Does the WEST report adequately address the overall objective, which is to analyze Program data to provide insight into whooping crane habitat selection and use?

This report provides the context and analyses needed to address the objective stated above, although no mention is made specifically within the report. The objective is achieved by addressing two general foci, Habitat Selection and Trends in Use using a data collected during a rigorous, multi-year survey effort and an in-depth measurement analyses for the spatial analyses in the former, and analyses of available data sets to address trends in use.

Each section of the report is well written and focused; A minor reorganization is suggested, as it is unclear why the report is numerically subdivided and separating sections of the Introduction, methods, results of each analysis instead of maintaining a standard convention of these major headings (as used in the Discussion), and use of subheading for each analysis. I will also discuss the use of appendices for what appear to be additional analysis sections within Question 6. Additionally, I have included a fairly comprehensive literature review intended to be used to more completely introduce the target species, conservation challenges of its recovery pertinent to the central Platte River ecosystem, and key studies that have variously addressed historical location databases, habitat evaluations and development of metric criteria to guide management and restoration. Overall, I believe that the results provide a major contribution to aid in management focus and decisions that will support Whooping Crane migration habitat along the central Platte River, and that consideration of these revisions will strengthen the contribution.

Suggest revisions:

1) Reorganize report to following format:

Introduction
- Habitat Selection
- Trends in Use

Methods
- In-channel Habitat Selection
  - Whooping Crane Group Observational Data
  - Whooping Crane In-channel Habitat Selection
  - Statistical Modeling of Aerial Survey Detection
- Diurnal Habitat Selection
  - Whooping Crane Group Observational Data
  - Whooping Crane In-channel Habitat Selection
- Trend (Correct to Trends and Use)
  - Whooping Crane Group Observational Data
  - Aransas-Wood Buffalo Whooping Crane Population Estimates
  - Statistical Methods

Results
- In-channel Habitat Selection
  - Whooping Crane Group Observations
  - Whooping Crane In-channel Habitat Selection for Spring and Fall Combined
  - Spring In-channel Habitat Selection
  - Fall In-channel Habitat Selection

Aerial Survey Detection
Diurnal Habitat Selection
Whooping Crane Group Observation
Diurnal Habitat Selection for Spring and Fall Combined
Trend (change to Trends in Use)
Whooping Crane Group Observations
Trends in Proportion of Population Using the central Platte River
Trends in Crane Use Days per Bird in the Population
Discussion
In-channel Habitat Selection
Diurnal Habitat Selection
Trend (change to Trends in Use)
Summary of Findings (see below)
References

Suggested revisions:

2) Clearly state the objective of the study in the Executive Summary (p. 7, para. 1, line 1) and in the Introduction (p. 8, para. 1, line 10)

3) Add a "Summary of Findings" section to the report to provide concise review of the main results of the study that can be used to convey this information to managers and decision makers

2. Do the authors of WEST report draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

This report lays out a logical and sequential evaluation of defining metrics which influence habitat selection by migrating whooping cranes in the central Platte River ecosystem. I believe the research questions and evaluations were strong and well executed in the main body of the text and in associated appendices. I found the statistical approach and conveyance of results well defined and organized. The following minor recommendations are intended to provide additional information to create a stand-alone report and strengthen the conclusions provided by the results.

The report does not introduce information about the target species, or previous studies that have not adequately addressed this study's objective in the specificity needed to make management decisions.

1) Provide a brief overview of the Whooping Crane including the following:
    a. Description and life history
    b. Reasons for population decline and Endangered status
    c. Importance of migratory corridor for the Aransas-Wood Buffalo population, with emphasis on central Platte River, including critical habitat designation

Suggested citations:

1.a. and 1.b.

Allen, RP. 1952. The Whooping Crane. Res. Rpt. No. 3. National Audubon Society, New York. 246 p.

Canadian Wildlife Service and United States Fish and Wildlife Service. 2007. International Recovery Plan for the Whooping Crane. Recovery of Endangered Wildlife (RENEW), Ottawa, Canada and U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA. 162 p.

Lewis, J.C., E. Kuyt, K.E. Schwindt, and T.V. Stehn. 1992. Mortality in fledge cranes of the Aransas-Wood Buffalo population. 1988 North American Crane Workshop:145-148.

1.c.

Canadian Wildlife Service and United States Fish and Wildlife Service. 2007. International Recovery Plan for the Whooping Crane. Recovery of Endangered Wildlife (RENEW), Ottawa, Canada and U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA. 162 p.

Pearse, AT, Brandt, DA, Harrell, WC, Metzger, KL, Baasch, DM, Hefley, TJ. 2015. Whooping crane stopover site use intensity within the Great Plains. U.S. Geol. Surv. Open-File Report 2015-1166. http://dx.doi.org/10.3133/ofr20151166.

Tacha, M., A. Bishop, and J. Brei. 2010. Development of the whooping crane tracking project geographic information system. Proceeding of the North American Crane Workshop 11:98-104.

2) Provide a brief literature review of previous studies that identified need for management criteria and habitat evaluations
   a. History of change in this region
   b. Establishment of PRRIP
   c. Overview of contribution of previous studies
   d. Management needs within PRRIP that are to be addressed by this study

Currier, P.J., G.R. Lingle, and J.G. VanDerwalker. 1985. Migratory bird habitat on the Platte and North Platte Rvers in Nebraska. The Platte River Whooping Crane Critical Habitat Maintenance Trust, Grand Island, Nebraska.

PRRIP citations in report and website

(for 2.c. see suggestions under Question 3)

3. Are there any <u>seminal</u> peer-reviewed scientific papers that the WEST report omits from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

The challenge that any scientific paper has faced when linking whooping crane use of migration habitat at the central Platte River, or any other location within the Aransas-Wood Buffalo population range, is the paucity of data. However, management and policy decisions have been implemented to proactively protect, restore, and maintain sufficient quantity and quality of habitat within the migratory corridor to promote its recovery of this species. Therefore, the research that has been published to date can serve as an important contribution to this report, and serves the most appropriate comparison to the results provided in this report. In addition, the methods employed in this research design are intended to produce results that are more statistically defensible than previous studies.

Currently, the discussion section within this report does not provide any comparisons with previous work and would be strengthened by this inclusion. I am providing notes for each paper to provide what I believe to be pertinent points and arranged the papers in chronological order to assist in the overview suggested in Question 2, Suggested Revision 2.c.

Johnsgard, P.A. and R. Redfield. 1977. Sixty-five years of whooping crane records in Nebraska. Nebraska Bird Review 45:54-56.

Opportunistic observations from 1912-1977, thus imperfect detection recognized

- Variations in use of Platte over years
  - More sighting in early 1930s
    - Period of low population numbers
    - During prolonged drought period
  - Should examine variations in levels of Platte R
- Between spring and fall migration
  - More sighting in spring than fall
  - Peaking April 1-20
- Regional distribution in Nebraska
  - Over half of total 162 sightings in Buffalo and Kearney Cos.
  - Over 90% within 30 miles of Platte River
  - 80% between Lexington and Grand Island
- Reommendations
  - Major stopover for whooping cranes
  - Maintenance of adequate flow necessary to provide suitable habitat
  - Presence of federal wildlife refuge important for habitat protection

Johnson and Temple (1980) in Faanes et al. 1992

Johnson, K.A. and S.A. Temple. 1980. The migratory ecology of the whooping crane. Unpublished Report, Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C. 120 pp.

Attributes of crane roost sites with multiple criteria: channel width, flow, water depth, vegetation in channel, substrate, horizontal visibility, overhead visibility (tall trees or high banks), feeding sites, isolation from human development, sandbars

Currier, P.J., G.R. Lingle, and J.G. VanDerwalker. 1985. Migratory bird habitat on the Platte and North Platte Rvers in Nebraska. The Platte River Whooping Crane Critical Habitat Maintenance Trust, Grand Island, Nebraska.

Historical changes on Platte River

- Hydrological and morphological
- Woodland vegetation development
- Agricultural conversion from prairie

Management recommendations for Whooping Crane migratory habitat

- Listed p.145
- Metrics for:
  - management of trees/shrubs near roost sites
  - maintenance of river flows to provide wide, water-filled channel
  - restoration of meadows and marsh near river for feeding, courtship, loafing, away from disturbance

Howe, M.A. 1989. Migration of radio-marked whooping cranes from the Aransas-Wood Buffalo population: patterns of habitat use, behavior, and survival. US Department of Interior, Fish and Wildlife Service, Fish and Wildlife Technical Report 21. 33pp.

- 86 stopover site using 15 radio-marked or companion birds
- Metrics for water depth, maximum visibility, feeding sites

Armbruster, M.J. 1990. Characterization of habitat used by whooping cranes during migration. U.S. Fish and Wildlife Service, Biological Report 90(4). 16 pp.

- Set of assumptions from a workshop
- To serve as testable hypotheses, including:
  - Horizontal visibility, water depth, little human disturbance, feeding areas nearby

Faanes, C.A., D.H. Johnson, and G.R. Lingle. 1992. Characteristics of whooping crane roost sites in the Platte River. Proceedings of North American Crane Workshop 6:90-94.

Big Bend of the Platte River

Good historical review of roost site studies including:

- Other studies up to this point lacked comprehensive habitat characteristics defined
- River profiles at 23 confirmed nocturnal roost sites 1983-1990
- Measured at 19 transects: total channel width, water depth and distance to shore at each interval, deeper water adjacent to point
- 1,400 sites of which 19 were actual roost sites (similar to choice sets)

- Frequency distribution graphs of roost sites verse unused sites for water depth, relative distances to nearer shore, distances to shore
-

Austin, J.E. and A.L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant whooping cranes in the United State, 1943-99. U.S. Geological Survey, Northern Praire Research Center, Jamestown, North Dakota, and State Museum, University of Nebraska, Lincoln, USA.

Summarized information in Tracking Project database from 1975-1999 linking to habitat evaluations
- Overall distributions relatively similar in fall and springs, except higher in fall for ANWR, CBSWA, SPWNR and TX
- Timing of spring and fall similar to earlier descriptions over 57-year period
- 3 types of stopover habitats: roost sites, feeding sites, and dual-use sites
- Site characteristics: wetland type or class, wetland size, river width, water depth, water quality, wetland substrate, wetland shoreline slope, dominant emergent vegetation, distribution of emergent vegetation, primary adjacent habitat, similar habitat with 10 mi, site descriptions, distance to feeding sites, primary potential food sources, observed foods consumed, distance to human development or utility lines, visibility, other birds present, site ownership, site security
- Habitat use flyway-wide palustrine >75% records, except Nebraska palustrine 56.0%, riverine 39.6%)
- In Nebraska, most roosts used by single cranes or nonfamily groups, particularly on Platte; not so for feeding or dual-use sites
- Several characteristics of riverine systems given including roosting cranes on unvegetated sites; feeding sites as upland crops; dual-use site more wetlands
- Habitats adjacent to roost sites mostly cropland and upland perennial cover
- Woodland habitat adjacent to riverine roost sites
- No patterns in distance between roost and closest feeding sites
- >2/3 sites were <0.5 mi from human developments
- Nearly ½ roost sites and 2/3 feeding sites unobstructed visibility of <0.25 mi.
- Private ownership >60% all sites used and >80% feeding sites, high use of crop fields

Observational database has limitations (listed and discussed) involving individuals reporting, confirmation, habitat data collection, landscape variability differentially limiting detection
Recommendations given including:
- Systematic surveys
- documentation of use-days and habitat use, habitat condition, management

Tacha, M., A. Bishop, and J. Brei. 2010. Development of the whooping crane tracking project geographic information system. Proceeding of the North American Crane Workshop 11:98-104.

30 years of whooping crane sightings (1,981 confirmed through spring 2008)
Distribution at two levels: flyway-wide and state-specific analyses
- Flyway-wide
  - Results indicate 75% of sighting in 59.6 mi wide corridor, 85% 99.4 mi, 95% 169.0 mi
- State-specific results substantial differences between state
  - Highest occurrence in North Dakota, Nebraska and Kansas

  - Width of corridor varies among states, Nebraska is slightly wider than the flyway corridor results
  - May be related to differential habitat availability
  - Or location may be chosen as a result of poor weather conditions
  - May be affected by observer bias, such as around refuges or main roads and populated areas
  - Absence of documented use does not indicate lack of use
  - Precision of data point in GIS may limit use of the point with habitat data or measurement from other defined variables

Recommendation

- To address observer bias, more independent method to detect whooping crane locations on the landscape

Belaire, J.A., B.J. Kreakie, T. Keitt, and E. Minor. 2013. Stopover habitat to guide site selection for wind energy projects. Conservation Biology 28:541-550.

Whooping Crane Tracking Program database for Nebraska only

- only first observation used
- used all points in 2 most-precise categories – GPS and public land survey system cadastral quarter sections (grid cell size 0.6km^2, 0.37mi^2)
- binary maps of detection and nondetection cells
- used 1990-2006
- evaluated change of landcover 1992-2001, and 2001-2006 (Frye et al. 2009)
  - Predictor variables: Land cover - agricultural land, roads, urban area, wetlands and water
  - Broad-scale landscape variable – bearing
  - Fine-scale landscape variable - ecotone (Euclidean distance from nearest agricultural and nearest wetland area)
- Results
  - Bearing highest, percent cover of roads second
  - Partial dependency plots – areas of high agricultural cover, low coverage of roads and urban areas, and intermediate wetland cover higher predicted relative suitability
  - Ecotone categories – areas closest to wetlands (<100m) combined with <1 km from agricultural land may have greatest predicted suitability

Suggested Revisions: A following corrections are needed to eliminate inconsistencies between citations in the text (missing references in text and Reference section) and formatting within the Reference sections:

Page	Comment	Action Needed
	Inconsistent use of issue number in journal citations	Standardize use of issue number and correct as necessary
39	Aarts… 2013 - unnecessary comma after Brasseur	Remove comma
	Aarts ... 2013 - no period at end of reference	Insert period
	Arthur - no and before last author	Insert and
	Boryan - wrong format for author names	place junior authors' initials before last name
	Boryan – unnecessary comma after authors	remove comma
	Brei and Bishop – not in text	Use or remove
	Brei et al 2002 – not in text	Use or remove
	Burnham and Anderson – unnecessary space between author initials	Remove spaces
	Burnham and Anderson - Extra space after date	Remove space
	Butler et al. – unnecessary space between author initials	Remove space
39	Gesch – not in text	Use or remove
	Gesch – Unnecessary commas around date	Remove commas around date
	Gesch et al. - Period missing after date	insert period after date
	Gesch et al. – not in text	Use or remove
	Gesch et al. - Unnecessary commas around date	remove commas around date
	Gesch et al. - Period missing after date	insert period after date
40	Hefley et al. – unnecessary semicolon after volume number	remove semicolon
	Jin et al. – not in text	Use or remove
	Jin et al. - wrong format for author names	place junior authors' initials before last name
	Jin et al. – unnecessary comma after Journal name	remove comma after journal name
	Jin et al. – unnecessary spaces around hyphen	remove spaces around hyphen
	Johnson et al. 2006 - unnecessary space between author initials	Remove spaces
	Johnson et al. 2006 – missing period at end of reference	Insert period
	Johnson et al. 2013 - wrong format for author names	place junior authors' initials before last name
	Kutner et al. - wrong format for author names	place junior authors' initials before last name
	Manly 1997 – not in text	Use or remove
	Manly 2001 – not in text	Use or remove
	McCullaugh and Nelder – unclear why FRS is	Complete or remove

Page	Comment	Action Needed
	included	
41	Melvin and Temple 1982 – not in text	Use or remove
	PRRIP 2010 – unnecessary spaces around date	Remove spaces
	PRRIP 2015b – unnecessary “b”	Remove b
	Rawlings et al. 1998 – not in text	Use or remove
	Rawlings et al. 1998 – unnecessary space between author initials	Remove spaces
	Warton and Aarts 2013 – missing in References	Insert reference

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

The monitoring design and implementation that has been underway for over 15 years is impressive. It, in no small way, reflects the substantial commitment that the PRRIP has invested in developing statistically defensible metrics to guide the management decisions. This draft report focused primarily on quantifying the functional response of whooping cranes to habitat variables. The in-depth analyses and modeling approach presented here provides valuable information over a range of both temporal and spatial complexity. Results presented within this report that can guide and facilitate management decisions on the central Platte River and achieve goals defined in the PRRIP management plan. It is always a challenge to ask system-wide questions and reply within detailed, quantifiable approach.

Most of the revisions suggested within this review were developed to help answer this key question above. It is my hope that by incorporating information detailed in this review these relationships can be more clearly discussed in the report. These key points could center on:

1) a more informative Introduction that provides the historical context of this endangered species and its linkage and dependence on this altered riverine ecosystem;
2) reviewing previous research that sets the stage for understanding the monitoring and assessment challenges; and, comparing those results with results of this report to assess the current approach and results in this report
3) discussing continuing challenges and dilemma of designing monitoring programs that provide data appropriate for use in the questions being asked and make recommendations for improving the monitoring program;
4) processing these results into tangible management strategies that achieve the Program objectives.

Suggested revision: At that point, the authors should consider addressing the question above to describe the outcomes of the report in a Summary of Key Findings section.

5. Are the statistical methods used in the WEST report valid and current, and are the associated results presented in manner useful to decision makers for the Program?

Yes, using the Resource Selection Function is a preferred method to identify which resources (often landscape features serve as a proxy for those resources) drive species distributions in selective habitats. RSF can be interpreted as being proportional to expected density of observations (Aarts et al. 2012), and thus provides useful metrics to use in evaluating the study area. The approach used in these analyses is used widely in contemporary, published literature investigating similar research and adaptive management questions. In most cases, detailed information was provided for methods in the report and appendices.

The report addresses three components of whooping crane habitat selection and use of the central Platte River in Nebraska. The in-channel habitat selection evaluates criteria necessary for roost habitats, diurnal habitat selection evaluates foraging habitat, and the spatial relationships tested between the two areas to satisfy migratory needs in both fall and spring seasons. The format and presentation of results is clear and easily compared in text and associated figures and tables, and also used in appendices. To improve the importance of information in Appendices C and D, please provide the following information in the Methods:

Suggested revisions:

1) Whooping Crane Group Observation Data (p. 10, para. 1, line 1)
    a. summarize the explanation given in Appendix C (paragraphs 3-6) at the beginning of this paragraph,
    b. provide justification of why these analyses are beneficial in the report, then
    c. introduce this sentence with "Therefore, we conducted…"

2) Whooping Crane Group Observation Data (p. 10, para. 1, line 2)
    a. summarize the explanation given in Appendix D (paragraphs 3-6) at the beginning of this paragraph,
    b. provide justification of why these analyses are beneficial in the report, then
    c. introduce this sentence with "Therefore, we perform…"

6. **Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the WEST report and then discussed in the results and conclusions sections?**

The authors address the potential biases regarding the use of data collected within the PRRIP monitoring program that included systematic aerial PRRIP surveys, ground monitoring following surveys, as well as opportunistic sighting from public and professional biologists. The in-channel section within the draft report being reviewed here only presents the systematic unique data results. It appears that a previous draft of the report may have included the analyses from all systematic unique, systematic unique and non-unique, and all systematic and opportunistic analyses, since Appendices C and D provide detailed methods and results.

Since the authors do believe the information is valuable to the overall study, I think that the information within these appendices brings value to the report, with more justification and inclusion of key findings in the main body. It is important to address the pros and cons (potential bias versus information gained) of including all three analyses, particularly what each provides provides in terms of informing future management and policy decisions pertinent to this Program. Therefore, the following revisions would necessary to provide history, justification, and contribution of the appendices.

Suggested revisions (see also 5. Suggested Revisions relating to results and discussion):

1) Within the Introduction, present an overview of historical observational databases and the advantage of aerial versus ground surveys, and using unique and non-unique data points.
2) Within the Introduction, justify the inclusion of 2nd and 3rd approaches as either appendices or including in the main report in the Introduction
3) Provide more details about the value of including 2nd and 3rd approaches in the Methods to accompany Table 1
4) In Results, add summary results of 2nd and 3rd approaches and reference tables and figures that are located in appendices; for example, identify the variables within the top models
5) Compare the results among three approaches more fully in the Discussion, for example, the differences of model results and the importance of these finding to achieve the objectives of the study
6) Since conclusions are limited in all sections of this report, I suggest providing recommendations of use of these approaches in Summary of Findings

APPENDIX B
INDIVIDUAL REVIEWER COMMENTS – HABITAT SYNTHESIS CHAPTERS

Cade	B-1 to B-6
Shields	B-7 to B-27
Smith	B-28 to B-38

Review of report for PRRIP: Whooping Crane Habitat Synthesis Chapters (draft dated 29 September 2016).

Reviewed by Brian S. Cade, Fort Collins Science Center, USGS, October 2016.

(7) *Does the combined set of whooping crane habitat synthesis chapters adequately address the overall objective, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for whooping cranes?*

Yes, overall I think this is done fairly well. Chapter 1 provides a nice overview of the issues. The challenge of interpreting the dynamics of wide, unvegetated (unobstructed) channels in the Platte River with respect to the roosting requirements of whooping cranes that exhibit considerable flexibility in their habitat selection are reasonably met but can be improved (see below).

(8) *Do the authors of the whooping crane habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.*

The relationships and interpretations are reasonable as far as they go. But I think a more defensible statement about what the RSF analyses in Chapters 2 and 3 indicate with regards to important roost site conditions to maintain for whooping cranes can be made by focusing interpretations more on intervals of values (e.g., unobstructed channel widths) that are consistent with intervals of highest relative selection ratios (90% CI). I do believe, as mentioned below under (11) and in my review of the Correlates of Whooping Crane Habitat Selection document, that the variation in relative selection ratios as estimated by the 90% confidence intervals suggest that a much greater range of the predictor variable values (e.g., unobstructed channel width) are consistent with the highest selection ratios. This requires less focus on the point estimates of the partial regression plots and more emphasis on the confidence intervals around those estimates. For example, the 90% confidence intervals in Figures 5 and 6 above line 285 suggest that the highest relative selection ratios are largely indistinguishable for all unobstructed channel widths >200 ft (Fig. 5) or nearest forest >200 ft (Fig. 6) based on the overlap of their 90% confidence intervals for the relative selection ratios with the 90% confidence intervals for the relative selection ratios associated with the maximum point estimate. Such an interpretation is completely consistent with the raw observations of the crane roost use, where few cranes actually use the greatest unobstructed channel widths or greatest distances to nearest forest that are available, mostly concentrate use at intermediate values, and never completely avoid using narrower unobstructed channel widths or shorter distances to nearest forest (Figs. 5 and 6). This implies that the relative selection ratios as equating to something that whooping cranes require is very tenuous except perhaps in a statement reflecting a large interval of values. This perhaps may be a distressing interpretation for crane biologists but certainly suggests that there may be much wider targets of desired characteristic for roost sites for management actions to focus on. Furthermore, it suggests that the small increases in unvegetated or unobstructed channel widths that are predicted to occur from increases in 40-day mean peak discharges (Chapter 4, Table 11) have little likelihood of improving crane roosting habitat given the wide intervals of values that they use. The predictions simulated in Chapter 4, Table 11 provide small increases (0-12 ft) in unobstructed channel widths for channels that are already wide enough to have relative selection ratios consistent with the highest relative selection ratios estimated by the model (based on overlap of 90% CI). To actually provide more suitable roosting habitat for whooping cranes consistent with the RSF model (Figure 5, Chapter 2) will require that channel widths are increased on channels with much smaller widths, e.g., increase a 150 ft wide unobstructed channel width to a 350 ft wide unobstructed channel width. The RSF model suggests that given the wide variation (90% CI) of selection ratios for optimal selection, that changing unobstructed channel widths for channels with unobstructed widths >200 ft will have minimal impact on relative selection ratios.

(9) *Are there any seminal peer-reviewed scientific papers that the whooping crane habitat synthesis chapters omit form consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.*

Again, I have not tried to keep up on all the literature, but there are no obvious deficiencies that I am aware of. However, a quick google scholar search turned up the following that I did not see cited and that could potentially have relevant information:

Richert, A. L. D. 1999. Multiple scale analysis of whooping crane habitat in Nebraska. Ph.D dissertation, Univ. Nebraska.

Currier, P. J. 1997. Woody vegetation expansion and continuing declines in open channel habitat on the Platte River in Nebraska. In Urbanek and Stahlecker eds. Proceedings of the Seventh North American Crane Workshop, 1996 Jan 10-13, Biloxi, Mississippi. Grand Island, NE: North American Crane Working Group. Pp 141-152.

(10) *Is the relationship between management actions, riverine processes, species habitat, and species response clearly described and do Program monitoring, research, and reference materials help to verify and/or validate this relationship?*

See above under (8).

(11) *Are the statistical methods used in the combined set of whooping crane habitat synthesis chapters valid and current, and are the associated results presented in a manner useful to decision makers for the Program?*

The statistical analyses and interpretations are reasonable as far as they go but could be interpreted more effectively. Below I discuss some issues that I think could be handled better.

Important issues to address for making report acceptable

<u>Chapter 2.</u>

Seems like similar RSF analysis as Crane correlates document except CI for response function were estimated by bootstrapping. Same mistake here in calling these estimated relative selection ratios “probabilities”. The exponential RSF used estimates quantities on interval of [0, +∞] and, thus, they are not probabilities. Better word choice would be relative selection ratios.

Now n = 55, was n = 53 in Correlates of Whooping Crane Habitat Selection document. Why the inconsistency in sample size between the two documents?

So for UOCW and NF model 3.47 + 3.69 + 1 = 8.16 edf with a sample of n = 55 used locations. Probably over parameterized. Something closer to edf = 5 would likely have more precise estimates. Automated procedures for picking number of parameters to estimate, which effectively is what Simon Wood’s gam() implementation is doing by picking number of terms in the spline function, are almost always going to suggest a greater number of terms (edf) than can really be reasonably estimated with small sample sizes. Remember for these logit model it is not the total sample size that is limiting but the sample size for smallest group - crane roost locations. I’m guessing that the discrete choice model really requires greater sample sizes than a conventional logistic regression model to provide reasonably precise estimates.

Line 271: Wording “indicating a parsimonious selection of covariates” seems unnecessarily obtuse. All the comparisons of the delta AIC between the top model and the null, intercept only model indicates is exactly the same thing as the hypothesis test that all the regression coefficients are zero – at least one coefficient is not zero. This same statement is used repeatedly in the Correlates of Whooping Crane Habitat Selection document too.

Figures 5 and 6. Interesting that relative selection ratios drop as both unobstructed channel width and distance to nearest forest get too large. Any interpretations to offer? One could argue that the sampling variation is so great for these decreasing estimates of selection ratios at the larger distances (spread of 90% CI) that there is no strong evidence that there really is a decline from their peak at intermediate distances. Again, I would argue as above that this really needs to be interpreted in terms of an interval of predictor values that is consistent with an interval of values for the highest relative selection ratios. I could also argue that your GAM model suggests that a simpler piecewise linear spline that allowed an increasing slope at shorter distances, with one knot where selection ratios are maximum at intermediate distances, followed by another slope that would probably be only slightly declining at higher distances. This would require fewer edf and probably provide a more parsimonious interpretation of the data pattern. What is the correlation structure between unobstructed channel width and distance to nearest forest? I’m guessing that there is some strong linearity for some range of values (the smaller distances) and that for larger values the correlation pattern then gets stranger. Here I note that the restricted plotting of partial estimates is not made to $<75^{th}$ percentile of used locations so a more complete picture of the estimated relationship is provided than in the Correlates of Whooping Crane Habitat Selection document.

Line 296: What does it mean that results with the n = 75 observations were “but slightly higher than results ….”?

Lines 297-298: The statement that higher relative selection ratios when UOCW was ≥522 feet and NF was ≥549 feet is not consistent with the model estimated with n = 55 because you actually had declining resource selection ratios at higher distances. Is this really what you meant to say?

Lines 348-349: The math related to your logic to get to 279 feet from the bank line of a 488 foot wide channel is not immediately recognizable. This should be stated explicitly so that it is obvious that you are subtracting half of 488 from 523 feet.

Chapter 3

Again, I would eliminate the terms "relative probability of use". They are not probabilities scaled on [0, 1]. They are relative selection ratios that you've chosen to scale to [0, 1]. See my additional explanations in my review of the Correlates of Whooping Crane Habitat Selection document.

I note that n = 158 roost locations is a much more suitable sample size for estimating these spline functions than the n = 55 in Chapter 2.

Figures 5 and 6: For these partial effects the restriction to just lower 3 quartiles (<75th percentile) of used locations unnecessarily restricts the region of the response. Why not show closer to the full range as was done in Chapter 2? But yes, one of the consequences of fitting very flexible spline functions is that you can get more wonky results at more extreme points of the predictor domain.

The decreasing selection ratios with increasing distance to nearest forest from 200 to 425 feet and then increasing selection ratios with increases above 425 feet needs some serious interpretation. And again, as discussed in my review of the Correlates of Whooping Crane Habitat Selection document, all the interpretations of partial effects need to really be done with respect to the confidence intervals of the relative selection ratios rather than focusing on just the point estimates. Doing this would indicate that the data and statistical models suggest a much wider range of channel widths as having indistinguishable relative selection ratios.

Lines 183-205: But an interesting aspect of this discussion that is not made is that the data actually shows cranes make less use of the widest unobstructed channel widths and distances to nearest forest that were available, and primarily focus roosts more on intermediate distances (Figures 5 and 6). Reconciling this would seem to be important in arguing about how critical wide open channel areas are to cranes. Is it possible that those widest, open channels actually end up having water depths that are too shallow to provide the security from predators that conceptually they might be seeking? Or something else?

Chapter 4

Figure 1: I can't see any green line that is referenced in the caption.

Line 226-228: The terminology "multiple" rather than "multivariate" regression is more appropriate as the former typically implies multiple predictor variables whereas the latter implies multiple response variables. Robust regressions is defined later.

Line 338: Should this be 48 feet (0.48 × 100)?

Figures 9, 10, 11, 12, 13, 14: Are these really 95% confidence intervals on the predicted means? I would expect the confidence intervals to have the typical bow tie shape with decreased interval lengths near the mean of the predictor variable and wider interval lengths at more extreme predictor values. These are parallel lines. I'm wondering if these really are 95% prediction intervals for a single new observation. This should be checked.

Line 398: Should that be 20 feet (0.02 × 1000)?

Line 401: Should that be 19 feet (0.19 × 100)?

Line 436: Some statement about what the Monte Carlo random sampling was across should be made here. There are many ways to conduct Monte Carlo simulations.

EDO memo:

Line 124: WEST and the EDO are correct to be cautious about using model averaging. The comment suggests that the Trust was suggesting model averaging regression coefficients into a "best" model. There has never been good theoretical or empirical evidence that model averaging individual regression coefficients ever achieves anything useful in terms of addressing model uncertainty in a multimodel inferential context. Indeed, Cade (2015. Model averaging and muddled multimodel inferences. Ecology 96: 2370-2382) and Banner and Higgs (2016. Considerations for assessing model averaging of regression coefficients. Ecological Applications, In press) have presented a fairly thorough indictment of simple model averaging of regression coefficients. Furthermore, model averaging individual regression coefficients for the spline terms in the GAM used here would seem to be even more nonsensical. It still might be useful to model average the predicted responses across the multiple models to address model uncertainty in the predictions, but this in no way results in a calculation that is equated to a "best" model.

Other less critical issues that could be addressed

Chapter 4

Lines 229-230: It seems like quantile regression could perhaps be better employed here to evaluate unobstructed channel widths while treating this measure as a continuous variable, avoiding creating the arbitrary binomial breaks at 400, 500, 600, 700, or 800 feet.

Lines 236-243: Quantile regression where you estimate an interval of quantiles could have perhaps more easily been used here. Quantile regression estimates for those quantiles less than the extreme values will be little influenced by the extreme values. Furthermore, the quantile regression estimates could easily be used to provide a prediction interval (e.g., 80% prediction interval based on 0.10 and 0.90 quantile estimates) without making any distributional assumptions. Cade and Noon (2003) provides a concise introduction and Koenker (2005) is the definitive text on quantile regression.

Lines 360-378 and 424-435: These comparisons make the common mistake of thinking that the mean regression estimated should be close to all observations in a system where there is considerable variability. It would be more informative to look at the prediction interval lengths (for a single new observation), say for 95% prediction intervals, and then see what proportion of observations are outside that interval (is it more than 5%). The point estimate of the predictions from the estimated mean regression model should not really be the focus for determining the suitability of the model estimates. The intervals associated with the predictions are more relevant.

Lines 449-469: Again, I think if quantile regression had been used for the modeling of UOCW and TUCW, that the proportion of the probability distribution being modeled by the covariates exceeding some selected values (400, 500, 600, 700, and 800 feet) would have been easily determined without these logistic regressions.

Appendix IV – Oracle Crystal Ball Monte Carlo Simulations: There is too little detail provided to determine whether this simulation analysis is accomplishing anything of merit. For example, why assign the particular probability distribution functions to the various predictor variables, e.g., gamma for peak discharge, beta for median grain size, etc.?

(12) *Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the whooping crane habitat synthesis chapters and then discussed in the results and conclusion sections?*

It seems like an adequate effort has been made at exploring potential biases that cannot be completely eliminated.

RATING (1 = excellent, 2 = very good, 3 = good, 4 = fair, 5 = poor)

Scientific soundness	2
Degree to which conclusions are supported by the data	2
Organization and clarity	1
Cohesiveness of conclusions	2
Conciseness	1
Importance to objectives of the Program	2

RECOMMENDATION

Accept	
Accept after revision	X
Unacceptable	

PRRIP review—WEST Report and Habitat selection synthesis chapters

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October 2016

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Table of Contents

General observations 3

WEST Report 4

General Questions 4

RATING 8

Category Rating 8

Recommendation 8

Editorial Comments 9

Habitat Synthesis Chapters 10

General Questions 10

RATING 22

Category Rating 22

Recommendation 22

Editorial Comments 23

Works cited 27

General observations

Please allow a few observations that do not clearly fall under any question below. I realize some of my comments here are well outside the general purview of the PRRIP. The documents for review describe long-term, expensive efforts to provide adequate habitat for a small subset (5-10%) of the small surviving population of a single species for, "~two to three days on average," and range from, "one to several days," twice a year. The western migratory population is estimated to be about 300 individuals (Chapter 1, Figure 3), so we are talking about 15-30 animals using a 90-mile-long reach of the Platte for less than 7 days per year, total. Perhaps the numbers are even smaller, as Table 8 of the WEST report shows an average of 11 and 8 animals, or 4% and 3% of the population, using the AHR in Spring and Fall, respectively for the period 2001-2014.

These ~7 days of annual use (2 to 3 days in Spring and 2 to 3 days in Fall) are spread over several weeks in the Spring and in the Fall. Such an intense focus on lightly-used habitat for a single species seems illogical. In my view the ESA process misplaces emphasis on species rather than habitat. A focus on restoring the properties and characteristics of the ecosystem, more specifically habitat and associated processes that create and sustain habitats, would potentially benefit a wider range of species and lead to better long-term outcomes than attempting to precisely target the preferences of a single species.

I am aware that the PRRIP is also addressing issues associated with least tern, piping plover and pallid sturgeon. However, the documents covered by this review are completely silent about those species. In particular, I think it would be valuable to discuss management activities that potentially benefit all four targeted species or, more to the point, activities that produce pre-impact habitats and processes.

Second, the small size of the studied population and their transient presence in the AHR creates an extremely difficult problem when trying to produce defensible scientific results. I appreciate the dedication and effort of the teams involved in this work, but clear-cut, objective conclusions are hard to obtain. The resource selection documented by the systematic monitoring, if it is perfectly accurate, shows the habitat preferences of members of a depleted population acting in a degraded and stressed system. In a system more similar to the one that existed in the nineteenth century, selection behavior might have been different.

Habitat Synthesis Chapters

General Questions

1. Does the combined set of whooping crane habitat synthesis chapters adequately address the overall objective, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy may not achieve the Program's management objective for whooping cranes?

   The synthesis chapters do provide evidence that higher flows, disking and herbicide application increase whooping crane stopover habitat, particularly when all three occur together. I do note that the increase in mean UOCW due to SDHF releases alone is essentially negligible, but it is important to note that the WC do not react to mean conditions along the AHR. Instead, they need some minimum level of habitat availability. Figure 15 shows that a 40-day peak discharge of 1,000 cfs is associated with a ~25% probability that a managed transect will have a UOCW ≥ 600 ft. A three-day SDHF of 8,000 cfs requires 45,000 ac-ft above a base flow of 500 cfs (or 26,000 to 68,000 ac-ft, lines 495-496), while a 40-day flow of 1,000 cfs requires 40,000 ac-ft above a baseflow of 500 cfs, so a 40-day flow would be attainable with current water allocation. If 25% of the AHR provided UOCW ≥ 600 ft, would that represent an improvement over current conditions? Over projected future conditions? Would it be biologically significant with respect to WC habitat availability?

2. Do the authors of the whooping crane habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and the specifics of each situation.

   Size and status of WC population. The statement that the AHR is used by 5-10% of the WC migratory population (Chapter 4, line 32) may be at variance with the blue bars of Figure 3 of Chapter 1, which Figure badly needs a legend. The top half of this figure shows whooping crane numbers of ~175 for 2010-2014. If this is 175 individuals per year, then 175 >>30. If it is 175 individuals for the entire period 2010-2014, then 175/5 = 35 ~ 30. Line 235 of Chapter 1 states that WC use of the Platte River declined between 1950 and 1980, but Figure 3 shows an increase during this period.

   Do we know how cranes select stopover locations?
   Please refer to Chapter 2, lines 161-170 and Chapter 3, lines 94-100. I do not find adequate justification for the assumptions made about the process whooping cranes use to select habitat. Line 165 states that it was assumed that the area evaluated was "centered on the use location and extended 10 miles upstream and downstream from that point." It is unclear if the evaluated area is 10 or 20 miles long in total, but line 169 implies that was assumed to be 10 miles. The justification given is that, "cranes could reasonably evaluate this area based on an aerial evaluation of viewsheds from 3,000 ft above ground level." No data are provided regarding the

flight altitudes of approaching migrating crane flocks. An assumption is made that human eyesight and bird eyesight are comparable. How sensitive are your findings to the 10-mile assumption? Would an assumed available reach length 5 miles for the choice set produce a different outcome?

I assume that monitoring flights were conducted in such a way that the overflying aircraft did not modify crane behavior, but it would be good to read an assurance to that effect.

Please refer to Chapter 2, lines 188-202. The description of statistical methods is heavily weighted with jargon. No definition is provided for the left hand side of the equation, $w(X_{ij})$, or X_{ij} for that matter. Is it the probability that the ith unit in the jth choice set is selected for use by a crane flock?

It is not clear how bird movement during a multi-day stopover was handled when assigning a single location for the “stopover site” (e.g., Chapter 3, lines 89-91).

<u>Habitats other than shallow open water are also important part of stopover habitat suitability</u>. Chapter 1, line 64, states, “a wetland is nearly always associated with a stopover site.” Line 242 mentions, “….suitable bottomland (wet meadow) habitat deemed to be essential for foraging.” Lines 305-305 mention the importance of, “wet meadows where cranes feed and rest.” Chapter 3 lines 45-46 states, “At stopover sites, whooping cranes typically roost standing in shallow water associated with palustrine or lacustrine wetlands and river channels….” In apparent contradiction to these statements, Chapter 3, line 178 notes that both, “roost sites and day-use sites tend to consistently lack vegetation.” But line 204 notes reports by Austin and Reichert (2005) that, “70% of roost sites were adjacent to woodland habitat.”

Despite the apparent importance of wetlands in WC stopover resting and foraging, the overall approach and data presented in these chapters are largely agnostic with respect to wetlands. Is the entire effort directed at riverine roost habitat? If that is clearly stated or <u>justified</u> in the documents, I did not see it.

Although observations of whooping cranes used to build the datasets used for the analysis were all daytime observations, when presumably cranes would use the non-roosting habitats such as wetlands, no mention of wetlands or variables or metrics to describe wetland proximity to roost sites are presented. Lines 69-72 note that, “Flights took place in the morning intending to located crane groups before they departed the river to begin foraging at off-channel sites,” but how successful were you in deciding what time in the morning that would be? Further, the same passage continues with the statement that return flights took place later and, “systematically surveyed upland areas and smaller side channels.” So if you found a crane group in a wetland or field how was that observation handled? Is that part of your data set? Why or why not?

Further, lines 87-88 of Chapter 3 state that "Locational data……was filtered to only include stopover (use) locations that occurred in riverine habitat…." Exactly what is meant by riverine habitat? Does this mean you intentionally did not consider wetlands and use of other habitats outside the main river channel? Chapter 3, lines 104-105 notes that, "When locations generated along the river system…did not fall within the channel….they were relocated to the channel." It seems to me that this practice would completely invalidate your findings about the relationship between habitat selection and habitat variables such as NF and UOCW.

Chapter 2, lines 103-104 mention, "characteristics of in-channel habitat." What other habitat types were included in the 7-mile + channel width-wide corridor? Why were they excluded?

Chapter 2, lines 48-50 state that "riverine habitat has by far the highest incidence of stopover use by whooping cranes." Exactly what is meant by riverine habitat? Are floodplains riverine? Backwaters? Islands? Sporadically connected wetlands?

Chapter 2, lines 65-67 states that, "the monitoring protocol encompasses 3.5 miles on either side of the central Platte River…" So what use was made of observations of cranes within this seven-mile-wide (3.5 x 2) band?

Chapter 3 indicates that, "selection probability was maximized….when distance to the nearest forest from the edge of the channel…..was ≥ 190 ft." I am concerned that management measures based on this finding would lead to clearing riparian zones. Did it matter what was growing along the unforested channel margins? Would cropland and wetlands or wet meadows have the same effect on selection probability?

Chapter 4, lines 23-25 mention that area of suitable foraging habitat is a performance indicator, but no mention of data collected to evaluate this indicator is provided.

3. Are there any <u>seminal</u> peer-reviewed scientific papers that the whooping crane habitat synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

I am very surprised there is no mention of Bankhead et al. (2016). I realize this paper was published after these documents were written, but since Bankhead's work was sponsored by the PRRIP, it must have been available to the authors! I strongly recommend that PRRIP reconsider the findings of Chapter 4 in light of recently-published process-based research such as Bankhead et al. (2016), Kui et al. (2014), Diehl et al. (2016), Manners et al. (2015) and Edmaier et al. (2015). The work by Bankhead et al. (2016) indicates that even the largest flows will be inadequate to remove well-established (>~2 yr old) vegetation from bar tops. However, their experimental work was conducted using plants with maximum (midsummer) root growth. Winter or early spring resistance due to roots would be far less. Further, their work focuses on dislodgement of plants from bar tops, and they note that plants might be more likely removed by a combination of hydraulic and geotechnical processes acting on bar and bank margins. In fact, Bankhead et al. (2016) cites another paper in review that deals with this topic, and I imagine the underlying research was also sponsored by PRRIP.

Work by Diehl et al. (2016) and Manners et al. (2015) indicates that vegetation impacts are different in channels with sediment loads in equilibrium with transport capacity and those that are deficient in sediment (degradational). Given statements in lines 124-131 of Chapter 4, it would be interesting to see if trends above and below Kearney are different. Chapter 10, Table 4 indicates mean observed UOCW upstream of Kearney was 388 ft (ignoring segment length) and below Kearney was 486 ft. This might have implications for sediment augmentation.

Corenblitt et al. (2015) is a very general review paper that you might consider.

There have been several model studies regarding interactions among flow, sediment load, vegetation and planform in this reach of the Platte River (e.g., Fotherby 2009). I am surprised that the approach taken here is entirely empirical and does not draw at least partially on use of simulation models. A model is mentioned in line 128 of Chapter 4, but this model does not seem to inform the current study to any significant degree.

Johnson (1994) is cited, but I wonder if his findings were fully utilized. He presents several management recommendations that include <u>flow timing as well as flow magnitude</u>, and his recommendations are linked closely to biological processes.

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and referenced materials help to verify and/or validate this relationship?

   Chapter 1, lines 103-115 and Figure 2 offer minimal definition of the key physical variables: UOCW, NF, UFCW and TCW. Later some documents mention UCW (Crane Trust) and TUCW (Chapter 4). The February and September 2016 pdf copies of chapter 4 have conflicting uses of TCW and TUCW.

   The relationship between NF in Chapter 2 and "nearest forest" in Chapter 3 is very confusing. The text of Chapter 3 (lines 109-115) attributes the difference to the fact that "annual delineations of river-channel banklines for river systems throughout the corridor are not available except for within the …AHR." So, if you do not know where the river channel bank is, why do you define NF as the distance from the [presumably unknown] "edge of the channel to the nearest forest…"? A couple of diagrams/sketches, one showing a plan view and the other a cross section or two, would greatly facilitate understanding here and alongside lines 222-225 of Chapter 3.

   Better maps are needed throughout the synthesis chapters. Figure 1 in chapter 1 should show the limits of the AHR and label features such as the "north channel" and the "south channel." A regional map showing North and South Platte and major reservoirs, diversions and returns is also needed. The same map is presented as Figure 2 in Chapter 4, and there the locations of all management actions (disking, spraying, sediment augmentation) are needed as well as a location for Shelton, NE, which is featured in Table 2. Why is sediment load lower at Shelton than at Kearney or Grand Island?

I am wondering if the role of discharge in regulating habitat availability has been fully addressed. For example, line 142, chapter 2 notes that, “the temporal component [of changing habitat conditions] is associated with changes in channel form through time.” Perhaps I am thinking of different time scales or I am simply quibbling about words, but it seems to me that the regression analysis shows that key habitat characteristics (e.g., UOCW) vary from year to year based on the magnitude and duration of high flows, not just “changes in channel form.”

Figure 1 is confusing. As an aside to the overall treatment of flow-related effects, I note that presentation of Figure 1 in Chapter 4 is confusing. The associated text (lines 68-70) mentions SDHF of 5,000-8,000 cfs for three days in two out of three years. No basis is given for selecting this discharge or duration. Lines 71-72 says that the three proposed actions are “hypothesized to be sufficient to increase the unvegetated width of the main channel,” and refer to Figure 1. Figure 1 shows a hypothetical relationship between the 1.5-year return interval discharge and the elevation of riparian plants along the river margins relative to the stage for a discharge of 1,200 cfs.

- Is 1,200 cfs the current $Q_{1.5}$?
- Figure 1 contains no information about proposed actions 1 and 2 (mechanical actions and sediment augmentation), except the two dashed lines, red and blue are labeled “with mechanical actions” and “no mechanical,” respectively.
- Figure 1 contains no information about the relationship between the “green line” elevation and channel width (and the term “green line” is confusing and had me looking for green lines in the figure).
- Figure 1 contains no information about flow duration.
- Can any data be added to Figure 1 to support the hypothesis? By that, I mean what is the relationship between the elevation of riparian plants and the most recent three years’ peak flows?

Hydrocycling. As another aside, Chapter 1 contains a long quote from the Biological Opinion. Lines 308-337 deal with effects of “hydrocycling.” (This term should be defined). Does hydrocycling have the potential to perturb the findings regarding the relationships between habitat and crane use? If so, the topic should be explored. If not, this section should be deleted since it is a distraction.

Terminology. As another aside, I am uncomfortable with referring to the maximum 40-day duration discharge as the “peak.” In my experience, “peak” is used to refer to the single maximum discharge in a time series. In a series of daily mean discharges, it would be the highest daily mean. In a series of “instantaneous discharges” (values measured by USGS at 15-min intervals), it would be the highest 15-min value. Typically peaks occur at the peak of an event hydrograph. The quantity referred to as the "40-day peak" in these chapters would be called the annual maximum 40-day mean following the example of Richter et al. (1996). Alternatively, this quantity might be referred to as the maximum 40-day discharge volume.

The term "40-day peak" is also confusing when assigned to a particular date, as in Figure 8 of Chapter 4. What date within the 40 days is used to create this plot? How are data from the four gages combined to produce the plot?

Conveyance issues. I am puzzled by the statement in lines 76-78 of Chapter 4 that, "Implementation of SDHF releases has been limited by flow conveyance issues upstream of the AHR but natural high flow events during the period of 2007-2014 have provided natural peak flows in excess of what the Program could produce at full FSM implementation." How were the natural flows conveyed by the channel? Did the natural flows cause unacceptable flooding?

Flow timing is as important as magnitude and duration. Page 79 of Johnson (1994) paper lists four management options:

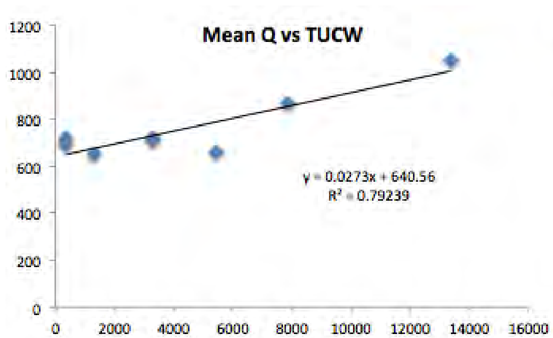
> *….prohibit recruitment in the active channel by augmenting June flows to maintain a several-year average of at least 75-85 m^3/s below the J-2 Return (Table 1, Fig. 5) and 30-40 m^3/s above the Return; and increase seedling mortality by (2) raising winter flows to increase ice scouring, (3) increasing spring peak erosive flows to remove seedlings, or (4) reducing late-summer flows to increase seedling desiccation.*

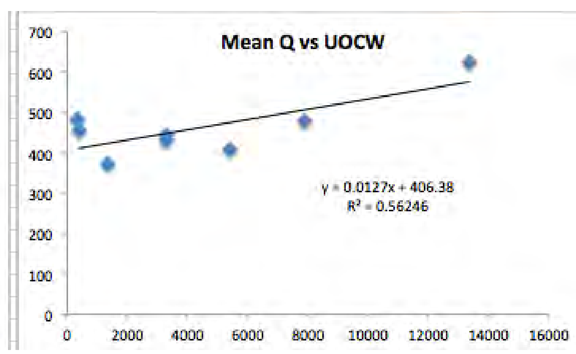
Johnson ties his recommendations to biological processes dependent on river stages and flows (recruitment and seedling mortality), but the PRIP synthesis is largely silent on the process linkage between flow and key parameters of WC habitat: NF, UOCW, TCW, and TUCW. All of Johnson's suggested management options involve flow timing as well as flow magnitude, whereas most of the analysis presented here focuses only on the magnitude and duration (e.g., 40-day peak) without regard to when these flows occur. Timing is important in the interaction between the fluvial and biological (woody plant) systems. For example, Johnson (p.80) states, "The statistical results showed that only small increases in flow would cause large increases in seedling mortality in winter." Fundamental experimental work by Kui et al. (2014), Edmaier et al. (2015) and Bankhead et al. (2016) emphasizes the dependence of plant resistance to dislodgement on root length, and Bankhead et al. (2016) noted the seasonal variation in root length for key species that colonize bars in the AHR:

> *The results presented here provide further quantitative support for the explanation of the findings reported in the outdoor flume experiments of Kui et al. (2014). In their experiments to investigate the location and occurrence of plant dislodgement during high discharge events, they found that only 1% of plants were removed from a sandbar during a flow event. Plants that were dislodged had shorter roots, with the probability of dislodgement only being substantial in plants whose roots were <0.1m in length. Further, their statistical analysis showed that for every centimeter increase in root length, the probability of dislodgement*

decreased by 16%. As root length varies between and within each growing season, there is a temporal aspect to the potential for plants to be removed by flows. Of the three species studied, cottonwood seedlings are expected to show the smallest cyclical changes in above- and below-ground biomass but fine root biomass will die back in autumn and leave seedlings most susceptible to removal in winter and early spring. This fine biomass will be renewed and the rest of the root network will be extended during the next growing season. Reed canarygrass and Phragmites are likely to show larger intra-annual changes in their above and below-ground biomass. Indeed, Liffen et al. (2013) showed that the roots of the emergent macrophyte Sparganium erectum all but disappeared during the winter months, leaving a network of shallower rhizomes that were highly vulnerable to scour in winter and spring. In addition, the presence of annual plants such as Eragrostis, Cyperus, Xanthium and Echionochloa on the Platte (Johnson, 2000) increase the hydraulic roughness of bars and thus reduce bar top velocities and shear stresses. These points emphasize that <u>floods timed to occur towards the beginning of the growing season have the greatest potential to remove bar top vegetation.</u>

Furthermore, with respect to flow timing, the mean June discharge is listed as one of the variables included in the robust regression in Chapter 4, Table 4, but this variable is only mentioned again in the appendix. Table I-4a shows the AIC for this variable yielded an extremely low likelihood. However, simple correlation of the TUCW and UOCW means (2008-2015) in Chapter 4, Table 5 with the mean June discharge at Grand Island yields r^2 values of 0.79 and 0.56, respectively and nice-looking scatter plots. I understand that these scatter plots consider only global means for the entire reach and do not account for the influence of other variables such as disking or spraying.





Please note that Johnson recommends increasing June flows so that the minimum value for "a several-year average," is greater than 75-85 m^3/s, which equates to 2,650-3,000 cfs. I think there is an argument that <u>a series of years</u> with adequate June flows, or a series of 3 years out of 4 with adequate flows should have a different effect on UOCW and TUCW than an isolated high flow year. However, the regression analysis presented in Chapter 4 does not consider the influence of flows in preceding years.

The robust models consist of linear combinations of the independent variables, and there are no interaction terms (such as discharge x disking, for example). Clearly, the synergistic and continued effects of all three components in the FSM approach is important, as Bankhead et al. (2016) report that,

> *Another interesting finding of the 2012 monitoring report was that although disking in Fall 2010 had been successful in breaking up the Phragmites root mat, rhizome fragments still present in the bars were able to regenerate and form dense stands the following growing season. The field notes collected as part of this study also suggested that rhizomes of sprayed areas looked healthy, even where the above-ground biomass was dead and brittle.*

It is noted (Chapter 4, lines 278-279) that "40 day peak discharge….generally occurred between early May and early July," but the figure cited has quartiles that span almost the entire year. And how were dates assigned to 40-day-long events?

Chapter 4 presents an "Analysis of SDHF Performance" in which the effects of adding an SDHF "during April in two out of three years" during dry periods is assessed. No biological or ecological reason is given for staging these releases in April is given, but if the predicted impacts on TCW and UOCW are based on the robust regression results presented earlier in the chapter, the timing of the release is irrelevant since the only way the SDHF enters the equation is through its effect on 40-day peak. (As an aside, I found the explanation of where these predicted TCW and UOCW values came from to be weak.) Please contrast this approach with Johnson's findings about effects of June flows and winter flows.

5. Are the statistical methods used in the combined set of whooping crane habitat synthesis chapters valid and current, and are associated results presented in manner useful to decision makers for the Program?

I have limited experience and expertise in the resource selection function type of analysis presented here.

Was a preliminary analysis of autocorrelation used to determine that only every fifth transect would be used in regressions (line 236, chapter 4)? Clearly, fluvial systems display varying levels of upstream/downstream linkage, so the independence of adjacent observations is a concern in performing regression analysis.

I have a little trouble with the interpretation of the top model for TUCW presented in lines 334-341 of Chapter 4. I understand that the model is a linear combination of the independent variables, but I wonder how independent their effects are. For example, if you disk a transect prior to the 40 day period when the maximum discharge occurs, wouldn't you expect more scour and removal of sediment and perhaps additional erosion of vegetation compared to a transect that was not disked prior to the high flow? Line 335 suggests a relationship between flow and TUCW, "when no disking or herbicide treatment was applied," and I see how the equation can be used to produce that result, but isn't there an interaction between flow, disking and herbicide that produces a synergistic effect on TUCW?

With respect to synergy among the various management measures, the chapters contain many references to "disking" and "mechanical tree removal," (are these two synonymous?) as actions distinct from sediment augmentation, but lines 117-118 of Chapter 4 allude to sediment augmentation conducted as part of, "channel widening activities." Four of the rows in Table 1 of Chapter 4 mention, "island leveling," but it is not clear how this action entered the robust regression analysis, if at all. Has consideration been given to use bar grading as a method to combine removal of vegetation and sediment augmentation?

Why are no data points plotted in Chapter 4, Figure 10?

According to Bankhead et al. (2016), infestations of *Phragmites* are the most difficult to control. They spread throughout the system rapidly and are relatively insensitive to high flows. Lines 99-104 note the importance of herbicide spraying as a control measure for this species. Lines 553 notes that disking is limited to specific areas. Why isn't spraying similarly limited? Why can spraying be applied more broadly than disking?

Lines 34-38 of the summary of key findings mentions only SDHF and disking; spraying herbicide is not mentioned. I understand that the statistical analysis showed that spraying only explained about 3% of the variation in UOCW (line 441), but the top equation does include spraying (and see P = 0.01, line 459). Further, spraying evidently may be applied on a broader spatial scale than disking (although the chapters do not explain why), and it is needed to combat the highly flow-resistant Phragmites.

6. Are potential biases, errors, or uncertainties appropriately considered within the methods sections of the whooping care habitat synthesis chapters and then discussed in the results and conclusion sections?

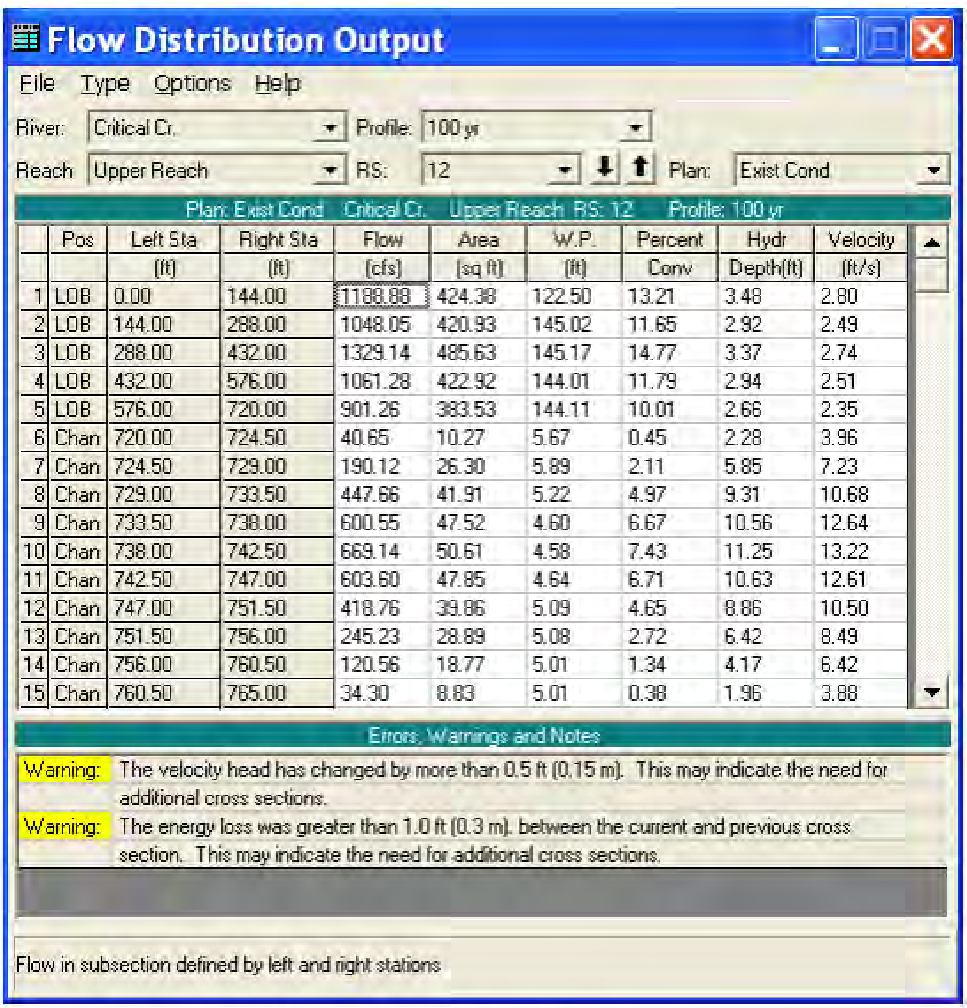
   Discussion for Chapter 2 (lines 276-277) notes that, "wetted width and area of suitable depth are highly dependent on instantaneous flow and change continuously…"

   Given this fact, the development of unit discharge (UD) values for use in the analysis is troubling (Chapter 2, lines 120-122). Line 349, Chapter 1 quotes from the Biological Opinion, "Whooping cranes stand in shallow (usually <0.7-foot) slow-moving water to roost." No range of current velocity is provided, but local unit discharge is the product of local depth and local velocity. The average unit discharge for a cross section is discharge divided by flow width (**not** channel width). (I believe the report uses the expression "wetted width" in a way equivalent to my use of "flow width.") Cranes likely do not respond to cross-section average UD, however. They respond to local UD. So the UD of importance in evaluating habitat is the <u>local</u> UD occurring at the time and place where the birds are roosting. Line 168 of the USFWS comments/EDO response indicates that the area used is typically < 50 ft x 50 ft. Local depth likely varies across a substantial range in time and space in the AHR of the Platte, so computation of cross-section average UD based on 2009 surveys is unlikely to yield much information about the availability of habitat with <0.7-foot depth when selection was made.

Lines 131-170 of the USFWS comments and EDO responses discuss how UD was computed. Line 150 states that UD is based on "total channel width," which remains relatively constant at a location through time. Further TCW includes islands, so dividing discharge by TCW yields a result that is not even accurate for cross-section average UD.

The aforementioned EDO response explains the difficulty of obtaining representative UD values, but it would seem that at least some field measurements are needed to validate the UD values used in the analysis. Are the values used in the analysis actually representative of those occurring when habitat selection was made?

As shown in the Figure extracted from Brunner (2010) below, HEC-RAS allows computation of <u>local</u> depth and velocity. Therefore HEC RAS simulations could be used to obtain more representative UD values than the methodology presented in these documents, given discharges contemporary with crane stopovers and recent cross section or bathymetric surveys.


Flow Distribution Output

File Type Options Help

River: Critical Cr. Profile: 100 yr

Reach: Upper Reach RS: 12 Plan: Exist Cond

Plan: Exist Cond Critical Cr. Upper Reach RS: 12 Profile: 100 yr

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)
1	LOB	0.00	144.00	1188.88	424.38	122.50	13.21	3.48	2.80
2	LOB	144.00	288.00	1048.05	420.93	145.02	11.65	2.92	2.49
3	LOB	288.00	432.00	1329.14	485.63	145.17	14.77	3.37	2.74
4	LOB	432.00	576.00	1061.28	422.92	144.01	11.79	2.94	2.51
5	LOB	576.00	720.00	901.26	383.53	144.11	10.01	2.66	2.35
6	Chan	720.00	724.50	40.65	10.27	5.67	0.45	2.28	3.96
7	Chan	724.50	729.00	190.12	26.30	5.89	2.11	5.85	7.23
8	Chan	729.00	733.50	447.66	41.91	5.22	4.97	9.31	10.68
9	Chan	733.50	738.00	600.55	47.52	4.60	6.67	10.56	12.64
10	Chan	738.00	742.50	669.14	50.61	4.58	7.43	11.25	13.22
11	Chan	742.50	747.00	603.60	47.85	4.64	6.71	10.63	12.61
12	Chan	747.00	751.50	418.76	39.86	5.09	4.65	8.86	10.50
13	Chan	751.50	756.00	245.23	28.89	5.08	2.72	6.42	8.49
14	Chan	756.00	760.50	120.56	18.77	5.01	1.34	4.17	6.42
15	Chan	760.50	765.00	34.30	8.83	5.01	0.38	1.96	3.88

Errors, Warnings and Notes

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

Flow in subsection defined by left and right stations

Figure 4-11 Output for the Flow Distribution Option.

The report is unclear regarding the discharge values that were used to compute UD. Ideally, the discharge that occurred on the date when the cranes made their habitat selection is the discharge that should be used.

Perhaps the way that UD was determined contributes to its lack of influence in the top models for in-channel habitat use (e.g., Table 6, Chapter 2 and lines 291-292). Of course, it is troubling that UD was not used as an a priori model as the other key variables were used for models 1-5, Table 1, Chapter 2. (Note that there are two model 5's in this table).

Further, it is interesting that HEC-RAS was used for TCW determination (Chapter 2, lines 120-122). I could not find a definition for TCW in any of the Chapters. There is a definition for "Wetted Width at Bankfull Discharge" in Table 4, Chapter 2, and it is,

> *"Wetted width of the channel at bankfull discharge. Metric included to represent 'vegetation ratchet' control on width adjustment potential. Widths were delineated from June 2011 aerial imagery, which was flown at near bankfull discharge. Areas of shallow overbank flow were omitted."*

I prefer to define bankfull width is as a <u>geometric property</u> of a given cross section and it may or may not relate to a specific return interval discharge. As shown in the figure below, bankfull width is the straight line distance between the bank tops, which are determined as pronounced inflection points marking the limit of the floodplain flat. When one top bank is higher than another, the width is determined by drawing a line from the low bank top to the point where it intersects the opposite bank. In a braided or anastomosing channel such as the Platte, the bankfull width should be measured between the extreme outer banks and encompass intervening islands and bars. So the "total channel width" in these chapters would more accurately be termed bankfull width, in my opinion.

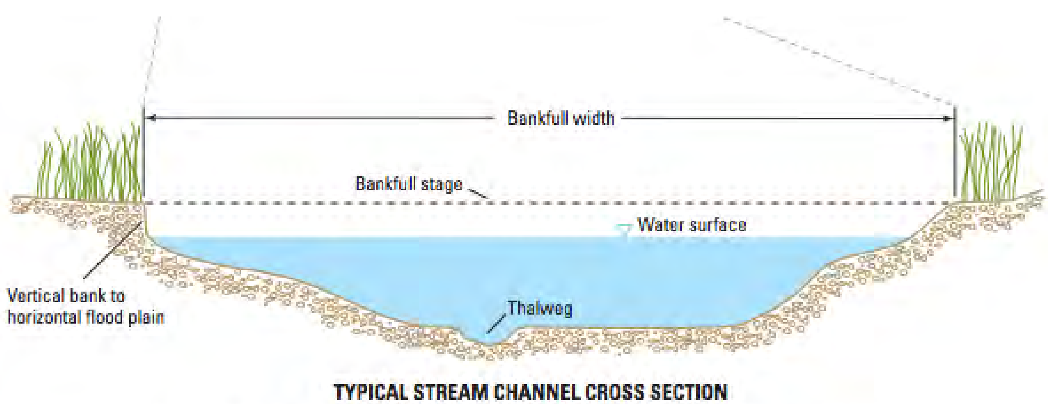


Figure 2. Typical channel reach and cross section for measurement of channel features.

At any rate, it is not clear how "bankfull discharge" was determined for use in HEC-RAS for finding "bankfull wetted width," or what all this has to do with the TCW values used in the regression analysis. If the June 2011 discharge occurring when aerial imagery was flown was adopted as bankfull discharge, I am curious to know the magnitude and return interval of that discharge. Which gage records were used to determine the discharge for HEC-RAS runs to compute width?

I find confusion among the treatments of width in Chapters 2, 3, and 4. Specifically, the discussion for Chapter 2 (lines 322-323) states, "……we were unable to establish a strong relationship between UFCW or TCW and whooping crane use." However, Chapter 4 (lines 45-47) states that probability of WC use, "…is maximized when….unforested corridor width reaches 1,011 ft…" Certainly there is no text, tabular information, or figure showing the effect of UFCW in Chapter 2.

Further confusion ensues due to apparent contradiction between line 301 and Table 6 of chapter 4. The former states that, "Wetted width ranged from 603 ft to 1,717 ft," while the latter presents only a global mean value of 1,044 ft based on 2011 aerial imagery. Why are annual mean widths not presented in Table 6 as for the other variables? What widths were used to develop Figure 10? Were all widths used in the analysis from 2011? Similar comments apply to Figure 11.

Measured or model-produced numerical data are needed to support statements about spatial trends in sediment deficit in lines 108-113 of Chapter 4. If the deficit, "is made up…in the south channel downstream of the return," are additional sediments added in the deficit region or above or below this deficit zone?

RATING

1 = Excellent; 2 = Very Good; 3 = Good; 4 = Fair; 5 = Poor

Category Rating

Scientific soundness ____3__

Degree to which conclusions are supported by the data __4____

Organization and clarity __5____

Cohesiveness of conclusions _4____

Conciseness ___4___

Important to objectives of the Program __2____

Recommendation

Accept ______

Accept with revisions ___X__. Acceptable only if the recently published process-based research cited above (Bankhead et al. 2016, Bankhead and Simon in review, and similar papers) can be fully exploited to inform results, concerns stated above regarding UD values used in the analysis can be addressed, and synergistic, interactive effects among management measures (flow, sediment, mechanical) can be fully considered. Finally, the synthesis should provide evidence that the Program is taking an ecosystem-based view of managing the AHR that considers all listed species as well as others.

Unacceptable ______

Editorial Comments

Synthesis Chapter 1

Chapter	Line Number	Comment
Chapter 1	28	"Nine years implementing"--see line 7 of preface
Chapter 1	71	"ANR" should be "ANWR"
Chapter 1	118	After "monitoring effort "insert "on the Platte River"
Chapter 1	133	"maximized at 1,150…" should be "maximized at UOCW of 1,150…"
Chapter 1	189	"no width change" between what dates?
Chapter 1	273	between the J-2 Return and….. something left out after "and"
Chapter 1	311	should be illustrated with a map
Chapter 1	315	define hydrocycling
Chapter 1	326	"thought" should be" though"

In paper, but not in reference list

1. Allen 1952
2. Randal and Samad 2003

Synthesis Chapter 2

Chapter	**Line**	**Comment**
Chapter 2	11	"the ability of to alter" should be "alteration of"
Chapter2	67	remove parenthesis
Chapter 2	84	Comma before quotation marks
Chapter 2	87-93	Apparent contradictions between these three phrases "with the exception of spring 2003," "excluded crane group observations during 2001", "AHR, spring 2001-spring 2013," and line 52. please clarify
Chapter 2	98	need to make comma after “River” a semicolon
Chapter 2	113	"updated" should be "supplemented"
Chapter 2	114	"gaged" should be " gage"
Chapter 2	135	there are two number 5's in Table 1
Chapter 2	141	"geomorphic channel type" should be " channel morphology "
Chapter 2	155	"This distribution" should be "distribution set"
Chapter 2	256	Table 2 unit discharge units are ft^2/s/ft, not feet
Chapter 2	292	“crane use” should have a comma after it
Chapter 2	302	“465ft)” should have a comma after it
Chapter 2	321	after "width" insert “(UOCW)" and after “forest” insert "NF"
Chapter 2	330	after “data” there should be a comma

In paper, but not in reference list

1. Freeman 2010
2. Phillips et al 2006
3. Phillips and Dudik
4. Manly 1997

Synthesis Chapter 3

Chapter	Line	Comment
Chapter 3	59	"whooping roosting habitat" should be "whooping crane roosting habitat"
Chapter 3	95	location should have a comma after it
Chapter3	109	"was defined in Chapter 3" should be "is defined in this chapter"
Chapter 3	111	"throughout migration" should be "other than"
Chapter 3	112	"corridor are not available except for within" should be "were not available"
Chapter 3	126	Show and explain definition for NF in a figure like 2-2.
Chapter 3	196	"telemetry" should be "Our telemetry"

In paper, but not in reference list

1. Freeman 2010
2. Austin Reichert 2001? Maybe a mistake?

Synthesis Chapter 4

Chapter	**Line**	**Comment**
Chapter 4	46	"UOCW reaches” should be "UOCW exceeds"
Chapter 4	46	"unforested corridor width reaches" should be "unforested corridor width exceeds"
Chapter 4	48	"UOCW reaches 739ft" should be "UOCW exceeds 739ft"
Chapter 4	48	"unforested corridor width reaches" should be "unforested corridor width exceeds"
Chapter 4	49	"1,119ft" insert "(Chapter 3) before the period"
Chapter 4	66	"Number 2 offsetting" should be inserted "Partially offsetting"
Chapter 4	76	"AHR but natural high flow" should have "AHR, but natural high flow"
Chapter 4	146	"mean discharge more than doubled and " should be "mean discharge more than doubled, and"
Chapter 4	164	"TUCW" should be spelled and defined, and present figure 4 here
Chapter 4	176	"First Increment of the Program" should be defined
Chapter 4	178	"estimates for maintenance of 400-800" should be "estimates for maintenance should be 400-800 ft"
Chapter4	186	"focuses solely on the 84-miles" should be "focuses solely on 84 miles"
Chapter 4	189	"Largely confined to the north channel and hydropower" should be "largely confined to the north channel, and hydropower"
Chapter 4	190	"south channel in this reach making it difficult" should be "south channel in this reach, making it difficult"
Chapter 4	288	"with increasing TUCW but" should be "with increasing TUCW, but"
Chapter 4	304	"At full-scale implementation, up to 83%" should be "At full-scale implementation be 83%"
Chapter 4	362	"betas previously stated" --betas should be defined
Chapter 4	415	"Dischargemain" should be "Discharge"
Chapter 4	525	"may not be that important as UOCW" should be "may not be that important, as UOCW"

In paper, but not in reference list

1. Murphy et al 2001

Works cited

Bankhead, N. L., Thomas, R. E., and Simon, A. 2016. A combined field, laboratory and numerical study of the forces applied to, and the potential for removal of, bar top vegetation in a braided river. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.3997.

Brunner, G.W. 2010. HEC-RAS River Analysis System Hydraulic Reference Manual. U.S. Army Corps of Engineers. Institute for Water Resources. Hydrologic Engineering Center. Davis, CA.

Corenblit, D., Baas, A., Balke, T., Bouma, T., Fromard, F., Garófano-Gómez, V., and Kim, D. 2015. Engineer pioneer plants respond to and affect geomorphic constraints similarly along water–terrestrial interfaces world-wide. *Global Ecology and Biogeography*, 24(12), 1363-1376.

Diehl, R. M., Wilcox, A. C., Stella, J. C., Kui, L., Sklar, L. S. and Lightbody, A. 2016. Fluvial sediment supply and pioneer woody seedlings as a control on bar-surface topography. Earth Surface Processes and Landforms. Published online. DOI: 10.1002/esp.4017.

Edmaier, K., Crouzy, B. and Perona, P. 2015. Experimental characterization of vegetation uprooting by flow. *Journal of Geophysical Research: Biogeosciences*, 120(9), 1812-1824.

Fotherby, L. 2009. Preliminary Assessment of Planform Change at Low Flows with Vegetation Expansion: Platte River, Nebraska. *World Environmental and Water Resources Congress 2009*, 1-10. doi: 10.1061/41036(342)594.

Johnson, C.W. 1994. Woodland expansion in the Platte River, Nebraska: Patterns and Causes. *Ecological Monographs*, 64(1), 45-84.

Kui, L., J. C. Stella, A. Lightbody, and A. C. Wilcox. 2014. Ecogeomorphic feedbacks and flood loss of riparian tree seedlings in meandering channel experiments, *Water Resources Research*, 50, doi:10.1002/2014WR015719.

Manners, R. B., Wilcox, A. C., Kui, L., Lightbody, A. F., Stella, J. C. and Sklar, L. S. 2015. When do plants modify fluvial processes? Plant-hydraulic interactions under variable flow and sediment supply rates. *Journal of Geophysical Research: Earth Surface*, 120(2), 325-345.

Richter, B.D., Baumgartner, J.V., Powell, J. and Braun, D.P., 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation biology*, 10(4), 1163-1174.

Whooping Crane Habitat Synthesis Chapters Report

RATING:

Please score each aspect of this manuscript using the following rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

Scientific soundness	2
Degree to which conclusions are supported by the data	2
Organization and clarity	2
Cohesiveness of conclusions	1
Conciseness	1
Importance to objectives of the Program	1

(For use by internal review panel only

RECOMMENDATION	(check one)
Accept	
Accept after revision	Yes
Unacceptable	

Reviewer Responsed to General Questions for Whooping Crane Habitat Synthesis Chapters

1. Does the combined set of whooping crane habitat synthesis chapters adequately address the overall objective, which is to present lines of evidence for broader examination of the conclusion that implementation of the Program's Flow-Sediment Mechanical (FSM) management strategy may not achieve the Program's management objective for whooping cranes?

These four chapters provide the context and analyses needed to address the objective to "contribute to the survival of whooping cranes by increasing habitat suitability and thus use of the Associated Habitat Reach (AHR) along the central Platte River in Nebraska" (p. 2, lines 5-7). To achieve that objective through developing a multi-scale and temporal research design and maintain a rigorous field-oriented data collection that provides the data needed in the statistical analyses is no small task. To be charged with coming to definitive conclusions within a finite time frame is challenging, and I am impressed with the amount of effort undertaken and presented in this report. I believe that the results provide a major contribution to the evaluation of program management in the AHR.

In Chapter 1, a combination of three approaches is presented as a "combination of monitoring of physical and biological response to management treatments, predictive modeling, and retrospective analyses". This process would be achieved by "producing multiple lines of evidence across a range of spatial and temporal scales". The conclusion given within Chapter 1 and reiterated in Chapter 4 states that the implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy, particularly the flow component, may not achieve the stated management objective and sub-objectives for whooping crane and "contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR". If this strategy were the only one identified in the Adaptive Management Plan, the objective of the project would be simple to evaluate. What is unclear is why both alternatives were not the intended focus of evaluation in this report.

As stated on p. 23, lines 375-387:

"Two competing management strategies to achieve the objective of improving survival of WHCR during migration: 1) Mechanical Creation and Maintenance (MCM) approach 2) flow-sediment-mechanical (FSM) approach

1) Mechanical creation and maintenance of both in- and off-channel habitats including channel widening through management activities such as in-channel and bank line vegetation removal, acquisition and restoration of off-channel wetland habitat, and construction and preservation of wet meadow habitat; few uncertainties about ability to do this, uncertainty is characteristics that influence selection of in and off channel habitats, and most economical means of creating and maintaining that habitat
2) Water-centric, restoring channel width, improving sediment supply, and increasing annual peak flow magnitudes to increase braided channel morphology, maintain unobstructed channel width"

Within the research design and statistical analyses of Chapter 2, several physical metrics (serving to assess habitat suitability) metrics were tested in conjunction with few flow metrics. Whereas, in Chapter 4, flow metrics were tested with areas where management practices were employed (disking, herbicide) and potentially enhancing the habitat suitability. The only metric missing involves measurement evaluating "manageable lands" via the acquisition of properties to facilitate the ability for more management to occur, thus also improving habitat suitability at a broader scale for migrating whooping cranes. In Chapter 4, the limitation is defined as "The major limitation of disking is the lack of a system-scale beneficial effect. The Program can utilize disking to effectively manage UOCW at Program habitat complexes, but cannot utilize disking to manage UOCW on other conservation or private lands without landowner agreements" (p. 108, 553-555).

Suggested Revisions: provide a more comprehensive evaluation for Program decisions and promotion of policy by:

1) Incorporating more discussion in each section relating to the interpretation of results that address components of both MCM and FSM;
2) Providing more information about locations of conserved/managed areas as part of MCM management potential;
3) Providing more discussion of MCM strategy effectiveness in Chapters 2 and 4;

2. Do the authors of the whooping crane habitat synthesis chapters draw reasonable and scientifically sound conclusions from the information presented? If not, please identify those that are not and specifics of each situation.

This report remained focused on providing a better understanding of habitat selection by migrating whooping cranes and suitability of that habitat as affected by competing management strategies. I believe the research questions and evaluations were strong and well executed in these chapters (2, 3, 4). I do feel that more discussion of findings and conclusions could be expanded, particularly since so much analyses and results were provided. In Chapter 1, (p.2, line 23) no conclusion statements for Chapters 2 and 3 are given (that address habitat characteristics and MCM), before reaching conclusion on Chapter 4 FSM approach.

Suggested revision: Add conclusion statements for Chapters 2 and 3 in Chapter 1

In Chapter 2, authors explained how the metrics wetted area and suitable depth within the channel would improve habitat suitability for whooping cranes. However, they were unable to quantify those metrics and used unit discharge as a proxy, which was a measure of flow and channel width, which did not score high in the top four models, a result that was counter to previous studies (p. 47, line 321). They do state that "it may not be appropriate to assume flow metrics are not important to selection of habitat by whooping cranes. Instead, it appears area of suitable depth and wetted width surrounding areas selected by whooping cranes were equally available and potentially adequate at flows observed during times of whooping crane use". Given that the main purpose of this report involves determining if SDHF regimes were adequate to maintain habitat suitability, it appears this last statement may be unfounded, and potentially erroneous.

Suggested revisions:

1) Provide a more detailed discussion on the results of the other studies
2) Suggest an alternative approach generating necessary data for future studies, given the importance of this hydrologic metric.

In Chapter 3, the evaluation of whooping crane habitat selection is expanded to a broader spatial scale to encompass the north-central Great Plains. However, no locations were given even at the river system level. Along this line, the point concerning UOCW in Chapter 3 states that the variability of this metric was among different river systems within the migratory corridor (p. 66, lines 225-265). The explanation that these other rivers are typically wider than the AHR at Platte River are not founded on any results provided in the chapter. I believe this would elevate the value of the chapter findings as a potential publication of merit, as well as providing information on the importance of these multiple stopover sites throughout the Great Plains for migrating whooping cranes.

Whooping Crane data used in this research were provided by a telemetry study intended to evaluate migration corridor dimensions and habitat use. However, these 68 birds were of varying ages (juveniles, subadults, adults), groups (families, pairs, subadult flocks), and evolving migration experience through the time of the study (5 years). In addition, weather conditions can additionally affect habitat availability; however, weather conditions during the study period were not introduced as a metric, or as a descriptor of habitat suitability. Although these may variously affect the study, and may have not been in the research design, they should be considered as affecting the results.

Suggested revisions:

1) Provide a location map or text description of river systems (or alternatively, basins) used during this study
2) Discuss potential effects bird age, group, or experience may affect habitat choice (e.g., in telemetry juveniles in fall migration, locations are chosen by experienced parents, most likely on their >5th migration)
3) Characterize the general weather conditions throughout the study in terms of potential water availability (drought index, for example)

Chapter 4 draws from the results of previous chapters, primarily the metrics from the top four models in Chapter 2, that define habitat suitability indicators using actual whooping crane location data. In Chapter 4, the overarching objective of evaluating the FSM management strategy is explored and evaluated in the context of providing hydrologic conditions necessary to maintain river channel conditions conducive to suitable whooping crane habitat on the AHR of the Platte. Returning to the conclusion statement about the implementation of the Program's Flow-Sediment-Mechanical (FSM) management strategy, particularly the flow component, that may not achieve the stated management objective and sub-objectives for whooping crane and "contribute to improved whooping crane survival during migration through increasing habitat suitability and use of the AHR". The discussion in Chapter 4 could be expanded when describing the constraints from upstream management to provide flow releases of 5,000-8,000 cfs. It may be helpful to understand how effective those short-duration high flows as designated in the AMP affect shallow water roost conditions within the channel to ensure suitable habitat conditions for whooping cranes in the AHR during migration periods.

Suggested revision:

1) Include discussion in Chapter 4 that acknowledges any benefits derived from SDHF improving habitat suitability;
2) Provide any recommendations on the flows necessary to achieve the AMP objective based on reported analyses.

3. Are there any seminal peer-reviewed scientific papers that the whooping crane habitat synthesis synthesis chapters omit from consideration that would contribute to alternate conclusions that are scientifically sound? Please identify any such papers including citations.

I did not find that the conclusions were contrary to other scientific work in the literature; however, this field is not well-developed. I do believe that the authors should consider publishing in peer-reviewed journals to encourage such discussion at a broader level.

The debate does exist regarding the appropriate maintenance and recovery of shallow, braided river systems when hydrologic pulses are severely altered. I recommend incorporating more of these publications in the chapters and provide some key citations below for consideration at the discretion of the authors.

Geomorphology, alternate views of braided river processes

Faanes, C.A. 1992. Factors influencing the future of Whooping Crane habitat on the Platte River in Nebraska. 1988 North American Crane Workshop:101-109.

Farnsworth, J.M., J.F. Kenny, and C.B. Smith. 2015. Comment on “Progressive abandonment and planform changes of the central Platte River in Nebraska, central USA, over historical timeframes. Geomorphology 250, 437-439.

Gurnell, A.M., W. Bertoldi, and D. Corenbilt. 2012. Changing river channels: the roles of hydrological processes, plants and pioneer fluvial landforms in humid temperate, mixed load, gravel bed rivers. Earth-Science Reviews. 111,129-141.

Horn, J.D., C. Fielding, and R.M. Joeckel. 2015. Progressive abandonment and planform changes of the central Platte River in Nebraska, central USA, over historical timeframe. Papers in the Earth and Atmospheric Sciences. Paper 317.

Kinzel, P.J. 2008. River channel topographic surveys collected prior to and following elevated flows in the central Platte River, Nebraska, spring 2008. US Geological Survey Data Series 380, 10 p.

Pfeiffer, K. and P. Currier, P. 1992. An adaptive approach to channel management on the Platte River. 1988 North American Crane Workshop. 9,151-154.

O’Brien, J.S. and P.J. Currier. 1987. Channel morphology, channel maintenance, and riparian vegetation changes in the Big Bend reach of the Platte River in Nebraska. Platte River Trust, Grand Island, Nebraska. 49 p.

Piégay, H., G. Grant, F. Nakamura and N. Trustrum. 2009. Braided river management: from assessment of river behaviour to improved sustainable development. *Braided Rivers: Process, Deposits, Ecology and Management, Sambrook Smith GH, Best, JL, Bristow, CS, & Petts, GE (Eds)*, pp.257-276.

Smith, C.B. 2011. Adaptive management on the central Platte River – science, engineering, and decision analysis to assist in the recovery of four species. Journal of Environmental Management 92:1414-1419. *FSM alternative*

Suggested Revisions: A few corrections are proposed within each of the chapters to eliminate inconsistencies between citations in the text and those within the Literature Cited.

Page	Line	Comment	Action Needed:
	Chapter 1		
4	21	(Program 2006a) referenced in Literature Cited as PRRIP 2006a	Correct to PRRIP 2006a, standardize throughout report (also p. 8, line 134, p. 19, line 361, etc.)
6	51	Latest edition of this reference is 2007	Correct to 2007
9	111	Pitts (1985) incomplete citation	Could not find this citation, should delete if not available
19	270	Peake et al. 1985 not in Literature Cited	Add to LC
19	273	EIS 2006 cited as Department of Interior in Literature Cited	Determine correct citation
19	274	no date of citation in text after Sidle et al.	Insert date 1989, if correct in LC
21	380	Reichert misspelled throughout document	Correct to Richert
27	470	Incomplete citation	Add source of material
27	443	Not cited as PRRIP in text	Correct throughout
27	448	Not cited as PRRIP in text	Correct throughout
	Chapter 3		
57	91	No reference for figure 2	Use Pearse et al. 2015
	Chapter 4		
81	199	Vague citation	Provide more reference

4. Is the relationship between management actions, riverine processes, species habitat, and species response clearly described, and do Program monitoring, research, and reference materials help to verify and/or validate this relationship?

The objectives, research design, analyses, and interpretation of results are well developed and appropriate for this study. This report was well organized and clearly written, with minor additions and corrections needed. The report provided the necessary information to substantiate justification of the project, methods of approach, and results. The discussion within each chapter was brief, yet informative; the summary of findings provided the comprehensive points. Summary of Findings section articulates the results and conclusions of the study very well and is provides a format easy to understand and convey to managers.

Suggested revisions throughout the report:

1) Standardize between standard and metric, or give both throughout report
2) Standardize spacing between number and measurement (e.g., 10ft vs 10 ft) among chapters
3) Correct spelling of Richert from Reichert throughout report
4) Correct PRRIP from Program for citing program reports throughout this report

Suggested revisions:

Page	Line	Comment	Action Needed:
		Chapter 1	
3	59	State 200-mile wide corridor	Actually less, as cited in Tacha et al. 2010 and substantiated by Pearse et al. 2015; also cite Pearse et al. for Figure 2 map, since same as in this publication
7	75	ANR	Correct to ANWR as identified in line 58
8	Fig. 2	Figure scale not consistent throughout report	Standardize to Km or mi throughout
9	103	Most birds arrive by early-mid December, not mid-November (Butler et al. 2014…winter abundance)	Correct to early-mid December
9	106	Generalized statement of sub-adults near natal area of first winter,	Correct to relate actually form loose flocks and travel outside defended territories where they first wintered (Stehn and Prieto 2010)
9	106	Paired cranes often locate territories near their parents winter territory	Correct to near the male's parent winter territory (need citation to send)
9	109	Crane missing after whooping	Insert
11	138	No metric following $\geq$ 1,150	Insert feet
12	160	Much information in Table 1, not given	Expand explanation of percentage changes throughout the period
21	380	Reichert misspelled	Correct to Richert
25	410	No space between page numbers	Insert space
26	433	Semicolon after first author name	Replace with comma
26	440	Comma after year	Replace with period
		Chapter 2	

33	111	Priori in subtitle not capitalized	capitalize
42	270	Crane missing after whooping	Insert crane
		Chapter 3	
53	4	No mention of purpose of the chapter, Program objectives,	begin with a similar, perhaps condensed version, of Program information at beginning of Abstract; see Chapter 2, Abstract, p. 28 lines 4-16
53	13	Did not list number of samples	Insert "at 158 stopover sites" after habitats
53	13	No mention of connection to Chapter 2 results, where decision to use UOCW and NF in models	Provide connection to report objectives; Insert "Based on the results of Chapter 2..."
60	148	Table 2 no measurement for values	Insert ft in both columns
64	188	Discuss water presence, but did not measure or analyze that in this chapter;	Insert "While we did not examine presence of water at each use site, we assumed that surface water was available in a riverine site". ?
68	280	Curier misspelled	Correct to Currier
		Chapter 4	
70	12	UOCW not defined previously in Chapter	Define and relate to previous chapters
70	12	TUCW not defined previously in Chapter	Define and relate to previous chapter
70	15	AHR not defined previously in Chapter	define
72	45	Acronym not defined	Insert NF
72	48	Acronym not used	Use NF
74	Fig. 1	Font size not standardized in figure	Standardize font
74	Fig. 1	Unclear what "?" means in y axis	Correct
74	Fig. 1	Green color does not show up in figure	Correct green line
74	87	Refer to overall length here	Insert 90-mi reach
75	93	Incorrect title for organization	Insert National Audubon Society
75	101	Lower case genus name	Capitalize genus
76	Fig. 2	Noted that map not to scale – why not?	Scale map
79	Fig. 3	Incorrect x-axis title	Insert Total before Volume
79	158	Total missing before volume	insert
81	198	No hyphen	Insert hyphen photo-interpreted
84	236	Not sure if term eliminate is appropriate	Suggest reduce
85	246	Hyphen missing	Insert hyphen in five-step
91	339	Results for herbicide only missing	Add information
92	342	"Other" missing between "no" and "management"	insert
97	Fig. 12	Disking and herbicide (blue) missing in legend	add
97	404	Results for disking only missing	Add information
105	497	Space missing between value and measure	Insert space
120	119	TUCW not defined in Table caption	define

5. Are the statistical methods used in the combined set of whooping crane habitat synthesis chapters valid and current, and are the associated results presented in manner useful to decision makers for the Program?
6.

Yes, using the Resource Selection Function is a preferred method to identify which resources (often landscape features serve as a proxy for those resources) drive species distributions in selective habitats. RSF can be interpreted as being proportional to expected density of observations (Aarts et al. 2012), and thus provides useful metrics to use in evaluating the study area. The approach used in these analyses is used widely in contemporary, published literature investigating similar research and adaptive management questions. In most cases, detailed information was provided for methods in each chapter; additional information was provided in associated appendices.

I found very few weak points in the report; however, one particular key component in the analyses involved the Unobstructed Open Channel Width (UOCW) metric bears discussion. In Chapter 1, an excellent overview of the literature comparing the optimum UOCW results from several studies (p. 11). Given the importance of this metric in the report's model results, it would be beneficial to discuss in this section, and/or in the succeeding chapters why this variability might occur. In addition, it appears that UOCW is measured differently within this study which may affect results in Chapter 2 compared with Chapter 4. Also, a new metric, Total Unobstructed Channel Width (TUCW) was introduced in Chapter 4 research design and analyses.

Suggested Revision:

1) Review the method descriptions and discern if the difference only appears within the figures and not in the definitions, Fig. 2 (Chapter 2, p. 33) as possibly multiple lines across the channel, while only measured once within the channel in the approach depicted in Fig. 6 (Chapter 4, p. 82).
2) Address the differences when defined in Chapter 4, including the use of the new metric (TUCW) if it differs from UOCW in Chapter 2.

Results and Discussion sections in each chapter were well written and concise. Chapter 1 provides a good overview of the Program, objectives of the study and pertinence to Program objectives. Summary of Findings section articulates the results and conclusions of the study very well and is provides a format easy to understand and convey to managers.

7. Are potential bias, errors, or uncertainties appropriately considered within the methods sections of the whooping crane habitat synthesis chapters and then discussed in the results and conclusion sections?

Potential bias in both sampling bias and detection bias was discussed in Chapter 4 (p. 64, line 178) in relation to the US Fish and Wildlife Service's Whooping Crane opportunistic sighting database. One pertinent papers was sighted in regard to this specific database in the report. In addition location error was mentioned with regard to this database. Potential errors in measurement data using GIS platforms were also identified within the report. The reviewers were provided with an amended report on October 10, 2016 in which a series of memos and reply memos were included that discussed how these bias and errors may affect the results of the study, or affected data collected for the purpose of use in the analyses. I am not prepared to delve in any more detail than was discussed in these memos.

APPENDIX C – BIOGRAPHICAL SKETCHES

Brian Cade, PhD – USGS

Proposed Peer Review Panel Member for Platte River Recovery Implementation Program

Name	Brian S. Cade
Title	Dr.
Affiliation	U. S, Geological Survey, Fort Collins Science Center
Address	2150 Centre Ave., Bldg. C, Fort Collins, CO 8052-8118
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Education	B.S. 1977. Wildlife Biology, Colorado State Univ., Fort Collins, CO.; M.S. 1985. Wildlife Biology, Colorado State Univ., Fort Collins, CO.; PhD. 2003. Ecology, Colorado State Univ., Fort Collins, CO.

Unique Qualifications

I have spent 30+ years conducting, evaluating, and interpreting statistical analyses for models relating organism responses to environmental conditions (see publications in my CV). I provided statistical expertise for project evaluating whooping crane habitat on the Platte River that was published in a USGS Scientific Investigations Report (see Farmer et al. 2005 in my CV)

Short Biography of Proposed Peer Review Panelist

I provide statistical consultation and research in support of programs trying to predict and understand organism responses to their environment, especially as related to making environmental impact assessments or evaluating habitat management alternatives. Because of the inherent heterogeneity in responses associated with biological systems, my statistical research has focused on the enhanced information provided by quantile regression and various permutation procedures. I emphasize the utility of prediction and tolerance intervals and equivalence testing for improved frequentist inferences for scientific investigations and environmental monitoring. My early years with the U. S. Fish and Wildlife Service involved using habitat evaluation procedures for conducting environmental impact assessments or evaluating habitat management alternatives.

Research and Professional Experience:
1978 – 1979: Wildlife technician, Univ. Idaho.
1980 – 1983: Graduate Research Assistant, Colorado Div. Wildlife and Colorado State Univ.
1984 – 1989: Wildlife Biologist, U.S. Fish and Wildlife Service, Fort Collins, CO.
1989 – present: Research Biological Statistician, U. S. Geological Survey, Fort Collins, CO.

F.D (Doug) Shields, Jr., PhD – Shields Engineering, LLC

Proposed Peer Review Panel Member for Platte River Recovery Implementation Program	
Name	F. D. Shields, Jr.
Title	Principal engineer
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	1983-87 Colorado State University; Hydraulics; Ph.D. 1987, 4.0/4.0
Education	1975-77 Vanderbilt University; Environmental and Water Resources Engineering; M.S.,
	1983-87 Colorado State University; Hydraulics; Ph.D. 1987, 4.0/4.0

Unique Qualifications

Shields has been active in stream and river restoration research and design since about 1980 and has authored several key papers in the field. Key topics of interest include ecological role and function of large wood, effects of dams and river training on large river geomorphic processes, physical habitat monitoring and signficance, interactions among vegetation, sediments and fluvial processes and riverine sediment transport.

Short Biography of Proposed Peer Review Panelist

Doug Shields has 39 years of experience in water resources and environmental engineering, including 12 years for the U.S. Army Corps of Engineers and 22 years as a Research Hydraulic Engineer at the National Sedimentation Laboratory in Oxford, Mississippi. Dr. Shields' research focuses on response of fluvial systems to human influences and development of environmental design criteria for all types of channel stabilization and modification projects, including stream bank erosion controls and management of riverine backwaters. He is a leading authority on stream and river restoration. Doug has authored or co-authored more than 300 technical publications and has completed consulting projects dealing with stream restoration, erosion protection of riparian cultural resources sites, stream bank erosion, geomorphic assessment, and local flooding.

Elizabeth Smith, PhD – International Crane Foundation

Proposed Peer Review Panel Member for Platte River Recovery Implementation Program

Name	Elizabeth Hovey Smith
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Education	Ph.D. Wildlife & Fishery Science, Texas A&M University; M.S. and B.S.Biology, Corpus Christi State University

Unique Qualifications

My career focus has always been directed toward habitat assessment and conservation planning, at an academic and conservation organization level. I have extensive experience in developing and implementing applied science questions with the intent to address management objectives at a landscape level. My research, monitoring, and advocacy for the endangered Whooping Crane in their wintering grounds primarily is focused on maintaining a sustainable environment for their recovery.

Short Biography of Proposed Peer Review Panelist

My dissertation research employed both field-based and modeling approaches to more quantitatively describe coastal vegetation dynamics along the northwestern Gulf of Mexico in relation to drought/wet cycles and management in a federal refuge. I continued this professional interest in understanding the interplay and consequences of natural perturbations and management outcomes in hydrologically-driven systems. My academic responsiblities as Research Scientist at a coastal research center involved procuring funding and mentoring graduate-level students in real-world research and application. I have continued the conservation emphasis as Conservation Biologist for a nongovernmental organization in participating in the integration of both mandated environmental flow regime assessments and more voluntary approaches to water conservation at a basin level. My roles as directing the Texas Program in the sole wintering grounds of the Aransas-Wood Buffalo population of endangered Whooping Cranes involves directly collaborating with agencies, consulting firms, academic institutions and NGOs. Our combined effforts, while not always in congruence with current repective water use needs, will provide the comprehensive dialogue leading to an integrated water management program in the central Texas coast. As part of this review panel, I hope to provide unbiased comments and suggestions as well increase my understanding of the complex process needed to evaluate these programs.