Platte River Recovery Implementation Program (PRRIP -or- Program)

Independent Scientific Advisory Committee (ISAC) – Fall 2022 Issues/Questions

ISAC comments are in blue with the main author identified by their initials.

The PRRIP Executive Director's Office (EDO) prepared the following set of issues/questions for the ISAC to consider in advance of, during, and after the Fall 2022 ISAC meeting in Kearney, NE. These issues/questions represent the leading edge of scientific and technical challenges the PRRIP is beginning to wrestle with during early implementation of the Extension Science Plan. The ISAC questions are not necessarily as specific as those typically posed, rather they are presented as thought questions for the ISAC to help engage in better discussions with the EDO and Technical Advisory Committee (TAC) during the Fall 2022 ISAC meeting. The EDO does not expect the ISAC to develop the typical written response and associated presentation related to these questions; rather, we hope this spurs conversation among ISAC members about these issues and helps to generate more specific questions to be addressed during the 2023 Science Plan Reporting Session in February 2023.

<u>ISSUE #1 – Evaluation of Vegetation Response to Germination Suppression/Inundation Flow Releases</u>

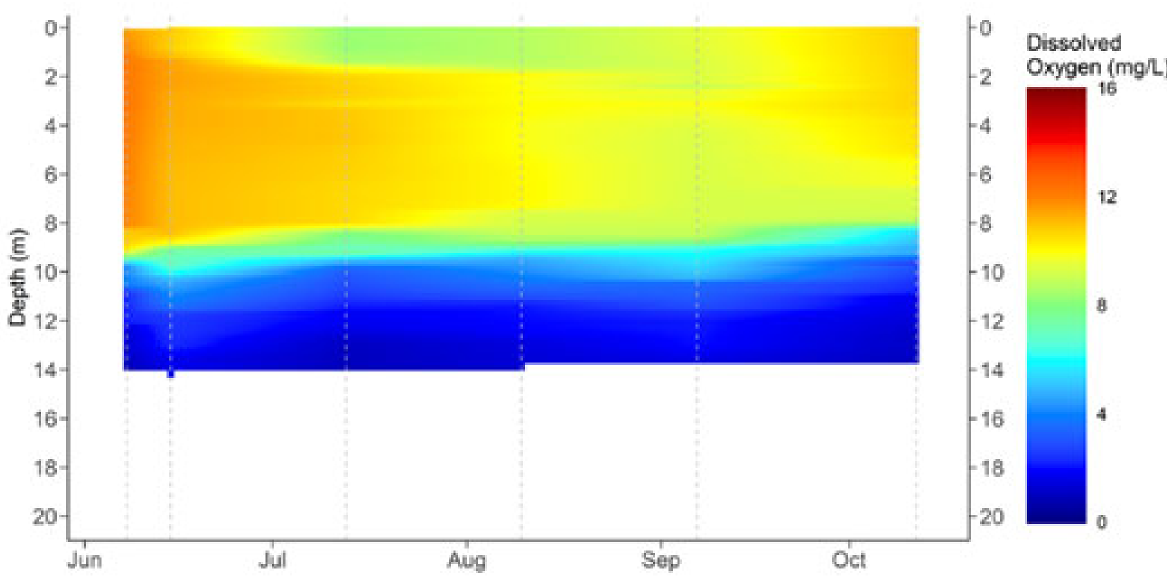
Aerial imagery captured in June provides information on area covered by water, bare sand, and vegetation of various heights. October imagery captures what WC will see while they are here in the fall following June flow releases. Topo bathymetric LiDAR is acquired only in the fall each year, and, in combination with river gage data and our 2D hydraulic model, helps us to get a good sense of how much of the river channel is covered by June flow releases. These efforts give us system-scale spatial coverage but leave gaps in temporal coverage. We are using time-lapse cameras and exploring potential for drones to fill in these temporal gaps with regard to water coverage and vegetation response, but at only a few locations chosen for their representation of the reach.

ISAC QUESTION: What short time scale dynamics can be captured this way that are of interest? How can the imagery be effectively analyzed to produce data for these variables of interest?

<u>DM THOUGHTS</u>: It's worth carefully phrasing the hypothesis that you're testing (e.g., *Germination suppression/inundation flows will prevent an increase of more than X % [measurable effect size of interest] in the area of these vegetation metrics [to be specified]*). It's also worth drawing out the functional relationships / data analyses that you'll use to test this hypotheses and the outcomes which would imply acceptance or rejection (or degree of belief in a Bayesian approach). This will help you to assess what data you're missing and need to collect.

For example, one approach to testing this hypothesis might be to quantify (on the x-axis) the *signal* from the suppression / inundation flows (perhaps duration in hours of water coverage > z cm for a given segment of the channel) as well as (on the y-axis) the *response* in vegetation metrics for that channel segment, from LIDAR (Δ area of various forms of vegetation). The signal from the suppression / inundation flows will diminish as you move downstream. I would expect that if you graphed Δ vegetation area vs. longitudinal position it would have a positive slope (i.e., areas furthest upstream with maximum inundation might show a decrease in vegetation area [negative number], areas a bit further downstream might show no change in vegetation area, while areas furthest downstream would receive the least amount of benefit from inundation flows and would show an increase in the area of various vegetation metrics. An alternative hypothesis is that drought is a good thing for limiting the growth of vegetation, and the driest areas would show decreases in vegetation area. Of course there will be variation within each segment across types of vegetation (e.g., cottonwood vs. Phragmites), so there would be a graph for each vegetation metric. Having articulated one form of data analysis to test the hypothesis, this tells me that I want to document the *signal* of the suppression / inundation flow as accurately as possible, as well as the year on year vegetation response metrics. I also need to understand the uncertainty in both the signal and the response, and the spatial stratification which would be most appropriate (small enough channel segments to ensure homogeneity in the signal and the response, large enough to capture enough vegetation types of interest). I think that the spatial variability in X (flow) and Y (vegetation change) will provide useful information, even though the X's (flow) are correlated, and not independent.

As an aside, it occurred to me during Seth's summary of recent years' inundation flows that it might be helpful to illustrate flows by graphing colored contour plots of the estimated flows at each point along the river (date on x-axis; distance downstream on y-axis). This kind of plot is commonly used by limnologists (example from a meromictic / non-mixing lake below showing interpolated oxygen levels at each depth and date, based on measurements taken on the dates shown by the dashed lines). You could then use the data from this graph to assign a flow signal to each location on each date for the analyses described above.



Jason Farnsworth raised an excellent point during the meeting, which is that it may be easier to first cluster into groups the segments which showed similar vegetation responses (i.e., the Y-axis), and **then** look for what combinations of covariates (the X-axis) best discriminate between these groups. You could use discriminant analysis, perhaps with some non-linear covariates (e.g., the cube of flow to represent stream power to erode banks). Discriminant analysis is however constrained to linear combinations of covariates. Perhaps other statistical methods allow non-linear combinations of covariates if there's a physical / biological basis for such formulations.

EDA As the question is proposed, there is a suggestion that the program feels the need to observe and analyze the entire AHR, in order to answer this question. Is it, in fact, correct that identifying representative reaches or sections of the channel is not feasible? Perhaps, there are good arguments why the entire AHR must be concerned, however I feel it is worthwhile to consider this assumption. David Marmorek's comments concerning the benefit of framing the question more specifically, includes this issue as well as others. The design of a sampling approach in practice involves choices; eg. covering an entire reach in less detail and less frequently versus greater geomorphic hydrologic and vegetation specificity (as well as perhaps more frequently). Is it possible to identify the circumstances under which the loss of crane habitat due to germination is most likely to occur? What geomorphic features are most likely to be colonized by vegetation and reduce effective channel width? Here, I am thinking of an individual channel bar or bank. These features are not flat, hence they are inundated to different depths, for different durations, and portions may be affected to various degrees of scour and fill. In summary, identify those portions of the channel where objectionable encroachment is most likely, and concentrate on them. Perhaps, a dozen or so sites, covering a few to several acres. Drones and or repeatedly occupied camera sites should be helpful, however as I have suggested applied more frequently to smaller, more possibly critical locations.

MT This question of spatial versus temporal resolution is a great one and a very common one on large braided rivers. Twice annual aerial imagery and annual LIDAR constitute an impressive data set! I think it is worth taking a step back and examining whether it is being fully exploited, clearly identifying what has been gleaned from this dataset, and clearly identifying what remains poorly understood (Ned's comment) in order to identify if /what kind (e.g. resolution) of additional monitoring is necessary. I entirely agree with Dave that this would be best achieved by posing clear hypotheses regarding germination suppression flows that are testable with the data available: area covered by water, veg, sand from aerial images and channel topography from LiDAR. Comparison of June and October imagery are sufficient for evaluating how effective germination suppression flow releases are from a planform perspective as well as for validating the 2D hydraulic model. The statistics of channel topography from the LiDAR should confirm the planform trends but are essentially a bonus. Their greatest added benefit to me is for the following (which I would be happy to discuss in more detail with the new geomorphology hire):

A. Updating the bed of the 2D hydraulic model annually (no doubt already being done)
B. Conducting differential DEM analyses in order to identify how sediment flux (e.g. bed mobility) varies along the reach and how this relates to channel morphology (e.g. laterally constrained versus wider reaches) and in turn impacts channel - vegetation dynamics.
C. Validating a 2D morphodynamic model: this could be an interesting direction for the program to consider. More and more 2D models are available with morphodynamic capabilities as well as vegetation.

Separately, I think it could be insightful to integrate the 2D hydraulic model data in a statistical habitat model to study PS habitat, e.g., Lamouroux N., Capra H. (2002) Simple predictions of instream habitat model outputs for target fish populations. Freshwater Biology, 47, 1543-1556.

JH: Minor suggestion for Seth: in your plot of date vs flow for 2020, 2021, 2022: on the right-hand side of the plots, state the number of days above 1500 in the 45-day window. Having that information readily available would be useful for these visual comparisons.

ISSUE #2 – Evaluation of Inundation Flow and Herbicide Effectiveness on *Phragmites*

Our study design is blocked over three reaches and by herbicide application or no-spray zones. *Phragmites* study plots were selected at random locations within that blocking to represent the variability in *Phragmites* patches (distribution, size, density, etc.) and estimate attainable benefits under current management (get information on effectiveness of *status quo* management). After receiving June 2022 herbicide application polygons, we noted the "search and spray" herbicide application largely missed our *Phragmites* study patches within the herbicide application block. In addition, only about 1/3 of study patches are on-channel and at low enough elevations to be potentially impacted by inundation flows, providing less information about its effectiveness to delay channel encroachment by *Phragmites*. The response of on-channel vs off-channel patches to herbicide is likely different as well. In this random selection of patches within a block small, sparse and large, dense patches have equal chance of inclusion in the study design, but large, dense patches are more likely to be problematic and receive herbicide. We are considering modifying our sampling design to include bank line surveys and/or polygon-informed target spraying of *Phragmites* study patches. This approach may help address specifically how *Phragmites* responds to flow releases and water but will not necessarily provide cost/benefit of these management actions that are representative of the system as a whole.

ISAC QUESTION: Are there alternative study designs that might better address both representativeness and targeted learning? What are the assumptions, requirements, and limitations of these alternatives?

46 **DM THOUGHTS:** Again, start with a clearly worded hypothesis (e.g., *Suppression / inundation flows have no benefit in preventing vegetation encroachment (no biologically significant increase in vegetated area) unless the flow-wetted areas have also received herbicide spraying*). From a management perspective, a practical question would be: *"If we're always going to spray all areas anyway, why bother testing this hypothesis with contrasts in herbicide application?"* You could still evaluate (as you do under ISSUE #1) how the benefits of suppression / inundation flows vary across different densities of *Phragmites* in nearby channel segments which receive a similar signal of suppression / inundation flows. If however the GC and EDO were considering *not* spraying some areas, then doing this experiment with contrasts in spraying is more valuable. What alternative spraying actions are being considered? What design contrasts will best inform those alternative choices? If the purpose of these contrasts is to improve a management tool, then what design contrasts would be most helpful for improving that tool?

47 I think you need to talk with the pilots to determine how precise they can be with their spraying, and therefore the minimum size block you can consider. Say it was a 500m block. Then you need to look at your map of *Phragmites* with 500m rectangular puzzle pieces and design a study which would give you the most helpful contrasts to test your hypothesis (i.e., a research study, but not spatially representative). OR, you could use a systematic randomly stratified approach (random start, then 500m steps, alternately assigning treatments of SPRAY or DON'T SPRAY). I would defer to Jennifer…

JH: Kudos to Malia for designing a study and collecting data very soon after she was hired. The original 157 sites might be useful for examining effects over time if you visit the same sites each year. It will be important to consult with a statistician before designing the 2023 data collection about how to best use the original sites and how to create a design that better meets your needs. I suggest that you consider other types of study designs for future studies. Dave's suggestions to start with the hypothesis is the most important first step.

I don't recommend the random study blocks design approach. There are multiple publications that show that this is not an efficient design for your type of study. Given that phrag often spreads along the shoreline, shoreline transects of targeted areas may be appropriate. Below I list a few references that might be useful to improve the study design.

1. Simple study designs in ecology produce inaccurate estimates of biodiversity responses. Perhaps consider a Before–After Control-Impact design, for example.
2. Spatially balanced design (there may be more modern methods available)

- Stevens Jr, D. L. and Olsen, A. R. (2004). Spatially balanced sampling of natural resources. Journal of the American Statistical Association, 99(465):262-278.
- Olsen, A. R., T. M. Kincaid and Q. Payton (2012). Spatially balanced survey designs for natural resources. Design and Analysis of Long-Term Ecological Monitoring Studies. R. A. Gitzen, J. J. Millspaugh, A. B. Cooper and D. S. Licht. Cambridge, UK, Cambridge University Press: 126-150.
- GRTS package in R : implements the Generalized Random Tessellation Stratified design from Stevens and Olsen.

3. Key issues in rigorous accuracy assessment of land cover products (has some relevant references)

Also, given comments during that Thursday field trip, it will be important to include the date of spraying and the type of chemical used as part of your analyses since the chemicals have different impacts on the phragmites.

DM comment: The study designs that Jennifer recommends above (Stevens and Olson 2004, Olson et al. 2012) are rotating panel designs, similar to what was originally recommended by Lyman MacDonald of WEST for system-level monitoring of geomorphology in the 2007 AM Plan for the Platte Program (see pdf pages 214-222 in Appendix F of the 2007 AM Plan. Anchor points were established at 400m intervals:

> “The anchor points sampled in any year under this protocol will be components of a pure panel and a rotating panel of sites. A panel is made of a group of sampling sites that are always visited at the same time. The pure panel will consist of a group of sites that are visited at each sampling time [year]. The rotating panel will consist of 4 groups of sites, with only one group visited at each sampling time and each group revisited once every 4 sampling times [year].” [From pdf pg. 214 of the 2007 AM Plan (Appendix F)]

The EDO and ISAC realized during the First Increment that this rotating panel sampling design was not helpful for characterizing sediment balance, since it didn’t capture finer scale spatial variability. Green LIDAR provides a census of channel conditions and is much more helpful for evaluating changes in sediment storage, though even Green LIDAR has limitations in evaluating sediment augmentation, as Ned notes under ISSUE #3. So, a question I have for the vegetation survey study design is: “*what’s the target population of interest?*”. I don’t think it’s vegetation over the entire Associated Habitat Reach (AHR). It would seem that the target population is a subset of areas where vegetation encroachment is a concern, and that points within these areas will either be treated (inundation flows, spraying, both) or be some form of control sites (no flows, no spraying, or neither). So, perhaps it makes sense to identify a subset of areas where vegetation encroachment is a concern, and then develop a GRTS design for that subset of the AHR.

JH comment: Good insights from Dave M. GRTS didn't work for sediment balance and general vegetation surveys, but it might work for evaluation of phragmites only. I suggested GRTS as one idea to have Malia start thinking about study design alternatives. There are many other designs that can be useful. The references I provided above are a first step in that consideration. Most importantly, it is imperative to consider the goals of the study before considering which design to use.

ISSUE #3 – Sediment Augmentation

We have implemented full-scale sediment augmentation (60,000-80,000 tons annually) from 2017-2021. An evaluation of effectiveness of this management action for halting the narrowing and incision in the south channel downstream of the J-2 hydropower return has been scheduled for late 2022 with the intention of determining whether sediment augmentation is necessary to create and/or maintain suitable whooping crane habitat (Extension Big Question #3). We are currently developing methods for quantifying the rate of downstream migration of channel incision prior to and following sediment augmentation. System-scale remote sensing efforts provide topo bathymetric LiDAR in tandem with aerial imagery. The combination of LiDAR informed elevation data, field measurements, and imagery enables us to calculate as-built augmentation volume, identify aggradation and degradation trends, and identify changes in channel slope, wetted channel width, and average channel width.

ISAC QUESTION: Can you suggest other methods or metrics we might want to consider for addressing how sediment augmentation below the J-2 return is contributing to sediment balance below the Overton bridge to maintain suitable WC habitat at Cottonwood Ranch? How effective has sediment transport been following augmentation?

DM THOUGHTS: Again, start with a clearly worded hypothesis (e.g., *The total area of suitable WC habitat [or some metric of sediment balance] at these channel segments (below Overton Bridge, Cottonwood Ranch, etc.) has been significantly improved by sediment augmentation below the J-2 return.)* As with the suppression / inundation flows, one would expect both the signal of sediment augmentation and the response to that signal to diminish as you move downstream (or that the signal will be diluted by other tributary inflows). To converge on methods and metrics, I would ask the following questions:

a) What values of sediment / channel metrics would provide the strongest evidence of downstream benefits from sediment augmentation below the J-2 return?
b) What values of sediment / channel metrics would provide the strongest evidence of no downstream benefit from sediment augmentation below the J-2 return?
c) What LIDAR slicing, metrics and data analyses would provide the clearest differentiation between condition a) and condition b)?

Ideally, the analysis would document the spatial extent of benefits (i.e., clear signal of sediment augmentation, and clear response in sediment balance or WC metrics), and where those benefits diminish to zilch.

EDA: I concur with Dave's suggestions and will add the following. The fundamental issue is whether the river bed degradation (and associated channel narrowing) is propagating down the south channel beyond the point of augmentation. It may be helpful to consider the relative magnitude of augmentation, 80,000 tons per year, spread uniformly across a reach 1 mile in length and 500 ft wide. The average thickness would be 0.20 ft., which would be difficult to measure accurately over an uneven surface, year to year. The south channel is `~ 7 miles long. Hence, the augmented volume in a year would only be about 0.03 ft, if there was no downstream transport. The current annual volume of augmentation when distributed along the south channel is too small to be measured with any confidence over relatively short periods, a year, 5 years, or a decade. The current volume may be effective in maintaining the reach downstream of the Overton Bridge, but we won't know for some time.

Some perspective; the reach downstream from the Overton Bridge contains some of the most utilized crane habitat in the AHR. It is really important. The cost of annual augmentation, ~$300K, seems like a good investment even if there is considerable uncertainty.

An alternative approach to consider: Currently, the augmentation is being made upstream, relatively near the J-2 return. It is understandable to focus the augmentation effort at the point of the problem, i.e. clear water return. There is crane habitat, that is, suitable channel width and some usage, however, it's towards the downstream end of the south channel. Rather than augmenting with X tons of sediment, could the program focus on making and improving crane habitat through the south channel by widening the active channel, i.e. by pushing in bank and terrace material, and working upstream to extend the habitat that now exists. Yes, there is sediment augmentation, but think about it as constructing crane habitat through channel widening. The difference is perhaps subtle, but the program would have new habitat to show while protecting the downstream reach.

MT I fully agree with Dave's suggestions, and I really like Ned's approach to thinking about this restoration effort as well as the limits of what can be seen in the data. Not much more to add at this stage. Regarding my comment [about using the standard deviation to construct a metric] at the meeting, I was thinking of an interesting non-dimensional parameter proposed by Liebault et al. 2013, BRI* (standard deviation of channel topography normalized by channel width), that has proven to be a successful indicator of whether sediment supply is sufficient to maintain braiding or insufficient, in which case the channel is expected to narrow and incise. The study was on gravel-bed rivers but it could be an insightful parameter to compare longitudinally along the south channel (and along the AHR reach in general) and before and after augmentation.

Liébault, F., Lallias-Tacon, S., Cassel, M. et Talaska, N. (2013) Long Profile Responses of Alpine Braided Rivers in Se France. River Research and Applications, vol. 29, n°10, p. 1253-1266.

ISSUE #4 – Whooping crane Roost Site Selection Analyses

The PRRIP manages on-channel whooping crane (WC) habitat based on habitat suitability criteria derived from resource selection analyses. These analyses utilize first observed on-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). An update of this analysis is scheduled for 2022 to incorporate an additional five years of data (2017-2021). The current check-in is designed to address a First Increment Big Question – Do WC select suitable riverine roosting habitat in proportions equal to its availability?

We are using explanatory variables and a resource selection analysis to be comparable with previous analyses for evaluation of possible changes in roost site selection criteria over time. 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 discrete-choice 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.

ISAC QUESTION: In addition to that, is there a different type of model structure or analysis that might better answer our question?

DM THOUGHTS: Since I don't know enough about "discrete-choice resource selection function estimation frameworks", I would defer to other ISAC members, especially Jennifer Hoeting, Aaron Pearse and David Galat. I think it's important that as you evaluate alternative methods you think hard about the small sample sizes of WCs. Can you do a power analysis to determine if you have enough birds to draw meaningful conclusions? Do you need to reduce the number of habitat types to maintain a reasonable number of degrees of freedom in the analysis?

JH: Some suggestions about steps to take for this analysis with the latest data: First, repeat the old discrete-choice analysis including the new data. That way you can compare the results before and after the new data on the same scales. Do that before you fit the new model with the added metrics. You can't reliably compare the new model to the old model results so that's why I'm suggesting this approach.

EDA: My comments here apply to both Questions # 4 & # 5 and touch on Dave's comment in ISSUE # 1 regarding an alternative hypothesis for droughts. Our visit to the Chapman Complex was an eye opener and raised a number of questions. Michal and I had a very helpful conversation, which led to the hypothesis developed below. The Platte River between Chapman and the Loup River confluence appears to have many reaches that are more than 1000 ft wide, some to almost 1500 ft. I have looked at Google Earth images as well as the site we visited. I understand, however, that this segment is not prime crane habitat. (Is that correct?) The Program has some interest in the Chapman to Loup River segment, though this portion of the Platte does not seem to get as much attention from either crane's or the Program. The Chapman to Loup River segment has plenty of wide reaches, i.e. vegetation encroachment does not appear to be so aggressive in this segment compared to the North Platte to Kearney segment. Why? Is it that the Chapman to Loup River segment is dry (mostly) for a few months each year? See Dave's comment about drought under Question # 1. Given that the channel width seems to make the Chapman to Loup River segment ideal habitat, why is this reach not used by cranes? The answer might be the same, it is dry during crane migration time. Is this correct? An effort to understand why the Chapman to Loup River has many wide reaches, but does not attract crane's seems to offer two opportunities, one scientific and one practical. If the Chapman to Loup River reach is too dry for much encroachment of vegetation and too shallow (i.e. dry) for cranes, then there is a long channel gradient of channel widths and water depths from Kearney to below Chapman that encompasses the conditions central to Questions # 1, 4 and 5. It would appear that there is a natural experiment to observe. I expect that the Program is already well aware of the downstream trend to a drier channel, however the opportunity to investigate 1) the effects of inundation depth and duration on germination, and 2) water depths preferred by cranes is, perhaps, being overlooked. Turning to the practical opportunity. If the generally greater unobstructed channel widths are, in fact, the result of a (at times drier channel) then one may hypothesize that there is a hydrograph, i.e. distribution of flow magnitude through the year that, will minimize vegetation encroachment, maximize channel width, and provides sufficient depth of flow during the crane migration. The characteristics of such a hydrograph should be observable through the Kearney to Loup River reach, and there may be an opportunity to design and "engineer" a favorable hydrograph that will expand crane habitat, i.e. a somewhat drier channel downstream from Cottonwood Ranch, but with sufficient flow during the crane migration.

MT Thank you, Ned, for summarizing this perfectly. I fully agree that there is a natural experiment here that is worth making full use of and that it behooves the program to consider the availability of water from all aspects in terms of vegetation dynamics. There may very well be a Goldilocks "just right" condition that permits it to thrive and that both too much and/or too little prevent colonization. We touched on this idea in a study on braided rivers draining Mount Pinatubo in which there is an extreme difference in water availability between wet and dry season: (Gran et al. 2015). And rivers in the desert in Israel are all braided!

Gran, K. B., Tal, M., Wartman, E.D., 2015, Co-evolution of riparian vegetation and channel dynamics in an aggrading braided river system, Mount Pinatubo, Philippines. Earth Surf. Process. Landforms, 40, 1101–1115. doi: 10.1002/esp.3699.

AP: The analysis presented is appropriate and supported by the current state of the literature. Specifically, this type of analysis considers selection of different river reaches, given that it ultimately decides to choose the river (your choice set only includes different river sections). This does limit your inference but plays nicely with the next analysis you are preparing (why do cranes choose the river or fly over). Finally, I agree with other ISAC members that emulating the past analysis with additional data is good practice. After repeating the analysis, you might consider adding in a few extra covariates into the models. I would focus on potential disturbance that might otherwise make good habitat used less than one might expect. Distance to river bridge, distance to adjacent roads, and distance to homes/buildings (likely the hardest to get) might be potentials. The key here is not that one would attempt to manage or alter these factors, rather one would just be taking these into account along with the things that can be manipulated.

As I said at the ISAC meeting, some consideration might be given to birds/groups that are associated with sandhill cranes vs. birds/groups that are primarily or exclusively whooping cranes. It isn't that I would discount whooping crane locations with sandhill cranes, but I might expect them to be at sites that are larger to accommodate the sandhill crane flock. In these situations, the whooping cranes may have not been the ones to make the actual choice to be at a location – they may have chosen the site simply because they are moving with the sandhill crane flock (they chose to be with the birds rather than choosing roost locations).

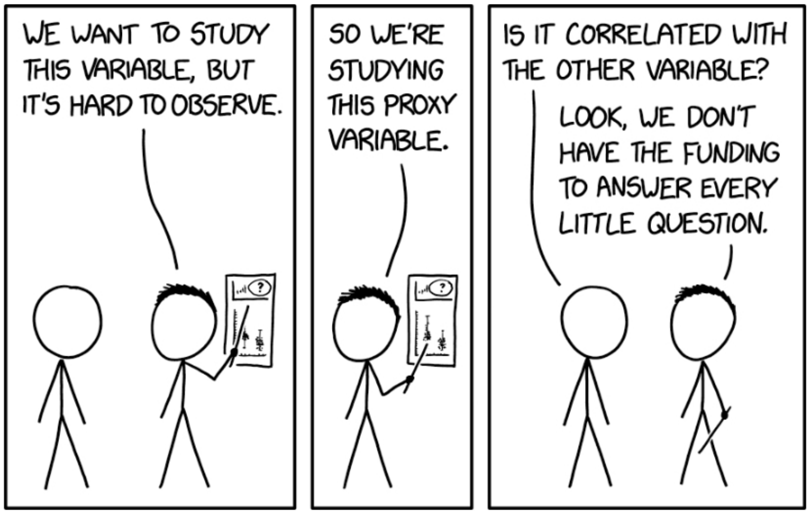
I would suggest giving this paper a look. Northrup, J. M., E. Vander Wal, M. Bonar, J. Fieberg, M. P. Laforge, M. Leclerc, C. M. Prokopenko, and B. D. Gerber. 2022. Conceptual and methodological advances in habitat-selection modeling: guidelines for ecology and evolution. Ecological Applications 32(1):e02470. 10.1002/eap.2470

ISSUE #5 – WC Stopover vs Flyover Corridor Wide Analysis

We are just beginning to explore the potential for a collaborative agreement with the WC Telemetry Tracking Partnership. We would like that to include a collaborative approach toward data analysis so both parties get their questions answered. The Extension Science Plan defines Program relevant explanatory variables with the focus being on flow. For the PRRIP Associated Habitat Reach (AHR) we have detailed information to support modeling efforts to determine how flow translates into wetted widths and depths, but we will not have that type of information for other river systems. The relationship between river flow and suitable WC habitat is not the same across river systems.

ISAC QUESTION: How do we translate (or, how useful are) the more general explanatory variables that are applicable over a wider scale of analysis (like wetted width, area covered by open water type) into specific learning for central Platte River flow management? What river flows are likely to reduce the probability of a WC stopping on the central Platte River?

DM THOUGHTS: Determine the set of proxy flow variables (e.g., wetted width) that are best correlated with flows in the Platte AND are widely available in the much larger data set of the WC Telemetry Tracking Partnership. Explore whether WC stopovers are correlated to the proxy flow variables in the larger data set. If they are not, then it implies that WC stopovers in the Platte (as well as in other rivers) are not likely to be correlated with flows. If the proxy flow variables are correlated with stopovers in the larger data set (perhaps a parabolic relationship) then you can work backwards to determine the range of flows which would influence WC stopovers in the Platte. My guess is that the range of flows in the Platte which would affect WC stopovers will be larger than what the Program can provide, but well within what nature can provide.



AP: An initial idea would be to concentrate on wetted width (shortest bank-to-bank measurement) of non-river stopovers. Given the hydrologic dynamics of wetlands, I would think that one would need to either visit sites right after whooping crane use or have access to decent resolution satellite imagery to get quality and timely data on wetted width. We did field visits for a few years (Program has those data). One could attempt a repeat of those field methods, but we found them difficult to implement (for example, securing landowner permissions in a short period of time). Extracting information from satellite data would be less time consuming, although I might suggest limiting spatial scope to reduce effort.

Considering expanding the analysis to flyover/stops in other river systems might alleviate some of the issues presented. Clearly, you still don't have detailed knowledge of these systems like you do at the Platte, but the systems are more comparable in that they are rivers. Satellite data or field visits to specific river systems might be as or more fruitful than trying to make comparisons with other wetland types.

This paper has some good food for thought regarding stopover site use: DOI: 10.1111/brv.12839
A final random thought: Have you given any consideration to birds that fly around the area of interest? Some use the Platte in these areas or fly over, just not in the reach of interest. These data are not as clean-cut as actual flyovers but may serve some purpose.

<u>ISSUE #6 – Climate Change</u>

The availability of water, how much we need, our ability to deliver it, and how the timing and quantity of water impacts vegetation and channel conditions are the focus of the Extension Science Plan. In addition, we continue to evaluate how WCs respond to this (now working over a corridor-wide scale). All of these analyses are done using long term datasets when possible so we can identify more recent changes (check-in on First Increment learning). We anticipate developing and implementing a Structured Decision-Making (SDM) process late in the Extension to integrate information and identify and evaluate tradeoffs among water uses and target species.

ISAC QUESTION: What is missing from our science to help the Program plan for climate change going into Second Increment Negotiations?

DM THOUGHTS: Good that Brian Bledsoe is here. I would do a CRIDA (Climate Risk Informed Decision Analysis - https://en.unesco.org/crida). Explore a very wide range of flow conditions, informed by GCM output. What series of drought years / extreme floods would "break the system", either ecologically, economically or socially? How could the Program increase its resilience to extreme events? Consider the actions in the table below, some of which the Program is already doing (Table 7 from Marmorek et al. 2019)

AP: When I think about climate change and the Great Plains, drought comes to mind first. Some consideration of how water supply might change under different future conditions seems like a starting point. See these papers as examples: https://doi.org/10.1016/j.jhydrol.2008.02.020 and https://doi.org/10.1029/2018EF001091

I also would consider how the Platte's water supply or habitat suitability will compare with other locations cranes use or might use regionally. How will alternative stopover locations regionally respond to climate change, **relative** to the Platte? During a drought reliable and permanent surface water will be needed (we see indications they are used more during drought, especially in the southern portion of the migration corridor). Can the Platte provide drought refugia or will it be as vulnerable to drought as other wetlands in the region?

Table 7. Synthesis of the challenges created by climate change in the five case studies, and the possible CCA strategies to deal with these changes. X=Climate challenges observed within a case study. Abbreviations in cells related to strategies that have either been implemented (I) or are under consideration (UC).

Attributes of each case	Case Studies of AM Projects				
	Dry Creek	**Trinity River**	**Okanagan River**	**Platte River**	**Missouri River**
Challenges created by climate change:					
1. Extreme runoff and flow events have destroyed habitat and property.	X		X	X	X
2. Decreasing precipitation leading to longer periods of drought have negative impacts on biota.	X	X	X		
3. Scale of climatic impacts and required intervention >> scale of AM program control	X	X	X	X	X
CCA strategies to deal with these challenges:					
a. Use variability in flow to test flow-habitat hypotheses	I	UC	I	I	I
b. Use real time decision support systems to manage flows	I		I	UC	I
c. Develop advanced systems for anomaly detection and flood forecasting from weather	UC		UC		
d. Increase storage (dams, groundwater, wetlands, ponds) to reduce impacts of drought.				UC	
e. Rethink and re-design habitat restoration for greater resilience during droughts and floods.	I	UC	I	I	I
f. Implement actions to reduce water demand	I		I		
g. Revise basin-wide water management strategies to meet species' needs and accommodate increased variability in flows.	I	UC	I	UC	UC

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References Cited

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