Spatial relationships of potential beaver dams in the Tualatin watershed of Portland, Oregon

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Introduction

A creature lurks in the waters. Without living next to the stream most people might never know a beaver family eats, works, and plays right next door. On the contrary, people who live on or near a stream may feel confounded and annoyed at nearby beavers who flood the landscape and their basements. Beaver-made wetlands and ponds work well in natural areas where ducks, herons, fish, frogs, and deer are the only neighbors, but in urban landscapes the North American beaver (*Castor canadensis*) goes unnoticed or outgunned by concrete infrastructure. Diverting urban streams through culverts may cause major flooding issues worse than beaver dams, and removes any possibility of the presence of the biodiversity attracted to beaver ponds - the ducks, birds, frogs, turtles, and fish drawn to aquatic habitats as much as people are drawn to observing them and enjoying their presence. Many studies have shown how much beaver ponds really attract a diverse array of other species. These naturally made water features are favorites among many salmon species including steelhead[1], coho[2], and sockeye[3]. Beaver ponds attract diverse populations of amphibians (frogs and salamanders) by providing protection from predators and increasing sunlight for basking[4,5]. Many bird species use beaver ponds including ducks, kingfishers, and herons which exemplifies how beaver presence attracts rich and abundant bird populations[6].

For people to benefit from beaver activity as much as other species we must better understand how to work with beaver in an urban landscape – where the people are. The field of urban ecosystem services has expanded in recent years, and green spaces provide many benefits to the urban landscape[7]. Portland, Oregon, provides a perfect opportunity for targeted beaver management because green space (parks and natural areas) surrounds much of the suburban river network. Understanding where beaver are now, where they used to be, and where we want them to be will inform our management decisions in planning for a future where people and beaver live in harmony. Many examples highlight the benefits of beaver restoration in deep forests or national parks including surface water retention and ground water recharge[8]. The importance of water retention grows with the continued on-set of global climate change, and many aquatic scientists have taken note of the ability beaver have to retain water[9]. Few assessments consider these same benefits applied to urban spaces. This lack of reasoning was likely driven by the 'nuisance' moniker obtained from urban issues in which beaver commonly receive the blame[10]. Now urban land managers have just begun to take notice of the benefits of beaver, and better analyses are needed to assist in shaping planning and policy for decades to come. The purpose of this analysis is to explore beaver dams on the urban landscape in terms of spatial distribution of dams, habitat connections within a complex urban ecosystem, and city zoning/land use impacts of dam locations.

How are the dams arranged in the urban landscape?

Preliminary questions about beaver in the urban landscape look to quantify beaver and associated activity - how many beaver are there, where are they, and where are their dams? Answering these questions allows deeper analysis into why beavers prefer certain habitat, the types of habitat that support beaver colonies, what formerly occupied beaver wetlands look like today, as well as a plethora of other topics. To delve into dam location, I used a visual analysis of aerial imagery provided free to the public by USGS (US Geological Survey). Study streams were randomly chosen in suburban Portland, Oregon. Four study streams were all located within the Tualatin River watershed which is a tributary of the Willamette River. All images and computations were performed in Esri. For the study reaches, two streams were considered from mostly residential areas (Beaverton Creek and Butternut Creek) and two streams from mostly agricultural areas (Chicken Creek and Burris Creek; figure 1; note: from here out referred to as "rural"). Using aerial imagery, I analyzed the landscape looking for evidence of beaver activity. Primary evidence included backed up river water, ponding, wetlands, felled trees within backed up patches, stream obstructions, dying canopy, visible dams, open meadows, and side channeling. Points were placed where evidence indicated potential beaver presence, and each point was given a probability, or "likelihood", of beaver dam rating where 1 was extremely unlikely and 5 was almost definitely a beaver dam. Analyzing wetlands and ponds not created by beaver was just as important as analyzing very likely beaver dams so future comparisons can be made between landscapes impacted by beaver, human, or other environmental factors. 56 points were identified and ranked by beaver dam likelihood (figure 2).

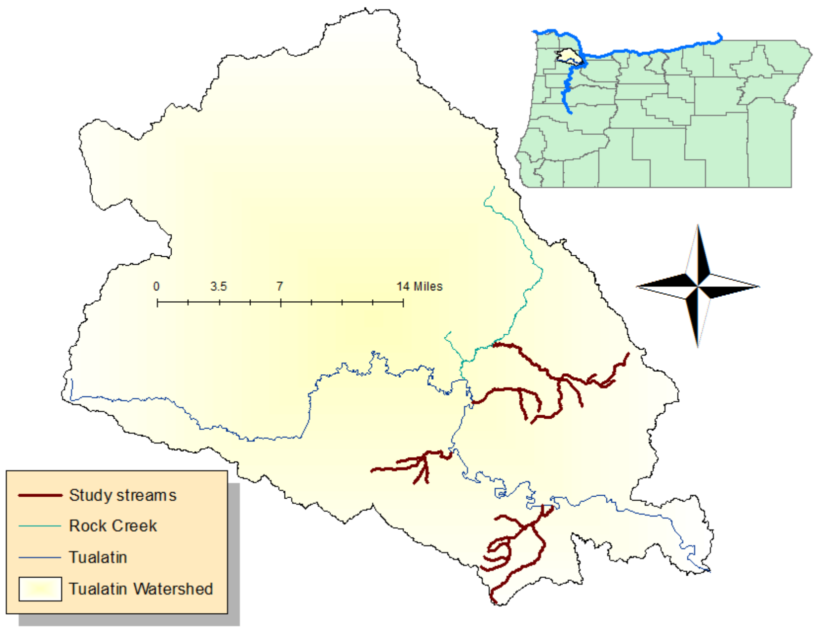

Figure 1. The Tualatin watershed is located in Northwest Oregon. The study streams (in red) were Beaverton Creek and Butternut Creek, Chicken Creek, and Burris Creek.

Running basic statistical analyses show many more potential beaver dams in more densely populated areas compared to rural areas (possible suburban dams = 42; possible rural dams = 14). A point

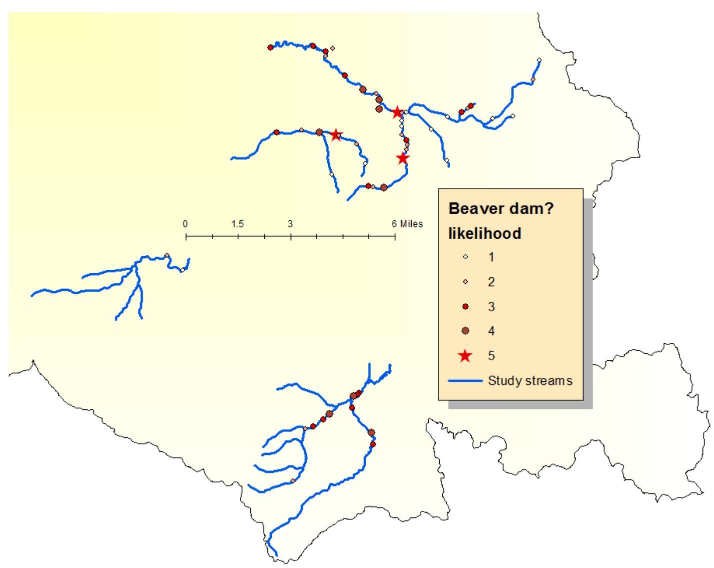

Figure 2. Points where landscape factors indicate potential beaver dam locations. The likelihood of an actual beaver dam present was ranked from 1 to 5.

analysis showed the nearest distance between each potential dam decreased as likelihood of a dam increased (figure 4). When the likelihood of a beaver dam was low (likelihood = 1) the average nearest distance to the next point was 861 meters, and when dam likelihood was high (likelihood = 5) the average nearest distance to the next point was 246 meters. This suggests model accuracy because a single beaver unit (colony or individual) tend to build more dams out from a central location. One very likely dam could translate into more (and generally smaller) dams nearby. Also, the closest distance between the most likely beaver dam points was over one kilometer (2129 meters) which was congruent with studies suggesting each colony requires at least one kilometer of space down each direction of the stream for territorial purposes[11]. The point distance analysis was performed on a straight line suggesting the sinuosity of a river may increase the distance between likely dams. This greater distance between in urban beaver dams compared to the spatial distance between dams in Barták et al. (2013) may advocate urban beavers require more space. Resources may be more limited on the urban landscape and colonies may respond by enlarging territory.

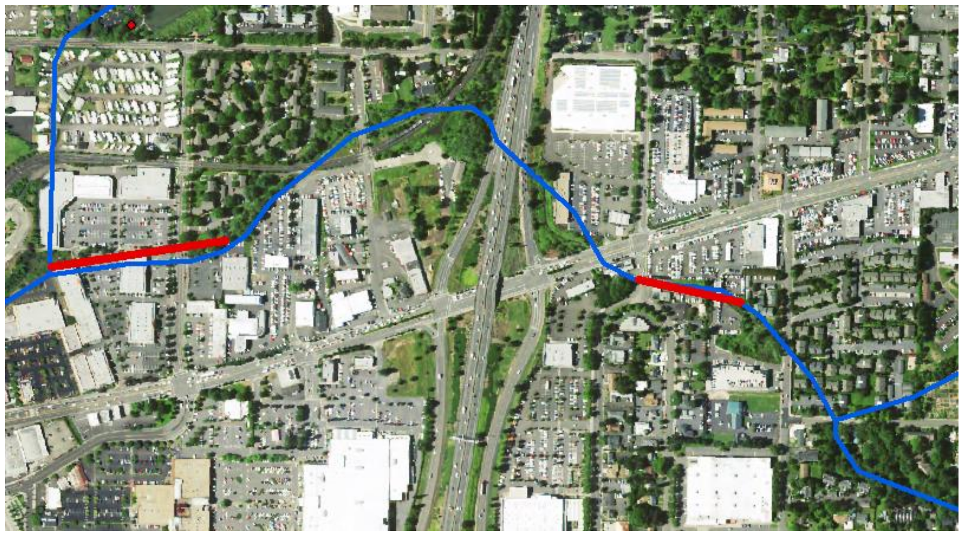

Figure 3. The river segment shown in blue was culverted. Red lines overlay sections of the river under parking lots or commercial infrastructure.

Habitat connections

Figure 4. Part of the stream was diverted or culverted (orange). However, potential beaver dams (likelihood = 3) persisted upstream.

To better understand how potential dam sites relate to one another, I analyzed the river network in terms of landscape type. I wanted to explore how much of a natural buffer might be required for dams to persist along a stream network, and how patches of green spaces (parks and designated natural areas) relate to dam location particularly upstream of green spaces. Conversely, disconnected stream reaches might prevent dams upstream of the diverted, culverted, or otherwise blocked stream segments.

The analysis showed major stream culverting which appeared to lower the likelihood of dams upstream (figure 3). There were points upstream suggesting potential beaver habitat, but the species may lack the ability to traverse the urban landscape to reach more suitable habitat. Length and amount of stream blockages may play a role in dispersal ability. There were occasions where likelihood increased upstream of culverts in the urban landscape (figure 4). An increase in data points and model verification would improve current understanding of habitat connections.

Rural streams may lack dams because agriculture has caused extensive changes to hydrological system. Streams were highly channelized in more rural agricultural areas, and frequently culvert (figure 5). These streams appeared much smaller in size either due to small order status or because of the much higher water usage in agricultural areas. To highlight water usage from surface streams, I found a farm adjacent to Chicken Creek that appears to be channeling water either to or from the stream (figure 6). Also, visual analysis of the landscape suggests there may have been a beaver dam present at one time. The dead patch south of the farm canals suggests recently dried water as well as some trace amounts of woody debris. Because beaver are known for water retention, and water systems in agriculture areas are particularly degraded, targeting restoration efforts using beaver to agricultural areas may prove particularly beneficial to all parties involved.

Figure 5. Burris Creek runs toward Tualatin River channelized along a country road between farms, and cuts north through a culvert.

Figure 6. Farm canals channeling water onto the farm out of Chicken Creek in Rural Oregon. The scarred patch around the river indicates recently dried wetlands or pond.

Beaver dams and city zoning

Wally Macfarlane, Joseph Wheaton, and colleagues at Utah State University developed the Beaver Restoration Assessment Tool (BRAT) to be used in decision making when planning how to restore rivers and wetlands around the state of Utah[12]. The model works by analyzing several variables including slope, stream power, vegetation availability, and land use to determine the ability a stream segment has for support beaver dams (figure 7). If a stream can support many dams it has a high dam capacity and may

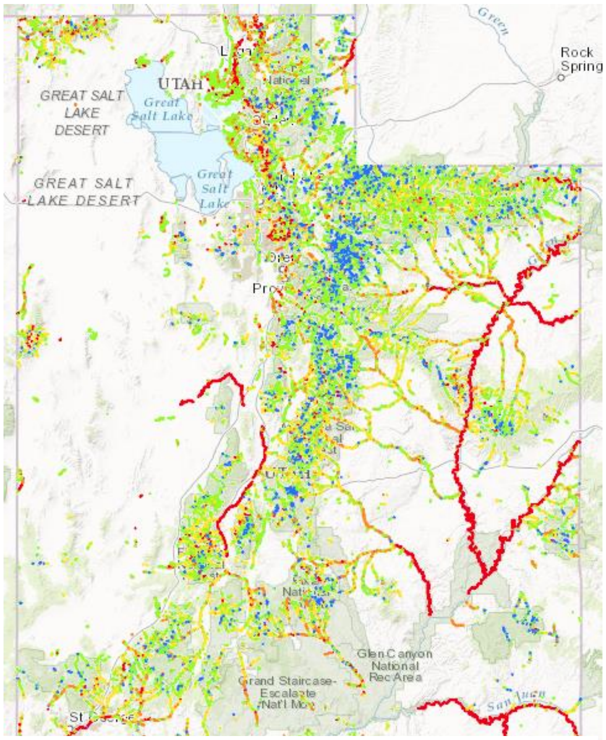

Figure 7. The Beaver Restoration Assessment Tool (BRAT) laid over the state of Utah. Areas of color represent the stream network of Utah. Blue and green = high dam capacity; orange and red = low dam capacity. From Macfarlane et al. 2014.

Figure 8. BRAT suggested high dam capacity in a channelized river through a golf course and through major infrastructure. The green line equals a river segment can support 5-15 dams.

be appropriate for targeting cheap and efficient beaver assisted restoration. Streams with low capacity for supporting beaver dams (dry regions with less available vegetation or streams moving too fast and too wide) are areas to avoid using beaver as a restoration tool. Wheaton et al. (2014) designed a robust and extremely helpful model for understanding dam distribution, but it is not without shortcomings. For example, the BRAT does not consider land use as a factor in dam capacity, so the model does not accurately determine good locations of beaver dams on the urban landscape (figure 8). However, the urban landscape has the ability to support beaver, and beaver can thrive in this setting, as our analysis suggests. Honing in on green spaces around the study streams and how land is zoned around urban streams more clearly highlights how to plan for beaver activity in an urban setting.

To perform this analysis, a 100-meter buffer was created around stream reaches because beaver generally forage no further than 40 meters from edge of water[11]. This distance was more than doubled (100 meters) to allow for width of stream and potential increase of water size from ponding. Data from the Intertwine Regional Conservation was used in analyzing green space land use[13]. In the urban streams, 17 of the 42 points were located in green spaces, and six of those 17 points were located in designated natural areas (figure 9). Two of the three most likely beaver dam points fell in green spaces (a park and a natural area), and the third point was 21 meters down stream of Brookhaven Park, a natural area managed by Tualatin Hills Parks and Recreation District. Parks and natural areas were more likely to have potential beaver dams than other green space types (figure 10). In rural streams, four of the 14 points fell in green space and three of those four were considered natural areas (figure 11). Using data from Metro, a closer inspection determined those four "rural" points were actually within the Sherwood city boundary. Using a study stream outside the Urban Growth Boundary would present more accurate information. Three points in Sherwood were zoned in single-family residential areas and one point was zoned commercial.

Data from Metro continued to present inconsistencies in the zoning of buffers around the study streams. In fact, nearly all the green spaces identified by Metro were around Fanno creek, a tributary relatively far downstream from all study sites and particularly the urban sites. This widely available and commonly depended upon data set was freely distributed for planners and citizens to check zoning regulations. Zooming into segments of Beaverton Creek reveals points classed as most likely beaver dams were within residential and industrial zones (figure 12). A breakdown of all the points of likelihood found industrial and commercial zones to be the most likely zones for beaver dams (figure 13). While I recognize the need for more data points to run more robust and significant statistics, this particular information may suffer from industrial zone having a sample size of two points. However, finding 21 points in single-family residential zones may be telling. It may be data provided by Metro inaccurately described land use, or it may be the nature of classification of single-

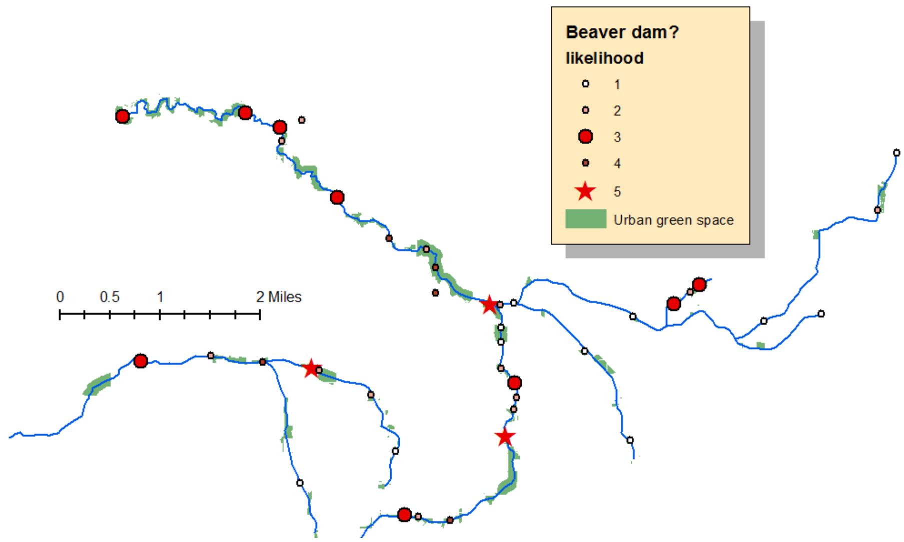

Figure 9. Green spaces may contribute to beaver activity through a stream network.

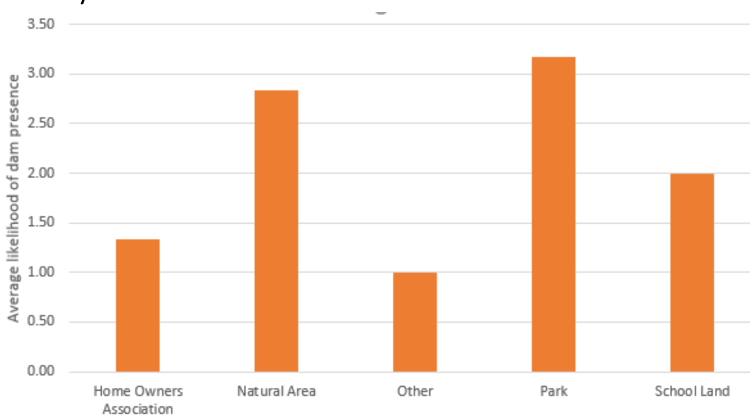

Figure 10. Potential beaver dam habitat increased in park and natural area green spaces as opposed to HOA, schools, or other green spaces.

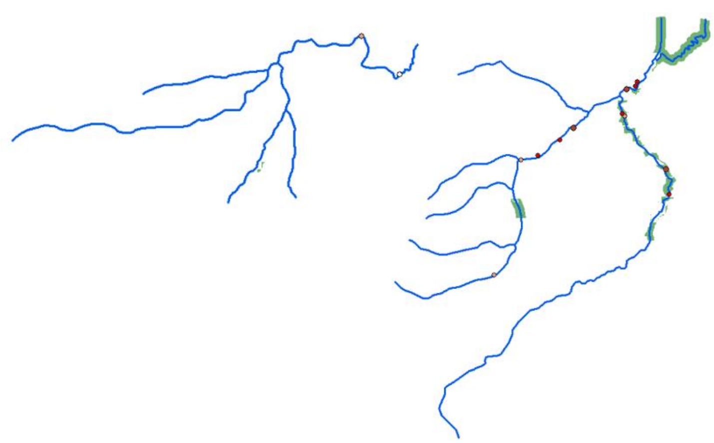

Figure 11. Rural streams had less green space and fewer potential dam sites within the green spaces.

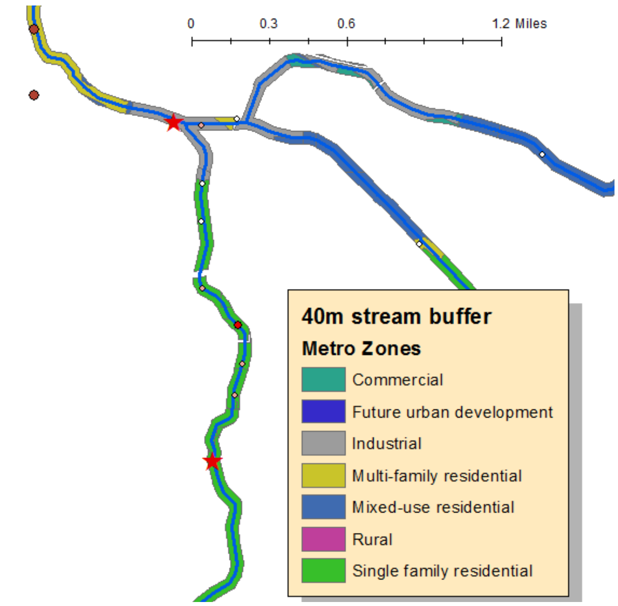

Figure 12. A section of Beaverton Creek shown with different land use types around a 40 meter buffer. Two most likely beaver dam sites were marked with red stars

family zones: these areas may have less dense infrastructure compared to other zones which may provide better habitat for beaver colonies.

Assumptions and limitations

The need for verification in the form of physically visiting these stream reaches characterizes the major assumption of a GIS analysis of beaver dams on a landscape of this nature. A number of potential reasons prevent clear identification of dams in orthoimages, aerial photography, and google earth includes dense canopy cover, resolution limitations, and other habitat requirement assumptions. The BRAT provides a good measure of habitat requirements for beaver, and it would be very beneficial to have a similar model for the Pacific Northwest. Additionally, the BRAT could be adjusted to respond more accurately to urban factors which would provide excellent data to add to the model presented here. Comparing BRAT findings in the Tualatin watershed to the locations of potential dams in this study may provide verification of each model, or might help to identify inaccuracies in this model or in BRAT.

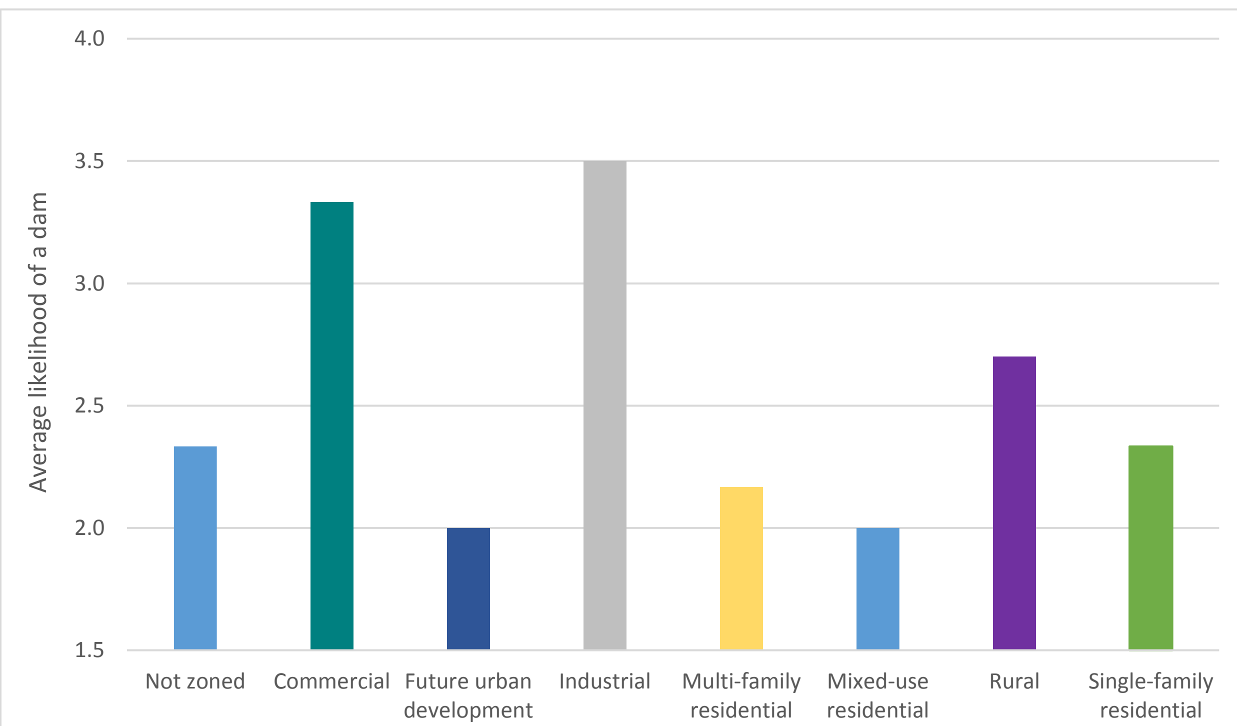

Figure 13. The average likelihood of a beaver dam within particular city zone types. Although the industrial zone was the most likely place to identify beaver dams, the sample size was too small for advanced statistics (industrial = 2; n=56).

Major limitations in statistical analysis prevented deeper understanding of habitat connectivity. The network analysis required for studying river systems requires more data points, and relating a network analysis to the green space polygons may reveal a better understanding of how the presence of corridors allow beaver to disperse. I was limited in the option to expand the dataset in this preliminary exploration, but this provides excellent opportunities for further explorations in this particular topic. Understanding how green spaces may provide habitat patches for upstream dispersal may increase knowledge of beaver needs and behavior. Conversely, understanding blockages may benefit managers and planners. Perhaps a particularly sized culvert allows passage for beaver and provides access to appropriate habitats while preventing beavers from plugging culverts. These relationships can be studied in more depth to improve best management practices.

Conclusions

This exploration presents a good start to considering beaver activity on the urban landscape in beneficial terms as opposed to designating beaver as a pest. Providing real data of potential dam locations has not been executed in the way presented, and these dam locations, ranked by likelihood, present real opportunities for further analyses. Knowing what appears to be good beaver habitat allows planners and managers to make sound decisions based on the resources around each site, and how changes to the hydrology may impact nearby infrastructure. If beaver are moving into relatively less dense residential areas, as this study suggests, it will be good to know why and how residential areas can live with and benefit from increasing beaver activity. Beaver relocation programs have grown in popularity over the past few years, and these programs can be expensive, time consuming, and require space for individual beaver as they are transported from one place to another. Beaver populations are increasing[14], so relocation efforts can fail in removal because new individuals will quickly move into available habitat. Finding more areas to allow beaver may benefit our ability to limit removal, save time and costs, and provide ecosystem services to communities. Beaver are territorial, so responsibly managing existing colonies and populations may limit inhabited space within one kilometer (upstream and downstream) of a beaver colony. This means managing dam building in one location may prevent dam building at sites nearby that could provide less support for flooding regimes. However, the lack of scientific investigations of beaver population dynamics limits the accuracy of this one kilometer concept. In an area like the Tualatin watershed which provides excellent habitat needs for beaver, population density may be much higher. The more planners know about where beaver like to build dams, and how many beaver currently inhabit a system, the more prepared urban management can be in providing space for this ecosystem engineer that provides a plethora of benefits to many landscapes.

The lack of potential dam sites in rural areas at first appeared detrimental to the accuracy of the statistics presented in this exploration. However, low dam likelihood in rural areas presents excellent management strategies. Dams act as natural water savers, and agricultural activity in rural areas can benefit greatly from simply attracting or allowing more beaver activity within river networks on the landscape. There may be shortcomings in this model that account for the lack of rural dams. For example, more information on preferred beaver habitat similar or equal to the BRAT would likely improve the selection of study sites for an analysis similar to what has been presented here. In rural lands just outside the urban growth boundary that have the ability to support beaver activities, more land managers could explore how beaver may benefit water retention which may also benefit agriculture.

Despite the lack of dam points in the industrial zoned land use data, finding one very likely dam suggests another management strategy worth informing future policy. The area zoned industrial that has a beaver dam may be an on-site mitigation wetland for the building of or activity from the industrial facility next to the beaver dam. The presence of beaver in wetland mitigation sites should return the same benefits here as it would in other areas. Therefore, attracting beaver to a wetland mitigation site should receive a higher success rating in terms of how mitigation is regulated and rated. Furthermore, time, money, and energy spent by land manager/owner in creating and/ or maintaining a mitigation site could be greatly reduced as beaver tend to engineer sites in ways that benefit natural recruitment of diverse flora and fauna[15]. Including beaver presence and impacts in wetland mitigation policy may greatly benefit strategic methods of improving natural landscapes.

There are many shortcomings within this analysis, and it is important to remember this document was not meant to be an exhaustive report on beaver dams within an urban ecosystem. This exploration represents a beginning of perceiving urban beaver as a natural part of the urban landscape. Understanding where beavers are and how they got there creates opportunities to work with them more closely so we may benefit one another. This investigation was written to be accessible to all readers. A more rigorous scientific examination may prove or disprove some hypotheses brought forward in the text. Any and all future analyses written about beavers in Portland or around other urban areas are highly welcomed. Watershed specific analyses may provide particularly useful as some watersheds provide much better habitat than others (another reason the BRAT should be expanded). Environmental managers will benefit from better scientific understanding of these city dwellers regardless of evidence contrary or in support of ideas presented here.

Citations

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