Mapping Conservation Opportunity Areas for The Intertwine's Regional Conservation Strategy

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Summary

As part of efforts to develop the Regional Conservation Strategy (RCS) for the greater Portland-Vancouver region, Oregon State University's Institute for Natural Resources (INR) was asked to use spatial modeling to identify conservation opportunity areas (COAs). To complete the project, INR analysts proposed a strategy that would map high value areas using a landscape approach that is focused on relatively high spatial resolution data sets available for the whole metropolitan region. The approach creates 2 main metrics: one focused on terrestrial organisms and the other focused on aquatic and riparian organisms. These are combined to create a map of highly ranked land areas that can be used to formulate a map of conservation opportunity areas.

The purpose of the COA mapping project was to use geographic information system methods to identify landscape patches with conservation and restoration potential. The criteria used to identify these high value patches was based on a number of base- and derived-data sets that we call "data inputs." The data ranged from recently mapped land use and land cover types, hydrological data to indicate species habitat requirements, and road influence on habitat patches. The project identified some areas in which data gaps exist (e.g., region-wide biodiversity data collected and mapped in consistent ways) and some opportunities for improving existent data sets (e.g., land use/land cover map).

The project provided several layers that can be used to guide the final Regional Conservation Strategy in selecting conservation opportunity areas. The best layer will depend upon the needs of the RCS efforts, however, in our opinion the most appropriate layer to use is COA 3.11.1 which weights wetlands fairly high, but not as highly as the second data draft. COA 3.10.1 offers similar results as well. Overall it appears that the model results corroborate corridors analysis done previously (Hennings and Soll 2010). There are some issues remaining that we feel can most adequately be addressed by updating the base land use/land cover map.

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Section 1. Introduction

As part of efforts to develop the Regional Conservation Strategy (RCS) for the greater Portland-Vancouver region, Oregon State University's Institute for Natural Resources (INR) was asked to use spatial modeling to identify conservation opportunity areas (COAs). To complete the project, INR analysts proposed a strategy that would map high value areas using a landscape approach that is focused on relatively high spatial resolution data sets available for the whole metropolitan region. The approach creates 2 main metrics: one focused on terrestrial organisms and the other focused on aquatic and riparian organisms.

The COA mapping project fits into the broad-natured and long-reaching view that is being taken by the RCS. The project uses a set of methods that are distinctive relative to the rest of the RCS work efforts, and can be used to corroborate and highlight results from earlier efforts to map important habitat patches and corridors within the RCS region.

The purpose of the COA mapping project was to use geographic information system methods to identify landscape patches with conservation and restoration potential. The criteria used to identify these high value patches was based on a number of base- and derived-data sets that we call "data inputs." The data ranged from recently mapped land use and land cover types, hydrological data to indicate species habitat requirements, and road influence on habitat patches. The project identified some areas in which data gaps exist (e.g., region-wide biodiversity data collected and mapped in consistent ways) and some opportunities for improving existent data sets (e.g., land use/land cover map).

This document contains five sections. Sections 2 and 3 describe the Swim and Walk metrics used to create the COA map product. Section 4 describes how the COA map product was obtained. The document concludes with some lessons learned and recommendations in Section 5. An appendix series describes the data sets used and the methods that were explored but not used in the final product's development. Two data reviews were held to discuss and guide the map products. Reviewer comments are contained in the appendix series as well.

Revisions and modifications

A number of revisions and modifications were suggested through the two data review meetings and follow-up commentary. The original notes from these meetings are found in Appendix C and Append D. Our interpretation of the comments from these meetings is summarized below.

Swim Metric

Data Review 1

Issue	Solution
1. Correct overvaluing of areas like Swan Island and Industrial NW in walk metric and possibly swim metric as well.	Calibrated curve number values (see Section 2) returned by the Swim metric to reduce mapped value of industrial areas
2. Incorporate stream widths into swim metric	Used stream flow to calibrate the area considered important by the algorithm. Rationale: flow is a

Issue	Solution
	function of the depth and cross-sectional area and often indicates stream width. Please note that calibration of curve numbers in Issue #1 increased the ranks of waterbodies (including streams and rivers) more dramatically than incorporation of stream flow. The effect of the two modifications is additive.
3. Incorporate wetlands into swim metric/Incorporate wetlands into walk metric	Wetlands were burned into the LULC layer
4. Make sure the following questions been adequately answered:	
a. Which streams contribute the highest volume of **temperature** impaired water to the mainstem Willamette ➔ temperature load in NHD	Incorporated stream temperature loads
b. Which streams have the best **riparian cover** to ameliorate solar gain?	Riparian cover is incorporated into the Swim metric via the land use/land cover map. If good quality trees (i.e., large) are correctly classified, they receive a lower Manning's *n* (high surface roughness value) and curve number (high water infiltration potential) to indicate better habitat potential (e.g., shade, food sources, etc.). We reviewed detailed maps of Willamette and Johnson Creek; FLIR data describing streamside riparian vegetation; and heat source loads in the DEQ TMDLs for the lower Willamette to check this part of the algorithm. These data were not used in the model because they are not geo-rectified and would be time consuming to incorporate.
5. Incorporate more species or more indicators of biodiversity into the swim metric (e.g., temperature, other?)	Incorporated additional stream attributes, but did not incorporate biodiversity data *per se*.
6. Calibration suggestion: Calibration is required to pick up areas where "situations where water enters a confined channel, and rises higher than local topography may suggest because of the surge effect. This effect is too complex to model in an effort like this, but the FEMA data incorporates a degree of that. Areas like Willamette Narrows, and perhaps some of the confluence sites with major tribs should be checked against those ancillary data.	Calibrated the floodplain development portion of the model. See Issues #1 and #2 for solutions that get at this comment.

Issue	Solution
(MSchindel)”	

Data Review 2

Issue	Solution
1. Indicate the importance of the water bodies themselves, not just the land surrounding them.	Modified curve numbers to increase the rank of open water.

Walk Metric

Data Review 1

Issue	Solution
1. Incorporate wetlands into swim metric/Incorporate wetlands into walk metric	Wetlands were burned into the LULC layer
2. Calculate habitat interspersion/diversity (fragstats? Or FocalVariety in ArcGIS?)	Habitat interspersion was not completed because the number of habitat types used to generate patches was reduced at the request of the Data Review Subcommittee. The reduction in the number of habitat types to natural and semi-natural yielded more homogeneous habitat areas.
3. Recalculate “ground condition” using an inverse square function or similar to penalize close distances more strongly than far.	Discussion with M. Schindel and T. Albo allowed a solution to be reached that was satisfactory. Roads were weighted differentially and buildings were updated.
4. Improve how connectivity is represented as a data input	Discussion with M. Schindel concluded with approval of the method used.
5. Remove slope from walk metric because may be correlated with development potential. Consider other ways to include slope/topography.	Slope was omitted from the analysis

Data Review 2

Issue	Solution
1. Correct the tiling issue related to the weighted patch size layer	Patch density was run over the entire LULC map.
2. Decrease the weight of wetlands	Wetland weights were decreased. Various weighting schemes are included in the data provided.
3. Treat clear cuts as forest instead of semi-natural	This and additional modifications of the LULC map will

lands be addressed in a subsequent proposal.

COA Map

Issue: Understand issues with impervious surfaces and errors in the COA product.

Solution: Analysis using Bob Pool's impervious surfaces data was completed to ascertain where the data inputs contained error that contributed to misclassification of high priority areas due to impervious surfaces.

Section 2. The Swim Metric for Aquatic and Riparian Organisms

Joe Bernert and Michael Polly

Background

The primary objective of the Surface Water Integration Metric (SWIM) metric is to evaluate potential stream-related habitat in terms of aquatic species including fisheries, macroinvertebrates, plankton (primarily phytoplankton and zooplankton) and aquatic plant species (i.e., macrophytes). The metric should be able to identify areas of higher quality habitat for aquatic taxa and how they are connected to other species (in the upland terrestrial habitat). The primary objectives of determining the metric for the Portland Metropolitan Regional Conservation Strategy (RCS) are:

- To make maps of suitable habitat locations inside and outside of the urban boundaries within the geographic region determined by the Regional Conservation Strategy for aquatic taxa that are primarily riparian and aquatic (a.k.a. swim metric). Specifically,
  - Ranked aquatics habitat quality, and
  - Rank potential for conservation opportunities.
- To make maps of conservation opportunity areas as defined by the combination of the walk and swim metrics.

Stream ecology has identified numerous factors related to classifying and evaluating aquatic habitats (Naiman and Bilby 2001; Hauer and Lamberti 2007). Since most of the detailed geographic data related to aquatic habitat is sparse, or only from localized studies, it often requires using surrogate and/or other measures related to habitat quality. The relationship of the easily identifiable terrestrial habitat and the aquatic can be very complex. Bisson (et al 2009) note the complex spatial and temporal variability in physical processes with respect to fisheries. The connectivity is specifically identified:

> *"The role of physical and biotic connectivity in freshwater ecosystems is widely acknowledged to be essential for maintaining habitat dynamics and species responses. Ecological connectivity is similarly critical for processes essential to the function of freshwater ecosystems, including a wide variety of complex aquatic and terrestrial interactions that regulate channel dynamics, food webs, and water quality (e.g., Naiman and Bilby 1998, Power and Dietrich 2002). Riparian forests on valley floors and on alluvial terraces adjacent to stream channels play an important role in the dynamics of the water table beneath and adjacent to streams, in moderating discharge during flow extremes, in controlling the concentration of soluble nutrients, in mediating the seasonal input of organic matter and terrestrial food items to aquatic ecosystems, and in regulating microclimate (Naiman et al. 2005, Richardson et al. 2005)."*

Additionally, the scale of the analysis has a profound impact on any metric related to measured habitat potential for aquatic species (see Bisson et al 2006 for an additional discussion). The scale for the Portland Metro RCS analysis is at the stream reach, and the relative importance of the hydro-geomorphic factors is critical. Classic methods for fisheries assessment, such as Hankin and Reeves (1988), require detailed sampling, whereas methods like Rosgen Stream Classification are based on geomorphology and generalized patterns (Rosgen and Silvey 1996). Neither of these approaches specifically gets at the project's objectives. Naiman (2001) identifies several scales of biotic stream classifications varying in recovery time and sensitivity to disturbance:

Watershed (10^4 m & 10^6 yrs) >
Stream (10^3 m & 10^5 yrs) >
Segment (10^2 m & 10^3 yrs) >
Reach (10^1 m & 10^1 yrs) >
Habitat (10^0 m & 10^0 yrs)>
Microhabitat(10^{-1} m & 10^{-1} yrs)

The data sets used in this analysis are focused on the stream reach scale with identifying priorities at the habitat scale. The Geographic Information System (GIS) is the tool which can integrate the data using simple spatial relationships and overlays.

GIS tools for fisheries habitat modeling have been used historically in Oregon by Oregon Department of Fish and Wildlife, NOAA Fisheries, StreamNet and others. Various spatial data have been used for evaluating aquatic habitats including: stream depth, velocity (with linkages to hydrologic models [see Merwage et al 2004]), near shore riparian habitat (Reeves et al 1998), channel slope, side slope, floor width, riparian vegetation, and bank material (Grant 1990). The Oregon Department of Environmental Quality routinely uses FLIR remote sensed data on streams to model and evaluate the importance of temperature and near stream shading including Johnson Creek and in the Tualatin River in the Portland Metropolitan area. Total Maximum Daily Load (TMDL) analyses in the lower Willamette Basin demonstrated the significance of riparian communities on the stream thermal budget and the potential relationships for fisheries habitat.

The objective of developing the Swim metric was to leverage existing data covering the entire study area, use physical factors related to the habitat for potential rankings, and to allow easy manipulation of the metrics so multiple scenarios can be assessed and the relative sensitivity for specific parameters can be evaluated. However, we must understand that this is a ranking schema. Karr and Chu (1999) point out that habitat surrogates for aquatic species evaluations do not get at any information regarding the biological resources. Their analogue of a medical doctor examining your workplace and home when you are sick makes us readily understand that there are many other factors that are important in the complex aquatic ecosystem. Therefore the primary objective is to rank potential habitat but to examine the actual habitat in more detail.

Critical Data

There are several types of critical data for building a Swim metric. The readily available data for this project were:

- Hydrographic Network with attributions (for aquatic habitat characteristics)
- Riparian and near shore habitat (compiled from recent INR remote sensed and LIDAR land cover classification).
- Adjunct data related to upland landscape (including soils drainage, elevation)

The first data identifies the primary network of water bodies to be used. There are several common databases for hydrography, which are based on various scales of input data. Some are based on regional databases such as National Hydrographic Dataset (NHD) or Pacific Northwest River Reach data (Stream Net, 1:100,000). Specific attributes like stream characteristics, fisheries data, and water quality limitation (i.e., 303[d] and 305[b]) have been attributed to this data since they have been available for a longer time period. These attributes are not easily transferred and would require conflagration, which is a time-consuming GIS task. A more recent version of the NHD (NHDPlus) was developed by the Environmental Protection Agency and US Geological Survey, which have added many estimated water related parameters including flow rates and velocities. Higher resolution (1:24,000) data and/or detailed LIDAR-based hydrographic networks are also available but do not have attribution. Therefore, acknowledging that it has some limitations, NHDPlus was used as the primary base data for hydrography, and will rank the overall stream reach but not specific components of the reach (as would be done with larger-scale data). Some additional attributes related to fisheries to these NHDPlus line work were transferred[1].

Reach Preference Data

The SWIM metric was computed based on various inputs related to fish habitat preference in the Portland Metropolitan area. The extent of the analysis was based on watershed boundaries and the study area boundary. A primary input geographic dataset is the hydrography network since this limits where fish are located. Attributes for the hydrographic network are compiled from the National Hydrography Dataset (NHD) and from local StreamNet data (using dynamic segmentation based on LLIDs). Where possible, attributes from these datasets were transferred onto common primary stream reaches in the hydrographic network. The primary parameters for determining fisheries preference on each stream segment were:

1. Flow Rate (cubic feet per second [cfs] for contributing area) – from NHDPlus.
2. Flow Velocity (feet per second [fps]for reach) – from NHDPlus.
3. Reach Adjacent Land Uses and Land Covers – from a weighted Manning's *n* on streamside buffers (300 ft either side of stream) for existing land cover (from INR localized classification).
4. Presence and type of fish habitat (Migration, Rearing and Spawning) – from StreamNet's fisheries data for Winter Steelhead. Winter Steelhead has the largest spatial distribution for all salmonid species in the study area.

These data were attributed to the same stream line network: National Hydrography Dataset (NHD). Stream and upstream reach information were attached to downstream reaches as needed in order to represent cumulative conditions. The data were combined into a single composite dataset so that attributes with the stream segments could be queried to allow various ranking methodologies. The underlying goal was to use physical parameters related to water quality/quantity for the fish habitat and physical processes that constrain fish use. Water flow and velocity were compiled from attributes in the NHDPlus database. This dataset (compiled in combinations with USGS, EPA and others) provides a base hydrography with attributes including data from the National Elevation Datasets, National Land Cover

[1] Event based data were transferred to line work by buffering lines and overlaying attributes. Database queries were run for eliminating small line segments. Note that small discrepancies may exist in the datasets due to dynamic segmentation models.

Datasets, Watershed Boundary Dataset as well as climatic data from Parameter-elevation Regressions on Independent Slopes Model (PRSIM) and other data. This information is used to determine flow attributes, catchment characteristics, cumulative drainage, and other attributes assigned to specific reaches. The primary datasets related to fisheries habitat compiled from the NHD included the flow volume and flow velocity. The unit hydrograph method was used for the flow measures in order to have better spatial coverage and because of its common use. Fisheries data (available from StreamNet) were transferred to the arcs by making a Metro-wide, generalized, reach-based, line coverage. Additional information on each parameter is provided in the next sections.

Flow Volume

Stream flows are extremely important in terms of potential aquatic habitat and directly relate to how much habitat is available (Reeves et al 2001). Flow measures the rate of water volume (specifically depth and width) over time. Higher flow rates are associated with larger streams and rivers. The overall flow for all the reaches has a bimodal distribution since small streams exist in the area and several large rivers have lower reaches (i.e., Willamette and Columbia Rivers). The maximum average annual flow from a Unit Hydrograph is 279,115 cfs (for the Columbia) whereas the average is 5.42 cfs (with a standard deviation of 37.23) and the median is 9.8 cfs. These statistics indicate how smaller streams dominate the landscape. To better evaluate this parameter in the metric it was log transformed and normalized.

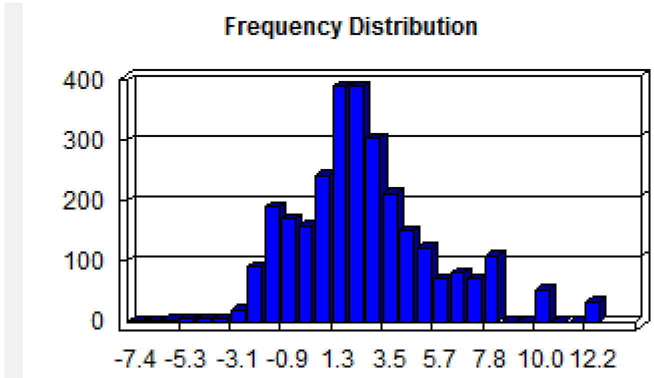
Overall, the larger streams are more critical for aquatic habitats. The small streams often do not support a large diversity of aquatic taxa. An evaluation of the low flow characteristics in the Portland Metropolitan area can be done by reviewing the 7-day, 10-year (7Q10) annual low-flow statistics (Table 1). These are based on an annual series of the smallest values of mean discharge computed over any 7-consecutive days during the annual period (Risley et al 2008) for Portland area streams. Typically, the 7Q10 averages about 10% of the median annual flow rate.

Table 1. Annual low-flow statistics based on 7-day, 10-year (7Q10) in the Portland Area.

usgs	Name	lat	Long	time	7q10
14210000	CLACKAMAS RIVER AT ESTACADA, OR	45.30	122.35	1909-1955	658.10
14242580	TOUTLE RIVER AT TOWER ROAD NEAR SILVER LAKE, WA	46.33	122.84	1982-2005	252.71
14241500	SOUTH FORK TOUTLE RIVER AT TOUTLE, WA	46.32	122.70	1940-1957	66.48
14200000	MOLALLA RIVER NEAR CANBY, OR	45.24	122.69	1929-2005*	45.07
14245000	COWEMAN RIVER NEAR KELSO, WA	46.13	122.84	1951-1982	27.39
14201000	PUDDING RIVER NEAR MOUNT ANGEL, OREG.	45.06	122.83	1940-1965	15.48
14193000	WILLAMINA CREEK NEAR WILLAMINA, OR	45.14	123.49	1935-1991	10.36
14196500	NORTH YAMHILL RIVER NR PIKE, OREG.	45.37	123.29	1941-1951	7.24
14201500	BUTTE CREEK AT MONITOR,OREG.	45.10	122.75	1941-1952, 1967-1985	5.51
14202500	TUALATIN RIVER NR GASTON,OREG.	45.44	123.17	1941-1984*	2.05
14202850	SCOGGINS CR AB HENRY HAGG LAKE NR GASTON, OR	45.50	123.25	1973-1995	0.66
14195000	HASKINS CREEK NEAR MCMINNVILLE, OREG.	45.31	123.36	1929-1951	0.35
14202920	SAIN CR NR GASTON, OR	45.48	123.25	1973-1995	0.12

Flow rates for the Portland Metropolitan streams were log transformed for this analysis (Figure 1). Overall they are very small and may not support many aquatic vertebrates.

Figure 1. The log transformed frequency distribution of Portland Metropolitan stream flow rates.



Flow Velocity

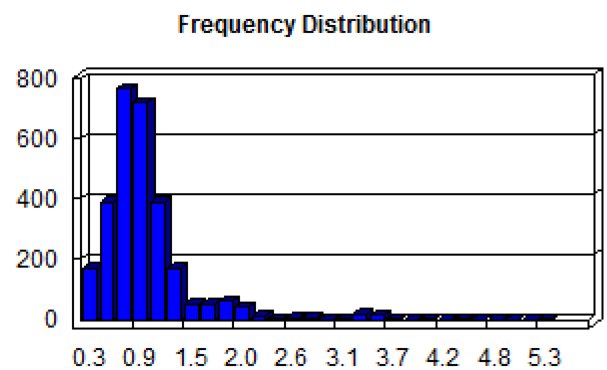
Whereas flow indicates quantity, flow velocity indicates a component of the water quality. Flow velocity and flow volume are not necessarily related to one another. The importance of velocity can be seen from the data in the FishXing database for swim speeds (Furniss et al 2006) since species have specific requirement for optimum habitats. Thirteen common species in the Portland Metropolitan area were extracted from the database and are summarized in the following table (Table 2). Overall, better habitat is typically associated with higher velocity reaches, which most anadromous fish needed in over 5 fps. Many fish species will not reproduce in low velocity streams. For the Portland Metropolitan area streams, the average annual estimated velocity was 1.02 feet per second (with a standard deviation of 0.46 fps; Figure 2). The minimum velocity was 0.35 and the maximum was 5.42. Overall, the stream velocities are on the low end for habitat requirements (Table 2) but are expected to be variable across the flow regime.

Table 2. Stream velocities associated with species (compiled from FishXing Model (Furness et al 2006) database).

Common Name	Studies	Mean	Std Dev	Max.	Min
Steelhead	7	7.12	7.71	20.34	2.19
Coho salmon	9	6.78	7.54	16.01	0.43
Longnose sucker	3	5.96	-	5.96	5.96
Cutthroat trout	3	5.76	3.68	9.99	3.28
American shad	4	4.85	4.22	10.75	1.50
Common carp	4	4.78	2.85	9.00	2.75
Sockeye salmon	13	4.29	2.22	8.40	1.97
Chinook salmon	8	4.11	5.08	14.00	0.46
River lamprey	1	3.61	-	3.61	3.61
Northern pikeminnow	1	3.51	-	3.51	3.51
Pink salmon	6	3.38	4.72	11.35	0.44
Goldfish	3	3.12	1.95	4.49	1.74
Chum salmon	6	2.94	3.48	8.01	0.42
Rainbow trout	7	2.39	0.21	2.62	2.16

Pacific lamprey	4	1.83	1.13	2.83	0.50
Bonytail chub	6	1.80	0.21	2.03	1.54
Three-spined stickleback	1	1.19	-	1.19	1.19

Figure 2. The distribution of the flow velocities in the Portland area are presented in Figure 2.



Streamside Corridors (Reach Level)

The quality and amount of vegetation along streamside corridors impacts the shade on the stream, potential food sources, and acts as a filter for sediment and pollution sources. These factors all impact potential habitat and potential fish assemblages' presences on a reach. Better shaded areas with native species provide potential aquatic habitat including feeding and resting locations for fish species, whereas areas with no shade and low flows are expected to have less refuges.

One of the objectives of the COA mapping project was to link stream reaches to riparian habitats and carry riparian information into the final analysis and mapping in order to evaluate the potential impacts of streamside vegetation. To accomplish this, we created a buffer for all stream reaches, the buffer was 300 feet to either side of all streams, and summarized the streamside vegetation to the buffered area. The 300 foot buffer distance was somewhat arbitrary and could be modified to represent other distances and/or dataset parameters in the future, however, the Swim metric was not highly sensitive to this distance. The buffer retained all stream segment identifiers (i.e., reach's unique label). The reach buffer was overlaid with the detailed INR high spatial resolution land use/land cover map to join each reach with adjacent land covers. Land use/land cover was converted into a quantitative measure of the streamside surface roughness using Manning's *n* and summarized over the buffered area per stream reach.

Manning's *n* is a common measure of surface roughness used in hydrology. The parameter is typically associated with bed or floodplain characteristics (Shen and Julien 1993) as has been empirically determined. Alternatively, Manning's *n* can be estimated using Strickler's Equation using the median sediment size (i.e., D_{50}). Manning's *n* relates to overland flow resistance in the floodplain area associated with the buffers and land covers on the reaches. It was determined using a crosswalk with the land covers (see Table 3) in the buffer on each respective reach. The data was cross-tabulated in a relational database and the attributes summarized by each reach and the areal extent. The maximum weighted

Manning's *n* on a reach was 0.136 (which was dominated large native conifers). The maximum stream side buffer size associated with a reach was 27.5 acres. The smallest weighted Manning's *n* was near 0.015 and associated with water and pavement.

Table 3. Manning's *n* for Portland Metro Stream side buffers of INR land Cover types. Data from Chow/Maidment 1993.

Description	Chow Description	Manning's *n*	Statistic
Open water; also includes darker-colored roads	clean, straight, full stage, no rifts or deep pools	0.030	Normal
Most paved areas	Asphalt (Smooth)	0.013	Normal
Shorter buildings and other structures (e.g., bridges), semi trucks and rail cars; includes some edge portions of the canopies of tall shrubs and short trees (sometimes shadows)	Gravel bottom with sides of gravel	0.020	Normal
Taller >30' buildings and other structures (e.g., bridges); ; includes some edge portions of the canopies of tall shrubs and short trees (sometimes very dark shadows from steep embankments/cliffs)	Concrete bottom float finish with sides of mortar	0.017	Normal
Sparse and/or very short vegetation (e.g., lawn); includes some water with emergent or submersed vegetation, or with overhanging vegetation canopy or shadow being cast on water surface	Pasture, no brush - Short grass	0.030	Normal
Fairly sparse and/or short vegetation (e.g., crops, pastures, lawn, *Phalaris*)	Pasture, no brush - High grass	0.035	Normal
Crops, low shrubs, tall crops, medium-sized shrubs, medium-sized tree regen	mature field crops	0.040	Normal
Conifer woody crops, tall shrubs, small trees, largely tree regen	Trees w/Stumps, but with heavy growth of sprouts	0.060	Normal
Conifers less than 70' tall; includes some broadleaved trees with shaded canopies, adjacent to water, or with bright, sparsely vegetated backgrounds (e.g., in urban environments)	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100	Normal
Conifers 70-120' tall	heavy timber - with flood stage reaching branches	0.120	Normal
Conifers 120'-200' tall	heavy timber - with flood stage reaching branches	0.140	Q3
Conifers > 200' tall, old growth	heavy timber - with flood stage reaching branches	0.160	Max
Woody crops, tall shrubs, small trees (e.g., willow, ash), large tree regen	dense willows, summer, straight	0.150	Normal
Broadleaved trees less than 70' tall (e.g., ash); includes some conifers with brightly illuminated canopies	heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100	Normal
Broadleaved trees 70-120' tall (e.g., red alder)	heavy timber - with flood stage reaching branches	0.120	Normal
Broadleaved trees over 120' tall (e.g., big leaf maple, cottonwood)	heavy timber - with flood stage reaching branches	0.140	Q3
Some cuts detected from 2000 or even earlier, most likely is representative of herbaceous or even shrub by now.	medium to dense brush, in winter	0.058	Q2
Clear cut between 2006 and 2008, most likely is representative of herbaceous or bare ground.	medium to dense brush, in summer	0.085	Q2
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	light brush and trees, in summer	0.050	Q2
Clear cut between 2008 and 2010, representative of bare ground.	light brush and trees, in winter	0.043	Q2
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	scattered brush, heavy weeds	0.050	Normal
Lacustrine	clean, straight, full stage, no rifts or deep pools	0.030	Normal

Description	Chow Description	Manning's *n*	Statistic
Palustrine	very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100	Normal
Riverine	clean, straight, full stage, no rifts or deep pools	0.030	Normal

Fish Habitat Preference

Fish habitat preference data were obtained from StreamNet. For the initial assessment, data from several species were visually examined and winter steelhead was found to have the widest geographical distribution. This data also coincided with species not being present above fish barriers such as dams. We used the following habitat preference value, which we based on the species life stages:

- 1 = No information available
- 2 = Migration Only
- 3 = Rearing and Migration
- 4 =Spawning and Rearing

These relative ranks can be changed to vary the importance of fisheries and/or specific life stages.

Stream Preference

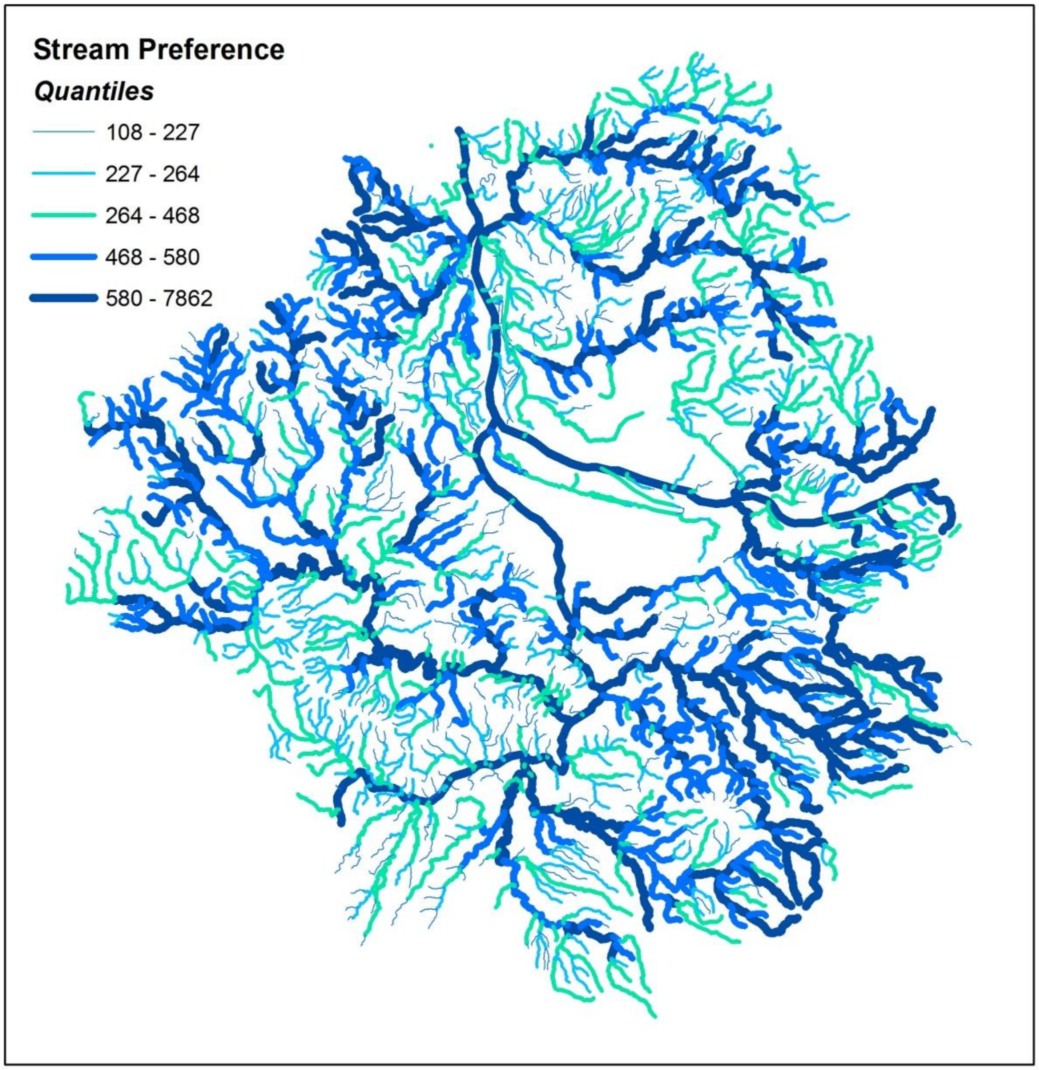
The stream preference input combined fish habitat ranks, flow attributes, and surface roughness (Manning's *n*). This input is used to determine the area over which streamside habitat pixels are analyzed and ranked in the final calculation stage of the Swim metric. The score is essentially used to calculate individualized analysis buffers at the stream reach level so that for any stream reach, the area of analysis will be a function of the habitat it contains, its flow attributes, and the surrounding surface roughness.

The GIS data, and their attributes, were tabulated in a relational database to allow multiple methods of creating ranking scores for potential habitat. For the initial rankings, the stream reaches were assigned a calculated score using the following equation:

$$\text{Stream Preference Score} = f\,(\text{Fish}+[(\text{Log}(\text{flow}/\text{Flow}_{Max}))+(\text{velocity}/\text{Velocity}_{Max})+(\text{Manning}/\text{Manning}_{Max})]*100 + (\text{Flow}_{Max}/3.443)^{0.7875})$$

Numerators and log calculations were used to normalize the flow rate, velocity, and Manning's *n* parameters to a 0 to 1 scale. Habitat was ranked from 1 to 4 for species preference. The raw potential range for the stream preference score was 1 to 7, however, the score for stream preference was modeled to allow values up to 8000 using multiplies (Figure 3), allowing more riparian habitat to be evaluated in areas of higher quality streams for fish preference. Under no circumstances were all parameters ranked at the highest scores. Overall stream headwaters and major rivers such as the Clackamas, Sandy, Tualatin, and Lewis had the highest scores primarily due to the weighting on the fish habitats and flow.

Figure 3. Stream preference scores grouped into quintiles. These values were used to determine the buffer area for habitat rankings developed in subsequent steps. Stream preference scores greater than 600 were associated with the very largest streams (e.g., Willamette River).



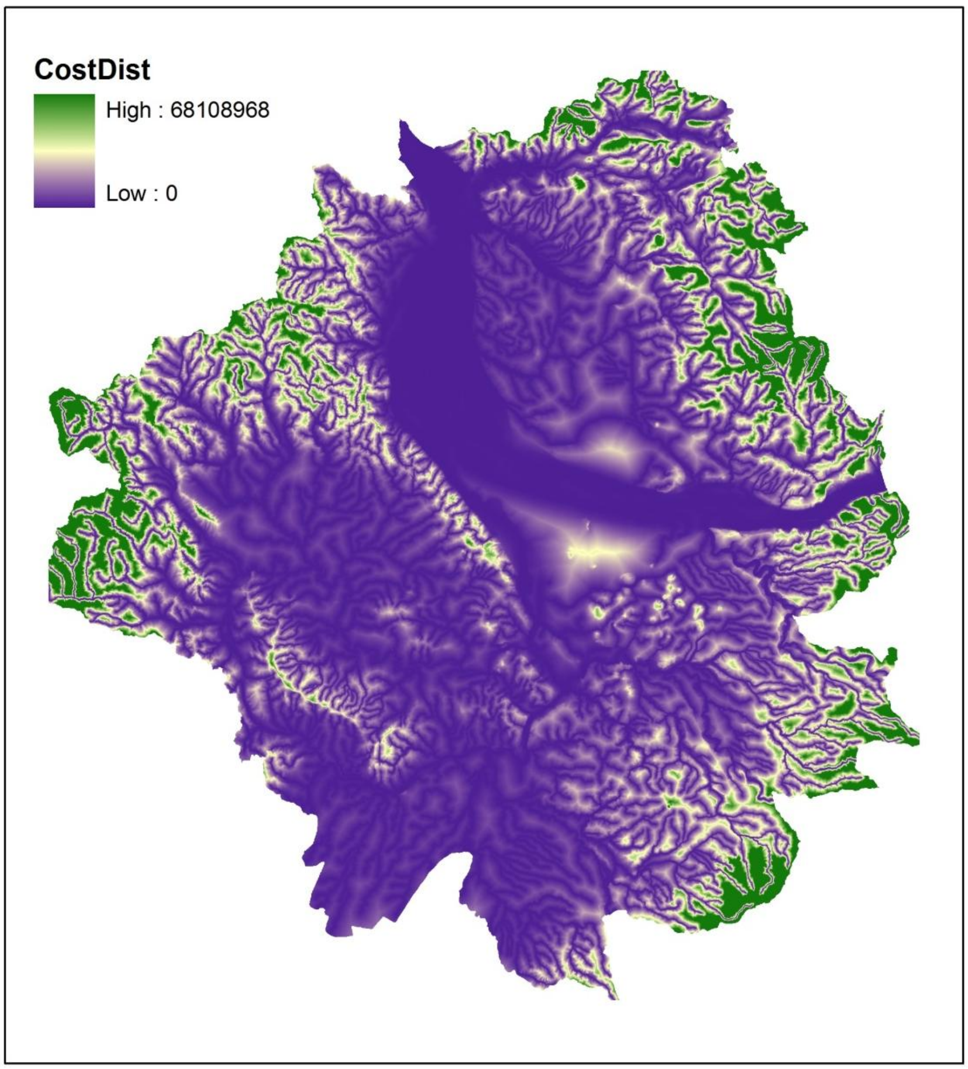
Specific Stream Vegetation

In order to rank riparian habitat in the final steps of creating the Swim metric, land use and land cover data was summarized using the curve number to indicate water infiltration. Habitats were assigned ranks based on the curve number, combined with an indicator of floodplain, and finally combined with the stream preference-derived buffers to identify highly ranking riparian habitats and water bodies based on fish habitats and stream flow.

The buffered stream vegetation characteristics used in the stream preference score used a 300-foot streamside buffer of Manning's *n* to evaluate the overall reach land cover. This does not specifically get at patches, types, and characteristics of the vegetation directly adjacent to the stream segment. For instance, a reach may have both good and poor habitat which need to be specifically evaluated but would be ranked similarly to a reach with moderate habitat across the entire reach. A means for differentiating and refining the stream preference scores was needed. Floodplains are ecologically important features of the landscape and were used to perform this task.

The streamside floodplain and area directly adjacent were determined with raster processing using the cost distance function. Cost distances were calculated from the stream network using elevation as the input surface (Figure 4). The cost distance ensures that areas in close proximity to streams and floodplains were ranked more highly than more distant areas based on elevations and floodplain characteristics in the final Swim metric. Elevation was determined from a 10-meter digital elevation model since more detailed LIDAR is not available for the entire study area. Overall, the floodplains in the lower stream reaches are ranked higher than large floodplains in the Columbia floodplain.

Figure 4. Proximity to streams using elevation as a cost factor for evaluating floodplains. The layer represents the results of a cost distance analysis.



It is well understood that various land covers have different effects on fish habitat. For instance, native vegetation often promotes better quality habitat than developed riparian areas. This can be quantified in many different ways. As a surrogate measure for the quality of the habitat, the runoff curve number was used as a quantitative ranking for the streamside land covers. Curve numbers are commonly used in hydrological and water quality studies for evaluating anthropogenic impacts to stream flow. The curve number reflects the percentage of runoff from various land uses and soils. The detailed county soils survey data (i.e., SSURGO) was used to compile a hydrologic soils group map identifying runoff groups A, B, C, and D. Group A has low runoff potential and high infiltration due to being dominated by deep sands and coarse materials. Correspondingly, Group D has high runoff and low infiltration when wetted due to clay contents (Rawls et al 1993). To build the runoff curve numbers, the soils hydrologic groups were overlayed with the detailed land covers/uses. This composite was combined with information in Table 3 (using the hydrologic group and land use in a two way look up table) to build curves numbers. Table 4 presents the crosswalk used in the analysis. The Curve Numbers were compiled by INR and used with the cost surface, allowing more distance from the stream based on lower costs. For example, native vegetation with small distances from the stream are ranked higher than distant developed and impervious land uses. This analysis allows variable widths to be determined from the elevation (i.e., flood plain zone and the vegetation/land cover types).

Soil Conservation Service (SCS) Curve Numbers can be affected by the soil type, land use, hydrologic condition, and antecedent moisture conditions (Mishra and Singh 2003). Typically, in hydrological assessments wetlands are considered to have high runoff potential (as was used in the initial model runs). However, in terms of the SWIM metric, the better quality habitat is associated with terrestrial areas having a higher infiltration (i.e., lower Curve Numbers). The high runoff curve numbers are associated with two types of impervious runoff: 1) hardened surfaces from development and 2) water. The impervious area from buildings, pavement and other development were maintained at higher values near 99. The water and wetland runoff number were remapped from curve number of 99 to lower values to improve the SWIM metric. Computationally, SCS Curve numbers can range from 15 to 100. All of the wetland/water habitats for the Portland Metro area were mapped to lower Curve Numbers, as defined below (representing a continuum of habitat quality).

- Palustrine - as defined BY NWI data were available = 15. Examples include major and minor emergent, shrub scrub and forested wetlands. Roughly 50,600 acres in Metro area.
- Riverine - as defined by NWI and hydrographic network = 20. Examples are seen in the main stem of Willamette and Columbia River. Roughly 45,500 acres in Metro area.
- Lacustrine - as defined by NWI (using Palustrine unconsolidated bottoms and aquatic beds) and hydrographic network = 25. Examples include Lakes (Oswego, Vancouver, Smith, Bybee), Ross Island Lagoon and other ponds. Roughly 17,500 acres in Metro area.
- Water - as defined by INR remote sensed classification = 22. These are remote sensed as water but no NWI or hydrographic data. Primarily adjacent to other classified water. Roughly 4,900 acres in Metro area.

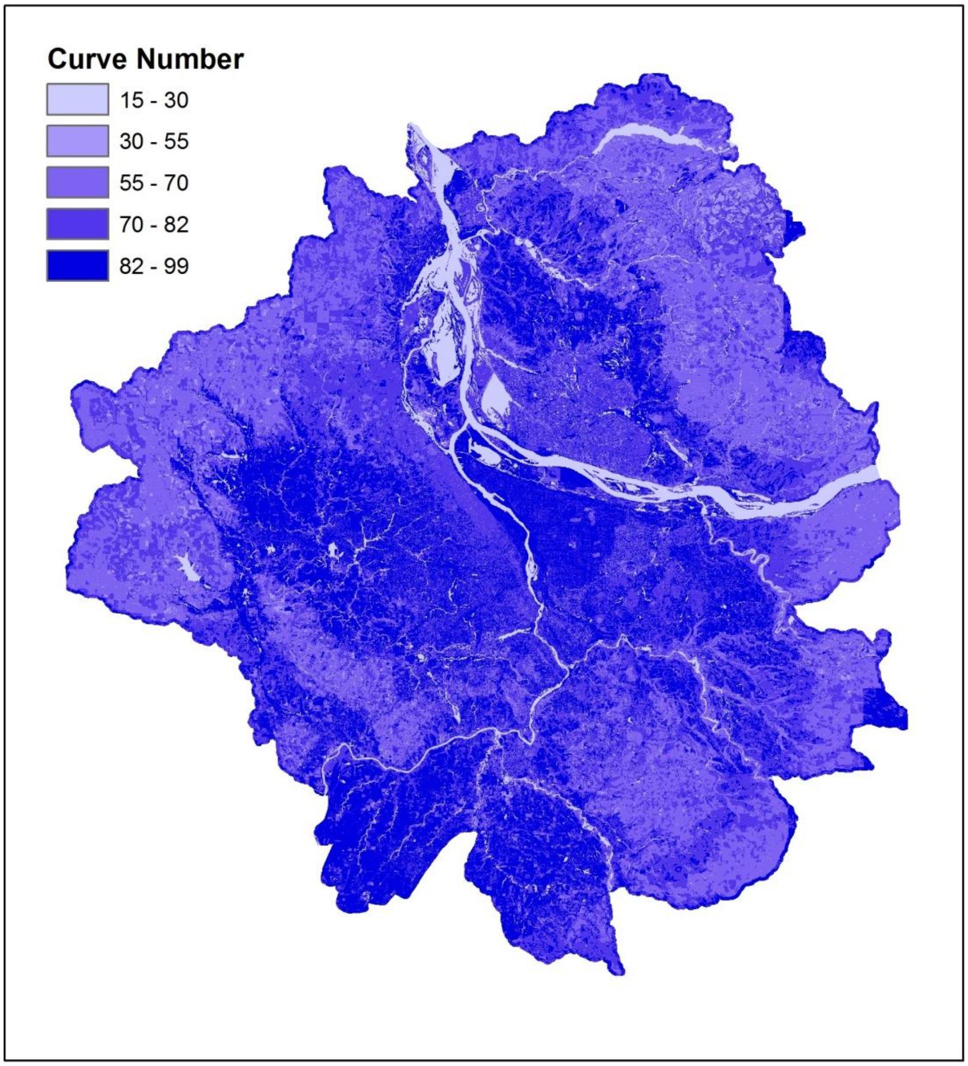
Table 4. Portland Land Covers and Curve Numbers (by SCS Soil Hydrologic Group) from Maidment 1993.

Description	CN Descriptions (SCS)	A	B	C	D
Open water; also includes darker-colored roads	Water	22	22	22	22
Most paved areas and recently disturbed and clear cuts	Streets & Roads - Dirt	72	82	87	89
Shorter buildings and other structures (e.g., bridges), semi trucks and rail cars; includes some edge portions of the canopies of tall shrubs and short trees (sometimes shadows)	Streets & Roads - Gravel	76	85	89	91
Taller >30' buildings and other structures (e.g., bridges); ; includes some edge portions of the canopies of tall shrubs and short trees (sometimes very dark shadows from steep embankments/cliffs)	Streets & Roads - Paved with curbs and storm sewers	98	98	98	98
Sparse and/or very short vegetation (e.g., lawn); includes some water with emergent or submersed vegetation, or with overhanging vegetation canopy or shadow being cast on water surface	Pasture – Poor	68	79	86	89
Fairly sparse and/or short vegetation (e.g., crops, pastures, lawn, Phalaris)	Pasture – Good	39	61	74	80
Crops, low shrubs, tall crops, medium-sized shrubs, medium-sized tree regen	Cultivated Land w/Conservation	62	71	78	81
Conifer woody crops, tall shrubs, small trees, largely tree regen	Brush (good, >75% ground cover)	30	48	65	73
Conifers less than 70' tall; includes some broadleaved trees with shaded canopies, adjacent to water, or with bright, sparsely vegetated backgrounds (e.g., in urban environments)	Woods/Forest Hydrologic Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Conifers 70-120' tall	Woods/Forest Hydrologic Fair (grazing but not burned; some brush) interpolated	41	63	75	81
Conifers 120'-200' tall	Woods/Forest Hydrologic Fair (grazing but not burned; some brush)	36	60	73	79
Conifers > 200' tall, old growth	Woods/Forest Hydrologic Good (no grazing; brush covers ground)	30	55	70	77
Woody crops, tall shrubs, small trees (e.g., willow, ash), large tree regen	Brush (good, >75% ground cover)	30	48	65	73
Broadleaved trees less than 70' tall (e.g., ash); includes some conifers with brightly illuminated canopies	Woods/Forest Hydrologic Fair (grazing but not burned; some brush) interpolated	41	63	75	81
Broadleaved trees 70-120' tall (e.g., red alder)	Woods/Forest Hydrologic Fair (grazing but not burned; some brush)	36	60	73	79
Broadleaved trees over 120' tall (e.g., bigleaf maple, cottonwood)	Woods/Forest Hydrologic Good (no grazing; brush covers ground)	30	55	70	77
Some cuts detected from 2000 or even earlier, most likely is representative of herbaceous or even shrub by now.	Agriculture With conservation treatment (terraces, contours)	62	71	78	81
Clear cut between 2006 and 2008, most likely is representative of herbaceous or bare ground.	Agriculture Without conservation treatment (no terraces)	72	81	88	91
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	Agriculture With conservation treatment (terraces, contours)	62	71	78	81
Clear cut between 2008 and 2010, representative of bare ground.	Agriculture Without conservation treatment (no terraces)	72	81	88	91
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	Agriculture With conservation treatment (terraces, contours)	62	71	78	81

Description	CN Descriptions (SCS)	A	B	C	D
Lacustrine	Water	25	25	25	25
Palustrine	Meadow - Good	15	15	15	15
Riverine	Water	20	20	20	20

The Curve Numbers for Portland metro are presented in Figure 5.

Figure 5. Curve Number in Portland Area (based on INR data and SSURO soils).



The combination of the Path Distance Ranks and Curve Number:

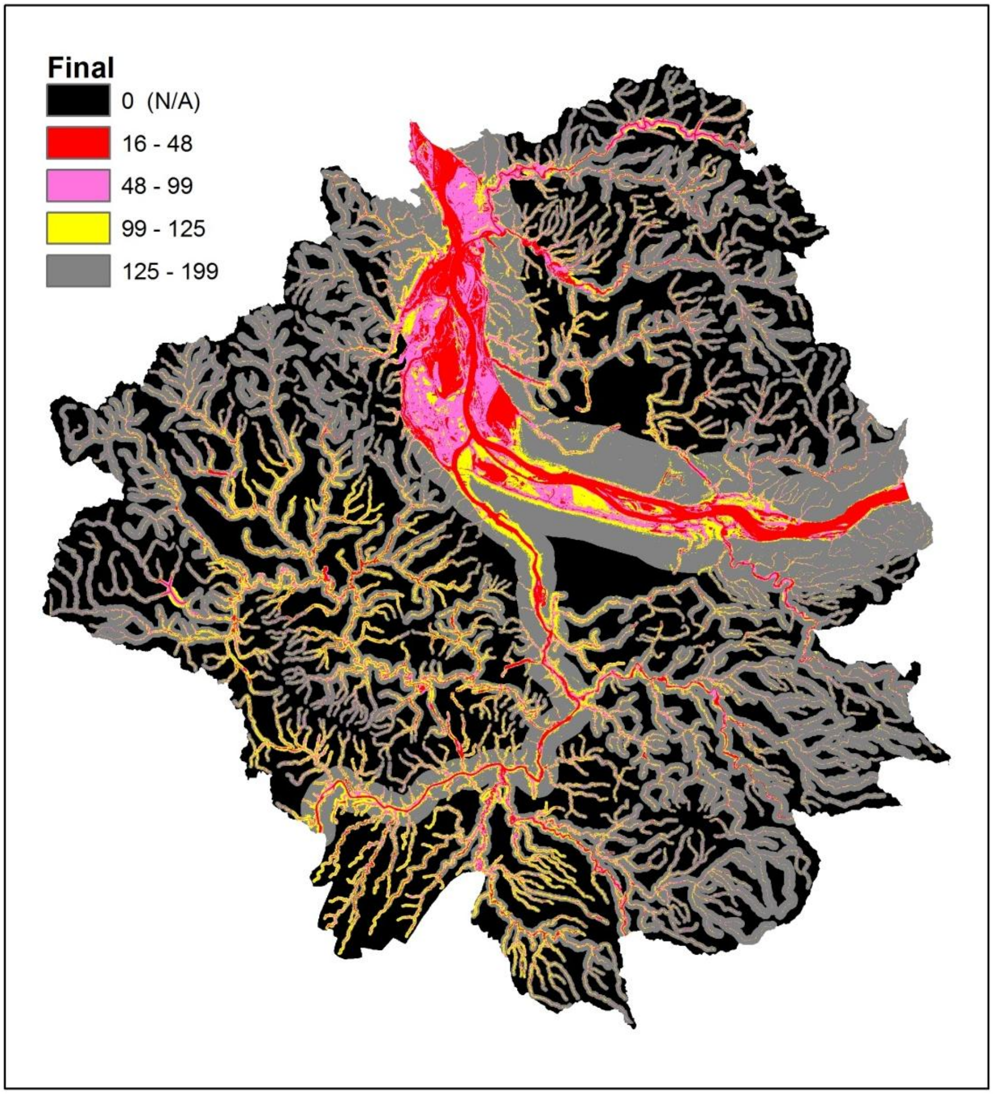
Habitat Score = f(Path Cost Distance + Curve Number).

The metric rank can vary from 0 to potentially 200.

Composite

The final SWIM metric raster was created by overlaying the buffer of the stream preference score with the habitat preference scores (Figure 6). The top categories were converted into a polygon dataset so that it could be used to evaluate parcel sizes, patch configuration, location on the stream, and the number of potential land owners associated with the habitat.

Figure 6. Final raw rankings for streamside habitat and stream channels.



Overall, not many areas are in the best habitat categories (<48 score) and since they are small patches difficult to discern at the regional scale. Several areas are examined at a higher resolution. The score represents the habitat ranked quality but does not get at opportunities. This requires additional detailed data on public versus private ownership and cadastral data, and evaluation of habitat fragmentation. The objectives of preserving existing habitat, or defining area of largest habitat improvements, need to be discerned.

Below are some detailed maps.

Figure 7. SWIM metric for Johnson Creek.

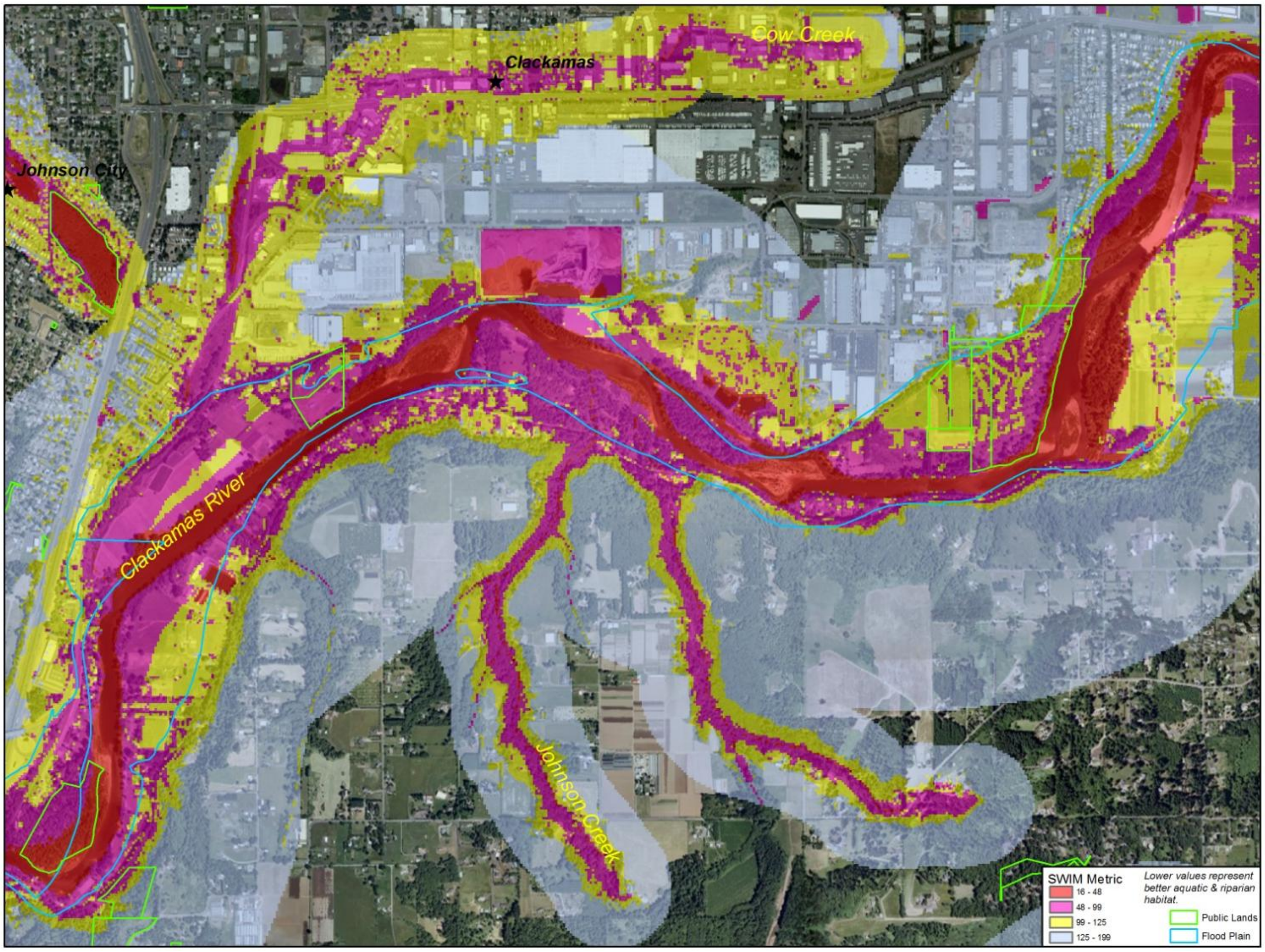


Figure 8. SWIM metric for Sandy River (near the Crown Point Highway Bridge).

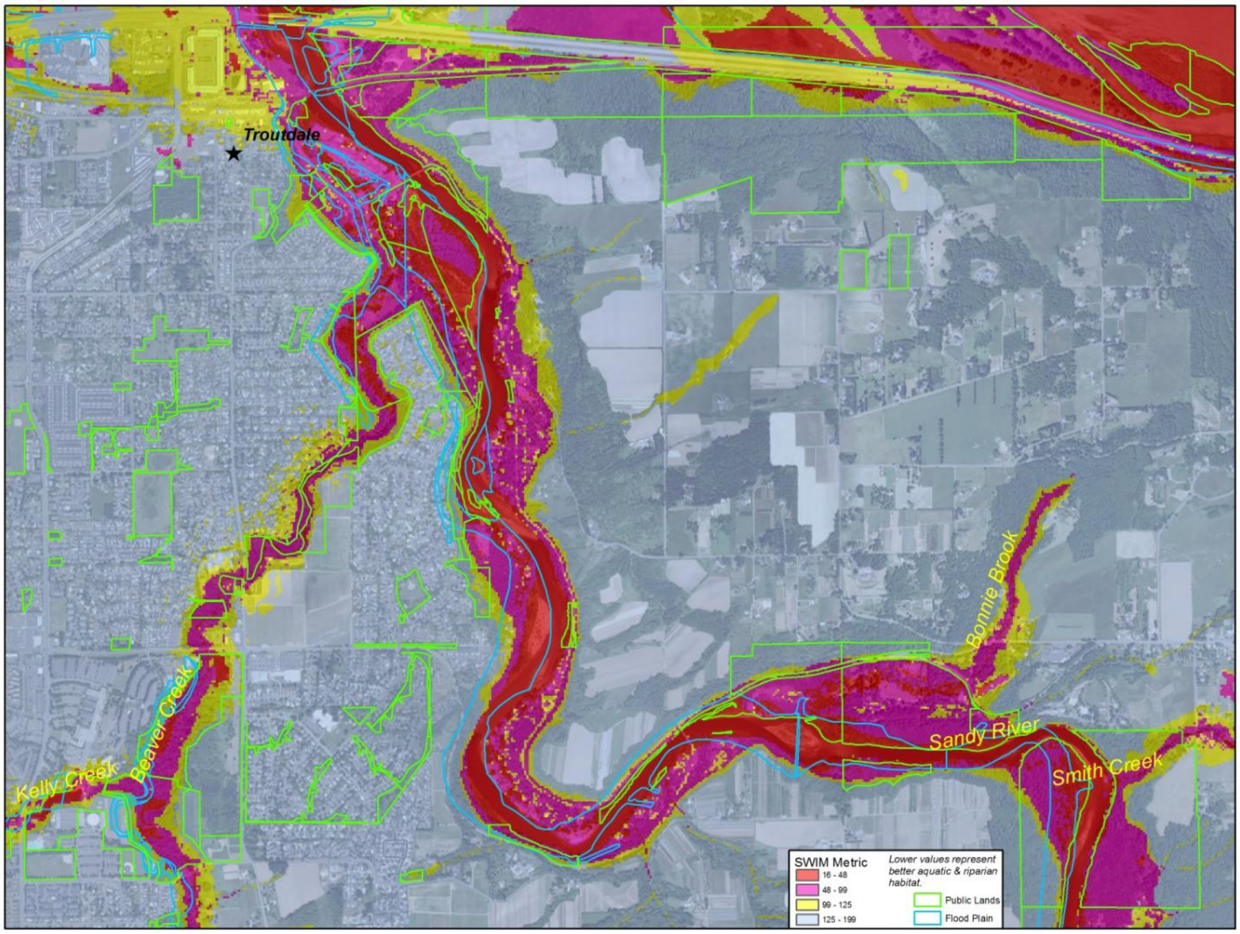


Figure 9. SWIM metric for Hayden Island.

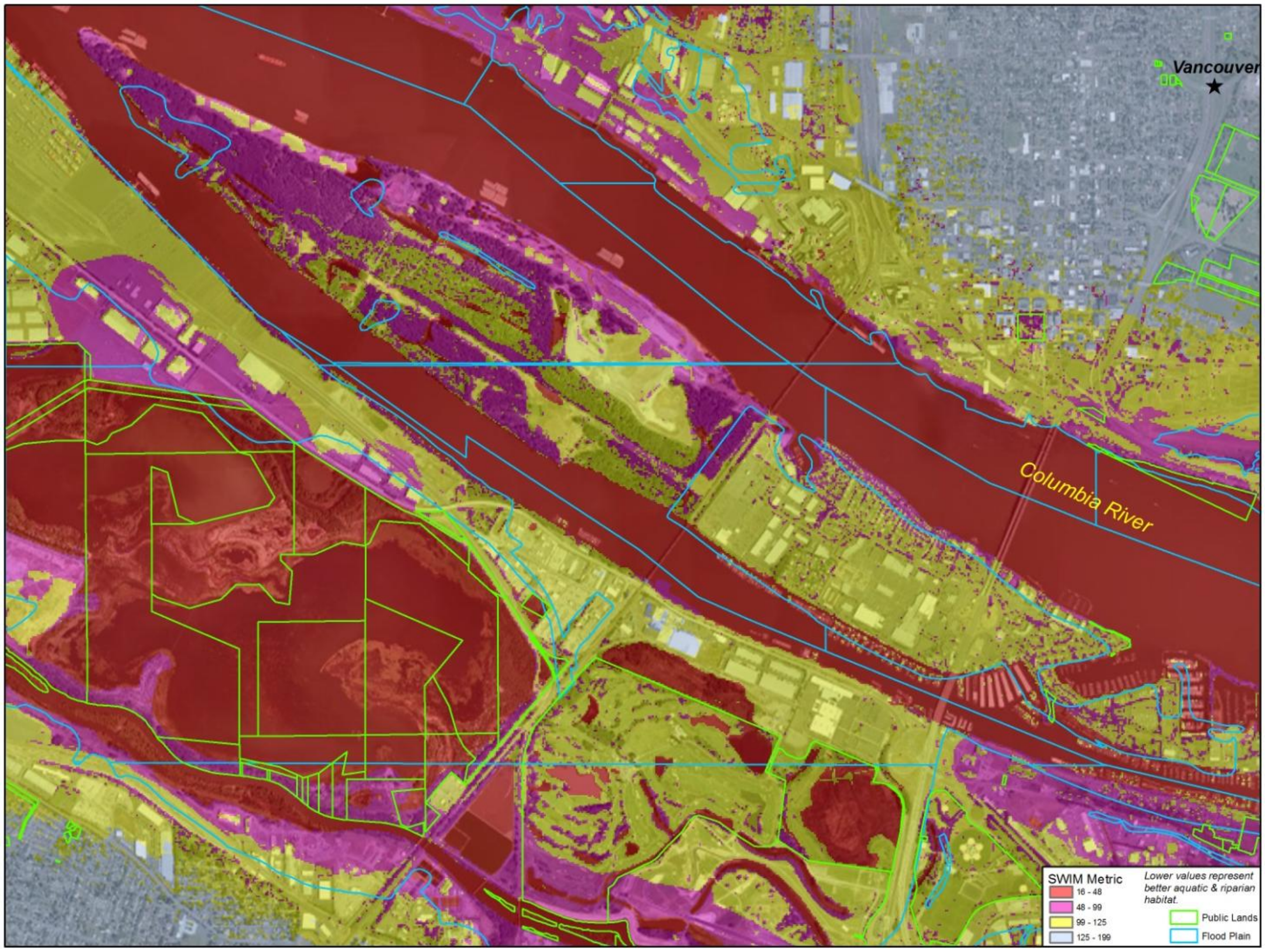
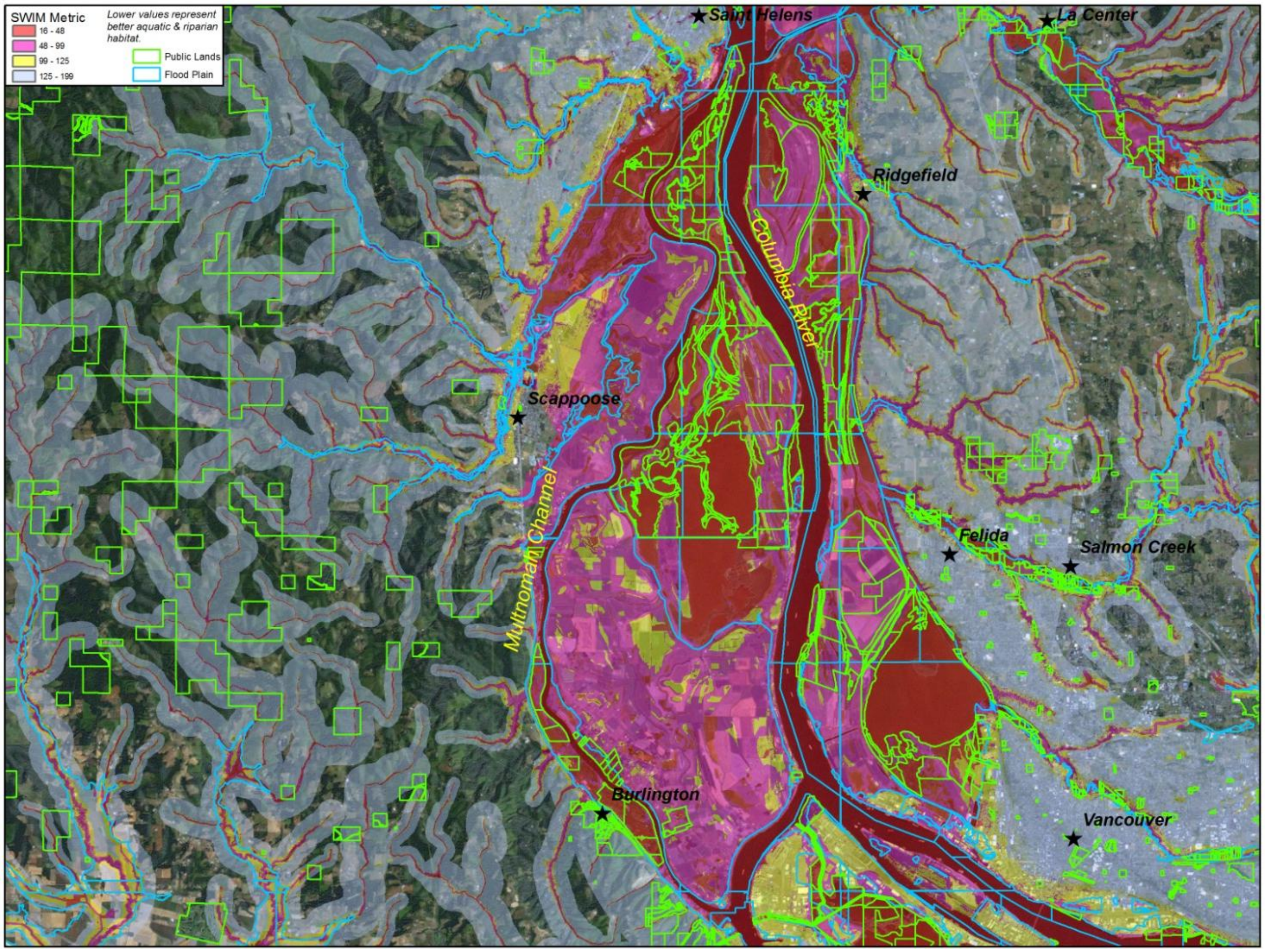
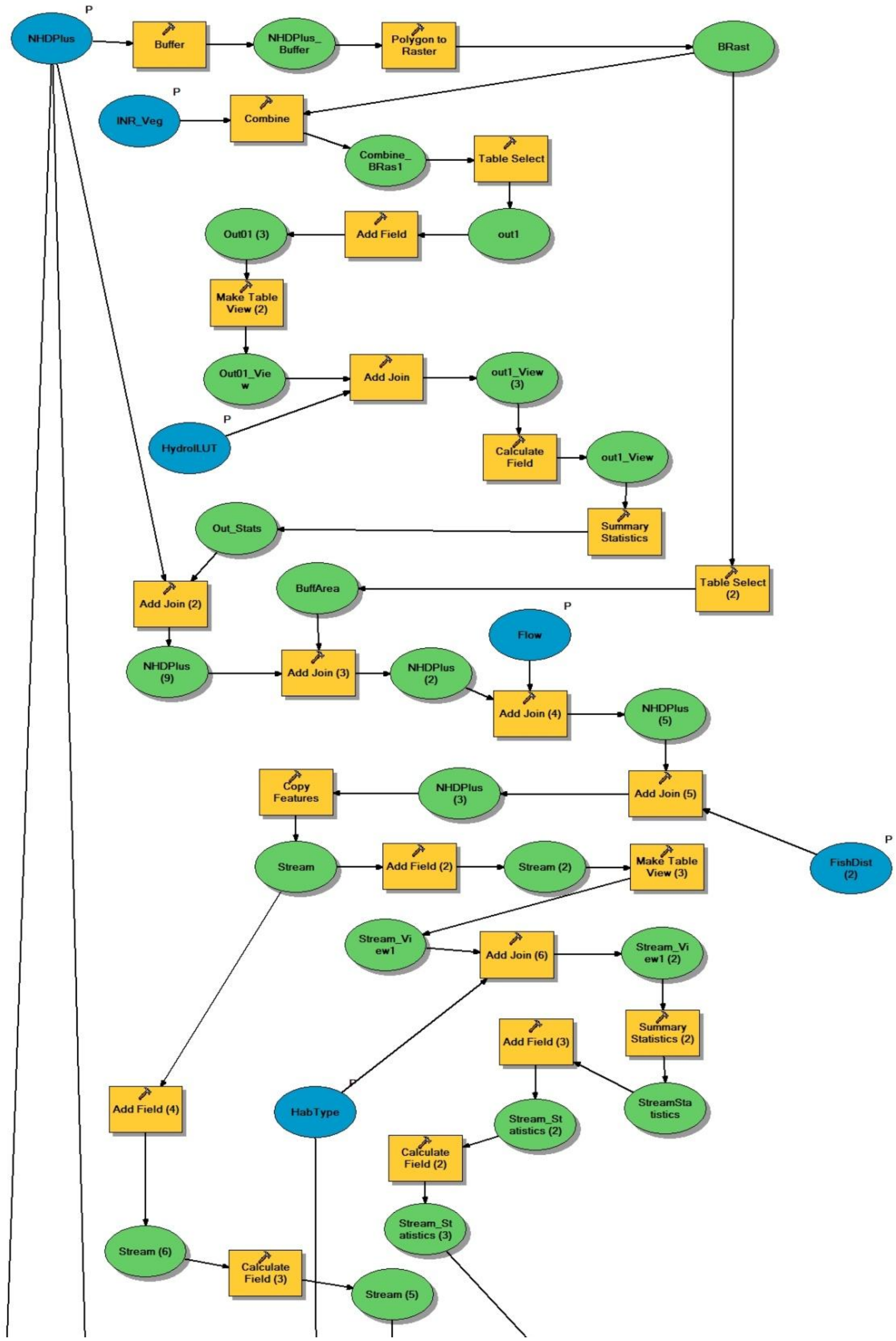
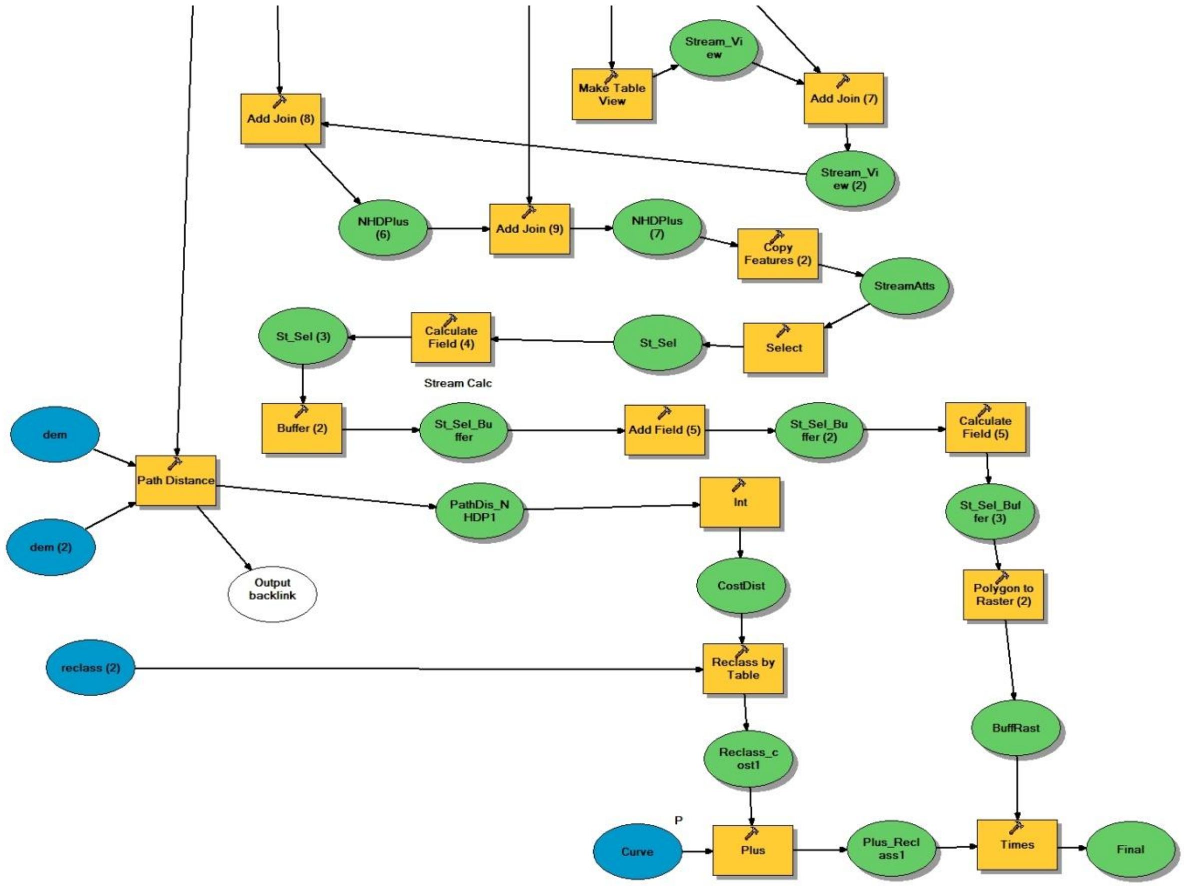


Figure 10. SWIM metric for Sauvie Island.



SWIM Metric GIS Model *(displayed in two pieces)*




Stream_View
Make Table View
Add Join (7)
Add Join (8)
Stream_View (2)
NHDPlus (6)
Add Join (9)
NHDPlus (7)
Copy Features (2)
StreamAtts
St_Sel (3)
Calculate Field (4)
St_Sel
Select
Stream Calc
dem
Buffer (2)
St_Sel_Buffer
Add Field (5)
St_Sel_Buffer (2)
Calculate Field (5)
Path Distance
PathDis_NHDP1
Int
St_Sel_Buffer (3)
dem (2)
Output backlink
CostDist
Polygon to Raster (2)
reclass (2)
Reclass by Table
BuffRast
Reclass_cost1
P
Curve
Plus
Plus_Reclass1
Times
Final

Section 3. The Walk Metric for Terrestrial Organisms

Jennifer Dimicelli and Theresa Burcsu

Assigning Species to Walk and Swim Metrics

Using the species list in the Metro Wildlife corridors and permeability report (April 2010), all non-fish vertebrate species that occur in the metro area, with the exception of exotics and historic occurrences, were assigned to the walk, swim and fly categories. If a species utilized a metric for regular activity, such as foraging, roosting or nesting, it was assigned a value for that metric in order of importance or frequency of use (1 = high use, 2 = occasional or infrequent use, 0 = no use).

Development of Habitat Preference Data

Using habitat suitability index values

Landcover categories were assigned ranks of walk habitat conductance using the Habitat Suitability index values from the Oregon Natural Heritage Program's Westside wildlife habitat relationship (WHR) database. All Metro species that were assigned a walk metric use value of 1 or 2 were queried out of the WHR database so that their Habitat Suitability Index scores could be examined.

Crosswalking land use/ land cover data

Using a crosswalk of Metro landcover types and Johnson & O'Neil Habitat Types to WHR's as a guideline, a crosswalk was created from the landcover categories into representative WHR categories (Table 5).

Assigning Ratings to Landcover Categories

Using the crosswalk of landcover classifications to WHR habitats, a summary of HSI ranks for each habitat type was used to assign ratings to each landcover category (Table 2). For landcovers with > 75% of species ranking that habitat as good or fair, the rating was assigned a 5. For landcovers that were fair or good for 70-75% of species, the rating is 4. For landcovers that were fair or good for 50-70% of species, the rating is 3. For landcovers that were fair or good for 35-50% of species, the rating is 2. Finally, water was the only landcover with <35% of species for which this habitat was ranked fair or poor, and this was assigned a rating of 1. The road class was not evaluated on its own, but will be given a value of 0, as it is likely a barrier for many species.

Table 5. Crosswalk of Landcover categories to representative Wildlife Habitat Relationship (WHR) categories and natural vs semi-natural habitat types.

Value	Landcover	WHR Category	WHR Name	Natural/Semi-Natural
1	Open water; also includes darker-colored roads	-	-	
2	0-2.5' Most paved areas and recently disturbed and clearcuts	-	-	
3	10'-30' Shorter buildings and other structures (e.g., bridges)	-	-	
4	> 30' Taller >30' buildings and other structures (e.g., bridges)	-	-	
5	0 - 2.5 'Sparse and/or very short vegetation (e.g., lawn)	60	Parks/Open Space	semi
6	2.5' - 5' Fairly sparse and/or short vegetation (e.g., crops, pastures, lawn, Phalaris)	60	Parks/Open Space	semi
7	5' - 13' Crops, low shrubs, tall crops, medium-sized shrubs, medium-sized tree regen	17	Early Shrub-Tree	semi
8	14' - 30' Conifer woody crops, tall shrubs, small trees, largely tree regen	17	Early Shrub-Tree	semi
9	30' - 70' Conifers less than 70' tall; includes some broadleaved trees with shaded canopies	18	Mixed Hardwood-Conifer	natural
10	70' - 120' Conifers 70-120' tall	33	Douglas-fir - Western Hemlock Forest	natural
11	120' - 200' Conifers 120'-200' tall	33	Douglas-fir - Western Hemlock Forest	natural
12	> 200' Conifers > 200' tall	33	Douglas-fir - Western Hemlock Forest	natural
13	14 - 30' Woody crops, tall shrubs, small trees (e.g., willow, ash), large tree regen	17	Early Shrub-Tree	semi
14	30' - 70' Broadleaved trees less than 70' tall (e.g., ash); includes some conifers with brightly illuminated canopies	18	Mixed Hardwood-Conifer	natural
15	70' - 120' Broadleaved trees 70-120' tall (e.g., red alder)	18	Mixed Hardwood-Conifer	natural
16	> 120' Broadleaved trees over 120' tall (e.g., bigleaf maple, cottonwood)	18	Mixed Hardwood-Conifer	natural
17	Cut before 2006	17	Early Shrub-Tree	semi
18	Cut 2006-2008	17	Early Shrub-Tree	semi
19	Partial cut 2006-2008	33	Douglas-fir - Western Hemlock Forest	natural
20	Cut 2008 - 2010	17	Early Shrub-Tree	semi
21	Partial cut 2008-2010	33	Douglas-fir - Western Hemlock Forest	natural
22	Recode:0 - 2.5 'Sparse and/or very short vegetation	60	Parks/Open Space	semi
23	lacustrine wetland	-	-	
24	paulistrine wetland	15	Marsh/Bog/Emergent Wetland	natural
25	riverine wetland	-	-	

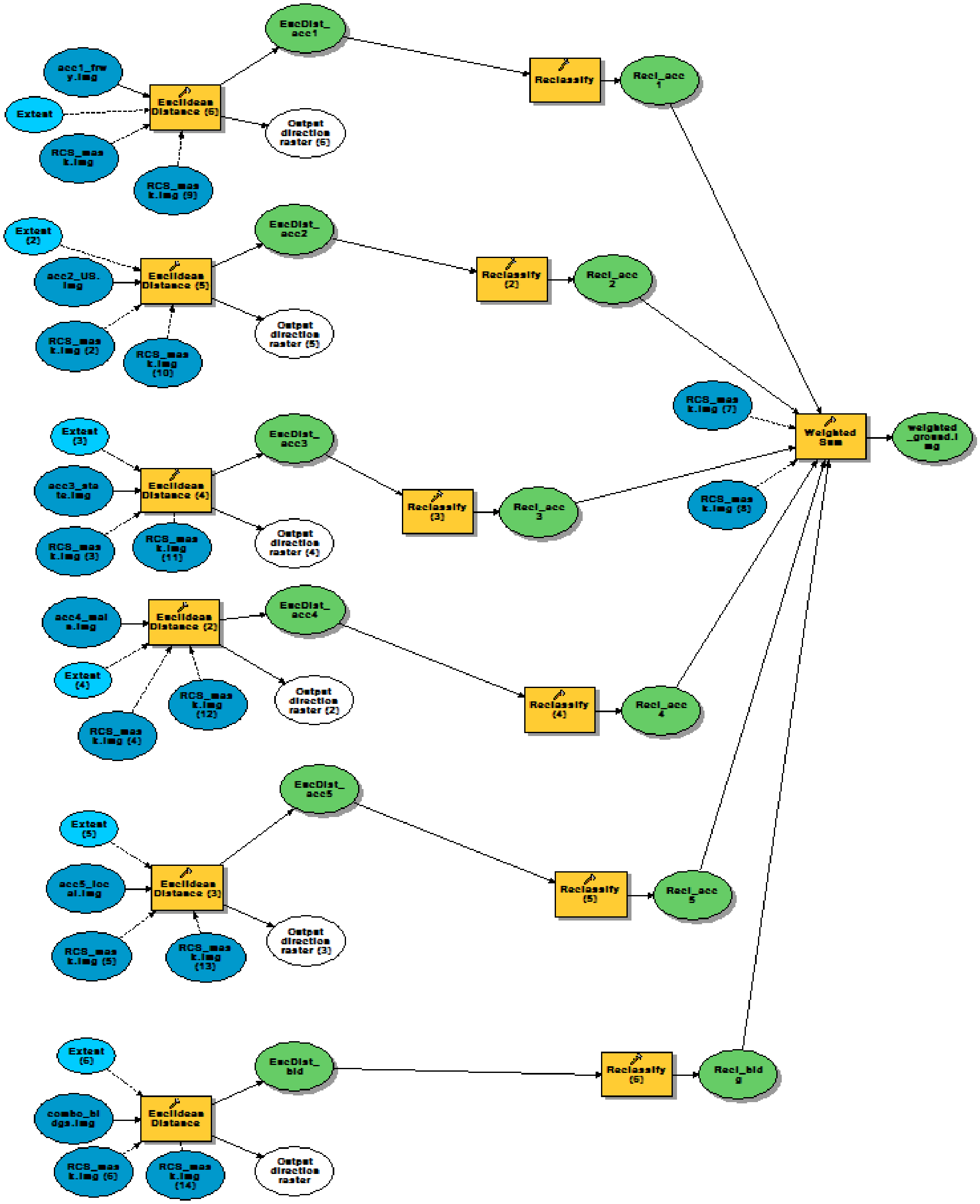
Table 6. Number of species (n=147) that fell under each HSI category and the final Habitat Rating for each habitat, as well as the cost assigned to each land cover.

	Habitat Suitability Index					Final Habitat Rank	Other Assignments
Land use/land cover class	Not-Habitat	Poor	Fair	Good	*Summary* % Good and Fair		Resistance
Broadleaf (>120')	30	2	24	91	78%	5	1
Broadleaf (30-70')	30	2	24	91	78%	5	1
Broadleaf (70-120')	30	2	24	91	78%	5	1
Conifers (>200)	32	0	43	72	78%	5	1
Conifers (120-200')	32	0	43	72	78%	5	1
Conifers (30-70') Includes some Broadleaves	30	2	24	91	78%	5	1
Conifers (70-120')	32	0	43	72	78%	5	1
Conifers Small Shrubs/ Low Shrubs/ Willow (14-30')	35	8	38	66	71%	4	3
Crops/ Low Shrubs/ Tree Regeneration (5-13')	35	8	38	66	71%	4	3
Harvested 2006-2008	35	8	38	66	71%	4	3
Harvested 2008-2010	35	8	38	66	71%	4	3
Harvested Before 2006	35	8	38	66	71%	4	3
Mostly Broadleaves (14-30')	35	8	38	66	71%	4	3
Partial Harvest 2006-2008	32	0	43	72	78%	5	1
Partial Harvest 2008-2010	32	0	43	72	78%	5	1
Paved Roads / Bare Soil / Clearcuts	-	-	-	-	-	0	10 – 100,000
Recode - Sparse Short Vegetation/ Crops/ Pasture/ Lawn (2.5-5')	67	7	65	8	50%	3	5
Short Development (10-30')	85	9	45	8	36%	2	100,000
Short Vegetation (0-2.5')	67	7	65	8	50%	3	5
Sparse Short Vegetation/ Crops/ Pasture/ Lawn (2.5-5')	67	7	65	8	50%	3	5
Tall Development (30'+)	85	9	45	8	36%	2	100,000
Water	101	1	14	31	31%	1	10
Lacustrine Wetlands	101	1	14	31	31%	1	10
Riverine Wetlands	101	1	14	31	31%	1	10
Paulistrine Wetlands	53	5	34	43	57%	3	4

Ground Condition

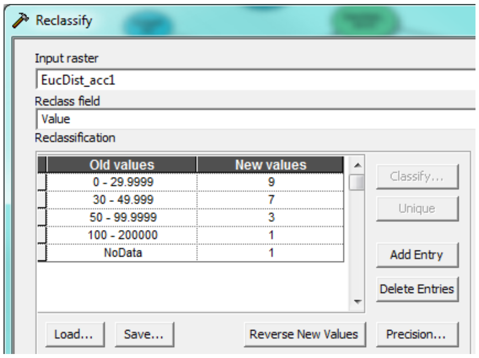
To get at a measurement of ground condition, distance to 5 categories of roads and distance to buildings rasters were created using the ArcGIS Spatial Analyst Euclidean Distance tool. These were then reclassified to values from 0-9, and a weighted sum of these reclassified layers was calculated. For the base layers, the 2005 Esri roads layer provided by Tommy was rasterized, and a combined Metro and Clark County buildings layer was mosaiced with buildings extracted from landcover raster in order to provide the most complete coverage of the available buildings datasets.

Figure 11. Model of Ground Condition



Inputs to model:

ACC1_frwy:



Reclassify

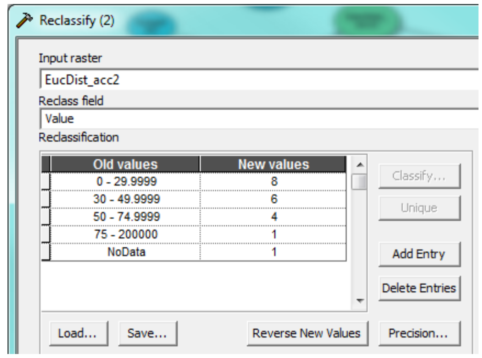
Input raster: EucDist_acc1

Reclass field: Value

Reclassification

Old values	New values
0 - 29.9999	9
30 - 49.999	7
50 - 99.9999	3
100 - 200000	1
NoData	1

ACC2_US:



Reclassify (2)

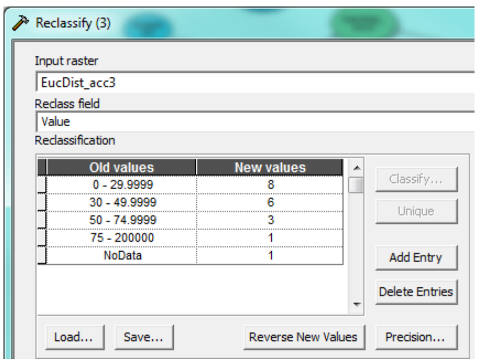
Input raster: EucDist_acc2

Reclass field: Value

Reclassification

Old values	New values
0 - 29.9999	8
30 - 49.9999	6
50 - 74.9999	4
75 - 200000	1
NoData	1

ACC3_state:



Reclassify (3)

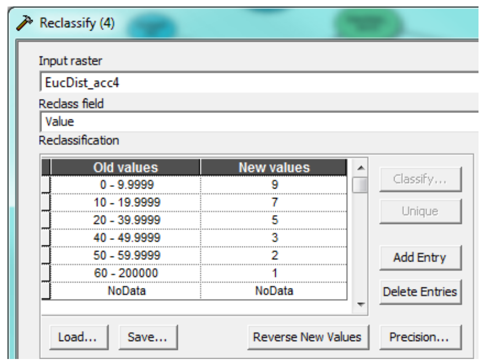
Input raster: EucDist_acc3

Reclass field: Value

Reclassification

Old values	New values
0 - 29.9999	8
30 - 49.9999	6
50 - 74.9999	3
75 - 200000	1
NoData	1

ACC4_main:



Reclassify (4)

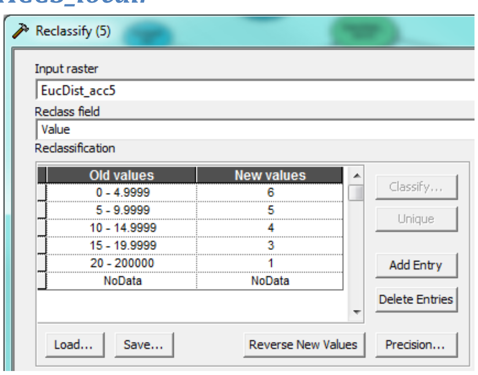
Input raster: EucDist_acc4

Reclass field: Value

Reclassification

Old values	New values
0 - 9.9999	9
10 - 19.9999	7
20 - 39.9999	5
40 - 49.9999	3
50 - 59.9999	2
60 - 200000	1
NoData	NoData

ACC5_local:



Reclassify (5)

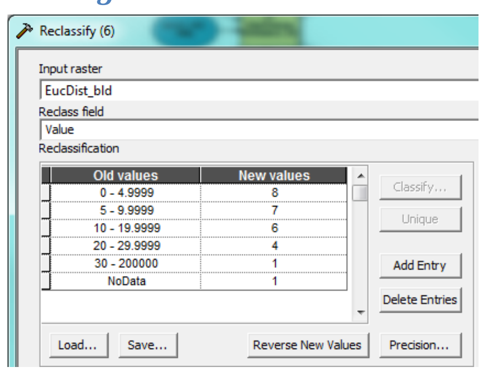
Input raster: EucDist_acc5

Reclass field: Value

Reclassification

Old values	New values
0 - 4.9999	6
5 - 9.9999	5
10 - 14.9999	4
15 - 19.9999	3
20 - 200000	1
NoData	NoData

Buildings:



Reclassify (6)

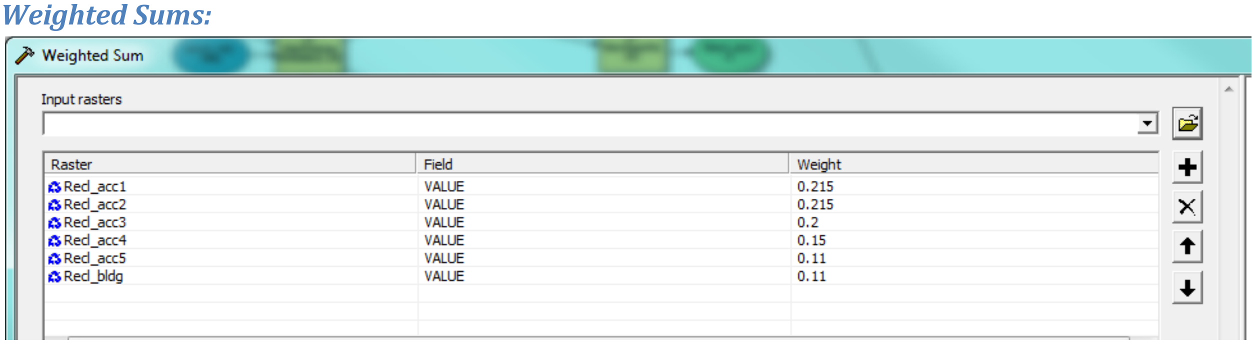
Input raster: EucDist_bld

Reclass field: Value

Reclassification

Old values	New values
0 - 4.9999	8
5 - 9.9999	7
10 - 19.9999	6
20 - 29.9999	4
30 - 200000	1
NoData	1

Weighted Sums:



Weighted Sum

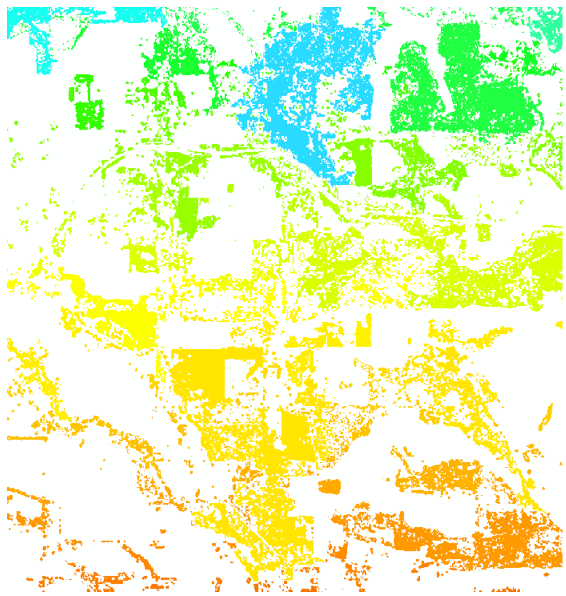
Input rasters

Raster	Field	Weight
Recl_acc1	VALUE	0.215
Recl_acc2	VALUE	0.215
Recl_acc3	VALUE	0.2
Recl_acc4	VALUE	0.15
Recl_acc5	VALUE	0.11
Recl_bldg	VALUE	0.11

Habitat Patches

Habitat patches were created for both natural and semi-natural landcover types as well as for the following five WHR categories: Parks/Open Space, Early Shrub-Tree, Mixed Hardwood-Conifer, and Douglas-fir - Western Hemlock Forest, and wetlands (Table 6). For WHR patches, the landcover raster was reclassified to WHR habitat types, and each habitat type was extracted and then grouped into patches using the Region Group tool with the eight neighboring cell connectivity option.

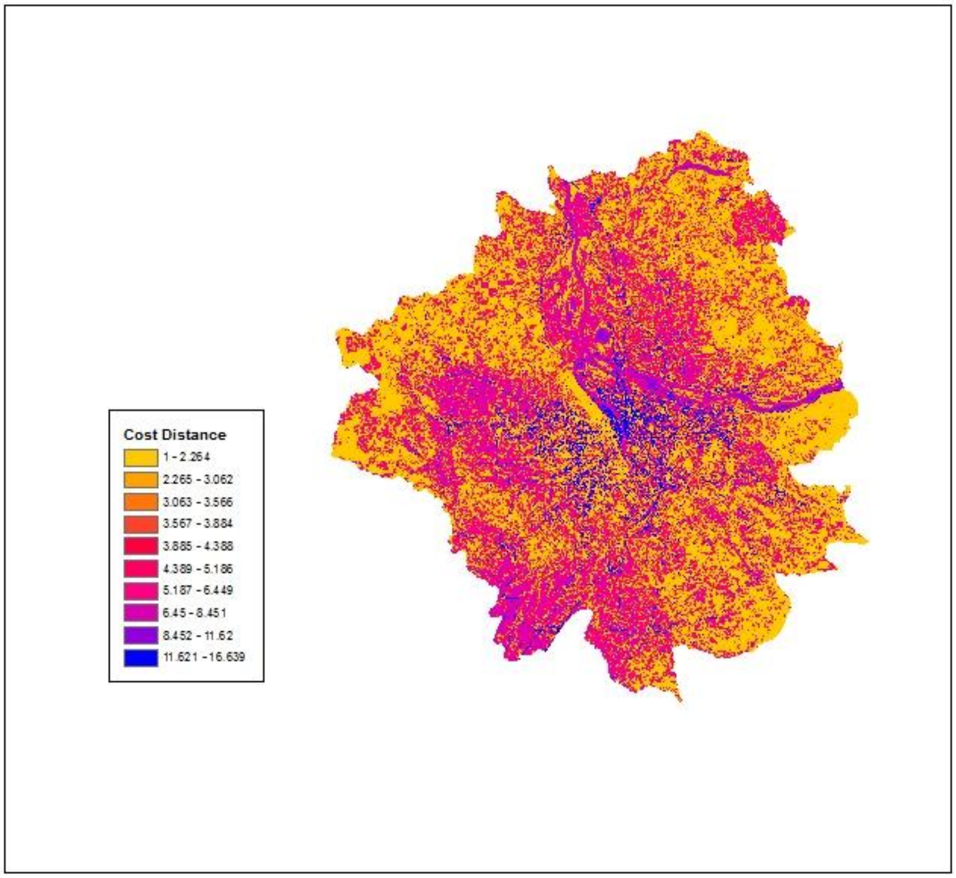
Figure 12. Habitat patches of WHR category Mixed Hardwood-Conifer. Each region/patch is represented in the figure by a unique color and has been assigned a unique identifier.



Connectivity using Cost-Distance

Connectivity was incorporated into the model using a cost distance raster. The cost raster was created by assigning costs to landcover categories based on the ratings they received in the HSI evaluation (Table 2). The costs assigned to each landcover range from 1 for the least cost and 10 for the highest. Instead of using no data for the roads and buildings to make them an absolute barrier, a value of 100,000 was assigned to freeways and highways, as well as buildings, and a value of 10,000 was assigned to major roads, as was recommended by Jeff Lin in the manual for the Linkage Mapper tool, which we may consider using for further analysis. A cost-distance raster was created using the Spatial Analyst tool as a measure of friction between patches classified as natural vegetation. This dataset was scaled using the ln tool.

Figure 13. Cost distance raster of costs between patches of the natural.



A major challenge of the terrestrial analysis has been use of the Circuitscape software. The use of Circuitscape and other ancillary software was identified as a potential project limitation in the project scope. The software has size limitations beyond which it cannot function. Our input datasets surpass those limits by an order of magnitude. Given the time frame defined by the scope of work, we were unable to determine workarounds that would allow the successful implementation of Circuitscape. In lieu, we have provided the cost distance data layer to represent connectivity between patches in terms of habitat friction.

Patch Size

Weighted patch size

Patch size is an important habitat characteristic for wildlife. The RCS members are interested in identifying patches that are large in their respective neighborhoods. This means that in locales where there are many, relatively small patches, i.e., patch density is high such as in the urban neighborhoods, RCS would like to identify the largest of these smaller patches. RCS also would like to have patches identified that are large at the scale of the Portland-Vancouver metropolitan region.

To accomplish this goal, patches were delineated to create patch maps for natural and semi-natural vegetation. The habitat patch maps were filtered using a majority filter (3x3) to remove one-pixel patches and holes in larger patches. More importantly, this step reduced the total possible number of patches and subsequent processing time. The filtered patch maps were used to develop layers representing patch area with one layer per habitat type and one layer representing all four habitat types in combination.

A patch density map was developed from the combination patch map containing all four habitat types. The all habitat-type patch map was coarsened from a 5 m to 20 m cell size. This step facilitates processing time. Patch density was calculated using a 1 km^2 (51 x 51 cell) moving window. For this analysis, the moving window identifies alls patches that occur within its boundaries and assigns the central cell the total number of patches identified, yielding an estimate in units of number of patches per square kilometer. The patch density map was resampled to a 5 m cell size, squared to emphasize higher patch densities. The scaled patch density map was multiplied by the patch area map to produce the weighted patch size layer. The weighted patch size layer converted to an integer layer for further processing and viewing purposes.

$$Weighted\ Patch\ Size = \ln(PA * PD^2)$$

Metric Calculation

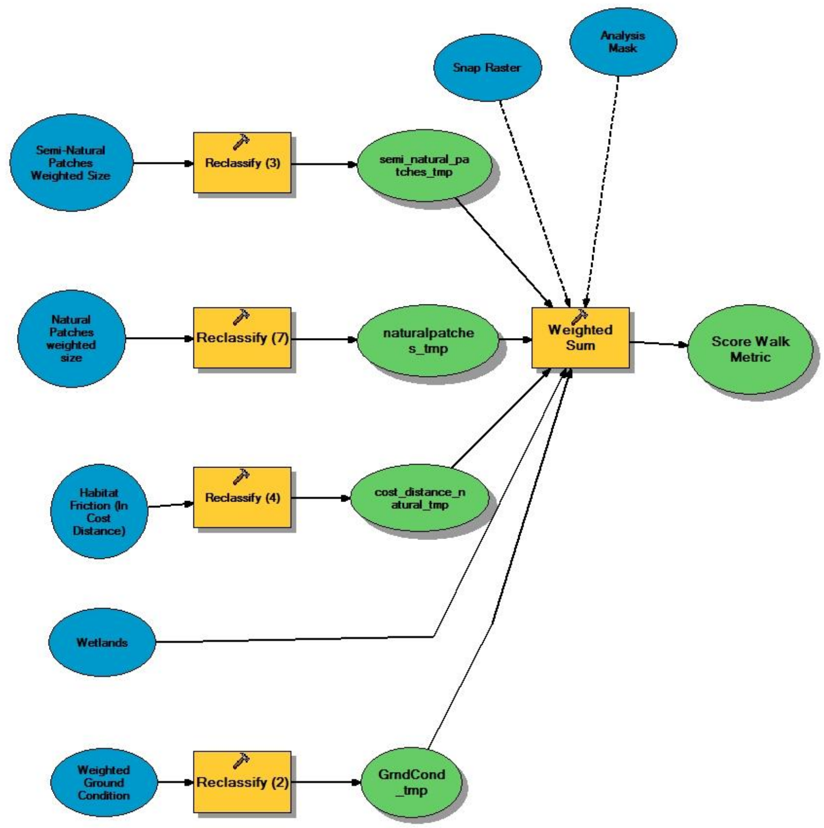
The walk metric combines five data input layers additively, using the weighted sum function. Each data input is composed of large numbers of values that have been reclassified (1-10) using deciles or geometrical intervals. The exception to this is wetlands, which were all given a value of 10. The classification of values is something that can be altered to better reflect the ecological processes and to calibrate the model. Three different weighting schemes were attempted to alter the importance of wetlands in the final metric (Table 7).

$$\text{Walk} = (\text{Habitat friction} + \text{Ground Condition} + \text{Natural Vegetation}_{\text{patch size}} + \text{Semi-natural Vegetation}_{\text{patch size}} + \text{Wetlands}) / 5$$

Table 7. Weights applied to inputs in the walk metric. We explored several weighting schemes for wetlands.

Input	Score 3.8		Score 3.9		Score 3.10		Score 3.11	
	Wt	Scheme 1	Wt	Scheme 2	Wt	Scheme 3	Wt	Scheme 4
Habitat Friction	1	0.225	1	0.2375	1	0.215	1	0.21
Ground Condition	1	0.225	1	0.2375	1	0.215	1	0.21
Semi-natural patch size	1	0.225	1	0.2375	1	0.215	1	0.21
Natural patch size	1	0.225	1	0.2375	1	0.215	1	0.21
Wetlands	0.44	0.1	0.21	0.05	0.65	0.14	0.8	0.17
Sum	4.44	1	4.21	1	4.65	1	4.8	1.01

Figure 14. Model of walk metric.



Classifications used to rank values in habitat types

Habitat types were reclassified to normalize and rank values from 1-10. Using the 1-10 range allows data sets to remain as integer data and still retain variability. Another advantage of using 10 classes opposed to more is that the classes are easier to understand when combined.

Figure 15. Semi-natural habitat patches.

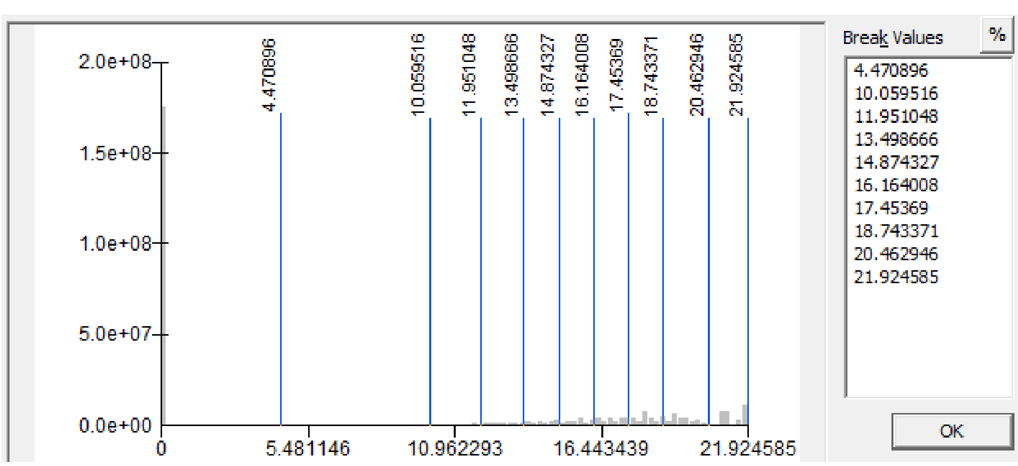


Figure 16. Natural habitat patches.

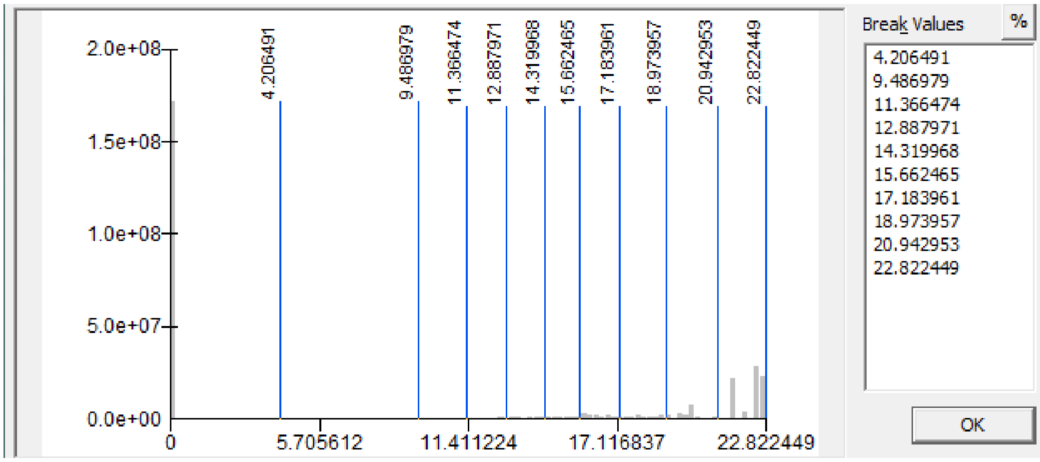


Figure 17. Habitat Friction

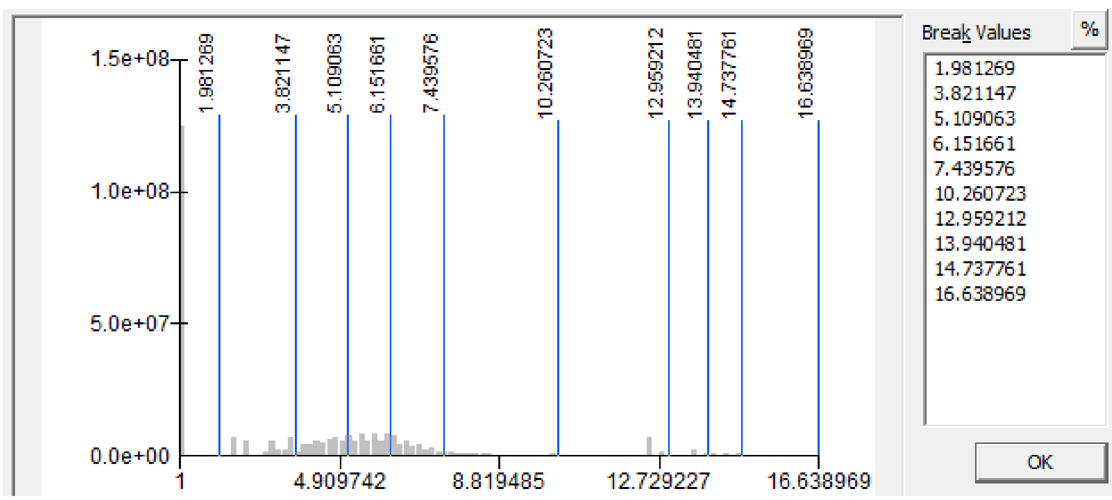
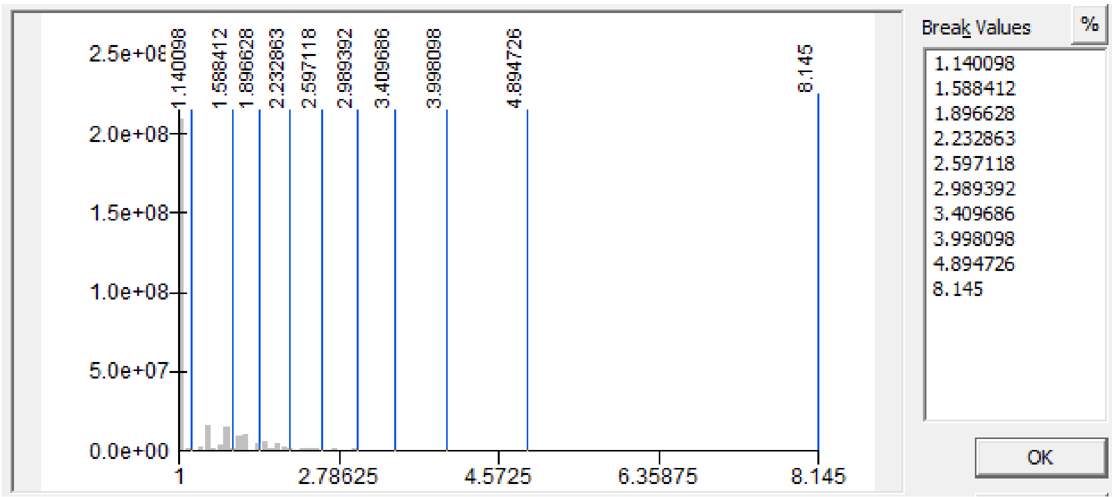


Figure 18. Weighted ground condition.



Section 4. Mapping the Conservation Opportunity Areas

Calculating the COA

The COA calculation was performed by scaling the metrics to have the same value range. The Walk metric was rescaled to match the Swim metric's range of values (0 – 200) by using the range over which the Walk metric varied and remapping the raw values to the range divided by 200 (Equation 1). The metrics were also scored using the reversed rankings; the Swim metric best scores were low values while the Walk metric best scores were high values. The Swim metric values were remapped so that both metrics ultimately have the best scores represented by the highest values.

$$Scaling\ factor = \frac{(high - low)}{200} \qquad \textbf{(}\text{Equation 2)}$$

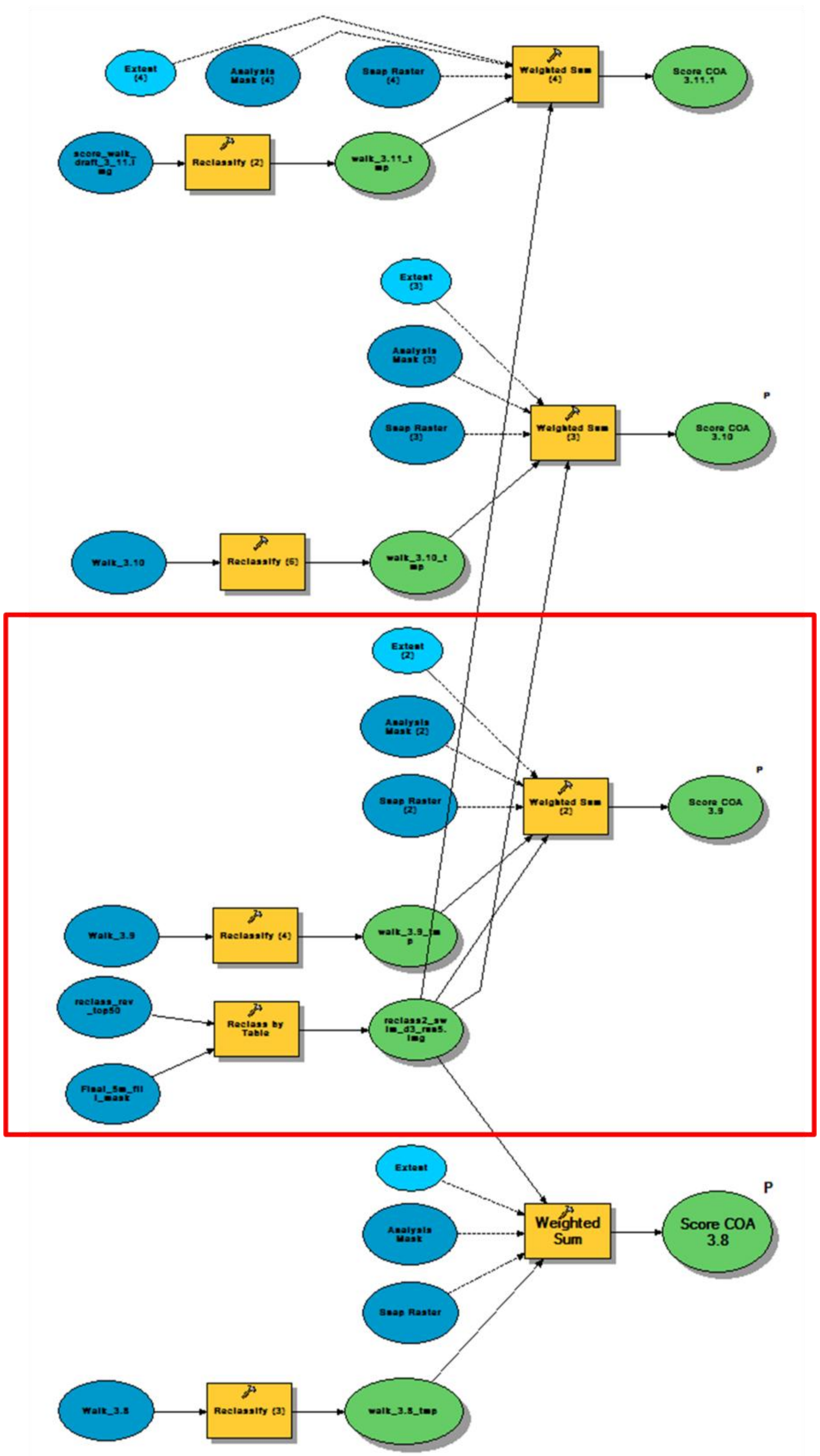
Several versions of the Walk metric were produced using different weighting schemes (Table 3). From this, several version of the COA map were also produced (Table 4.) Users have been provided with all of these output layers. The COA_Score Toolbox contains models that can be used to generate the provided and other weight combinations.

The COA map layer is produced using a weighted sum of the Swim and Walk metrics, normalized as described above. Any number of weighting schemes is possible; we provide two schemes that use the four versions of the walk metric (Table 8, Figure 19).

Table 8. The weighting schemes used to generate versions of the COA map and qualitative ranks of their usefulness. The relative weight of the wetlands layer combined with other data inputs used to generate the Walk metric is indicated by the value of low, mid, high, or highest. See Table 3 for actual weights used.

Name	SwimWt	WalkWt	SwimFile	WalkFile	Rank
COA 3.8.1	0.25	0.75	Swim	Walk (3.8 - mid)	Good
COA 3.9.1	0.25	0.75	Swim	Walk (3.9 - low)	Poor
COA 3.10.1	0.25	0.75	Swim	Walk (3.10 - high)	Better
COA 3.11.1	0.25	0.75	Swim	Walk (3.11 - highest)	Better
COA 3.8.2	0.5	0.5	Swim	Walk (3.8 - mid)	Good
COA 3.9.2	0.5	0.5	Swim	Walk (3.9 - low)	Poor
COA 3.10.2	0.5	0.5	Swim	Walk (3.10 - high)	Good
COA 3.11.2	0.5	0.5	Swim	Walk (3.11 - highest)	Good

Figure 19. The model used to generate conservation opportunity areas. The base model used is contained by the red box.



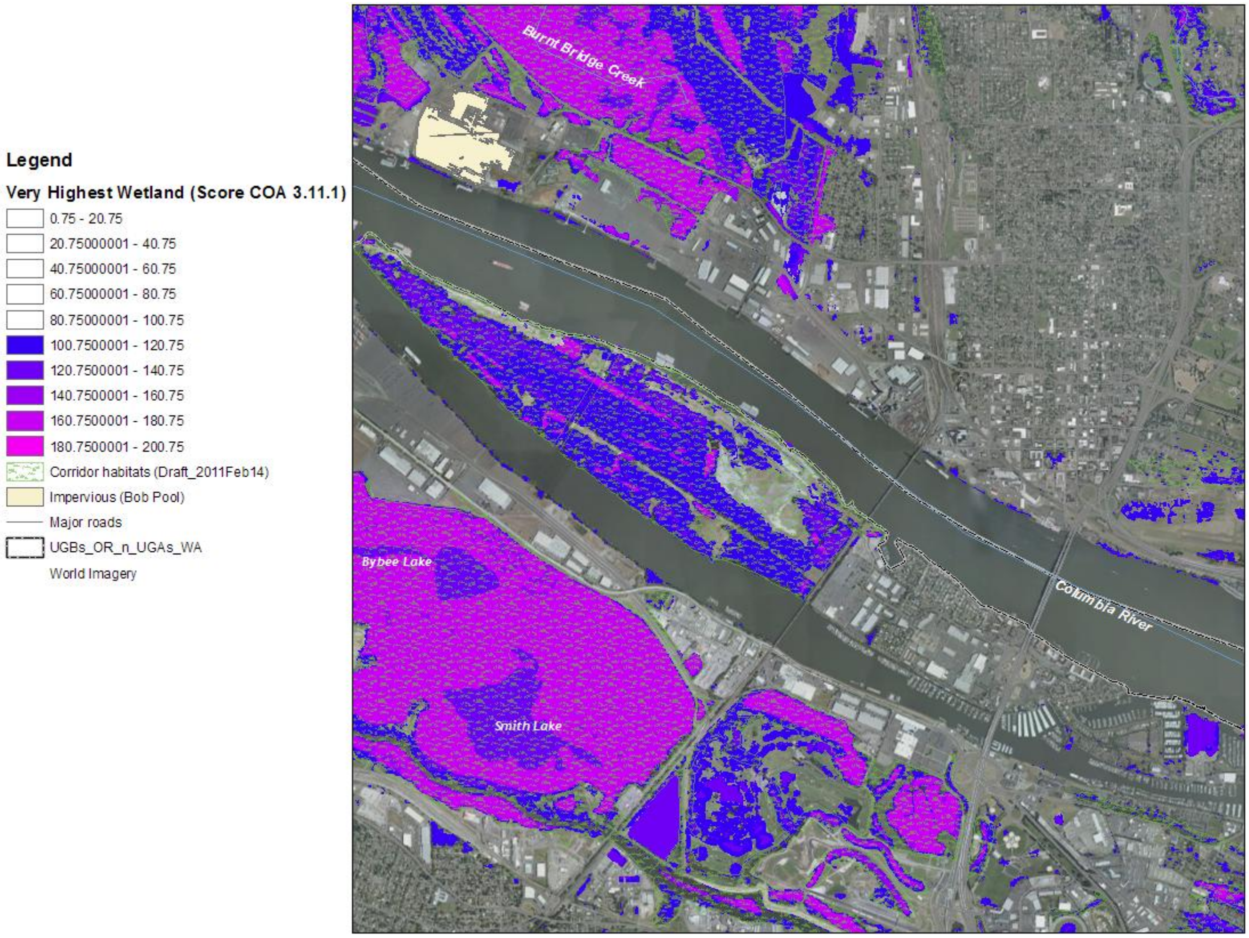
Results

The COA map is a continuous surface that represents all good and poor potential restoration sites. By examining the top 50% ranks of the map (percentiles 60-100), analysis of map outputs is facilitated. Please note that the major rivers are included in the 50th percentile, and fall out of the subsequent analyses. Also, palustrine wetlands were included in the generation of the walk metric, however lakes were not. Lakes were included in the swim metric, but if the lake is actually a reservoir, it was largely treated by the algorithms like its source stream (e.g., Henry Hagg Lake).

Hayden Island

Hayden Island is located in the main stem of the Columbia River. It possesses both highly industrialized and natural land uses and covers. There seems to be fairly good correspondence between the previous corridor work done for the Hayden Island area and the modeled conservation areas created for this report.

Figure 20. Hayden Island represents highly divergent land use/land cover conditions and has been discussed at both of the data reviews. Notice that quarried area is not designated as priority, The quarried area is included in the 50th percentile score, along with the river body itself.



Sauvie Island

Agriculture plays an important role on Sauvie Island, but has been built over wetland soils (Figure 21). The model results still rank the agricultural areas in the top 50% of the ranks, specifically in the 60th percentile, due to soils and proximity to the Columbia River. By updating the LULC map, this error could be easily corrected.

Figure 21. The southern tip of Sauvie Island, shown here with the 70th-100th percentile ranks. Agricultural lands are ranked in the 60th percentile (not shown here).

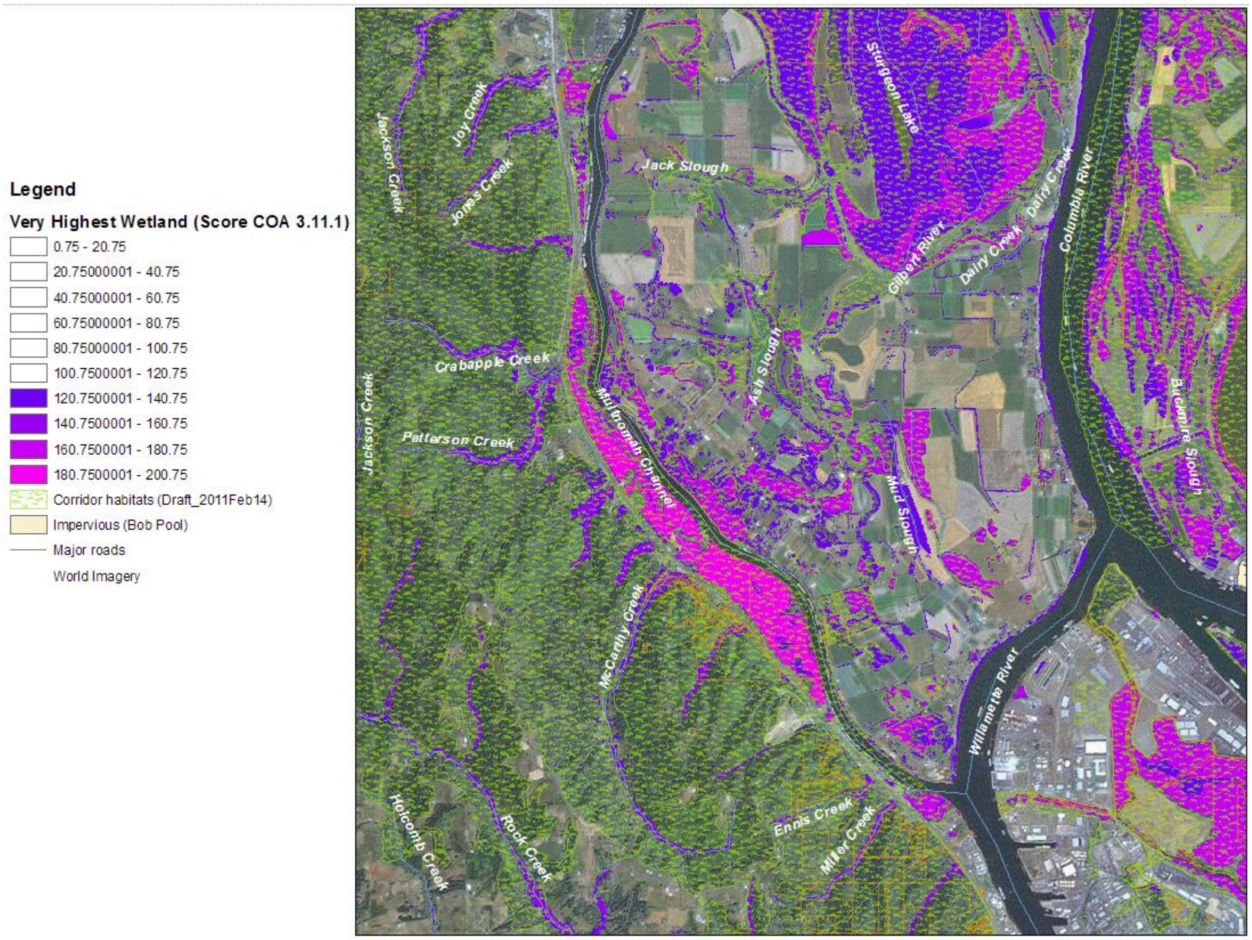
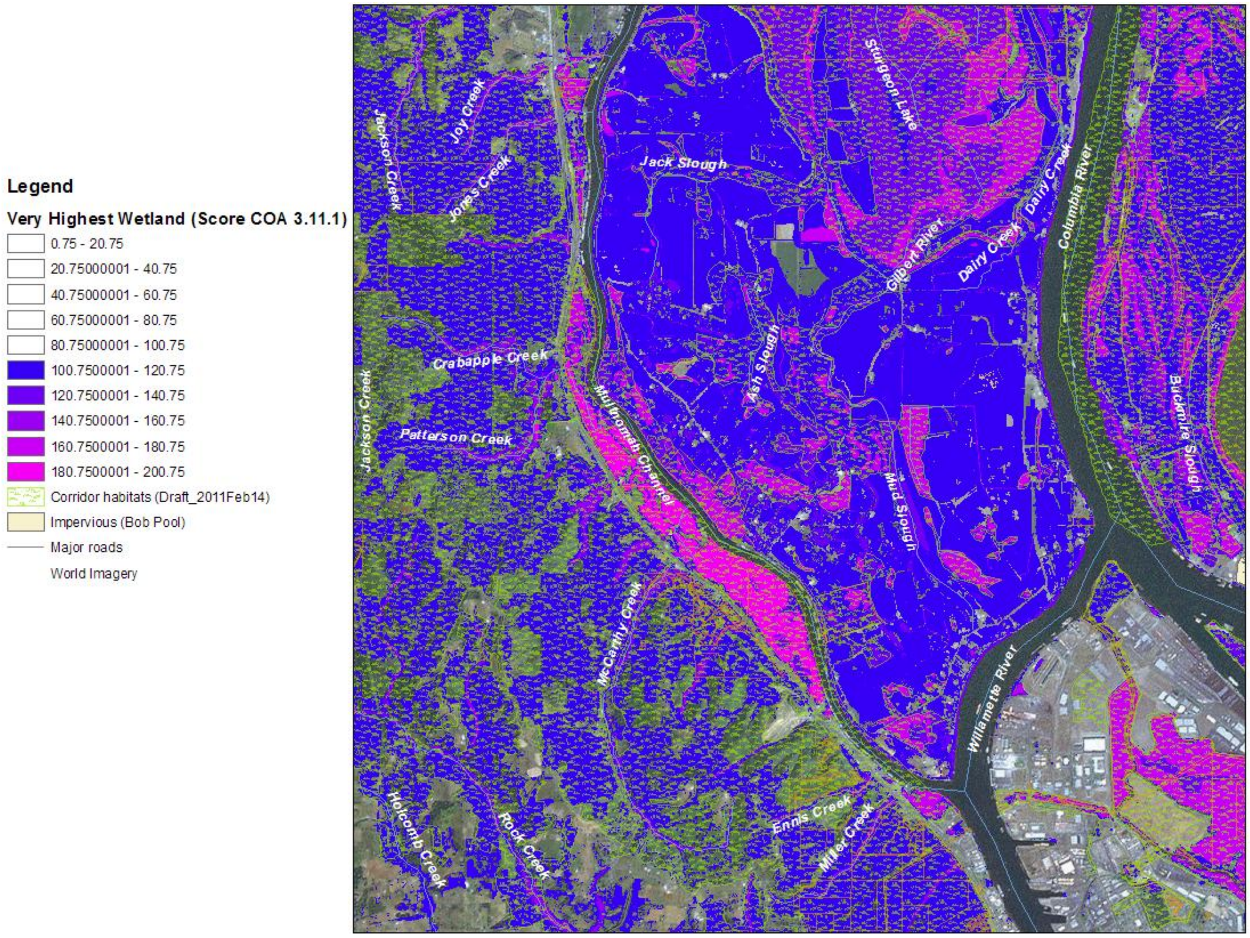


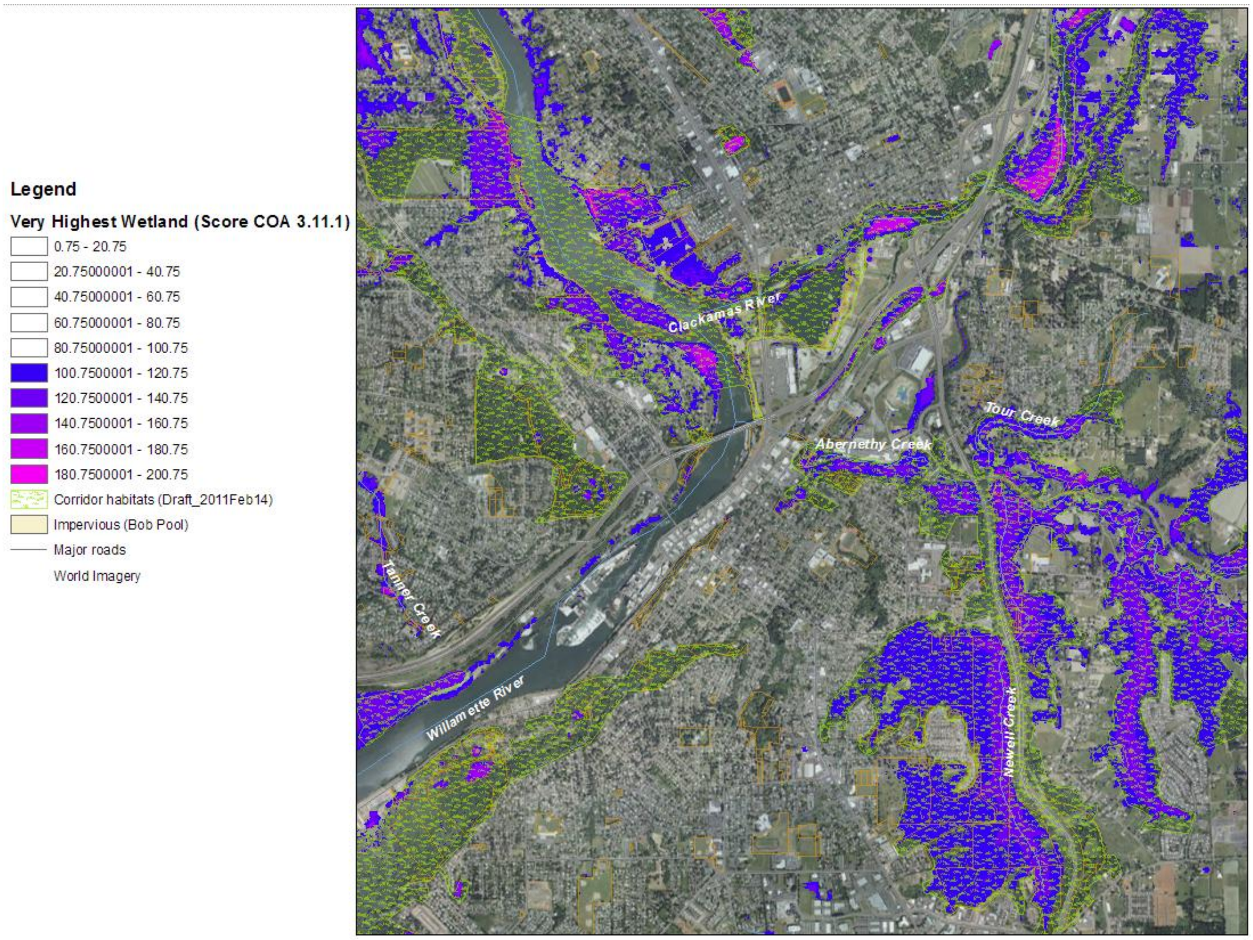
Figure 22. The southern tip of Sauvie Island, shown here with the 60th-100th percentile ranks. Agricultural lands still show up as ecologically important areas. Updating the land use/land cover map with an agriculture class would correct this error.



Mouth of the Clackamas

The mouth of the Clackamas js an ecologically important area because of the merging of two highly productive rivers. The modeled conservation opportunity ranks appear to corroborate the corridors work and identify public land holdings. A few patches occur in the modeled result along the west bank of the Willamette River, along Willamette Falls Drive north of the locks.

Figure 23**. The mouth of the Clackamas is an important ecological area because merging of two large river bodies increased habitat complexity and population mixing.**



Northern Vancouver Outskirts

In the outskirts of Vancouver, there are large areas of wetlands interspersed with urbanized, agriculture, and residential land uses as well as natural land covers. Many wetlands have been converted to other land uses. The model results pick up converted wetlands, in the 60th percentile, similar to ranks returned on Sauvie Island. Again, an updated agriculture spatial layer or LULC map would correct this error, or simply using the 70th-100th percentile ranks may be useful in the RCS's final efforts. Analysis of the modeled COAs that employed the lowest wetland weight in the Walk metric, showed extreme confusion in this area; wetlands were not separated from other patches and strings of highly ranked pixels occur. This artifact seems to be driven by the habitat friction layer.

Figure 24. Distribution of wetlands in the north Vancouver outskirts. Wetlands along the eastern edge of the the wetland cluster in the northern third of the map appear to have been converted to agriculture.

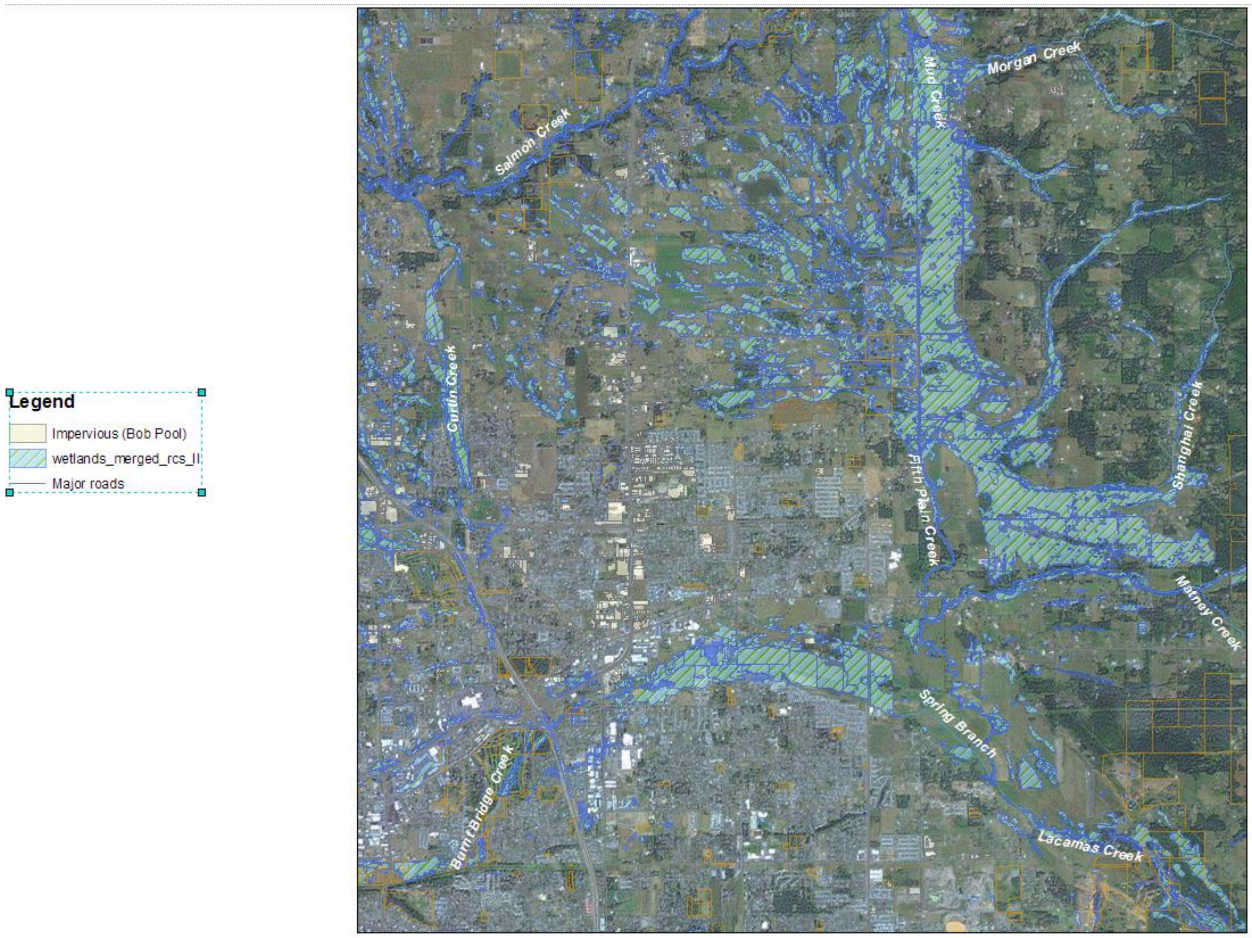


Figure 25. The outskirst of northern Vancouver. The 60th percentile contains wetlands that have been converted to agricutlure, as shown here.

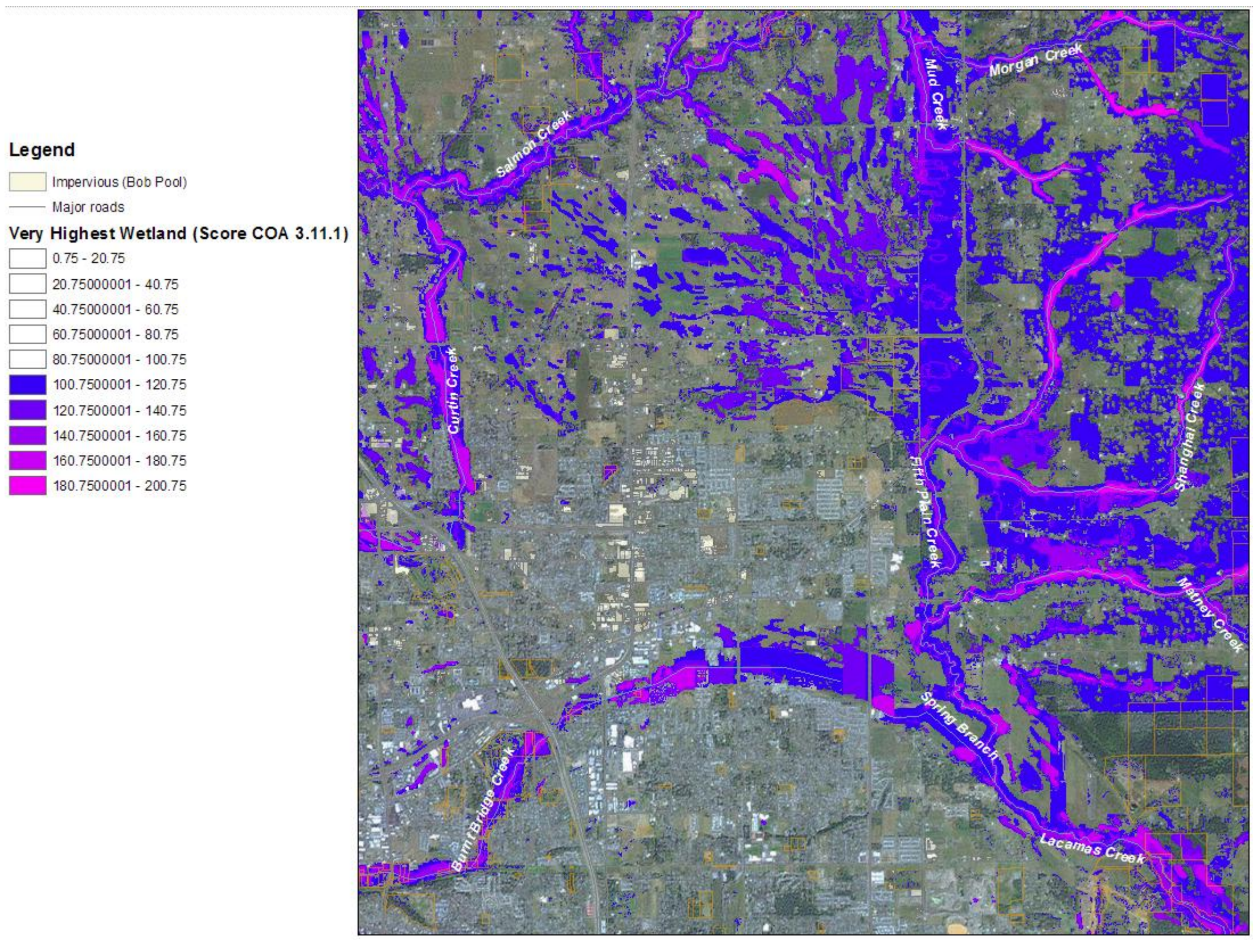
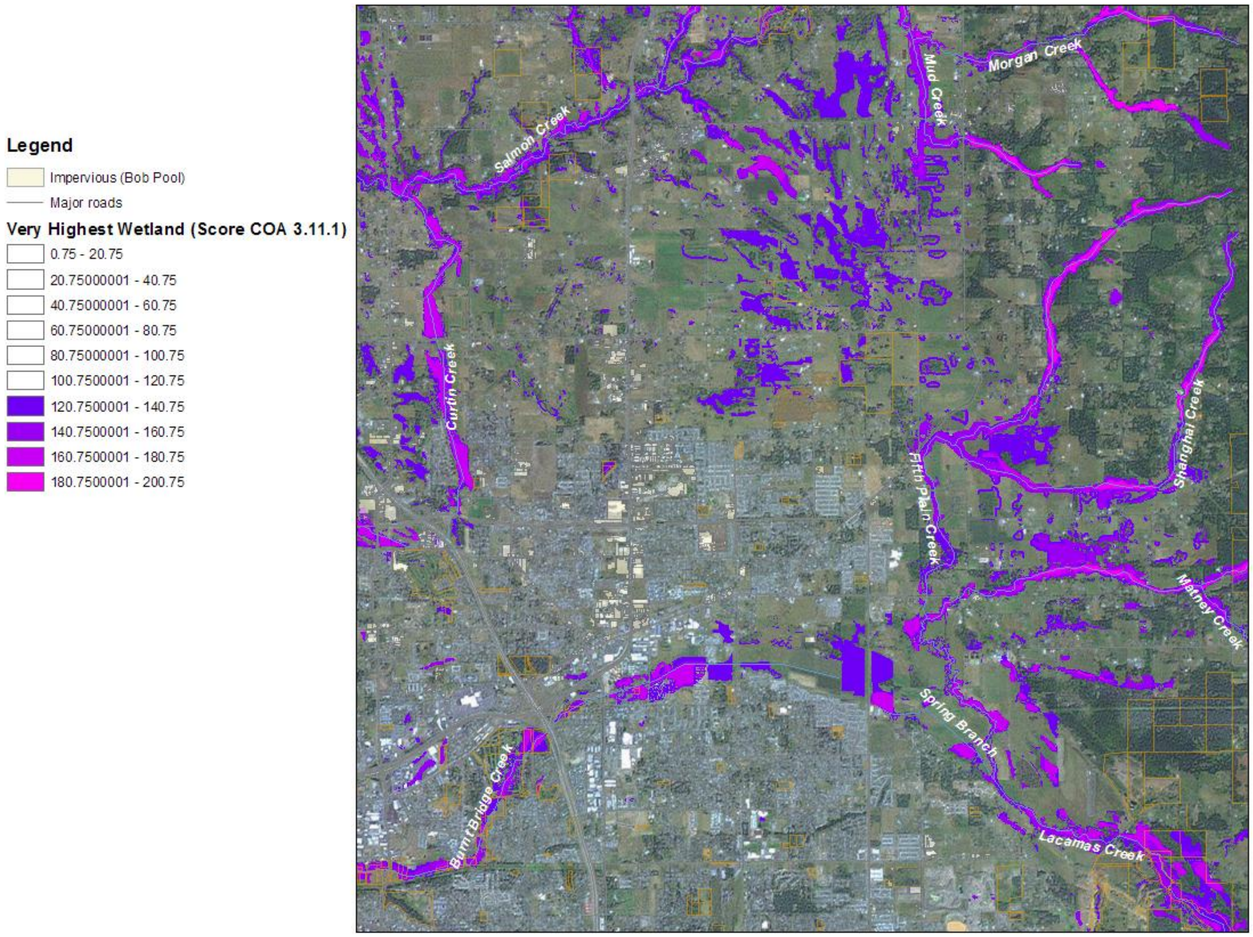


Figure 26. The outskirts of northern Vancouver shown with the 60th-100th percentile ranks.



Section 5. Recommendations and Limitations

Models are representations of the world and, if one takes the less optimistic view, are never right. But as George Box said, hopefully some models are useful. The Conservation Opportunity Areas Mapping Project sought to map areas within the Regional Conservation Strategy's area of interest using the best available data and to create a method that can be used as additional data becomes available. The methods and data are modifiable for future analyses and provide potential areas only. Further exploration with weighting schemes at levels are apt to create very different results from those presented here. Some expert opinion will be required to take full advantage of the data presented.

In our opinion, the data provide reasonable results, but are limited by the input data used. In the future the product would be improved by incorporating more information on focal species distributions and other biodiversity data. Updating the LULC map with information on agriculture and impervious surfaces will provide significant improvement as well.

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Appendix A. Data sets and data derivatives

Appendix B. Methods attempted but not used in the final product

Swim Metric

Curve number

The original curve numbers used to indicate water infiltration

Description	CN Descriptions (SCS)	A	B	C	D
Open water; also includes darker-colored roads	Water	99	99	99	99
Most paved areas and recently disturbed and clear cuts	Streets & Roads - Dirt	72	82	87	89
Shorter buildings and other structures (e.g., bridges), semi trucks and rail cars; includes some edge portions of the canopies of tall shrubs and short trees (sometimes shadows)	Streets & Roads - Gravel	76	85	89	91

Taller >30' buildings and other structures (e.g., bridges); ; includes some edge portions of the canopies of tall shrubs and short trees (sometimes very dark shadows from steep embankments/cliffs)	Streets & Roads - Paved with curbs and storm sewers	98	98	98	98
Sparse and/or very short vegetation (e.g., lawn); includes some water with emergent or submersed vegetation, or with overhanging vegetation canopy or shadow being cast on water surface	Pasture – Poor	68	79	86	89
Fairly sparse and/or short vegetation (e.g., crops, pastures, lawn, Pharis)	Pasture – Good	39	61	74	80
Crops, low shrubs, tall crops, medium-sized shrubs, medium-sized tree regen	Cultivated Land w/Conservation	62	71	78	81
Conifer woody crops, tall shrubs, small trees, largely tree regen	Brush (good, >75% ground cover)	30	48	65	73
Conifers less than 70' tall; includes some broadleaved trees with shaded canopies, adjacent to water, or with bright, sparsely vegetated backgrounds (e.g., in urban environments)	Woods/Forest Hydrologic Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Conifers 70-120' tall	Woods/Forest Hydrologic Fair (grazing but not burned; some brush) interpolated	41	63	75	81
Conifers 120'-200' tall	Woods/Forest Hydrologic Fair (grazing but not burned; some brush)	36	60	73	79
Conifers > 200' tall, old growth	Woods/Forest Hydrologic Good (no grazing; brush covers ground)	30	55	70	77
Woody crops, tall shrubs, small trees (e.g., willow, ash), large tree regen	Brush (good, >75% ground cover)	30	48	65	73
Broadleaved trees less than 70' tall (e.g., ash); includes some conifers with brightly illuminated canopies	Woods/Forest Hydrologic Fair (grazing but not burned; some brush) interpolated	41	63	75	81
Broadleaved trees 70-120' tall (e.g., red alder)	Woods/Forest Hydrologic Fair (grazing but not burned; some brush)	36	60	73	79
Broadleaved trees over 120' tall (e.g., bigleaf maple, cottonwood)	Woods/Forest Hydrologic Good (no grazing; brush covers ground)	30	55	70	77
Some cuts detected from 2000 or even earlier, most likely is representative of herbaceous or even shrub by now.	Agriculture With conservation treatment (terraces, contours)	62	71	78	81
Clear cut between 2006 and 2008, most likely is representative of herbaceous or bare ground.	Agriculture Without conservation treatment (no terraces)	72	81	88	91
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	Agriculture With conservation treatment (terraces, contours)	62	71	78	81
Clear cut between 2008 and 2010, representative of bare ground.	Agriculture Without conservation treatment (no terraces)	72	81	88	91
Less than 50% volume removal, most representative of mature conifer forest 70' and greater	Agriculture With conservation treatment (terraces, contours)	62	71	78	81

Areas highlighted in previous documents Mouth of the Clackamas River

The mouth of the Clackamas River had some high and moderate priority rankings. This is associated with Goat Island and the near shore riparian habitat on the Clackamas. The river is also a migration and rearing stream, in a flat floodplain with good vegetative cover. It should be noted that a large Blue Heron Rookery is present here and a shallow rapids in both the Willamette and Clackamas rivers,

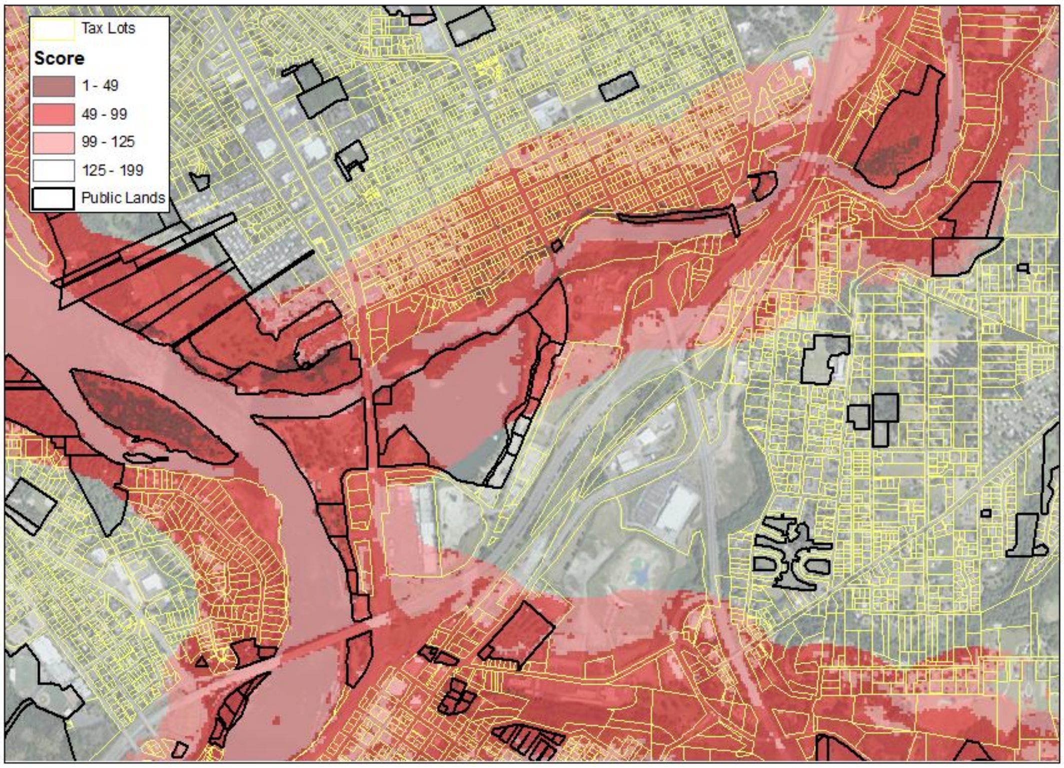


Figure 27. Mouth of Clackamas River

Sandy River (River Mile 3)

The Sandy River near the Crown Point Highway Bridge also has a significant amount of high and moderate scored habitat. This is in both public and private ownerships.

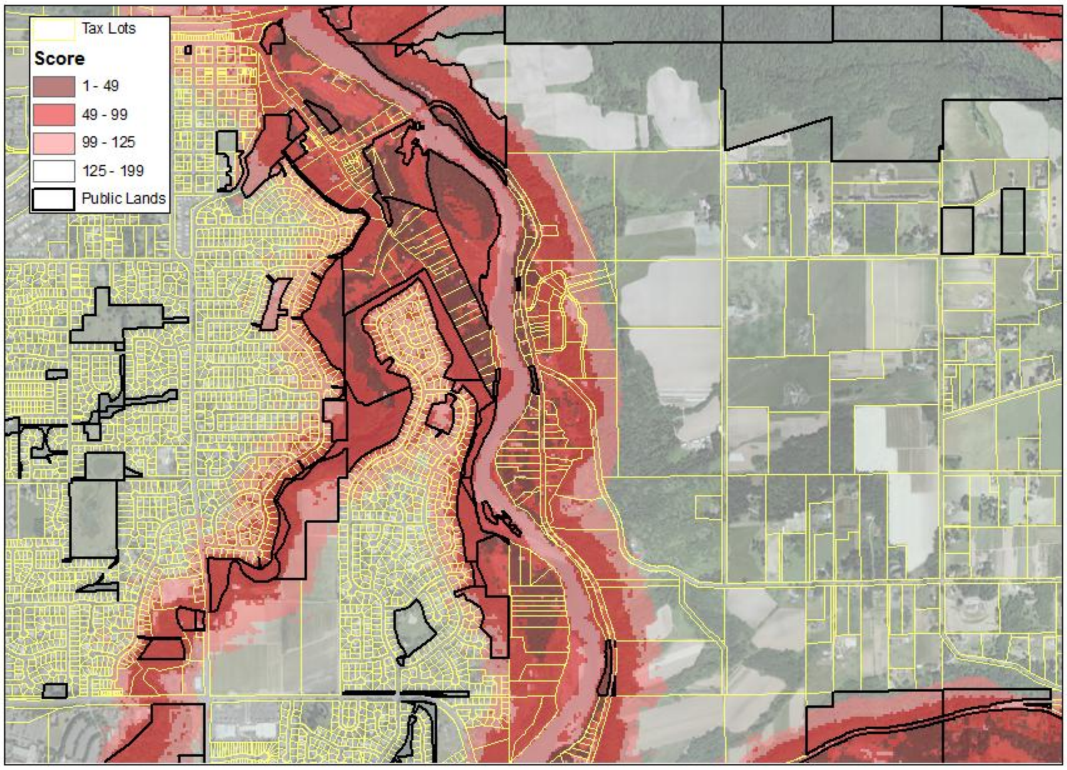


Figure 28. Sandy River.

Sauvie Island

Sauvie Island has a large amount of moderate habitat score primary due to its proximity to water and the floodplain connections. However, the fisheries preference data constrained the spatial extent. Only a few patches of small high scored habitat are present. The area is primarily in private ownership.

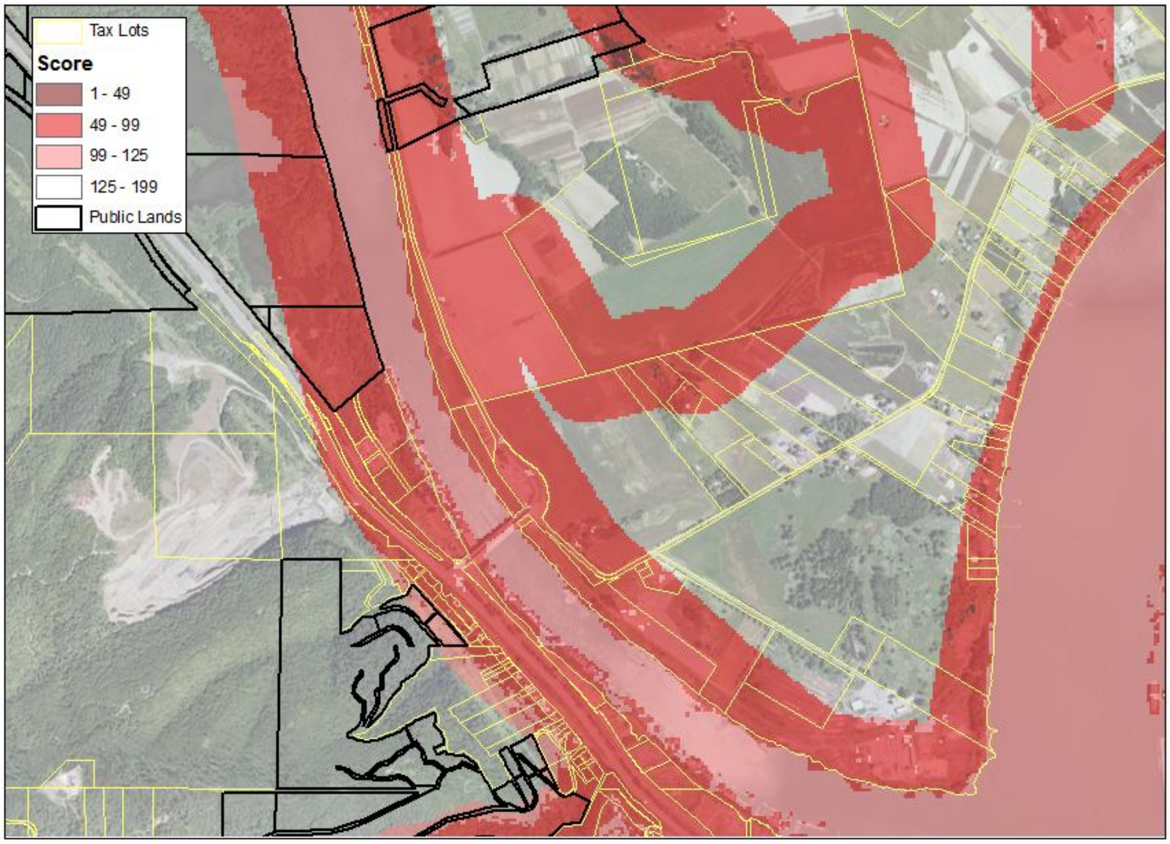


Figure 29. Sauvie Island.

Johnson Creek

Johnson Creek was dominated by moderate habitat that was very variable in width and spread between public and private ownership.

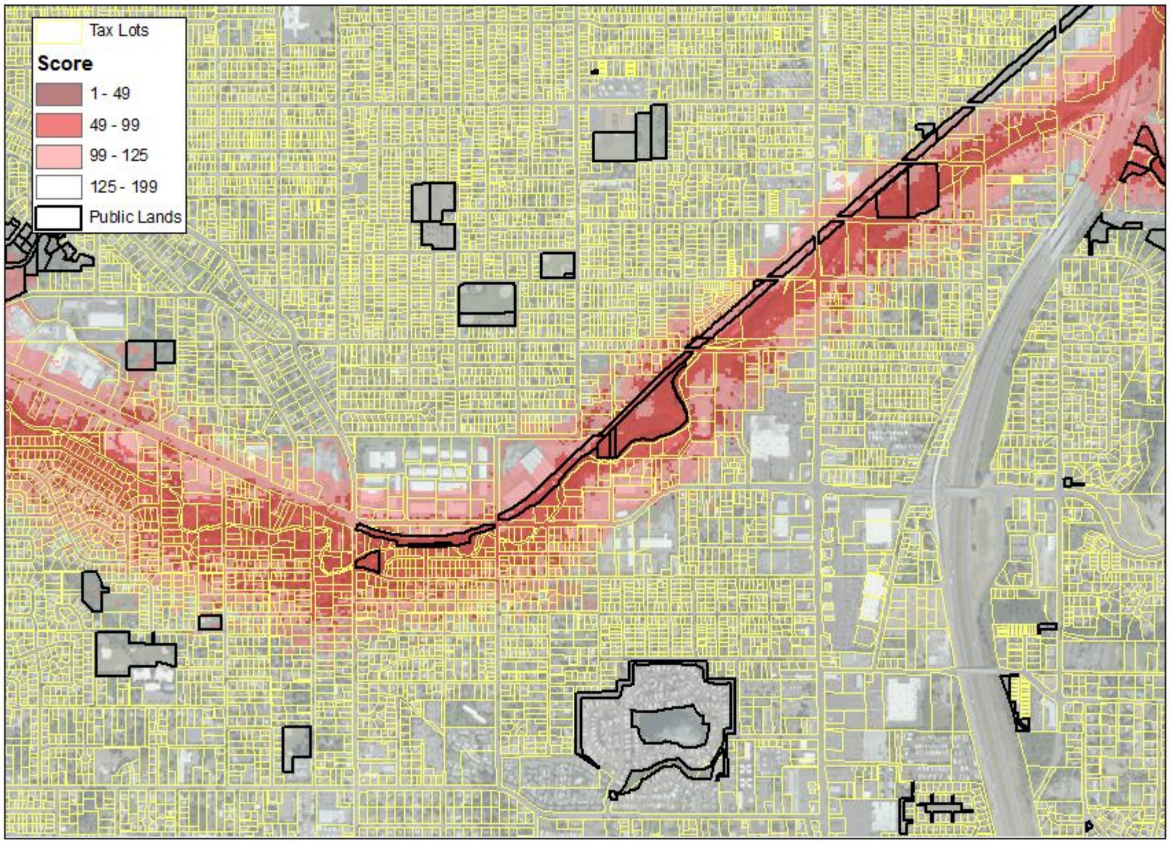


Figure 30. Johnson Creek.

Lewis River

Sections of the Lewis River have moderate and some small patches of higher scores.

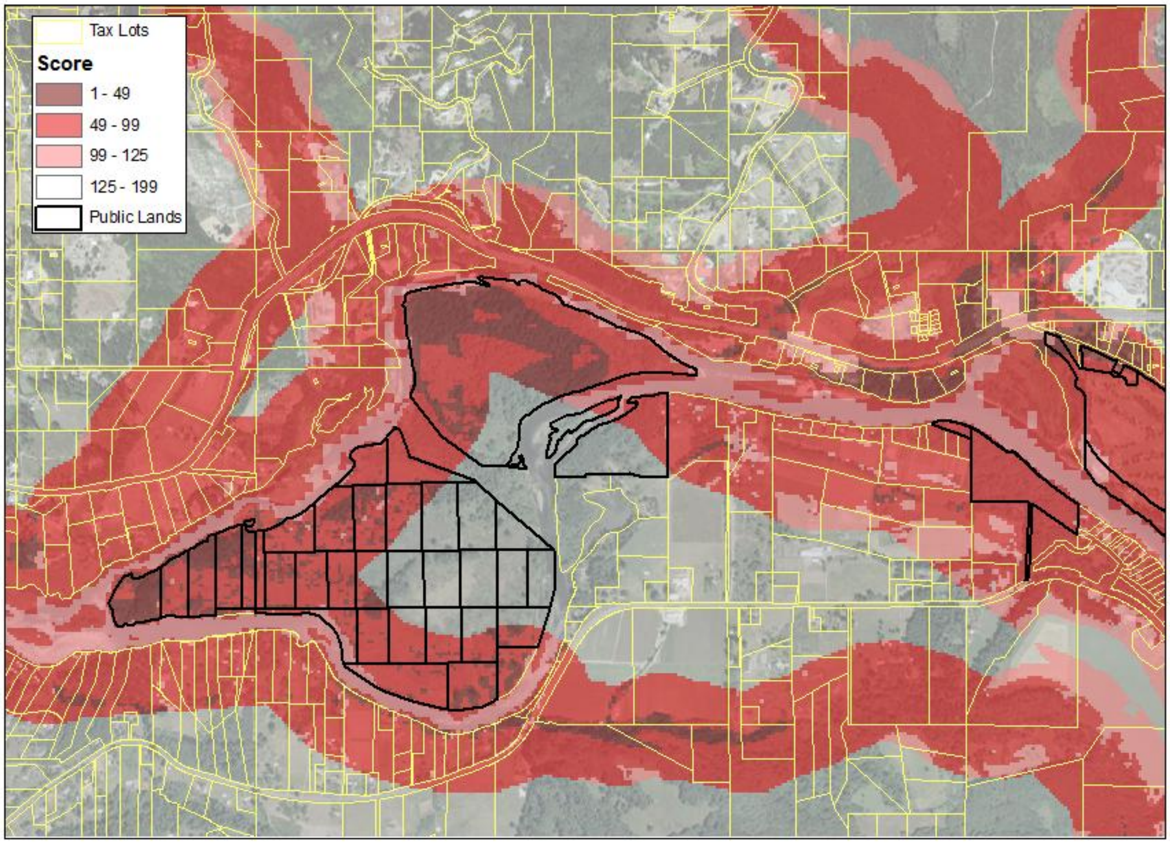


Figure 31. Lewis River below Staples Creek.

Walk Metric

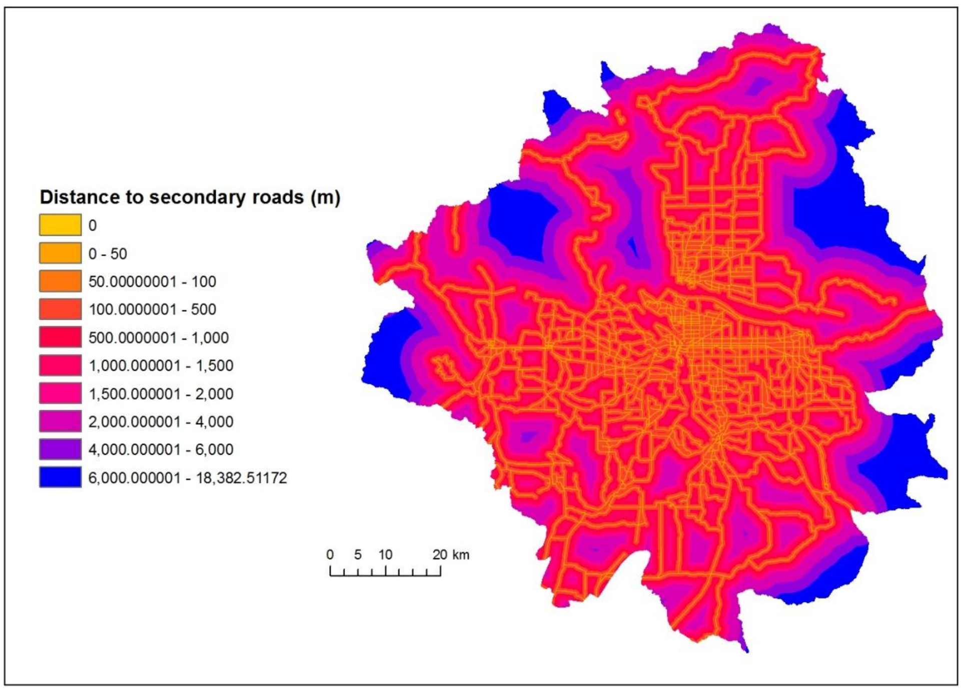
Distance to Roads

A continuous distance to roads raster was calculated for 4 categories of roads using the ArcGIS Spatial Analyst Euclidean Distance tool. The 2003 ESRI roads layer provided by Tommy was used as the base layer. Using the FCC attribute field to break out the categories, the following distance rasters were created:

- Distance to limited access roads
- Distance to highways and highway ramps
- Distance to secondary roads
- Distance to small roads

The distance to roads component was integrated with ground condition in the final walk metric model.

Figure 1. Distance to Secondary Roads.



Road Density

A road density raster was created for the Metro area using the ArcGIS Line Density tool (calculated in units of length per unit of area). The ROADS_ESRI_ALL dataset is the base layer used to calculate road density. In order to weight the roads in the density computation by the type of road, the Pop1 attribute was added to the roads layer and was calculated based upon the ACC attribute as follows:

Arterial Classification Code	ACC	Pop1	Notes

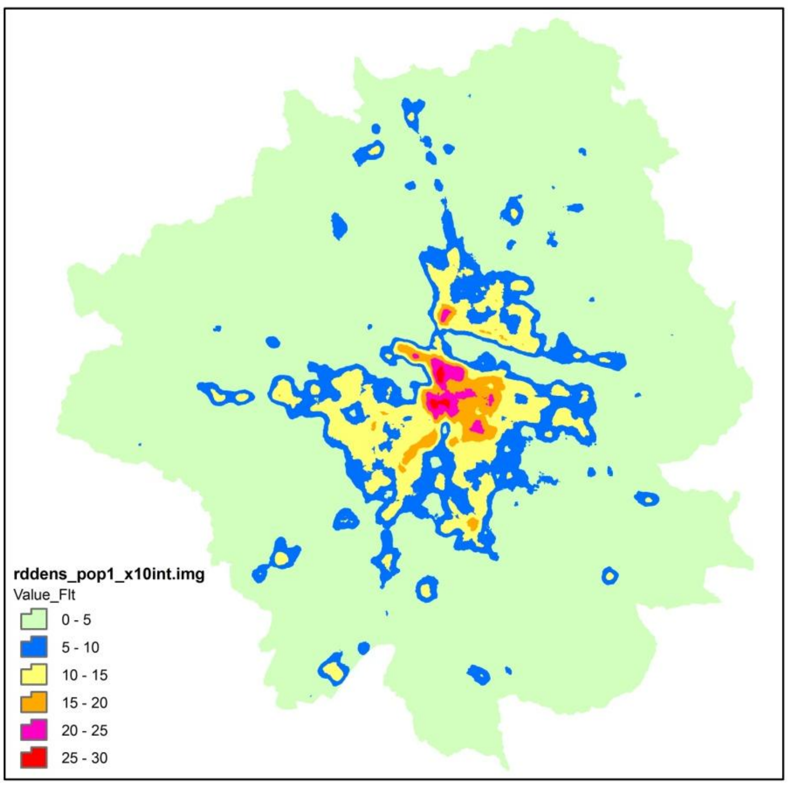
Arterial Classification Code	ACC	Pop1	Notes
Inter-state	1	2	
Inter-Metropolitan Area	2	1.5	
Intra-State/Intra-Metro/Inter-Metro	3	1.25	
City/County/Local	4	1	
Neighborhood	*5*	---	*No ACC 5 in dataset.*

City streets are counted once; interstate highways twice. The output cell size is 5 meters. The search radius is 1,000 meters (1 kilometer). The output area units is square kilometers.

The output raster is RDDENS_POP1.IMG (Imagine file). Since this is a floating raster, it was converted into an integer (used the Times tool to multiply cell Values by 10, then ran the Int tool to convert this into integer values). So, pixel Values in the RDDENS_POP1_X10INT.IMG raster contain one decimal to the right of zero; a Value_Flt attribute was added to the raster attribute table and represents the true value of each pixel (Value/10).

The density component was dropped from the final walk metric model, as it was determined that the ground condition element provided the needed information.

Figure 2. The road density layer was developed using the road type. Interstates were wieghted highest (2). Neighborhood streets were not weighted as they were not included in the dataset. These seem to have been lumped with city, county, and other local roads.



Relative patch size: a filtering approach

As a surrogate for measure of relative patch size, a moving window focal majority analysis was done to identify the largest patches in the following WHR habitat types:

- Parks/Open Space (60)
- Early Shrub-Tree (17)
- Mixed Hardwood-Conifer (18)
- Douglas-fir - Western Hemlock Forest (33)

For each habitat type, separate analyses were completed using a range of four window sizes, with the thought that a smaller window could capture the smaller patches, and the larger windows would pick up the larger patches. The four window sizes used on the 5m datasets were:

- 5 x 5
- 7 x 7
- 9 x 9
- 15 x 15

The idea for producing these data was to develop four patch density zones ranging from low to high patch density. In the lowest patch density zone, the results from the largest window analysis (15 x 15 cell) would be assigned. In the highest patch density zone, the smallest window analysis (5 x 5 cell) results would be assigned, and for the other zones, the remaining window analysis results would be assigned. This approach has not been tested, but is presented here as an alternative to using the weighted patch size layer.

Appendix C. Data review 1 Comments (April 22, 2011)

Notes from RCS Technical Committee Meeting 4/22/2011: Presentation of data input and preliminary model results from Institute for Natural Resources (Theresa Burcsu)

Compiled by Jonathan Soll

Use stream width not center lines for Manning's calculations, since wider streams otherwise get ranked lower.

We discussed how to include wetlands in the model. There seemed to be agreement that they should be burned in, without buffers (because of the accuracy of our landcover?) and ranked at he highest value as wildlife habitat.

There was discussion about how to adequately value undeveloped (unbuilt) floodplains, especially FP areas mapped in the low vegetation category; there was some assurance that combining walk and swim would do so, but we will want to look at that.

We discussed whether the modeling approach was as good or better than FEMA floodplain lines – consensus was that it is, due to being based on the LiDAR layer, albeit resampled to 10m.

There was concern about how to value interspersed habitats vs large blocks of homogeneous habitat

Parks/Open Space needs to be renamed so it isn't confusing as does Urban Habitat (which is actual urban, not actual habitat)

Are roads being overcounted / counted multiple times. Some felt using distance from road was enough. Counting multiple times is likely to downgrade all urban areas.

We need to be sure Swan Island and Industrial NW does not come up as high quality habitat. Is there a mistake in the input? Or, what about the model is valuing what was once floodplain but is now totally developed.

Consider amalgamating all natural habitat prior to assessing patch size and measures of interior habitat. That should do a better job picking out and valuing patches of undeveloped habitat. There was concern that divisions based on tree height are misleading for wildlife value.

Notes from RCS Technical Committee Meeting 4/22/2011: Presentation of data input and preliminary model results from Institute for Natural Resources (Theresa Burcsu) with comments from M. Schindel

Compiled by Jonathan Soll (and modified by M. Schindel)

Use stream width not center lines for Manning's calculations, since wider streams otherwise get ranked lower.

We discussed how to include wetlands in the model. There seemed to be agreement that they should be burned in, without buffers (because of the accuracy of our landcover?) and ranked at he highest value as wildlife habitat. Agreed

There was discussion about how to adequately value undeveloped (unbuilt) floodplains, especially FP areas mapped in the low vegetation category; there was some assurance that combining walk and swim would do so, but we will want to look at that.

We discussed whether the modeling approach was as good or better than FEMA floodplain lines – consensus was that it is, due to being based on the LiDAR layer, albeit resampled to 10m. Yes, I think the FEMA floodplains should be used to make sure we haven't excluded any known floodplains, but I generally think the LIDAR based DEM method is sound, merely requiring a bit of calibration. My only concern involves situations where water enters a confined channel, and rises higher than local topography may suggest because of the surge effect. This effect is too complex to model in an effort like this, but the FEMA data incorporates a degree of that. Areas like Willamette Narrows, and perhaps some of the confluence sites with major tribs should be checked against those ancillary data.

There was concern about how to value interspersed habitats vs large blocks of homogeneous habitat

Parks/Open Space needs to be renamed so it isn't confusing as does Urban Habitat (which is actual urban, not actual habitat)

Are roads being overcounted / counted multiple times. Some felt using distance from road was enough. Counting multiple times is likely to downgrade all urban areas. I would only use distance to roads, not road density, as there is a mismatch in the scale of the data vs. the analysis with density. I might use an inverse square function to weight the distance of roads, such that areas immediately adjacent to roads get a much higher penalty compared to areas 10s of meters away. This might effectively solve the "street tree problem".

We need to be sure Swan Island and Industrial NW does not come up as high quality habitat. Is there a mistake in the input? Or, what about the model is valuing what was once floodplain but is now totally developed.

Consider amalgamating all natural habitat prior to assessing patch size and measures of interior habitat. That should do a better job picking out and valuing patches of undeveloped habitat. There was concern that divisions based on tree height are misleading for wildlife value. Agreed. When identifying "patches", all of the LIDAR based veg classes should be lumped into "natural" vs "non-natural" categories. All veg classes should be used later on to assess diversity at a site.

Additional thoughts:

I think there is a little too much emphasis in the swim data on salmonids. While I think these are an important target group that need to be addressed, and they may also serve to help calibrate aspects of the modeling, we need to bear in mind that we are trying to develop base data for factors that may be applied to multiple taxa. The sorts of questions we want to answer are things like: which streams contribute the highest volume of temperature impaired water to the mainstem Willamette; which streams have the best riparian cover to ameliorate solar gain; which streams might see the greatest improvements through vegetation restoration? I do think the basic information you are developing (Manning's *n*, curve, etc) get at some of these basic issues. We just need to be sure they are interpreted in a way that allows the end user to ask the basic questions.

As I expressed to Theresa, I am so sorry you have had trouble with the CircuitScape approach. I will be out of town the rest of this week, but when I am back next week I will dig into this and figure this out. **I will do the permeability analysis myself to make amends for the time you wasted on my account.** In the meantime, it was really unclear to me how connectivity was being handled in the current modeling. I think I should come over there sometime next week and discuss this aspect of the problem with you directly.

I'm not a big fan of including slope as you have in the walk metric. Slope may be correlated with development potential, but that is a future threat, not a current condition problem. Our goal is to develop the data that describes the current condition of the biota in the RCS area that public agencies can use to inform landuse decisions in the future. I think we need to keep the focus on the here and now, not what may be.

Appendix D. Data review 2 (May 12, 2011)

Comments on the draft RCS model.

After the meeting on the May 12th a few of the GIS folks stuck around and discussed the maps, process, budget and a few priorities to resolve.

1) The number one concern was the tiling issue related to patch size analysis. There were some pretty apparent lines differentiating the landscape based on which tile they were analyzed on. INR is working at resolving this.
2) The Wetlands were brought in at the highest level and this we thought could be dialed back some, not to devalue the importance of wetlands but we felt placing them so high was actually decreasing other valuable habitats
3) Treat clear cuts as forest instead of semi natural lands as these were receiving scores similar to as urban areas.
4) Some areas of highly developed floodplain (lower Clackamas along Hwy 224) were noted on the map – we should be sure we investigate (Jennifer Thompson USFWS)

Other Comments received

After sending out links to the data or to ways to view the data we received a few comments, I suspect we may get a few more in the next few days. A number of folks were very impressed with the level of detail.

Concern about areas within floodplains that may have high value/rare wetland soils, like Labish may be devalued relative to riparian wetlands. – (Curt Zonick Metro). (Curt also mentioned specifically needing to value undeveloped floodplains more. Looking at Sauvie Island I think we already rank them pretty high. But we should probably look at how they are valued - Jonathan)

Concern about NWI data in Clark County not covering some important areas. Clark county has done extensive wetlands mapping and this data could add value if incorporated. – (Bob Pool Clark County) (I've attempted to patch Clark County Data (for Clark County) as well as Metro's for the areas within the UGB, wetlands conservancy data for OR outside UGB and NWI for Skamania and Cowlitz Counties – Tommy)

Concern about rapidly developing residential neighborhoods, one example is the Costco site around I-205 and Paden, could we incorporate impervious areas– (Bob Poole Clark County)
(RCC Landcover classification may have missed this as the LiDAR height data is rather old Bob provided impervious data and we can look at this. -Tommy)

Buildings appear to be represented somewhat inconsistently. – (Tommy Albo Metro)

(little nit-pickey maybe but this may go along with Bob's comments on representing the developed areas as best we can. It may be worth combining the RCS classification buildings with Metro's and Clark Counties buildings in creating the distance to roads and buildings model –Tommy)

High value upland resources are always subordinate to resources with aquatic value, even if they are of lower aquatic value. e.g farmland (seminatural) in large river floodplains shows up as higher -or similar value as large tracts of upland forest) Doesn't seem right to me but perhaps the model was constructed that way on purpose (noting comment above to give even more weight to seminatural floodplain land (Deb Lev City of Portland)

I agree with slightly reducing wetlands as they seem double counted in the walk and swim scores. (Deb Lev City of Portland)

Was the protection status from GAP data included? It would help differentiate between potential (future - JAS) old growth forest and clearcut/ plantation (Deb Lev – Portland).

Did natural land adjacent or proximate to streams or rivers increase the scores for walk or swim? (Deb Lev, City of Portland)

Is the swim score really about the aquatic environment? If so why are the water bodies themselves of lower value than the floodplain? (Deb Lev, City of Portland) [TKB: in other words are we adequately valuing the best river segments?]

Prairies, oaks and other priority habitats and species locations mapped by WADFW in WA were not picked up in the model (Jeff Azerrad) (Jeff picked up that the model is weak in those areas since we don't have regional data sets that consistently map those habitats – we will have to correct that during the expert review phase of mapping final priority areas; in fact much of that is already included in the maps created by Lori's workshops.

Comment from Elaine Stewart; Streams and wetlands appear over weighted. Forest holdings along Sandy River appear to only be getting a medium priority? Prairies and Grasslands do not seem to be as well represented as other habitats. Within the UGB Golf Courses and Cemeteries appear to have a higher value than mt. Talbert and Scouter Mountain.

Comparing similar Landscape types. Would it add value to compare just the uplands (over 650ft elevation with uplands), Floodplains with Floodplains, Urban with Urban, and other with other(outside UGB less than 650elev) -tommy