Platte River Recovery Implementation Program (PRRIP or Program) and U.S. Fish and Wildlife Service (USFWS) Whooping Crane Tracking Partnership (WCTP) Collaborative Research Proposal

Working Title: Factors associated with whooping crane stopover decisions along the southern portion of the migratory corridor.

I. INTRODUCTION

A. Context

It has been hypothesized that whooping cranes respond to flow in the central Platte River by increasing or decreasing their use of the river during migration. To date, the Program has utilized systematic aerial surveys to document ground use locations and associated habitat characteristics, but has found no relationship between flow and riverine roost site selection (Baasch et al. 2019). In June of 2022 the Program's Governance Committee (GC) approved the First Increment Extension Science Plan (PRRIP 2022) including three specific questions asking what factors are associated with 1) whooping crane stopover decisions, 2) stopover lengths, and 3) differences in stopovers by season. The Program has specific management hypotheses focused on learning about how important river flow is for whooping crane stopover decisions, but also alternative hypotheses that ask about the role of channel widths unobstructed by dense vegetation, landcover, time of day, weather, previous stopover locations and stay lengths, and group composition.

B. Why cellular telemetry?

Cellular telemetry tracking data collected on individual whooping cranes from Fall 2017 forward are uniquely suited to address these questions, providing locations at 15 min intervals. This fine temporal scale provides information on locations while the birds are still in the air approaching a potential stopover site, whether or not the bird actually stops. Additionally, these data are collected over the entire migratory corridor encompassing multiple stopover and stay length decisions for each telemetered individual over both spring and fall migratory seasons, allowing for more robust conclusions. The Program's Independent Scientific Advisory Committee (ISAC) has suggested that a wider look across the migratory corridor will not only provide a larger dataset for evaluating our three priority hypotheses, but also help us understand the role of the Platte in the wider migratory corridor. The Program's Governance Committee concurs and has directed the Executive Director's Office (EDO) to approach the WCTP with the intent to establish a collaborative partnership to address these research questions.

C. Collaborative proposal

We are not making a traditional data request, but rather asking to develop a collaborative research partnership with the Telemetry Tracking Partnership to develop research that addresses common research questions. The appropriate temporal and spatial frame and analytical methods will be developed collaboratively with WCTP. The current document outlines the broad strokes of a study plan to address Program research questions and identifies elements of study design that will need

to be further elaborated with WCTP input. We anticipate that the only non-WCTP entity that will have access to the data is the EDO. Program participants will be briefed on methods and results but will not have access to raw data.

II. OVERARCHING TIERED ANALYSIS PLAN

A. Research Questions and Hypotheses

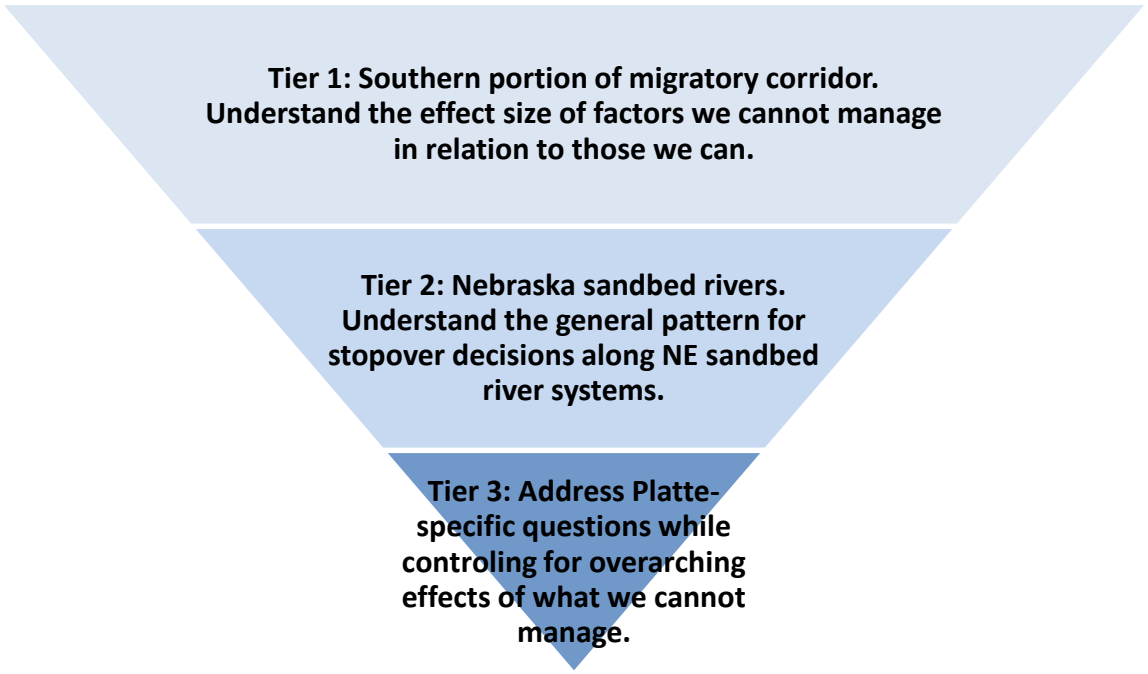
Three research questions have been prioritized for learning during the Program's First Increment Extension to provide information needed to better manage whooping crane stopover habitat.

1) What factors influence whooping crane decision to stop or fly over the Program's Associated Habitat Reach along the central Platte River?
2) What factors influence whooping crane stopover length within the Program's Associated Habitat Reach along the central Platte River?
3) Why is spring whooping crane use greater than fall use of the Program's Associated Habitat Reach along the central Platte River?

Each of these research questions has ***management and physical process hypotheses*** that focus on learning about the importance of river flow and area of suitable wetted width and depth on whooping crane decision making. However, previous research done by the Program, Program partners, and other entities have provided support for ***alternative hypotheses*** that include factors that can be managed as well as those that may not be manageable. Included in this list are features of the landscape such as wide river channels unobstructed by dense vegetation; open, unforested landcover types; wetland landcovers; agricultural landcovers; and amount of development. Factors associated with a sequence of migratory decisions such as point in migration, time at last stopover, distance since last stopover, and time of day when stopover decisions are made have all been suggested as important. Additionally, weather conditions and season are also expected to be important for decision making as spring and fall migrations show different patterns that may be a function of life-history, group composition, associations with other migratory species, resource availability, and weather.

B. Tiered Analysis Plan

In developing this study plan, we have taken into consideration the strong recommendation made by our ISAC and GC to broaden our scale of analyses to include the entire migratory corridor. We also understand the request made by members of the WCTP to limit the scale of the analysis to include locational data over the spatial and/or temporal scales necessary to answer targeted research questions. We believe the cellular telemetry data collected from **Fall 2017 forward** are best suited to answer the questions posed above due to the shorter sampling interval that will reduce temporal mismatch of stopover behavior with flow conditions. We are also proposing three tiers of analyses each addressing a specified spatial scale as outlined below.



III. TIER 1 – FACTORS INFLUENCING DECISIONS IN SOUTHERN PORTION OF MIGRATORY CORRIDOR

A. Research Questions and Hypotheses

We hypothesize that there are overarching factors important for decision-making that are consistent across the migratory corridor. Many of these overarching variables are largely unmanageable such as point in migration, previous stopover distance and stay length, time of day, and weather, but they exert an effect on decision making over the entire corridor. Learning about the effect size of these largely unmanageable, non-habitat variables in relation to those habitat variables that may be managed (e.g. channel width) within the same analysis will help inform model selection to identify factors that play a role at a regional level. Additionally, information on relative effect sizes of unmanageable versus manageable explanatory variables will reduce uncertainty and clarify expectations for whooping crane response to landscape features we can manage.

We are interested in comparing patterns throughout the southern portion of the migratory corridor to those we see for Nebraska sand bed rivers (Tier 2) and the Platte River (Tier 3). Over the states of Nebraska, Kansas, Oklahoma, and Texas, whooping cranes encounter a landscape dominated by riverine wetland features, grasslands, and agricultural fields that are similar to what they encounter in Nebraska. By reducing variability in landcover metrics, our analysis will focus more on obtaining information on the importance of unmanageable, non-habitat variables like time of day, distance since last stopover, and weather. In addition, effect sizes resulting from this level of analysis will be more relevant for informing variable selection for analyses specific to Nebraska

(Tier 2 and Tier 3). Comparing the factors associated with stopover and stay length decisions over this broader scale to those specific to the Nebraska sand bed rivers and the central Platte River will also provide information requested by the USFWS to better understand how Nebraska sand bed rivers and the central Platte River in particular contribute to the wider migratory corridor.

B. Whooping Crane Locational Dataset

Cellular telemetry data collected from Fall 2017 forward are best suited to answer the questions posed. For this tier of analyses our study area would include the migration corridor for the Aransas Wood-Buffalo population within Nebraska, Kansas, Oklahoma, and Texas. We are requesting the dataset include all migratory locations (in-flight and stopover locations) within these states. This dataset would not include locations associated with overwintering in Texas. We would also like to work with the WCTP to inform variables such as point in migration, distance since last stopover, length of stay at last stopover, and weather conditions experienced during migration that require information from locations outside of these four southern states.

C. Explanatory Variables

Table 1 provides an example of explanatory variables of interest for inclusion in analyses. We expect explanatory variables for this scale of analysis to be broad-scale metrics available across the region in comparable form, such as landcover types available from the National Land Cover Database and National Wetlands Inventory. We also anticipate using broader riverine metrics such as channel width and discharge/channel width to broadly represent how flow is distributed over channels that differ in width. Results from broader-scale tiers of analyses will help inform model selection for smaller scale regional analyses.

D. Potential Analyses

Our focus at this broad scale of analysis is to understand how important unmanageable, non-habitat variables are to stopover decisions in relation to broader landcover and riverine metrics. To examine factors important for making stopover decisions at a broad scale we will likely take an approach similar to a use vs. available resource selection model (Pearse et al. 2021). We will use the telemetry location data to define the scale for the choice set of available locations to compare with stopover locations. The buffer area around each point location used to quantify area-based habitat metrics will also be informed by movement patterns derived from the telemetry dataset.

One potential analysis to test for factors associated with stopovers and duration of stay uses a general linear mixed model regression approach. Correlation of explanatory variables will be examined, and results used to reduce the number of variables included in models for testing. Collinearity among multi-variable landcover models will also be examined. *A priori* hypotheses derived from Program science and published literature will drive model selection. We will compare models to identify best explanatory variable combinations using Akaike Information Criterion adjusted for small sample size (AICc). As we are interested in how stopover decision contexts may differ across years and seasons, we will examine these as fixed effects in our model

predicting stopovers and duration of stay. We will also control for non-independence of multiple stopover decisions by an individual telemetered bird by including individual ID as a random effect in our analyses. If seasonal effects are important for predicting stopovers and stay lengths from previous analyses, we will perform the prior analyses described above separately for spring and fall to compare model results.

IV. TIER 2 – FACTORS INFLUENCING DECISIONS ALONG NEBRASKA SAND BED RIVERS

A. Research Questions and Hypotheses

The Program's priority hypothesis is to learn more about the relative importance of river flow to whooping crane stopover decisions. To address this management hypothesis, we would like to examine patterns across Nebraska sand bed river systems. The Loup River, Niobrara River and Platte River are all west to east flowing sand bed rivers that are close in proximity (alternative stopover locations within the same flight day) and are similar in terms of both on- and off-channel habitat. Here we will be looking at general patterns that persist across these river systems and comparing explanatory variables included in top models and effect sizes across three Nebraska sand bed river systems. Model differences may help us understand how selection for the Platte River may differ from other river systems that whooping cranes have to choose from within the same regional context.

B. Whooping Crane Locational Dataset

For this tier of analysis, we will focus on Nebraska sand bed river stopover locations and compare them to in-flight locations associated with flyovers of these rivers. Though this tier is focused on a smaller regional scale, we will need the full dataset requested for Tier 1 to test alternative hypotheses on factors such as weather, time of day, distance since last stopover, point in migration, etc., that may affect these stopovers.

C. Explanatory Variables

We expect explanatory variables for this regional riverine analysis to be similar to those examined over the broader scale as more refined riverine metrics are not available across all three systems in comparable form.

D. Potential Analyses

To examine factors important for making stopover decisions along Nebraska sand bed rivers we will compare the factors associated with stopovers along the Platte, Loup, and Niobrara rivers to the factors associated with encounters with those rivers that result in flyovers. The scale for the choice set of flyover locations to compare with stopover locations will be defined by the geomorphological characteristics of the river. The buffer area around each point location used to quantify area-based habitat metrics will be informed by flight patterns derived from the telemetry dataset.

A multivariable complementary log-log regression model is an option to test for associations between potential explanatory variables and stopovers. Correlation of explanatory variables will be examined, and results used to reduce the number of variables included in models for testing. Collinearity among multi-variable landcover models will also be examined. *A priori* hypotheses derived from Program science and published literature will drive model selection. We will compare models to identify best explanatory variable combinations using Akaike Information Criterion adjusted for small sample size (AICc) and calculated area under the precision-recall curve (AUC-PR) to evaluate model performance (Sofaer et al. 2019). As we are interested in how stopover decision contexts may differ across years and seasons, we will examine these as fixed effects in our models while also controlling for individual bird ID as a random effect if our dataset includes multiple stopovers or flyovers of individual telemetered birds. We will also account for differences across rivers by including river as a random variable. Separate analyses for each river system may be informative if there are sufficient stopovers along each river. If seasonal effects are important for predicting stopovers and stay, we will perform the prior analyses described above separately for spring and fall to compare model results.

V. TIER 3 – FACTORS INFLUENCING DECISIONS ALONG THE CENTRAL PLATTE RIVER

A. Research Questions and Hypotheses

The Program is primarily interested in learning about the factors that affect whooping crane decisions to stop, how long they stay, and the potential seasonal differences in this decision context along the central Platte River. However, sample sizes limit the power of statistical analyses and confidence in conclusions. A preliminary Platte-specific analysis using cellular telemetry locations of 49 individual birds within 100 km of the central Platte River from Fall 2017 - Fall 2020 provided only 9 stopovers to compare with 108 flyovers, with 5 of those stopovers occurring within a single season. That preliminary analysis indicated that time of day was a better predictor of stopovers along the Platte than either unobstructed channel width or river flow. However, with such few data points, confidence in the wider applicability of results was low. Tier 2 adds information from the Loup River and Niobrara River that are close in proximity and similar to the Platte in both on- and off-channel habitat to increase sample sizes and widen applicability of conclusions. If stopover locations along the Platte River alone provide an adequate sample size with stopovers distributed across years and seasons, we would also perform a Platte-specific analysis of the factors important for stopover and stay length decisions.

This Platte-specific tier of analysis would focus on river flow as the management hypothesis to be tested, but would also include detailed landcover and riverine metrics available only for the Platte River. Additionally, we will incorporate unmanageable variables in the analysis to examine effect size in comparison to those items the Program can manage.

Information provided by this tier of analyses is expected to provide specific information to inform Program water and land management along the central Platte River. As Dr. Aaron Pearse is currently a member of the Program's ISAC, responsible for independent review and evaluation of

Program science used for policy decision making, we are proposing Tier 3 analyses be conducted by PRRIP Executive Director's Office staff without input from the WCTP. We provide a brief overview here for informational purposes that allow the wider WCTP to consider our broader data request to perform Tier 3 analyses.

B. Whooping Crane Locational Dataset

For this tier of analyses, we will focus on central Platte River stopover locations within the 90-mile Associated Habitat Reach of the Program from Lexington to Chapman, Nebraska. However, to test alternative hypotheses on factors such as weather, time of day, distance since last stopover, point in migration, etc., that may affect these stopovers, we will need the full dataset requested for previous tiers.

C. Explanatory Variables

Tier 3 analyses will include the explanatory variables from previous analyses but at a more refined scale, informed with more robust landcover and riverine specific datasets. For the Program's Associated Habitat Reach we have more detailed and annually updated landcover data layers for both the flood plain surrounding the active river channel and within the active channel itself. In addition, annual LIDAR flights provide detailed information on channel geomorphology to inform 2D hydraulic modelling that allows us to estimate metrics like wetted widths at a given flow.

D. Potential Analyses

We will use a similar analysis to that described in Tier 2 above to compare the factors associated with stopovers along the central Platte River to the factors associated with encounters with the central Platte that result in flyovers. Another option for understanding the context for whooping crane stopover decision-making specific to the central Platte River would be to compare the set of factors associated with whooping crane flyovers upon encountering the central Platte River to the factors associated with the stopover location ultimately selected just past the Platte River.

VI. ANTICIPATED PRODUCTS

The Program typically produces programmatic documents distributed via the Program's secure website to inform stakeholders of results, synthesizing information to help inform habitat and river flow management activities on the central Platte River. The raw data will not be released, only reports or products synthesizing or summarizing results. We also anticipate publishing and presenting results in collaboration with the WCTP. Any products derived from this collaboration, written or oral, will be developed in collaboration and subject to review by all parties.

VII. POSSIBLE IMPLICATIONS

Together, we would develop implications of the proposed research that are applicable over the wider migratory corridor and over regional riverine systems. Program stakeholders would develop

implications specifically for the central Platte River. Direct implications for the Program include developing a better understanding of the relationship between flow and whooping crane use and stopover length. Those relationships will be used by Program decision-makers to weigh the costs and benefits of flow releases during migration against other flow management actions such as inundating releases to suppress seedling establishment and maintain unvegetated channel width.

VIII. TIMELINE

We would like to continue this collaboration until the end of the tracking project. We anticipate at a minimum incorporating new cellular telemetry data into the analysis framework developed under this collaboration on an annual basis, producing an annual summary to be shared at our Science Plan Reporting Session in February of each year. Multi-year evaluations and syntheses are planned for 2023 and again in 2027.

IX. REFERENCES

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Sofaer HR, Hoeting JA, Jarnevich CS. 2019. The area under precision-recall curve as a performance metric for rare binary events. Methods in Ecology and Evolution 10:565-577. https://doi.org/10.1111/2041-210X.13140

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Tier	Explanatory Variable	Description
Unmanageable Non-Habitat Variables		
1,2,3	Time of Day	Number of hours before dark (daily sunset plus 30 mins) for the last location recorded before a stopover and for the flyover locations.
1,2,3	Point in Migration	Proportion of days into a migration season for each stopover or flyover location. OR Proportion of total distance traveled during a migration season for each stopover or flyover location.
1,2,3	Latitude	Latitude associated with a point location.
1,2,3	Longitude	Longitude associated with a point location.
1,2,3	Distance since Last Stopover	Distance traveled since previous stopover location.
1,2,3	Length of Stay at Last Stopover	Days spent at previous stopover location.
1,2,3	Weather	Includes a suite of variables such as wind speed and direction, precipitation, temperature, barometric pressure, etc. associated with a stopover or flyover location. Cumulative exposure to weather conditions leading up to a stopover/flyover.
3	*Group Composition**	Number, age category, reproductive status of telemetered individuals and group they with which they are associated. Associations with sandhill cranes are also of interest. **This information is available for Platte River only*.
On-Channel Habitat Variables		
1,2,3	Unobstructed Channel Width	Width of active channel unobstructed by tall vegetation or wooded islands measured perpendicular to midline of the channel at use or available location.
1,2,3	Nearest Forest	Distance to nearest riparian forest measured from use location or available point in any direction.

Tier	Explanatory Variable	Description
1,2,3	Unit Discharge	River discharge (cfs) extrapolated from nearest gage within 15 mins of time stamp on point location, per linear foot of total channel width.
3	Instantaneous river flow (cfs)	River discharge extrapolated from nearest gage within 15 mins of time stamp on point location.
3	*Point-based river flow (cfs)**	River discharge at whooping crane locations and available locations obtained from 2D hydrodynamic model with input from nearest gage within 15 mins prior to locational data. **This information is available for Platte River only*.
Landcover Habitat Variables		
1	Landcover	Predominant landcover type within buffer area
2,3	Wetland	Proportion of buffer area covered by wetland.
2,3	Wetland Shoreline	Total linear distance around perimeter of wetlands (shoreline) within buffer area.
2,3	Wetland Distribution	Size, distribution, proximity of wetlands to one another withing the buffer area.
3	*Distance to Ground Water** *Distance above/below River Elevation**	Distance to ground water. OR Distance above or below river elevation. **This information is available for Platte River only*.
3	Sand and Water	Proportion of buffer area covered by unvegetated sand and water.
2	Grassland	Proportion of buffer area covered by grassland.
3	Prairie	Proportion of buffer area covered by upland grassland.
3	Meadow Marsh	Lowland grassland + Wetland Footprint (Natl. Wetlands Inventory) + Flooding Frequency (USDA NRCS) (Baasch et al. 2022)
2,3	Forest	Proportion of buffer area covered by forest.

Tier	Explanatory Variable	Description
2,3	Agriculture	Proportion of buffer area covered by agriculture of any type.
3	Corn	Proportion of buffer area covered by corn.
3	Soybeans	Proportion of buffer area covered by soybeans.
3	Alfalfa	Proportion of buffer area covered by alfalfa.
3	Other	Proportion of buffer area covered by other agricultural crops.
3	Agricultural Wetland	Proportion of buffer area covered by agriculture + wetland footprint + Flooding Frequency (USDA NRCS) (Baasch et al. 2022).
2,3	Developed	Proportion of buffer area covered by anthropogenic development (roads, parking lots, buildings, infrastructure, etc.).
3	Distance to Development	Distance to nearest developed landcover type (see above definition) measured from use or available location in any direction.
3	Distance to Transmission Lines	Distance to nearest transmission lines measured from use or available location in any direction.
3	Length of Transmission Lines	Total length of transmission lines within buffer area.

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