TO: PRRIP TECHNICAL ADVISORY COMMITTEE
FROM: PRRIP EXECUTIVE DIRECTOR'S OFFICE
SUBJECT: WC RIVERINE ROOST SITE SELECTION
DATE: 1 JULY 2022

I. Framing the Discussion Context and Big Questions

PRRIP manages in-channel (and off-channel) WC habitat based on habitat suitability criteria derived from resource selection analyses. These analyses utilize first observed in-channel WC use locations from unique whooping crane groups collected during PRRIP aerial systematic monitoring. The last analysis of riverine roost site selection was conducted in 2017 (incorporating data from 2007-2016). The Extension Science Plan has an update of this analysis scheduled for 2022 to incorporate an additional 5 years of data (2017-2021). As a check in that incorporates more data into a previous analytical framework, the EDO has no intent to change statistical techniques but would like to update modeling assumptions to reflect additional learning. The current memo outlines how the EDO has used cellular telemetry data to evaluate uncertainties and garner feedback on what changes might be made to update the analysis.

II. Context and Big Questions

The current check in is designed to address the following **First Increment Big Question**: **Do whooping cranes (WC) select suitable riverine roosting habitat in proportions equal to its availability?**
To answer this question past habitat selection analyses have focused on quantifying habitat characteristics surrounding WC roost sites as potential criteria for roost site selection (Howlin and Nasman 2017, PRRIP 2017, Baasch et al. 2019). Roost site selection analyses utilized documented WC riverine roost site locations obtained from PRRIP conducted systematic aerial surveys. The same set of habitat characteristics were also quantified for a non-selected random choice set of 20 available potential in-channel roosting sites drawn from within 10 miles upstream and 10 miles downstream of the observed roost location. In-channel metrics were linear and measured from the use and available points. Off-channel landcover metrics were area-based and quantified over a 3-mile radius surrounding each riverine use and available point (Howlin and Nasman 2017). Analyses contrasted the habitat characteristics surrounding selected roosting sites with those surrounding non-selected randomly available potential roost sites to ask whether WC select for the characteristics surrounding roost sites more frequently than predicted by their availability throughout the landscape. A resource selection function estimation framework was chosen due to its ability to account for the temporal and spatial changes in availability of appropriate habitat within a dynamic river system.

Identification of characteristics surrounding use locations that occur more frequently than predicted by their availability throughout the landscape has provided guidance for Program habitat creation and maintenance. Specifically, minimum habitat requirements established for in-channel WC roosting have been set to reflect the results of these selection analyses. The Program actively creates/maintains maximum unobstructed channel widths ≥ 650 feet and clears riparian forest from the river's edge to create an unforested corridor width of 1000 feet. No relationship was found between flow-dependent metrics like discharge, wetted width, or area at a suitable depth and WC use.

Moving Forward into the Extension
In addition to checking in on what we have learned about WC roost site selection as we continue to manage habitat for WC through the Extension, the Extension Science Plan also poses the following question to be addressed:

EBQ #4: What factors influence WC decision to stop or fly over the Associated Habitat Reach (AHR)?
EBQ #5: What factors influence WC stopover length within the AHR?
EBQ#6: Why is spring WC use of the AHR greater than fall WC use?

The nature of these questions may require different scales for WC decision-making. WC may utilize different criteria evaluated over different scales as they encounter the AHR in flight, as they descend to land within the AHR, and on ground as they decide on a specific roost location. To address EBQs and check in on WC roost site selection criteria, the EDO proposes a conceptual study design that considers these potentially different scales for decision-making when evaluating habitat selection criteria.

III. Conceptual Study Design Considers 3 Decision Contexts

a. In flight as encounter the AHR - Decision TO STOP OR NOT? = EBQ#4
b. In flight descending to the AHR - Decision: WHERE TO STOP?
c. On ground - Decision: ***WHERE TO ROOST?** – This is our 5-year check in for 2022.

* ***Priority for today's discussion***

For these analyses, the "biologically relevant scale" must be defined for limiting the spatial extent of the choice set of available locations. Additionally, the buffer for quantifying habitat characteristics surrounding each roosting and randomly available location must be defined. To help us define the scale for each of these contexts, we have used WC behavior and movements as captured by telemetered birds. We are not trying to redesign the entire study or methods of analysis. What we are trying to do is take advantage of better information provided by telemetry data to select an appropriate scale for the analysis. Initially we used what was visible to the human eye flying in a plane at a typical WC altitude. Now we will let WC movements and habitat use define the scale over which habitat is considered "available" for WC use, that is defining ***the scale of both the choice set of available points and the scale of the buffer around each use location and available location. We would also like to consider the benefits to using point-based vs. area-based measurements for in-channel variables (like unobstructed channel width, total channel width, and distance to nearest forest). Based upon the choices for spatial scale, we need to decide how many random available points to compare to our roost location.***

IV. Typical WC Movement and Use

Data collected during both spring and fall migratory seasons from Fall 2017- Fall 2021 from cellular telemetered individual WC, collected at 15-minute intervals during migration, were used to help inform scale of WC use. The Program's current data request from the Cellular Telemetry Tracking Partnership provides locational information covering a 62 mile (100 km) buffer surrounding the AHR from Lexington to Chapman, NE. This wider swath of data allows us to include WC that encounter, flyover, and stop along the AHR on the central Platte River (approx. 20 total Platte stopover events), but also along portions of the Middle and North Loup River (approx. 20 total Loup stopover events) and a few on other small riverine systems to total 52 riverine stopover events in the dataset.

Reducing uncertainty around scale for the choice set: Telemetry data tells the story of a typical WC flight path as it approaches the riverine stopover site. The flight paths leading up to the 52 riverine stopover events were evaluated to determine the trajectory of an original flight path prior to encountering the river, and any deviation from that original flight path upon encountering the river. These flight paths tell us something about how much of the landscape WC pass through and gather information about prior to landing. *The deviation distance from the original flight path can be used to inform the scale for the choice set of available roosting locations.* For each flight path we identified the first location point within 3.5 miles of the river (applying AHR boundary definition across all rivers). This was considered the 1st point of encounter with the river. From there we looked backward through time to identify the 2 sequential locations prior to encountering the river at least 15 minutes apart (gathering information from approximately 30 min prior to encountering the river). The straight-line direction connecting these two locations prior to 1st encounter with the river was defined as the trajectory of the original flight path. The deviation distance from this original flight path was calculated by drawing a straight line from the original flight path and perpendicular to the original flight path to the 1st on the ground use location and measuring this distance (Figure 1).

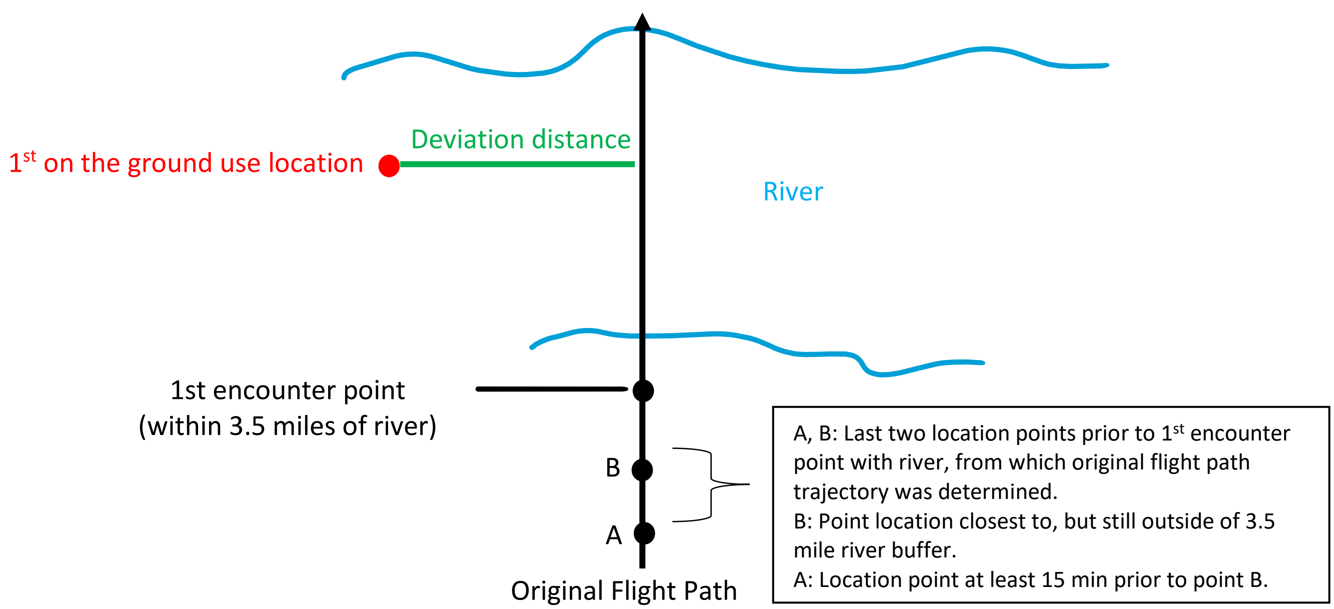

Figure 1. Calculation of deviation distance from original flight path.

There were 35 flight paths out of the 52 riverine stopover events for which we had enough locations prior to encountering the river to determine an original flight path. These 35 flight paths were included in the calculation of deviation distance. Deviation from original flight path to first on the ground use location varied from 0.1 – 8 miles, with a median of 2.15 miles and an average of 2.54 miles (Figure 2). That is, a typical WC that stopped on a Nebraska river system within our data grab sat down within 2 miles from its original trajectory. A few WC were observed deviating as much as 8 miles from their trajectory before sitting down on the ground.

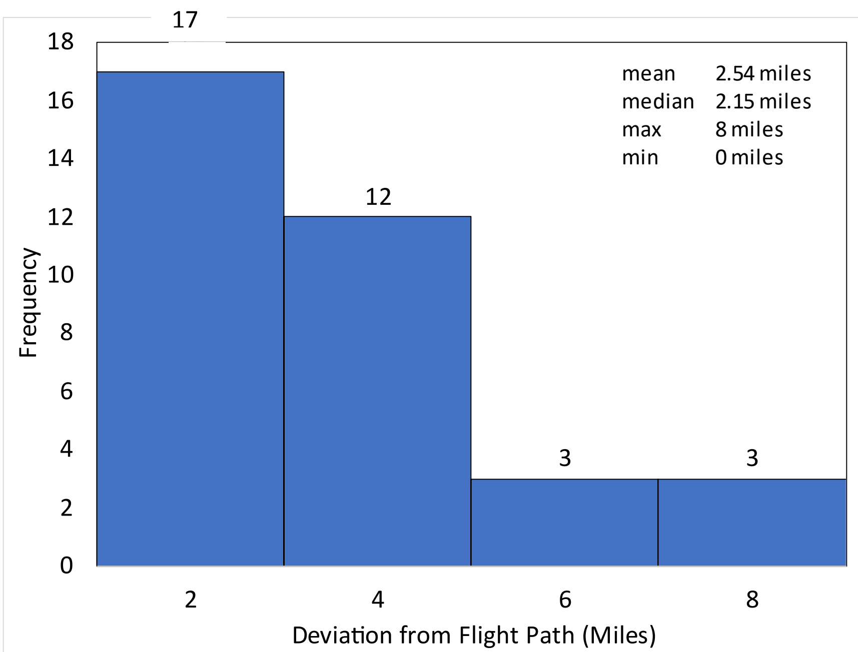

Figure 2. Number of WC stopover events with the indicated deviation distance (miles) from original flight path to first ground location within a stopover.

Reducing uncertainty around scale for the habitat buffer: We utilized the 52 stopover events in our dataset to reduce uncertainty about the scale of WC habitat use during a stopover. We used telemetry locations to answer the following questions relevant to our choice of scale for the habitat buffer in our analyses:

- When WC stop, how much of the landscape do they experience or use as they choose and utilize a roosting site?
- Is it different as they move through the habitat from one day to the next?
- Is this different for gathering information in-channel vs. off-channel?

Gathering information to address these questions helps us define the scale for the habitat buffer in our analyses.

Fifty stopover events had enough data to estimate a 95% autocorrelated kernel density to get an area of use for the entire stopover event. We used the point cloud area to back-calculate a radius for the habitat buffer, based upon the formula for the area of a circle (shape to be applied as the buffer for measurement of habitat characteristics). We calculated a radius for the point cloud around each first, unique on the ground in-channel use location including all ground locations (both in-channel and off-channel locations) over all days within the stopover. This area defined the total spatial extent of use for the entire stopover. We also calculated a radius for the point cloud around each first, unique on the ground in-channel use location for the 1st day of use only (includes all location points from initial point at time of arrival, thru roosting, to cutoff time associated with when aerial surveys of river channel are typically finished and when most WC have left river roost sites for the day (9 a.m.)). Then we calculated a radius for each subsequent 24-hour period of use to see if distribution of habitat use changed over stay length. As fewer stopover events occurred that lasted multiple days, the number of events with enough data points to estimate an area of use decreased with stay length.

We then filtered the dataset to include only in-channel ground locations (n=41 events between Platte, Middle Loup, North Loup, and Loup Rivers) and repeated the calculations of buffer radius to get total in-channel extent of use over entire stopover, 1st day extent of use within the channel, and for each subsequent 24-hour period following the 1st day.

Combined in-and off-channel radius of movement:

Over the entire extent of their stay WC tended to move over an area with a radius of 0.41 miles (median). This radius ranged from 0.01 – 5.71 miles, with an average of 0.77 miles (n=50 events) (Figure 2). Typical stopovers were for a single night only (32 of 52 stopover events stayed a single night) with only 20 stopover events of 2 nights or more. Radius of use over the 1st day tended to be 0.22 miles (median) (Figure 3). Individuals that stayed longer tended to have a wider radius of use, with a median 24-hour activity radius of generally less than 1 mile each day (except during the 5th day of stay).

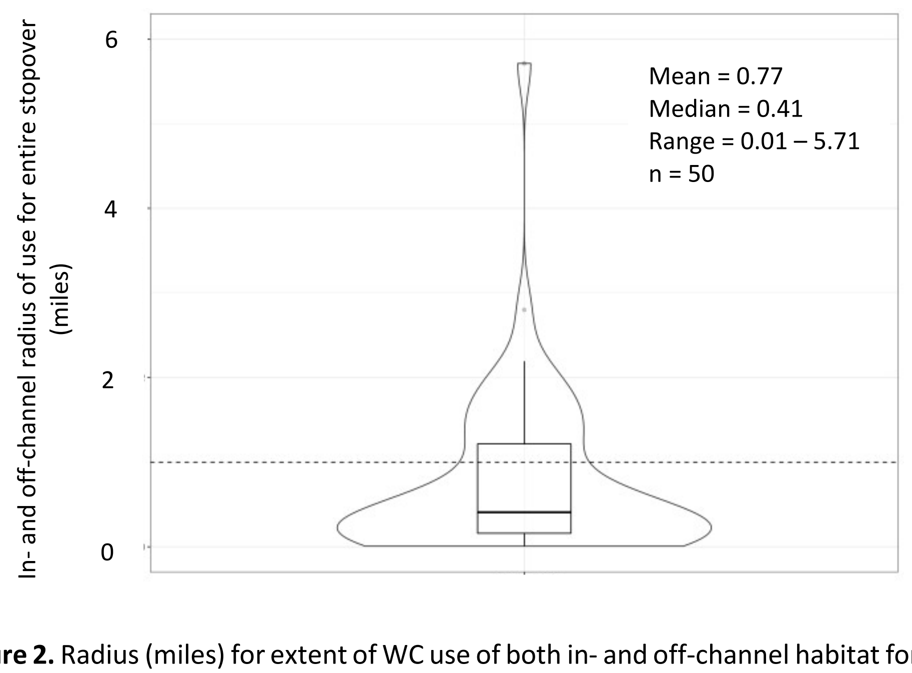

Figure 2. Radius (miles) for extent of WC use of both in- and off-channel habitat for entire stopover. Radius for a circular buffer calculated based upon area estimated by 95% autocorrelated kernel density (n=50 stopover events).

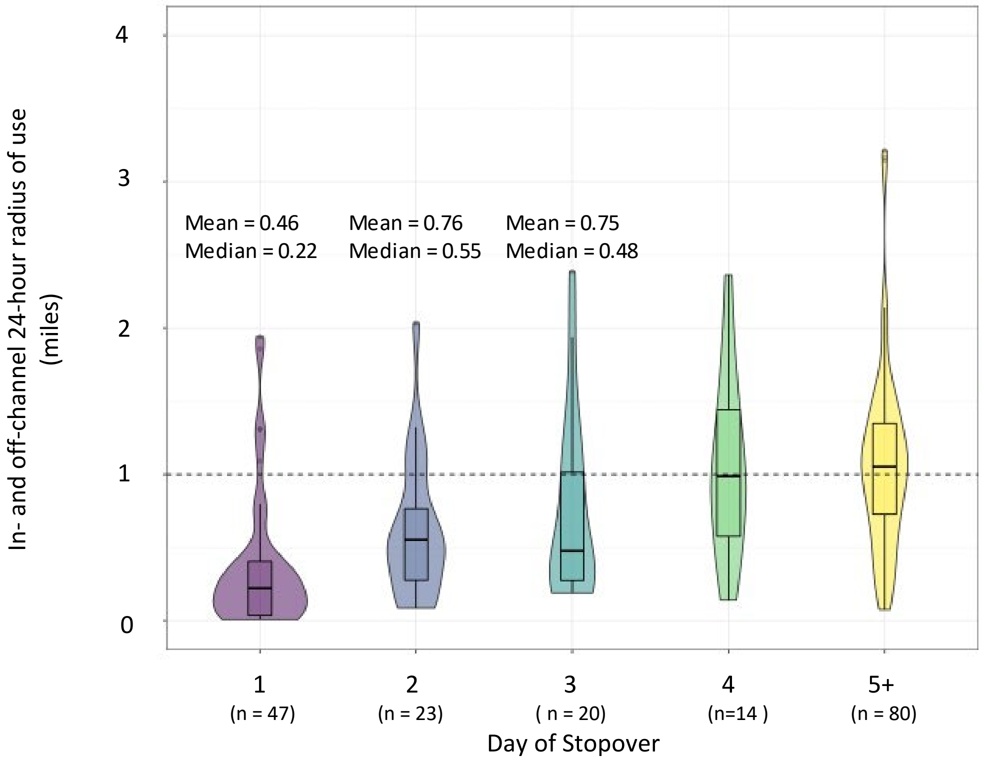

Figure 3. Radius (miles) for extent of daily WC use of both in- and off-channel habitat (by day of stopover). Radius for a circular buffer calculated based upon area estimated by 95% autocorrelated kernel density (number of stopover events utilized for each kernel estimate in parentheses below day of stopover).

In-channel radius of movement only:
Over the entire extent of their stay WC tended to move within the river channel over an area with a radius of 0.30 miles (median). This radius ranged from 0.01 – 1.49 miles, with an average of 0.48 miles (n=41 events) (Figure 4). Radius of riverine use over the 1st day tended to be 0.11 miles (median) (Figure 5). Individuals that stayed longer tended to have a wider radius of riverine use, with a median 24-hour activity radius of generally less than 0.5 mile each day (except during the 4th day of stay).

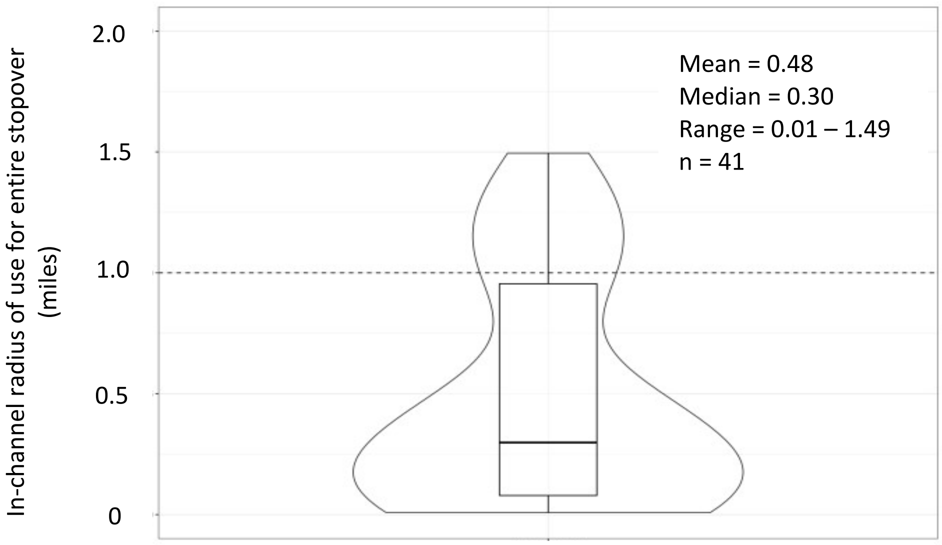

Figure 4. Radius (miles) for extent of WC use of only in-channel habitat for entire stopover. Radius for a circular buffer calculated based upon area estimated by 95% autocorrelated kernel density (n=41 stopover events).

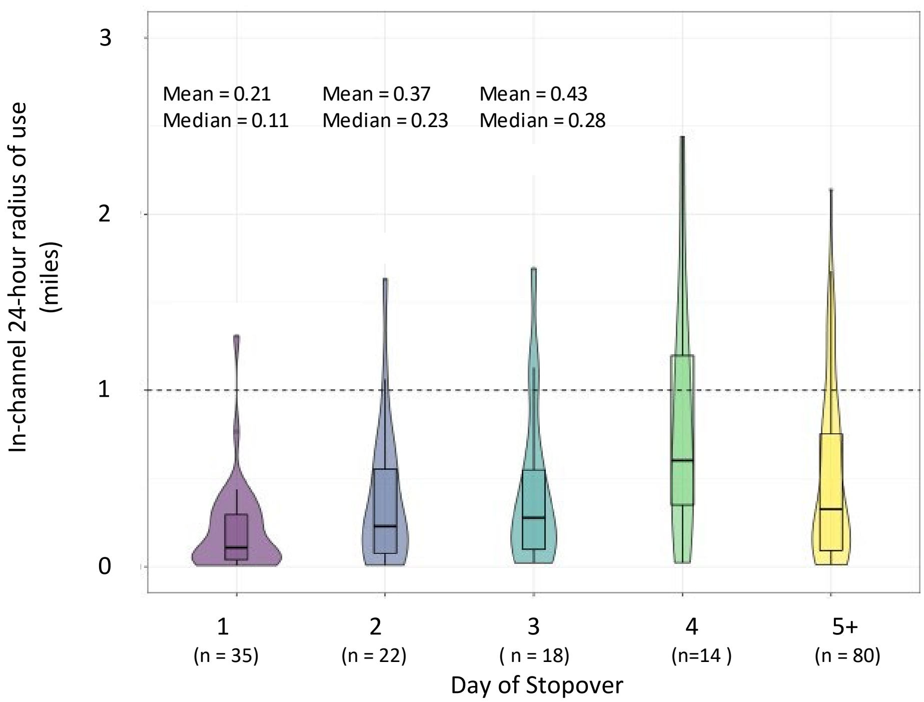

Figure 5. Radius (miles) for extent of daily WC use of only in-channel habitat (by day of stopover). Radius for a circular buffer calculated based upon area estimated by 95% autocorrelated kernel density (number of stopover events utilized for each kernel estimate in parentheses below day of stopover).

V. Applying the Information to Choose Scale of Analysis

Defining the Choice Set (availability) for the Roost Site Selection Analysis

The idea is to let WC behavior and movement patterns define the distance over which WC select use sites. The deviation distance reflects choice made over a WC relevant scale of demonstrable visibility and consideration (including energetic cost/benefit).

EDO Recommendation: The choice set of non-selected available sites will be drawn from within 8 miles (maximum distance of deviation from approaching flight path) either upstream or downstream from the first, unique, in-channel use location, including 16 riverine miles as available in the choice set. We are using the maximum deviation distance in this case to reflect the widest distance over which WC are documented to gather information within the AHR to make the "Where to stop?" decision to select an initial roost site.

Note for TAC discussion: The EDO would like to include side channels as well as the main channel when selecting random in-channel available points.

Alternatives:

- A suggestion was made to do the analysis twice: 1) as stated above with the 16-mile choice set, and 2) a second analysis with an 8-mile choice set to reflect the 4-mile deviation distance observed for the majority of flight paths (29/35). An 8-mile span for the choice set may reduce the heterogeneity of sampled points and reduce independence among sample points.
- Removing side channels from the available choice set is another option. Previous analyses appear to be driven by side channels in that results reflect more of what WC avoid rather than what characteristics of the main channel they select. By removing side channels from consideration your analysis will be focused on main channel characteristics (the focus of Program management) but does not consider the full range of habitat features WC have to choose from.

Defining the Habitat Buffer for the Roost Site Selection Analysis

For quantifying characteristics surrounding the use location or available point location, it is useful to ask, "What is the typical distance or range of movement or area utilized around any given use location?". This allows WC behavior to define what the bird experiences and chooses from around a use location as it is making the decision.

EDO Recommendation: We will use a habitat buffer with a radius of 0.41 miles around each first in-channel use location as well as the random in-channel points in the available choice set for quantifying habitat characteristics. The radius of the 360-degree buffer around each point was defined by the median radius of use of both in- and off-channel habitat by the majority of individual telemetered birds over the entire stopover period associated with a single roost site. As such it reflects the habitat most WC have experienced on the ground and about which they have knowledge for selection. It is a good proxy for the scale over which habitat may be evaluated on the ground to select roost sites.

Alternatives:

- A suggestion was made to do the analysis twice: 1) once with a habitat buffer of 0.41 miles (median) and 2) with a habitat buffer of 0.77 miles (mean). Using the wider buffer takes the movements of a few broader roaming WC into consideration but does not represent the typical movements of the larger number of WC observed. This alternative begs the question, how do you decide which result is more informative and should be used for decision-making after the fact?

- Focusing on information gleaned from in-channel patterns of movement only, the option was also presented to do the analysis twice: 1) using a radius of 0.30 miles (median) and again 2) using a radius of 1.49 miles (top of the range).
- Another suggestions was made to use two habitat buffers in a single analysis: 1) one reflecting more limited in-channel movements to quantify in-channel metrics (0.30 mile radius) and 2) a second buffer reflecting wider in- and off-channel movements to quantify off-channel metrics (0.41 mile radius). The EDO believes the difference in these two buffers is not enough to warrant the additional analyses and favors consistent use of the wider buffer.

VI. Area vs. Point-based Measurements of In-Channel Habitat Metrics

In previous analyses off-channel landcover variables were area-based, but all riverine habitat characteristics such as unobstructed channel width, wetted width, and unforested corridor were point-based. These variables were measured as the linear distance from the use point or random point, providing only a single measurement corresponding to a single point. We know that WC move around their roost location, and that a single location point provides only a snapshot. The suggestion was made to replace in-channel point-based metrics with area-based estimates that capture the range of in-channel conditions experienced by and available to a WC as it selects a roosting site. With the additional information provided by telemetry, we now see that the majority of WC move only about 0.11 miles within the channel around their roost site during the first day, with most WC staying only a single night. The question then becomes whether area-based estimates are necessary for capturing the variability that exists within this 0.11-mile radius through which WC move?

EDO Recommendation: Continue to use point-based in-channel metrics such as unobstructed channel width, total channel width, and distance to nearest forest as done for previous analyses but add area-based in channel metrics such as proportion of buffer with open water and proportion of active channel unobstructed by vegetation. Off-channel metrics such as proportion forest, grassland, and agriculture would remain area-based. The EDO believes that a point estimate for the linear distance metrics mentioned above will give the same answer as an area-based estimate given the small scale over which WC move within the channel. Additionally, for those metrics that might be more heterogenous at this scale, such as unobstructed channel width, the point where the WC was observed reflects WC selection better than the entire area around that point. Repeating the analysis with point-based in-channel metrics allows the additional 5-years of data to be added to an existing dataset and analysis, allowing for incremental assessment, comparison of results, and clearer interpretation of any changes in WC selection that may result. Maintaining consistent methods allows us to do the analyses in incremental time steps to identify if and when WC selection patterns changed and giving us a better chance of narrowing down why they may have changed.

Alternative:

- Calculate point- and area-based in-channel metrics using a 0.11-mile radius as a buffer around a few WC roost locations distributed throughout the AHR to determine whether they are correlated. This will help determine whether there is heterogeneity of in-channel metrics at this scale or not. If so, use area-based measurements for both in- and off-channel metrics to better represent the range of conditions experienced by and available to a WC as it selects a roosting site.

VII. Number of Available use Locations in the Choice Set

The number of random available locations within the choice set is a function of the heterogeneity of the habitat metrics they are designed to capture. The more heterogenous the landscape, the more points you will need to capture this. However, the 16-miles of river within which your random points must fall limits the number of points you can include before points are close enough to one another often enough to be non-independent samples of this variability. As the number of random points increases, the probability of spatial autocorrelation between sampled points also increases.

EDO Recommendation: Continue to use the 20 random points drawn from the available choice set as has been done in previous analyses. The scale for the choice set has not changed appreciably for this analysis (assuming we move forward with the 16-miles) and previous analyses showed little decrease in variability of one hydraulic metric as the number of samples increased above 20 (Howlin and Nasman 2017). Again, there is added benefit to maintaining methods similar to previous analyses.

Alternatives:

- Test 10, 20, and 30 random points to determine if increasing sample size reduces mean error of habitat metrics
- A suggestion was made to move away from random sample points (from which point-based measurements are made), replacing them with complete coverage (area-based measurements) of the 16-mile choice set. Divide your 16-mile choice set into slices, one containing the 1st on the ground riverine location as the use site, the rest as the non-used available habitat about which you have complete information. The size of the slices would be based upon the radius of the point cloud around the use location. Consecutively sampled slices will suffer from spatial autocorrelation, violating assumptions of the analysis based upon a random draw of available habitat.

VIII. EDO Recommendation for Moving Forward

Compare habitat characteristics surrounding first, systematic, unique, in-channel, ground locations obtained from PRRIP systematic aerial monitoring versus 20 random available in-channel locations within 8 miles upstream and downstream of this point. Utilize a 360-degree 0.41-mile radius around each location to quantify habitat characteristics. Continue to use point-based metrics for linear distance in-channel metrics and area-based metrics for off-channel landcover metrics. Add area-based in-channel metrics such as proportion of buffer with open water and proportion of active channel unobstructed by vegetation. Utilize the same analytical framework as done previously, adding additional roost locations from 5-years of monitoring to this analysis to examine incremental changes in WC riverine roost site selection.

References

Baasch, D.M.; Farrell, P.D.; Howlin, S.; Pearse, A.T.; Farnsworth, J.M.; Smith, C.B.. 2019. Whooping crane use of riverine stopover sites. PLoS ONE 14(1): e0209612. https://doi.org/10.1371/journal.pone.0209612

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