**PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP -OR- Program)**

**Germination Suppression Data Analysis Outline**

# INTRODUCTION

Whooping crane roosting along the central Platte River is dependent upon wide, shallow river channels unobstructed by tall, dense vegetation. Flow releases to inundate the active channel early in the growing season have been designed to test the effectiveness of using Program water to suppress germination of problematic perennial species like cottonwoods (*Populus* spp.) and willows (*Salix* spp.), and to attempt to slow encroachment of *Phragmites australis* into the channel. Information collected during the implementation of germination suppression flow releases is used to evaluate the biological response of riparian vegetation to the inundation of the channel and the effectiveness of these releases in maintaining wide unobstructed channel widths for whooping crane roosting.

**Two Extension “Big Questions” (EBQs)** relate directly to measuring vegetation response to germination suppression flow releases ([**PRRIP 2022**](https://platteriverprogram.org/document/prrip-extension-science-plan)):

* ***EBQ #1 –*** How effective is it to use Program water to maintain suitable whooping crane roosting habitat?

Management Hypothesis: Releases to achieve a 30-day minimum flow target of 1,500 cfs between June 1 – July 15 will suppress germination, slow vegetation expansion into the channel, and increase the percent of AHR channel that remains highly suitable for whooping crane roosting (germination suppression release).

* ***EBQ #2 –*** How effective is Program management of *Phragmites* for maintaining suitable whooping crane roosting habitat?

Management Hypothesis: Releases to achieve a 30-day minimum flow target of 1,500 cfs between June 1 – July 15 in combination with continued herbicide spraying will slow *Phragmites* rhizome/stolon expansion into the channel and increase the percent of AHR channel that remains highly suitable for whooping crane roosting.

Implementation of germination suppression flow releases to address these questions provides valuable information on the quantity of Program water necessary for effective channel maintenance while providing information on the cost and benefits of a water alternative for maintaining suitable roosting and in-channel foraging habitat for whooping cranes.

## EVALUATION OF EFFECTIVENESS

The combination of remote sensed and on the ground field measurements enables us to quantify the amount of spatial and temporal water coverage achieved during the flow release, quantify vegetation response to inundation, and estimate subsequent unobstructed channel widths to evaluate the effectiveness of using Program water to maintain wide, unobstructed channels for whooping crane roosting.

**Machine Learning Model**

The primary tool for evaluation of effectiveness is a random forest model developed to utilize historical information gathered for the central Platte about how natural peak flows and flows during the early growing season (germination period) interact with channel geomorphology over time to affect unobstructed channel width. The model also accounts for mechanical management such as river channel disking and herbicide application to predict the effectiveness of germination suppression flows to maintain highly suitable unobstructed channels widths for whooping cranes (**Table 1**).

The four explanatory variables most crucial to quantify the effectiveness of germination suppression flows include:

1. *Previous year maximum unobstructed channel width*: Provides an annual starting point of channel conditions;
2. *June average flows*: Captures the period of germination suppression releases, as well as peak flow events in most years;
3. *Wetted width at bankfull discharge*: The extent of a channel potentially inundated with water.
4. *Flow consolidation*: Estimate how much flow during June is traveling through a channel.
5. *Winter flows*: Emerging as a potential hydrologic metric of interest.

These four variables, along with the additional explanatory variables in **Table 1**, will be included in a modeling process consisting of three steps.

Step One:

* Use data from 2004 – 2019 to train the model.
* Validate model by leaving out 20% of data in each geomorphic reach.
* Predict changes in channel width during the period of implementation of germination suppression flows (2020-2023) to understand how well flow releases for germination suppression mimic natural flows of a similar magnitude to maintain highly suitable unobstructed channel widths for whooping cranes (**Figure 1**).

Step Two:

* Directly add data from years with germination suppression flows (2020 – 2023) into the training data to create the model.
* Include a grouping variable to distinguish years with germination suppression flows and those without.
* Validate model by leaving out 20% of data in each geomorphic reach.
* Compare Step 1 results to Step 2 results. How well did the model with 2004-2019 data predict effectiveness of germination suppression flows? Did we over- or under-estimate? Why?
* Compare influence of germination suppression flows to river channel disking and herbicide application.

Step Three:

* Use the model from step two to predict future channel conditions under various flow and mechanical management scenarios to inform the SDM process for the Second Increment.

**Vegetation State Change**

A grid-based analysis of the relationship between inundation (2-D model/June aerial imagery) and in-channel vegetation state (inundated, unvegetated, vegetated) will be conducted on an AHR scale. Discriminate analysis can be used to identify inundation timing, duration, and percentage channel inundated in relation to vegetation states, specifically conditions that lead to a state change. These analyses will also take any mechanical or chemical management into account.

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| --- |
| *This analysis is early in development. Ideas are represented in outline and figure format to introduce the steps in the process and to facilitate discussion.* |

* State Change Model
  + Objective – Correlate germination suppression flow magnitude with vegetation establishment and succession.
    - Is there a relationship between inundation and vegetation establishment?
    - How much of the channel that is inundated by a germination suppression flow release remains unvegetated through time?
  + Conceptual model
    - Large peak flows laterally scour channel banks/islands and remodels the channel bed – generally by flattening topography.
    - Vegetation becomes established in channel if aerially exposed
      * Wet years – channel inundated = no establishment except on high bars and islands where sand deposited (buried woody reemerges)
      * Dry years – Veg establishes across range of bed elevations
        + Low surfaces – inundated in winter and vegetation destroyed
        + High surfaces (not inundated) - vegetation persists into next year
        + Amount of channel inundated is a function of winter flows
      * Intermediate years – scouring of low surfaces and deposition on intermediate surfaces
    - Germination suppression flow – inundate channel & prevent germination on surfaces that are above winter flow elevation.
  + Analysis
    - Data sources
      * LiDAR (bare earth and highest hit) processed into 3 ft grids
      * CIR Imagery (veg signature)
      * 2D Hydrodynamic Modeling – Deterministic modeling of channel hydraulics (water surface elev, flow depth, velocity, shear stress, etc.)
        + Range of flows 500 – 5000 cfs with flow splits
    - Timeframe
      * 2019 = wet / peak flow year (system reset)
      * Germination suppression flow releases 2020 – 2023 (only have 2020 – 2022 data to date)
        + 2020 target 2000
        + 2021 target 1500
        + 2022 best example of dry year, but irrigation limited release
        + 2023 very high flows out of S Platte, way above 1500 cfs target
    - Hydrologic Metrics
      * 40-Day Mean Max Discharge
      * Germ-Suppress Period Discharge
      * Winter/Spring Baseflow – NEED TO DISCUSS
    - Channel Hydraulics
      * RAS 2D model(s) generated from LiDAR rasters
        + 3-ft rasters of hydraulic metrics that are coincident with LiDAR
    - Vegetation Data
      * ECognition vegetation classifications (annual)
        + LiDAR & CIR Imagery
    - State Change Analysis
      1. Intersect annual ECognition results to identify in-channel vegetation change by year (**Figures 2-3**)
         1. Unvegetated (sand, water) to:

Vegetated < 2ft

Vegetated 2-6 ft (obstructed)

* + - * 1. In-channel vegetation with no change (stays vegetated)
      1. LiDAR – Intersect rasters to identify cells that change from 0 canopy height to:
         1. < 2 ft canopy height
         2. 2 – 6 ft canopy height
         3. > 6 ft canopy height
         4. Note: need to correct for mechanical clearing – Primarily @ Rowe & WCT flow splits
      2. Intersect vegetation change (polygon or raster) with hydraulic model flow depth @ 1,500 cfs raster (and/or other discharges) (**Figures 4-5, Table 2**)
         1. Distribution of flow depths by vegetation change classes
* Becomes a Big Data Problem
  + - * + 1 million points per river mile
        + Everything correlated
        + Undefinable uncertainty (multiple sources of uncertainty)
        + Zero inflated
        + You can see it – best way to analyze it?

*ISAC question:* How do you “sample” your full dataset in a way that allows you to examine the relationships between water depth and change in vegetation state? Billions of pixels with associated modeled depths and LiDAR vegetation heights is too big of a dataset to work with and all spatially and temporally correlated.

**Channel Width Maintenance**

* Width maintenance model
  + Objective – Estimate maintainable (with flow) width potential at Program complexes based on state change modeling results
    - Key understandings:
      * Much of the reach flow split between main and secondary channels (**Figure 6**).
      * Probability of maintaining width w/o mechanical is highly dependent on % of flow consolidated in main channel and total channel width (**Figure 7**).
      * Width potential increases through reach (everything covaries with RM)
      * Observed unvegetated width likely doesn’t = width potential in many places due to vegetation reinforcement of banks
        + Have to be picky about site selection
    - Multi-variate analysis
      * TCW, TUCW, MUCW, Consolidation, river mile, discharge
      * Univariate example in figure below.

REFERENCES

Platte River Recovery Implementation Program (PRRIP). 2022. Platte River Recovery Implementation Program First Increment Extension Science Plan. <https://platteriverprogram.org/document/prrip-extension-science-plan>

TABLES

**Table 1.** Response variable, or dependent variable, and explanatory variables used in the machine learning model to quantify the effectiveness of germination suppression flows to maintain highly suitable unobstructed channel widths for whooping cranes, while accounting for additional management actions and spatial differences within the Associated Habitat Reach.

|  |  |
| --- | --- |
| **Response Variable** | **Variable Type** |
| Annual Change in Maximum Unobstructed Channel Width | Channel Width |
| **Explanatory Variables** |  |
| Previous Year Maximum Unobstructed Channel Width | Channel Width |
| Average June Flowa | Flow |
| 40-day mean peak discharge (Year-1)b |
| 40-day mean peak discharge (Year-2) b |
| 40-day mean peak discharge (Year-3) b |
| 40-day mean peak discharge (Year-4) b |
| Winter Flows |
| River Channel Disking | Management |
| Herbicide Application | Management |
| Wetted Width at Bankfull Discharge | Geomorphic |
| Flow Consolidation | Geomorphic |
| Geomorphic Reaches | Spatial |

aAverage flow during June, which corresponds to the period of flow release for germination suppression.

bPeak flows from previous years. For example, “Year-1” refers to the peak flow from the prior year, while “Year-2” refers to peak flows from two years prior to the current year.

**Table 2.** Example of relationship between inundation and vegetation class change for the Rowe Sanctuary Reach. As noted in table, 95% of the area that remained unvegetated was inundated at a discharge of 1,500 cfs. Conversely, 85% of the area that transitioned from unvegetated to obstructed (> 2ft veg) was above water at 1,500 cfs.

|  |  |  |  |
| --- | --- | --- | --- |
| Vegetation Class Change | Percent of Total Area | Percent of Area Inundated @ 1,500 cfs | Percent of Area Dry @ 1,500 cfs |
| Remained Unvegetated | 76% | 95% | 5% |
| Unveg to Veg < 2ft | 21% | 46% | 54% |
| Unveg to Veg > 2ft | 3% | 15% | 85% |

FIGURES

A green line with blue line

Description automatically generated

**Figure 1**. Median maximum unobstructed channel width in the Associated Habitat Reach (green) and predicted for 2020­–2022 (blue) based on the Program’s machine learning model of channel width dynamics. The gray region indicates the middle 50%, or widths observed between the 25th and 75th percentiles,while the light blue region denotes the middle 50% of predicted widths annually. As indicated in analysis step one, data prior to germination suppression flow releases were used to train the model (up to 2019) and then the model predicted channel width dynamics from 2020 to 2022. The similarity of average observed MUCW and predictions of MUCW from 2020–2022 provides an indication of the ability of germination suppression flows to mimic natural flows, of a similar magnitude, to maintain highly suitable unobstructed channel widths for whooping cranes.

A close-up of a map

Description automatically generated

**Figure 2.** Example of in-channel vegetation change from fall of 2019 to fall of 2022 for an unconsolidated segment in Rowe Sanctuary reach (top two panels) and a fully-consolidated reach upstream of Wood River (bottom panels). Note proliferation of in-channel vegetation unconsolidated segment.

A close-up of a map

Description automatically generated

**Figure 3.** Channel segments from Figure 1 with vegetation class changes from 2020 to 2022. Light pink polygons are areas that changed from unvegetated to vegetation < 2 ft tall. Dark pink polygons changed from unvegetated to vegetation > 2 ft tall (visually obstructed). Light green polygons represent areas that were vegetated in 2020 and had not changed by 2022.

A comparison of a river

Description automatically generated with medium confidence

**Figure 4.** 2022 channel segments from Figure 2 with vegetation class change polygons with 1,500 cfs flow depth raster overlay.

A collage of images of a river

Description automatically generated

**Figure 5.** Zoomed view of Rowe segment vegetation class change polygons with and without 1,500 cfs flow depth raster overlay.

A blue lines on a surface

Description automatically generated

**Figure 6.** Flow depth at 1,500 cfs demonstrating flow split downstream of the Kearney bridge. In this reach, approximately 42% of the flow is conveyed in the historical main (south) channel.

**Figure 7.** Hypothetical example of relationship between flow consolidation and unvegetated width of the main channel. Reaches where Mean TCW falls below dashed line may be narrower than can be maintained with flow indicating channel widening could increase TUCW and MUCW. Areas where TCW is above the dashed line likely can’t be maintained solely with flow and will require mechanical clearing. The farther TCW falls above the line, the greater the magnitude of mechanical management needed. Reaches where TCW falls at/near the line can likely be maintained free of vegetation (TCW=MUCW) with limited mechanical intervention.