Riparian Habitat Restoration in Devil's Tower National Monument

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Scope of Work

This study was undertaken to assess the current condition of riparian areas in Devil's Tower National Monument (DETO), and to evaluate the feasibility of proposed restoration actions, particularly with respect to the population of Plains Cottonwood (*Populus deltoides* Marshall Subsp. *monilifera*) trees within DETO. A previous restoration effort failed, and a new proposed restoration plan (partially described below) is being considered. An ancillary aspect of the current project was to characterize the condition of mature cottonwood trees located within the Belle Fourche Campground in DETO. This additional information could be useful in developing a management plan for maintenance and/or removal of dying trees located in the campground. This study was funded by the RM-CESU, #H1200040001.

Background and Introduction

Plains cottonwood is a native tree growing in riparian areas along much of the eastern slope of the Rocky Mountains, and is believed to be a subspecies of Eastern cottonwood (*Populus deltoides* subsp. *deltoides*), with which it frequently interbreeds. Seed germination and seedling recruitment are disturbance-dependent and usually corresponds to snowmelt and runoff in the spring (Scott et al. 1993). The bare sites created by this annual runoff and seasonal flooding provide a suitable substrate for the germination and establishment of cottonwood and are considered critical elements of its persistence (Moss 1938; Schopmeyer 1974). Following germination and early growth, recruitment of seedlings is highly dependent upon sustained moisture for several years (Engstrom 1948;

Mahoney and Rood 1991; Segelquist et al. 1993). Notably, both roots and stumps of young trees are known to vigorously resprout, producing abundant vegetative reproduction, but this condition declines as trees age (Sudworth 1934).

Plains cottonwoods are also especially sensitive to extended drought conditions, similar to climatic patterns throughout the Rocky Mountain region over the past decade. Extensive mortality can occur during such dry periods, even as high as 59%, as happened during the drought of the 1930s (Albertson and Weaver 1945). In addition, historic river channel relocations of the Belle Fourche River have left many small galleries of cottonwoods with their "feet dry" in and around DETO. Further, creation of the Keyhole Reservoir, located approximately 30 km upstream from DETO, has resulted in the impoundment of much of the spring runoff that has historically caused seasonal spring flooding. This cessation of high spring floods has likely played a large role in the reduction of new seedling establishment, as well as mortality of some mature trees along the river channel.

Methods of Assessment

This study involved three major aspects: 1) an initial site visit to DETO to examine existing riparian areas and the status of the population of Plains Cottonwood trees throughout DETO; 2) a subsequent visit to characterize the condition of the living trees located within the Belle Fourche Campground in DETO; and 3) completion of a report of findings and recommendations for future riparian restoration and campground maintenance.

<u>Initial Site Visit</u> – An initial visit to DETO by the PI took place on August 21-22, 2007. This visit included spending considerable time with the DETO ecologist, Taryn

Flesjer. An orientation to the park, which included viewing current and historic aerial photographs, GIS maps and reviewing park objectives, culminated with an extensive tour of the park and the various areas of cottonwood trees. Visits were made to mature cottonwood trees growing along the Belle Fourche River, as well as groups of individuals that were experiencing considerable mortality, due to relocation of the river channel. Also, previous and current efforts of cottonwood restoration were observed, along with areas where invasive species were threatening native vegetation. Meetings continued the second morning with other resource managers working at DETO, and ended with a final tour of the campground and cottonwood tree restoration efforts along its margins. It was during this tour of the campground that it was determined that an intensive examination of cottonwood trees growing in and around the campground would be beneficial to the park, as this area contains some of the "healthiest" trees found in DETO, at least visually.

Subsequent Campground Visit and Sampling – A second visit to DETO took place in mid-October 2007, involving the PI and three students from the University of Wyoming. Our objective during this visit was to characterize the condition of the mature cottonwood trees within Belle Fourche Campground.

All individual trees at each campsite along both the 'A' and 'B' campground loops were mapped on paper, relative to the parking pullout of each site. Distances from each campsite sign to all trees within that site were recorded. We also measured the height of each tree using a digital hypsometer and estimated the diameter at breast height (1.37 m) using a dbh tape. We also collected tree cores from 59 trees using a tree increment borer. This was done to estimate the age of each tree, as well as gain insights into the condition of the tree, e.g., presence of heart rot or water pockets. Cores were stored in labeled paper straws for transport to the University of Wyoming for subsequent analysis. Finally, we ranked all 152 trees into one of three condition classes (Table 1).

In the laboratory, all tree cores were extracted from the straws and mounted on wooden slats using wood glue. All mounted cores were sanded to aid in identifying and counting rings. Many trees contained significant heart rot and we were not able to obtain reliable estimates of age. Each core was assigned a "rot class" of either 1 (intact, with no sign of wood rot), 2 (< 50% of core shows signs of wood rot), and 3 (> 50% of core shows signs of wood rot – unable to count or measure rings). For those trees that were sound to the core, ages were determined using a Velmex dendrochronological bench and a Zeiss microscope; tree ring widths were recorded using Measure J2X software for subsequent analysis of Annual Aboveground Net Primary Productivity of each tree. This was done using allometric equations that predict total aboveground biomass based on dbh and height. By subtracting the diameter of each ring over the last five years of growth, it was able to calculate annual productivity by difference.

Findings and Recommendations

General Observations – As mentioned above, a major problem regarding existing mature cottonwood trees in DETO is the relocation of the main channel of the Belle Fourche River. This has likely removed a major source of groundwater, or sub irrigation that is critical for these trees, especially during times of drought. The new river channel appears deeper than the old, natural channel, making establishment of new saplings difficult, again due to the depth of sub-irrigated areas of soil.

We observed many cottonwood saplings that had been planted on upland benches, sometimes as much as 20 feet above the flood plain. Most or all of these had died. The likelihood of long-term survival for those saplings that were still living is low, given the root depth that must be attained to find a sufficient water supply. For saplings that were planted along the new flood plain, non-native species probably represent levels of competition that young cottonwood saplings cannot overcome.

We also noticed that, even where planted saplings had been enclosed by wire, the size of the exclosures was not sufficient to prevent browsing by mule deer. Also, very young, small saplings had apparently been browsed by small mammals, such as rabbits or ground squirrels.

General Recommendations for Future Restoration Efforts – DETO has a proposed restoration plan for a 2-mile section of the Belle Fourche River. This proposal includes many reasonable and sound approaches for restoration of the riparian corridor along the river, including a rigorous monitoring program. Should DETO continue riparian restoration efforts into the future, the following recommendations, many of which echo the approaches proposed by the park, are emphasized:

- All new seedlings/saplings (and saplings with a well-developed root system are recommended) should be planted along the existing flood plain of the Belle Fourche River. This takes advantage of groundwater sub-irrigation as well as spring runoff. Even though the Keyhole Reservoir stores much of the spring runoff that historically would cause seasonal flooding along the Belle Fourche, there are numerous drainages downstream of the reservoir that must surely provide an increase in streamflow during the spring months. Conversely, it is our opinion that planting cottonwood saplings on elevated benches far above the current flood plain will likely not be successful.

- Where new saplings are planted along the existing flood plain, it will be necessary to frequently and regularly water the young trees until root systems have developed that can take advantage of the groundwater. This may take 3-4 years, depending on annual climatic variation, but diligent watering is critical for sapling survival.
- Removal of non-native plant species, such as leafy spurge, would increase the survivorship of newly planted cottonwood saplings. The RAVE evaluation system currently adopted by DETO should ensure that only herbicides that do not contain Tordon should be retained, but herbicide application should continue to remove the high densities of non-native, invasive species. Additionally, mechanical removal of some plants, at some times of the year, may also be feasible approaches to reduction of non-native species. Whichever method is used, it is critical to remove these competitors, given the limited water supplies along these riparian corridors. And, if current trends continue, reduced precipitation makes water availability even more crucial for young trees.
- Reduction or elimination of damage and mortality by animal browsing should also be a priority. While some newly-planted saplings were surrounded by animal exclosures, most of the ones observed were too short (deer could easily reach across the top of the small fence) or too close to the tree, or both. Simply erecting larger exclosures, i.e., of a larger diameter from the tree, should greatly reduce the impacts of browsing, without the need to increase the height of the fencing. Based on previous work done by me and some of my colleagues in Yellowstone National Park,

a minimum distance of 2 meters from tree to the edge of the exclosure is required to prevent deer or elk from reaching over and browsing the young trees.

- The proposed soil sampling to detect residual levels of Tordon may only be cost-effective and useful if the specific locations of earlier applications of herbicide occurred. While some herbicide may be bound to soil particles, because of frequent turnover of groundwater, it is unlikely that contamination below the rooting zone would persist year to year. Perhaps a more economical approach would be to collect small soil samples from specific locations where new saplings are to be planted.

Campground Assessment - The intention of this study was not to make direct recommendations as to specific trees that should be removed, but rather to build a knowledge base that will be helpful for resource managers of DETO. Management decisions will likely be made based upon the likelihood of a tree or its limbs falling, along with what the potential targets of a particular falling tree might be. Some sites have a greater risk for not only property damage, but personal injury. Sites of interest are campsites which have grills and tables, along with restroom facilities. People congregate in these areas, so trees that are capable of hitting these areas may be given extra consideration for removal.

A total of 152 trees were measured within the campground and 59 mature cottonwood trees were cored during October 2007. All cores were evaluated as to degree of degradation and rot. Because so many trees contained significant heart rot, only 21 trees produced cores that allowed us to estimate the ages of those trees. The average age of the 21 trees with complete cores was 112 years; the youngest tree cored was 51 years of age and the oldest was 209. These numbers are fairly remarkable, given that cottonwood trees are often considered relatively short-lived, compared to other trees of the Intermountain West. Of the

21 complete cores, 14 were > 100 years of age. Given these advanced ages for these trees, and assuming that the trees with complete cores are likely the healthiest trees, we can conclude that many of the trees in the campground are experiencing considerable senescence, and may die in the near future.

Fifteen percent of the trees in the campground were rated as condition class 1, 74% as condition class 2, and 11% as condition class 3. A similar trend was found for tree core rot classes – 31% of cores were rot class 1, 61% were rot class 2 and 8% were rot class 3. There was a significant, but weak positive correlation between tree condition class and tree core rot class ($R = 0.19$; $p < 0.05$). However, this relationship is not strong enough to reliably use tree condition as an indicator of degree of heart rot within an individual tree. This is unfortunate, as this would have provided a relatively simple way for managers to assess the structural integrity of trees and possibly help make decisions about hazard trees. In fact, the tree core condition alone is probably the best index of whether or not a tree is more or less likely to be weak and possibly more susceptible to breaking or falling over. Notably, 69% of the tree cores were showed either moderate or advanced rot. Interestingly, however, all tree core rot class 3 trees were characterized as either condition class 2 (60%) or 3 (40%).

There was a relatively weak negative correlation between tree condition class and dbh ($R = -0.17$), and a somewhat stronger negative correlation between tree condition class and tree height ($R = -0.27$). This suggests that taller trees are more likely to be in a lower condition class than shorter trees and, to a lesser degree, larger diameter trees are more likely to be in a lower condition class. These relationships may be useful for future monitoring of mature cottonwood trees in the Belle Fourche Campground.

Other Considerations - Trees that have been identified as having rot, have a strong lean, or are located along the outside of the stand (especially toward the windward side) should be carefully monitored or removed if they have the potential of falling and either injuring a visitor, or hitting a campsite or other structure. If they pose no threat they should be left as a wind block for the rest of the stand.

Conclusion – The proposed restoration plan for riparian areas in DETO seems to be sound, but could prove to be a difficult task, largely due to some factors out of the control of resource managers such as climate and annual precipitation. Other factors that may make the recover difficult include the abundance of non-native plant species along riparian corridors. While these invasive species may respond to some control efforts, complete eradication is unlikely and restoration efforts should be concentrated where competition with exotic plants species is minimal. Continued monitoring of mature cottonwood trees in the Belle Fourche Campground is essential, and some relationships identified by this small study may prove useful for this.

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Table 1. Tree condition criteria used for ranking each mature cottonwood tree measured in the Belle Fourche Campground. Trees ranked as condition class 1 were considered in the best condition; class 3 were considered to be in the worst condition.

Tree Condition	Branching Pattern	Crown Depth	Crown Width
1	Complex	> 50% of tree height	> 75% of tree height
2	Moderate	25-50% of tree height	50-75% of tree height
3	Minimal	< 25% of tree height	< 50% of tree height