Urban Forestry Management Plan – FAQ about the forest structure and wildlife connectivity methodologies

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Submitted to:

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1.0 About this FAQ document

The City of Bellingham is developing an Urban Forestry Management Plan (UFMP). This UFMP is envisioned as a citywide strategic plan to guide sustainable, long-term urban forest management in Bellingham. Phase 1 of UFMP development was an assessment of the City's existing forest conditions. Science-based methods were selected to capture citywide information cost-effectively. Existing data, at a scale and level of detail suitable to inform the citywide management plan was used by the Project Team and five City departments. Citywide spatial analyses were conducted and documented in the Canopy and Forest Structure Analysis Summary Report (Diamond Head, 2021) and Wildlife Corridor Analysis (Diamond Head, 2021). These reports were completed to support the development of the UFMP.

The purpose of this Frequently Asked Questions (FAQ) document is to provide more detailed responses to methodology questions submitted by the community. The following questions are answered in this document:

- How were Bellingham's forests classified?
- Why are some forest areas classified as young even though there are mature or old trees present?
- Were forest areas assigned to a forest structure class based on age?
- How was tree height estimated for each forest area?
- What is the wildlife corridor analysis?
- Why were habitat ratings lower for urban habitat patches?
- How were the focal species selected for the wildlife corridor analysis?
- How were riparian corridors integrated into the wildlife corridor analysis?
- How were various types of ecosystems and their relative importance assessed?
- What are the purpose and limitations of the wildlife corridor analysis?

The Phase 1 reports will also be updated to include these more detailed explanations about the methodologies used.

How were Bellingham's forests classified?

Forest structure in Bellingham was explored using successional stages (Figure 1), type (deciduous or coniferous), height class, forest health factors (invasive or pest presence) and multi-strata (one or more canopy strata detected by LiDAR). Six classes of forest succession were used to describe forest structure, see illustration in Figure 1.* The forest successional classes broadly describe how forest characteristics change as they become older, larger and more structurally diverse. Forest stands across the city were assigned to one of six forest successional stages based on height, LiDAR/imagery review and ground sampling plots throughout the city.

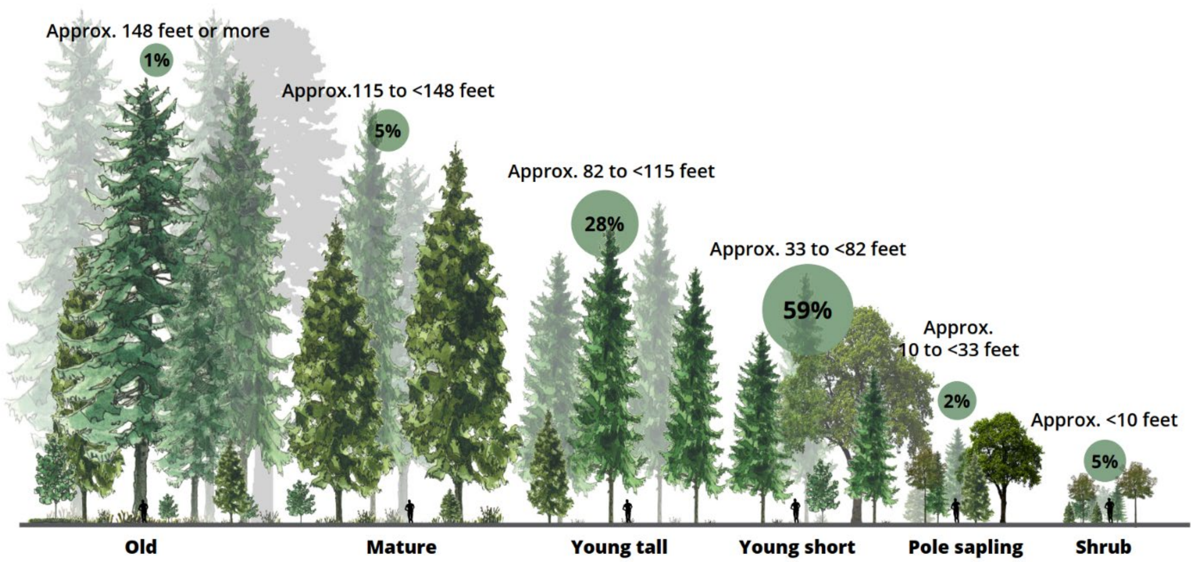

Figure 1. Composition of overall forest structure classes and criteria used in assessing the six forest structure classes.

* The successional stage classes used in the analysis were defined by the US Department of Agriculture and British Columbia Forest Service and are illustrated in Figure 1 and detailed in Table 1.

Table 1. Forest structure class descriptions including approximate height and representative details.

Forest structure class	Approximate height (feet)	Successional status description
Old Forests	148 or more	Stands that are very old with complex structure; patchy shrub and herb understories are typical; regeneration is usually of shade-tolerant species with composition similar to the overstorey; long-lived seral species may be present in some ecosystem types or on edaphic sites. Old growth structural attributes will differ across biogeoclimatic units and ecosystems. These forests are typically greater than 240 years.
Mature Forests	115 to <148	Trees are well established and large in size; stand openings exist and a second cycle of shade-tolerant trees may have become established; shrub and herb understories become well developed as the canopy opens up; habitat features such as standing dead trees and large stems on the ground exist. Forests with these attributes tend to be greater than 80 years old but this varies depending on the species and productivity of the site.
Young Forest Tall	82 to <115	Self-thinning has become evident and the forest canopy has begun to differentiate into distinct layers (dominant, main canopy, and overtopped); trees have vigorous growth and the canopy is more open compared to the Pole/Sapling stage; this stage can begin as early as 20 years old in highly productive stands and can extend to approximately 80 years or more depending on when the stand structure becomes more complex.
Young Forest Short	33 to <82	
Pole Sapling Forests	10 to <33	Trees > 10 ft tall, typically densely stocked, and have overtopped shrub and herb layers; vertical structure are not yet evident in the canopy; these stands are usually younger than 20 years old.
Shrub	<10	Early successional stage or a shrub community maintained by environmental conditions (e.g., wet soils, cold air accumulation) or disturbance (e.g., avalanche track); tree cover sparse, but tree seedlings and advance regeneration may be abundant; either dominated by shrubby vegetation, or if sparsely vegetated overall, shrub cover and stature characterizes the community as a shrubland.

Why are some forest areas classified as young even though there are mature or old trees present?

Many forest areas in Bellingham have multistoried canopies, or areas with trees of different ages. These areas likely experienced multiple stand disturbances, leading to a mix of tree ages. Due to the large size of the forest areas classified (necessary for a city-wide scale analysis), there may be intermixed pockets of trees that are older or younger within an area.

The most dominant age class, height and structure were used to select the single class for each large, forest area analyzed. The successional stage classes are broad, and large forest areas were assigned to a single class to represent the most dominant age class, average height and canopy structure. The coarse resolution of the analysis was suitable to answer broad questions about the quantity, composition, and structure of forest areas in Bellingham for the citywide plan. However, the results of this initial analysis are not suitable for planning at smaller scales, such as the site or park scale, because those plans would require a higher resolution of mapping and field inventory to capture differences in structure within forest stands.

Were forest areas assigned to a structural class based on age?

While many of Bellingham's forest areas were classified as young forest, the assigned structural class is not only based on tree age.

The forest structure classes were based on information available about tree heights, deciduous/coniferous, multi-strata canopy attributes and 16 field plots that included some tree cores to obtain ages. The structure classes are **not entirely based on age and are not based on the presence of a select number of trees of known age.** Instead, as described above, structure classes are broad and based on a combination of dominant age class, height and structure. The report acknowledges limitations to using height, composition, and limited field data to infer forest age because different species grow at different rates, and productivity differs between sites. The descriptions of Table 3 in the Forest Structure Analysis report are being updated to avoid misleading readers by suggesting that there is strict adherence to a specific age across broad forest areas dominated by a specific structural class.

Given the intended use of the data to inform the citywide plan the limitations of the analysis were acceptable for the budget, scope and intended use. The results of this analysis are not suitable for planning at smaller scales, such as the site or park scale, because those plans would require a higher resolution of mapping and field inventory to capture differences in structure within forest stands.

How was tree height estimated for each forest area?

The project team used Light Detection and Ranging (LiDAR) data to estimate tree heights. LiDAR provides accurate heights of individual trees in forest stands (see Appendix 1 for the vendor's accuracy assessment summary). The average height assigned to each forest area was an average of the height of every tree, at all canopy levels, across the entire forest stand area. Figures 2 to 13 illustrate specific examples of tree heights and height distribution for the Chuckanut Community Forest, northern Sehome, southern Sehome, Whatcom Creek, and Whatcom Falls.

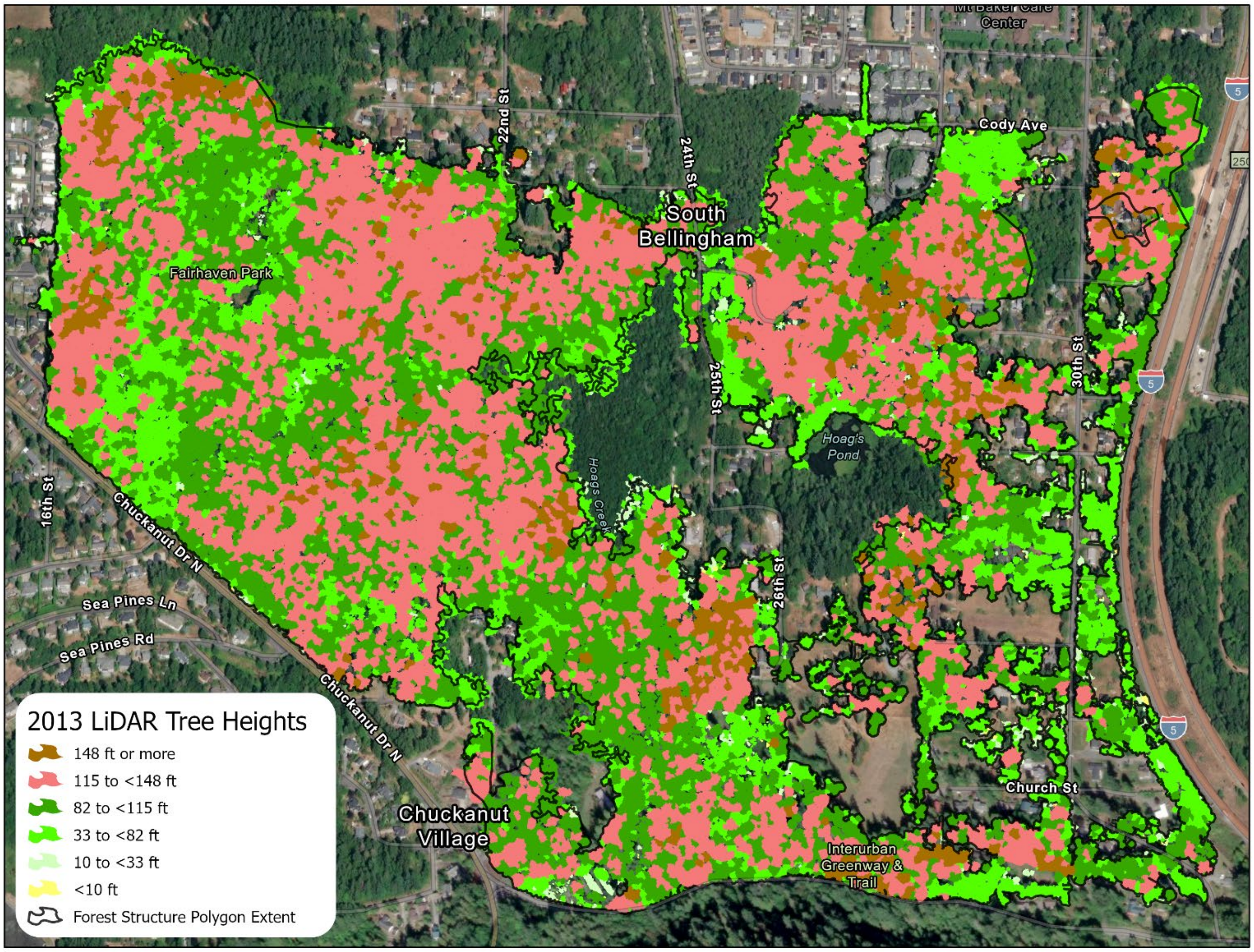

Figure 2. South Bellingham forest structure polygon, inclusive of the Chuckanut Community Forest

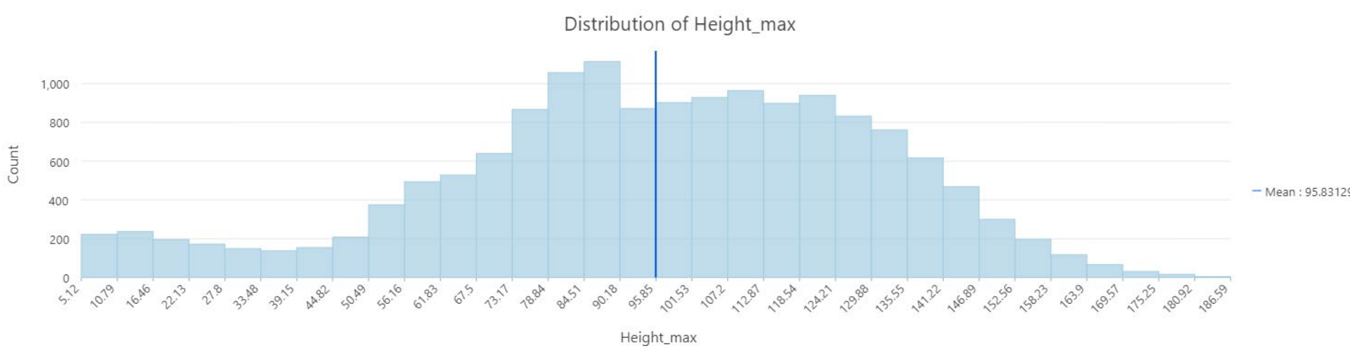

Figure 3. South Bellingham forest structure polygon LiDAR tree height distribution

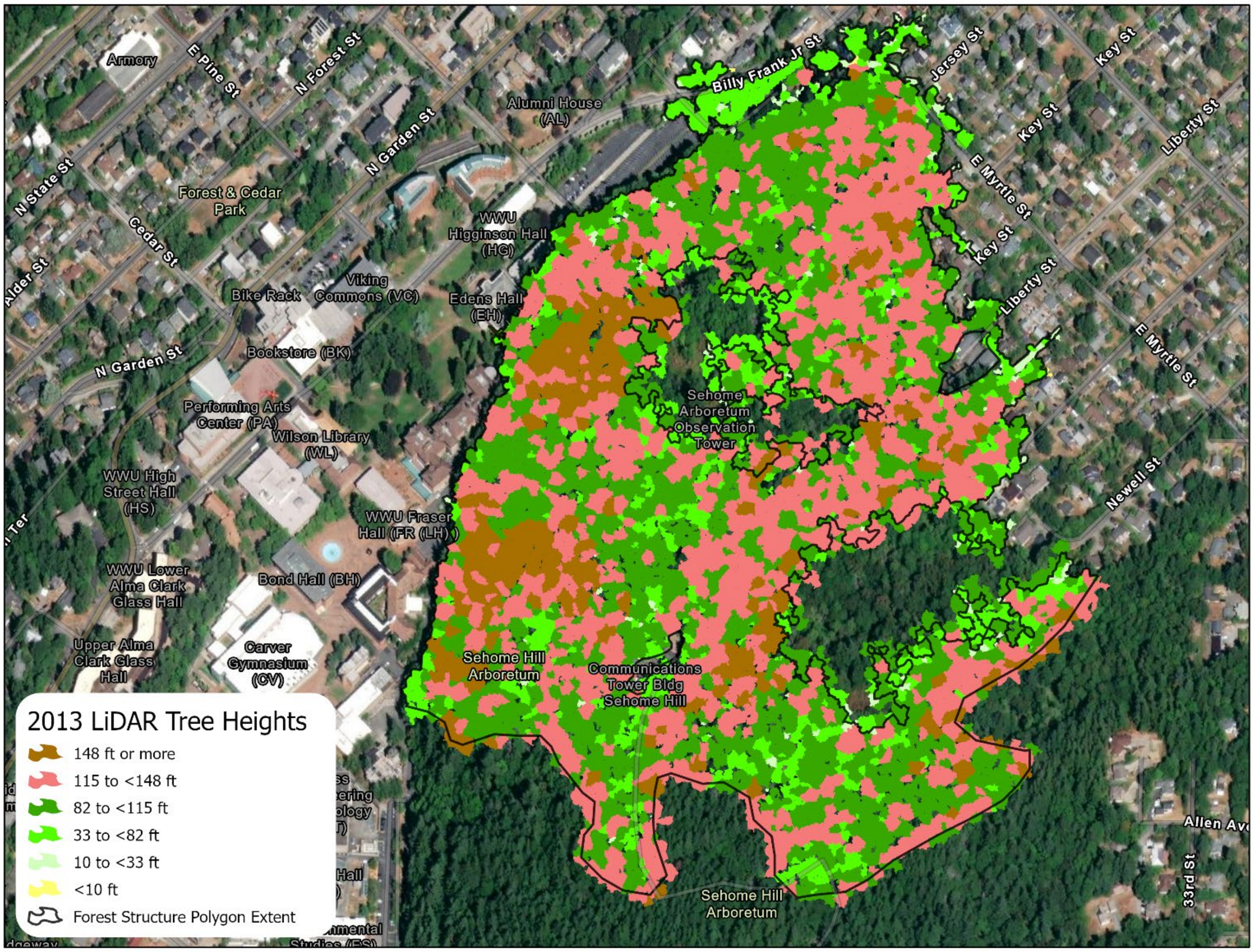

Figure 4. Northern Sehome Hill forest structure polygon

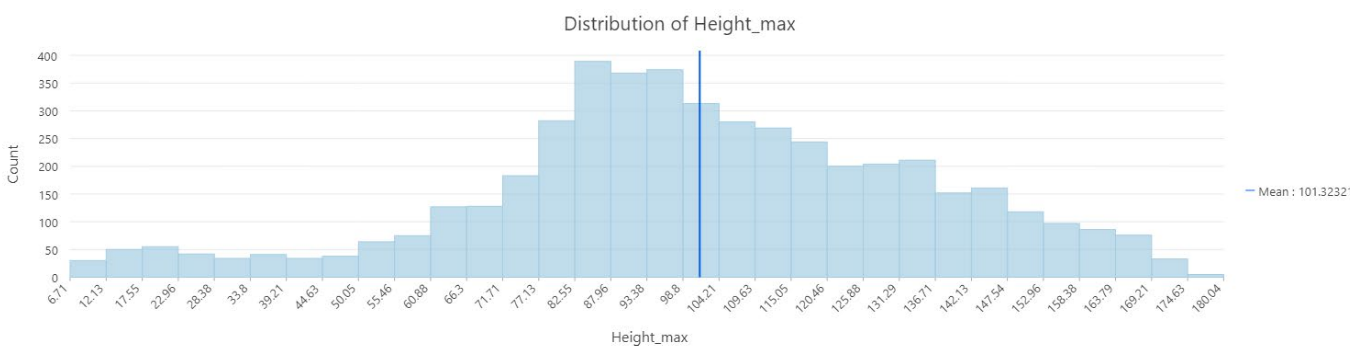

Figure 5. Northern Sehome Hill forest structure polygon LiDAR tree height distribution

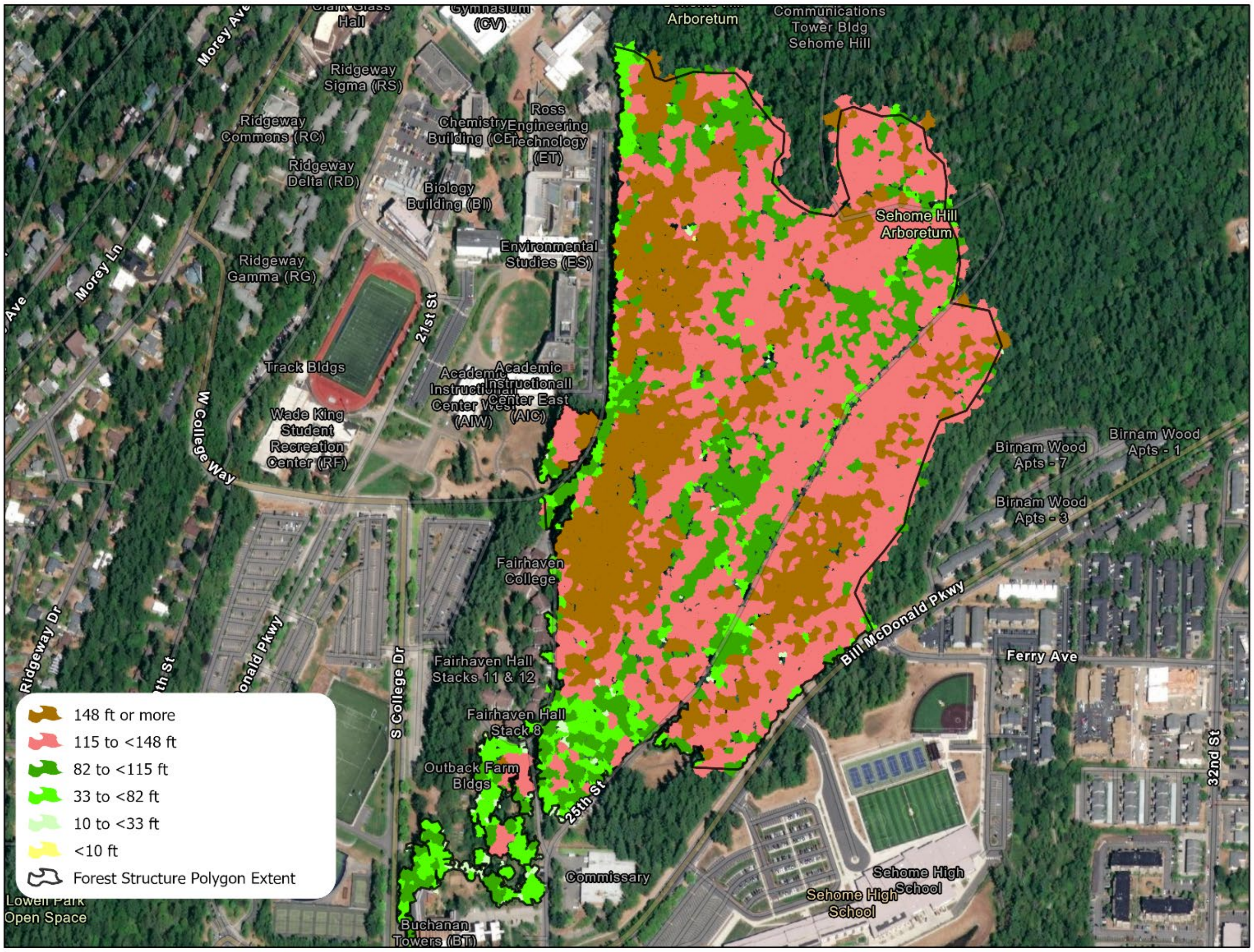

Figure 6. Southern Sehome Hill forest structure polygon

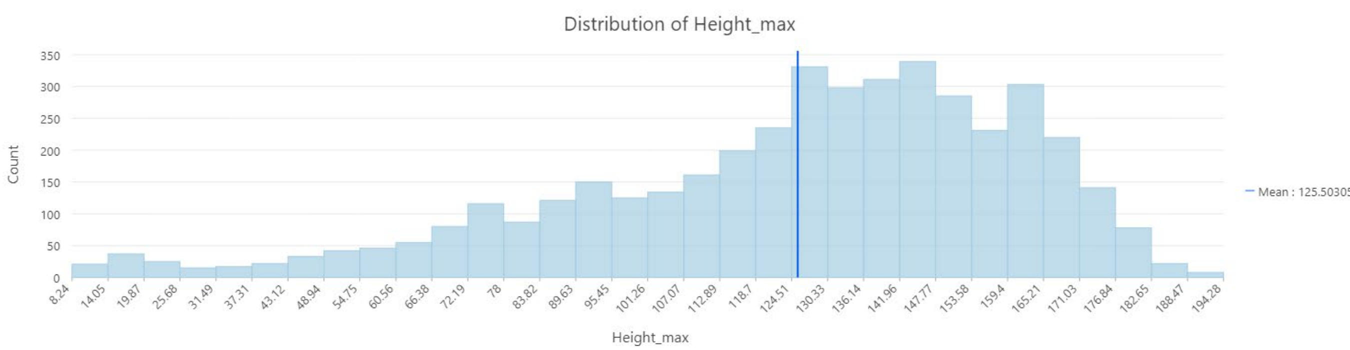

Figure 7. Southern Sehome Hill forest structure polygon LiDAR tree height distribution

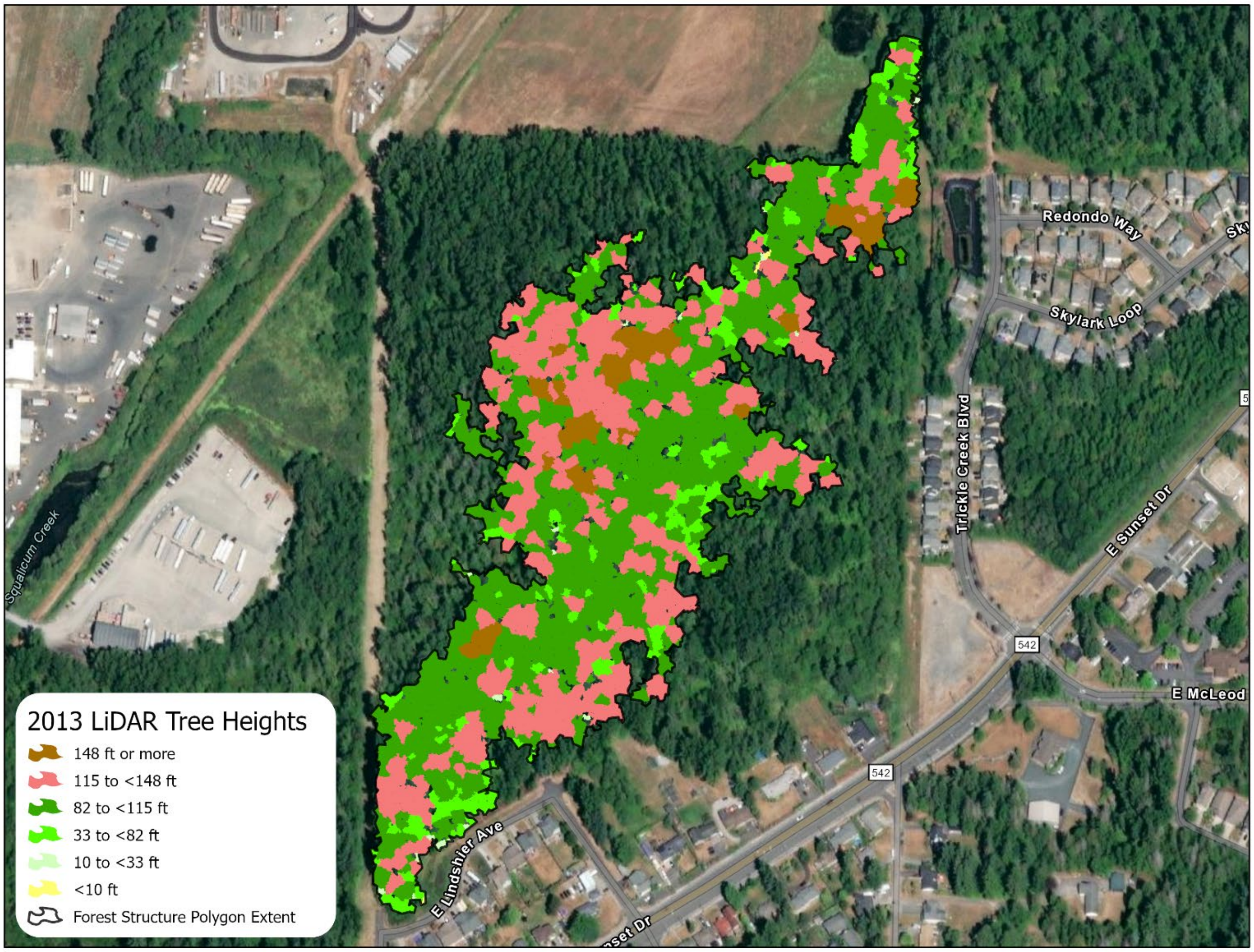

Figure 8. Sunset Drive, Washington Department of Natural Resources forest structure polygon

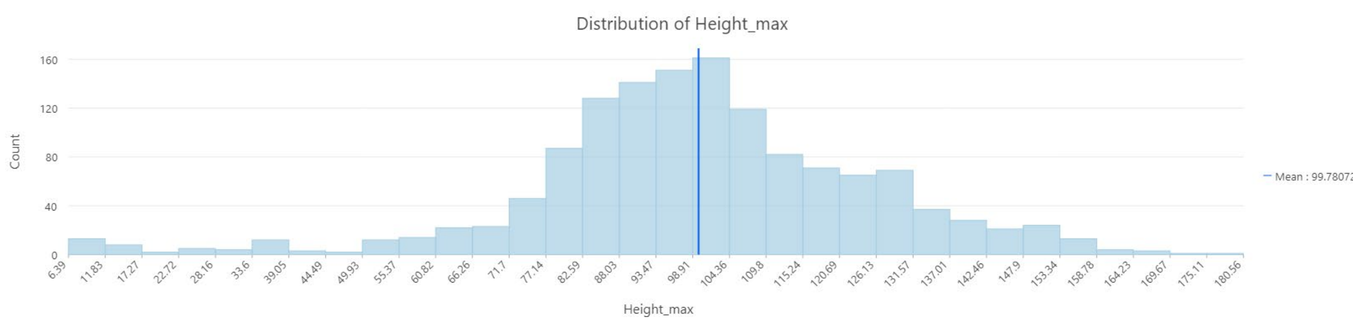

Figure 9. Sunset Drive forest structure polygon LiDAR tree height distribution

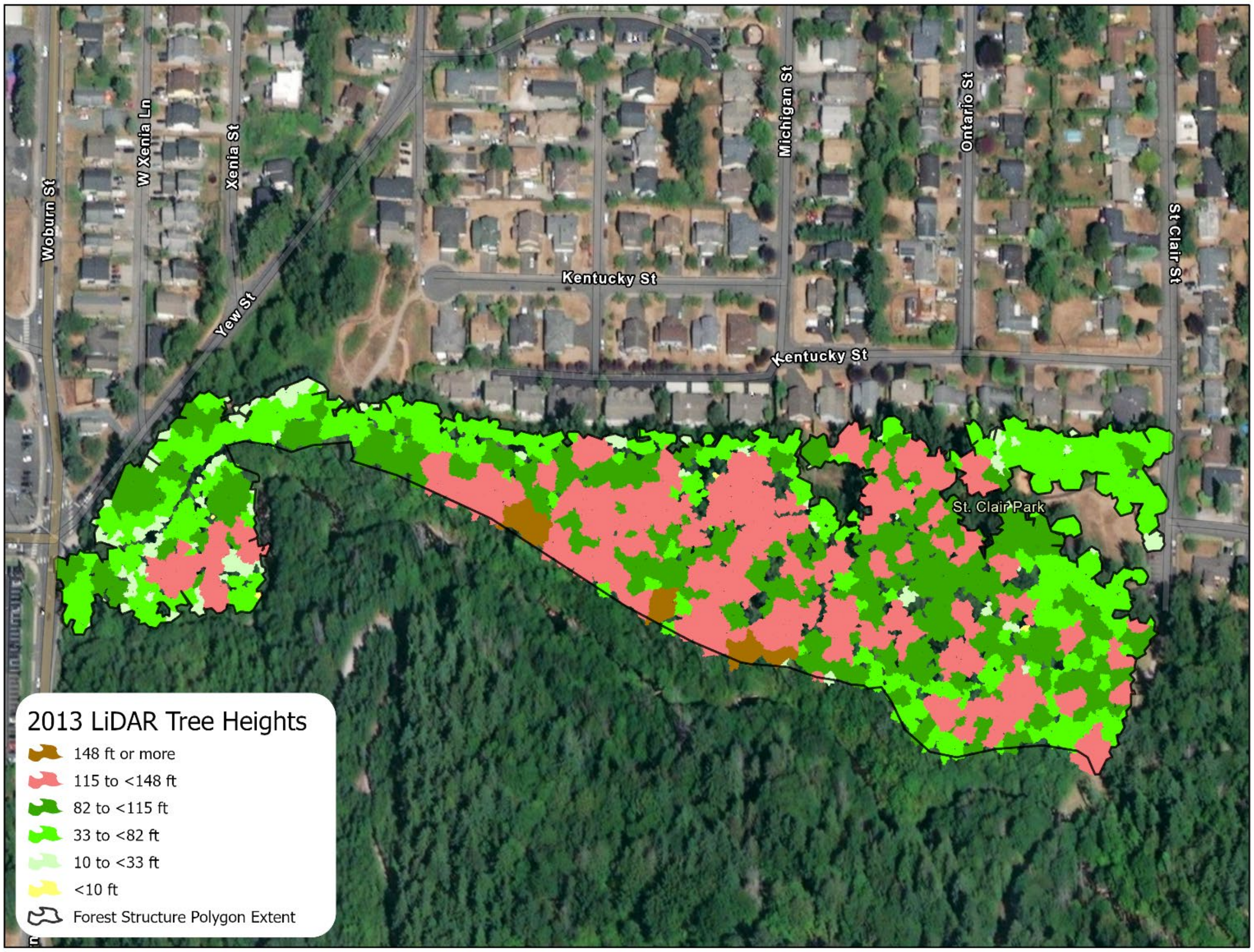

Figure 10. Whatcom Falls Park forest structure polygon

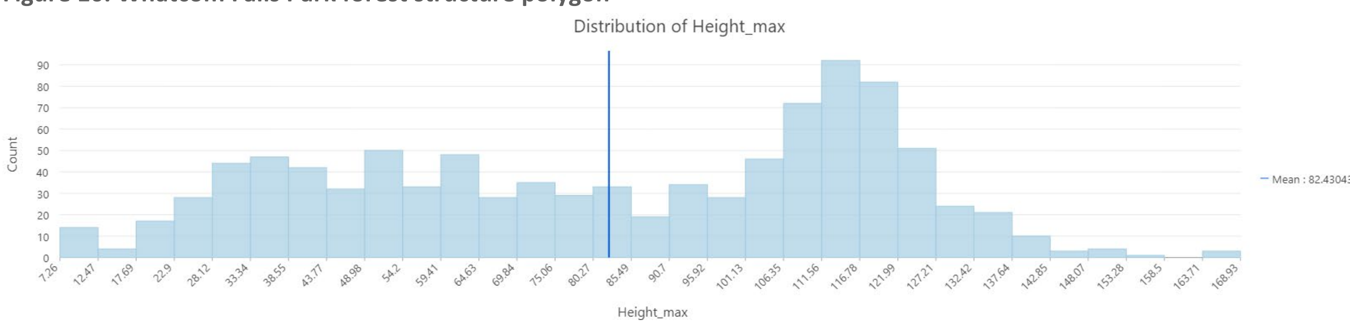

Figure 11. Whatcom Falls Park forest structure polygon LiDAR tree height distribution

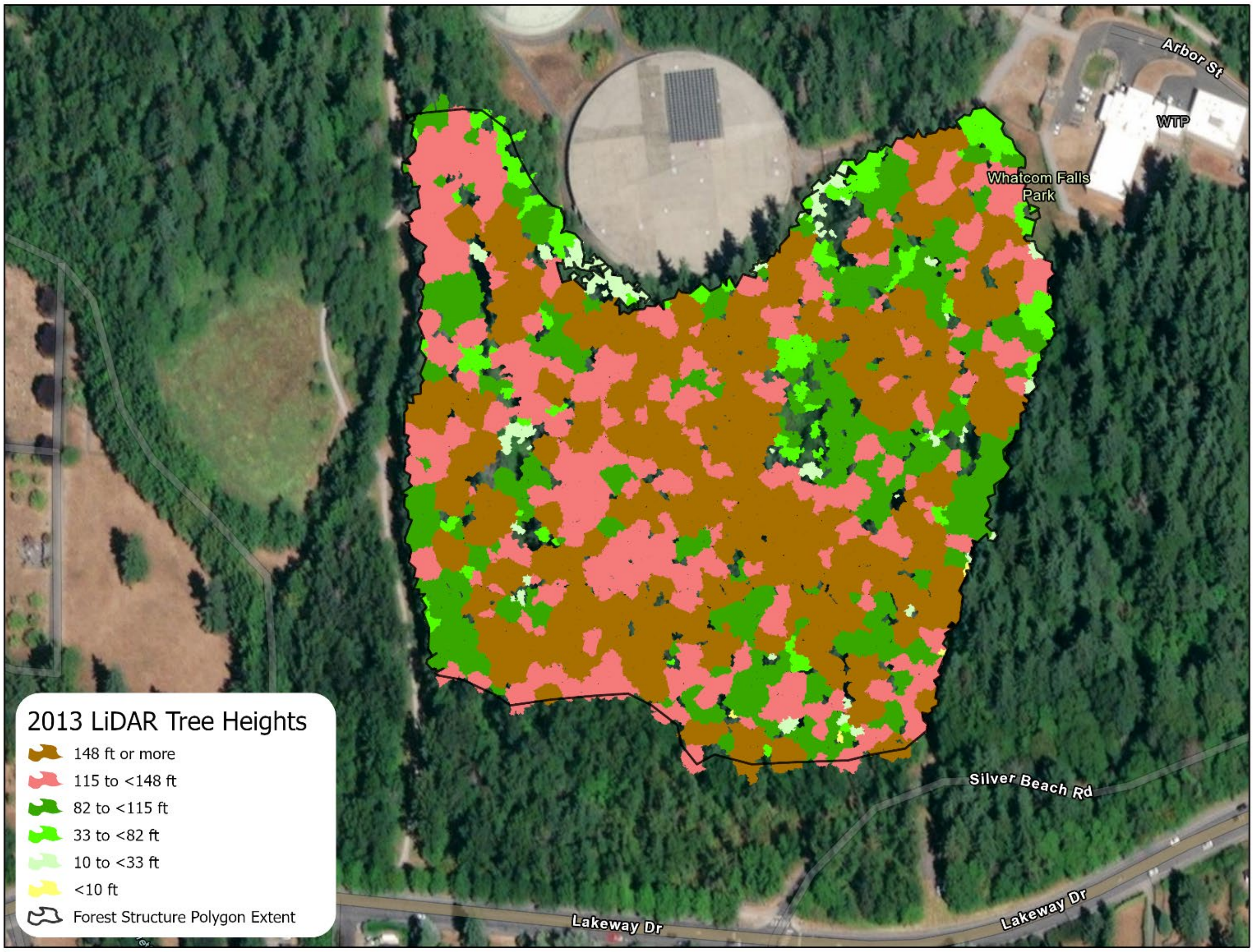

Figure 12. Whatcom Falls forest structure polygon

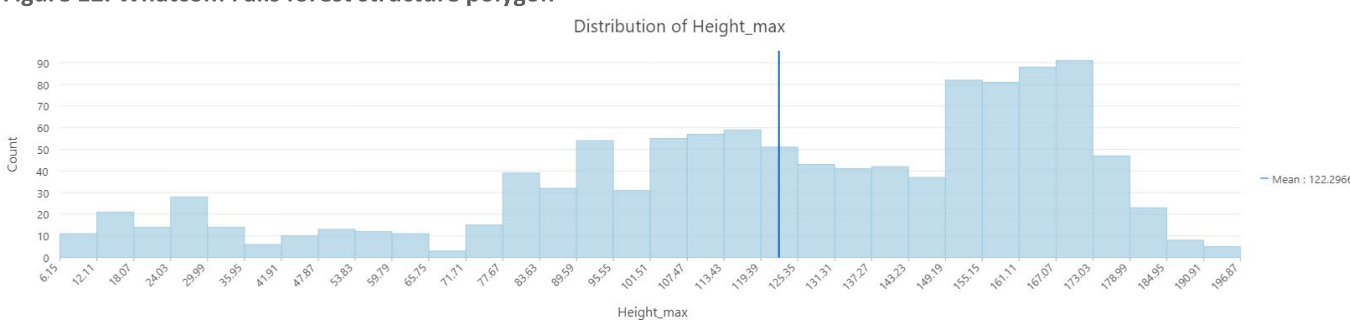

Figure 13. Whatcom Falls Park **forest structure polygon LiDAR tree height distribution**

What is the wildlife corridor analysis?

The canopy analysis identified an accurate extent of the natural forests in the City. The purpose of the wildlife corridor analysis was to identify important areas where terrestrial wildlife can live as well as the corridors that they use to move around the City limits and urban growth area (UGA; Figure 15). The analysis provided up to date information about terrestrial habitat areas in the City and supported the findings in the draft 2003 City of Bellingham Wildlife Habitat Assessment (Nahkeeta Northwest 2003), which was never finalized. The wildlife corridor analysis also filled data gaps identified in the 2015 Bellingham Habitat Restoration Technical Assessment (ESA 2015).

The wildlife corridor analysis used a model called Conefor. The model used the habitat requirements of three focal species to identify important terrestrial habitat areas and corridors. The ecosystem types that these three species rely on were identified as inputs to this model. For example, wetlands and riparian areas are considered valued habitat areas for the red legged frog analysis. High-value habitat identified for Douglas-squirrel included larger patches of conifer dominated forests. Other inputs to the model include a minimum patch size and tolerance ratings to barriers and urban impacts. See "How were focal species selected for the wildlife corridor analysis?" below for additional information.

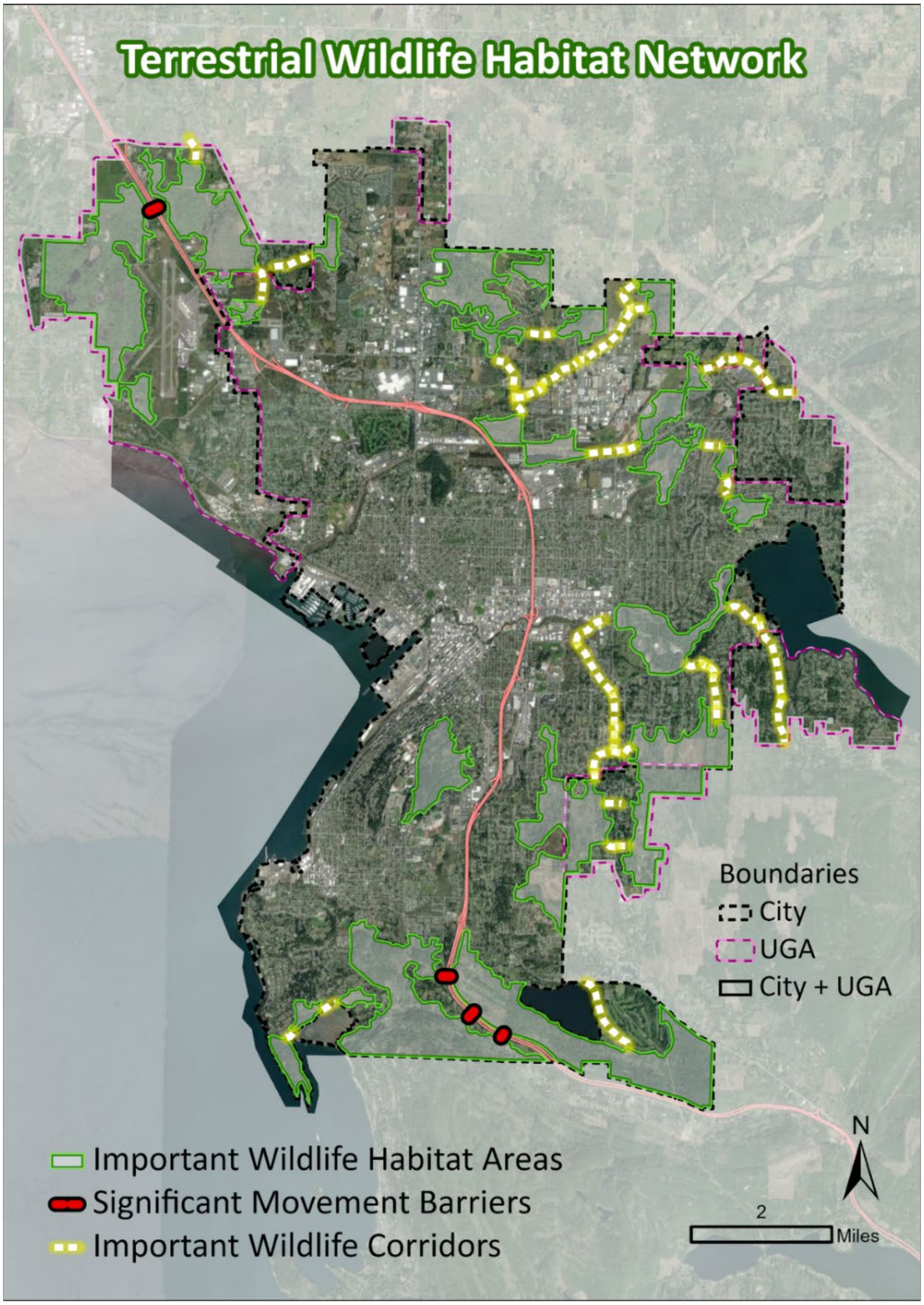

Figure 14. Terrestrial Wildlife Habitat Network. This analysis does not consider habitat extending outside the City boundary or habitat for marine or freshwater fish.

Why were habitat rating values lower for urban habitat patches?

The model compared the value of habitat patches across the entire City. Smaller patches within the City Center were compared to large natural areas found further out around the edges of the City. Small habitat areas surrounded by urban development provide lower value for wildlife compared to large continuous forests that connect to the larger natural landscapes surrounding the City.

How were the focal species selected for the wildlife corridor analysis?

The focus of this project is urban forest management, so the project scope and budget for this wildlife analysis was limited to choosing three focal species and focusing on habitat connectivity in terrestrial areas. The project team chose one amphibian, one bird and one mammal species: red legged frog (*Rana aurora*), Douglas-squirrel (*Tamiasciurus douglasii*), and Brown Creeper (*Certhia americana*). These species were chosen in collaboration with City staff, local wildlife consultants, the Washington State Department of Fish and Wildlife Area Habitat Biologist, the Washington State Department of National Resources Region Biologist, and the Washington State Department of Transportation Habitat Connectivity Biologist. Each focal species represents a general group of terrestrial wildlife species with similar habitat requirements. The model provides citywide outputs to identify large and significant habitat areas and connecting corridors relied on by these three focal species. It does not identify corridors that are degraded, and that could be restored. The model outputs do not represent all wildlife species and do not identify all possible habitat areas and corridors.

How were riparian corridors integrated into the wildlife corridor analysis?

The model includes habitat patches that meet a minimum patch size. It does not differentiate riparian areas from other natural areas. In many cases, riparian corridors that extend through the City are fragmented by roads and urban areas. In the wildlife corridor analysis, the riparian areas found in urban settings were compared in value to those within large natural areas outside the urban areas. Riparian corridors that are smaller and more fragmented were therefore rated much lower in comparison. For example, a wider naturalized riparian corridor connected to large natural areas provides higher value to wildlife than a narrow, disturbed, and fragmented corridor through an urban setting.

How was the relative importance of various types of ecosystems assessed?

The scope of this model exercise was focused on terrestrial habitats, which were a data gap in previous studies including the Bellingham Habitat Restoration Technical Assessment (Environmental Science Associates, 2015). Marine habitat was not considered since they have been analyzed in detail in previous studies such as:

- WRIA 1 Nearshore & Estuarine Assessment and Restoration Prioritization Plan (Coastal Geologic Services, 2013)
- City of Bellingham Marine Nearshore Habitat Connectivity Study (Environmental Science Associates, 2014)

Why was the Conefor model used for the wildlife corridor analysis?

The Conefor model is a popular and affordable software for analyzing wildlife connectivity spatially. The model can use LiDAR canopy data, which was readily available for this project, as an input. Conefor provides citywide results that can be used to identify significant habitat areas and high-value connecting corridors. There are limitations associated with this model. Only certain types of input variables can be used and it does not identify or prioritize degraded areas that could be restored to improve connectivity.

Appendix 1. LiDAR accuracy assessment

The table below summarizes the accuracy assessment completed by the vendor for the LiDAR data used in the forest structure analysis, WSI Applied Remote Sensing and Analysis. The vertical accuracy assessment was conducted using 2716 real-time kinetic (RTK) points using Trimble GPS surveying equipment

Table 2. LiDAR accuracy assessment from the vendor

LiDAR Survey Settings & Specifications		
Area of interest	**City of Bellingham**	**Lake Whatcom Watershed**
Sensor	Leica ALS50	Leica ALS50
Survey Altitude (AGL)	1400 m	900 m
Target Pulse Rate	150 kHz	150 kHz
Sensor Configuration	Multi Pulse in Air (MPiA)	Single Pulse in Air (SPiA)
Laser Pulse Diameter	32 cm	21 cm
Field of View	24°	26°
GPS Baselines	≤13 nm	≤13 nm
GPS PDOP	≤3.0	≤3.0
GPS Satellite Constellation	≥6	≥6
Maximum Returns	4	4
Intensity	8-bit	8-bit
Resolution/Density	Average 8 pulses/m^2	Average 8 pulses/m^2
Accuracy	$RMSE_Z \leq 15$ cm	$RMSE_Z \leq 15$ cm