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2018 Platte River Basin Ecosystem Symposium Proceedings

PROCEEDINGS OF THE THIRTEENTH PLATTE RIVER BASIN ECOSYSTEM SYMPOSIUM

Platte River at Sunset by Doreen Pfost

Restoring, conserving, and understanding the Central Platte River Valley from wet meadows to Whooping Cranes: where we have been, where we are now, and where we are going

5-6 June 2018

Wood River, Nebraska, USA

COMPILED BY

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PREFACE

From 1990 to 2003, the Platte River Basin Ecosystem Symposium was held yearly and then biennially with funding provided by the U.S. Environmental Protection Agency (EPA) and coordination by the currently inactive University of Nebraska-Lincoln's Platte Watershed Program. Its intent was to provide researchers and land stewards an opportunity to stay abreast of ongoing research within the Platte River Basin and develop shared goals for future inquiry and management. Organizations including the Audubon Society, the Nature Conservancy, and the Platte River Whooping Crane Maintenance Trust (Crane Trust) have been actively conserving and studying habitat in the Central Platte River Valley (CPRV) since the 1970s, cooperating with regional partners including the University of Nebraska-Lincoln, the University of Nebraska-Kearney, the U.S. Fish and Wildlife Service, the U. S. Geological Survey, the Nebraska Game and Parks Commission, the Central Platte Natural Resources District, and others. Additionally, the Platte River Recovery Implementation Program was initiated in 2007 and has focused on studying and improving habitat for federally threatened and endangered species.

To celebrate 40 years operating on the Platte River, the Crane Trust (est. 1978) hosted the *13th Platte River Basin Ecosystem Symposium* with the support of the University of Nebraska-Lincoln's Nebraska Water Center and our conservation partners throughout the Platte River Basin. The symposium was reconvened to provide a snapshot of ongoing research in the Central Platte River Valley, a broad assessment of the ecosystem's current condition, and further clarify future conservation and research priorities. We sought applied science presentations from practitioners, academics, graduate students, and others on all topics related to conservation efforts in the CPRV and adjacent ecosystems. The symposium included 19 presentations separated into two half-day sessions, respectively, focusing on *Waterbird Habitat* and *Biodiversity and Hydrology*. Keynote presentations were given for each session, one delivered by Dr. George Archibald of the International Crane Foundation and one by Michael Farrell of the Platte Basin Timelapse Project. Presentations took place at the Crane Trust Nature and Visitor Center in Wood River, Nebraska, on June 5th 2018 and were followed by an interactive workshop on the morning of June 6th. Workshop participants helped identify and prioritize conservation needs based on "what we currently know." They also identified and prioritized "knowledge gaps" in our scientific understanding of the CPRV ecosystem that need to be addressed to improve our conservation practices. This document contains the abstracts for all 19 presentations as well as a manuscript synthesizing the results of the interactive workshop. The symposium had approximately 70 attendees and 26 workshop participants. This effort would not have been possible without the support of the entire Crane Trust staff. A special thanks to Joshua D. Wiese for technical support and logistics, Sandy Douglas for moderating the event, Alyx Vogel for preparing signage and materials, Catherine Cargill for preparing sustenance, adding organization, and proofreading materials, and Craig Thompson for suggesting this event take place. Also, a warm thanks to all of our presenters and workshop participants for contributing so much to this event. – A. J. Caven

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SESSION 1: WATERBIRD HABITAT

CRANES AND WATERBIRDS IN THE CENTRAL PLATTE RIVER VALLEY AND THE GREAT PLAINS

SANDHILL CRANE ROOSTING HABITAT AND RIVER FLOWS

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ABSTRACT. Wide channels with short bank vegetation, access to nearby foraging habitat, shallow water areas (<30 cm), and absence of disturbance features are factors commonly associated with suitable roost sites for Sandhill Cranes (*Antigone canadensis*). However, since channel width has typically been evaluated independently of channel depth or flow, it is possible that use of narrow channels is not limited so much by a requirement for wider channels, but by deeper water that flows through these narrow channels. We used a discrete-choice modeling framework and nine years of Sandhill Crane roost location data to evaluate the influence channel-width measures and flow per linear unit of channel width have on roost-site selection by Sandhill Cranes. Roost site selection was influenced by maximum unvegetated channel width and flow per unit length of total unvegetated channel width of all channels. The relative selection ratio increased as maximum unvegetated channel width increased to 131 m for small groups (0–500 cranes) and 275 m for large groups (>5,000 cranes), but was statistically similar across a wide range of maximum unobstructed channel widths. Medium sized Sandhill Crane groups (501–5,000 cranes) were less influenced by in-channel vegetated islands and selected channels based on wide total unvegetated channel widths. Our results also suggest flows ≤39.05 cms (1,379 cfs), in channels that are 275 m in unvegetated width, maximizes selection ratios for medium and large crane groups so increasing flows above this level may not improve Sandhill Crane roosting habitat conditions during the spring migration and staging season within the central Platte River. While Sandhill Cranes stage within the central Platte River valley for a longer time interval in the spring, Whooping Cranes (*Grus americana*) also use the Platte River as a stopover point. Both species share similar indices for roosting habitat such as unobstructed channel width and shallow water depths. Results of our investigation could be used to revise existing or establish new flow targets within a range expected to generate the highest amount of use by Sandhill Cranes along the central Platte River.

HABITAT USE OF SANDHILL CRANES AND WATERFOWL ON THE NORTH AND SOUTH PLATTE RIVERS IN NEBRASKA

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ABSTRACT. Numerous studies have examined migration ecology and habitat use of spring migrating birds using the Central Platte River, yet less is known about use of the North and South Platte Rivers (NSPR) in western Nebraska. The efficiency and effectiveness of conservation efforts in the NSPR could be greatly improved with access to better information and landscape prioritization tools. We used aerial surveys to determine population distribution and migration phenology of ducks, Canada Geese (*Branta canadensis*), and Sandhill Cranes (*Antigone canadensis*) using the NSPR during the mid-February to mid-April spring migration. We used these data and geospatial information to identify important river reaches for these species and habitat covariates that discriminate between those used at lower and higher densities. We found that Sandhill Cranes and waterfowl generally used different segments of the NSPR and, subsequently, different factors were associated with intensity of use. Larger densities of Sandhill Cranes were found near wider river reaches with less area of unvegetated sandbar and more wet meadow within 1 km. Use by Canada Geese and ducks was most intense in segments associated with wetland and sand pit habitats when compared with segments associated with wet meadow areas. Human disturbance variables in this rural region had little effect on identification of areas used intensively by all groups. Based on our results, habitat conservation efforts that specifically target Sandhill Cranes will not have similar positive effects on waterfowl use and distribution in the NSPR. Our identification of priority core segments should allow managers to better target resources to areas that will have the greatest impact on either waterfowl or Sandhill Cranes during spring migration.

TEMPORAL AND SPATIAL SHIFTS: THE EFFECTS OF WINTER TEMPERATURES AND HABITAT CHANGE ON SANDHILL CRANE ROOSTING DISTRIBUTIONS IN THE CENTRAL PLATTE RIVER VALLEY

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ABSTRACT. Over 80% of the midcontinent Sandhill Crane (*Antigone canadensis*) population (MCP), estimated at over 600,000, stages in the Central Platte River Valley (CPRV) from mid-February through mid-April with individual cranes staying about three weeks. Research suggests Sandhill Cranes may be shifting their distributions both temporally and spatially within the CPRV in reaction to changes in appropriate habitat in the region and weather patterns throughout their wintering range and southern migration corridor. We conducted weekly aerial surveys estimating the abundance and distribution of Sandhill Cranes staging in the CPRV from mid-February to mid-April from 2002 to 2017 to examine temporal and spatial trends in the abundance and distribution staging habitats of Sandhill Cranes to inform regional conservation planning efforts. We utilized weather data, including mean monthly temperatures and the mean monthly Palmer Drought Severity Index measures from major Sandhill Crane wintering regions to assess the impacts of late-winter and early-spring weather on the arrival of various portions of the midcontinent Sandhill Crane population to the CPRV. We also measured channel width metrics utilizing aerial imagery from 1938, 1998, 2015, and 2016, in addition to land cover metrics utilizing aerial imagery from 1998 and 2016. We utilized generalized linear models, cumulative link models, and Akaike Information Criterion, corrected for small sample sizes (AICc), to compare temporal and spatial models. Temperatures and drought conditions in wintering and migration locations heavily utilized by Greater Sandhill Cranes (*Antigone canadensis tabida*), in particular the Texas Coastal Plain, best predicted the arrival date of 15% the year's peak count, arrival dates of 30,000 or more Sandhill Cranes, and the count of Sandhill Cranes in survey week four (03/055 March - 03/11 March). The proportion of the main channel lost since 1938, and not the channel's absolute width in 2016, along with the proportion of land cover as lowland tallgrass prairie-wet meadow within 800 m of the main channel of the Platte River, best predicted the proportion, density, and trend in Sandhill Crane use per bridge segment. The proportion of woodland-forest within 800 m of the main channel of the Platte River also had a negative influence on both Sandhill Crane use and change in channel width, suggesting areas with historically high accretions may continue to provide less valuable habitat despite efforts to improve them. Our data suggest that Sandhill Cranes continue to move east and concentrate into smaller reaches of the CPRV, despite robust efforts to improve channel widths throughout the survey area. These trends should be addressed to protect the ecological integrity of the Sandhill Crane migration in the CPRV. The eastern most survey bridge segments, between Chapman and Grand Island, Nebraska are seeing increases in use and are currently less than 1% protected within 800 m of the Platte River's main channel by conservation organizations. We also need to adjust conservation planning efforts to accommodate an increasing number of Sandhill Cranes in February, and potentially earlier. Improving habitat for Sandhill Cranes has the potential to benefit a diversity of prairie and braided river endemic species of conservation concern.

LEAST TERNS AND PIPING PLOVER NESTING ECOLOGY WITHIN OFF-CHANNEL HABITATS WITHIN THE BIG BEND OF THE PLATTE RIVER

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ABSTRACT. Endangered Interior Least Terns (*Sternula antillarum athalassos*) and threatened Piping Plovers (*Charadrius melodus*) nest on barren sandbars, shorelines and off-channel habitats throughout their range. Given the high productivity of Interior Least Terns and Piping Plovers on constructed off-channel nesting sites along the central Platte River in Nebraska, USA, and the possibility of creating similar habitats at other locations within their breeding range,

understanding how these species use off-channel nesting habitats is important. We used data collected along the central Platte River in Nebraska, USA, over a 15-year period (2001-2015), and a discrete-choice modeling framework to assess the effects of physical site attributes and inter- and intraspecific associations on off-channel nest-site selection by Interior Least Terns and Piping Plovers. We found that Piping Plovers avoided nesting near each other, whereas colonial Interior Least Terns selected nest sites near those of conspecifics. In addition, the relative probability of use for both species was maximized when distance to the nearest predator perch was ≥150 m and elevation above the waterline was ≥3 m. Probability of use for nesting by Interior Least Terns increased as distance to water increased whereas the probability of use by Piping Plovers was maximized when distance to water was ~50 m. Efficient site designs for Interior Least Terns would be circular, maximizing the area of nesting habitat away from the shoreline, whereas an effective site design for Piping Plovers would be more linear, maximizing the area of nesting habitat near the waterline. An efficient site design for both species would be lobate, incorporating centralized nesting habitat for Interior Least Terns and increased access to foraging areas for nesting and brood-rearing Piping Plovers. We also used 15 years of data at off-channel sites along the central Platte River to assess the influence of several biotic and abiotic factors on the survival of Interior Least Tern and Piping Plover nests and broods. We observed high survival rates for Interior Least Tern and Piping Plover nests and broods as 2/3 of Interior Least Tern and 3/4 of Piping Plover nests were successful and 3/4 of all Interior Least Tern and Piping Plover broods were successful. We found productivity of Interior Least Terns and Piping Plovers was reduced during both the nesting and brood rearing stage by weather-related factors rather than factors that can be controlled. As such, we conclude habitat management activities implemented at off-channel sites such as tree removal, predator trapping, construction of a water barrier surrounding the nesting area and installation of predator fences, are sufficient for maintaining high levels of productivity for Interior Least Terns and Piping Plovers at off-channel sites along the central Platte River.

WAS THE HISTORIC CENTRAL PLATTE RIVER HYDROLOGY HOSTILE TO SUCCESSFUL NESTING ON SANDBARS?

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ABSTRACT. The Platte River is one of several wide, sandy, braided rivers traversing the Great Plains region of the United States. Historically, these rivers provided ample emergent sandbar nesting habitat (ESH) for migratory waterbirds as well as local riverine species such as the softshell turtle. Over the past 100 years, these habitats have been degraded through a combination of hydrologic and channel morphologic alteration. Recent arguments have been made that the hydrology of the historic central Platte River was "hostile" to successful nesting for listed bird species (Interior Least Tern and Piping Plover), and that nesting in the Big Bend region by these species is mainly a result of the proliferation of more stable lakeshore habitats (sandpits) over time. However, the general pattern of historic and post-development hydrologic 'hostility' to nesting across the Great Plains remains unresolved. We asked the question "Was the hydrology of the central Platte River an outlier in the Great Plains with regards to nesting hostility"? We analyzed long-term daily discharge records to examine historic and post-development ESH inundation probabilities across the Great Plains. Our results indicate the historic hydrology of northern Great Plains rivers (Platte, Niobrara, Missouri) was typically less hostile to nesting than the hydrology of southern Great Plains rivers (Arkansas, Canadian, Red, lower Mississippi). Likewise, modern inundation probabilities in northern Great Plains rivers, although higher than historic levels, are similar to modern levels in southern Great Plains rivers. Our analysis suggests the key difference between northern and southern Great

Plains Rivers is that ESH formation processes in the northern Great Plains rivers have been more substantially impacted by human alterations to hydrology and channel morphology.

WHOOPING CRANE MIGRATION CORRIDOR: A SHIFT IN TIME

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ABSTRACT. □"Defining and identifying changes to seasonal ranges of migratory species is required for effective conservation. Historic sightings of migrating Whooping Cranes (*Grus americana*) have served as the sole source of information to define a migration corridor in the Great Plains of North America (i.e., Canadian Prairies and United States Great Plains) for this endangered species. We updated this effort using past opportunistic sightings from 1942–2016 (*n* = 5,055) and more recent (2010–2016) location data from 58 telemetered birds (*n* = 4,423) to delineate migration corridors that included 50%, 75%, and 95% core areas. All migration corridors were well defined and relatively compact, with the 95% core corridor averaging 294 km wide, although it varied approximately ±40% in width from 170 km in central Texas to 407 km at the international border of the United States and Canada. Based on historic sightings and telemetry locations, we detected easterly movements in locations over time, primarily due to locations west of the median shifting east. This shift occurred from northern Oklahoma to central Saskatchewan at an average rate of 1.2 km/year (0.3–2.8 km/year). Associated with this directional shift was a decrease in distance of locations from the median in the same region averaging -0.7 km/year (-0.3–-1.3 km/year), suggesting a modest narrowing of the migration corridor. Changes in the corridor over the past 8 decades suggest that agencies and organizations interested in recovery of this species may need to modify where conservation and recovery actions occur. Whooping Cranes showed apparent plasticity in their migratory behavior, which likely has been necessary for persistence of a wetland-dependent species migrating through the drought-prone Great Plains. Behavioral flexibility will be useful for Whooping Cranes to continue recovery in a future of uncertain climate and land use changes throughout their annual range" (Pearse et al. 2018. PloS one 13(2):e0192737).

WHOOPING CRANE HABITAT ALONG THE BIG BEND OF THE PLATTE RIVER

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ABSTRACT. A portion of 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. Within several stretches of river, the Platte River Recovery Implementation Program (Program) owns land or has management agreements that allow for the ability to alter physical features, such as unobstructed channel width, distance to nearest forest, and total channel width of an area, through mechanical intervention. Through the Fish and Wildlife Service's Environmental Account, the Program also has access to a limited amount of water that, through timed releases, could be used to influence unit discharge and thus several hydrologic metrics. The objectives of our analyses were to develop habitat models that could be used to direct management activities along the central Platte River. As such, we focused our analysis on metrics the Program has the ability to influence to some degree. We used Whooping Crane roost site data collected via systematic aerial surveys of the central Platte River from 2000-2017 and an *a priori* set of models to evaluate the influence of various metrics on the probability of Whooping Crane use. We found unobstructed channel width and distance to the nearest forest were good predictors of Whooping Crane use. We also used telemetry data obtained from a sample of 68 birds over the course of seven years (2010-2016) to provide an unbiased evaluation of Whooping Crane use of riverine habitat throughout the migration corridor. 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. Based on results of both analyses, it appears maintaining unobstructed channel widths of 600–700 feet and unforested corridor widths of ≥1,100 feet would result in highly favorable Whooping Crane riverine roosting habitat and thus increased use of the central Platte River.

WHOOPING CRANES MIGRATION STRATEGIES IN CENTRAL FLYWAY

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ABSTRACT. Whooping Cranes migrate across the Platte River Basin and surrounding ecosystems twice annually. We characterized migration strategies of birds marked with telemetry equipment for multiple migration seasons, 2010–2016. Spring migration averaged 29 days beginning in early March and ending late May. Adults initiated and completed migration 10 days earlier than subadults. Autumn migration averaged 45 days from late September to early December. Adults with young initiated migration 10–15 days later than other birds, but completed migration at approximately the same time. Whooping Cranes followed a relatively narrow but variable width migration corridor that was ~300 km wide when crossing the Platte River. Analysis of historical sightings suggests the corridor's center has shifted eastward in Nebraska. Whooping Crane use in Nebraska extended across multiple river systems and wetland complexes. Repeated use

of sites by individual cranes was low and use by multiple marked cranes at the same sites within a migration season occurred with greater frequency. For individuals and the population, timing of migrations was more predictable than space use. Across years, 90% of Whooping Cranes used the region between 22 Mar and 2 May during spring and 25 Oct and 19 Nov during autumn. Whooping Cranes were faithful to a defined migration corridor but generally opportunistic in selection of nighttime stopover sites; hence, spatial targeting of conservation actions maybe better informed by associations with landscape and habitat features rather than documented past use at specific locations. The retention of variation in migration strategies existing within this species that experienced a severe demographic bottleneck suggests that Whooping Cranes have maintained a capacity to adjust strategies when confronted with future changes in land use and climate.

GRASSLAND CRANE HABITAT: COMPARING MONGOLIA AND THE GREAT PLAINS

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ABSTRACT. ICF and the USFS are helping colleagues at the Wildlife Science and Conservation Center of Mongolia with studies of cranes and their habitats in the Khurkh Valley that rests in the heart of the temperate grasslands of northeastern Mongolia, a region that might resemble the tall grass prairie of the Midwest before settlement. This valley supports the largest known population of breeding pairs of the threatened White-napped Crane (65 pairs), about 120 breeding pairs of Demoiselle Cranes, 12 breeding pairs of Eurasian Cranes, and non-breeding flocks of Hooded and Siberian Cranes. Current research includes the relationship between the rate of grazing and loss of permafrost, the migration routes and resting areas through satellite telemetry, and the life history information of both radio marked and color banded cranes. Conservation actions have included officially protecting the area though the collaboration of 4 municipalities that each administer part of the valley, advising against overgrazing, and supporting an annual crane festival to celebrate cranes.

SESSION 2: BIODIVERSITY AND HYDROLOGY

CONTEXTUALIZING THE CENTRAL PLATTE RIVER VALLEY AND AREAS OF EMERGING CONSERVATION CONCERN

BIODIVERSITY AND ANIMAL ACTIVITY ASSOCIATED WITH A BEAVER LODGE NEAR THE PLATTE RIVER

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ABSTRACT. North American beavers (*Castor canadensis*) modify physical landscapes and influence hydrologic and biotic components of ecosystems. Positive associations between beaver-modified habitats and various species are well

documented, though limited information is available about phenological dynamics and organisms associated with beaver lodges. The objective of our study was to document activity patterns of beaver and the diversity of species utilizing the exterior of a beaver lodge. We used a modified home-security camera to acquire images of a beaver lodge adjacent to the Platte River in south-central Nebraska, USA, over a nine-month period. Presence of beavers, which included two adults and four kits, peaked from late April to early July, when river discharge was high. Most observations of beavers adding materials to the lodge occurred prior to June, and the contour of the lodge flattened during summer. Thirty species of animals, primarily herons and passerines, were identified on the lodge, often during distinct times of the day or seasons. Our findings highlight the use of a beaver-built structure by a diversity of species and changes in activity pattern and lodge structure associated with environmental variables, further elucidating the significance of beaver on the landscape.

CLIMATE AND HABITAT CHANGE IMPLICATIONS FOR A DECLINING GRASSLAND SONGBIRD

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ABSTRACT. Grassland birds comprise the most rapidly declining group of birds in continental North America, warranting urgent conservation attention. Habitat loss and degradation, as well as accelerating climate change, pose major threats to grassland birds. Although grassland bird responses to habitat management are well-documented, much less is known about how external factors, such as climate, interact with management actions to affect their populations. We evaluated how habitat management and climate parameters influenced the abundance of the Grasshopper Sparrow (*Ammodramus savannarum*), a declining Neotropical migratory species that breeds in the Great Plains, using mark-recapture data. Specifically, we investigated responses to management actions including prescribed burning, cattle (*Bos taurus*) grazing, and haying, and their interactions with varying temperature and precipitation regimes on private conservation land in the Platte River Valley, Nebraska. We found that Grasshopper Sparrow abundance was primarily correlated with prescribed burning and spring precipitation, peaking around 25-28 months after burning, and declining with greater spring precipitation levels. Grasshopper Sparrows in grazed pastures responded favorably to higher cattle stocking rates, which in this study ranged from 0.75 to 5.3 animal unit months per hectare. The impacts of grazing, burning, and drought on Grasshopper Sparrow abundance are likely ecosystem-specific, where factors that reduce vegetation biomass are correlated with increased abundance in mesic tallgrass prairie, but may negatively impact the species in more xeric shortgrass systems. As the bird populations in this study were strongly affected by climate, we may expect ongoing climate change to have a significant effect on future Grasshopper Sparrow population trends.

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40 YEARS OF REGAL FRITILLARY DATA AT AUDUBON'S ROWE SANCTUARY

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ABSTRACT. We examined the trends and variation in Regal Fritillary (Regal) abundance using nearly 40 years of Fourth of July butterfly count data collected at Audubon's Rowe Sanctuary from 1979 to 2017. Regal counts ranged from 0 (first observed in 2005) to 636 (represented the highest count in the US in 1994; median = 39, mean = 82.5±123.4, n= 39). Least Squares Regression Models demonstrated that Regal abundance had a quadratic relationship to survey year (*Year: t= 3.195, p= 0.0029*; *Year^2: t= -3.197, p= 0.0029*), yearly abundance trends did not fit a linear model. Counts exhibited a steady increase from 1979 to 2003, before demonstrating a precipitous decline from 2004 to 2017. We explored potential causes of the decline by gathering covariate data including precipitation totals and mean daily average temperatures from the fall (Sept. to Nov.), winter (Dec.-Feb.), and spring (May to Mar.) seasons in the year preceding survey efforts. We also gathered land management data, but records were incomplete for some years. Management data was complete from 1995 to 2007 and 2014 to 2017, but was not consistently recorded from 1979 to 1994 or from 2008 to 2013. However, broad management philosophies and practices were recorded for these time periods. Examining the management records we determined that there were four general management regimes over the last 40 years at Rowe Sanctuary. The first regime existed from 1979 to 1994 and included volunteers sporadically haying and burning portions of the prairie on a semiannual basis. Regime two from 1995 to 2003 included rotationally haying half of the prairie and burning and resting a quarter of it each year. Regime three from 2004 to 2013 included grazing half and resting half of the pasture annually, and regime four from 2014 to 2017 included grazing half of the pasture, resting one-sixth, haying one-sixth, and burning one-sixth. We used the median values from each management regime to impute missing management data. We included the proportion of the management unit that was burned, grazed, or hayed during the survey year. We also included the percent of the pasture that was burned 3 and 5 years previous to counts as well as the percent of the pasture grazed 1 year previous to counts to examine potential lag effects. Finally, we included the percent of corn grown in the US that is herbicide tolerant (Ht) as a covariate in our analyses, as Ht corn has been linked to increased herbicide use shown to negatively impact some butterfly species by decreasing floral nectar resources in and adjacent to agricultural lands. We used Pearson's Product Moment Correlations to conduct two separate analyses: one using our full dataset with imputed missing values (n= 39) and the other using only complete yearly observations (n = 17). Analyses of complete observations (n = 17) demonstrated that summer grazing (*r = -0.61, p = < 0.01*) and Ht corn (*r = -0.49, p = < 0.05*) had negative relationships with Regal abundance and a positive relationship with management regime two (rotational haying ½, burning ¼, and resting ¼ annually without grazing). Data with imputed values demonstrated similar results. The percent of the pasture grazed during the count year (*r = -0.42, p = < 0.01*), the percent grazed the previous year (*r = -0.42, p = < 0.01*), and Ht Corn (*r = -0.37, p = < 0.05*) demonstrated negative relationships with Regal abundance. Persistent summer grazing may have a long-term impact on isolated Regal populations through the trampling of larvae, defoliation, or otherwise. Rowe Sanctuary's Regal population may be increasingly isolated by decreasing nectar resources for dispersal along farm field edges as a result of Ht corn. Population isolation can lead to genetic decline and eventual population loss. Regals in fragmented landscapes are likely more sensitive to disturbance regimes that historically maintained grassland systems throughout the Great Plains. Conducting management on smaller portions of prairies and rest from both grazing and burning (*other studies*) may be necessary to maintain isolated populations. Our data demonstrates that haying may have a limited impact on Regal abundance, which could be a good management alternative in isolated prairies. Given the coarse nature of this data, findings should be applied with caution and taken in the contexts of other studies employing more rigorous data collection methods. Raw count data used in this analysis was not corrected for survey effort, as survey effort was not available for some years.

A DESCRIPTIVE ANALYSIS OF REGAL FRITILLARY (*SPEYERIA IDALIA*) HABITAT UTILIZING BIOLOGICAL MONITORING DATA ALONG THE BIG BEND OF THE PLATTE RIVER, NE

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ABSTRACT. □ "*Speyeria idalia* populations have declined as much as 95 percent over the last three decades. Here we critically evaluate prairie habitat components along the Platte River in central Nebraska that *S. idalia* populations require in an effort to better inform conservation efforts. We utilized *S. idalia* count data from biological monitoring transects where vegetation, soils, land management, and flooding frequency data were also collected to describe the habitat constituents associated with *S. idalia* presence. We utilize comparative statistics, Pearson's correlation analysis, and random forest analysis to model *S. idalia* habitat on land owned and managed by a small conservation NGO. Our findings suggest that *S. idalia* occupies specific habitat niches with a preference for well-drained soils (Inavale series) dominated by facultative upland plants, most prominently *Andropogon gerardii*. *S. idalia* is positively associated with large connected tracts of relict prairie containing *Viola sororia* and very moderate management regimes that remove shrubby cover (negatively associated) and promote forb cover (positively associated), while providing ample recovery time on burned and grazed patches for litter development (positively associated). Random forest analysis describes the presence of *V. sororia*, percent forb cover, and habitat isolation as the top three habitat variables of importance in predicting the presence/absence of *S. idalia*. Our finding that habitat isolation is a major predictor of *S. idalia* absence suggests many populations may be both spatially and genetically isolated. *S. idalia*'s future demands the preservation of tallgrass prairie fragments under management regimes that promote healthy populations and habitat connectivity" (Caven et al. 2017. Journal of Insect Conservation 21(2):183-205).

CLIMATE CHANGE IN THE NORTH PLATTE HEADWATERS

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ABSTRACT. □North Platte River headwaters in Wyoming's Wind River Range mirror other alpine areas throughout the world that are undergoing climate change. Unlike the Colorado headwaters of the Platte, the Wind River Range is home to the largest number of alpine glaciers and the largest glaciated alpine area in the contiguous United States. However, Wind River Range glaciers are rapidly disappearing. What will this disappearance mean to the alpine headwaters and moreover to the North Platte River?

HYDROLOGIC DYNAMICS OF A WET MEADOW ALONG THE PLATTE RIVER

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ABSTRACT. Wet meadows, ephemeral wetlands interspersed with tallgrass prairie, are among the rarest ecosystems in the Central Platte River Valley and provide habitat for numerous species, including Sandhill Cranes (*Antigone canadensis*), Whooping Cranes (*Grus americana*), grassland breeding birds, Platte River caddisflies (*Ironoquia plattensis*), regal fritillary butterflies (*Speyeria idalia*), and western prairie fringed orchids (*Platanthera praeclara*). Wet meadows associated with the Platte River have been reduced and degraded by hydrological depletions, conversion to agriculture, encroachment by invasive species, and other human alterations. Understanding the hydrological regime of the few wet meadows that remain is necessary to guide management and restoration efforts of these vulnerable systems. The objectives of our study were to: i) characterize inundation dynamics of an archetype wet meadow on the Crane Trust's Mormon Island, and ii) advance image-analysis techniques directed at measuring landscape-level environmental changes. Using time-lapse imagery acquired from January 2011 to May 2017, we examined the spatial and temporal extent of wet meadow inundation in relation to groundwater, streamflow, and precipitation using wavelet analysis. Preliminary findings indicated standing water was present (hydroperiod) in the meadow, on average, from 11 January to 1 May (ranging from 1 January to 2 July), with the greatest extent of surface inundation occurring, on average, on 1 April (ranging from 24 February to 29 April). Previous research suggests that periodic inundation is necessary to recharge and sustain the ecological functioning of wet meadow systems. This method of capturing high-temporal imagery for analysis has allowed us to look at fine scale variation of inundation to better understand the complex hydrology of wet meadow systems and provides an approach to examine long-term hydrological dynamics in other complex systems with changing aquatic-terrestrial ecotones.

EVOLUTION OF THE 'GROUNDWATER MOUND' BENEATH THE PHELPS COUNTY CANAL, NEBRASKA

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ABSTRACT. The western Rainwater Basin of Nebraska is one of the few areas of the High Plains that have experienced a significant rise in the groundwater table since development of the High Plains-Ogallala Aquifer. The area south of the central Platte River, encompassing the Tri-Basin Natural Resource District, is host to wetland habitats that form a vital support to the Central Flyway. Evidence from scientific literature suggests that as the water table has risen and naturally occurring playa lakes were drained and filled groundwater-fed wetlands have supplanted runoff-fed wetlands. In this study, we investigate the development of the 'groundwater mound,' using a combination of statistical and process-based modeling, to quantify the timeline of groundwater rise and the likely impact of rising water levels on the region's precious wetland habitat. We find that, although water tables have increased tens of meters beginning in the 1930's, the rate of groundwater increase is sensitive to drought, and this rate of water table rise slowed between 2009 and 2013. Water table increase is strongly related to surface water infrastructure, including Elwood Reservoir, Johnson Lake, and the many canals in the area.

TREE-RINGS STABLE ISOTOPES SHOW DIFFERENT ADAPTIVE STRATEGIES OF NATIVE AND INVASIVE WOODY SPECIES TO STREAMFLOW FLUCTUATIONS ALONG THE REPUBLICAN RIVER IN NE

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ABSTRACT. Persistent shifts in riparian vegetation associated with the invasion of introduced *Elaeagnus angustifolia* (Russian olive) and native *Juniperus virginiana* (eastern red cedar) have been reported in the Great Plains, with significant impacts on ecosystem services and resilience. In Nebraska, these species have been expanding into the understory of the native *Populus deltoides* (Eastern Cottonwood) riparian forests. We used dendroecological (tree rings) techniques and stable isotope ratios (δ13C and δ18O) to examine the acclimation and adaptation strategies of these species to climatic variability and change. Streamflow was the strongest predictor for performance, and together with above average annual precipitation resulted in peak raw and standardized tree ring widths (or growth) in *P. deltoides* followed by J. virginiana, but little response in *E. angustifolia*. δ18O values indicated that all species competed for the same water source, and values followed a bimodal trend tracking precipitation and streamflow and displaying significant enrichment during periods of decreased water availability, indicating a shift in the depth of water uptake during periods of drought. δ13C ratio and water use efficiency (WUEi) were significantly higher in *J. virginiana* than in *P. deltoides* and *E. angustifolia* and increased in all species over time. The increase in WUEi over time indicates a positive impact of increased CO2 levels in the atmosphere on growth, independent of climate variability. The combined analysis of δ13C and δ18O showed that *P. deltoides* and to a lesser extent *E. angustifolia* exhibited a strong stomatal control over photosynthesis relative to *J. virginiana*, which exhibited an anisohydric stomatal behavior, enabling the species to function under low water potentials (or drought). Our results show that once established, *J. virginiana* and *E. angustifolia* thrive in the understory of *P. deltoides* using different adaptive strategies. Based on current water flow management and without high flood pulses through the riparian zone, these species will continue to spread in riparian areas with significant impacts on ecosystem services.

HISTORY OF RESTORATION AND MANAGEMENT OF THE CENTRAL PLATTE RIVER

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ABSTRACT. This presentation explores the humble beginnings of conservation along the central Platte River in Nebraska. Beginning in 1970 with the “Spring Rivers Conference” the biological and ecological significance of the Platte River for migratory waterbirds was brought to the national stage. Subsequent research throughout the 1970’s recognized the national and international importance of the central Platte River for Sandhill Cranes, Whooping Cranes, waterfowl, shorebirds and numerous other wildlife species. By 1974, the first conservation activities were occurring on the river. By the mid to late 1970’s, it became apparent further land protection, restoration, and management of in-channel and adjacent wetland and wet meadow habitats along the river was needed. This presentation examines the evolution of conservation, restoration, and management activities along the river over the past four decades and the birth of collective collaborative conservation. Past and current habitat restoration and management techniques are identified and discussed as well as the future of collective conservation and habitat management along the river. This presentation supports new and innovative ways to solve current and future management issues on the river and its habitats.

MY PATH TO THE RIVER

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ABSTRACT. This is an exploration of my personal journey from childhood to the present and how the many threads of personal discovery and meaning, family, natural, tribal and national history have been braided together over time - and how all of that led me to a career making documentary films about our region and eventually to co-found Platte Basin Timelapse which seeks to understand and reveal the essence and issues in the Platte Basin Watershed seen over time.

CONSERVATION NEEDS AND KNOWLEDGE GAPS IN THE CENTRAL PLATTE RIVER VALLEY ECOSYSTEM: RESULTS FROM AN INTERACTIVE STAKEHOLDER WORKSHOP

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ABSTRACT. The Central Platte River Valley (CPRV) is a biologically unique and important ecosystem, which supports four federally threatened and endangered species, as well as habitat for several species of regional concern. However, the Platte River has been highly augmented through the appropriation of flows for human use and infrastructure projects to manage water. Concerted efforts have been made to preserve the CPRV ecosystem since the mid-1970s. Today the CPRV continues to face a number of threats including industrial and suburban development, continued appropriation of river flows, conversion of wet meadows and tallgrass prairies to agricultural fields, and invasive species. The Platte River Basin Ecosystem Symposium (PRBES) was held yearly and later biennially between 1990 and 2003, with the goal of providing conservation organizations, researchers, and government agencies an opportunity to stay informed regarding ongoing research in the Platte River Basin and advance shared objectives for future research and management. The sixth and later the eighth PRBES, in 1995 and 1997 respectively, included participatory research needs forums. We sought to examine the current knowledge gaps in our understanding as well as the current conservation needs of the CPRV ecosystem 23 years after the original research needs forum. We conducted an interactive workshop that followed an iterative process of brainstorming, explanation, and democratic prioritization, to define and rank practical conservation and research needs in the CPRV. Workshop results ranked *habitat restoration, outreach and education, in-stream flow protection, invasive species control,* and *habitat protection* as top conservation needs and *human dimensions and economics, invasive species management and control, restoration research*, *water research*, and *prairie-meadow ecology* as top knowledge gaps to address. Several broader themes ran throughout the workshop, particularly the need to conduct long-term research, to coordinate more closely with partners in conservation and management efforts, and to communicate and engage with the broader community. Our workshop results demonstrate great progress in answering some research questions, and very little progress in others since the research needs forums of the mid to late-1990s.

INTRODUCTION

The Central Platte River Valley (CPRV) is an important landscape both biologically and agriculturally, supporting one of the most productive agricultural areas in the region (Dappen et al. 2008, Thormodsgard 2009), as well as high endemic

biological diversity (Springer 1981, Hay and Lingle 1981, Lingle and Hay 1982, Nagel and Kolstad 1987, Davis 2005, LaGrange et al. 2005, Riggins et al. 2009, Geluso and Harner 2013, Caven et al. 2017). The CPRV is home to four species listed as threatened or endangered under the Endangered Species Act including the Whooping Crane (*Grus americana*), the Pallid Sturgeon (*Scaphirhynchus albus*), the Piping Plover (*Charadrius melodus*), and the Interior Least Tern (*Sternula antillarum athalassos*) (National Research Council 2005, Smith 2011), as well as 11 species listed as "tier-1 at-risk" by the state of Nebraska (Schneider et al. 2011). Furthermore, under the Endangered Species Act, most of the CPRV is listed as "critical habitat" for the Whopping Crane (USFWS 1978). However, this biologically important landscape faces significant development pressures that threaten its ecological integrity, including sand and gravel extraction, water diversion, invasive species encroachment, suburban expansion, and the continued conversion of tallgrass prairies and wet meadows to agricultural fields (Sidle et al. 1989, Eisel and Aiken 1997, Birgé et al. 2018, Pauley et al. 2018, Caven et al. *in press*). Several conservation organizations are dedicated to maintaining and improving habitat for species of concern in the CPRV, include Audubon's Rowe Sanctuary, the Nature Conservancy, the Platte River Recovery Implementation Program, the Crane Trust, and others. These conservation organizations work closely with government agencies, the University of Nebraska system, and regional water users including the Central Platte Natural Resources District (CPNRD), the U.S. Fish and Wildlife Service (USFWS), the Nebraska Game and Parks Commission (NGPC), and others.

Identifying stakeholders is an iterative process, meaning that as an investigation deepens, new interested parties are discovered and should be engaged (Reed et al. 2009). Effective conservation strategies and habitat management actions depend on engaging a diverse constituency in the planning and implementation process (Schusler et al. 2003, Birgé et al. 2018). Social learning is a process that takes place when stakeholders communicate openly to build shared understanding, which can help create common goals and enhance cooperation (Schusler et al. 2003). This process requires a true engagement of ideas, including constructive conflict that engages disparate perspectives (Schusler et al. 2003, Bentley Brymer et al. 2018). Social learning is an essential component of collaborative resource management and is fostered by open dialogue, sustained engagement, democratic processes, inclusive participation, and constructive debate (Schusler et al. 2003). Because collaborative planning processes can be hindered by power disparities between and restrictive organizational cultures of stakeholders, planning methods that focus on *process*, for example cooperatively defining the problems, may be most effective (Selin and Chevez 1995).

The sixth and eighth Platte River Basin Ecosystem Symposiums (PRBES), held in 1995 and 1997 respectively, included "research needs" forums, which provided interactive opportunities for scientists and land managers to define research priorities for the CPRV ecosystem (Eckert and Franti 1995, Herpel 1997). The ninth PRBES, held in 1998, included a qualitative analysis of stakeholder's statements regarding resource management (Allen 1998). The 1995 research needs forum included small working group sessions, a panel discussion, and two surveys (at the start and end of the symposium) focused on determining and ranking research priorities (Eckert and Franti 1995). The 1997 research needs forum was composed of stakeholder interviews conducted in 1996 and 1997 (Herpel 1997). Results from the 1995 "research needs survey" determined aquatic habitats, flow quantity requirements, wet meadows, and riparian habitats were topic areas in need of further research in the CPRV (Eckert and Franti 1995). Each of these topic areas was further broken down by small working groups. For instance, the top research theme for "flow quantity requirements" was: "[What are the]…flow requirements to restore the desired ecosystem including threatened and endangered species?" (Eckert and Franti 1995). For the 2018 PRBES, we followed the general approach for a science-based workshop outlined by NC TraCS (2018) to determining research and land management priorities in the CPRV 23 years after the initial research needs forum was held in 1995. The interactive workshop included a diverse group of stakeholders comprised of scientists, land managers, conservationists, and interested members of the general public. The workshop process was facilitated as an open and democratic dialogue.

METHODS

The interactive workshop was an iterative process of brainstorming, explanation, and democratic prioritization (NC TraCS 2018) focused on two basic questions regarding conservation needs and knowledge gaps in the Central Platte River

Valley. The first session addressed the question, "given what we currently know regarding the Central Platte River Valley, what are the actions we could take broadly as a conservation community to make tangible improvements to its ecological health?" The second session focused on addressing research gaps (areas not yet researched thoroughly) and knowledge gaps (holes within established areas of research) regarding the Platte River Basin ecosystem. Namely, "what are the most pressing applied research questions that need to be addressed to improve the effectiveness of our conservation efforts?" The results of this workshop are intended to serve as a roadmap, helping our conservation community prioritize and collaborate regarding conservation actions and research plans looking toward the future.

Each session began by posing one of the major workshop questions: i) *What are the most important conservation needs to address given what we know?* ii) *What are the knowledge gaps we most need to address to improve our conservation practices?* In each session workshop participants were split into 5 groups of about 5 people, and were encouraged to separate from regular coworkers and collaborators as the workshop was designed to increase the intermixing of ideas. For each session, groups independently compiled a list of responses to the session's main question, resulting in five separate lists of topics. Following the input of participants, these items were integrated into a workable number of topics (10 -12) on a single white-board. Each participant was then given two votes to prioritize the topics they found most important to address by show of hands. Votes were tallied in real-time and the top five topics were selected for redistribution among the groups. Each group was randomly assigned one priority topic to further brainstorm on and dissect into a list of 6-12 focused themes, or if necessary, first subtopics and then respective themes. The resulting theme lists for each of the five priority topics were displayed on easel pads for all participants. Each group took turns explaining, editing, and iteratively updating the focused themes based on input from all workshop participants. Participants then voted on the clarified and updated themes, with each allowed two votes per priority topic or subtopic, to further define conservation and research priorities within respective sessions.

The workshop included 26 participants for a total of 52 potential total votes per topic, although not every participant voted on every topic. Participants represented several stakeholder organizations involved in the management of the CPRV ecosystem including the Crane Trust, Audubon Rowe Sanctuary, the US Fish and Wildlife Service, the US Geological Survey, the Rainwater Basin Joint Venture, the Platte River Recover Implementation Program, the Platte Basin Timelapse Project, the International Crane Foundation, the Nebraska Game and Parks Commission, Nebraska Public Power District, Central Nebraska Public Power and Irrigation District, Ducks Unlimited, the University of Nebraska-Lincoln, the University of Nebraska-Kearney, the University of Wyoming, and more. We summarized the results from each session regarding "conservation needs" and "knowledge gaps" in two large tables below, including both the tallied votes and the percentage of votes per theme for research topic (Tables 1, 2). The themes that received a significant amount of vote, defined here as more than 10% of the vote and one of the top four themes, were described in further detail in-text. We further explained key themes using quotes from workshop participants.

RESULTS

SESSION 1: CONSERVATION NEEDS IN THE CPRV

Given our current knowledge of the ecosystem and the threats facing it, the most important conservation needs to address in the CPRV were deemed to be: i) habitat restoration; ii) outreach and education; iii) in-stream flow protection; iv) invasive species control; and, v) habitat protection (Table 1).

Top themes to address regarding habitat restoration were to improve the connectivity of restoration efforts (25.0%), develop a strategic restoration plan (13.6%), incentivize private restoration (13.6%), and increase wet meadow restoration efforts (13.6%; Table 1). A workshop participant summed up the need for a cooperative restoration plan to improve the connectivity of restoration efforts as follows: "The idea behind a strategic plan is that we have all these habitats we want to restore, how do we prioritize them, how do we go about doing that? We have one entity working on cutting their own trees on their own property; what if we have 3 or 4 entities to attack [adjacent areas] together. We could get a lot of work

done like that. I think that's part of the strategic plan, picking your battles, what do you really need to restore first to connect areas [of quality habitat]."

Top themes regarding outreach and education were as follows: educating the general public (informal education, media) to increase support for conservation efforts (31.1%), improve university student and early career professional opportunities (funded internships) to remove bottlenecks in the university to professional pipeline (28.9%), and increasing youth engagement (outdoor classrooms, kid-centered media) (17.8%; Table 1). A participant artfully summed up the need for environmental outreach and education in the CPRV: "I think there's a real hunger out there today, and there's an entire generation of young people that are coming up and dealing with environmental issues every time they wake up in the morning. You're going to have people that have never cared about this river and these habitats because they just don't see it in their lives. But the vast majority of people have an opportunity to care, just simply open the door, shine the light. I'm seeing it throughout the entire Great Plains of North America; there is a disconnect between science and the public. It's nobody's fault, but there's great opportunity right now to build that bridge. We talked about all those tools of restoration on the land yesterday; there are lots of tools to tell stories today too, and it doesn't have to be perfect, it doesn't have to be Disney, we don't have to use technology that are delegated to NASA or Hollywood, it just has to be authentic, it has to be true."

Top priority themes regarding in-stream flow protection were as follows: revisit legal framework for in-stream flows (31.8%), conserve groundwater (27.3%), and protect natural peak flows (22.7%; Table 1). There was widespread recognition among workshop participants that their top three priority themes were highly connected. The workshop discussion regarding in-stream flows focused on refining the legal framework protecting them to allow for more flexibility and therefore improved water management in the CPRV. A participant noted, "In states where there are in-stream flow protections that allow for flexible water management it is easier to get water back into streams. For example, in Colorado, a bunch of wealthy people with hobby ranches in the Aspen corridor had great priority water rights, and no framework for transferring them to streams. If they did, they would lose their priority. They developed a framework that just allowed for the temporary transfer of water rights to the streams, so the stream didn't go dry and unprotected. You cannot do that in this state." Participants also agreed that a major challenge to securing protections for in-stream flows in a semiarid landscape dominated by industrial agriculture is the fierce competition for water resources. As one participant noted, "Any time a drop of water becomes available, there are 7 hands reaching for it."

Top priority themes regarding invasive species control included: research and monitoring of treatment responses (27.9%), secure new funding sources (23.3%), increase collaboration on priority exotic species (18.6%), and increased documentation of management actions (14.0%; Table 1). Workshop discussions focused on the need to both better document invasive species control efforts and continue long-term study of the response of invasive species and ecosystems to various treatments. The invasive species seen as most important to control to preserve the ecological integrity of the CPRV were Common Reed (*Phragmites australis*: 42.9%), Eastern Redcedar (*Juniperus virginiana*; 26.2%), Russian Olive (*Elaeagnus angustifolia*; 11.9%), Canada Thistle (*Cirsium arvense*; 7.1%), and Purple Loosestrife (*Lythrum salicaria*; 7.1%).

Top themes regarding habitat protection included: protect corridors and complexes of quality habitat (riverine, grassland) (31.0%), educate landowners on easement options (21.4%), and secure funds through partnerships (21.4%) (Table 1). Participants agreed that habitat protection should focus on protecting larger expanses of and corridors between quality habitats important to the function of the Platte River ecosystem and species of concern, including wet meadows and wide river channels. Participants also agreed that a cooperative plan would help specify priority areas and appropriate methods (easements, acquisition, etc.) for cooperative efforts to protect habitat. A nuanced conversation developed regarding conservation easement provisions, namely whether management clauses could be effectively added to agreements with private landowners, or whether properties that need significant management and restoration should be targeted for acquisition. A participant summarized this conversation well: "It's great if we have an easement on a native prairie, but, what good is it doing if we aren't helping that landowner manage their property? We do that on some [properties], but it's

up to the landowner to allow that. In terms of what you would want to have in an easement; you've got a roosting site with a meadow, you obviously don't want development. No-build easements can be fine for certain areas, but if you're talking about actual habitat, you need to have an active management component in the easement."

TABLE 1. Topics and subthemes outlining conservation needs given current scientific knowledge in the Central Platte River Valley, Nebraska, developed during session one of the interactive workshop held at the *Thirteenth Platte River Basin Ecosystem Symposium* on 6 June 2018 in Wood River, Nebraska. Each participant was given two votes to prioritize conservation needs topics and subthemes based on the importance of addressing them to improving and maintaining the ecological health of the CPRV.

CONSERVATION NEEDS	***VOTE***	***PERCENT***
Habitat restoration	8	18.2
Outreach and education	8	18.2
In-stream flow protection	6	13.6
Invasive species control	6	13.6
Habitat protection	6	13.6
Applied research	4	9.1
Secure funding	3	6.8
Improve partnerships and cooperation	2	4.5
Protect native species	1	2.3
Improve water quality	0	0.0
Totals	44	100.0
HABITAT RESTORATION	***VOTE***	***PERCENT***
Improve the connectivity of restoration efforts	11	25.0
Develop a strategic restoration plan	6	13.6
Incentivize private restoration	6	13.6
Wet meadow restoration	6	13.6
Restoration funding	5	11.4
Create habitat buffers (around valuable habitats)	5	11.4
Backwater slough restoration	2	4.5
Facilitate partnerships for restoration	2	4.5
In-channel nesting island habitat restoration (for Least Terns, Piping Plovers)	1	2.3
Grassland restoration (focused on birds, pollinators, plants)	0	0.0
Riverine roosting habitat (for crane species)	0	0.0
Totals	44	100.0
OUTREACH AND EDUCATION	***VOTE***	***PERCENT***
Educating the general public (informal, media)	14	31.1
University student and early career professional opportunities (funded internships)	13	28.9
Youth engagement (outdoor classrooms, kid-centered media)	8	17.8
Landowners engagement (developing common goals)	4	8.9
Leverage partnerships (cross-promote, etc.)	4	8.9
Continuing education (adult formal programs, teacher training, master naturalists, etc.)	2	4.4
Encourage ecotourism	0	0.0
Totals	45	100.0
IN-STREAM FLOW PROTECTION	***VOTE***	***PERCENT***
Revisit legal framework for in-stream flows	14	31.8
Conserve groundwater	12	27.3
Protect natural peak flows	10	22.7
Minimal seasonal flows	4	9.1
Improve water management	4	9.1
Secure in-stream flows for recreation	0	0.0

Totals	44	100.0
INVASIVE SPECIES CONTROL	***VOTE***	***PERCENT***
Research and monitoring of treatment responses	12.0	27.9
Secure new funding sources	10.0	23.3
Increase collaboration on priority exotic species	8.0	18.6
Increased documentation of management actions	6.0	14.0
Improve public education regarding invasive species	3.0	7.0
Prioritize species to target	2.0	4.7
Reseed treatment areas (off-channel)	2.0	4.7
Equipment access	0.0	0.0
Totals	43.0	100.0
INVASIVE SPECIES IMPORTANT TO CONTROL	***VOTE***	***PERCENT***
Common Reed (Phragmites australis)	18	42.9
Eastern Redcedar (Juniperus virginiana)	11	26.2
Russian Olive (Elaeagnus angustifolia)	5	11.9
Canada Thistle (Cirsium arvense)	3	7.1
Purple Loosestrife (Lythrum salicaria)	3	7.1
Reed Canarygrass (Phalaris arundinacea)	1	2.4
Saltcedar (Tamarix ramosissima)	1	2.4
Smooth Brome (Bromus inermis)	0	0.0
American Bullfrog (Lithobates catesbeianus)	0	0.0
Silver Carp (Hypophthalmichthys molitrix)	0	0.0
Narrow-leaf Cattail (Typha angustifolia)	0	0.0
Leafy Spurge (Euphorbia esula)	0	0.0
Western Mosquitofish (Gambusia affinis)	0	0.0
Yellow Flag Iris (Iris pseudacorus)	0	0.0
Totals	42	100.0
HABITAT PROTECTION	***VOTE***	***PERCENT***
Protect corridors and complexes of quality habitat (riverine, grassland)	13	31.0
Educate landowners on easement options	9	21.4
Secure funds through partnerships	9	21.4
Account for future conservation needs in protection plans	3	7.1
Create an integrated land protection/acquisition plan	3	7.1
Whole channel protection for quality habitats (both sides of river)	3	7.1
Further develop easement options and language	2	4.8
Develop tools/models to identify key areas for conservation	0	0.0
Improve relations with adjacent landowners	0	0.0
Totals	42	100.0

SESSION 2: KNOWLEDGE GAPS FOR THE CPRV

The most important knowledge gaps to address in our understanding of the CPRV ecosystem were deemed to be: i) human dimensions and economics; ii) invasive species management and control; iii) restoration research; iv) water research; and, v) prairie-meadow ecology (Table 2).

Top research themes to address regarding human dimensions and economics were: environmental values (regional opinions regarding conservation) (30.0%), evaluate the effectiveness of conservation communication (messaging efforts, etc.) (22.0%), and approaches to making the river more accessible (22.0%; Table 2). These research themes centered on conservation organizations gaining a better understanding of their neighbors and communities. For instance, what

challenges do farmers and ranchers face during the spring Sandhill Crane migration when ecotourism is high? A workshop participant summarizes this succinctly: "It is very important to understand the tension between a lot of the farmers and conservation people, as tourists stop their cars in the road and inconvenience farmers and other locals. The Sandhill Cranes are absolutely depending on the farmer's agricultural fields and the farmers are not getting much benefit from the tourism. How can we bring landowners into the economic stream?" Participants agreed that a comprehensive evaluation of farmers' and ranchers' opinions regarding conservation efforts in CPRV could be a valuable first step.

Top research themes to address regarding invasive species management and control were: best management strategies to prevent invasion (28.9%), a spatial assessment of Russian Olive and Eastern Redcedar cover (22.2%), and an assessment of biological control options (13.3%; Table 2). Workshop participants agreed that assessing the spatial distribution of the most problematic invasive species and further clarifying management strategies to control them were top research priorities. However, participants' opinions varied widely regarding the potential use of biological controls to achieve their goals and related research: "When we identify potential biological controls for some of these species … [how can we effectively] identify unintentional consequences [of their use]? If something is utilized in Texas for a species, do we want to bring that biological control into this area?" However, key arguments for biological controls and related research were also made: "I think looking at potential biological controls instead of exclusively relying on chemicals to treat some of these invasive species might be something worth looking into."

Top research priorities to address regarding restoration research were: to summarize lessons learned from restoration projects in the CPRV (37.0%), Prairie: Determining best management practice to promote natives and control exotics (23.9%), and Woodland: Determine species benefits from woodland habitat (15.2%; Table 2). Workshop participants agreed that evaluating the effectiveness of prairie and wetland restoration techniques in both short and long-term scenarios should be a key research priority as we have very little data on how restoration efforts have fared, especially in the absence of long-term management. Research focused on the effectiveness of management techniques to control for and/or manage against invasive species in restored prairies was of particular interest. A participant asked: "We all know that [in the early stages of a prairie restoration], especially when starting from a cornfield, tilling it and then planting it, right away you're going to have a big invasive problem. Is there a way to mitigate that?" An interesting discussion also emerged regarding prairie restoration in areas dominated by closed canopy riparian forest that largely developed within the last 80 years in response to fire suppression and flow reductions in the CPRV (Currier 1982). Participants thought this area deserved further research, and one participant noted a dilemma: "Existing cottonwood gallery forests along the [Platte] river have a tremendous value for neotropical migrants…. How can you manage cottonwood gallery forest habitat in concert with crane management, which needs a wide sweep of open countryside, particularly along the river. You can maintain those gallery forests for neotropicals, or you can remove all the forest because it's a good thing for cranes. There's going to be some cost to one species to benefit another."

The topic of water research was broken up into three subtopics including water quality, physical hydrology, and riverine ecology. Top research priorities regarding water quality were: human and wildlife health (pathogens) (27.3%), downstream effects of pollution (fate and transport of particular pollutants) (21.2%), integrate water quality research with other disciplines (i.e. - as ecological indicators) (15.2%), and interactions between chemicals as well as unintended effects of chemicals (12.1%; Table 2). Top research priorities regarding physical hydrology were: the effects of climate change on physical hydrology (25.0%), identify unexpected ecosystem services provided by the river (20.0%), and the effects of hydrology on microhabitats and ecotones (15.0%; Table 2). Top research priorities regarding riverine ecology were: interactions among native and introduced species (fish species, plant species) (32.6%), nutrient cycling (natural vs. anthropogenic influences) (21.7%), integrate riverine ecology parameters into ecosystems monitoring programs (19.6%), and interactions between geomorphology and wildlife habitat (13.0%; Table 2). Workshop discussions regarding water research centered on questions regarding flow variation and habitat structure, land cover and water quality, and the potential impacts of climate change on water resources in the CPRV.

Top research priorities concerning prairie-meadow ecology were: the effects of particular management actions on species of interest (41.2%), determining, quantifying, and communicating ecological services to private landowners (23.5%), and hydro-connectivity between river flows and wet meadows (19.6%; Table 2). The discussion regarding prairie-meadow ecology centered on tracking the long-term responses of these ecosystems to land management actions (fire, grazing, haying, herbicide treatments, etc.) and hydrological fluctuations (groundwater depth, flooding, etc.). The conversation also focused on what metrics could be used to track the long-term health of prairie-meadow ecosystems. Ecosystem health measures identified included the presence of rare endemic species (i.e.- Regal Fritillary *Speyeria idalia*, Henslow's Sparrow *Ammodramus henslowii*), invasive exotic vascular plant species relative abundance, vascular plant and avian biodiversity (i.e.- Simpson Diversity Index) and species richness, relative abundance of quality nectar resources (i.e.- milkweeds *Asclepias* spp.), responses of wildlife communities across multiple taxa (i.e.- songbirds, butterflies, small mammals, etc.), and percent shrub and tree cover. Participants also discussed the difficulty of communicating the value of prairie habitats to private landowners.

TABLE 2. Topics and subthemes outlining current research and knowledge gaps in our understanding of the Central Platte River Valley ecosystem developed during session two of the interactive workshop held at the *Thirteenth Platte River Basin Ecosystem Symposium* on 6 June 2018 in Wood River, Nebraska. Each participant was given two votes to prioritize research topics and subthemes based on the importance of addressing them to improving and maintaining the ecological health of the CPRV.

KNOWLEDGE GAPS (research needs)	***VOTE***	***PERCENT***
Human dimensions and economics	14	28.0
Invasive species management and control	10	20.0
Restoration research	9	18.0
Water research	7	14.0
Prairie-meadow ecology	5	10.0
Avian ecology	2	4.0
Climate change impacts	2	4.0
Wildlife ecology	1	2.0
Wetland ecology	0	0.0
Woodland ecology	0	0.0
Totals	50	100.0
HUMAN DIMENSIONS AND ECONOMICS	***VOTE***	***PERCENT***
Environmental values (regional opinions regarding conservation)	15	30.0
Evaluate the effectiveness of conservation communication (messaging efforts, etc.)	11	22.0
Approaches to making the river more accessible	11	22.0
Economics of crane season	5	10.0
Environmental impact assessment of regional ecotourism	5	10.0
Methods to integrate the river into public life (demonstrate its value to the community)	3	6.0
Totals	50	100.0
INVASIVE SPECIES MANAGEMENT AND CONTROL	***VOTE***	***PERCENT***
Best management strategies to prevent invasion	13	28.9
Spatial assessment of Russian Olive and Eastern Redcedar cover	10	22.2
Assessment of biological control options	6	13.3
Construct an invasion/expansion timeline for key invasive species in the CPRV	4	8.9
Herbicide impacts to water quality	3	6.7
Impacts of invasive species on grassland nesting birds	3	6.7
Impacts of Common Reed on channel morphology and sediment transport	2	4.4
Best chemicals for controlling specific invasive species	1	2.2

Fate of treated (dead) invasive plant materials	1	2.2
Impacts of invasive species on native plant communities	1	2.2
Identify external vectors by which invasive species could reach the CPRV	1	2.2
Saltcedar assessment and detection	0	0.0
Totals	45	100
RESTORATION RESEARCH	***VOTE***	***PERCENT***
Summarize lessons learned from restoration projects in the CPRV	17	37.0
Prairie: Determining best management practice to promote natives and control exotics	11	23.9
Woodland: Determine species benefits from woodland habitat	7	15.2
Prairie: Assess components of relict prairies missing from restoration seed mixes	4	8.7
Riverine: Assessment of recent slough restorations following floods	3	6.5
Woodland: Methods for maintaining relict cottonwood gallery forests	3	6.5
Woodland: Assessment of the benefits of restoring relict cottonwood gallery forests	1	2.2
Prairie: Optimizing seed mixes for application	0	0.0
Riverine: Identify decommissioned impoundments for removal	0	0.0
Totals	46	100
WATER RESEARCH		
WATER QUALITY	***VOTE***	***PERCENT***
Human and wildlife health (pathogens)	9	27.3
Downstream effects of pollution (fate and transport of particular pollutants)	7	21.2
Integrate water quality research with other disciplines (i.e.- as ecological indicators)	5	15.2
Interactions between and unintended effects of chemicals	4	12.1
Compare water quality between recharging vs. discharging water bodies	3	9.1
Integrate water quality parameters into ecosystems monitoring programs	3	9.1
Where are chemicals diluted and accumulated?	2	6.1
Impacts of physical pollution	0	0.0
Total	33	100
PHYSICAL HYDROLOGY	***VOTE***	***PERCENT***
Effects of climate change on physical hydrology	10	25.0
Identify unexpected ecosystem services provided by the river	8	20.0
Effects of hydrology on microhabitats and ecotones	6	15.0
Interactions between geomorphology and wildlife habitat	4	10.0
Groundwater dynamics in the CPRV	4	10.0
Effects of rare flow events (risk, perturbation)	3	7.5
Water quantity and supply	3	7.5
Integrate physical hydrology parameters into ecosystems monitoring programs	2	5.0
Total	40	100
RIVERINE ECOLOGY	***VOTE***	***PERCENT***
Interactions among native and introduced species (fish species, plant species)	15	32.6
Nutrient cycling (natural vs. anthropogenic influences)	10	21.7
Integrate riverine ecology parameters into ecosystems monitoring programs	9	19.6
Interactions between geomorphology and wildlife habitat	6	13.0
Dynamics in the hyporheic zone (subsurface flows)	5	10.9
Interactions between riverine and other ecologies	1	2.2
Riverine food web dynamics	0	0.0
Total	46	100
PRAIRIE-MEADOW ECOLOGY	***VOTE***	***PERCENT***
Effects of particular management actions on species of interest	21	41.2
Determining, quantifying, and communicating ecological services to private landowners	12	23.5

Hydro-connectivity between river flows and wet meadows	10	19.6
Meadow-prairie restoration effects on biota	4	7.8
Influence of patch size on biodiversity, species use, and management strategies of prairies	2	3.9
Identifying suitable sites for Western Prairie Fringed Orchid (*P. praeclara*) reintroduction	2	3.9
Hydrologic and environmental influence on invertebrate communities	0	0.0
Total	51	100

DISCUSSION

Workshop participants prioritized a wide range of *conservation needs* in the CPRV; however, unifying ideas were present that specified actions important to meeting our collective conservation goals. For instance, *habitat protection* and *habitat restoration* needs both focused on improving the connectivity between areas of quality relict habitat. Participants discussed the potential of creating a cooperative integrated land protection and restoration plan that would improve connectivity for species of concern through the construction of corridors and larger complexes of quality riverine and meadow habitat. This call for cooperation was echoed as a theme within other conservation needs topics; for instance, increasing collaboration regarding management for the most problematic invasive species. Other common themes included the need to secure new and sustainable funding sources and reaching out to our neighbors and the surrounding community to build support for our conservation efforts. Finally, conservation needs included protecting the historic structure and function of the CPRV ecosystem by conserving remaining quality habitats such as relict meadows and wide channels, protecting hydrological variability including peak flows, and preserving groundwater resources in the CPRV.

Knowledge gaps included a wide range of topics, but generally called for three different types of research: long-term research and monitoring, assessments summarizing ecological problems and methods for dealing with them, and research focused on or integrating human dimensions. The topics of *restoration research*, *invasive species management and control*, and *water research* (*physical hydrology*) provided good examples of long-term research themes. Some examples include: i) summarizing "… the lessons learned from restoration projects in the CPRV" [beginning in the late 1970s] by revisiting old restoration sites; ii) constructing "…an invasion timeline" for the most problematic species in the CPRV (i.e. - *P. australis, J. virginiana*, etc.); and, iii) identifying the "effects of climate change on [the] physical hydrology" of the Platte River. The topics of *invasive species management and control* and *water research* (*water quality*) provided good examples of "assessment" research themes, including: a "spatial assessment of Russian Olive and Eastern Redcedar cover" and an assessment of the "downstream effects of pollution (fate and transport of particular pollutants)."

Though *human dimensions* was a stand-alone research topic, other topics such as *water research* (*water quality*) also included human dimension research themes, such as "human and wildlife health (pathogens)" relating to the Platte River. Discussions surrounding this topic included the role of wet meadows as filters of water and the potential risks to humans from wildlife pathogens present in the Platte River, particularly in March during the peak of the Sandhill Crane migration. Human dimensions research topics focused on better understanding the environmental values of the surrounding community and how to engage that population in conservation efforts.

A common theme that emerged during both the *knowledge gaps* and *conservation needs* workshops was the need to increase collaboration amongst conservation organizations, government agencies, and the general public to improve conservation outcomes. Specific goals that emerged included the increased sharing of data as well as the increased collaboration in the planning of habitat protection, restoration, and invasive species management efforts.

Looking back to the research needs forums and stakeholder surveys conducted in the mid to late 1990s suggests that we have made significant strides in some respects, while remaining somewhat vexed by some of the largest challenges in terms of both conservation and science. To start, the integration of *human dimensions research* as well as *education and outreach* efforts in the CPRV have been reiterated as necessary priorities throughout the prior decades and again emerged

as a priority during the 2018 workshop. Eckert and Franti (1995) noted that small working groups identified "the need to incorporate humans into the ecosystem and evaluate the economic impact [of conservation efforts] on them" into our research and planning processes. Relatedly, Allen (1998) stated that "…we have not shared as much information with the public as we need to." Finally, Herpel (1997) contended, "information exchange between stakeholders is a problem." In some ways we have improved stakeholder communication, for example conservation organizations and government agencies are now relatively integrated and there has been ongoing efforts to deliver information to wider audiences, such as through educational documentaries (Platte Basin Timelapse Project; *Follow the Water*, Nebraska Educational Telecommunications 2018) or outreach events (Audubon's Crane Festival). However, results from this workshop suggest we have not yet bridged the communication gap between conservation organizations and the surrounding community. Participants agreed that a focused effort on community engagement, open dialogue, and human dimensions research is needed to better understand public perspectives regarding the Platte River and related conservation efforts.

In this workshop we developed the idea of an integrated habitat protection, restoration, and management plan (this would encompass invasive species management as well). This plan would prioritize lands for protection, restoration, and management in the CPRV, as well as the methods by which to achieve these goals (conservation easements, tree thinning, controlled burning, etc.). Interestingly, Allen (1998) found that conservation stakeholders in the Platte River discussed this need twenty years ago "[a plan]…has to be a cooperative [effort]…that everyone can take part in, not just one particular group. Audubon can't do it all; they're doing all they can in the little bitty area they have, but that's just a small portion of the channel. We need something that will pull people together. I think the irrigators and the environmentalist are starting to listen to one another more." Today biologists from the Central Nebraska Public Power and Irrigation District, the Nebraska Public Power District, and the Central Platte Natural Resources District all share a seat at the table with conservation organizations including the Audubon Society and the Nature Conservancy in overseeing the Platte River Recovery Implementation Program (PRRIP; Smith 2011). However, PRRIP focuses on four key federally threatened or endangered species, and does not specifically coordinate with other conservation organizations to site restoration projects adjacent to existing tracts of quality habitat owned by other groups (Smith 2011). In short, the existence of the PRRIP is an improvement regarding collective conservation action and stakeholder engagement, but the cooperative plan idea developed during this workshop and in the late 1990s, has a broader and more comprehensive focus that transcends targeted management for endangered species. A cooperative plan would focus on conserving large tracts of land and corridors between quality meadow and riverine habitats to broadly benefit native biodiversity.

Aside from the comprehensive and cooperative conservation plan for the CPRV, a number of other parallels emerged between the 2018 workshop and themes from previous symposia's research needs forums and stakeholder engagement efforts. Herpel (1997) listed investigating "…the potential impact of changing Nebraska's [legal] system to allow for the leasing of water rights (willing seller/buyer) to acquire water for habitat in low years." Our workshop identified "revisiting the legal framework regarding in-stream flow protection" as the top theme under the "in-stream flow protection" conservation needs topic. The laws in Nebraska still do not allow for the flexibility to lease water rights for habitat maintenance during low flow years, which is present in some other western states. In addition, the need to develop, provide, and communicate incentives to protect wet meadow habitats for private landowners was discussed at the 2018 workshop, as well as during the 1997 research needs forum (Herpel 1997).

Herpel (1997) included identifying "…species/habitat relationships and how species fluctuate under various conditions" as a research priority. Since then our understanding of various species-habitat relationships, particularly regarding species formally recognized as being "at-risk" by the NGPC or listed as "threatened" or "endangered" by the USFWS, has improved markedly. We have also improved our understanding of CPRV ecosystem's biodiversity, structure, and function over the last two plus decades. Recent examples of work advancing our understanding of species-habitat relationships and ecology in the CPRV include: Sandhill Crane (Pearse et al. 2017), Whooping Crane (Farnsworth et al. 2018), Regal Fritillary (Caven et al. 2017), Platte River Caddisfly (Vivian et al. 2013), arthropod communities (Welti et al. 2017), native herpetofauna (Geluso and Harner 2013), Least Terns (Alexander et al. 2018), Piping Plovers (Baasch et al. 2017),

grassland breeding birds (Askins et al. 2007), raptors (Caven et al. 2018), and many more. We have also improved our understanding of wet meadow vegetation and hydrology (Henszey et al. 2004), restoration ecology (Meyer et al. 2010), and the links between physical hydrology and Platte River habitat (Horn et al. 2012). However, many technical questions regarding these subjects remain to be answered.

The largest technical knowledge gaps seem to remain in two specific genres: water research and long-term research. Participants in the 1995 research needs forum stated, "[the] establishment of some long-term ecological monitoring programs will be needed for effective management of the ecosystem" and also suggested creating an "ecological health index for monitoring [riverine habitat]." Similar ideas were echoed in various capacities at the 2018 PRBES, ranging from synthesizing long-term restoration outcomes to integrating riverine ecology parameters into ecosystem monitoring programs. Though many extended research efforts have taken place in the CPRV (i.e.- Kim et al. 2008), no consistent data collection effort, specifically regarding the vegetative community and associated fauna, has continued unabated since being recommended at the research needs forums in the mid-1990s. Fortunately, advances in technology, such as Geographic Information Systems (GIS), have allowed us to provide relatively course analyses of landscape level changes in the CPRV (Pauley et al. 2018). However, more specific goals laid out in early research needs forums, such as describing and classifying "the historical distribution and long-term successional trends in wet meadows" (Eckert and Franti 1995), have not yet been accomplished in the long-term decadal or multi-decal sense.

Though we have advanced our understanding of the physical hydrology of the Platte River ecosystem (Chen 2007), many questions regarding water research, particularly relating to water quality remain unanswered. For instance, the research needs forum in 1995 listed "determining [the] influences of anthropogenic impacts (non-point source – nutrients, pesticides) [on aquatic ecology]" as a priority. Similarly, understanding the "downstream effects of pollution (fate and transport)" was designated a top water research priority in 2018.

CONCLUSIONS

It is evident that a multitude of organizations and collaborations have advanced our understanding of the CPRV ecosystem and progressed conservation efforts over the last 23 years. However, many persistent challenges remain. Increasing cooperation in regards to habitat protection, restoration, and invasive species control efforts could be key to improving the expanse and connectivity of quality meadow-prairie and braided river habitats in the CPRV. This effort would require a cooperatively developed plan and a working group to support initiatives and help coordinate the actions of multiple organizations. Stakeholder's priorities suggest that conservation outcomes may benefit from cooperative engagement at every phase of the adaptive management cycle (Schusler et al. 2003, Williams 2011). For example, there is potential for organizations to work together to record data from their respective restoration projects in a common database to facilitate the long-term monitoring of such efforts. Financial and human resources may also be more efficiently deployed to meet conservation goals through increased cooperation. Our workshop results suggest that it is not only important to reach out to other professional stakeholders in the CPRV, but also to the wider community. Our continued success in conserving the CPRV may depend on improving our understanding of the human dimensions of our natural resources, improving engagement through outreach and education efforts, and providing incentives for private land owners to conserve and manage quality prairie-meadow and braided river habitats.

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