If You Build It, They Will Come – Management Planning for a Suburban Beaver Population in Arizona

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ABSTRACT: Management for beaver now ranges from lethal removal of nuisance individuals to reintroduction of individuals for wetland restoration and to increase wildlife and habitat diversity. Management, or lack thereof, is driven largely by stakeholder concerns at the local and regional level. In many cases with management of beaver and other species, there are unclear visions of how wildlife populations may exploit resources after successful restoration or with changing landscape conditions (e.g., habitat quality and competition). With increasing conversion of the modern-day landscape, natural resource managers must make pragmatic decisions on the potential effects habitat alteration has on system stability. In 2000, the United States Army Corps of Engineers received approval from Congress to construct the Tres Rios Ecosystem Restoration and Flood Control Project in Phoenix, Arizona. Upon completion, this multi-phased, 7-mile (11.3-km), 1,500-acre (607-ha) project is designed to include a 4.25-mile (6.8-km) flood protection levee, an effluent pump station, and development/maintenance of emergent wetlands, riparian corridors, and open water marshes to replace existing non-native saltcedar. In 2000, Tres Rios constructed a demonstration area on-site that used reclaimed wastewater from the 91st Avenue Treatment Plant to establish wetland habitat. Simultaneously, we began the Tres Rios Beaver Research Project to determine the possible effects beaver have on riparian and wetland habitats. Studies within this project found that existing non-lethal management techniques were generally ineffective; however, topical application of fructose and polyethylene glycol showed promise as a technique to increase palatability of invasive *Tamarisk* spp., while palatability of native tree species could be reduced by application of an herbivore repellent. Other studies developed new techniques for anesthetizing beaver and increasing radio transmitter retention time on beaver. Through monitoring movement of beaver and using landscape genetic techniques to explore population diversity, researchers found deviations from published literature on beaver, suggesting that density-dependent factors may be driving beaver behavior and movement in this environment. We describe the planning process involved in developing these research studies to address stakeholder concerns.

KEY WORDS: anesthesia, Arizona, beaver, *Castor canadensis*, damage, habitat, non-lethal methods, population dynamics, repellents, reproduction, surgical sterilization, vegetation impacts, wastewater, wetland management

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INTRODUCTION

Present populations of many wildlife species are the result of changes in environmental awareness, followed in many cases by improved legislation, sound stewardship, and successful restoration efforts. Moreover, some of the same species are managed as "overabundant" or "nuisance" where they cause conflict at the human-wildlife interface. The North American beaver (*Castor canadensis*) is one example of a species that was near extirpation in the United States, yet recovered following legislation and regulations (e.g., state harvest laws) and changes in stakeholder interests (e.g., reduction in the use of fur). Management for beaver now ranges from lethal removal of nuisance individuals to reintroduction of individuals for wetland restoration and to increase wildlife and habitat diversity. Management, or lack thereof, is driven largely by stakeholder concerns at the local and regional level. In many cases with management of beaver and other species, there are unclear visions of how wildlife populations may exploit resources after successful restoration or with changing landscape conditions (e.g., habitat quality and competition). With increasing anthropogenic changes to the modern-day landscape, natural resource managers must make pragmatic decisions on the potential effects habitat alteration has on system stability. As the human population continues to grow, so will conflicts between humans and wildlife.

STUDY AREA

We conducted a series of research studies on the Tres Rios Constructed Wetlands Demonstration Project in the southwest metropolitan area of Phoenix, Arizona. Tres Rios, Spanish for "three rivers", refers to the area surrounding the convergence of the Salt, Gila, and Aqua Fria Rivers in Maricopa County. The area is approximately 9.2 miles (14.8 km) in length and 1 mile (1.6 km) wide and encompasses approximately 5,600 acres (2,266 ha). Approximately 153 million gallons (580 million liters) of discharge per day were delivered to the Salt River by the City of Phoenix's 91st Avenue Wastewater Treatment Plant. The Salt River flowed into the Gila River just upstream of the 115th Avenue crossing. The Aqua Fria River flowed into the Gila River further

downstream. Elevations range from about 1,000 feet (305 m) at 75th Avenue to 920 feet (280 m) above sea level at the downstream end, near the Buckeye Irrigation District Diversion Dam.

The Tres Rios Constructed Wetlands Demonstration Project consisted of approximately 11 acres (4.5 ha) of emergent marsh free-water surface wetlands located adjacent to and within the confines of the City of Phoenix/SROG 91st Avenue Wastewater Treatment Plant. There were three operational wetland sites: Cobble (3.9 acres; 1.6 ha), Hayfield (5.9 ac; 2.4 ha), and the Research Cells (1 ac; 0.4 ha). One of the primary objectives of the Demonstration Project was to determine the net environmental benefit such a system and associated riparian habitat would have in the Salt, Gila, and Aqua Fria River area. The project regionally benefitted the cities of Phoenix, Mesa, Glendale, Scottsdale, Tempe, and the Gila River Indian Community.

TRES RIOS PROJECT

Since wetland construction began in 1995, the Tres Rios project group has been highly successful establishing small wetland habitats, occupied by a variety of flora and fauna. Project staff identified early on that wetland construction created suitable habitat for beaver and connectivity to existing colonies. Consequently, staff noted that excessive beaver activity was negatively impacting project goals. Although animal foraging on plant materials is a natural component of a balanced ecosystem, beaver activity at these sites had become destructive. Some areas have been rendered barren of aquatic plants because of heavy foraging by beaver. Numerous trees, primarily cottonwood and willow, had been cut or girdled, and extensive burrowing had undermined dikes and islands. Visual signs, including burrows, clipped vegetation, and runways, all indicated high beaver numbers.

In 2002, Tres Rios sought help from USDA Wildlife Services in defining the extent of beaver damage and developing techniques to reduce that damage on the Tres Rios project site. Initial assessments for guiding a management and/or research project focused on beaver damage revealed that spotlight surveys conducted by Tres Rio personnel had likely underestimated beaver population size at 14 individuals, and that the actual population was likely between 34 and 50. Furthermore, a nearby river served as a continuous source for additional animals to invade the site. Thus, beaver were likely coming from the river to forage on vegetation surrounding the demonstration sites. Roads surrounding the demonstration ponds showed signs indicating beaver were dragging tree cuttings across them, and it appeared beaver were using the demonstration ponds as corridors to reach and cut larger trees.

Planning assumptions for the Tres Rios Beaver Project included the following: 1) demonstration ponds provided optimum beaver habitat and beaver would continue to occupy these sites; 2) presence of some beaver should be considered a desirable component of these wetland habitats; 3) current high beaver populations would continue to be a destructive force; 4) under foraging pressure from high beaver populations, the current aquatic vegetation would continue to decline, and over time mature trees would likely disappear; 5) without management, existing vegetation would be replaced by less palatable and highly competitive species, such as saltcedar (*Tamarisk* spp.); and 6) beaver populations could be expected to decline with declining habitat quality.

Although the Tres Rios group recognized that beaver activity needs to be suppressed, they did not consider lethal removal to be a viable option. Live capture and removal also was not a viable option, because the Arizona Department of Game and Fish maintains a restrictive and conservative policy with regard to beaver relocation as a management option. Thus, the goal of the Tres Rios Beaver Project was to develop non-lethal methods and strategies to protect wetland restoration projects from damage by aquatic mammals. The Project consisted of 37 specific research objectives found within these 6 general categories: assessing existing methods, developing research methods, developing non-lethal methods, developing strategies to protect wetlands, monitoring, and education. Although we became involved in this project after beaver were a perceived problem, we provide the following considerations for others embarking on similar management activities or those that involve habitat restoration or species reintroduction. We address each of the 6 categories, but we do not explain the 37 specific research studies, as there was some overlap between common themes. Nevertheless, we submit that potential effects should be considered before initiating a similar project.

Assessing Existing Methods

One of the first decisions natural resource managers should make when proposing to create a situation that may result in human-wildlife conflict is to determine what existing tools are available to reduce or mitigate potential impacts of the wildlife species to resource(s). In this case, creation of the wastewater treatment facility and associated wetlands created usable space for beaver. Plantings and natural seeding of woody and herbaceous wetland vegetation were used by beaver, and these effects negatively impacted project goals. We conducted a literature search to identify current non-lethal methods available for reducing beaver impacts to wetland herbaceous and woody vegetation. Damage to trees and vegetation was the primary impact, thus we did not focus on existing methods to regulate water levels (e.g., pond levelers or deep-water fences). Consequently, we designed scientific studies to test the efficacy of fencing, an electronic beaver guard, and frightening devices to reduce beaver damage to on demonstration plots. These studies also assessed the potential impact of these techniques on non-target flora and fauna on demonstration plots (see Nolte et al. 2003). While these methods were generally ineffective at reducing impacts, that knowledge provided foundations for further research and guided thoughts for developing new research methods.

We assumed that beaver survival would be high, due to a lack of natural predators and the absence of trapping. We also assumed that beaver would continue to

reproduce and forage centrally around their dens, and that they would move further out as resources were depleted. In order to address these and other factors, we chose to utilize VHF radio telemetry. We also determined a need to conduct trials in captivity to address several basic questions, before testing applications in the field.

Developing Research Methods

In order to better understand the dynamics of beaver on the Tres Rios Project area, we developed a mobile laboratory to conduct beaver research and to temporally hold beaver while conducting fieldwork. The mobile laboratory was equipped with surgical and diagnostic equipment and could be modified to support various research studies. We also conducted basic bioassays at the National Wildlife Research Center's Field Station in Olympia, WA, which has the capacity to individually house up to 16 captive beaver.

To address reducing fitness without reducing adult survival, we conducted a study to investigate the efficacy of surgical techniques (e.g., vasectomy, tubal ligation) on inhibiting beaver reproduction. While we discovered the time and cost associated with surgical sterilization was not efficacious for Tres Rios, we also simultaneously evaluated chemical immobilizing agents for anesthetizing beaver. A combination of ketamine and metetomidine was found to be the best injectable anesthesia for beaver, with atipamazole as a reversal (Tom DeLiberto, Wildlife Services, unpubl. data). These findings resulted in increased care provided to research subjects during trials requiring anesthesia.

In order to monitor movement of beaver and estimate survival and cause-specific mortality using radio telemetry, we needed more range than internal transmitters could provide. We also needed longer retention time than documented in published literature. Thus, Arjo et al. (2008) found that a modified ear-tag transmitter fitted with a plastic sleeve and attached to the tail was efficacious in pen trials. Arjo et al. (2008) also found that incorporating a neoprene washer with this set-up in field trials increased retention time to over 3 times that reported previously, giving us an average deployment time of 344 days (*SE* 44) per tail-mounted transmitter.

Developing Non-lethal Methods

We conducted additional trials at the Olympia Field Station to develop novel non-lethal techniques for reducing beaver impacts. Harper et al. (2005) conducted pen trials to determine whether beaver could be conditioned to avoid select foods. They concluded that aversion conditioning is probably not a feasible approach to reduce beaver foraging on preferred foods.

Saltcedar (*Tamarisk* spp.) is an invasive woody plant on the Tres Rios Project site. It is rarely consumed by herbivores because it contains high levels of tannin and sodium chloride (NaCl). Cottonwood (*Populus balsamifera*) and willow (*Salix scouleriana*) trees are preferred food sources of beaver and were the object of much damage on Tres Rios. Kimball and Perry (2008) theorized that saltcedar palatability could be improved by topical application of fructose and polyethylene glycol (PEG), and that palatability of cottonwood and willow could be reduced by application of an herbivore repellent. As predicted, they found repellent application to willow and cottonwood cuttings in combination with fructose and PEG treatment of saltcedar altered beaver plant preference. Thus, such applications may promote increased herbivory of alternative plants while reducing loss of desirable ones (Kimball and Perry 2008).

Developing Strategies to Protect Wetlands

In order to protect wetlands, we wanted to develop an understanding of movements and dispersal that may impact existing populations of beaver on demonstration sites. Two fundamental gaps in our knowledge of beaver dynamics on Tres Rios were related to their movement and genetic diversity. Beaver were not introduced to Tres Rios when the wastewater treatment project was created, thus they immigrated from populations in adjacent temporally connected wetlands. We collected hair and/or tissue samples from all beaver captured on Tres Rios for genetic sampling. Information obtained from these data are being used to determine relatedness among individuals, population genetic structure, and genetic diversity within the population (T. Piaggio, NWRC, unpubl. data). An understanding of the origin and diversity of the population allows for improved management decisions. Preliminary results suggest that the entire Tres Rios beaver population came from a single maternal lineage. Furthermore, we found evidence that contradicts the classic paradigm that a beaver colony consists of an adult male, an adult female, and 2 sub-adults. Through radio telemetry, we found larger numbers of beaver constituting a colony. Moreover, we found multiple lactating females using the same den site (J. Fischer, NWRC, unpubl. data).

We captured and radio-marked 43 adult beavers (31 females and 12 males) along a 8.7-mile (14-km) stretch along the Tres Rios Demonstration Project. To develop strategies to better manage the wetlands and decrease beaver damage, we monitored beaver movement with stationary dataloggers (automated radio-telemetry receiving stations) and handheld receivers from 2004-2007. Radio-telemetry data were entered into a geographic information system to determine movements (daily, seasonal, and annual) of beavers and habitat use associated with restoration sites and the 5,600-acre (2,266-ha) study area. Preliminary results suggested that beaver movements declined from April through September, and only 2 of 43 marked beaver dispersed from the study site over the 4-year period (J. Fischer, NWRC, unpubl. data). Mean movements from fall 2004 through summer 2007 was 2.2 miles (3.5 km) for males and 2.5 miles (4.0 km) for females. Interestingly, mean beaver movement differed by age class with 1-year-olds moving farther than 2-year-olds and 3+ -year-olds.

Monitoring

Monitoring was a continuous part of this management and research project. We monitored floral composition to detect negative impacts by beaver in areas of special concern (e.g., demonstration areas). Surveys were conducted to detect beaver damage and to identify indicators of new beaver activity. Monitoring of

vegetation impacts also included assessments to detect changes in dynamics of invasive species (e.g., saltcedar) with respect to herbivory by beaver. Damage assessments conducted in conjunction with monitoring beaver also provided information on the effects of non-lethal control measures. Non-lethal methods used to deter beaver damage also were monitored for effectiveness, need for repairs, and need for modification. We collected biometric data on all beaver captured and released, and we maintained those data in a geospatial database. Movements of beaver were recorded continuously using stationary dataloggers, and data were analyzed in a geographic information system to search for relationships with damage locations. Combined with genetic analysis, this aided in understanding more about family behavior that might have otherwise gone unnoticed.

Educational

The final component of this endeavor was to disseminate our findings to our cooperators and to a broader audience of managers and researchers. Research results from the Tres Rios Project were incorporated into posters, demonstration projects, and over 50 multimedia presentations at local, regional, national, and international venues. Several studies were submitted to peer-reviewed journals for publication.

At the request of the Tres Rios cooperators, a workshop was held at the end of the 5-year Tres Rios research project. Over 50 individuals from 5 countries participated in The International Beaver Ecology and Management Workshop, held in Chandler, Arizona on Oct. 9-12, 2007. Over 30 presentations were delivered, ranging in topics from beaver ecology, to lethal and non-lethal management, to ethical concerns for beaver.

DISCUSSION

Today's society is becoming more aware of wildlife damage as anthropogenic activities continue to encroach into wildlife space. We offer this paper as an example of a logical thought process that may be used by others dealing with potential human-wildlife interactions. It is by no means flawless or all-inclusive. However, it touches some central themes and needs that are required in addressing wildlife damage. Furthermore, it reflects how basic gaps in knowledge can be identified while addressing applied research, and how plans can be modified to adapt to existing needs. Our findings on anesthesia and transmitter attachment will provide knowledge to future researchers conducting studies with live beaver, although they were not initially part of the original plan.

Trapping is a common and effective tool used to reduce beaver damage; however, it was not an option on this area. We found that when constrained to non-lethal methods to reduce beaver damage to trees and vegetation, existing methods were generally ineffective. Thus, we sought new ideas to reduce damage non-lethally. Our findings regarding food aversion conditioning were not promising; however, altering food palatability for beaver may be effective in reducing damage. Through monitoring movement of beaver and using landscape genetic techniques to explore population diversity, we found deviations from published literature on beaver, suggesting that density-dependent factors may be driving beaver behavior and movement in this environment.

While this case study includes North American beaver in the arid Southwest, it could be applied in any environment with any species of wildlife. Beaver left unabated in this area could have serious, deleterious effects on watershed quality and cooperators' interests. As managers of our natural resources, we must forecast the potential effects of anthropogenic actions on the systems in which we operate. In situations where the potential exists to create or enhance human-wildlife interactions, we must be prepared to address these conflicts.

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