1. Overview of the Tualatin Urban Beaver Dam Study

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Study Overview

Populations of North American beaver (*Castor canadensis*) have increased in recent years due to decreased trapping, habitat restoration, and recognition of their importance as a keystone species in stream ecosystems (Pollock and others, 2017). Previous studies have shown that beaver dams and associated ponds can change channel morphology, trap sediment (and attached pollutants), alter the composition and amount of riparian vegetation, slow down and push water into the floodplain, and change surrounding habitats for fish, amphibians, and birds in rural and mountainous streams. Little work, however, has been done to quantify the effects of beaver dams and ponds on urban streams.

The U.S. Geological Survey (USGS), in collaboration with Clean Water Services, is working to fill this knowledge gap and provide usable information for water-resource managers, regulators, and restoration practitioners. This study focuses on urban streams in the Tualatin River basin, where flashy hydrographs and channel incision have resulted in simplified stream habitats (fig. 1). As Clean Water Services and others consider restoration strategies that include encouraging beaver dam building or adding beaver dam analogs (BDAs) in urban streams, understanding the multi-faceted benefits and impacts of beaver dams and ponds is important context for anticipating and communicating realistic types and associated magnitudes of changes related to beaver dams, ponds, and habitat trajectories.

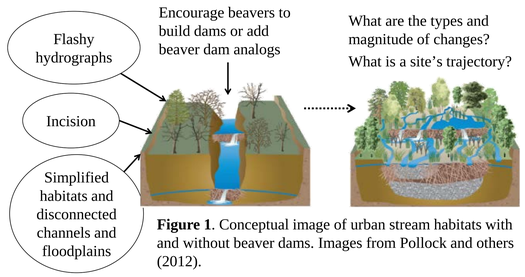

Figure 1. Conceptual image of urban stream habitats with and without beaver dams. Images from Pollock and others (2012).

Study Objectives

This study was designed to address several important questions about beaver dams and ponds and their associated effects on urban streams in the Tualatin River basin (fig. 2-3). Objectives are divided into three categories:

Basin scale – current and potential beaver dam distributions

1) Create a partial inventory of beaver dams by conducting strategic beaver dam surveys and compiling existing dam observations from basin partners; and
2) Estimate and validate potential beaver-dam capacity by modifying an existing beaver dam model that accounts for physical controls where beavers can build dams.

Reach scale – physical changes at the Fanno and Bronson Creek "intensive" sites

1) Assess hydraulic changes caused by beaver dams and ponds, including changes in wetted area, velocity, depth, and flow-recession rates during storm events;
2) Characterize temporal changes in water-quality conditions;
3) Assess spatial variability in water-quality conditions; and
4) Quantify changes in suspended-sediment transport and deposition and channel changes.

Reach scale – physical changes at five sites representing a greater range of channel types ("rapid sites")

1) Characterize temporal changes in water temperature, and
2) Assess geomorphic changes.

Linking physical and biological changes in beaver-affected reaches

This study also was designed to reflect the linkages between physical and biological processes summarized by the stream function pyramid (fig. 4). Clean Water Services and Wolf Water Services are conducting surveys to link biological communities with the changes observed at most of the beaver-affected reaches being studied by USGS.

Figure 2. Examples of beaver dams at: A) Bronson, and B) Stoller Creeks. USGS photographs.

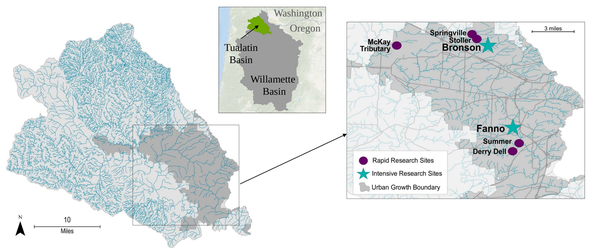

Figure 3. Map of the Tualatin River basin and study sites.

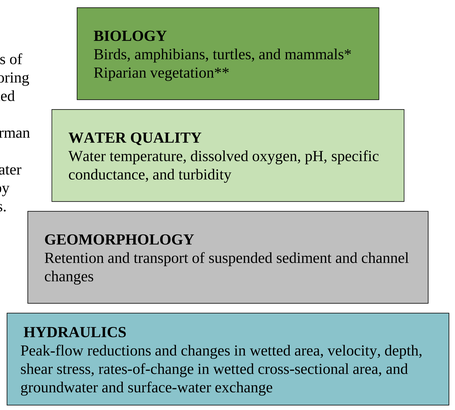

Figure 4. Components of the reach-scale monitoring organized by a modified version of the stream function pyramid (Harman and others, 2012). *Surveys by Clean Water Services, **Surveys by Wolf Water Resources.

Synthesis of Preliminary Results to Date

Beaver dams and associated ponding along Fanno Creek at Greenway Park have multiple effects on the reach's hydraulics, water quality, and sediment transport regime. These effects vary seasonally and with streamflow. They also vary spatially with changes in water depth, shading, and channel-floodplain connectivity along the stream reach. These physical changes are associated with increased diversity and prolonged site use by birds and the creation of still-water habitats for turtles and egg-laying amphibians.

Hydraulic Effects of Beaver Dams at the Fanno Creek at Greenway Park Reach (Poster 3)

- Beaver dams and ponds in the low gradient Greenway Park reach provide temporary water storage, modestly reduce peak flows, create more slow-velocity habitats as well as shallow- and deep-water habitats, and help reduce erosive forces on the channel.
- Storage by the beaver dams reduces peak flows slightly for lower magnitude events, but does not change the overall shape of the hydrograph. As streamflow increases, storage continues to increase, but peak flows are reduced by a smaller magnitude. This is because Fanno Creek carries substantially more water during storm events, compared to what the beaver dams and ponds can hold. This extra water helps Fanno Creek inundate the adjacent floodplain with or without beaver dams.
- The effects of beaver activity on velocity and depth distributions also diminish as streamflow increases because of normative floodplain inundation and storage processes that happen with and without beaver dams.
- Shear stress (an indicator of potential bed and channel erosion) is largely confined and higher in the main channel for model simulations without dams compared to those with dams. With beaver dams, shear stress is reduced because water is no longer confined to the channel and dams increase roughness, providing physical resistance to flow, at lower flows. Shear stress changes associated with the dams may allow for more areas of sediment deposition within the channel.
- Storage by the beaver dams and ponds may result in the slower release of stormwater over time. It also substantially increases the travel time of water during dry summer months.
- Floodplain features, such as the North Pond, store water in the low flow simulations with and without beaver dams. This suggests that floodplain features not associated with beaver dams may provide another management strategy for storing water in urban streams and floodplains.

Hypothesized Physical Effects in Other Beaver Affected Reaches

- We hypothesize that the physical effects of beaver activity on hydraulics, water quality, and sediment transport regimes are similar in other beaver-affected reaches similar to the Fanno Creek at Greenway Park reach.
- We do expect some differences in these physical effects in steeper streams with different sediment characteristics, greater floodplain storage capacity, and different vegetation for dam building. Over the next year, we will explore differences and similarities in physical changes associated with beaver dams at Bronson Creek and five rapid-assessment sites (figs. 2-3).

Effects of Beaver Activity on Sediment Transport and Deposition at the Fanno Creek at Greenway Park Reach (Poster 5)

- Beaver dams and ponds help slow down and store water moving through the Greenway Park reach, and thereby increase sediment deposition and generally reduce the transport of suspended sediment during storm events.
- For example, the south pond created by the long dam has stored a volume equivalent to the estimated average annual sediment load at Fanno Creek at Durham (Keith and others, 2014).
- Potential bioturbation may elevate turbidity during low-flow periods.

Effects of Beaver Activity on Water Quality in Fanno Creek at Greenway Park (Poster 4)

- Beaver dams and ponds do not have a single clear effect on the water quality of Fanno Creek at Greenway Park. The effects are complex and can be positive and negative, but often cause an increase the diversity of water-quality conditions and potential associated habitats.
- Where beaver ponds inundate the floodplain, water temperatures tend to warm in summer above levels that might occur if Fanno Creek remained in its channel. Despite general warming in exposed areas, the diversity of thermal conditions can greatly increase, with cooler water in deeper pockets and in areas with riparian cover. Warmed pond water reverts to more normal temperatures after re-occupying its channel some distance downstream.
- The ponded areas of Fanno Creek tend to have a wide dissolved-oxygen range, from near-anoxic in areas where trapped sediment and decaying organic matter exert high oxygen demands to supersaturated in areas of high photosynthetic activity.
- Photosynthetic activity by algae in the shallow and warm areas of beaver ponds can create pockets with elevated pH levels.

Effects of Beaver Activity on Birds, Amphibians, and Turtles

- The beaver dams and ponds at Fanno Creek at Greenway Park have prolonged the periods of inundation, and increased habitat connectivity between this reach and two nearby locations – Englewood Park and Koll Center wetlands.
- Because of the beaver activity, the reach supports a greater diversity of birds that are using the site for longer durations.
- Amphibians, such as Northwestern and Long-toed salamanders, are using the backwater, shallow habitats created by the beaver dams and ponds for egg laying in the winter.
- Native and non-native turtles are also using the still-water habitats.

Beaver Dam Inventory and Capacity Estimates in the Tualatin River Basin (Poster 2)

- Beavers are building dams in streams within the urban growth boundary (UGB).
- The availability of vegetation for dam building and food is the primary physical limiting factor on beaver dam building in the UGB. Other local constraints include high flow and high stream gradient.
- These analyses can help identify where future riparian plantings may improve dam-building opportunities for beavers as well as where restoration actions may have limited effects on dam-building activities.
- Dam-capacity modeling also can point out areas of potential future conflict.

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