PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Structured Decision Making Workshop Final Report

Rapid Prototypes for Implementation of Adaptive Management Plan (AMP)
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Authors: Drew Tyre[1], Jamie McFadden[2], Andrew Furman[3], Felipe Chavez-Ramirez[4], Mark Czaplewski[5], Mike Drain[6], Jason Farnsworth[7], Lisa Fotherby[8], Jim Jenniges[9], Chad Smith[10], Kevin Urie[11], Greg Wingfield[12]

Introduction

The goal of the workshop was to use Structured Decision Making and Rapid Prototyping to guide implementation of the Adaptive Management Plan of the Platte River Recovery Implementation Program (Program). In the following report, Structured Decision Making (SDM) is an approach to formally structure a complex decision to ensure that all aspects are considered (Gregory and Keeney, 2002). Adaptive Management (AM) is a special case of SDM that arises when the decisions are iterated and the consequences of future decisions depend on the outcomes of past decisions. This provides an opportunity for learning to improve decision making over time. Rapid Prototyping (RP) builds on the ideas of Tony Starfield and colleagues (Starfield, 1997) of using simple models to predict the consequences of different decisions. The framework of the workshop was built on iterating through a set of simple steps (Gregory and Keeney, 2001): defining the **PR**oblem, describing the **O**bjectives, listing the possible **A**ctions, predicting the **C**onsequences of those actions in terms of the objectives, and finally examining **T**radeoffs among the objectives to select the best action. These steps are summarized in the acronym **PROACT**, a reminder to be proactive in decision making. The remainder of this workshop summary follows this structure closely.

Problem

The first step in identifying a good problem to focus on is determining the spatial and temporal extent. The Program covers a 90-mile reach of the central Platte from Lexington to Chapman, Nebraska with eleven years remaining in the First Increment. This was used to constrain discussion during the workshop. In addition, it is important to recognize that the term “problem”

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[1] UNL School of Natural Resources, Lincoln, NE
[2] UNL School of Natural Resources, Lincoln, NE
[3] UNL School of Natural Resources, Lincoln, NE
[4] Platte River Whooping Crane Trust, Alda, NE
[5] Central Platte NRD, Grand Island, NE
[6] CNPPID, Holdrege, NE
[7] Headwaters Corporation, Holdrege, NE
[8] Bureau of Reclamation, Denver, CO
[9] NPPD, Kearney, NE
[10] Headwaters Corporation, Lincoln, NE
[11] Denver Water, Denver, CO
[12] U.S. Fish & Wildlife Service, Grand Island, NE

here refers specifically to a *decision*, a choice among alternative actions. This was a source of continual misunderstanding within the workshop because the fundamental focus of the Program's Adaptive Management Plan (AMP) is on "testing" for different responses between two broad overlapping management strategies – Flow Sediment Mechanical (FSM) and Mechanical Creation and Maintenance (Mechanical). FSM actions include: mechanical channel widening, addition of sediment near the upstream end of the critical reach, and pulse flows out of the Environmental Account (EA) in Lake McConaughy. Mechanical actions include: mechanical channel widening and sandbar construction (referred to in shorthand as "diesel" during the remainder of the workshop), creation/management of off-channel sand and water, and other actions.

The following questions were raised during the discussion of which problem to focus on:

1) Is the Cook property going to be acquired by the Program and used as a test site? Is the Cook property the only test site?
2) Should we clear phragmites and other invasives before implementation of the adaptive management plan?
3) Given water constraints, how can FSM be tested? And in terms of nesting habitat?
4) What is the best statistical and detection design for habitat use, bird monitoring, etc.?
5) Over the next 13 years, what is the best testing method between FSM and Mechanical?
6) Will birds respond to any action?
7) What is the schedule of water release and how do we obligate this limited resource with all its constraints?
8) What is the best array of land use configurations at one site? (Single large sandbar or several small sandbars – SLOSS debate in miniature).

In response to the above questions, and after significant discussion, one problem was selected:

"Over 11 years, given water constraints and 'N' sites (Program lands), how can we best detect the differences between FSM and Mechanical?" (See Figure 1).

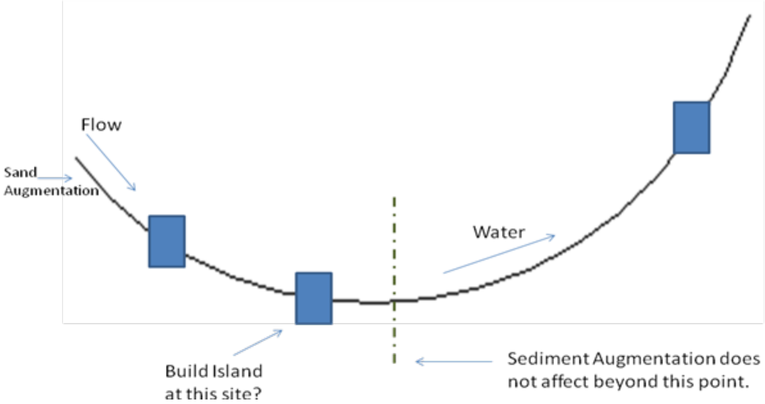


Figure 1: The above figure displays a suggested logistic plan for testing FSM and Mechanical on a given section of river with N sites. Here there are three research sites experiencing various combinations of actions.

Key Uncertainties

When the problem is seemingly too large, it is beneficial to narrow the original problem and step down to one of a few key uncertainties. The goal here is to evaluate each key uncertainty as a method of evaluating the problem.

- Can the FS actions of FSM maintain geomorphologic processes to build and/or maintain tern, plover, and crane habitat known as a braided river system?
- Do terns and plovers select FS bars over diesel bars? (Is there something about naturally created bars that attracts the birds? This unknown is termed "pixie dust.")

Refer to Figure 2 to see the acreage difference between on-river and off-channel habitat requirements for terns and plovers.

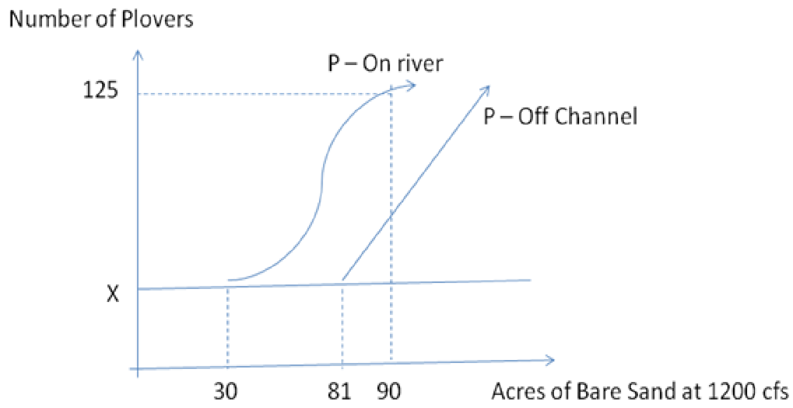


Figure 2: P-1 – additional bare sand habitat will increase the number of adult piping plovers. P-On river represents sandbar densities only on sandbars where birds were located. P-Off channel represents bird densities only on OCSW where birds were located. Line of slope zero represents bare sand where no birds were located.

Objectives

The following would show a difference between FSM and Mechanical when tested, if indeed there is a difference between the two:

- Water – Measuring Objectives = acre-feet. If all else is equal, less water is better (Figure 3)
- Number of terns and plovers – Measuring Objectives = # nests and # birds or pairs/each site
- Tern and Plover productivity – Measuring Objectives = fledge ratios by site
- Whooping crane use – Measuring Objectives = present/absence by site
- Braided river with no vegetation but is wide and shallow – Measuring Objectives = width to depth ratio. For the terns and plovers, it's the unvegetated width measurement. For whooping cranes, it's the unobstructed width measurement.
- Vegetation – Measuring Objectives = vegetated area by age
- Sediment – Measuring Objectives = cubic yards; if all else is equal, less sediment is better
- Sandbars – Measuring Objectives = height, area, % vegetation cover, wetted width, sand/water in a reach, and % vegetation cover on sandbar
- Cost ($)

Alternatives and Actions

Alternatives and actions are a set of creative options viewed as a means to completing the objectives given the constraints of the problem. The following is a list of actions:

- Build nesting islands on an existing foundation or created foundation
- Widen channels
- Clear vegetation
- Vegetation management
- Predator management
- Flow consolidation (could be done by pushing all the water into one channel)
- Flow management ("controlling the tap" by closing or opening channels)
- Sediment augmentation
- Out of channel sand in water
- Out of channel – wetlands
- Out of channel – uplands

To help decide the importance of an action, development of simple models allows for visualization of values. Refer to Figures 3 and 4 for helpful visuals on determining which set of actions is better and which holds more value. Refer to Figure 5 to view the value of and goal for on-river habitat vs. off-channel habitat.

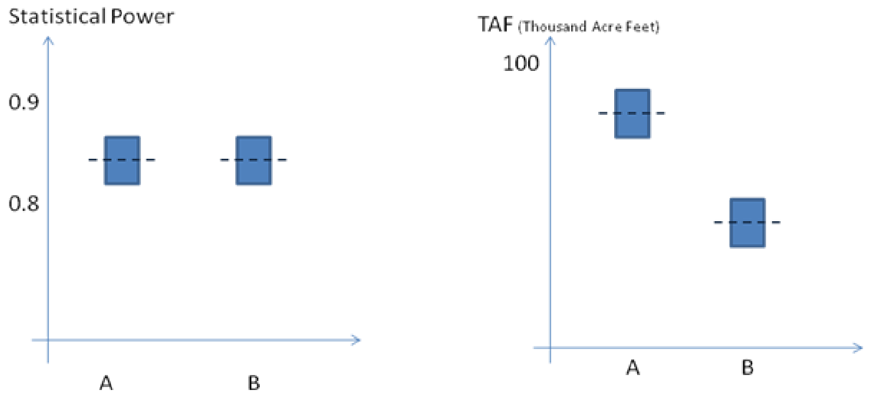


Figure 3: With A and B representing a set of different actions under FSM and/or Mechanical, which set of actions, A or B, would you choose given they use the same amount of power but differ in use of water?

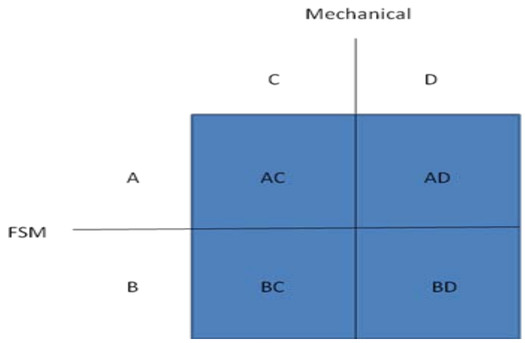


Figure 4: If between A and B, birds prefer B; while C and D are of the same value. Which is set is better?

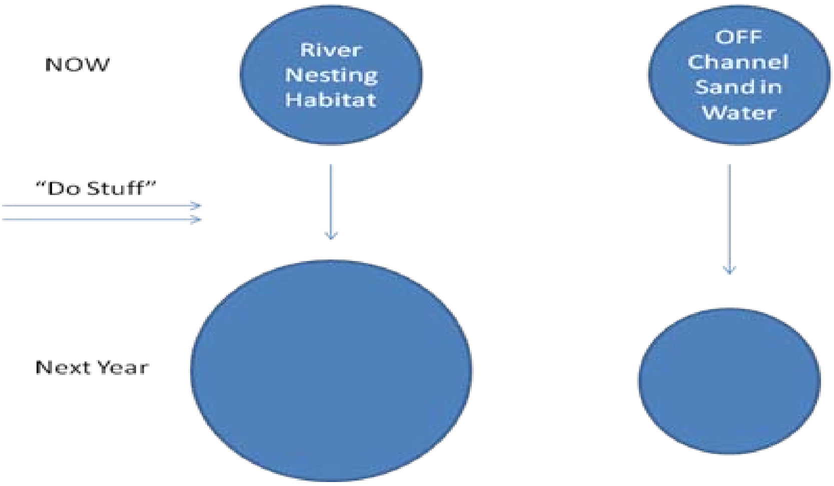


Figure 5: The above figure represents a valued goal by the following year through accomplishing a given set of actions. Here there is a value placed on riverine habitat for the birds where there is a preference to have more birds nesting on sandbars rather than on OCSW.

Consequences

Various scenarios including a set of actions under a given objective are evaluated using rapid prototyping (RP) to produce models testable against data. Through RP, consequences for sets of actions are determined and then reviewed against each other. The models assume no difference between FSM and Mechanical implementation, just that it has the impact of increasing habitat. Assume time is 11 years due to the 13-year constraint of the First Increment with two years into the Program. Refer to Figure 6 for visual diagram of the various influences on today's riverine habitat. Refer to Excel Spreadsheets for Rapid Prototype Models and Model Key Notes.

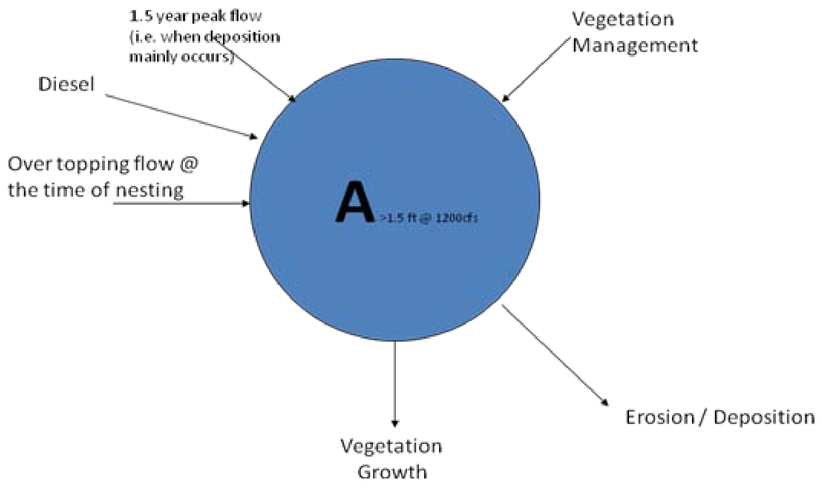


Figure 6: Processes affecting change in the amount of on river habitat area.

McConaughy Plovers

Model Assumptions – The assumption here is that piping plovers prefer river habitat, meaning they would rather nest on sandbars than off-channel sand and water (OCSW) habitat. This model also assumes habitat preference values from Lake McConaughy data applied to the central Platte plover population to display exponential growth with a preference for river habitat. The initial area of available habitat is 40 acres on river and 80 acres on OCSW. Bare sand is the assumed habitat.

Scenarios

This spreadsheet was created to evaluate four different scenarios of Program management.

Scenario A, the "do-nothing" option, attempts to simulate a complete halt to Program activities. River habitat remains at a constant low level, while OCSW habitat decreases at a low rate as it becomes unsuitable due to vegetation and development. Total wetted width and unobstructed width also remain constant.

Scenario B simulates the status quo, where the Program continues its current activities but does not implement a broader strategy. River habitat increases by 20-40 acres/year as the Program acquires land and constructs sandbars. OCSW habitat decays the same as in scenario A. Wetted width remains constant, but unobstructed width increases slowly on reaches east of the midpoint (representing Kearney) due to tree-clearing activities both inside and outside Program lands.

Scenario C simulates a new strategy, where large amounts of habitat are added. River habitat is at first added by 20-40 acres per year, but after Year Five the process speeds up, reaching 820 acres by year 11. OCSW operates much the same way it did in the other scenarios, but an additional 40 acres is added along the way and kept stable. Every two years one of the Program lands has its wetted width increased to 750 feet and is kept stable. Unobstructed width increases slowly as in scenario B.

Scenario D represents a similar plan, but implemented more aggressively. River habitat increases by 390 acres by Year Three and then increases more slowly, reaching the same final level as Scenario C. OCSW habitat operates the same as Scenario C, as does wetted width. Unobstructed width also maintains its slow growth, but each year one of the Program lands increases and maintains its unobstructed width at 1,200 feet.

Tern and Plover Scenarios – Model Assumptions

Models A – D examine interior least tern and piping plover populations and assume equal habitat preferences for both species. The current parameters of the models assume no preference or difference in vital rates between river sandbars and OCSW. However, the models do allow for manipulation and testing against data for such differences. Specifically, when the habitat preference is greater than one, the river as more attractive habitat and when it is less than one, OCSW is more attractive to the birds.

Additionally, there is an assumption to ignore the possibility of double-brooding and abnormally large clutch sizes when discussing fecundity in this model. While some data lends support for nesting differences between the two main habitat choices, the models assume no additional cost (increased predation, energy for longer flight distances, etc.) for nesting on OCSW. These differences may be approximated by changing the input parameters.

Lastly, each model differs in the distribution and amount of habitat broken up between sandbars and OCSW with initial amount of 40 acres of sandbar habitat and 80 acres of OCSW. The assumption is that habitat rather than food is the main limiting factor where fecundity drops with density but population does not decrease due to starvation. The models make no difference between sandbars maintained by flow and sandbars maintained by mechanical means. Examination of habitat distribution in these models is relevant as scheduling of actions impact the ability to detect differences when studying habitat preferences.

This following equation is the base for models A – D and calculates fledge ratio with density-dependant fecundity:

$$Fr = f * e^{-x(a/(\frac{h}{2}))}$$

Fr - Fledge Ratio
f - Maximum Fecundity
x - Habitat-specific Coefficient
a - Number of Adults
h - Acres of Habitat

In **Scenario A**, the amount of sandbar habitat remains constant at 40 acres and OCSW habitat has a decaying rate of 5% each year for 40 acres of the entire 80 acres. In **Scenario B**, there is a 30-acre addition per year for 11 years to the initial 40 acres of sandbar habitat and OCSW habitat has a decaying rate of 5% each year for 40 acres of the entire 80 acres. In **Scenario C**, there is a 60-acre addition per year until Year Six when this increases to 80 additional acres per year on the river; on OCSW 40 acres of the initial 80 decays by 5% per year but 40 additional stable acres are added in the sixth year. In **Scenario D**, there is an initial increase of 60 acres per year until the third year when 390 acres are added followed by 30 acre additions per year on the river. On OCSW, while 40 acres of the initial 80 decays by 5% per year, 40 additional stable acres are added in the third year.

The hypothesis is the birds are density dependent. One method to test this is to "shock" the birds with a large amount of habitat in the very beginning to help better determine the shape of the density versus fledge ratio model rather than just slowly adding small amounts of habitat that would cause a small fluctuation in the population. Therefore, adding large areas of habitat in the beginning of the Program allows for greater visibility of how the birds respond to density changes. Refer to Figure 7.

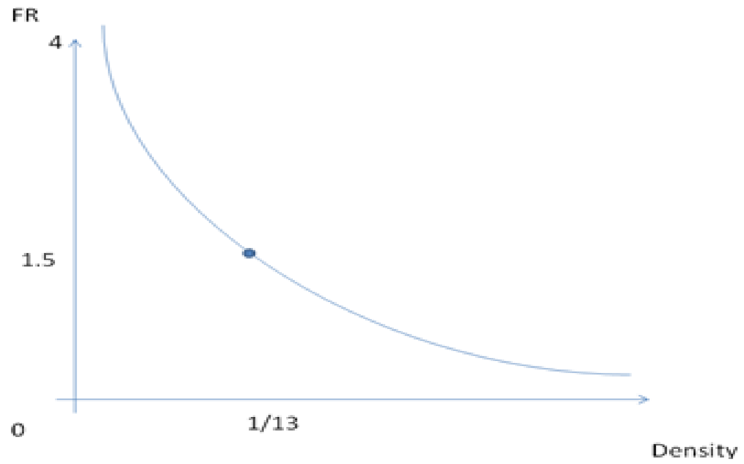


Figure 7: The above model displays density dependency of fledge ratios (Fr) where building more habitat decreases density which in turn would increase Fr. The thought here – as habitat increases, density decreases, and Fr increases.

Whooping Crane Scenarios – Model Assumptions

Models A – D examine given sets of actions tested with respect to whooping crane life history. An extensive discussion took place regarding the definitions of wetted and unobstructed width due to a diversity of definitions among workshop participants. The following definitions for model use in the workshop, which may or may not be consistent with other usages:

- Wetted width – distance from one side of the largest channel to the other
- Unobstructed width – distance between the nearest visual obstructions over three feet in height on each side of the largest channel

The following equation is the base for Models A – D and calculates relative probability that cranes will use a particular reach of river in a particular year:

$$P = \frac{e^{(0.015*W_1:W_{30}+0.01*U_1:U_{30})}}{\sum(e^{(0.015*W_1:W_{30}+0.01*U_1:U_{30})})}$$

P - Relative Probability
W - Wetted width
U - Unobstructed width

The models are arranged where each reach has a randomly distributed wetted width each year. The largest of these is multiplied by a randomly distributed coefficient to give the unobstructed width. These values are multiplied by a coefficient that represents the increase in probability of use as width increases. "Base e" is taken to the power of the result, then that value is divided by the sum of the same value for all reaches that year to yield the relative probability of use. The probabilities for each reach hypothetically owned by the Program are then added together. The scenarios simulate actions taken through Mechanical or FSM to maintain certain widths.

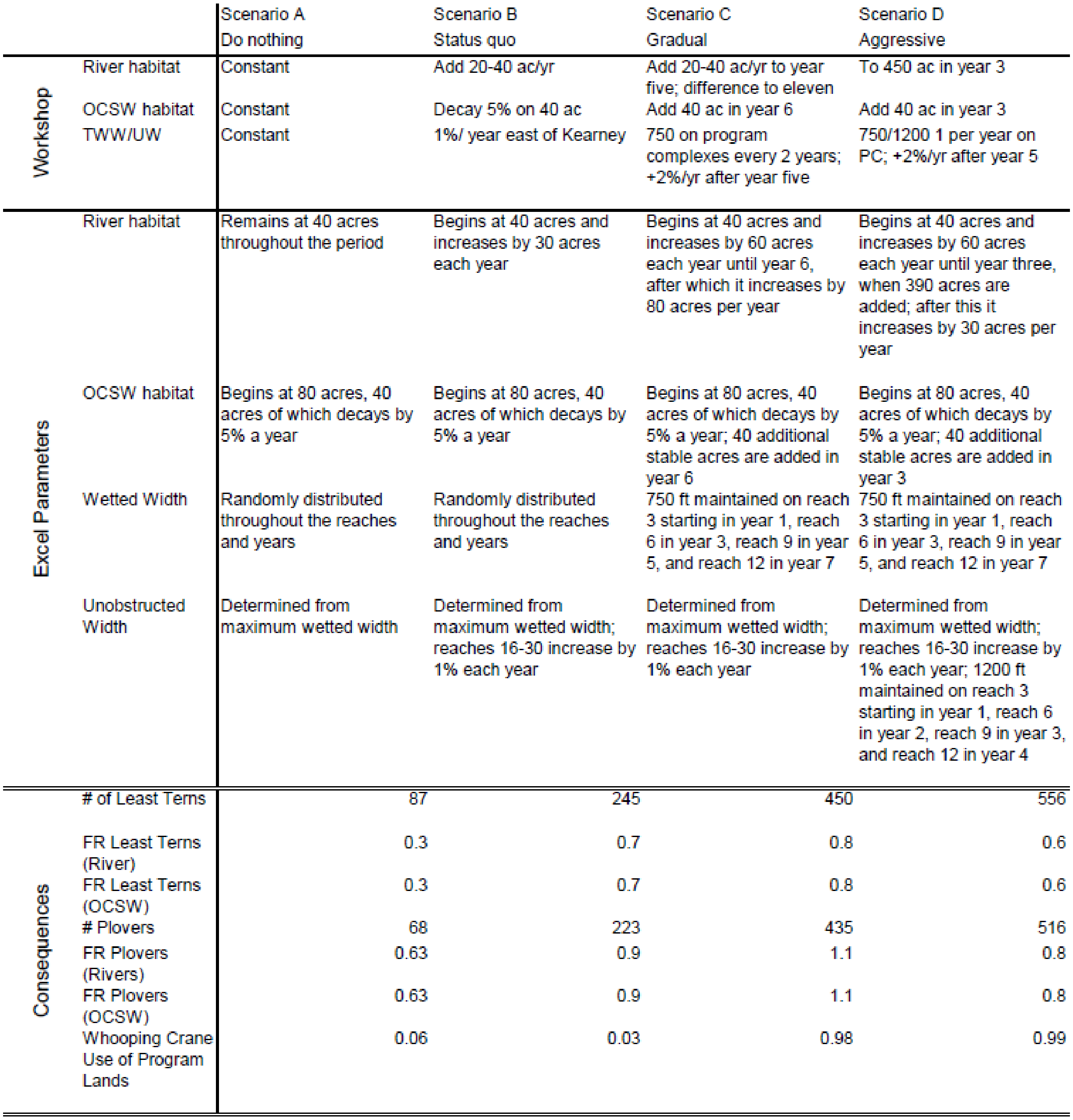
Fledge Ratios by Density

This worksheet shows the relationship of fecundity to density on both river and OCSW habitats. Fecundity decays logarithmically as density increases. Maximum fecundity is multiplied by "base e" to the power of the negative rate multiplied by the density. In this example, the fecundity on the river decays at a faster rate than fecundity on OCSW, simulating a situation where birds on the river suffer from stronger density dependent effects than those on OCSW.

Consequence Table

The Consequence Table is used to display the results of the different scenarios for evaluating which one is the most preferable. Based on the Consequence Table from these models, Scenario D is the best alternative (Table 1). Scenario C results in higher fledgling ratios due to a lower density, but fewer terns and plovers and slightly lower crane use of Program lands. Scenario C also results in higher fledge ratios than Scenario D, but a much smaller population and very little crane use. Scenario A results in the smallest population and lowest fledge ratios, though it also results in slightly higher crane use than Scenario B. Therefore, the best course of action according to this model is aggressive addition of habitat. Ideally, a Consequence Table would include some estimate of cost. If this table included cost, the decision might be different as Scenario D is likely to be the most expensive.

Table 1: Consequence Table outlining the four scenarios evaluated and their effects on the consequences.



		Scenario A Do nothing	Scenario B Status quo	Scenario C Gradual	Scenario D Aggressive
Workshop	River habitat	Constant	Add 20-40 ac/yr	Add 20-40 ac/yr to year five; difference to eleven	To 450 ac in year 3
	OCSW habitat	Constant	Decay 5% on 40 ac	Add 40 ac in year 6	Add 40 ac in year 3
	TWW/UW	Constant	1%/ year east of Kearney	750 on program complexes every 2 years; +2%/yr after year five	750/1200 1 per year on PC; +2%/yr after year 5
Excel Parameters	River habitat	Remains at 40 acres throughout the period	Begins at 40 acres and increases by 30 acres each year	Begins at 40 acres and increases by 60 acres each year until year 6, after which it increases by 80 acres per year	Begins at 40 acres and increases by 60 acres each year until year three, when 390 acres are added; after this it increases by 30 acres per year
	OCSW habitat	Begins at 80 acres, 40 acres of which decays by 5% a year	Begins at 80 acres, 40 acres of which decays by 5% a year	Begins at 80 acres, 40 acres of which decays by 5% a year; 40 additional stable acres are added in year 6	Begins at 80 acres, 40 acres of which decays by 5% a year; 40 additional stable acres are added in year 3
	Wetted Width	Randomly distributed throughout the reaches and years	Randomly distributed throughout the reaches and years	750 ft maintained on reach 3 starting in year 1, reach 6 in year 3, reach 9 in year 5, and reach 12 in year 7	750 ft maintained on reach 3 starting in year 1, reach 6 in year 3, reach 9 in year 5, and reach 12 in year 7
	Unobstructed Width	Determined from maximum wetted width	Determined from maximum wetted width; reaches 16-30 increase by 1% each year	Determined from maximum wetted width; reaches 16-30 increase by 1% each year	Determined from maximum wetted width; reaches 16-30 increase by 1% each year; 1200 ft maintained on reach 3 starting in year 1, reach 6 in year 2, reach 9 in year 3, and reach 12 in year 4
Consequences	# of Least Terns	87	245	450	556
	FR Least Terns (River)	0.3	0.7	0.8	0.6
	FR Least Terns (OCSW)	0.3	0.7	0.8	0.6
	# Plovers	68	223	435	516
	FR Plovers (Rivers)	0.63	0.9	1.1	0.8
	FR Plovers (OCSW)	0.63	0.9	1.1	0.8
	Whooping Crane Use of Program Lands	0.06	0.03	0.98	0.99

Geomorphology – Role of SedVeg Model

There is a connection between geomorphology and biology in relation to nest selection site for terns and plovers. This in turn determines what type of data to collect from a given research site to show why the birds choose that site on the sandbar. SedVeg is a simple yet complex model of the central Platte River potentially capable of showing this relation. The following attempts to capture a brief explanation of this model.

SedVeg is classified as a one dimensional model; its view of water movement is restricted to a forward direction. However, in the real world there are three dimensions for water movement. In addition to forward motion, there are also up and down directions for water movement. For this reason, the model is considered to be simple from an engineering standpoint. Compared to biological models, however, it tracks a large number of state variables (sediment profiles, water depth, velocity, sediment grain size profile) which makes it a very complex model from a biological viewpoint.

SedVeg gains complexity in other aspects of riverine habitat. In the model, division of the river is among a series of cross sections going down the river. This is the skeleton and base for all following assumptions: 1) It uses the monthly flows to made assumptions of daily flows during the given month, and 2) SedVeg then works on the daily flow to compute the water surface at each cross section on that day.

These cross sections have many variables. If SedVeg was only a flow model the river profile would always stay the same. However, in SedVeg the profile can change due to other variables. One of the main variables includes percent of sediment amounts in the water column. The model computes how much deposition of sediment occurs at the bottom of the channel to determine the shape of the profile in a given cross section. SedVeg is capable of detecting ten different sizes of sand grains and the elevation of the grains in the water column. This becomes relevant when the flow of the water changes. When tracking sediment, the water is capable of moving both small grains and larger grains when the flow is fast. However, if the flow is moving slowly, only the smaller sized grains move in the water column.

Another main variable SedVeg is capable of tracking is vegetation. Currently, the model tracks four different species of vegetation though it is capable of tracking up to ten species. When tracking the vegetation it examines the survival of the individual plants and their growth.

Overall, SedVeg is capable of tracking water flows, sediment, and plant growth within the braided river system. This model is based on 13 years of historic data from the USGS. The model was set to predict about 48 years into the future. While this model is based on historic data, it does allow for testing against future data sets to determine its accuracy. Overall, SedVeg has utility for teasing out data use for the Rapid Prototypes.

Reflection and Next Steps

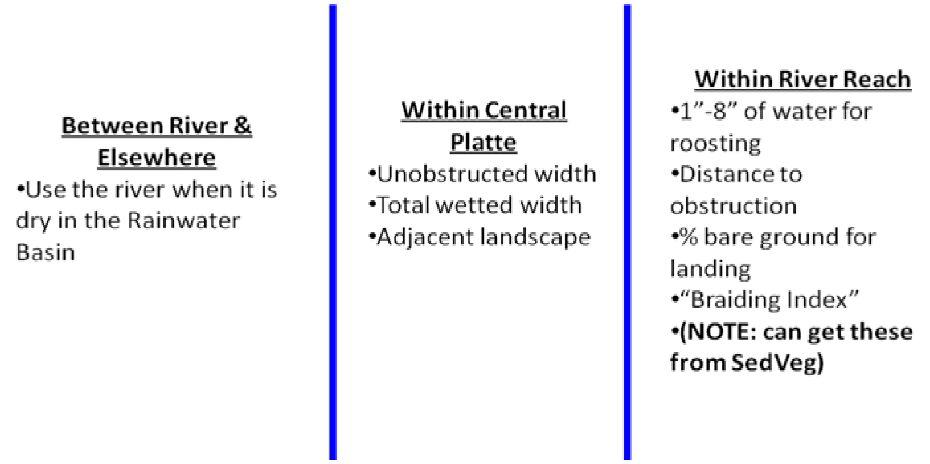
The following are lessons learned by the workshop participants throughout the workshop:

- Just because it is bare sand, doesn’t mean it is habitat
- Better understanding of biological questions
- Probe notion of current data gaps
- Regular revisiting of analysis
- Rapid Prototyping is useful
- Moved beyond discussion to predicting and planning
- Don’t need all the answers before we can make decisions

- Remaining concerns about the follow up
- Formalize historic data
- Determine future data collections
- Gained validation in work.

Discussion of Data Needs/Gaps

When devising environmental plans, determining the scope in terms of spatial and temporal dimensions is extremely helpful and provides better focus and direction. Refer to Figure 9 and Figure 10 to provide a general overview of the various dimensions of crane, tern, and plover habitat details that need to be gathered from ongoing or new monitoring and/or research to feed into these and other Rapid Prototypes.

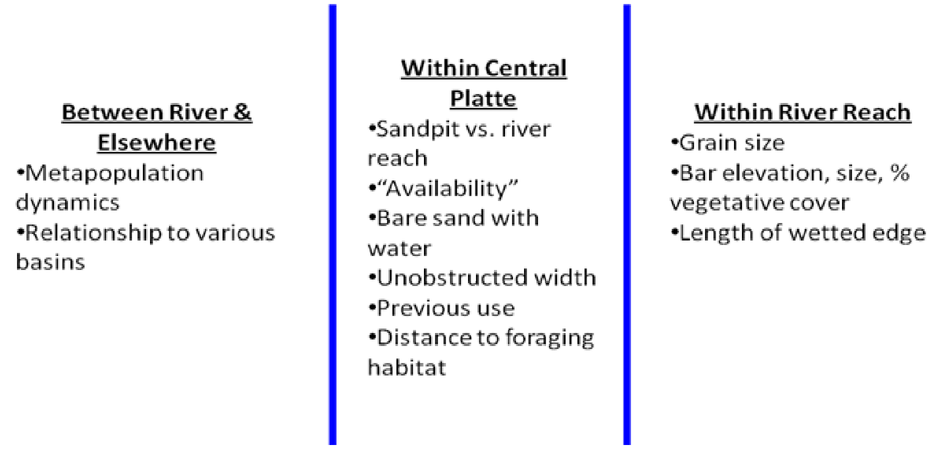


Between River & Elsewhere
- Use the river when it is dry in the Rainwater Basin

Within Central Platte
- Unobstructed width
- Total wetted width
- Adjacent landscape

Within River Reach
- 1"-8" of water for roosting
- Distance to obstruction
- % bare ground for landing
- "Braiding Index"
- **(NOTE: can get these from SedVeg)**

Figure 8: Above explains crane habitat on various scales.



Between River & Elsewhere
- Metapopulation dynamics
- Relationship to various basins

Within Central Platte
- Sandpit vs. river reach
- "Availability"
- Bare sand with water
- Unobstructed width
- Previous use
- Distance to foraging habitat

Within River Reach
- Grain size
- Bar elevation, size, % vegetative cover
- Length of wetted edge

Figure 9: Above explains tern/plover habitat on various scales.

Workshop participants discussed future actions and next steps. Initially, the results will be presented to the full Adaptive Management Working Group (AMWG). Continuing to collect data and analysis is necessary and is extremely beneficial in updating model parameters. Discussion of specific data collection will take place in the near future. One of the most useful outcomes of the Rapid Prototyping session was the conversion of "priority hypotheses" listed in the AMP into prototype quantitative models such as the whooping crane habitat use model.

Sensitivity Analysis

*** Please see "Sensitivity Analysis" worksheet in the Rapid Prototype Excel spreadsheet that accompanies this report.**

We (Drew, Jamie, Andrew) performed a sensitivity analysis on the outputs by varying the input parameters up and down by varying amounts. The variations we used consisted of increases and decreases by 50%, 20%, 10%, and 5%. This can be done interactively by altering the values in the pink column of the "Sensitivity Analysis" worksheet. The effect of any change will be immediately visible in the green area above; here both the values of the outputs and the percent they deviate from the original values are displayed.

Results of our analysis are summarized in the tables and graphs in the last worksheet of the Rapid Prototype spreadsheet, with each output represented by one table and graph under each scenario. Each graph features a line for each input parameter, with the percent change in input plotted against the percent change in output. Steep lines indicate that changes in the input have a strong effect on the output, while lines that are close to horizontal indicate the opposite.

All of the outputs are strongly tied to the adult survival rate. The first year survival rate has a strong effect on the fledge ratios (especially when decreasing), but little effect on the total population. The same is true of the habitat effect on the fledge ratios of the river. In OCSW habitat, however, habitat effect is the strongest influence on fecundity rates in all but Scenario A. In no scenario does it significantly affect the overall size of the population. The other inputs generally have little effect on the outputs, though all do influence them slightly. The relationships range from essentially linear to slightly curved, with a few exceptions. In Scenarios B-D, the habitat effect curve changes direction twice near the center of the graphs for total population and river fledge ratios in both species. A similar pattern can be seen in the OCSW coefficient with terns under Scenario C and in first year survival with plover river fledge ratio under Scenarios C and D and tern river fledge ratio under Scenario A.

The whooping crane model shows more sensitivity in Scenarios A and B than in C and D. In Scenario A, both wetted width and unobstructed width have a strong effect on the probability of whooping crane use of program lands, while in Scenario B only the wetted width has a strong effect. In Scenarios C and D, neither parameter has a significant impact.

Altering the parameters changed the magnitude of the results, but did not change their relationship to one another. While the exact values of these parameters may have significant effects on the results of the models, they do not affect the decision between these alternative sets of actions. Therefore, it is not necessary to seek more precise estimates of these parameters before taking action. However, the magnitude of the results becomes important when evaluating the scenarios with reference to cost; if the results are a lower magnitude than expected, the differences between them will also be smaller, which may affect the decision between two acceptable sets of actions with differing costs.

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Starfield, A. 1997. A pragmatic approach to modeling for wildlife management. J. Wild. Manage. 61(2):261-270.