Mapping of successful cottonwood recruitment and plantation in the South Fork Boise River

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Technical Report: Simulation of potential areas for successful cottonwood recruitment and plantation in the South Fork Boise River

Semi-Annual Progress Report

Reported to:	US Bureau of Reclamation
USBR Project #:	R12AC11025
Reported type:	Semi-annual progress report
Report Number:	10
Report Project Cycle:	Project period
Report Date:	September 30, 2017

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1. Introduction

Reservoir operations cause regulated and predictable pattern of stream flows, which may limit, if not prevent, successful recruitment of native riparian cottonwood species (Auble and Scott, 1998, Braatne, et al., 2007, Lytle and Merritt, 2004). Riparian cottonwood are highly productive, protects banks from erosion, which may have detrimental impact on aquatic habitats, maintains favorable water temperature for fish by providing shade and are source of nutrients and woody debris for the channel (Naiman, et al., 1993). The recruitment of cottonwood trees is strongly dependent on infrequent high flows that create moist bare emerged patches. It also requires specific flood recession pattern for seedlings to establish successfully (Figure 1) (Benjankar, et al., 2014, Braatne, et al., 2007, Burke, et al., 2009, Mahoney and Rood, 1998).

Riverbanks of the South Fork Boise River downstream Anderson Ranch Dam have mostly old stands of cottonwood trees without new generation establishment. The 2013 wild fire damaged most of those cottonwood stands, which successively died. Current efforts focus on planting cottonwood seedlings to restore cottonwood forest. However, unfavorable flow recession, location and timing of planting may prevent successful growth resulting in loss of the investment.

This investigation developed a two-dimensional (2D) hydraulic model coupled with a cottonwood recruitment model to predict favorable areas for cottonwood seedling plantation (In this report, plantation refers to areas that are planted with propagated cottonwood seedlings for the purpose of enhancing natural recruitment) and evaluated the opportunity for successful natural cottonwood recruitment for current post-dam flow release case.

2. Methodology

2.1 Study area

We focused on the first 23 km reach of the South Fork Boise River, downstream of USGS Anderson Ranch Dam gauge station to Private Bridge near Danskin Bridge. The reach is braided in several areas and has numerous side channels. Floodplain is 30 to 200 m wide and has some old cottonwood trees.

2.2 Requirement for successful natural cottonwood recruitment

The ecophysiologies of riparian cottonwoods and successful natural recruitment depend on riverine processes (Braatne, et al., 1996). Successful cottonwood seedling recruitment is associated with channel and bank geomorphology, sediment transport and timing, magnitude and duration of large floods (Amlin and Rood, 2002, Mahoney and Rood, 1998). River hydrology is the driving force for these processes. In natural systems, water surface elevations recede following large floods and expose barren areas on floodplains and riparian zones, which are colonized by cottonwood seedlings. Successively, surface moisture conditions and water table decline rates govern seedling survival (Johnson, 1994, Mahoney and Rood, 1991). If the rate of water table recession exceeds the rate of root elongation, seedling mortality occurs due to drought stress (Braatne, et al., 1996). This is one of the most common causes that prevents cottonwood recruitment in regulated reaches downstream reservoirs (Figure 1).

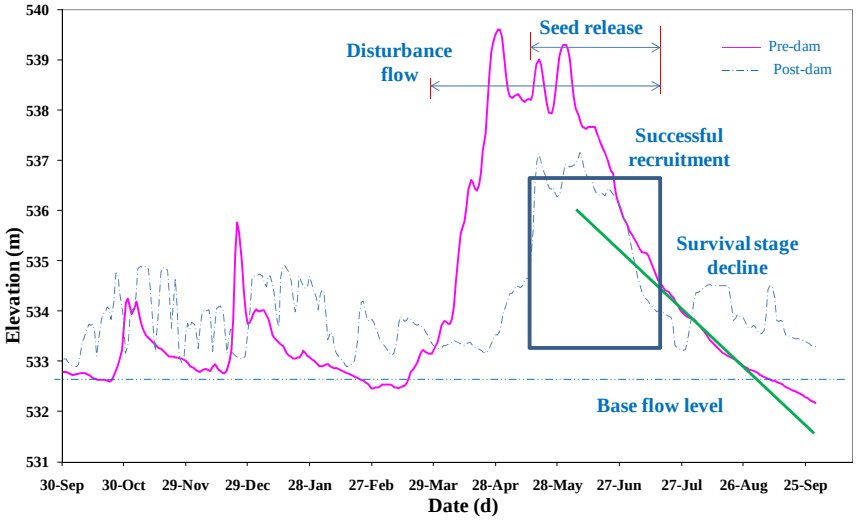

Figure 1: Required physical criteria for successful cottonwood requirement and typical hydrographs for pre-dam (unregulated) and post-dam (regulated) reaches (Benjankar, et al., 2014). Green line shows water surface optimal rate of change for cottonwood recruitment.

2.3 Survey of cottonwood recruitment sites

We surveyed cottonwood seedling recruitment areas in late summer 2016 (October) along the South Fork Boise River. We used hand-held GPS to survey cottonwood patches and delineated boundaries of cottonwood recruitment areas during the field visit. We observed sporadic cottonwood seedling recruitment in only few areas: at 5 main channel shoreline

locations and 8 islands or exposed sediment bars. This is the typical case in regulated river systems (Figure 2a). We observed cottonwood recruitment within a narrow band (2 to 4 m) close to the channel (Figure 2b).

Figure 2a: Field surveyed cottonwood recruitment areas.

Figure 2b: Field surveyed cottonwood recruitment on a narrow band near channel

2.4 2D hydraulic and cottonwood model

A 2D hydraulic model with grid size of 2m by 2m of the study area was developed and used to simulate water surface elevations and flow hydraulics for 300, 600, 1000, 1600, 2000,

2400, 3600, 5000, 6500 and 8000 cfs flow release from the Anderson Ranch Dam. We linearly interpolated water surface elevations for discharges between those simulated. This allows us to identify the water surface elevation for any released flow between 300 and 8000 cfs. Required input parameters for the cottonwood model are seed dispersal period, shear stress, mortality coefficient, which is function of water surface recession rate, and elevation of topography reference to the mean water level in the channel (Figure 3). The cottonwood model predicts fully favorable, partially favorable, low favorable and not favorable areas for successful cottonwood recruitment, using rule-based Fuzzy approach (Figure 3) (Benjankar, et al., 2014).

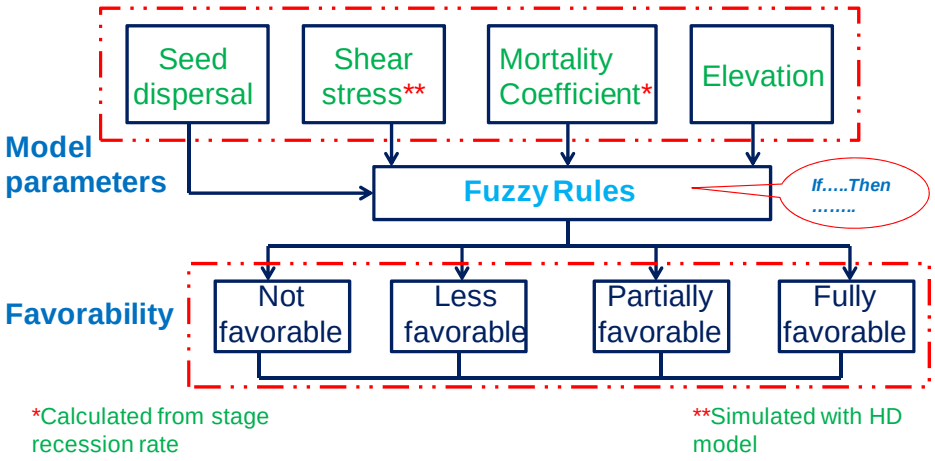

Figure 3: Input physical variables and output from the cottonwood model. Figure is modified from Benjankar, et al. (Benjankar, et al., 2014)

2.5 Prediction of areas for seedling plantation

For the scope of this project, we predicted only "Fully Favorable" (referred to as "favorable" for the remainder of this report) areas for cottonwood seedling plantation based on following assumptions:

- Cottonwood seedlings (1-year) have at least 50 cm root length and roots are fully buried into the ground during springtime.
- Shear stress is considered "Good" for entire area, because seedling will be planted.
- 3-day average water surface recession rate of ±1 to 10 cm per day is considered "Good" during May 20 to September 15
- Mortality coefficient <30 is considered "Good"
- Water surface elevation 25 to 120 cm above base flow level is considered "Good"

Favorable areas for cottonwood plantation were predicted based on the assumption that the ground water table is directly associated with water surface elevations in the channel. This is a reasonable assumption because of the confined characteristic of the canyon system. These assumptions are reasonable because seedling will be planted and not naturally germinating (Benjankar, et al., 2014).

3. Result and discussion

3.1 Survey of cottonwood recruitment sites

We observed sporadic cottonwood seedling recruitment in the South Fork Boise River along the 5 main channel shoreline locations and 8 islands or sediment bars surveyed. Hydraulic modeling showed that these areas are frequently flooded by medium- and high-regulated flows during spring and summer months. Thus, although seedlings were observed at these areas, subsequent spring and summer month floods may remove them because these areas were at low elevations relative to water surface elevation at minimum flow 8 m^3/s and near the channel. This field visit revealed that substrate at these areas were dominated by coarse gravels and cobbles. Large sediment sizes without fine materials indicate the river system has high stream power. We also noticed that most exposed gravel bars are notably armored indicating lack of fine sediment in the system. Riverbed armoring process is typical of regulated river systems like South Fork Boise River. Cottonwood seedling habitat requires moist sediment bars with elevations higher than low flow water levels (Mahoney and Rood, 1998). Consequently, these observations explain the unsuccessful natural cottonwood seedling recruitment in the South Fork Boise River. This is mainly due to lack of fine sediment on bars and unfavorable water surface elevation recession rates, which affect water table in the nearby areas of the channel.

3.2 Simulated favorable areas for cottonwood seedling plantation

The model simulated spatially distributed favorable areas for cottonwood seedling plantations (Figure 4). Favorable areas were located at Site 1, 2, and 3, which are located downstream from USGS Anderson Ranch gage station, Cow Creek Bridge and Danskin Bridge, respectively. These areas are primarily braided reaches with side channels and islands, which provide characteristics similar (but at a smaller scale) to developed floodplains. The predicted

areas were similar to the field conditions where matured and old cottonwood trees were observed.

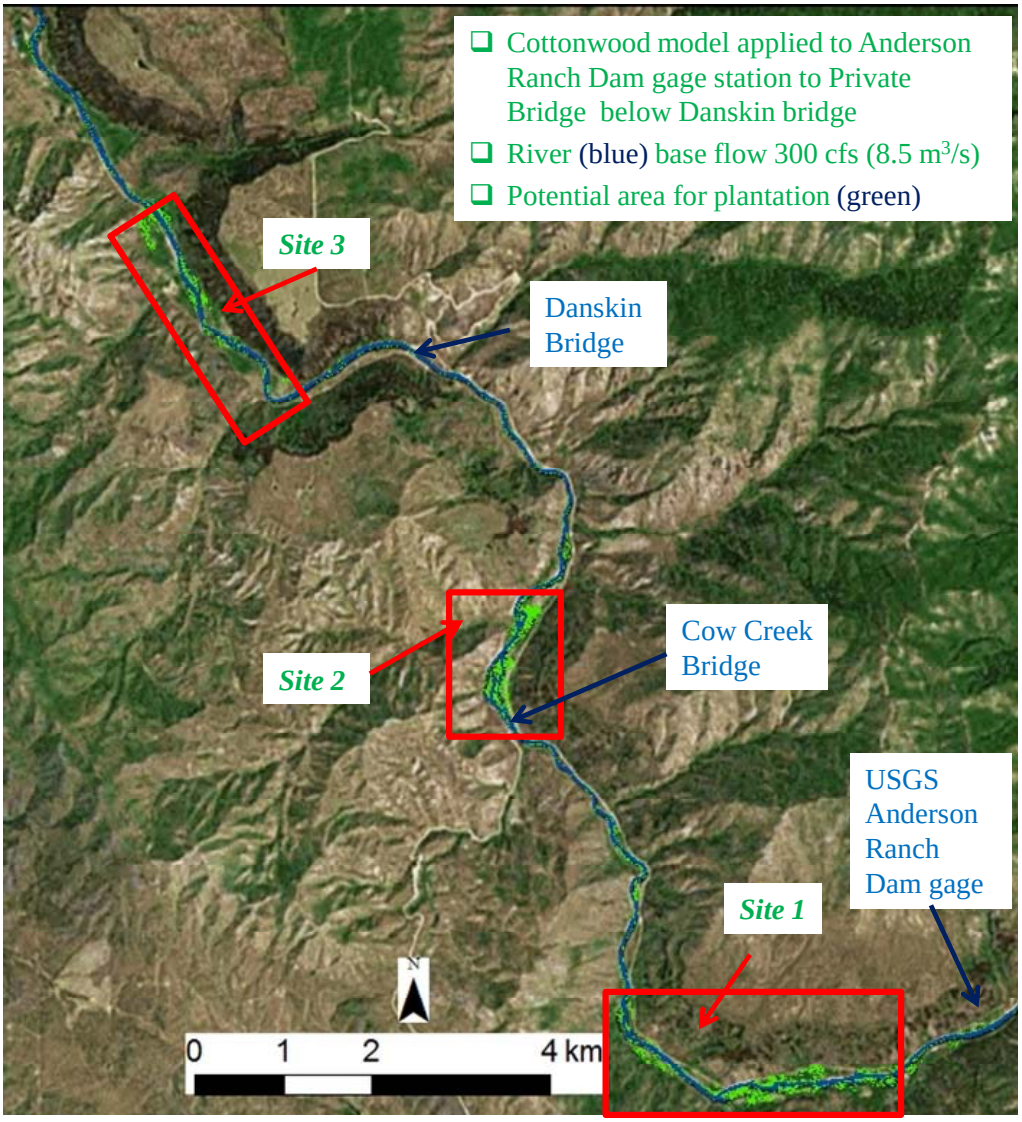

Figure 4: Favorable areas for cottonwood plantation.

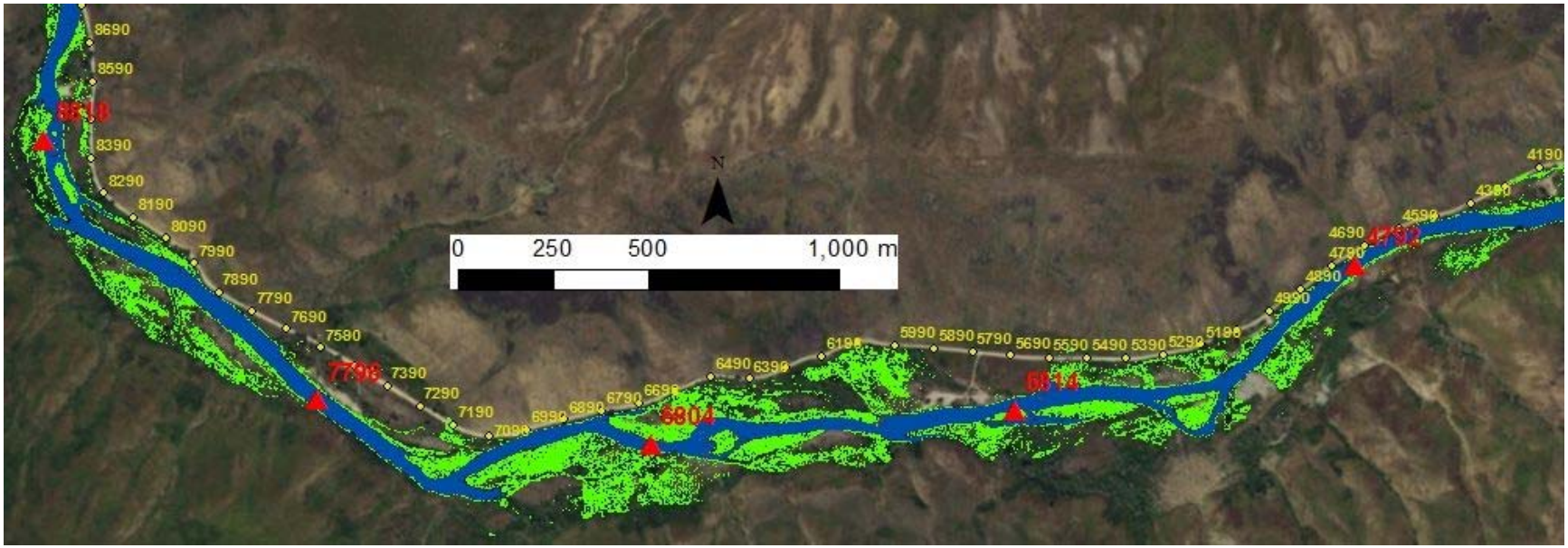

Figure 5: Detailed favorable areas (green) for cottonwood plantation at Site 1, downstream of Anderson Ranch Gage Station (2790 m river distance from the Dam). Red triangles and yellow circles indicate river distance (m) from Anderson Ranch Dam and road distance based on Anderson Ranch Gage Station, respectively.

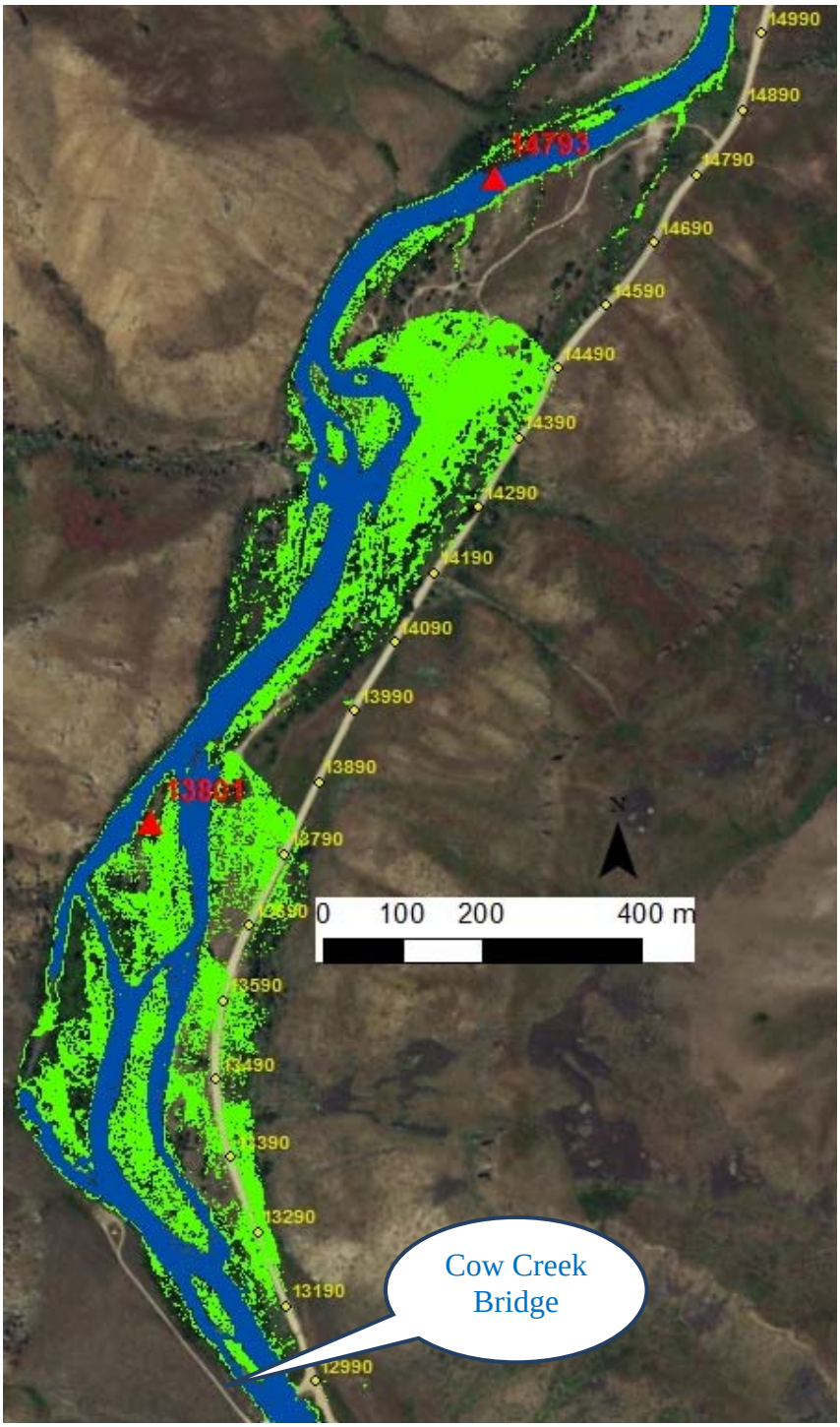

Figure 6: Detailed favorable areas (green) for cottonwood plantation at Site 2, downstream of Cow Creek Bridge (12990 m river distance from the Dam). Red triangles and yellow circles indicate river distance (m) from Anderson Ranch Dam and road distance based on Cow Creek Bridge, respectively.

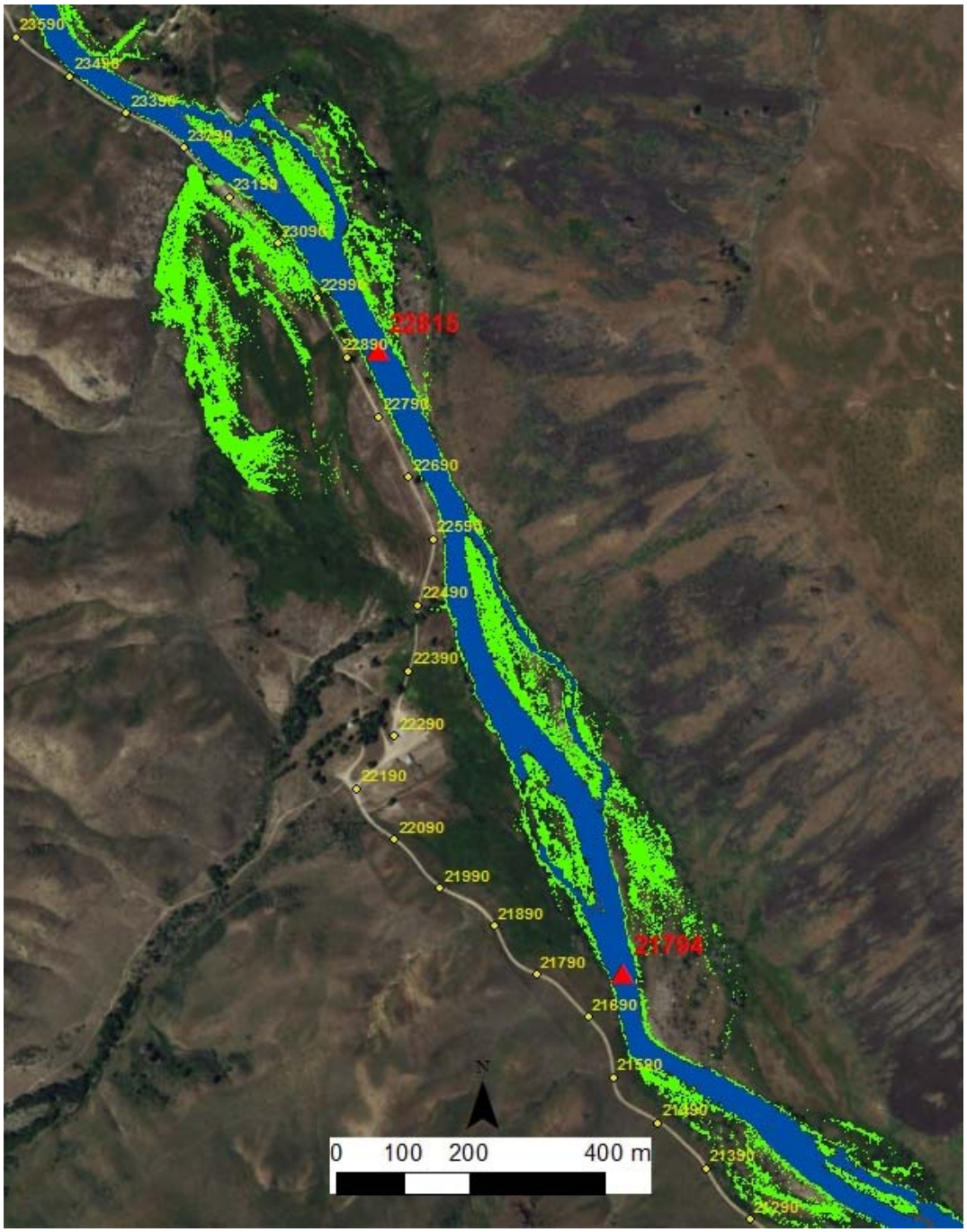

Figure 7: Detailed favorable areas (green) for cottonwood plantation at Site 2, downstream of Danskin Bridge (18690 m river distance from the Dam). Red triangles and yellow circles indicate river distance (m) from Anderson Ranch Dam and road distance based on Danskin Bridge, respectively.

Conversely from natural seedling recruitment, plantation has several favorable areas. These areas may also include part of road, campground and tributaries, which should not be used for cottonwood plantation. Spring months may provide favorable conditions for cottonwood seedling plantations because of moist soil resulting from snow runoff and precipitation in the watershed. The Arc-GIS files are provided in a zip archive for easy printing of the favorable planting zones.

4. Summary

Field observation and numerical modeling show that natural cottonwood seedling recruitment is not successful in the South Fork Boise River mainly due to lack of fine sediment on emerged bars during the seedling dispersal period and unfavorable water surface elevation recession rates.

Conversely, planting of cottonwood seedlings (1-year) with 50 cm root length can be successful along the upper 23km portion of the South Fork Boise River downstream Anderson Ranch Reservoir. The numerical model developed in this work identified several locations, which are provided in Arc-GIS files. We suggest planting cottonwood seedlings in early Spring when sediment is moist and plants start to become active.

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