Analysis of Suitable Urban Beaver Habitat in the Tualatin Basin: A Fuzzy Inference System Based Approach

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Abstract

Urbanization has degraded the stream network in the Tualatin Basin. Beavers (Castor canadensis) have the ability to help restore these degraded ecosystems with the benefits that their dam building activity provides. Beaver dams create stream complexity, which support a diverse variety of plants and wildlife. Their dams work to slow and store stream flow, then slowly release it back into the system, a process that can help to alleviate low flow during the dry months and reduce stream velocity during the wet months. To use beavers as restoration aid, we must first understand where in the Basin the habitat is conducive to beaver activity. The purpose of this analysis is to incorporate the main habitat requirements for beavers into a model to identify suitable habitat in the urbanized portion of the Tualatin Basin with the purpose of serving as a planning and management support tool.

Background

In 1973, Oregon passed a comprehensive land-use planning law, which led to the establishment of the Urban Growth Boundary (UGB). The purpose of the UGB is to restrict the expansion of urban development and minimize encroachment onto farming and forested lands. The UGB extends into the eastern portion of the Tualatin Basin, just outside the city of Portland, OR. The UGB has created a dense suburban environment in the Tualatin Basin, where the majority of the population resides in just 20% of the watershed. The increase in impermeable surface that has accompanied urbanization has altered and degraded portions of the stream network in the Basin. Studies have proven the benefits that beavers provide to stream ecosystems and a number of agencies are beginning to support beaver populations in order to take advantage of these benefits.

The Tualatin Basin is an ideal habitat for beavers because of the abundance of low gradient perennial water sources. Unlike some neighboring watersheds, the majority of the stream network in the basin has not been piped or filled. Importantly, beavers are native to the basin. Early descriptions of the Tualatin Basin date back to the 1820's, with trappers describing the valley floors as being filled with water connected by swamps with the flooding attributed to beaver activity (Shively, 1993).

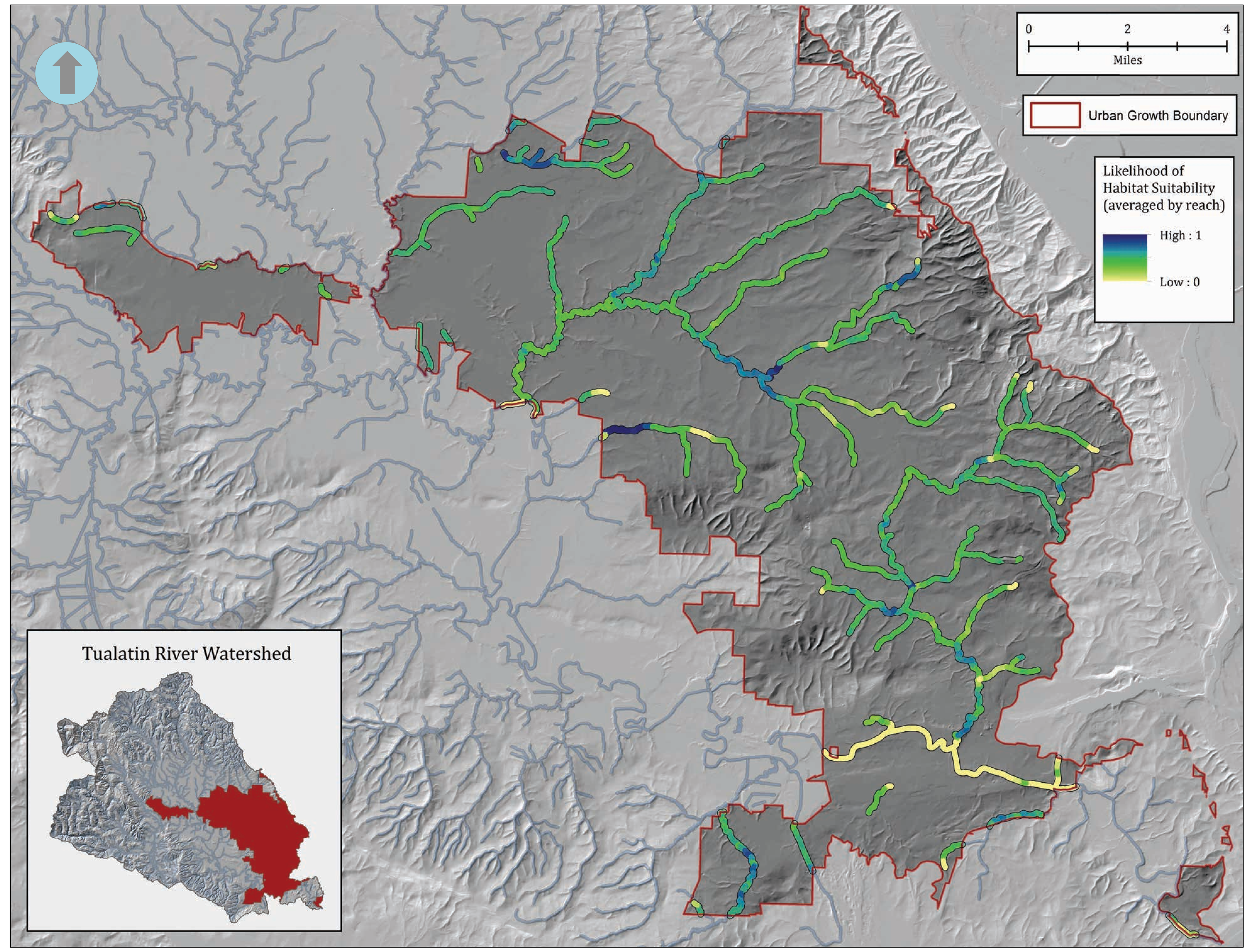

Figure 1: Results from the fuzzy habitat suitability model. The most suitable locations for beavers are shown in blue, the least suitable are shown in yellow.

Methods

A fuzzy inference system was used for this analysis. This method allows for flexibility when modeling behavior or processes that are not binary in nature. The ambiguous boundary between favorable and unfavorable beaver habitat makes a fuzzy inference method an effective approach to modeling potential beaver habitat.

Beavers have simple habitat requirements that include a perennial water source, vegetation that can support dam building activity, and low order streams with a low gradient. Prior to incorporating these variables into the model, some work was needed to get the data in appropriate condition for fuzzification. Land use data was reclassified, as shown in table 3. This classification system was based on WildEarth Guardians method (WildEarth Guardians. 2013). Developed land was given the lowest value, vegetated land was given the highest value and agricultural land fell in-between. Stream order was also classified based on WildEarth Guardian's method, as shown in table 1. Lastly, much work was needed to calculate stream reach slope. First, the streams were segmented into 820 foot reaches (Macfarlane & Wheaton, 2013), then a three foot buffer was created around each segment. These segments were then used as zonal boundaries to calculate the range in elevation (using a three foot resolution digital elevation model) within each segment. Since water flows downhill it is appropriate to assume that the difference between the highest cell value and the lowest cell value will represent the change in elevation. Each segment then had an associated range, which was divided by the length of the stream reach (820 feet) in order to approximate the stream reach gradient.

Gradient was reclassified based on the classification used in WildEarth Guardian's habitat model, shown in table 2. Once the pre-processing work was complete, a 330 foot buffer was created around perennial streams to represent a beavers typical foraging range (Macfarlane & Wheaton, 2013). This buffer was used as the boundary for the model.

Land-use data, stream reach slope and stream order were assigned fuzzy memberships using a linear transformation. Assigning fuzzy membership is a process that allows for the comparison of data with different units by standardizing the data through reclassification. The data was transformed to a continuous zero to one scale, based on the likelihood that the value was favorable to beavers. A value of zero was given when the value was not favorable to beavers, and a value of one was given when the value was favorable, with and a continuous linear range in-between.

Once the variables were assigned a fuzzy membership, a fuzzy overlay operation was performed. This operation allows multiple fuzzy membership sets to be analyzed together to determine the possibility of being an appropriate location for beaver habitat. There are multiple overlay methods, each method uses different criteria to combine the variables. For this analysis, the "and" method was used to combine the variables because it requires that all variables be favorable to beaver activity as appose to just one or two variables showing strong favorability.

HABITAT VARIABLE 1 – STREAM ORDER	
Order	**Reclassified Value**
1	8
2	10
3	9
4	7
5	5

Table 1: The stream order values were reclassified in order of suitability.

HABITAT VARIABLE 2 – STREAM GRADIENT	
Gradient	**Reclassified Value**
0 - 0.6	10
0.07 – 0.12	7
0.13 – 0.15	3
> 0.15	1

Table 2: The gradient values were reclassified in order of suitability.

HABITAT VARIABLE 3 - LAND USE CLASSIFICATION	
Type	**Reclassified Value**
Open Water	6
Developed, Open Space	4
Developed, Low Intensity	3
Developed, Medium Intensity	2
Developed, High Intensity	1
Barren Land	4
Deciduous Forest	6
Evergreen Forest	6
Mixed Forest	6
Shrub/Scrub	6
Grassland/Herbaceous	6
Pasture/Hay	5
Cultivated Crops	5
Woody Wetlands	6
Emergent Herbaceous	6

Table 3: Land use types were reclassified based on suitability.

Results & Future Analysis

The results from the suitability model are shown on the map in figure 1. The most suitable habitat is shown in blue, moderate habitat is shown in green and the least suitable habitat is shown in yellow. The model has yet to be tested, so its accuracy has not been determined. The next step in this analysis is compare the model to locations of known beaver activity

The stream network dataset used in this model limited the extent of the analysis because it was not comprehensive. Unfortunately, there is not a more inclusive dataset available for the Tualatin Basin. It would be useful to derive a new stream network using the high-resolution digital elevation model used for this analysis to determine elevation and calculate slope. A comprehensive stream network would allow for a more accurate slope calculation.

References

1. WildEarth Guardians. 2013 July 31. Assessing Beaver Habitat on Federal Lands in New Mexico
2. Macfarlane, W. Wheaton, J. 2013 January. Modeling the Capacity of Riverscapes to Support Dam Building Activity. Utah State University
3. Shively, D. October 1993. Landscape Change in the Tualatin Basin Following Euro American Settlement. Oregon Water Resource Research Institute.

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