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Purpose & Scope

The Skykomish Basin Land Protection Assessment and Mapping project employed a Geographic Information System (GIS) approach to evaluate the landscape within the Skykomish watershed with respect to conservation value and potential development threat in order to inform near- and long-term strategies to protect habitat in support of salmon recovery. By assessing these two factors in aggregation, the analysis indicates relative composite values in 16 rankings from Low Conservation/Low Threat to High Conservation/High Threat.

Specifically, this project used spatial analysis and mapping techniques on a parcel-by-parcel basis to identify private, unprotected lands for potential conservation acquisition (fee or conservation easement) in the Skykomish River Basin based on their hydrologic and habitat values, along with threat of development.

Our overarching objective for this project was to gather and analyze a wide range of data to provide information to Forterra, Snohomish County, King County, Tribes, NGOs, and other entities working in the basin in order to inform their conservation and resource management decision-making processes. The spatial data resulting from this analysis can be used as a tool to help guide these organizations in targeting land acquisitions that preserve hydrology and other natural functions, protect habitat, provide low-impact river access, and avoid development in floodplains. Additionally, the analysis methods and data may serve as the starting point for future update, refinement or expansion efforts for the Skykomish Basin, or serve as a model for similar work in other Puget Sound basins.

Study Area - Skykomish River Basin

The study area is comprised of the Skykomish River watershed (534,100 acres), which is a major part of the Snohomish River Basin. The Skykomish River system includes the main stem (29.2 miles) from its confluence with the Snoqualmie River just south of Monroe, to the confluence of the North Fork (28.9 miles) and the South Fork (19.19 miles) near Index. Besides the North and South Forks, the major tributaries include the Beckler, Rapid, Tye, Foss, Miller, Wallace, and Sultan Rivers. Major creeks include Woods, Index, Proctor, Maloney, Barclay, Money, Martin, Eagle, Troublesome, and Olney. Most of the basin is in Snohomish County, with about 1/4 in King County – comprising the majority of the South Fork Skykomish watershed.

Land Form & Land Use

The eastern two thirds of the basin is mountainous with ridges reaching over 5,000 feet. The basin receives heavy precipitation, up to 180” (e.g., Sultan Basin) much of it as snow. This portion of the basin is heavily forested except for alpine areas and rocky features. Most of this land is in public and timber company ownership. Management varies from wilderness to intensive timber production.

The western portion of the basin is comprised of forested foothills and lowlands near the river. Forestry and farming once covered most of that area, but suburban and rural development now occupy significant portions, especially in the vicinity of U.S. Highway 2.

Public Ownership

A large portion of the watershed is in public ownership (~79%), which was not directly evaluated in this study. While there are some exceptions, we assumed these lands would remain in public ownership, generally without commercial or residential development. Thus, habitat and hydrologic health would be a function of land management rather than ownership.

Approximately 327,600 acres in the basin is national forest land, part of the Mt. Baker-Snoqualmie National Forest. About 69% of that national forest land is protected as wilderness, while the remainder is managed for a variety purposes and includes an extensive road system.

The Washington Department of Natural Resources manages ~80,000 acres in the watershed. About a third of that is the Natural Resource Conservation Areas (NRCAs)
within or adjacent to the Sultan River sub-basin. Washington State Parks manages another 3,000 acres around Wallace Falls and Index. Other major public lands include the City of Everett lands around Lake Chaplain, and Snohomish County lands around Spada Lake. Both of these tracts are in the Sultan River sub-basin and total about 9,000 acres. Other public lands comprise about 2,000 acres.

Private Ownership
Of the 112,000 acres of private lands in the watershed, major timber companies own about 48,000 acres. Of that, about 11,000 acres are covered by a conservation easement that precludes conversion to development. Those lands were not included in this study. Thus, this study evaluated approximately 100,000 acres of unprotected private land.

Beyond the Scope
Several factors were beyond the scope of this study, including priority ranking, restoration, and the evaluation of conservation opportunity. Readers could combine these factors with the results of this study to further inform strategic decisions.

Priorities
It is important to note that this analysis does not set up a priority ranking. The focus and priorities for each interested entity and funding source vary. This tool focuses on key areas and can be adjusted to emphasize factors of most interest to each of those entities.

Restoration
This tool is designed to identify parcels with important conservation values and associated risks to those values from development. While restoration opportunities exist to varying degrees on these properties, restoration was not a factor in this analysis. Thus, with the exception of Culmback Dam and Sunset Falls, we have not evaluated human built barriers to salmon habitat.

Opportunity
While this analysis evaluates conservation values and threats, the third major consideration in conservation transactions is opportunity. This involves three key elements: funding sources, willing sellers, and entities that commit to long-term ownership and stewardship of the conservation lands. This study did not consider this factor, as it is highly variable, changes over time, and would require contact with every landowner, which was not possible within the scope of this study.

Data Acquisition & Compilation
This study relied predominantly on publicly available data as analysis inputs, covering a wide variety of agency sources, including the U.S. Departments of Fish and Wildlife and Agriculture, the Federal Emergency Management Agency, Washington Departments of Fish and Wildlife, Natural Resources, and Ecology, the Puget Sound LiDAR Consortium, and both King and Snohomish Counties. We also incorporated key datasets created and maintained by Forterra exclusively. Each input dataset is cited in more detail within the discussion for all conservation value or development threat criteria for which it was used.

We used county tax parcels as the fundamental unit of analysis for this study, upon which we measured all conservation value and development threat criteria. Candidate parcels are privately-owned lands not known to be protected by conservation easements or other legal instruments limiting further development, located within the Skykomish Basin. The study did not look at public lands such as national forest, state trust lands, state parks, county, or other conservation lands. However, when determining priorities, conservation entities often look at the proximity to existing public or conserved lands.

To integrate the results of each analysis metric into a decision-support tool useful to planners and conservation practitioners, we created a 4 x 4 matrix of aggregated conservation values and development threat metrics in order to convey a top-level picture of conservation opportunities at the parcel level.

For Conservation Values – greatest value = 4; lowest value = 1
For Development Threats – greatest threat = 4; lowest threat = 1
OVERVIEW, BACKGROUND & OBJECTIVES

INPUT VARIABLE - 2013 Air Photo

Source: USDA NRCS NAIP 4-Band Orthophotography

Date: Summer 2013

Description: We obtained state-wide coverage of the NAIP 4-Band orthoimagery from the Aerial Photography Field Office (APFO) located in Salt Lake City, Utah.

Resolution: 1 meter

Methods: We generated a true color mosaic by combining the Red, Green, and Blue bands into a composite raster file using the COMPOSITE BANDS command with Band 1 as Red, Band 2 as Green, and Band 3 as Blue.
OVERVIEW, BACKGROUND & OBJECTIVES

INPUT VARIABLE - Land Ownership

Source: Forterra

Date: December 21, 2013

Description: The Central Puget Sound Public, Tribal, and Protected Land Database is updated intermittently using a combination of data including county parcels, resource agency ownership data, Tribal data, and non-profit data on easements and acquisitions.

Methods: The CPS-PLDB contains numerous attributes characterizing land ownership, and this particular map utilizes the SYMBOL 1 field to provide a general overview of land ownership in the basin. For the purposes of the assessment, we used this data to identify the private, unprotected lands that are available for various conservation activities.
There are many interrelated conservation values in the basin. We looked at those that have a significant effect on hydrology and salmon. Thus, the analysis did not consider values such as recreation and scenery. We examined the riparian areas and the related uplands, as these portions of the landscape have the most direct impact on salmon habitat, and are a major factor in the health of these species’ populations. The assessment measured these values at the scale of the tax parcel – a challenge given the large disparity in the size of the parcels. For example, some larger parcels had smaller percentages of highly rated values, and some smaller parcels had less absolute value, but proportionately greater percentage of high value attributes. By using different metrics (absolute values and percentages), we attempted to find a composite metric for use in the evaluation phase.

The condition of uplands and headwaters are significant factors for maintaining high water quality. Riparian areas are key to maintaining suitably low water temperatures and providing sufficient woody debris. Accordingly, certain conservation value criteria address the characteristics of each parcel as a whole, while others address only the riparian areas within a given parcel, which we defined as that portion within 300’ of the stream channel (see FEMAT Report, 1994).

This section covers each conservation value addressed in the analysis, organized into two categories – those related to aquatic and riparian areas and those related to uplands. Within the discussion for each conservation value we cover our rationale for including each in the analysis, interpretation of the results and a discussion of the limitations of our approach, as well as a detailed description of the spatial analytical methods employed and citations for the source data. The maps associated with each conservation value provide an important portion of the character, but due to limitations on data or the quirks of parcel size, no one map gives a full picture. To adequately understand the situation in the basin, they need to be viewed together. That is done in Section 3 – Evaluation.

Reminder: These maps only display the subject resource on private lands. So, substantial amounts of these conservation values are on public lands, which are not shown on these maps.
CONSERVATION VALUES

INPUT VARIABLE - Salmonid Distribution and Use

The Skykomish River hosts, in some cases, multiple populations of Chinook, Coho, Pink, and Chum salmon, Steelhead, and bull trout, and coastal cutthroat. Habitat conditions vary widely – greatly affecting productivity of these populations. Under the assumption that reaches having a greater number of populations present represent higher benefit targets for conservation, a key element of this study was to identify parcels where one or more of these populations are present – with greater emphasis on those supporting a larger number of different populations, and where those populations are listed under the Endangered Species Act (ESA). This gives an indication of the importance of each parcel to salmonid populations as a whole. The Salmonid Population map shows relative presence of all populations combined, how each reach is used in the salmonid life cycle, and indicates whether those populations present are documented, presumed or potential, or exist due to active human intervention such as being transported across an existing fish passage barrier. Thus upper reaches of some streams are used by resident bull trout, but are not accessible by anadromous species.

The Salmonid Species map displays a dense network of salmonid bearing streams in the western portion of the watershed, mostly along the main rivers and tributaries in the foothills. Anadromous fish use is limited to main stem rivers and lower tributaries in the eastern portion due to high gradient streams on steep slopes.

Source Data

Statewide Washington Integrated Fish Distribution (SWIFD) database published by the Washington Department of Fish & Wildlife on January 10, 2013; Central Puget Sound Public, Tribal and Protected Lands Database (PLDB), ground condition of December 2013, maintained by Forterra.

SWIFD is presented as a linear feature class located along stream channel center lines based on Washington single-stream identifiers (LLID) that documents the distribution of anadromous and resident salmonids as well as various game fish.

The Central Puget Sound Public, Tribal and Protected Land Database (CPS-PLDB) is a vector polygon dataset that portrays the location, configuration, ownership, management and other characteristics of public lands and private protected lands in King, Kittitas, Pierce, and Snohomish Counties. The content is compiled from a variety of existing public data sources, including county tax parcels and municipal, county, state and federal agency datasets. The CPS-PLDB is maintained by Forterra to support conservation planning, management and reporting activities. The version of the database used in this analysis reflects the ground conditions as of December 31, 2013.

Methods

For the purpose of evaluating conservation values we were interested only in key native salmonid populations. SWIFD includes information on two game fish, Largemouth Bass and Rainbow Trout. We excluded these species from consideration, leaving us with records of the following populations:

- Coho
- Dolly Varden / Bull Trout
- Fall Chinook
- Fall Chum
- Pink Even Year
- Pink Odd Year
- Resident Coastal Cutthroat
- Summer Chinook
- Summer Steelhead
- Winter Steelhead

Several of these salmonid populations are currently listed under the Endangered Species Act (ESA), and parcels where these are present receive a greater emphasis with regard to this metric. These are:

- Fall Chinook
- Summer Chinook
- Summer Steelhead
- Winter Steelhead

To evaluate each candidate parcel relative to the salmonid populations present, we counted the number and ESA listing status of salmonid populations present within or adjacent to each candidate parcel. In most cases this was accomplished by overlaying the SWIFD data on the parcel data and assessing the populations present within the area of overlap.

Since many candidate parcel boundaries end at the edge of a river or stream channel, in many locations it was difficult or impossible to measure salmonid populations with any accuracy using a simple spatial overlay approach. As a partial solution in these instances, we converted the candidate parcel dataset to a raster format, retaining the Parcel ID field in the output raster table, used the Euclidean Allocation tool to extend those parcel boundaries until they met, and then used the Erase tool to remove all raster pixels that had “grown” into the spaces left by public or protected lands as represented in the CPS-PLDB dataset. We then converted the result of these steps to a polygon vector format based on Parcel ID, yielding an Edge-
Matched Parcel (EMP) dataset, and then repeated the overlay procedure using the EMP dataset. This technique, illustrated in the inset maps at right, closed the gap in parcel coverage representing a stream channel, and improved the accuracy of our scoring results.

There were additional locations where the boundaries of certain candidate parcels located along major rivers or streams did not intersect with any portion of the SWIFD stream centerline data, typically due to significant channel migration since the parcel boundaries were delineated by the counties. In these cases we invested a substantial amount of editing by hand in order to align the SWIFD line data with historic stream locations in order to assign accurate population measurements to each parcel using the overlay approach.

We assigned a Salmonid Population Score from one (1) to four (4) for each candidate parcel based on the number of salmonid populations present within or adjacent to that parcel according to the following value ranges:

- 4 = One or more listed populations present
- 3 = Three or more salmonid species present
- 2 = Two salmonid species present
- 1 = One salmonid species present

The Salmonid Population Score for each parcel is reported in the [Salmon_Spp_Score] field within the results geodatabase.
Salmonid Species

Distribution & Use Type
- Documented Presence
- Documented Spawning
- Documented Rearing
- Documented-Artificial, Presence
- Documented-Artificial, Spawning
- Documented-Artificial, Rearing
- Presumed Presence
- Transported Presence
- Transported Spawning
- Transported Rearing
- Potential: No Known Gradient Issues
- Major Barriers to Fish Passage

Skykomish Watershed
- Urban Growth Areas
- Highways
- Rivers
- Lakes

Major Barriers to Fish Passage

Map showing various locations such as Sultan, Gold Bar, Index, Skykomish, Monroe, Spada Lake, Roesiger Lake, and Chaplain Lake.

Text on the map includes:

- Sultan
- N. Fork Skykomish R.
- Wallace R.
- Wallace River
- N. Fork
- Skykomish R.
- Tye River
- Foss River
- Miller River
- West Fork Miller River
- S. Fork Skykomish River
- Beckler River
- W. Fork Woods Cr.
- Woods Creek
- Youngs Creek
- Proctor Creek
- Barr Cr.
- Olney Creek
- Gold Bar
- Index
- Monroe
- Stevens Pass
- Spada Lake
- Roesiger Lake
- Chaplain Lake

Salmonid Species

Documented Presence
Documented Spawning
Documented Rearing
Documented-Artificial, Presence
Documented-Artificial, Spawning
Documented-Artificial, Rearing
Presumed Presence
Transported Presence
Transported Spawning
Transported Rearing
Potential: No Known Gradient Issues
Major Barriers to Fish Passage
PARCEL ASSESSMENT - Salmonid Population

The Salmonid Population map shows the parcels within which these salmon populations occur. The geographical area matches the map, with smaller parcels in the Monroe/Sultan corridor and up the branches of Woods Creek. The Salmonid Population map shows a substantial amount of large parcels with salmonid presence, primarily timberland – such as Olney, Youngs and Proctor Creeks and Beckler/Tye Rivers.
Salmon Population Score

- 4 (One or more listed species present)
- 3 (Three or more salmonid species present)
- 2 (Two salmonid species present)
- 1 (One salmonid species present)
- 0 (No salmon species present)
CONSERVATION VALUES

PARCEL ASSESSMENT - Salmon Bearing Stream Length

The length of salmonid bearing streams on a given candidate parcel was used as an indicator of an important aspect of the relative value of that parcel to the health of the population(s) present. The qualities of the habitat are evaluated in other conservation value criteria.

The Salmonid Bearing Stream Length map is similar to the Salmonid Population map and shows a substantial amount of large parcels with significant length of salmonid streams, primarily on timberland, as these tend to have large parcels, and thus longer lengths of stream. These include Olney, Youngs and Proctor Creeks, and the Beckler/Tye Rivers. Woods Creek also has smaller parcels with significant stream lengths.

Source Data

Statewide Washington Integrated Fish Distribution (SWIFD) database published by the Washington Department of Fish & Wildlife on January 10, 2013; Edge-Matched Parcel (EMP) dataset created as part of the Salmonid Population metric above.

The SWIFD dataset is described in more detail in the Salmonid Population metric section, above.

The Edge-Matched Parcel dataset consists of candidate parcels that have been ‘grown’ so they cover any gaps between parcels representing water bodies, watercourses or transportation rights of way, excluding those gaps representing public or protected lands as documented in Forterra’s 2013 CPS-PLDB dataset. The creation of the EMP dataset is described in more detail in the section above concerning the Salmonid Population metric.

Methods

We defined and mapped salmonid-bearing streams within the SWIFD database as those supporting the presence of the same set of salmonid populations used for the Salmonid Population metric, described above. For this metric, however, no additional emphasis was placed on streams bearing ESA-listed populations.

To evaluate each candidate parcel relative to the spatial extent of salmonid-bearing streams on each parcel, we measured the length of such streams crossing or bordering each parcel. In most cases we accomplished this by intersecting the SWIFD stream centerline data with the EMP dataset, recalculating the stream length for each stream segment overlapping each candidate parcel represented in the EMP dataset, and then assigning the total stream length measurement as a tabular attribute to the corresponding candidate parcel.

As with the Salmonid Population metric, we faced situations where candidate parcels located along salmonid-bearing streams did not intersect with the SWIFD stream centerline data due either to stream channel migration or parcel boundaries ending at the stream bank. In these cases we improved the accuracy of our stream length measurements by using the EMP dataset for which parcel boundaries had been extended into stream channels and by hand editing SWIFD stream lines to align with historic channel locations.

We assigned a Salmonid Bearing Stream Length Score from one (1) to four (4) for each candidate parcel based on the length in feet of salmonid bearing rivers and streams present within or adjacent to that parcel according to the following value ranges:

- 4 = More than 100 feet
- 3 = 40.1 - 100 feet
- 2 = 20.1 - 40 feet
- 1 = 0.1 - 20 feet
- 0 = No salmonid bearing rivers or streams

The Salmonid Bearing Stream Length Score for each parcel is reported in the [Salmon_Strm_Score] field within the results geodatabase.
Salmon Stream Length Score
(Length in Feet)
- 4 (More than 100)
- 3 (40.1 - 100)
- 2 (20.1 - 40)
- 1 (0.1 - 20)
- 0 (0)
**CONSERVATION VALUES**

**INPUT VARIABLE - Floodplain**

Floodplains are a significant factor contributing to natural hydrologic function. Natural processes such as the long-term meandering of rivers and streams within their floodplain and the overflow of water from stream channel into the adjacent floodplain help form and sustain salmon habitat. Maintaining natural conditions, free of development and infrastructure, will allow these essential processes to continue. Even in reaches without active salmon use, the protection of these watershed features will contribute to maintaining high water quality and to avoid impacts downstream from artificially constrained streams. Therefore, we used the acreage of floodplain within a given candidate parcel as a measure of conservation value, with a greater amount of floodplain indicating a greater conservation value.

**Source Data**

Q3 flood data for Snohomish County, published by the Federal Emergency Management Agency on September 16, 2005; Revised Preliminary Digital Flood Insurance Rate Map (DFIRM) flood data for King County, created by the Federal Emergency Management Agency in collaboration with King County and published on July 16, 2010.

Q3 flood data products are geospatial representations of certain features contained within historic paper Flood insurance Rate Maps and include, among other information, estimations of 100-year floodplain (known as Special Flood Hazard Areas or SFHAs) and 500-year floodplain. Q3s were developed to support insurance-related activities and are designed to provide guidance and a general proximity of the location of SFHAs. They cannot be used to determine absolute delineations of floodplain boundaries, but instead should be seen as portraying zones of uncertainty and possible risks associated with flooding.

As a primary outcome of FEMA's Map Modernization program, begun in 2003, DFIRM flood data replaces the previous Q3 data. Where available, DFIRM data provides a more comprehensive picture of flood risk by including more recent information and floodplain boundaries are mapped with considerably greater accuracy and precision.

**Methods**

In order to evaluate each candidate parcel relative to the area of floodplain located within its boundaries we extracted the 100-year (SFHA) floodplain areas mapped as polygon features from both the Q3 and DFIRM datasets, and intersected those floodplain areas with the parcel boundary data. We then recalculated the floodplain area acreage within each parcel and assigned that acreage measurement as a tabular attribute to the corresponding parcel.

During the course of reviewing the data we noticed a significant discrepancy in the spatial extent of the mapped floodplain along the Skykomish River between the King County DFIRM and Snohomish County Q3 data. As illustrated on the inset maps at right, the Snohomish County portion of the floodplain was mapped to be considerably narrower than the portion of the floodplain in King County. We confirmed the absence of any major alteration to the topography in Snohomish County that would constrain the floodplain so drastically and, with guidance from King County, used a combination of LiDAR-derived slope, aspect, and height-above-river data to estimate the likely continuation of the King County floodplain north into Snohomish County. We used this corrected floodplain data for all subsequent measurements involving floodplain boundary data.

We assigned a Floodplain Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of floodplain located on that parcel according to the following value ranges:

- 4 = More than 50 acres
- 3 = 25.1 - 50 acres
- 2 = 5.1 - 25 acres
- 1 = 0.1 - 5 acres
- 0 = No floodplain

The Floodplain Acreage Score for each parcel is reported in the [Floodplain_Score] field within the results geodatabase.
The original Snohomish County Q3 Floodplain boundary is significantly narrower than the corresponding King County DFIREM Floodplain boundary to the south.

The amended floodplain, shown in light orange.
PARCEL ASSESSMENT - Floodplain Acreage

There is substantial floodplain adjacent to the main stem downstream of Gold Bar (including lower Wallace River). In the reach of the South Fork Skykomish between Baring and Skykomish, the floodplain is more limited. Additional narrower sections of floodplains are found along the lower North Fork Skykomish and Sultan Rivers.

As shown on the Floodplain Acreage map, the higher value parcels tend to be smaller and many are in agricultural use. (See Land Cover Classification map.)
**Conservation Values**

**Input Variable - Low-Lying Relative to Channel**

Floodplain areas below flood elevation are especially valuable in that they have a high likelihood of including both active and historic side channels, both of which provide important spawning or rearing habitat for salmonid. Also, a change of stream course could convert these low-lying areas into the main channel once again. Long-term management of hydrology needs to allow these natural changes to occur to provide the best conditions for robust salmonid populations. We therefore included the amount of low-lying floodplain within candidate parcels, measured in acres, as a conservation value criterion for this analysis.

The ideal metric to represent this conservation value would involve assigning a high score to those areas of the floodplain lying below the base flood elevation (BFE) of the river. Given that BFE data was unavailable for the Skykomish Basin at the time of our analysis, we instead chose elevation in relation to the river channel as a proxy, placing a higher score on “low-lying” portions of the floodplain, which we defined as those that had an elevation of five feet above the main stream channel, or lower, at the time the LiDAR elevation data was collected.

**Source Data**

Q3 flood data for Snohomish County, published by the Federal Emergency Management Agency on September 16, 2005, as revised for this analysis as described in the Floodplain Acreage section above; Revised Preliminary Digital Flood Insurance Rate Map (DFIRM) flood data for King County, created by the Federal Emergency Management Agency in collaboration with King County and published on July 16, 2010; Multiple LiDAR data sets, all at a horizontal resolution of one meter, acquired from the Puget Sound LiDAR Consortium:

- Snohomish County, 2005-2006
- North Fork Skykomish, 2007
- Tulalip Tribes, 2013
- King County, 2002 and 2003

The Q3 and DFIRM flood data used for this analysis are described in more detail in the section above concerning the Floodplain Acreage metric.

LiDAR is a remote sensing technology that employs an airborne laser combined with a Geographic Positioning System (GPS) to survey the elevation of the earth surface with a high degree of precision and accuracy. The technology measures the distance from the aircraft to the ground by illuminating the surface with a laser and measuring the distance traveled by the laser light reflected off surface features. By collecting millions of these measurements as the aircraft flies in a regular pattern across the landscape, and combining each individual distance measurement with the exact location of the aircraft at the time of that measurement using GPS, the technology produces a continuous surface coverage across the entire area of the survey.

LiDAR surveys provide two raster products used in this analysis: a “bare earth” surface, which represents the elevation of the ground underlying any surface features such as vegetation or structures, and a “first return” surface, which represents the elevation of the surface features. We mosaicked the various “bare earth” datasets to create a basin-wide, high resolution Digital Ground Model (DGM) for use in this and other portions of our analysis. We also mosaicked the various “first-return” datasets to create a high resolution Digital Surface Model (DSM) for the basin, which was used in other portions of this analysis.

**Methods**

Evaluating each candidate parcel based on the area of low-lying floodplain within its boundaries required a number of steps in preparation.

Given that we defined low-lying floodplain areas based on ground elevation relative to river channel elevation, our first requirement was to develop a digital elevation model for the surface of the river channel throughout the floodplain areas within the basin. To do this we first digitized a line down the center of the main stream channel of each floodplain area as it existed at the time the LiDAR data was collected and determined the elevation of the water surface along the stream channel centerlines. In some areas along the stream channel we found irregularities within the LiDAR DGM, such that small portions of what should be open stream channel showed anomalous high or low spots. In those locations we routed the digitized line around those anomalies.

We converted the channel centerline vector dataset to a raster dataset using the same resolution and X, Y origin as the LiDAR DGM raster dataset, such that raster pixels along the channel centerline were coded “1,” and all other pixels within the basin were coded “0.” We used the Raster Calculator tool to multiply the stream channel raster by the DGM raster, resulting in a channel centerline elevation raster that contained elevation values only along the channel centerline. We then extrapolated the channel elevation values to all areas within the floodplain using the Euclidean Allocation tool, which created a river elevation raster surface with every pixel assigned the height of the nearest channel centerline.
Our next step was to determine the elevation of the floodplain areas beyond the main stream channel relative to the elevation of the channel itself. We extracted the ground elevation within the boundaries of the floodplain from the DGM raster dataset, and then subtracted the river elevation raster from the floodplain ground elevation raster, yielding a "river-neutral" elevation raster that documents the relative elevation of the ground above or below the nearest channel.

To evaluate each candidate parcel relative to the area of low-lying floodplain within its boundaries, we used Raster Calculator to extract from our river-neutral elevation raster all areas having an elevation five feet above the nearest stream channel, or lower. We used the Raster to Feature tool to convert this raster extract to a vector format and intersected this low-lying area vector data with the candidate parcel boundary data. We then recalculated the low-lying area acreage within each candidate parcel and assigned that acreage measurement as a tabular attribute to the corresponding parcel.

We assigned a Low-Lying Floodplain Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of low-lying floodplain located on that parcel according to the following value ranges:

- 4 = More than 15 acres
- 3 = 5.1 - 15 acres
- 2 = 3.1 - 5 acres
- 1 = 0.1 - 3 acres
- 0 = No low-lying areas

The Low-Lying Floodplain Acreage Score for each parcel is reported in the [Low_elv_Score] field within the results geodatabase.
PARCEL ASSESSMENT - Low-Lying Floodplain Acreage

The extent of low-lying floodplain is similar to floodplain but more limited in extent, with most of the lower areas along the main stem below Gold Bar. Concentrations of lowest areas are near Monroe, Woods Creek, and between Sultan and Gold Bar, including the lower Wallace River. Again, these tend to occur on smaller parcels, reflecting historic homesteading and agricultural use.
CONSERVATION VALUES

INPUT VARIABLE - Upland Wetlands

Wetlands serve a number of natural functions critical to maintaining the natural hydrological function within a watershed to which salmonid populations are well adapted. Wetlands absorb and detain a volume of surface water runoff during rain events and slowly release it back into the system over time, ameliorating scouring and channelizing effects of high stream volumes and velocities on downstream reaches. Wetlands also absorb sediment present in runoff, keeping it from stream channels where it has a deleterious effect on salmonid survival.

For this analysis, we measured the amount of upland wetland area, in acres, on each candidate parcel, placing a higher conservation value on parcels supporting a greater wetland area. We considered only wetlands outside the floodplain for this criterion because floodplain wetlands tend to cover the lowest-lying ground, and we already captured the conservation value of those areas with our Low-Lying Floodplain Acreage metric in the Riparian Conservation Values section of this analysis.

Source Data

National Wetlands Inventory (NWI) maintained by the U.S. Fish and Wildlife Service, published May 22, 2008; Snohomish County Local Wetlands Inventory, published by Snohomish County on an unknown date and acquired for this project in March 2009; Q3 flood data for Snohomish County, published by the Federal Emergency Management Agency on September 16, 2005, as revised for this analysis as described in the Floodplain Acreage section above; Revised Preliminary Digital Flood Insurance Rate Map (DFIRM) flood data for King County, created by the Federal Emergency Management Agency in collaboration with King County and published on July 16, 2010.

The National Wetlands Inventory is a nationwide spatial database containing information on the location, configuration and extent as well as the physical, hydrological and biological characteristics of more than 45 million acres of wetlands and deepwater habitats across portions of the lower 48 states, as well as Alaska and Hawaii.

The Snohomish County wetlands dataset is a local wetlands inventory covering only developed and developing portions of the county, and which portrays the extent of mapped wetlands as vector polygons.

The Q3 and DFIRM flood data used for this analysis are described in more detail in the section above concerning the Floodplain Acreage metric.

Methods

For the purpose of this metric we included all wetland and deepwater polygon features within both the NWI and the Snohomish County datasets, and refer to them collectively as “wet area(s).”

To evaluate each candidate parcel relative to the area of upland wetlands within its boundaries, we first used the Merge tool to compile all polygons from the NWI and Snohomish County datasets into a single coverage, used the Dissolve tool to combine all features into a single feature, and then used the Erase tool to remove all wet areas, or portions thereof, located within the floodplains as delineated in the modified Snohomish County Q3 and the King County DFIRM datasets.

We then used the Intersect tool to extract the extent of all wet areas located within each candidate parcel, recalculated the wet area acreage within each parcel, and assigned that acreage to the corresponding parcel.

We assigned an Upland Wetland Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of upland wet areas located on that parcel according to the following value ranges:

- 4 = More than 25 acres
- 3 = 8.1 - 25 acres
- 2 = 2.1 - 8 acres
- 1 = 0.1 - 2 acres
- 0 = No upland wetlands

The Upland Wetland Acreage Score for each parcel is reported in the [Wetland_NonFlood_Score] field within the results geodatabase.
PARCEL ASSESSMENT - Upland Wetland Acreage

Significant upland wetlands occur in the watersheds of Woods and Youngs Creek, upper Proctor Creek, and northeast of the town of Sultan in the Bear and Olney Creek watersheds, plus high elevation wetlands on Windy Ridge (Tye River watershed).
The eastern portion of the watershed is predominantly evergreen forests, with deciduous and mixed forest along rivers, interspersed with medium density development. Higher development densities are confined to the towns of Index and Skykomish. The western portion has foothills with large areas of evergreen and mixed species forest, with agricultural, rural residential interspersed in areas near public roads, streams and lakes. Higher density development is concentrated in the towns of Monroe, Sultan, Startup and Gold Bar.

**Source Data**

2013 (summer) four-band aerial ortho photography at 1-meter horizontal resolution published by the U.S. Department of Agriculture (USDA) National Agricultural Imagery Program (NAIP); Multiple LiDAR data sets, all at a horizontal resolution of one meter, acquired from the Puget Sound LiDAR Consortium:

- Snohomish County, 2005-2006
- North Fork Skykomish, 2007
- Tulalip Tribes, 2013
- King County, 2002 and 2003

The LiDAR data used in this analysis is described in more detail in the section above concerning the Low-Lying Floodplain Acreage metric.

NAIP acquires aerial imagery during the agricultural growing seasons in the continental United States. A primary goal of the NAIP program is to make digital ortho photography available to governmental agencies and the public within a year of acquisition. NAIP is administered by the USDA’s Farm Service Agency (FSA) through the Aerial Photography Field Office in Salt Lake City. This “leaf-on” imagery is used as a base layer for GIS programs in FSA’s County Service Centers and is distributed freely to all interested parties.

NAIP imagery is acquired at a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within six meters of photo-identifiable ground control points, which are used during image inspection. The default spectral resolution is natural color (Red, Green and Blue, or RGB) but beginning in 2007, data for Washington State have been delivered with four bands of data: RGB and Near Infrared.

NAIP imagery products are available as digital ortho quarter quad tiles (DOQQs) in which each individual image tile within the mosaic covers a 3.75 x 3.75 minute quarter quadrangle plus a 300-meter buffer on all four sides. The DOQQs are provided in GeoTIFF format.

**Methods**

In order to identify and measure areas of forest cover within the Basin, we first needed to perform a Guided Classification of the most recently available four-band ortho photography data for the region. The product of a Guided Classification is a categorical raster dataset representing land cover, or the physical material covering the earth surface. A land cover dataset provides an unbroken coverage of the landscape representing different cover types, such as agricultural, forest, wetland, and man-made hardscape, or impervious surface, such as pavement or structures.

We extracted four bands from the individual NAIP tiles and created a mosaic for each band, Red, Green, Blue, and Near Infrared (Near IR). We created a Normalized Difference Vegetation Index (NDVI) using the Red and Near IR bands as follows:

\[
NDVI = \frac{\text{Near IR} - \text{Red}}{\text{Near IR} + \text{Red}}
\]

We created two texture layers for Green and Near IR, using the Focal Mean tool with a 7x7 moving window for the RANGE variable. These two layers were averaged to produce a single texture layer:

\[
texture_v1 = \frac{\text{Band2Rng7x7} + \text{Band4Rng7x7}}{2}
\]

We digitized 96 training polygons across 10 land cover classes as follows:

- Medium density development 16
- Deciduous 13
- Grass 10
- Water 10
- Bare Ground 9
- Mature Evergreen Forest 9
- Medium Evergreen Forest 8
- Shadow 8
- Shrubs & Small Trees 7
- High Density Development 6
- Sand Bars 6

With these training polygons we used the Create Signatures tool in conjunction with the six bands described above – Red, Green, Blue, Near IR, NDVI, and Texture – to generate a spectral signature file for the training polygons. We used the resulting
signature file with the Maximum Likelihood tool to generate the land cover classification dataset.

We detected class confusion in two areas: some portions of the river corridors that contain rocks and sand bars were misclassified as high density development, and numerous timber clear-cuts were misclassified as medium density development. We re-ran the classification for the river corridors alone, without high-density development training polygons, and swapped out the corrected river corridor data into the larger raster. We manually digitized clear-cut boundaries from the true color ortho photograph to correct the class confusion, and replaced the misclassified areas.

We used the Zonal Statistics tool to measure the percentage of each land cover class, as represented in the final land cover raster, within each candidate parcel in the Basin. By adding the percentages of all forested classes (Mature Evergreen Forest, Medium Evergreen Forest, Deciduous, Shrubs and Small Trees) occurring within each parcel and multiplying that sum by the acreage of the corresponding parcel we calculated the total acreage of forest cover within each parcel.

We assigned a Forest Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of forest located within that parcel according to the following value ranges:

4 = More than 80 acres  
3 = 20.1 - 80 acres  
2 = 5.1 - 20 acres  
1 = 0.1 - 5 acres  
0 = No forest

The Forest Acreage Score for each parcel is reported in the [Forest_Score] field within the results geodatabase.
CONSERVATION VALUES

PARCEL ASSESSMENT - Forest Acreage

Mature forest provides significant benefits to water quality and hydrology – in terms of limiting soil erosion that can deliver harmful sediment loads into stream channels and providing water storage through rainfall interception and absorption that decreases runoff volume into stream channels. Additionally, forest cover throughout the headwaters of the Basin, located predominantly at higher elevations, shade the winter snowpack and delays melting until later in the season, contributing to critical summer flows. They also provide substantial ecological values in the form of habitat for both terrestrial and aquatic species such as salamanders. Trees also provide the large woody debris in streams that is an essential element of salmon habitat, and this factor is addressed directly in the Riparian Forest and Riparian Tall Tree metrics.

To evaluate the significance of forest cover in this study, we considered total acreage of forest cover on each candidate parcel, placing a higher conservation value on parcels with a larger acreage of forest cover.

There are large blocks with large parcels that have substantial forests. These are located in Windy Ridge/Martin Creek, Eagle Creek/Becker River, Tye/Foss, Proctor, Youngs, Barr, Olney and Bear Creeks, and upper Wallace River. Most of these large blocks of forested land are managed by large timber companies. Smaller forested parcels are located in Woods Creek and Upper Williamson Creek.
**Conservation Values**

**Input Variable - 300’ Buffer on Perennial Streams**

The 300’ buffer on either side of perennial streams was adopted from the Forest Ecosystem Management Assessment Team Report (FEMAT) of 1994. This metric gives a reasonable guide to riparian and upland habitats that have significant effects on the hydrology of the basin.

**Source Data**

2013 (summer) four-band aerial ortho photography at 1-meter horizontal resolution published by the U.S. Department of Agriculture (USDA) National Agricultural Imagery Program (NAIP); Land Cover Classification derived from 2013 NAIP ortho photography as described in the Forest Acreage metric section above; Washington State Watercourse Hydrography (WCHYDRO) dataset published by the Washington Department of Natural Resources on 2011.

The 2013 NAIP ortho photography data, as well as the Land Cover Classification derived from it, are described in more detail in the section above concerning the Forested Acreage metric.

WCHYDRO, in combination with its polygon feature counterpart, the Waterbody Hydrography dataset (WBHYDRO), together comprise the most complete and up to date spatial hydrography information for the State of Washington. WCHYDRO represents stream center lines as arcs or lines. These occur alone as single arc watercourses representing streams, ditches, or pipelines, or as centerlines through water body polygons such as double-banked streams, lakes, impoundments, reservoirs, wet areas, or glaciers. Both datasets are edited daily and simultaneously, and updates are posted weekly for internal DNR use and monthly for public distribution. The primary purpose of these data is to aid in the application of timber harvest and other forest practices regulations and activities by the Washington State Department of Natural Resources (DNR) within the forested areas of the state. Other uses include cartography and analysis where hydrographic data is required.

**Methods**

Our first step in addressing this metric was to map the riparian area within which to measure the amount of forest cover, which we defined as the land area within 300 feet of the shoreline of a perennial stream.

Within the WCHYDRO dataset, perennial streams are identified within the [FP_PERIOD_CD] attribute field by the class code “p.” We performed a tabular query to identify those line features and then extracted them as a temporary dataset to represent single-line stream banks. For those rivers having a greater channel width – those with a visible channel width at scale of 1:3,000, which included mostly the main-stem of the Skykomish River and the main forks of major tributaries – we digitized the location of both banks by hand using the 2013 NAIP Orthophotography as a visual reference to create a separate, temporary polygon dataset representing double-line stream banks.

To map the riparian area we then ran two separate processes using the Buffer tool and a width of 300 feet, one on the line dataset representing the banks of narrower streams as a single line, and another one on the polygon dataset representing the banks of larger rivers. We combined the datasets resulting from both buffer processes using the Union tool, and then used the Dissolve tool to combine all buffer polygons to produce a final dataset to represent the riparian area as a single feature within which we would measure the amount of forest cover for this metric. A sample of the riparian areas data is illustrated in the inset map at right.

To measure the amount of forest cover within the riparian area, we first used the Raster Calculator to extract the area covered by all three forest classes (Medium Evergreen Forest, Mature Evergreen Forest, and Deciduous) from the land cover classification created for our Forest Acreage metric into a new forest cover raster dataset. We then converted the riparian area polygon dataset to a raster format using the same resolution and X, Y origin as the forest raster cover dataset.

Both the forest cover and the riparian area raster datasets are binary in nature, such that pixels representing the locations of the subject features are attributed with a value of “1,” and pixels representing all other portions of the data extent are attributed with a value of “0.” In order to identify locations within the riparian areas that contain forest cover, we simply multiplied the two raster datasets together using the Raster Calculator tool, resulting in a riparian forest cover raster. We then used the Tabulate Areas tool to measure the amount of forest cover in acres within the riparian area of each candidate parcel.

We assigned a Riparian Forest Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of forest cover located within the riparian area of that parcel according to the following value ranges:

- 4 = More than 80 acres
- 3 = 20.1 - 80 acres
- 2 = 5.1 - 20 acres
- 1 = 0.1 - 5 acres
- 0 = No forest

The Riparian Forest Acreage Score for each parcel is reported in the [For_Buff_Score] field within the results geodatabase.
Close up of 300' buffer (orange) on digitized river channel (light blue) and DNR Hydro layer (dark blue)
CONSERVATION VALUES

PARCEL ASSESSMENT - Riparian Forest Acreage

Riparian forest – forest located in close proximity to stream channels – is particularly important for water quality and salmon habitat due to the shade, bank stability and woody debris they introduce into the system. These benefits to water quality also accrue from reaches above where salmon are present. For the purposes of this study we defined riparian forest as that forest cover within 300 feet of perennial stream banks (see recommendations in FEMAT Report, 1994).

To address this conservation value we measured the amount, in acres, of riparian forest cover on each candidate parcel, assigning a higher value to parcels supporting a greater amount of riparian forest cover.

The results are similar to Forested Acreage, indicating a dense network of streams in the forested parcels. This may reflect the forest practices rules requiring leaving of trees in the stream buffer, though not as wide as the FEMAT recommendation.
Forest Buffer Score
(Areas of Forest within 300’ Buffer)

- 4 (More than 25)
- 3 (5.1 - 25)
- 2 (1.1 - 5)
- 1 (0.1 - 1)
- 0 (No forested buffer)
To measure the riparian area covered by tall tree canopy within each candidate parcel, we first converted the riparian tall tree raster to vector format. Using the Intersect tool we extracted the area of tall tree vector coverage from within the boundary of each candidate parcel and then used the Dissolve tool to combine all tall tree vector polygons within the boundary of each candidate parcel into a single feature for each parcel. Using the Field Calculator we calculated the total acreage of tall tree coverage within each candidate parcel. We then performed a Tabular Join between the candidate parcel dataset and the tall tree vector dataset using parcel ID as the join field to transfer the measurements of riparian tall tree acreage per parcel to the candidate parcel dataset.

We assigned a Riparian Tall Tree Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage dominated by trees 90' in height or taller located within the riparian area of that parcel according to the following value ranges:

4 = More than 10 acres
3 = 3.1 - 10 acres
2 = 1.1 - 3 acres
1 = 0.1 - 1 acres
0 = No 90'+ trees

The Riparian Tall Tree Acreage Score for each parcel is reported in the [For_100plus_Score] field within the results geodatabase.

Conservation Values

Input Variable - Forest Height

Tall trees are indicative of late successional stage – either they were never cut, or not likely to have been cut in over 50 years – and thus, re-establishing a predominantly natural condition. While tree height is affected by more than age, such as soil fertility and elevation, it is a good proxy for natural or substantially recovered forest conditions. The taller trees also provide shade for streams, wetlands and snowpack. We used 90' trees to represent taller and older trees.

The Forest Height map, shows several areas with concentrations of tall trees on the landscape: the South Fork Skykomish River; Windy Ridge/Tye River; Foss River; Beckler River, Maloney Creek, near Baring; Lake Serene; the North Fork Skykomish River near Galena; Wallace River; Olney, Youngs & McCoy Creeks; and Williamson Creek (Sultan Basin).

Source Data

Riparian forest cover raster dataset created for the Riparian Forest Acreage metric as described in more detail above; Digital Ground Model (DGM) and Digital Surface Model (DSM) datasets derived from various LiDAR datasets for the Low-Lying Floodplain Acreage metric as described in more detail above.

Methods

In order to measure the acreage of riparian area containing tall trees, we used an approach similar to that described above for the Riparian Forest Acreage metric, but instead limited the forest being measured to that covered by tree canopy with a height of 90 feet or more.

We first used the Raster Calculator to subtract the elevation measurements within the DGM raster from those within the DSM raster, yielding a raster surface representing the height of vegetation, in feet. In configuring this raster calculation we set the Processing Extent within the Environment Settings to the geographic extent of the riparian forest cover raster, created during the Riparian Forest Acreage metric analysis described above, in order to limit the extent of the vegetation height raster to the riparian area forest cover. We then used the Raster Calculator tool again to identify all areas of riparian forest with a height-above-ground of 90 feet or taller, yielding a riparian tall tree raster dataset.
PARCEL ASSESSMENT - Riparian Tall Tree Acreage

Taller trees are indicative of older trees and relatively undisturbed landscapes, as forests managed for timber generally undergo rotation cycles less than 80 years and often less than 50 years. Located in riparian areas, these older forest areas provide the highest degree of shading needed to maintain the cooler summer stream channel temperatures essential to salmonid survival, and are a source of very large woody debris that is important to anchoring – downstream morphology and providing stream complexity.

To evaluate the amount of older forest within the riparian areas of our study, we used tree height as a proxy for forest age, with a height of 90 feet or taller as a proxy for late-successional forest. To address this criterion, which highlights candidate parcels with very high ecological value, we measured the amount of riparian area supporting tall trees, in acres, on each candidate parcel, assigning a higher value to parcel supporting a larger amount of riparian tall trees.

A closer focus on higher scored parcels would include an in-depth evaluation of the timber.

Note: Tall trees may have been cut after the map data was developed (2013). Current aerial photography indicates recent logging in areas that show on the map as having significant areas of larger trees, such as Anthracite Creek and Beckler River near Skykomish; and north of Highway 2 north east of Baring; and in the Olney Creek watershed.

The Riparian Tall Tree Acreage map shows parcels with significant tall trees within the riparian zone: South Fork Skykomish River; Windy Ridge/Tye River; Foss River; Beckler River/Eagle Creek; Maloney Creek, near Baring; Lake Serene; the North Fork Skykomish River near Galena; Main stem - Wallace River and Olney Creek, Proctor Creek; Youngs & McCoy Creeks; and Williamson Creek (Sultan Basin).
### Forest 90+ Buffer Score

- **Tree Score**
  - 4 (More than 10)
  - 3 (3.1 - 10)
  - 2 (1.1 - 10)
  - 1 (0.1 - 1)
  - 0 (No 90'+ trees)

- **Map Legend**
  - Skykomish Watershed
  - Urban Growth Areas
  - Highways
  - Rivers
  - Lakes

- **Location Markers**
  - Monroe
  - Sultan
  - Gold Bar
  - Index
  - Skykomish
  - Stevens Pass

- **距離**

- **Map Scale**
  - 0 1 2 4 Miles

---

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CONSERVATION VALUES

PARCEL ASSESSMENT - Pervious Surface Acreage

Impervious surfaces have significant impacts on hydrology and, as a result, the quality of salmon habitat. Surfaces such as pavement or building roofs are not pervious to water. Rain falling on these surfaces, rather than infiltrating into ground water, will run off and increase the volume and velocity of water entering nearby stream channels. Increased runoff volume brings with it a higher load of sediments and other pollutants harmful to salmon. Greater volumes of water running into streams increases channel velocities, often producing flashy flows, which can scour stream channels of substrates that fish rely on as habitat. Depending on amount of pervious surface, King County studies show that more than 10% impervious surface can alter stream health (Perry Falcone, 2015).

This study identifies the amount of impervious surface, in acres, located on all candidate parcels and places a higher conservation value on those having a smaller amount of impervious surface.

The higher scoring parcels are similar to the forest cover and floodplain maps, with varied pervious surface in rural areas.

Source Data

Land Cover Classification derived from 2013 NAIP Orthophotography as described in more detail in the section above concerning the Forested Acreage metric.

Methods

To measure the amount of pervious surface on each candidate parcel we first extracted all pervious cover classes from the land cover classification raster dataset, created for the Forest Acreage metric described in more detail above, to a new pervious surface raster. For the purposes of this analysis we assumed that all cover classes with the exception of High Density Development and Medium Density Development represented 100% pervious surfaces. Using the Zonal Statistics tool we then calculated the acreage of all pervious surface cover classes located within each candidate parcel, and reported that acreage measurement as a tabular attribute for each parcel.

We assigned a Pervious Surface Acreage Score from one (1) to four (4) for each candidate parcel based on the acreage of pervious surfaces located on that parcel according to the following value ranges:

- 4 = More than 160 acres
- 3 = 40.1 - 160 acres
- 2 = 10.1 - 40 acres
- 1 = 0.1 - 10 acres
- 0 = No pervious land cover

The Pervious Surface Acreage Score for each parcel is reported in the [Pervious Score] field within the results geodatabase.
Pervious Surface Score
(Acres of Pervious Landcover)

- 4 (More than 160)
- 3 (40.1 - 160)
- 2 (10.1 - 40)
- 1 (0.1 - 10)
- 0 (No pervious landcover)

Skykomish Watershed

Urban Growth Areas

Highways

Rivers

Lakes
CONSERVATION VALUES: RESULTS & EVALUATION

Our evaluation combines the scores for each individual conservation value criterion, listed below, into a composite index from 1 to 4.

- Salmonid Population
- Salmonid Bearing Stream Length
- Floodplain Acreage
- Low Lying Floodplain Acreage
- Upland Wetland Acreage
- Forest Acreage
- Riparian Forest Acreage
- Riparian Tall Tree Acreage
- Pervious Surface Acreage

Combining these individual scores gives an indication of overall health of the resources on a parcel basis.
The un-weighted assessment combines the scores for individual conservation value criteria into a composite index via simple addition. While simple and straightforward, this approach omits from consideration any difference in the relative importance of one conservation value over all others. In other words, this approach treats each value as being equally significant, with no one value more important than any other. This issue of the relative significance between different conservation values is addressed in the Weighted Conservation Value Assessment, below.

The un-weighted conservation scores highlight certain areas with high values for conserving hydrologic function and salmon habitat. The main stem Skykomish from Woods Creek to Wallace River has high conservation values (3 & 4) due to importance of this main course for all salmon species, the interconnected side channels and lower ends of tributary streams. Tributaries to the main stem with substantial high values are Olney, Barr, upper Woods, Youngs, McCoy, lower Proctor Creeks, and lower reaches of the Sultan and Wallace Rivers. Also, small pockets occur along the North Fork Skykomish River. These are used by most salmon species up to impassable natural barriers.

Above Sunset Falls, major concentrations of high values with salmon present are found near the towns of Skykomish and Baring and in the lower reaches of the Beckler, Tye, and Miller Rivers. In addition, high conservation values are found in uplands near the Tye River (Windy Ridge), Maloney Creek, Money Creek, and upper Wallace River.

**Methods**

In order to derive an un-weighted assessment of all candidate parcels based on the combination of all conservation value metrics we added the scores for all nine variables together and divided by nine. This was calculated as follows:

\[
\frac{(\text{Salmon Spp Score} + \text{Salmon Strm Score} + \text{Floodplain Score} + \text{Wetland NonFlood Score} + \text{Low elv Score} + \text{Forested Score} + \text{For Buff Score} + \text{For 100plus Score} + \text{Pervious score})}{9}
\]

The result of this calculation is stored in the field [Cons Unweighted] within the results geodatabase as a floating point number. For the sake of consistency and simplicity we created integer versions of the composite un-weighted scores for each parcel and assigned values in the [ConsUnWt_INT] field as follows:

<table>
<thead>
<tr>
<th>Original Score</th>
<th>Integer Score</th>
<th># Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1</td>
<td>12,346</td>
</tr>
<tr>
<td>1.1 - 2</td>
<td>2</td>
<td>2,123</td>
</tr>
<tr>
<td>2.1 - 3</td>
<td>3</td>
<td>216</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>
UN-WEIGHTED CONSERVATION VALUE ASSESSMENT

Unweighted Conservation Score
Composite of 9 Variables

- 4
- 3
- 2
- 1

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes

0 1 2 4 Miles
The weighted version of this assessment adjusts those scores, based on our professional judgment, to better describe the relative importance of each variable to the overall conservation value of each parcel. This is accomplished by selecting a multiplication factor to apply to each individual conservation value score. The weights chosen for this study, listed below, are intended to emphasize the importance of salmon habitat and mature riparian trees. They are illustrative, not definitive, and can easily be changed so a new weighted assessment value can be calculated. Weights must sum to a total of 1.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonid Population</td>
<td>0.20</td>
</tr>
<tr>
<td>Salmonid Bearing Stream Length</td>
<td>0.10</td>
</tr>
<tr>
<td>Floodplain Acreage</td>
<td>0.10</td>
</tr>
<tr>
<td>Low Lying Floodplain Acreage</td>
<td>0.05</td>
</tr>
<tr>
<td>Upland Wetland Acreage</td>
<td>0.05</td>
</tr>
<tr>
<td>Forest Acreage</td>
<td>0.10</td>
</tr>
<tr>
<td>Riparian Forest Acreage</td>
<td>0.15</td>
</tr>
<tr>
<td>Riparian Tall Tree Acreage</td>
<td>0.20</td>
</tr>
<tr>
<td>Pervious Surface Acreage</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Again, GIS users working directly with our results data can adjust this weighting system to place a different emphasis on different variables. A similar process was performed on the threat values. Then these weighted values were cross-checked to build a matrix.

The weighted version gives added emphasis to the areas highlighted in the unweighted assessment discussion (above) plus additional upland areas in upper Tye River, Maloney Creek, Miller River, and upper Wallace River.

Methods

In order to derive a weighted assessment of all candidate parcels based on the combination of all conservation value metrics we multiplied the scores for all nine variables by the multiplication factor listed above and then added the nine products. This was calculated as follows:

\[(\text{Salmon}_Spp\_Score \times 0.20) + (\text{Salmon}_Strm\_Score \times 0.10) + (\text{Floodplain}\_Score \times 0.10) + (\text{Wetland}\_\text{NonFlood}\_Score \times 0.05) + (\text{Low}_{elv}\_Score \times 0.05) + (\text{Forested}\_\text{Score} \times 0.10) + (\text{For}_{\text{Buff}}\_\text{Score} \times 0.15) + (\text{For}_{100plus}\_\text{Score} \times 0.20) + (\text{Pervious}\_\text{score} \times 0.05)\]

The result of this calculation is stored in the field [Cons\_Weighted] within the results geodatabase as a floating point number. For the sake of consistency and simplicity we created integer versions of the composite weighted scores for each parcel and assigned values in the [ConsWt\_INT] field as follows:

<table>
<thead>
<tr>
<th>Original Score</th>
<th>Integer Score</th>
<th># Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1</td>
<td>11,340</td>
</tr>
<tr>
<td>1.1 - 2</td>
<td>2</td>
<td>2,877</td>
</tr>
<tr>
<td>2.1 - 3</td>
<td>3</td>
<td>444</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>4</td>
<td>30</td>
</tr>
</tbody>
</table>
DEVELOPMENT THREATS

Land development, defined for the purposes of this study as the conversion of farm, forest or vacant use to residential housing, can become attractive to landowners as market pressures increase the demand, and hence price, for developable land, such as when the value of farm or forest land becomes less than its potential value as residential or commercial land. The development of a property, though not universally undesirable, however, diminishes its ability to support the natural resource values it provides in its undeveloped state. The following Development Threat variables analyze the risk to natural resource conservation values from development of residential and commercial structures and uses. Using these values, this model predicts where development is likely to occur.
PARCEL ASSESSMENT - Assessed Land Value

Property value provides a fair approximation of the potential for development in that it reflects market forces. Given their responsibility to capture the fair market value of land for tax purposes, as the demand for developable land increases in a given area, county tax assessors can be expected to capture the corresponding increase in land value. We assume that the assessed value is a fair reflection of the demand for developable land, and as the market expands in a given area, assessed value provides an indicator of how soon a property is likely to become developed.

For this study we have used the portion of property value that represents the land alone, as determined by the county assessor, not including the value of any improvements made to the land. This represents the full and highest estimation of land value before any adjustments, credits or other discounts to which a given landowner may be entitled and that would reduce their tax bill.

A significant limitation to our results is that, within Snohomish County if not also King, the assessed value of Designated Forest Land enrolled in the county Current Use Tax program does not necessarily reflect full market value. According to state code, counties are not required to estimate the full market value of Designated Forest Land. In these cases we used the taxable value of the land. As such, the full development potential of these lands may not be captured with this threat variable.

This study calculates the assessed land value per acre of land for all candidate parcels and assumes a higher threat of development for those having a larger value per acre.

Large areas of higher value properties lie between Monroe and Sultan, mostly north of the river and along the major roads. Also, near Woods Creek and Lake Roesiger. There are also pockets around Gold Bar and south of the Skykomish River near Sultan. Small pockets are found along Highway 2 especially near Index, Baring and Skykomish.

The lands in category 1 ($500-7,942) are predominantly properties that are designated forest lands and assessed at current uses, plus some non-forest parcels with poor access.

Source Data

County Property Tax Parcel and Assessment data published King and Snohomish Counties on January 2 and June 17, 2015, respectively.

Snohomish County tax parcel boundary data is published with a number of county tax assessment database fields included as tabular attributes to individual parcel polygon features. King County distributes tax parcel boundary data separately from tax assessment database information, but both datasets are designed so that the tabular assessment information may be joined to the parcel boundary data using the tax parcel identification number as a common field. For both counties we were able to obtain the assessed (sometimes referred to as “appraised”) land value of all parcels for the 2015 tax year.

Methods

To calculate the assessed land value per acre we divided the assessed land value of each parcel by the acreage of each parcel as calculated from the parcel polygon area as represented in the tax parcel boundary data.

We assigned an Assessed Land Value Score from one (1) to four (4) for each candidate parcel based on the assessed land value per acre for each candidate parcel according to the following value ranges:

- 4 = $148,000 or more
- 3 = $34,000 - 147,999
- 2 = $7,943 - 33,999
- 1 = $500 - 7,942
- 0 = Less than $500

The Assessed Land Value Score for each parcel is reported in the [LandVal_Score] field within the results geodatabase.

Map Notes: Dollars per acre are based on assessed values. Timber and open space designations substantially lower the assessed value, and these values do not include the value of standing timber located within parcels.
DEVELOPMENT THREATS

PARCEL ASSESSMENT - Urban Growth Proximity

Washington’s Growth Management Act requires counties to design development regulations to direct future growth into designated Urban Growth Boundaries (UGAs). To the extent that these policies are successful, land within UGAs receives a significantly greater portion of new development than do areas outside the UGAs. While development is permitted on land outside UGAs, we assume that lands inside, or within close proximity, to existing UGAs are, in general, more likely to be developed sooner than lands located further from UGAs.

For this study we calculated the distance from all candidate parcels to the nearest UGA. We then assigned a greater threat of development to those located closer to UGAs, with those located inside an UGA having the highest threat with respect to this criterion.

This model shows broad concentric rings around the designated UGAs of Monroe and Sultan/Gold Bar. More limited areas are around Index and Skykomish due to large amounts of public lands near those towns. These areas are similar to the Assessed Land Value map, when the designated timberlands are deleted. One exception is the area between the two forks of Woods Creek, which has higher assessed value, but is more than five miles from the Monroe and Sultan UGAs. This is likely due to Highway 2 bordering this area, a network of roads and utilities, smaller parcels, and adjacent development. That area appears vulnerable to further development. The lands northeast of Sultan in the Bear Creek and Olney Creek watersheds also appear vulnerable to development, but most of this area is zoned for forestry and larger tracts are likely in forestland tax designation.

Source Data

Urban Growth Area (UGA) polygon boundary data published by Snohomish County on November 13, 2013 and by King County on January 30, 2015.

The Growth Management Act (GMA) requires certain counties, including both Snohomish and King, to designate in their Comprehensive Plan an Urban Growth Area wherein most future urban growth and development is to occur. UGAs are to include areas and densities sufficient to permit the urban growth that is projected to occur in the county over the next twenty years. Future urban growth is to be located first in areas already characterized by urban development where existing public facility and service capacity is available, and second in areas where public or private facilities or services are planned or could be provided in an efficient manner.

Methods

To calculate the minimum distance between each candidate parcel and its nearest UGA we first combined the source datasets from both counties into a single feature class using the Merge tool. We then used the Near tool to calculate the minimum Euclidean distance for each parcel. Note that this calculation considered UGAs outside as well as within the watershed, as a nearby UGA is expected to have the same influence on development probability for a parcel regardless of watershed boundaries.

We assigned an Urban Growth Proximity Score from one (1) to four (4) for each candidate parcel based on the minimum distance from that parcel to the nearest UGA according to the following value ranges:

- 4 = Inside or adjacent to the UGA
- 3 = 0.1 - 0.5 miles
- 2 = 0.6 - 2 miles
- 1 = 2.1 - 5 miles
- 0 = More than 5 miles

The Urban Growth Proximity Score for each parcel is reported in the [UGA_Score] field within the results geodatabase.
DEVELOPMENT THREATS

PARCEL ASSESSMENT - Surrounding Development

Development tends to spread from existing areas of development, sometimes leapfrogging undeveloped areas on their periphery, but generally growing outward from existing centers. This is due to a variety of factors, including regulatory intentions as reflected in zoning, the availability of roads capable of carrying larger traffic volumes, existing utilities, and other infrastructure. Conflicts between farming and forestry activities and the adjacent residential developments can make it difficult to continue with farming and forestry. This nearby development also tends to raise the assessed value of adjacent farm and forestlands, and hence property taxes, which can result in sale and conversion of those lands to higher-intensity uses. Thus, for this study we assumed that lands surrounded by existing development are more likely to develop sooner rather than later.

For this study we examined all parcels surrounding each candidate parcel, measured the percentage that were currently developed, and assigned a higher risk of development for those candidates having a higher percentage of surrounding development.

Areas with scores of 2 or higher (for which 25% or more of the surrounding parcels were developed) are concentrated in the western end of the valley. A very large area of development extends from Monroe to Sultan, including south of the river and up the Woods Creek watershed. Another large area is centered on Gold Bar. There are also small pockets near Index, Skykomish and Baring. This small footprint is due primarily to the substantial number of large forestland parcels and the adjacent public lands.

Source Data

County Property Tax Parcel and Assessment data published King and Snohomish Counties on January 2 and June 17, 2015, respectively; Edge-Matched Parcel (EMP) dataset created as part of the Salmonid Population metric analysis above.

Tax parcel and assessment data for King and Snohomish Counties is described in greater detail in the Assessed Land Value section above.

The Edge-Matched Parcel dataset consists of candidate parcels that have been ‘grown’ so they cover any gaps between parcels representing water bodies, watercourses or transportation rights of way, excluding those gaps representing public or protected lands as documented in Forterra’s 2013 CPS-PLDB dataset. The creation of the EMP dataset is described in more detail in the section above concerning the Salmonid Population metric methods.

Methods

In the attribute table of the EMP data we first created a new field called [DEV] and populated it to reflect the presence or absence of existing development on the property, where “0” reflects an undeveloped status and “1” a developed status. We defined developed status as having an improvement value greater than or equal to $10,000, and undeveloped status as having an improvement value less than that benchmark. In both cases, parcel improvement value was derived from the county tax parcel and assessment data.

We ran the Polygon Neighbors tool on the EMP data, setting [Parcel ID] as the Report By Field, to produce a table that yields a record for each unique combination of adjacent parcels and their Parcel ID. Note that parcels adjoining at their corners were considered adjacent for the purposes of this analysis. Please see the sample illustration at right for a visual explanation of this process.

We created a new field in the Polygon Neighbors output table to record development status for each adjacent parcel and performed a Tabular Join of the EMP attribute table to the Polygon Neighbors output table. This Join was configured to link the Parcel ID of the EMP table, which also reports the development status of that parcel, to the field in the Polygon Neighbors output table that reports the adjacent parcel’s Parcel ID. We then used the Field Calculator to transfer the development status of the adjacent parcel to the corresponding field created in the Polygon Neighbors output table to report whether or not each adjacent parcel is developed, and then removed the Join.

We then ran the Dissolve tool on the Polygon Neighbors output table, setting the Parcel ID as the Dissolve Field, to summarize adjacency records for every candidate parcel and calculate statistics for the sum of adjacent developed parcels and count of dissolved records. This resulted in a table with a single record for each candidate parcel that reports the number of adjacent developed parcels as well as total number of adjacent parcels. We then transferred those two statistics concerning adjacent and developed parcels to the candidate parcel dataset using a Tabular Join and the Field Calculator. Finally, we calculated for each candidate parcel the percentage of surrounding parcels that were developed by dividing the number of
adjacent and developed by total number of adjacent parcels and multiplying the quotient by 100.

We assigned a Surrounding Development Score from one (1) to four (4) for each candidate parcel based on the percentage of parcels surrounding it that were developed according to the following value ranges:

4 = 75 - 100%
3 = 50 - 74.9%
2 = 25 - 40.9%
1 = 0.1 - 24.9%
0 = 0

The Surrounding Development Score for each parcel is reported in the [SrndDev_Score] field within the results geodatabase.
**DEVELOPMENT THREATS**

**PARCEL ASSESSMENT - Topographic Slope**

Lands located on steeper slopes are more difficult, and therefore more expensive, to build on. In some cases building is prohibited due to the risk of slides. Given the abundance of level and developable land in the Basin we assumed they experience a lower risk of conversion to developed uses. While unprotected lands on steep slopes may at some time become developed, unprotected lands in flatter areas are more likely to be developed sooner.

To address this threat variable we measured the mean slope, in percent, for each candidate parcel and assigned a higher development threat to parcels with a lower, and hence flatter, mean slope.

The map shows the correlation between steeper slopes and lower assessed value on the landscape scale. Note that the mean slope measured across the area of an individual parcel, especially for larger parcels, may mask the presence of one or more level sites suitable for construction. For this reason our steep slope variable may to some degree underestimate the development threat for larger lands in the foothills and mountains as well as those along the edges of lowland river valleys.

The steeper slopes are mostly forested and in the south and eastern parts of the watershed. The gentler slopes are quite similar in location to the Urban Growth Proximity and Surrounding Development maps. This increases the lands vulnerability to development.

**Source Data**

Multiple LiDAR data sets, all at a horizontal resolution of one meter, acquired from the Puget Sound LiDAR Consortium:

- Snohomish County, 2005-2006
- North Fork Skykomish, 2007
- Tulalip Tribes, 2013
- King County, 2002 and 2003

The LiDAR data used in this analysis is described in more detail in the section above concerning the Low-Lying Floodplain Acreage metric.

**Methods**

We used the Slope tool to generate a percent slope raster dataset from the high-resolution DGM raster derived from LiDAR, then used the Zonal Statistics as Table tool to calculate the mean topographic slope within each candidate parcel.

We assigned a Topographic Slope Score from one (1) to four (4) for each candidate parcel based on the mean slope throughout the parcel according to the following value ranges:

- 4 = 0 - 5%
- 3 = 5.1 - 10%
- 2 = 10.1 - 20%
- 1 = 20.1 - 30%
- 0 = More than 30%

The Topographic Slope Score for each parcel is reported in the [Slope_Score] field within the results geodatabase.
Sultan River
N. Fork
Wallace R.
West Fork Miller River
S.Fork Skykomish River
Tye River
Spada Lake
Lake Roesiger
Lake Chaplain
Stevens Pass
Monroe
Slope Score
(Percent Slope)
4 (0 - 5)
3 (5.1 - 10)
2 (10.1 - 20)
1 (20.1 - 30)
0 (More than 30)
INPUT VARIABLE - Potential Dwelling Units per Parcel

The degree to which a given parcel has the potential to experience additional development is a key component in the assessment of the threat to those conservation values it may currently support. Local zoning and other development regulations define what uses, and at what intensities, are permitted on a given parcel of land. Independent of market forces that influence the probability of a given parcel being converted to development at a given time, which are addressed by the other variables covered in this analysis, whether or not a parcel may be developed depends on both the size of that parcel and its existing level of development with respect to these regulations. Furthermore, due to economies of scale within the construction and development sector, we assume parcels that could support a larger number of additional dwellings are, in general, a more desirable commodity to commercial developers, both large and small scale firms, than are parcels that could support only one or two additional dwellings.

According to this rationale, larger undeveloped parcels that have the potential to be subdivided into lots face a greater development threat than those that are fully developed, or that may allow only a single additional residence.

For this study we calculated an estimate of the number of additional residential dwelling units allowed on each candidate parcel and assigned a higher development threat to those that allow a greater number of additional units.

Source Data

Rural Residential Buildout Analysis for King and Snohomish Counties produced by CORE GIS on behalf of Forterra, October 2007; County Property Tax Parcel and Assessment data published by King and Snohomish Counties on January 2 and June 17, 2015, respectively; Zoning Designation data for King County published on September 21, 2015, and for Snohomish County on February 19, 2013.

The 2007 Rural Residential Buildout Analysis produced a tax parcel based dataset that estimated the maximum number of potential additional dwelling units that could be constructed on all private, unprotected parcels located outside county UGAs based on then-current zoning, parcel size, and number of existing dwelling units.

Tax parcel and assessment data for King and Snohomish Counties is described in greater detail in the Assessed Land Value section above.

County zoning datasets identify the current zoning designations for all unincorporated lands based on official zoning ordinances, which correspond with maximum allowable residential densities defined in each county’s development ordinances.

Methods

Starting with the results of the 2007 Buildout Analysis, we updated our original estimate of the number of potential additional residences allowed on each parcel based on information from current county Zoning and Tax Parcel and Assessment data to reflect current conditions.

For each county, we followed the same approach to estimating the number of unexercised development rights, using broadly similar methods. A more detailed description of the methods used for the 2007 analysis, which we replicated for consistency in performing the 2015 update for this project, is available from Forterra or CORE GIS. What follows here is a summary overview of the approach and principle operations performed in these analyses, with any significant differences noted.

The first step in each analysis was to identify the subject tax parcels for which to estimate development potential. Both analyses focused on private lands not protected by either a conservation easement or conservation (i.e. land trust) ownership, with protected lands having been identified using Forterra’s CPS-PLDB that was current at the time of each analysis. The original 2007 analysis covered privately owned, unprotected parcels outside of incorporated cities and Urban Growth Areas. Although this current study does cover private, unprotected lands within incorporated cities, we did not estimate development potential for those lands. The principle reason for excluding these incorporated lands is the considerable effort required to research development regulations in the five municipal jurisdictions in the basin, and performing separate calculations for the candidate parcels within each of them. Furthermore, we strongly suspected that spatial data portraying municipal zoning designations would not be available for most, if not all, of these cities and towns. Consequently the Development Potential criterion applies only to rural (unincorporated) candidate parcels within the basin.

The next step in both analyses was to determine the maximum residential density allowed for every subject parcel. We began by assigning the relevant zoning designation for each subject parcel, as defined by the zoning dataset for each county, which we recorded in a new field in the subject parcel dataset. In the State of Washington, local zoning designations are tied to local development ordinances, which among other things specify whether residential uses are permitted, and at what maximum allowable density. Researching the local development ordinances...
current to each time period, we determined the maximum allowable residential densities for each zoning designation that appeared within our set of subject parcels. We assembled this information into a lookup table that listed all relevant zoning designations along with their corresponding “density factor,” representing the maximum density allowed by local regulation in units per acre expressed as a decimal ratio. We then used a Tabular Join to add the density factor as a field in the subject parcel attribute table.

Of note is the fact that Snohomish County has a "density fringe" overlay zone that greatly restricts development within mapped floodplains. We spoke to Terry Whitesal at Snohomish County about this overlay when performing the original analysis, and he explained that it is not a blanket restriction but rather triggers a case-by-case evaluation. Based on that explanation – that these development prescriptions are imposed case-by-case – we decided to omit this overlay from consideration of maximum allowable densities in Snohomish County for this analysis.

At this point we were poised to calculate an estimate of the maximum number of dwelling units allowed under then-current regulations for every subject parcel. For the purposes of these analyses we made this calculation based on the gross parcel acreage and the density factor corresponding to the zoning designation for that parcel. Multiplying the parcel acreage by the density factor, which represented the number of dwelling units allowed per acre, typically yielding a fractional product representing the maximum number of units allowed. Since regulations for both counties specify that fractional dwelling units be discarded (i.e. may not be built or transferred to other parcels), we then rounded the multiplication product down to the nearest integer using the Field Calculator tool’s Floor function to arrive at a final estimate of the number of dwelling units allowed on each subject parcel.

We excluded from consideration site-specific development criteria such as lot coverage limits, floor-area ratios, setback requirements, and the locations of existing structures because to do so would have created an unmanageable level of complexity, well beyond the scope of this project. Furthermore, certain of these factors, as well as critical or sensitive area restrictions around features such as wetlands, important wildlife habitat, steep slopes, and other environmental hazards, are for the most part not mapped, or are mapped at a scale not suitable for analysis at the tax parcel scale.

Our next step was to estimate the maximum potential number of additional, or new, dwelling units that could be built on each subject parcel. Having just calculated a prediction for the total number of allowable units per parcel, we needed to know, or estimate, the number of dwelling units that exist on each parcel.

For parcels in King County, the Tax Assessment database includes specific records on the number of dwelling units existing on each parcel. This information is, however, apparently not documented for Snohomish County, so we developed the following approach to estimate that information. After researching the issue and considering a number of options we decided to use the improvement value assessed on each parcel, which primarily reflects the value of structures built on the property, as a proxy for existing dwellings. Based on conversations with Snohomish County staff we determined the minimum threshold to indicate the presence of a habitable structure would be an assessed improvement value of $10,000. For the purposes of this analysis, then, any subject parcel in Snohomish County with an improvement value of $10,000 or more was assumed to have an existing dwelling unit on the property.

We estimated the potential number of additional dwelling units allowed on each study parcel by subtracting the number of existing units (which, in the case of Snohomish County, were an estimate) from the total number of allowable units. As a final step in calculating this metric, we assigned all study parcels a development status, as follows:

- Undeveloped: A parcel with zero existing dwelling units
- Divisible: A parcel with one or more additional dwelling units allowed
- Fully Developed: A parcel with zero additional dwelling units allowed

We assigned a Development Potential Score from one (1) to four (4) for each rural candidate parcel based on the development status and number of potential new lots that could be created on each according to the following value ranges:

- 4 = Undeveloped
- 3 = Divisible into 4+ lots
- 2 = Divisible into 2-3 lots
- 1 = Divisible into 1 lot
- 0 = Fully Developed

Due to the infeasibility of estimating development potential on private, unprotected parcels within incorporated municipalities as described above, these urban lands received a Development Potential Score of zero. The Development Potential Score for each parcel is reported in the [PotDev_Score] field within the results geodatabase.
DEVELOPMENT THREATS

PARCEL ASSESSMENT - Development Potential

This map portrays our estimate of the number of additional residential dwelling units that could be created on each candidate parcel. This metric is most useful in areas that have a higher access and low remoteness rating. This must be viewed with other factors of access and steepness, which may offset the purported value increase based on subdividing.

This evaluation tried to deal with this complex situation, without artificially subdividing all parcels to determine which were not developable.

One result of this analysis is the higher score for large tracts (160-640 acres). These are mostly timber lands that can be subdivided into 80 acre lots, resulting in 2-8 smaller parcels. Therefore, these show higher Divisible ratings, despite the remoteness of many of these parcels.
DEVELOPMENT THREATS: RESULTS & EVALUATION

Our evaluation combines the scores for each individual development threat criterion, listed below, into a composite index from 1 to 4.

- Assessed Land Value
- Urban Growth Proximity
- Surrounding Development
- Topographic Slope
- Development Potential

Combining these individual scores gives an indication of overall threat of development, and corresponding loss of existing conservation values, on a parcel basis.

Most development in the basin to date has occurred along the Highway 2 corridor and near existing towns. Dispersed rural building occurs further into the foothills, mostly along the public roads. The maps indicate higher risk of development adjacent to these areas, plus spreading up the tributaries to the main stem. A very large area extends from Monroe to Sultan, including south of the river primarily along Highway 522 and 203 and up the Woods Creek watershed. There is also a large area around Gold Bar and small pockets are found near Index, Baring and Skykomish, such as the Tye-Foss River.

The weighted score adds upland and riparian areas in Tye, Beckler, and upper reaches of the tributaries.

The risk of development is most intense near towns and highways, but there is significant risk of development causing fragmentation of forests and incremental impacts on streams over a large portion of the study area, including more remote parcels.

The recent recession slowed the housing market and this was reflected in the slower rate of development of farm and forestland. Fragmentation, however, can unravel these resource lands with small developments. With the improving economy, the risk to these lands will increase.
UN-WEIGHTED DEVELOPMENT THREAT ASSESSMENT

As with our conservation value assessment, the un-weighted development threat assessment combines the scores for individual development threat criteria into a composite index via simple addition. This approach omits from consideration any difference in the relative importance of one development threat variable over all others. In other words, the un-weighted assessment treats each variable as being equally significant, with no one variable more important than any other. The issue of the relative significance between different development threat variables is addressed in the weighted assessment presented below.

Methods

In order to derive an un-weighted assessment of all candidate parcels based on the combination of all development threat metrics we added the scores for all five variables together and divided by five. This was calculated as follows:

\[
\text{Result} = \frac{\text{LandVal}_\text{Score} + \text{UGA}_\text{Score} + \text{SrmdDev}_\text{Score} + \text{Slope}_\text{Scr} + \text{PotDev}_\text{Score}}{5}
\]

The result of this calculation is stored in the field [Dev-Unweighted] within the results geodatabase as a floating point number. For the sake of consistency and simplicity we created integer versions of the composite un-weighted scores for each parcel and assigned values in the [DevUnWt_INT] field as follows:

<table>
<thead>
<tr>
<th>Original Score</th>
<th>Integer Score</th>
<th># Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1</td>
<td>616</td>
</tr>
<tr>
<td>1.1 - 2</td>
<td>2</td>
<td>5,539</td>
</tr>
<tr>
<td>2.1 - 3</td>
<td>3</td>
<td>6,137</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>4</td>
<td>2,401</td>
</tr>
</tbody>
</table>
Map Notes: This analysis does not address logging as a threat, only the potential development of new structures.
WEIGHTED DEVELOPMENT THREAT ASSESSMENT

The weighted version of this assessment adjusts those scores, based on professional judgment, to better describe the relative importance of each variable to the overall development threat to each parcel. This is accomplished by selecting a multiplication factor, collectively summing to one (1), that was applied to each individual threat variable score. The weights chosen for this study, listed below, are intended to emphasize the importance of factors that were deemed more powerful drivers of development, and which tend to focus in certain areas around existing towns and rural settlements.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessed Land Value</td>
<td>0.35</td>
</tr>
<tr>
<td>Urban Growth Proximity</td>
<td>0.20</td>
</tr>
<tr>
<td>Surrounding Development</td>
<td>0.15</td>
</tr>
<tr>
<td>Topographic Slope</td>
<td>0.05</td>
</tr>
<tr>
<td>Development Potential</td>
<td>0.25</td>
</tr>
</tbody>
</table>

GIS professionals working directly with our results data can adjust this weighting system to place a different level of emphasis on each variable.

Methods

In order to derive a weighted assessment of all candidate parcels based on the combination of all development threat metrics we multiplied the scores for all five variables by the multiplication factor listed above and then added the five products. This was calculated as follows:

\[(\text{LandVal} \times 0.35) + (\text{UGA} \times 0.2) + (\text{SrndDev} \times 0.15) + (\text{Slope} \times 0.05) + (\text{PotDev} \times 0.25)\]

The result of this calculation is stored in the field [Dev_Weighted] within the results geodatabase as a floating point number. For the sake of consistency and simplicity we created integer versions of the composite weighted scores for each parcel and assigned values in the [DevWt_INT] field as follows:

<table>
<thead>
<tr>
<th>Original Score</th>
<th>Integer Score</th>
<th># Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1</td>
<td>327</td>
</tr>
<tr>
<td>1.1 - 2</td>
<td>2</td>
<td>4,847</td>
</tr>
<tr>
<td>2.1 - 3</td>
<td>3</td>
<td>6,568</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>4</td>
<td>2,951</td>
</tr>
</tbody>
</table>
Map Notes: This analysis does not address logging as a threat, only the potential development of new structures.
The Conservation Value/Threat matrix. The numbers within cells represent the combined project results: Assessment Matrix

Mapping Conservation and Threat Simultaneously

After developing the data layers to represent conservation value and development threat, we decided to represent parcels based on their score for both of those factors simultaneously. We used a 4 x 4 matrix to represent each parcel's combination of conservation value and development threat. The colors used to represent these factors are structured so that greater saturation indicates higher conservation value, and warmer hues represent higher levels of threat. In other words, the deepest red color (4, 4) represents parcels with the greatest conservation value and the highest likelihood of development, given the variables we chose to represent those two characteristics. Conversely, the lightest green color (1, 1) represents parcels that are very low in conservation value and are unlikely to be developed in the near to midterm future.

Methods

We used a series of queries on the fields for weighted and unweighted conservation value and threat to identify all of the unique combinations. For example, the unweighted queries looked like:

ConsUnWt_INT = 1 AND DevUnWt_INT = 1 Receives value of 1 in the Cons_Unweighted field;
ConsUnWt_INT = 3 AND DevUnWt_INT = 2 Receives value of 7 in the Cons_Unweighted field, and so on

A similar process was used for the ConsWt_INT and DevWt_Int fields, which contain the weighted scores for each set of variables.

On the two maps that follow, the legend shows the matrix with the same colors as the graphic to the right; however, the numbers in each box represent the number of parcels falling into each category.

The four maps that follow the Weighted and Un-weighted Assessment Matrices are showing the same data displayed in the Weighted Assessment Matrix at a close-up scale.
COMBINED PROJECT RESULTS: ASSESSMENT MATRIX

Weighted Assessment

The study included 14,693 parcels, varying in size from less than an acre to 640 acres. The weighted Assessment scores resulted in complex patterns – very geographically focused. There are very few (30 parcels) with Very High composite conservation value (4), but there are very high numbers (11,291 parcels) in the low conservation value (1). However, some of the very high value parcels were large (>160 acres), covering proportionately larger amounts of the watershed and many of the low value parcels are much smaller (<1 acre) and in developed areas.

The threat values presented more of a bell shaped curve – with the mode (6,137 parcels) in the moderately high-risk (3) category.

Taken together, there are 453 parcels that have higher conservation values (3 & 4) and higher risk values (2-4). These would warrant immediate attention. If you add moderate value (2) with high threat (4) you add 114 parcels; including high and very high with low risk of development – adds an additional 79 parcels. The total of 646 parcels (out of 14,693) highlights the 4.5% of parcels that have significant conservation value at risk of development.

Geographical distribution may be more instructive than parcel count. Parcels in this grouping are found in the lower valley where high conservation values of parcels adjacent to the river or streams are also close to developed areas. Major areas are along the main stem of the Skykomish from the confluence with the Snohomish to the confluence with the Wallace River, the mid and upper reaches of Woods Creek and West Fork Woods Creek, Richardson Creek, Olney Creek, and the lower reaches of Barr, Youngs, Elwell, McCoy and Proctor Creeks and uplands in the Wallace River basin.

The upper valley also has parcels in this grouping. There are pockets along the North Fork, near the town of Skykomish and along the lower reaches of Beckler, Foss and Miller Rivers, and Maloney Creek. This grouping also included uplands along Windy Ridge and near Lake Serene. Note that high conservation values, especially for older forest elements, have low development values due to ruggedness or remote locations, but some of these areas could be logged.

A few key areas of moderately low threat but high conservation value are Williamson Creek, Windy Ridge, and upper Youngs and Proctor Creeks.
Overall Project Conclusions

This tool was designed to evaluate privately owned lands in the Skykomish River Basin with conservation values of importance to hydrology and salmon recovery and threats to those values from development. By cross-checking these two factors, the analysis indicates relative composite values in 16 rankings from Low Conservation/Low Threat to High Conservation/High Threat.

The maps show patterns of higher conservation value with varying degrees of vulnerability to development. The zoom-in maps are helpful to direct users to specific parcels – either as part of a group of similarly rated parcels, or an isolated parcel that exhibit these high conservation characteristics with higher risk of development.

Strategic conservation programs can focus on those areas and specific properties that show as having high conservation values – to insure they remain so. Using the threat rating, report users can then identify where those values are at risk from development in the near term.

This analysis informs conservation strategic planning. However, this evaluation does not include the opportunity factors such as funding availability, willing sellers, and entities that commit to long-term ownership and stewardship of the conservation lands. Those factors are critical for conservation planning.

Land Ownership

The maps show that the majority of the eastern and northern portions of the watershed are in public ownership – primarily national forest or state trust land. However, significant reaches of major rivers in these areas are in private ownership and have high values related to hydrology and salmon habitat. They also tend to have major public roads (e.g. Highway 2). In the middle watershed, significant private timberland ownership lies south of the Skykomish River and north of the Sultan-Gold Bar rural/suburban development area. These forestlands have higher conservation values, due to numerous streams, while development risk varies based on slopes and proximity to existing development and public roads. The remainder of the western watershed is a mix of private lands within the foothills forest, agriculture, rural development, and the urban centers of Monroe, Sultan, Startup, and Gold Bar.

Salmon

The maps show high salmon usage of the main stem, North Fork and major tributaries of the Skykomish. In addition, adult salmon are trucked around Sunset Falls, and use the South Fork and its major tributaries extensively. Culmback Dam blocks salmon from the upper Sultan watershed, known as the Sultan Basin. Wallace Falls blocks anadromous fish from the upper Wallace River watershed.

Conservation Values vs. Development Risk

The analysis shows substantial areas with high conservation values for salmon along the major rivers and tributaries and some upland tracts. It also shows the risk of development radiating out from the towns and major roadways.

The maps show that higher values with higher threats are concentrated along the lower Skykomish River and major tributaries near urban/suburban areas. Much of this is concentrated in a corridor from southwest of Monroe along Highway 2 to Gold Bar.

Weighted assessment scores resulted in a pattern where there were very few parcels with Very High composite conservation value scores (4) combined with high numbers in the low conservation value (1). However, some of the very high value parcels were large (>160 acres), having proportionately greater effect on hydrology and salmon. The threat values presented more of a bell shaped curve – with the mode in the higher risk (3), with almost half the parcels.

A review of the data indicate that most of the higher value parcels with some degree of risk of development amounts to about 5% of the privately owned parcels in the watershed.

These areas should be viewed with a sense of urgency. This suggests that these be examined more closely in subsequent studies and conservation efforts. One factor to consider in subsequent analysis of local areas is adjacency to public lands, where acquisitions can build on existing conservation areas.

The maps also show high conservation values in upland forests. Because these parcels are generally remote from other development or in rugged terrain, they tend to have low development threat values. While these parcels may not be threatened by development in the near term, this analysis does not evaluate the potential of road building or logging of late successional forests. These activities would have impacts on hydrology and salmon. The Riparian Tall Tree Acreage map focuses on that conservation value (large trees) and is reflected in the composite weighted score. Further investigation of those tracts would inform the timing of any conservation transaction intended to protect those values, as they are vulnerable to logging, even though they are not immediately threatened by development.
The relative cost of acquisition is directly related to its development potential. The size of a parcel is a key factor—as some parcels are entirely or mostly within a floodplain or other area where development is prohibited or discouraged. Larger parcels may include similar development restrictions, but which have sufficient upland acreage to develop a house or other structure. This evaluation tried to deal with this situation, without artificially subdividing all parcels to determine which were not developable. This was in part because subdivisions can be arranged in a myriad of ways. For reaches where parcels generally have high conservation values and high development threats, next steps would be to focus on these parcels, and do a more detailed analysis or projection. Based on current development trends, which are increasing in the Skykomish River Basin, the timing could be critical to begin a substantial acquisition effort to protect salmon habitat and large forested property.

Summary

While each parcel is unique in conservation value, threat and opportunity, the results of this geospatial analysis show patterns that provide a basis for focusing conservation efforts along certain reaches of streams and in certain upland forest blocks. While results might vary with different weightings or other factors, we believe the basic patterns will remain. Further analyses on these focus areas will provide more information to prioritize specific conservation programs.

Photo by Charlie Raines
APPENDIX

Watershed Characterization Maps
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Quartiled Importance of Water Flow Maps
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  Lower Mid-Skykomish River  77
  Mainstem Skykomish River  78
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WATERSHED CHARACTERIZATION DATA

Waterflow Importance Rank

Source: Snohomish and King County Assessors Parcel data

Date: 2015

Description: Although the Watershed Characterization Data was not ultimately included in the assessment model, it was used to inform our thinking on the importance of water flow and hydrological integrity. The maps are included here for reference. On the right is a map showing Planning Units ranked by importance for water flow.

Methods: To create this map we referenced the document Watershed Characterization for WRIA 7 Assessment and Recommendations for Protection of Water Flow Processes (March 2015, Publication No. 15-0-009).

For each sub-basin, the report ranks the planning units for waterflow processes. Within the Skykomish Basin, the planning units are ranked as follows for Water Flow Importance (p. 86-90):

1. North Fork Skykomish
2. South Fork Skykomish
3. Sultan River
4. Lower Mid-Skykomish
5. Skykomish Mainstem
6. Woods Creek

Within each of these planning units, the individual assessment units are also ranked, and those maps follow the Salmon Habitat Importance Ranking map.
Watershed Characterization Maps

- Sultan River
- N. Fork Wallace R.
- Skykomish R.
- Tye River
- Foss River
- Miller River
- W. Fork Woods Cr.
- W. Woods Creek
- Youngs Creek
- Proctor Creek
- Barr Creek
- Olney Creek

Waterflow Importance Ranking

1. North Fork Skykomish
2. South Fork Skykomish_WF_R
3. Sultan River
4. Lower Mid Skykomish
5. Skykomish Mainstem
6. Woods Creek

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes

Waterflow Importance Rank

0 1 2 4
Miles

Stevens Pass

Monroe

Index

Gold Bar

Sultan

Lake Roesiger

Lake Gold Bar

Lake Index

Lake Olney

Lake Proctor

Lake Sultan

Lake Youngs

Lake Tye
Salmon Habitat Importance Rank

Source: Snohomish and King County Assessors Parcel data

Date: 2015

Description: Although the Watershed Characterization Data was not ultimately included in the assessment model, it was used to inform our thinking on the importance of water flow and hydrological integrity. The maps are included here for reference. On the right is a map showing Planning Units ranked by salmon habitat importance.

Methods: To create this map we referenced the document Watershed Characterization for WRIA 7 Assessment and Recommendations for Protection of Water Flow Processes (March 2015, Publication No. 15-0-009).

For each sub-basin, the report ranks the planning units for salmon habitat importance. Within the Skykomish Basin, the planning units are ranked as follows for Salmon Habitat Importance (p. 86-90):

1. Woods Creek
2. Skykomish Mainstem
3. Sultan River
4. Lower Mid-Skykomish
5. North Fork Skykomish
6. South Fork Skykomish
Salmon Habitat Importance Ranking

1. Woods Creek
2. Skykomish Mainstem
3. Sultan River
4. Lower Mid Skykomish
5. North Fork Skykomish
6. South Fork Skykomish

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes

Miles

0 1 2 4
Quartiled Importance of Water Flow

High
Moderate High
Moderate
Low

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes

North Fork Skykomish

Monroe
Sultan
Gold Bar
Index
Skykomish
Stevens Pass
E. Fork Sklomish
W. Fork Woods Creek
W. Fork Woods Cr.
W. F. Woods Creek
N. Fork Skykomish
S. Fork Skykomish
Spada Lake
Lake Roesiger
Lake Chaplain
Index
Gold Bar
Sultan
Monroe
Stevens Pass

0 1 2 3 4 Miles

North Fork Skykomish

Quartiled Importance of Water Flow

High
Moderate High
Moderate
Low

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes

102
South Fork Skykomish Watershed

Map of South Fork Skykomish River showing:
- Skykomish Watershed
- Urban Growth Areas
- Highways
- Rivers
- Lakes

Legend:
- High
- Moderate High
- Moderate
- Low

Outlining the importance of water flow:
- High
- Moderate High
- Moderate
- Low

Miles Scale:
0 1 2 4

Locations:
- Sultan
- Gold Bar
- Monroe
- Index
- Stevens Pass
- South Fork Skykomish
Skykomish Mainstem

Quartiled Importance of Water Flow

- High
- Moderate High
- Moderate
- Low

Skykomish Watershed
Urban Growth Areas
Highways
Rivers
Lakes
The primary feature class containing the fields referenced in this document is parcels_merge_v3 and it is located in \Forterra_Skykomish\data\base\vector\forterra_skykomish.gdb.

The field definitions below are only for the attributes that were newly created for this analysis. The parcels data are a combination of Snohomish and King County parcels data, and the feature class contains the complete set of attributes for each as received from Forterra.

Unique_ID
Unique ID created to serve as a primary key for all parcels

Acres_flood
Acres of floodplain within the parcel

Pct_flood
Percentage of parcel covered by floodplain

Acres_Wetland
Acres of wetland within the parcel

Pct_wetland
Percentage of parcel covered by wetlands

Coho
Presence or absence of coho (1 = present, 0 = not present)

DV_Bull_Trout
Presence or absence of Bull Trout (1 = present, 0 = not present)

Fall_Chinook
Presence or absence of Fall Chinook (1 = present, 0 = not present)

Fall_Chum
Presence or absence of Fall Chum (1 = present, 0 = not present)

Pink_Even
Presence or absence of Pink even-year spawners (1 = present, 0 = not present)

Pink_Odd
Presence or absence of Pink odd year spawners (1 = present, 0 = not present)

Res_Coastal_Cutthroat
Presence or absence of resident Coastal Cutthroat trout (1 = present, 0 = not present)

Summer_Chinook
Presence or absence of Summer Chinook (1 = present, 0 = not present)

Summer_Steelhead
Presence or absence of Summer Steelhead (1 = present, 0 = not present)

Winter_Steelhead
Presence or absence of Winter Steelhead (1 = present, 0 = not present)

Fish_SPP_Count
Total number of species present within streams running through or adjacent to parcel

ACRES
Size of parcel in acres

PCT_WATER
Percent of parcel covered by water according to landcover classification

PCT_BARE_GROUND
Percent of parcel covered by bare ground according to landcover classification

PCT_GRASS
Percent of parcel covered by grass according to landcover classification

PCT_SHRUBS_AND_SMALL_TREES
Percent of parcel covered by shrubs and small trees according to landcover classification

PCT_DECIDUOUS
Percent of parcel covered by deciduous trees according to landcover classification

PCT_HIGH_DENSTY_DEV
Percent of parcel covered by high density development according to landcover classification

PCT_MED_DENSITY_DEV
Percent of parcel covered by medium density development according to landcover classification

PCT_EVERGREEN_FOREST
Percent of parcel covered by evergreen forest according to landcover classification

PCT_SHADOW
Percent of parcel covered by shadow according to landcover classification
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCT_SAND_BAR</td>
<td>Percent of parcel covered by sand bar according to landcover classification</td>
</tr>
<tr>
<td>Buf_300ft_Area</td>
<td>Area in square meters of 300 foot buffer from perennial streams; note this field has been superseded by Buf_300ft_Area_v2</td>
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<tr>
<td>Buf_300ft_Pct_For</td>
<td>Percentage of 300 foot buffer that is covered by forest</td>
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<tr>
<td>Buf_Pct_0_6</td>
<td>Percentage of 300 foot buffer covered by trees that are between 0 and 6 feet high</td>
</tr>
<tr>
<td>Buf_Pct_6_50</td>
<td>Percentage of 300 foot buffer covered by trees that are between 6 and 50 feet high</td>
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<tr>
<td>Buf_Pct_50_100</td>
<td>Percentage of 300 foot buffer covered by trees that are between 50 and 100 feet high</td>
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<tr>
<td>Buf_Pct_100_150</td>
<td>Percentage of 300 foot buffer covered by trees that are between 100 and 150 feet high</td>
</tr>
<tr>
<td>Buf_Pct_150_plus</td>
<td>Percentage of 300 foot buffer covered by trees that are more than 150 feet high</td>
</tr>
<tr>
<td>Buf_300ft_Area_v2</td>
<td>Area of 300' buffer corrected to incorporate buffer distance from bank (for large rivers/creeks) and inadvertent inclusion of multi-part polygons</td>
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<tr>
<td>pct_elv_0_or_less</td>
<td>Percentage of parcel that is at the same elevation or lower than the nearest channel</td>
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<tr>
<td>pct_elv_grt_0_5</td>
<td>Percentage of parcel that is at the same elevation or up to 5’ higher than the nearest channel</td>
</tr>
<tr>
<td>pct_elv_5_or_less</td>
<td>Percentage of parcel that is 5’ higher or lower than the nearest channel</td>
</tr>
<tr>
<td>Bank_mods_M</td>
<td>Length of bank modifications in meters</td>
</tr>
<tr>
<td>Existing_DUs</td>
<td>Number of existing dwelling units on parcel</td>
</tr>
<tr>
<td>Potential_DUs</td>
<td>Potential dwelling units that could be built if parcel were subdivided and or developed to maximum potential under current zoning (based on 2006/2007 analysis conducted for Forterra)</td>
</tr>
<tr>
<td>Dev_Category</td>
<td>Development potential category</td>
</tr>
<tr>
<td>UGA</td>
<td>Whether or not parcel is within an Urban Growth Area (1 = yes, 0 = no)</td>
</tr>
<tr>
<td>Rip_Func</td>
<td>Riparian function score, derived from Mobrand Biometrics Ecosystem Diagnosis and Treatment (EDT) model</td>
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<tr>
<td>WF_Summary_Score</td>
<td>Watershed characterization workflow summary score (this variable was not used in the assessment)</td>
</tr>
<tr>
<td>WQ_Summary_Score</td>
<td>Watershed characterization water quality summary score (this variable was not used in the assessment)</td>
</tr>
<tr>
<td>Low_elv_Score</td>
<td>Score for area of low elevation relative to channel</td>
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<tr>
<td>EDT_Score</td>
<td>Score for EDT riparian function (this variable was not used in the assessment)</td>
</tr>
<tr>
<td>Salmon_Spp_Score</td>
<td>Salmonid species score</td>
</tr>
<tr>
<td>Salmon_Strm_F</td>
<td>Salmon bearing stream length in feet</td>
</tr>
<tr>
<td>Salmon_Strm_Score</td>
<td>Salmon bearing stream length score</td>
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<tr>
<td>Floodplain_Score</td>
<td>Floodplain score</td>
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<td>Wetland_Score</td>
<td>Wetlands score</td>
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<tr>
<td>For_Buff_Score</td>
<td>Forest within 300’ buffer score</td>
</tr>
<tr>
<td>Buf_Pct_100plus</td>
<td>Acreage of trees 100’+ within 300’ buffer</td>
</tr>
<tr>
<td>For_100plus_Score</td>
<td>Trees 100’+ within 300’ buffer score</td>
</tr>
<tr>
<td>NEAR_FID</td>
<td>FID used in NEAR calculation</td>
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<tr>
<td>NEAR_DIST</td>
<td>Distance to between parcel and nearest UGA</td>
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<td>Variable</td>
<td>Description</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>LandVal_Score</td>
<td>Value of land per acre score</td>
</tr>
<tr>
<td>LandVal_Acre</td>
<td>Value of land per acre</td>
</tr>
<tr>
<td>UGA_Score</td>
<td>Urban Growth Area proximity score</td>
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<tr>
<td>Near_Dist_Miles</td>
<td>Near distance in miles between parcels and closest UGA</td>
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<tr>
<td>PotDev_Score</td>
<td>Potential development score</td>
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<td>SrndDev_Score</td>
<td>Surrounding development score</td>
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<tr>
<td>PctSrndDev</td>
<td>Percentage of surrounding parcels that are developed</td>
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<td>Pct_Slope</td>
<td>Average percent slope within parcel</td>
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<td>Slope_Scr</td>
<td>Slope score</td>
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<tr>
<td>Cons_Unweighted</td>
<td>Unweighted conservation score</td>
</tr>
<tr>
<td>Cons_Weighted</td>
<td>Weighted conservation score</td>
</tr>
<tr>
<td>Dev_Unweighted</td>
<td>Unweighted development score</td>
</tr>
<tr>
<td>Dev_Weighted</td>
<td>Weighted development score</td>
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<td>Unweighted conservation score integer</td>
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<td>Weighted conservation score integer</td>
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<tr>
<td>DevUnWt_INT</td>
<td>Unweighted development score integer</td>
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<tr>
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<td>Weighted development score integer</td>
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<td>Unweighted matrix score</td>
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<td>Matrix_Wt</td>
<td>Weighted matrix score</td>
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<tr>
<td>Shape_Length</td>
<td>Perimeter in meters</td>
</tr>
<tr>
<td>Shape_Area</td>
<td>Area in square meters</td>
</tr>
<tr>
<td>Acres_LowElev</td>
<td>Acres of each parcel that are 5' above or lower than nearest channel</td>
</tr>
<tr>
<td>Wetland_Ac_Outside_Flood</td>
<td>Wetland acres outside of floodplain</td>
</tr>
<tr>
<td>Acres_Forested</td>
<td>Acres of forest</td>
</tr>
<tr>
<td>Acres_300ft_forest</td>
<td>Acres of forest within 300' buffer</td>
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<tr>
<td>Wetland_NONFlood_Score</td>
<td>Score for wetlands outside of floodplain</td>
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<td>Forested_Score</td>
<td>Forested score</td>
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<td>Acres_Pervious</td>
<td>Acres of pervious landcover</td>
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<tr>
<td>Acres_300ft_Trees_100plus</td>
<td>Acres of trees 100’ plus within 300’ buffer</td>
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<td>Pervious_score</td>
<td>Score for pervious surface</td>
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<tr>
<td>Buf_Area_For_90_plus</td>
<td>Area of trees 90' plus within 300' buffer (SqM)</td>
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<tr>
<td>Buf_Pct_For_90_plus</td>
<td>Percentage of 300' buffer covered by trees 90' plus</td>
</tr>
<tr>
<td>Acres_Buf_For_90_plus</td>
<td>Acres of 300' buffer covered by trees 90' plus</td>
</tr>
<tr>
<td>For_90plus_Score</td>
<td>Trees 90’ + within 300’ buffer score</td>
</tr>
</tbody>
</table>
DATA ORGANIZATION AND NAMING CONVENTIONS

The spatial data for the Skykomish Basin Land Protection Assessment & Mapping Project is organized into multiple directories and sub-directories, as described below.

Files are named in sequential order of creation: v3 is newer than v2, which is newer than v1. The largest version number is always the most recently created version. Tabular files are pre-pended with tbl, and output from MS Access queries is pre-pended with qry.

Data: All spatial data, including unmodified source data

Analysis

Channel_elevation: contains all files related to the low-lying areas analysis (height above river)

Dev_Threat: contains all files related to the threat assessment

Hydrological_Value_and_Integrity: contains files from EDT, Watershed Characterization, bank modification inventory, etc., most of which were not used

NAIP_output: contains all files related to landcover classification

naip_bands.gdb: working GDB with multiple processing layers

sky_veg_v7.gdb: final landcover classification

NAIP_processing.tbx: ArcGIS toolbox containing multiple models used for processing and analyzing NAIP 4-band data

Stats: contains MS Access database, as well as numerous tables and query outputs used to populate the attributes used in the assessment

Veg_heights: contains all files related to the vegetation heights analysis

Watershed_Characterization: contains all files related to

our interpretation of the sub-basin importance rankings. This data was not used in the final assessment.

Base

Raster: contains bare earth and first return LiDAR for the entire basin

Vector: the foreterra_skyomish.gdb located here contains numerous data layers that are not specifically related to any individual analysis, organized into multiple feature datasets and feature classes. The most important feature class located here is the parcels_merge_v3, which includes all parcels and all of the fields described above.

Source: contains all of the data newly acquired for this project, unmodified from the original files. Data are organized by providing agency, or thematically depending upon the nature of the data.

Tables: contains MS Excel files and additional tabular data that was not produced as part of any particular analysis, or that incorporates data from multiple analyses

Deliver: contains output from MXD files

Layout: contains output from map files, InDesign documents, Photoshop documents, and other graphics

Maps: contains all of the MXDs produced for this analysis. Maps were created in ArcGIS 10.3, and all MXDs were saved with relative paths

Scripts: contains the skykomish_processing.tbx, with three iterating models that were used to process the source X, Y, Z first return point cloud from Snohomish County and produce the single mosaic LiDAR rasters