Optimizing Tree Installation Planning in King County through Site Suitability Analysis: A Decision Support Tool to Suit a Broad Range of Users

GEOG 569

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I. Recommended Course of Action

Our capstone group is proposing a proof of concept design for a spatial overlay analysis methodology that comprehensively integrates and analyzes multiple social and environmental features, phenomena and characteristics that exist within King County with the purpose of producing a raster-based site suitability rating system for potential tree installation sites centered on three specified goal categories. The three categories of site suitability include: 1) Urban Issues; 2) Ecological and Environmental Enhancement; and 3) Tree Survivability. The site suitability categories are intended to address a wide-range of community objectives and priorities while providing a range of potential tree installation areas that are tailored and focused on furthering the objectives and priorities of a particular individual user.

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II. Introduction

King County and Public Health - Seattle/King County seek to improve ecological and human health equity and resilience through enhancements to tree canopy and green infrastructure. Expanding tree canopy has multiple benefits including stormwater management, improved air quality, habitat restoration, aesthetic appeal, carbon sequestration, and increased green space within communities.

According to King County, most efforts to enhance urban forestry, regional green space and other canopy improvement projects, whether advanced by public, private and/or community-based organizations, are not optimized by a common planning and siting tool that directly derives guidance from multiple dynamic spatial data sets. Therefore, many of the initiatives to install new trees can be somewhat random and not necessarily consistent with varying community and government criteria and objectives. King County creates and maintains through their spatial data web portal (http://www5.kingcounty.gov/gisdataportal/) several social and environmental related datasets that could help inform decisions regarding where best to plant and install trees in order to increase multiple planting benefits, however, the data has not been analyzed comprehensively (via a spatial overlay). In addition, data from agencies and organizations outside of King County that could help inform tree installation planning has also largely not been integrated and analyzed comprehensively, with site suitability results accessible and viewable in one interactive web based location.

The scope and intent of this capstone project are to provide a proof of concept that outlines the design, build, and deployment of an ArcGIS Online (AGO) application that includes a spatial overlay analysis methodology and resultant outputs that comprehensively informs a users' guidance on tree planting locations that are context sensitive and values informed. The intended users of this web map and its data are individuals, agencies, and community-based organizations who are advancing tree planting efforts from various priorities and objectives such as climate resilience, ecological and environmental health, human health, as well as social and health equity priorities.

As an example, official policies that could utilize tree installation activities to further social equity priorities can be found in the City of Seattle Tree Canopy Assessment (TCA) and the King County Equity and Social Justice Strategic Plan. According to the TCA, in 2015 the Mayor of Seattle launched the Equity and Environment Initiative (EEI) to deepen Seattle's commitment to race and social justice as it relates to environmental initiatives while also creating the Environmental Action Agenda (EEA). The TCA goes on to state that the EEA is a series of community-developed goals and strategies that address environmental inequities and create opportunities for communities of color, refugees, people with low incomes, and limited English proficiency individuals to become leaders in Seattle's environmental movement. Two environmental equity measures were selected for analysis to highlight the traditional lower rate and disparity of green infrastructure investment by agencies and organizations in minority communities: people of color and people within 200% of the poverty level. The report found that there is a statistically significant inverse relationship between tree canopy and both people of color and people within 200% of the poverty level. To highlight the link of disparities of public investment in public green space in lower income and minority communities, the analysis found that in Census tracts with higher populations of people of color and lower incomes there tended to be lower amounts of tree canopy. In census tracts with high numbers of people of color, tree canopy is as low as 11% while in areas with not many people of color there is 55% canopy cover. It is important to note that although there is a general inverse relationship, there are numerous exceptions. Some locations within Seattle that have the highest concentrations of people of color and residents under 200% of the poverty level have a relatively high percentage of tree canopy due to the presence of parks and street trees (TCA, 2016. pg 10).

The spatial overlay analysis for site suitability and its associated web-based mapping tool is intended to promote and guide tree planting locations that are informed by urban socioeconomic factors and phenomenon, environmental sensitivities and hazards, land tenure, identified and established ecological enhancement priority areas, soil suitability characteristics, topographic considerations and other related factors. The web-based mapping interface will allow users to explore potential sites within the county based on their priorities and preferred outcomes.

III. Design & Methods

Our capstone project consists of a spatial overlay site suitability analysis, or "overlay analysis". In this type of analysis several data sets are "overlaid" one atop the other in order to produce one output raster. According to the ArcGIS Resource Center, an overlay analysis in GIS can be compared to an overlay of paper maps with the intended purpose of creating one resulting map combining criteria from the input of the multiple paper maps. Therefore, overlay serves as a method for identifying specific locations or areas that possess a certain set of attribute values that match the specified criteria. The specified criteria for our project being the three goal categories of 1) Urban Issues; 2) Ecological and Environmental Enhancement; and 3) Tree Survivability. The overlay analysis approach is typically used for finding locations which are suitable for a particular use or furthering a stated objective, such as planting trees near waterways to assist in temperature moderation (ArcGIS Resource Center 2012).

Primarily, two methods of overlay analysis are generally used: feature overlay (overlaying points, lines, or polygons) and raster overlay (overlaying raster datasets). Overlay analysis for identifying locations meeting certain criteria is in many cases best done using raster overlay. Our project utilizes raster overlay to assign a suitability score and rating to specific areas (i.e. the cells of the raster output). When using a raster overlay approach, the fact that each cell of each data layer references the same geographic location, the raster overlay is well suited for combining characteristics of numerous layers into one single layer. Typically, a numeric value or weight is assigned to each characteristic, or specified value. The weights allow for a mathematical combination of the layers and an assignment of a new value to each cell in the resulting output layer (ArcGIS Resource Center 2012).

In overlay analysis, it is desirable to establish the relationship of all the input factors together to identify the desirable locations that meet the goals of the model. For example, the input layers, once weighted appropriately, can be added together in an additive weighted overlay model. In this combination approach, it is assumed that the more favorable the factors, the more desirable the location will be. Thus, the higher the value on the resulting output raster, the more desirable the location will be (ESRI ArcMap Tools Help, 2016).

An overlay analysis methodology generally includes ranking attribute values by suitability and then summarizing these attributes. Each cell for each criterion is reclassified into a common preference scale. Our analysis uses a common (ordinal) reference scale of 1 to 5, with 5 being the most suitable and 1 being the less suitable.

The following are descriptions of the specific data layers used in each goal category as well as a general description of the preparation of the data layers for the raster overlay analysis.

Socio-Environmental Suitability

The Socio Environmental

SocEnv_Equal (Reclassify) = **SocEnv_Ready**

- ScoEnv_Equal = ("UHI_Ready" * 0.33) + ("ImpervJug_Ready" * 0.33) + ("SocialEquity_Ready" * 0.33)

Urban Heat Island (UHI_Ready)

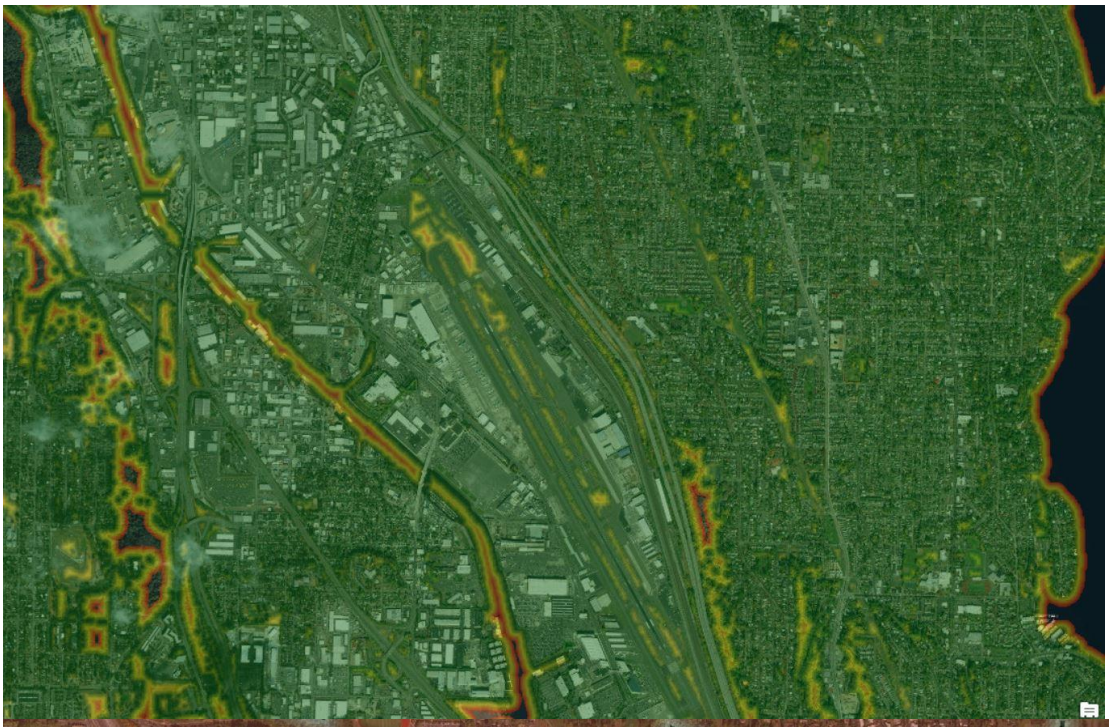
- UHI_Equal (Reclassify) = UHI_Ready
- UHI_Equal = ("VegHt_Ready" * 0.33) + ("ImpervSea_Ready" * 0.33) + ("PopDensity_Ready" * 0.33)

- UHI_2_4_4 = ("VegHt_Ready" * 0.2) + ("ImpervSea_Ready" * 0.4) + ("PopDensity_Ready" * 0.4)

Vegetation Height (VegHt_Ready)

- VegHt_Ready = 1-5; 5ft-1ft intervals of 1 foot
    - [VegHt_Sea <= 5ft]
    - VegHt_Sea (Reclassify) = VegHt_Ready *1-5 scale with 5 as most suitable
    - PreliminaryProducts_veght.gdb (Mosaic to New Raster) = VegHt_Sea

Impervious Proximity (Imperv_Ready)

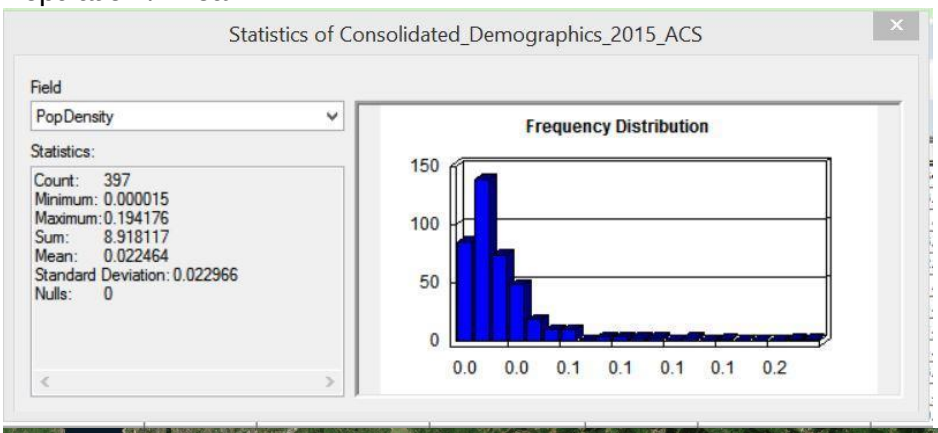


- Imperv_Ready
    - Imperv_Ready = 1-5; 250ft-50ft intervals of 50ft
        - EucDist_Imperv (Reclassify) = ImpervSea_Ready *1-5 scale with 5 as most suitable
        - Imperv_RR (Euclidean Distance) = EucDist_Imperv
        - ImpervSea_Reclass (Reclassify) to single value = Imperv_RR
        - Impervious_Sea (Reclassify) to binary = ImperSea_Ready *0 and 1 where 1 is not equal to impervious

- PreliminaryProducts_impsurf.gdb (Mosaic to New Raster) = Impervious_Sea

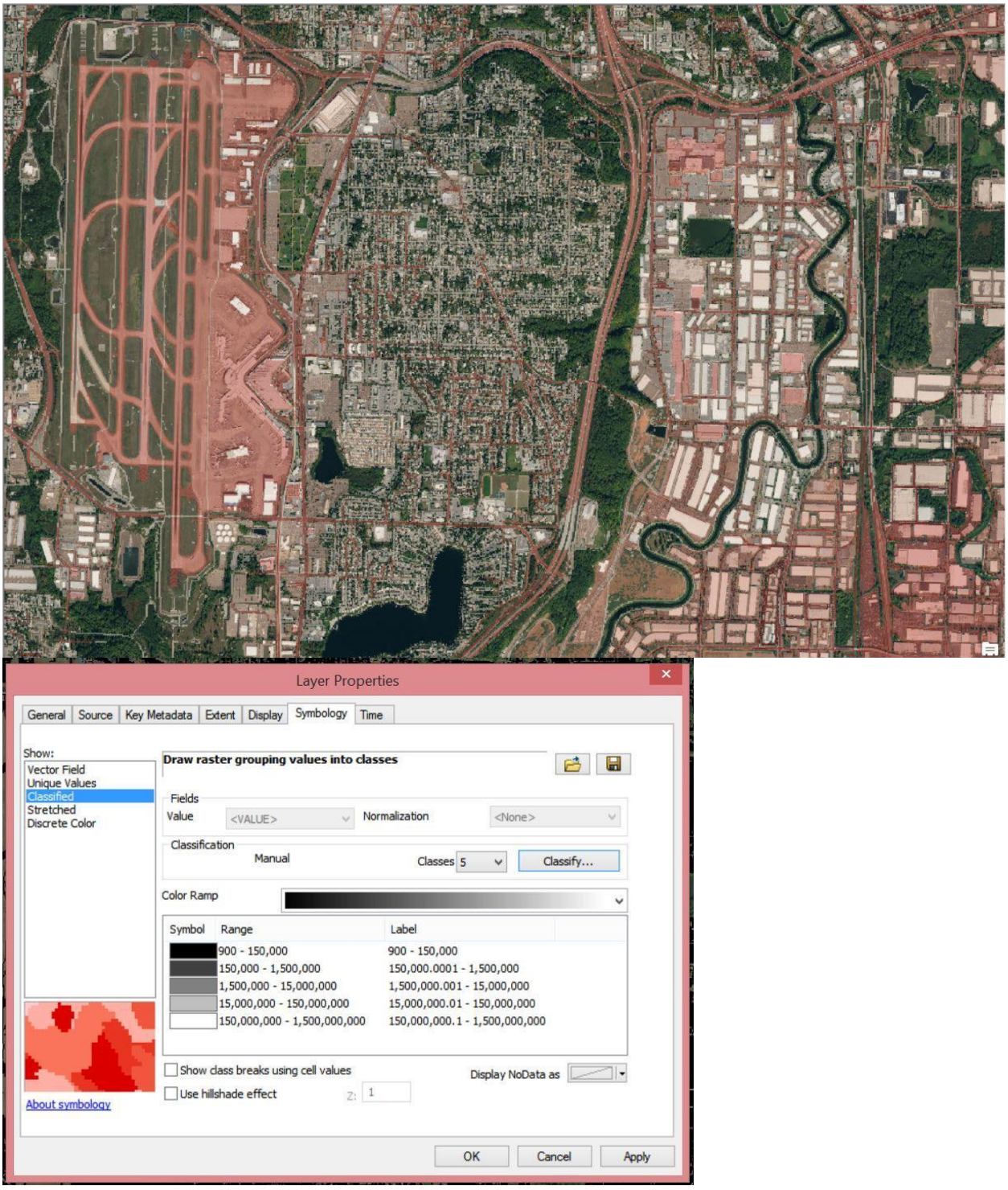
Population Density (PopDensity_Ready)

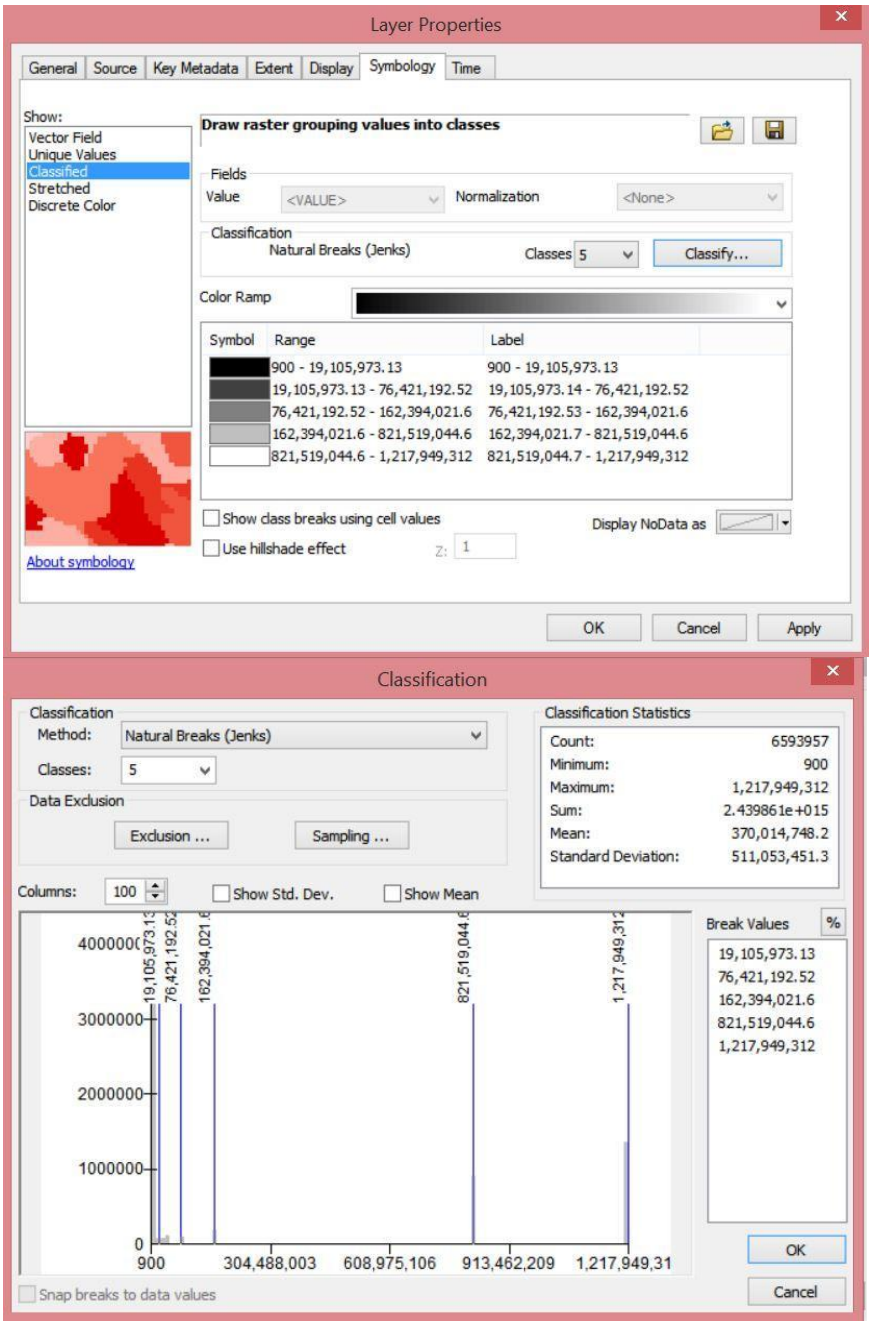
Population / Area:



- PopDensity_Ready
  - PopDensity_KC (Reclassify) = PopDensity_Ready *1-5 scale with 5 as most suitable
  - Consolidated_Demographics_2015_ACS (Polygon to Raster) on PopDensity field = PopDensity_KC
    - Consolidated_Demographics_2015_ACS (Calculate Field) = PopDensity = [Population / ShapeArea] * 100
    - Consolidated_Demographics_2015_ACS (Add Field = PopDensity)

Impervious Jungles (ImpervJug_Ready)





- **Impervious Jungles (ImpervJug_Ready)**
  - Imperv_Area (Reclassify) = ImpervJug_Ready *1-5 scale with 5 as most suitable
  - RegionGroup (Zonal Geometry) for Area = Imperv_Area
  - Impervious_Sea (Region Group) = RegionGroup
  - PreliminaryProducts_impsurf.gdb (Mosaic to New Raster) = Impervious_Sea

Social Equity

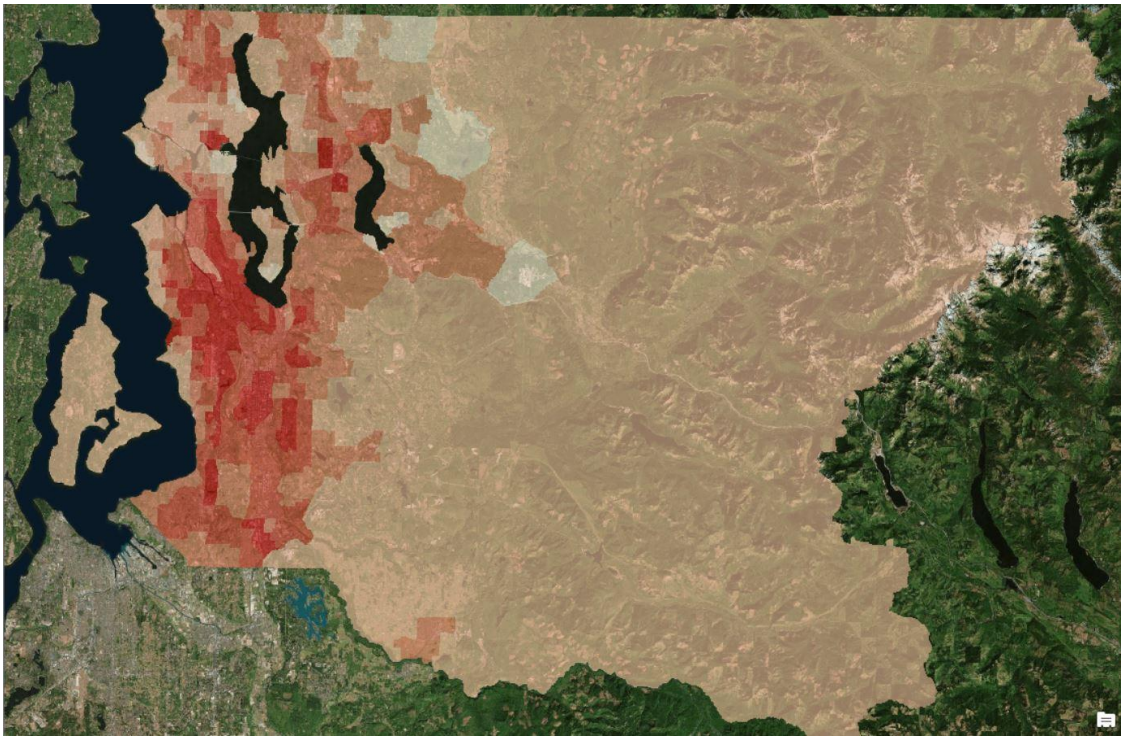


Image .

- **Social Equity (SocialEquity_Ready)**
    - SocialEquity_KC (Reclassify) = SocialEquity_Ready *1-5 scale with 5 as most suitable
    - Consolidated_Demographics_2015_ACS (Polygon to Raster) on Weighted Total field = SocialEquity_KC

Non English Speaking Population, Median Family Income, Non White Population

Environmental and Ecological Enhancements Category

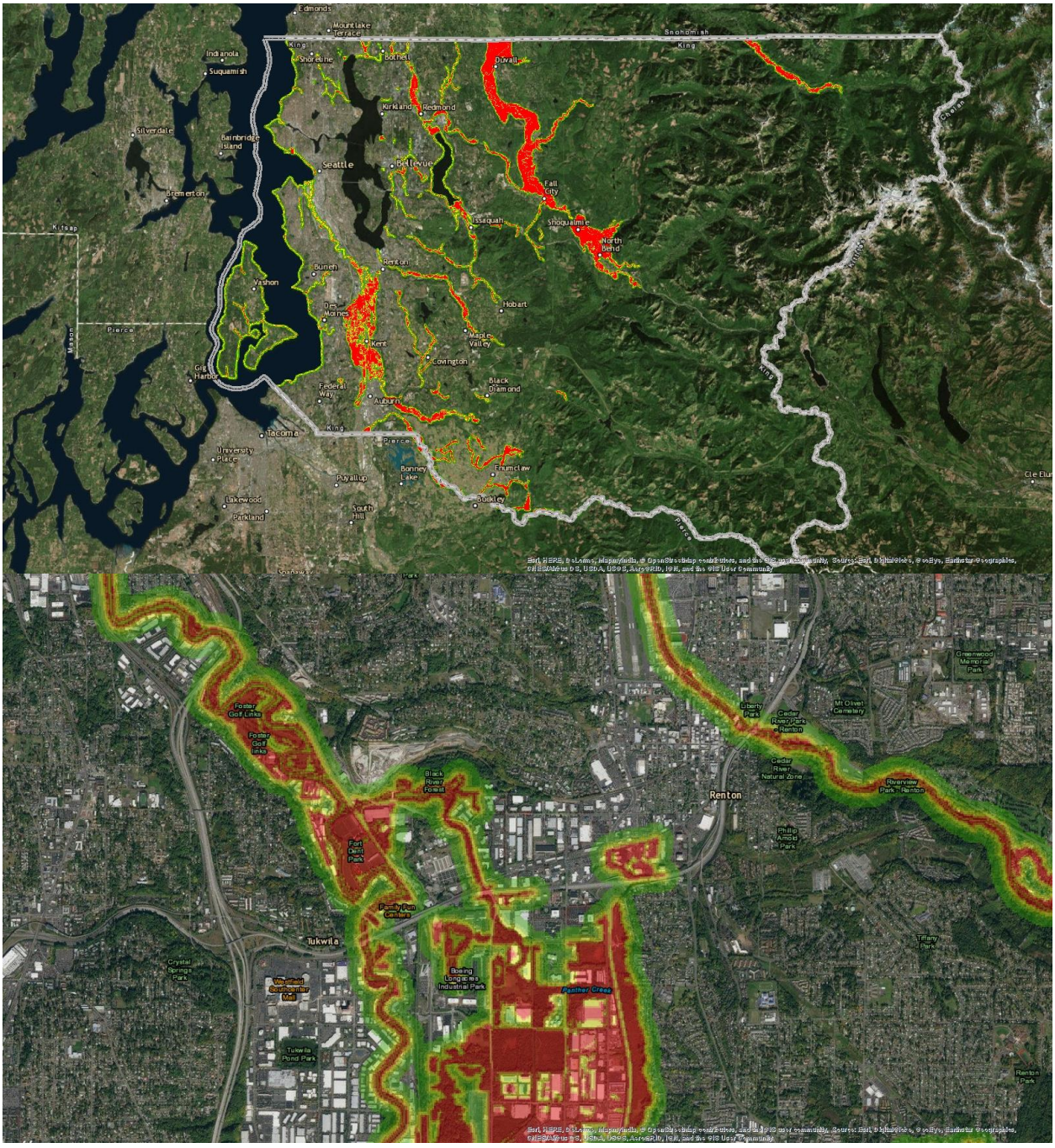
The spatial overlay analysis to determine site suitability to support the goal of Environmental and Ecological Enhancement is intended to support efforts that seek to address objectives related to climate resilience, ecological and environmental health, stormwater management, improved air quality, habitat restoration, carbon sequestration, and increased green space within communities. The following is a listing of various data sets from King County, the Washington State Department of Ecology and the environmental non-profit agency, StreamNet (http://www.streamnet.org/about/). The data sets listed in this section were all utilized (with some pre- and post processing as discussed) in the spatial overlay analysis for site suitability to support Environmental and Ecological Enhancement. The King County government has multiple agencies that create and maintain spatial data sets to aid in its responsibility for regulating, protecting and enhancing the environmental and ecological systems within the County. Those agencies primarily include the Department of Natural Resources and Parks and the Department of Permitting and Environmental Review. Both departments, as well as the majority of King County agencies, maintain and disseminate their spatial data sets via the King County data portal at http://www5.kingcounty.gov/gisdataportal/. The state of Washington's Department of Ecology (DOE) creates and maintains spatial data for its duty of regulating and enhancing regional or cross-county environmental and ecological features such as watersheds, shorelines and large waterbodies and networks. The DOE maintains and disseminates their spatial data sets via a web data portal at http://www.ecy.wa.gov/services/gis/data/data.htm#w. StreamNet is a cooperative information management and data dissemination project focused on fisheries and aquatic related data and data related services in the Columbia River basin and the Pacific Northwest. StreamNet maintains and disseminates their spatial data sets via a web data portal at http://www.streamnet.org/data/interactive-maps-and-gis-data/.

Data Layers and Features Included in Environmental and Ecological Enhancements Spatial Overlay Site Suitability Analysis:

1. 100 year Floodplain

A compilation of best available floodplain boundaries from FEMA NFIP maps. Suitability rating assigned is based on proximity to the flood zone.

- areas within the flood zone were assigned a 5 (Highest Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Tree Planting Benefits);
- areas within 150 feet were assigned a 3 (Medium Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 2 (Lower Suitability for Tree Planting Benefits);
- areas within 500 feet were assigned a 1 (Least Suitability for Tree Planting Benefits).

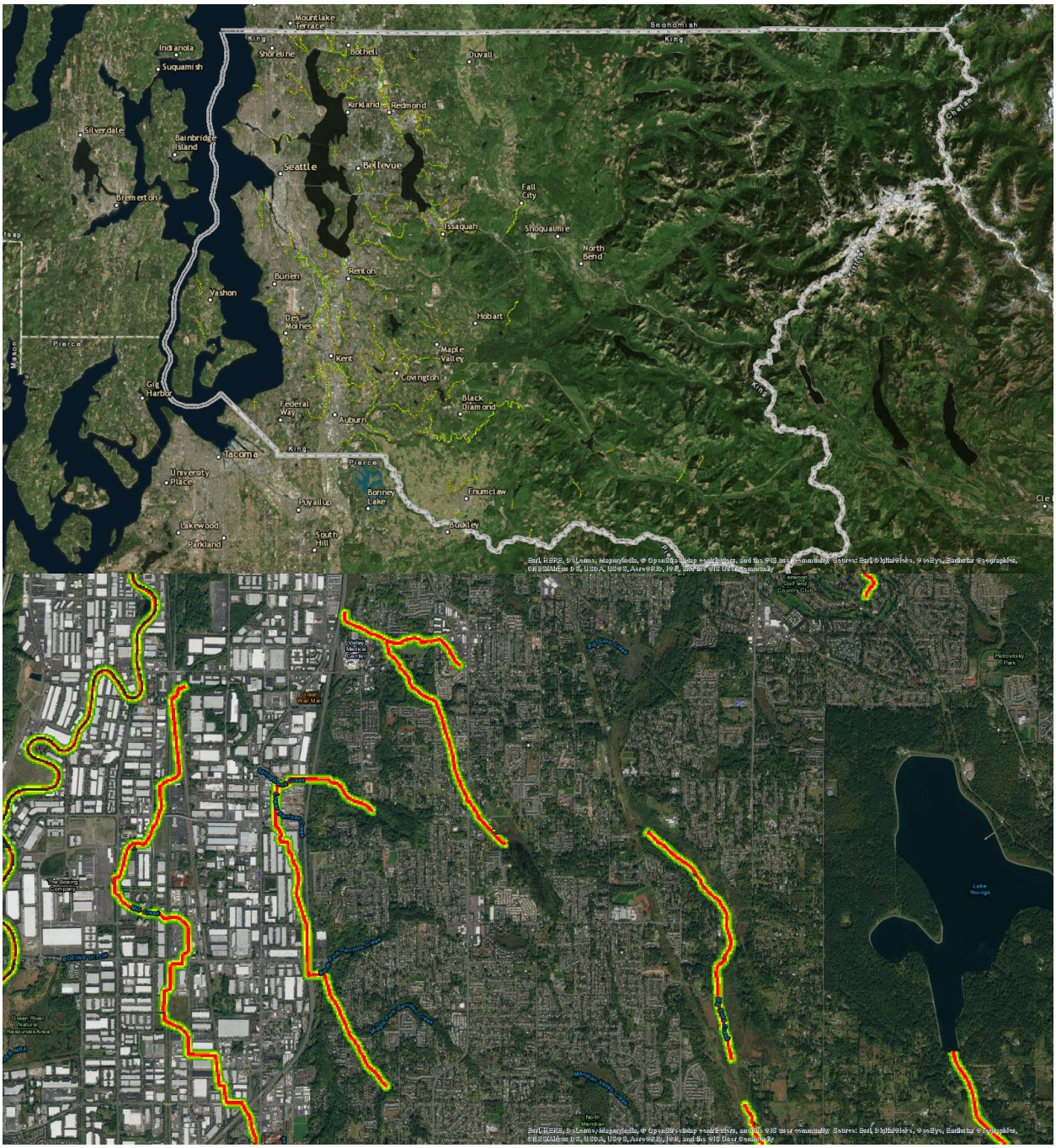


2. DOE Division of Water Quality 303 d waters for Temperature and Dissolved Oxygen

Washington State's current Water Quality Assessment (WQA) produced in the Environmental Protection Agency's *Integrated Report* format consisting of both the 303(d) List and the 305(b) Report. Water Quality's 303(d) website

Suitability rating assigned is based on proximity to the shoreline.

- areas along the shoreline were assigned a 5 (Highest Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Tree Planting Benefits));
- areas within 150 feet were assigned a 3 (Medium Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 2 (Lower Suitability for Tree Planting Benefits);
- areas within 500 feet were assigned a 1 (Least Suitability for Tree Planting Benefits).

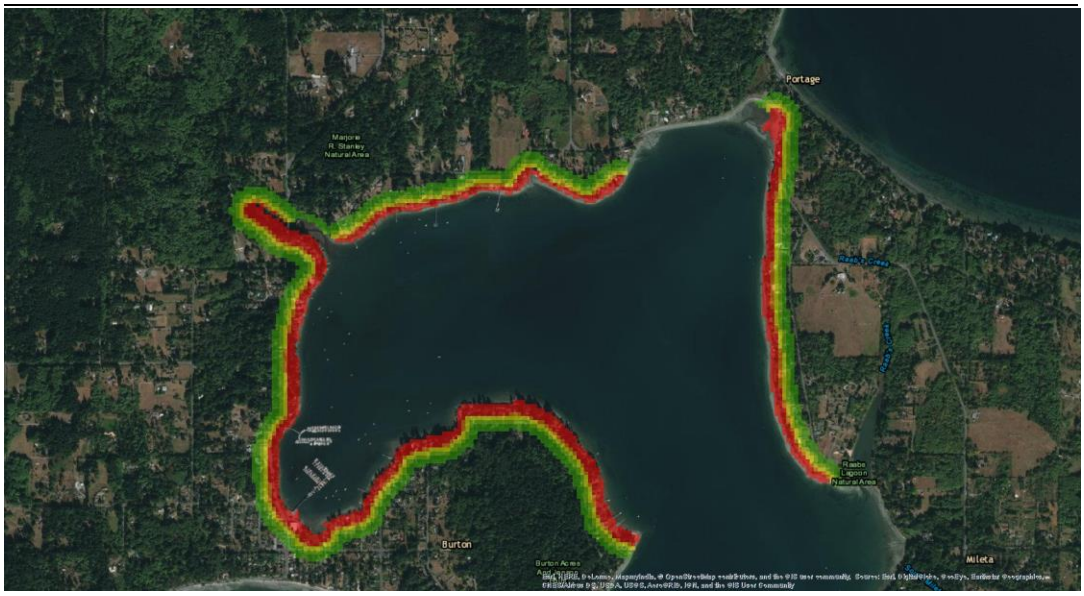


3. Shoreline Management Act: Shorelines with a Low and Medium Classification

Environmental conditions of marine shorelines. Low condition ratings are generally reflective of areas with high development intensity (e.g., the little presence or low use by critical species or little or no presence of rare, endangered or highly sensitive habitats). Medium condition ratings are gen erally reflective of areas with either high or moderate development intensity and moderate or low insignificant biological value.

Suitability rating assigned is based on proximity to the shoreline.

- areas within 25 feet of the shoreline were assigned a 5 (Highest Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Tree Planting Benefits);
- areas within 100 feet were assigned a 3 (Medium Suitability for Tree Planting Benefits);
- areas within 150 feet were assigned a 2 (Lower Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 1 (Least Suitability for Tree Planting Benefits);

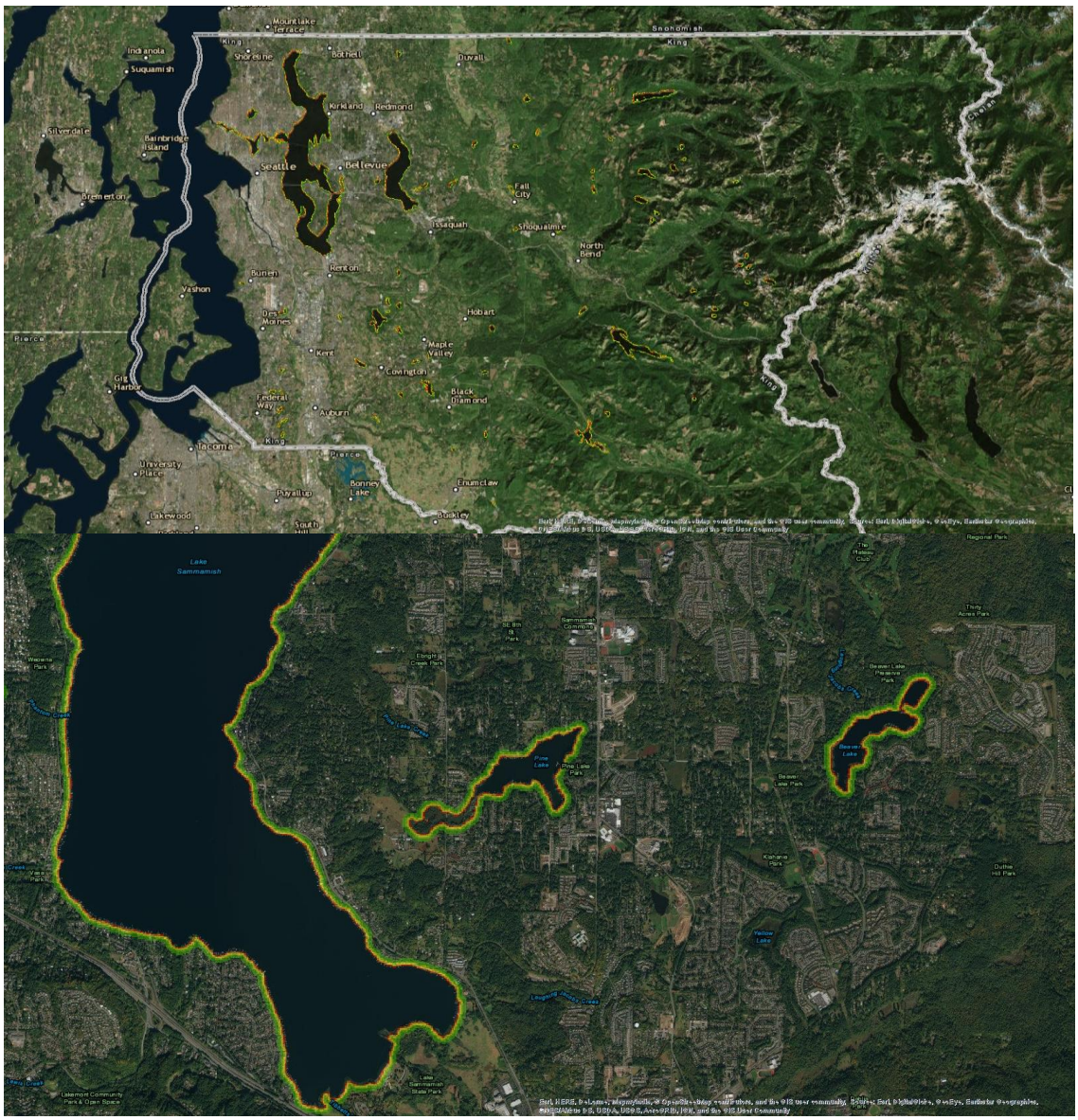


4. Shoreline Management Act: Shorelines of Lakes

Layer created to represent a polyline of the shoreline of lakes that fall under the SMA**.** Includes lakes 20 acres in size or more.

Suitability rating assigned is based on proximity to the shoreline.

- areas within 25 feet of the shoreline were assigned a 5 (Highest Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Tree Planting Benefits);
- areas within 100 feet were assigned a 3 (Medium Suitability for Tree Planting Benefits);
- areas within 150 feet were assigned a 2 (Lower Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 1 (Least Suitability for Tree Planting Benefits);



5. Streams with Identified Fish Populations (StreamNET)

Complete Generalized Fish distribution layer for all species in the StreamNet database. This dataset is a record of fish distribution and activity for ALL SPECIES contained in the StreamNet database. 2012. Distribution is based upon the best professional judgement of local fish biologists, in the Pacific Northwest Region. All data is referenced to StreamNet's Best Available Mixed-Scale Routed Hydrography as of January 2012 (MSHv3) on the LLID-based stream routing system.

Suitability rating assigned is based on proximity to the shoreline.

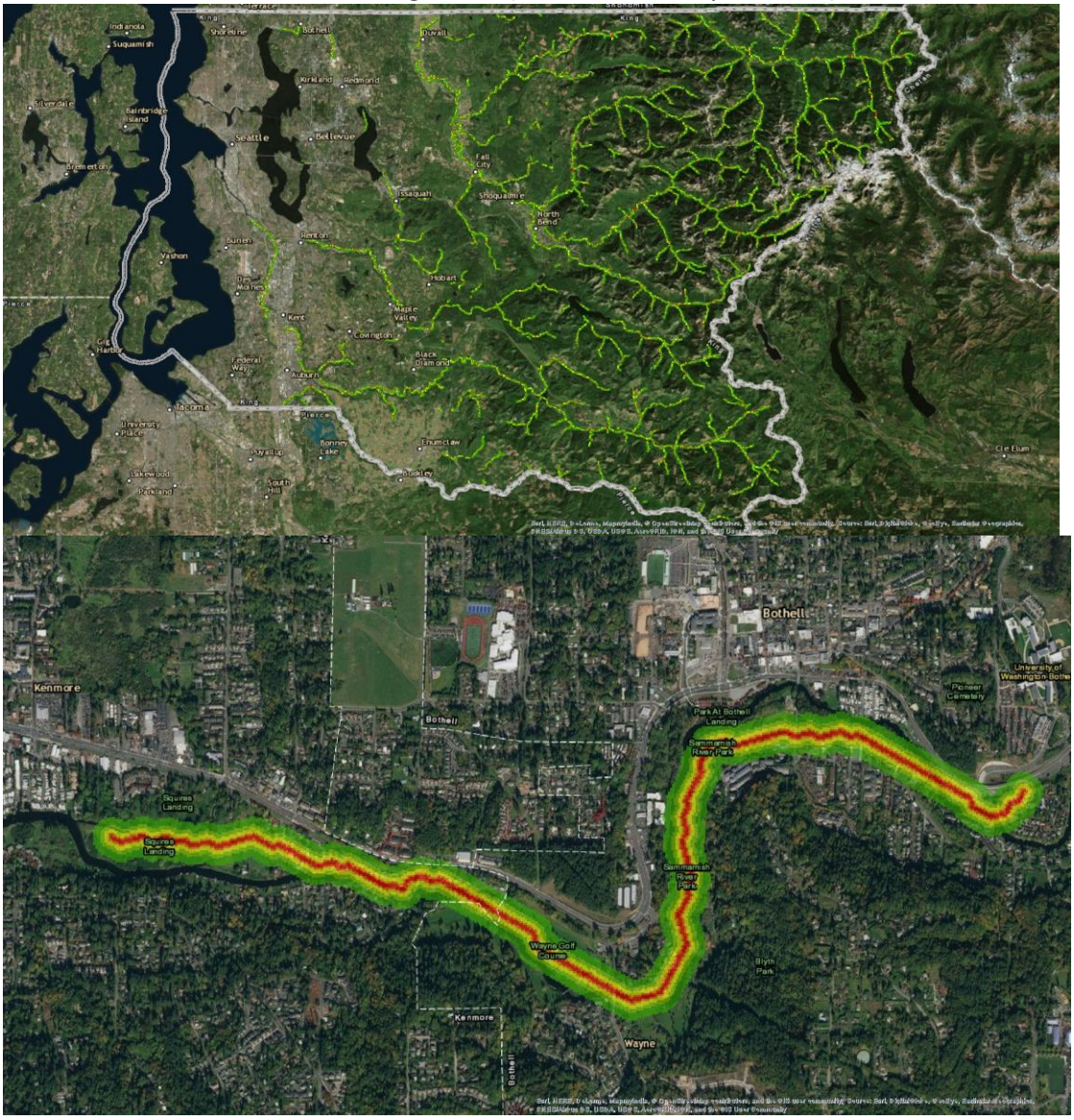
- areas within 25 feet of the shoreline were assigned a 5 (Highest Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Tree Planting Benefits);
- areas within 100 feet were assigned a 3 (Medium Suitability for Tree Planting Benefits);
- areas within 150 feet were assigned a 2 (Lower Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 1 (Least Suitability for Tree Planting Benefits);

6. DWQ Channel Migration Potential CHAMP

Stream networks of Western Washington (and much of Western Oregon) with associated data and information important for assessing channel migration activity.

Suitability rating assigned is based on proximity to the shoreline.

- areas within 25 feet of the shoreline assigned a 5 (High Suitability for Tree Planting Benefits);
- areas within 50 feet were assigned a 4 (High Suitability for Trees),
- areas within 100 feet were assigned a 3 (Medium Suitability for Trees),
- areas within 150 feet were assigned a 2 (High Suitability for Tree Planting Benefits);
- areas within 250 feet were assigned a 1 (Lowest Suitability for Trees).

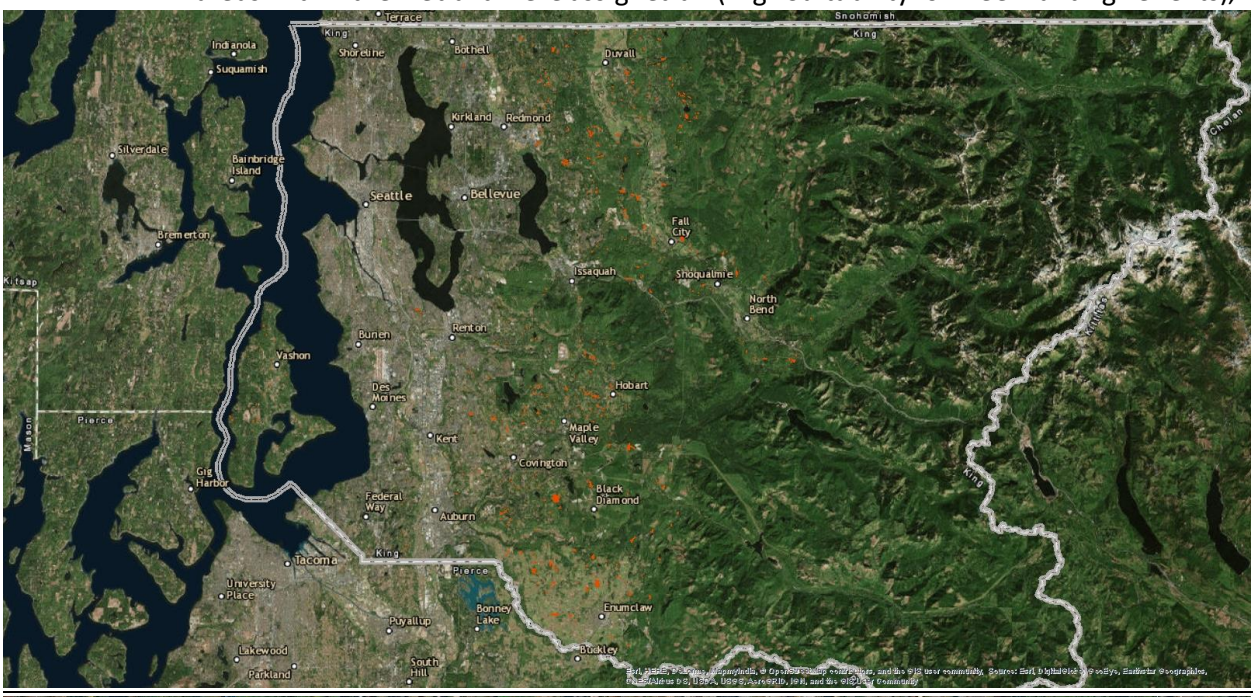


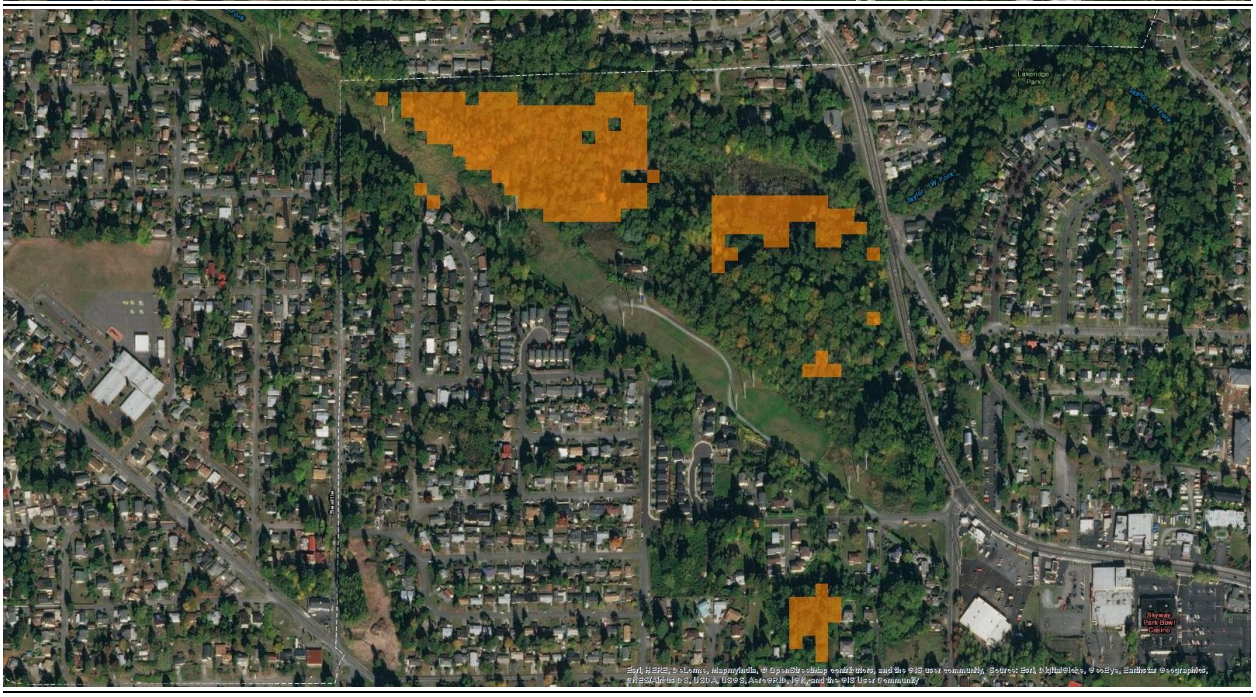
7. Wetland Areas

Documented wetlands in King County; WA. Attributes include the date captured and other details for each feature. Some features document only a portion of a larger wetland in the landscape. This represents only a small portion of all wetlands in King County.

Suitability rating assigned is based on proximity to the wetland.

- areas within the wetland were assigned a 4 (High Suitability for Tree Planting Benefits); .



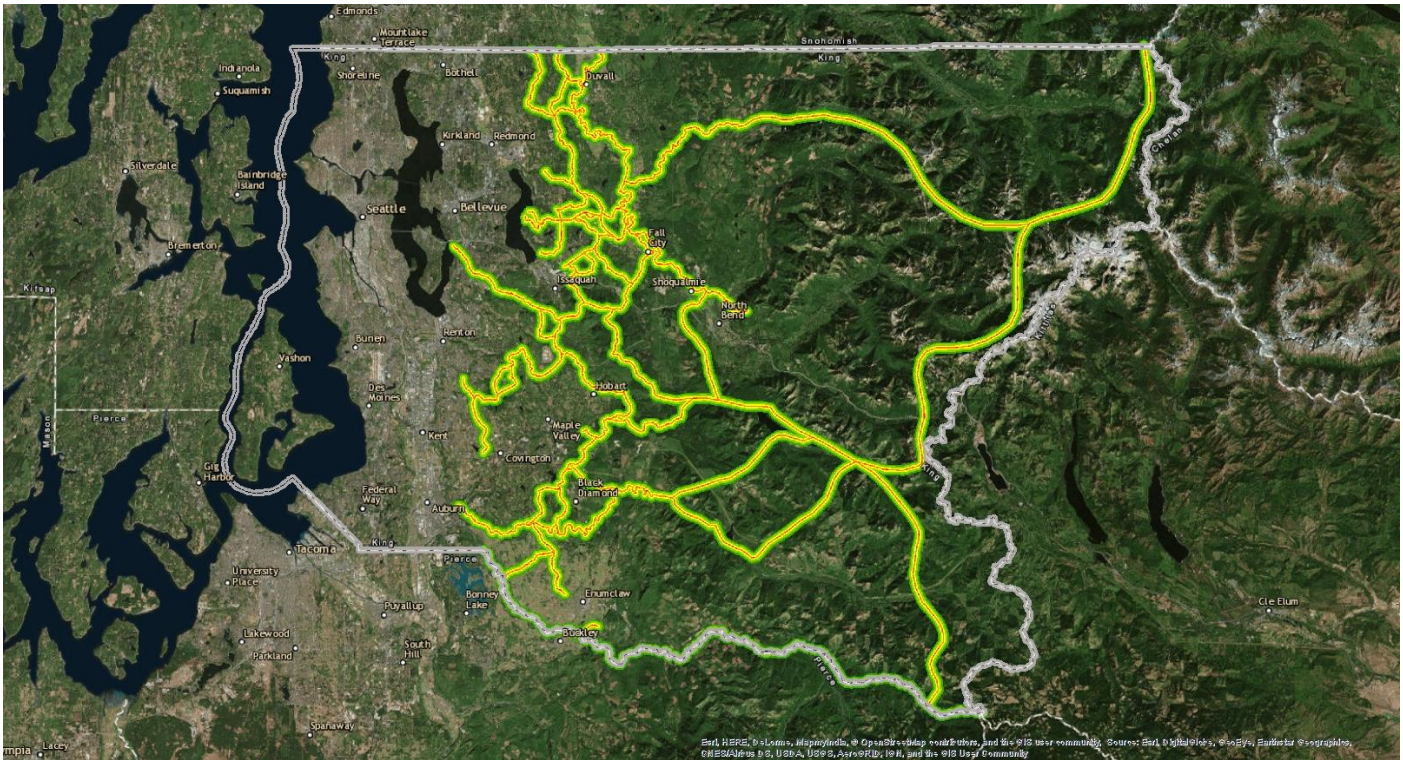


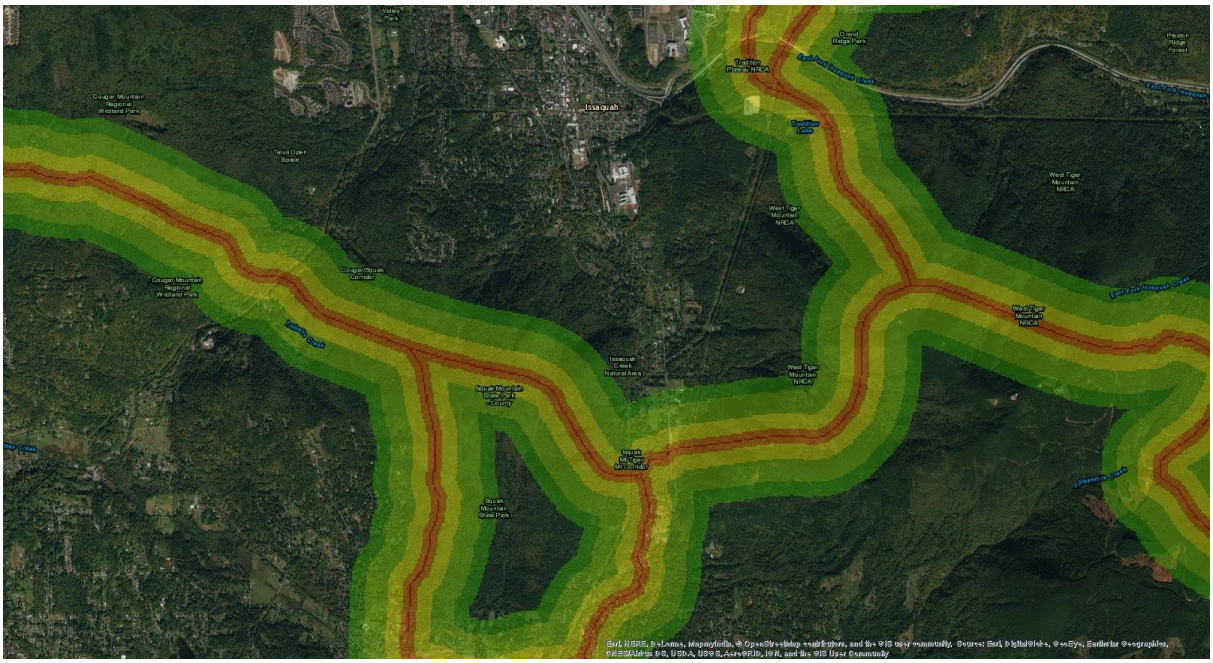
8. Buffered Area Around Wildlife Habitat Network

Wildlife Habitat Network as of 1996. Wildlife networks are land-based (terrestrial) ecosystems composed of unique interacting systems of soil, geology, topography, and plant and animal communities. For the purpose of this discussion of King County's wildlife areas, the best available science concerned with terrestrial conservation is reviewed, including literature that ranges from conservation theory to studies on select terrestrial wildlife species. For this analysis, wildlife areas are defined as those areas in which priority mammals, birds, amphibians, reptiles, and invertebrates of King County are likely to be found.

Suitability rating assigned is based on proximity to the network.

- areas within 25 feet of the network were assigned a 5 (Highest Suitable for Trees),
- areas within 250 feet were assigned a 4 (High Suitability for Trees),
- areas within 750 feet were assigned a 3 (Medium Suitability for Trees),
- areas within 1500 feet were assigned a 2 (Lower Suitability for Trees),
- areas within 2000 feet were assigned a 1 (Lowest Suitability for Trees).



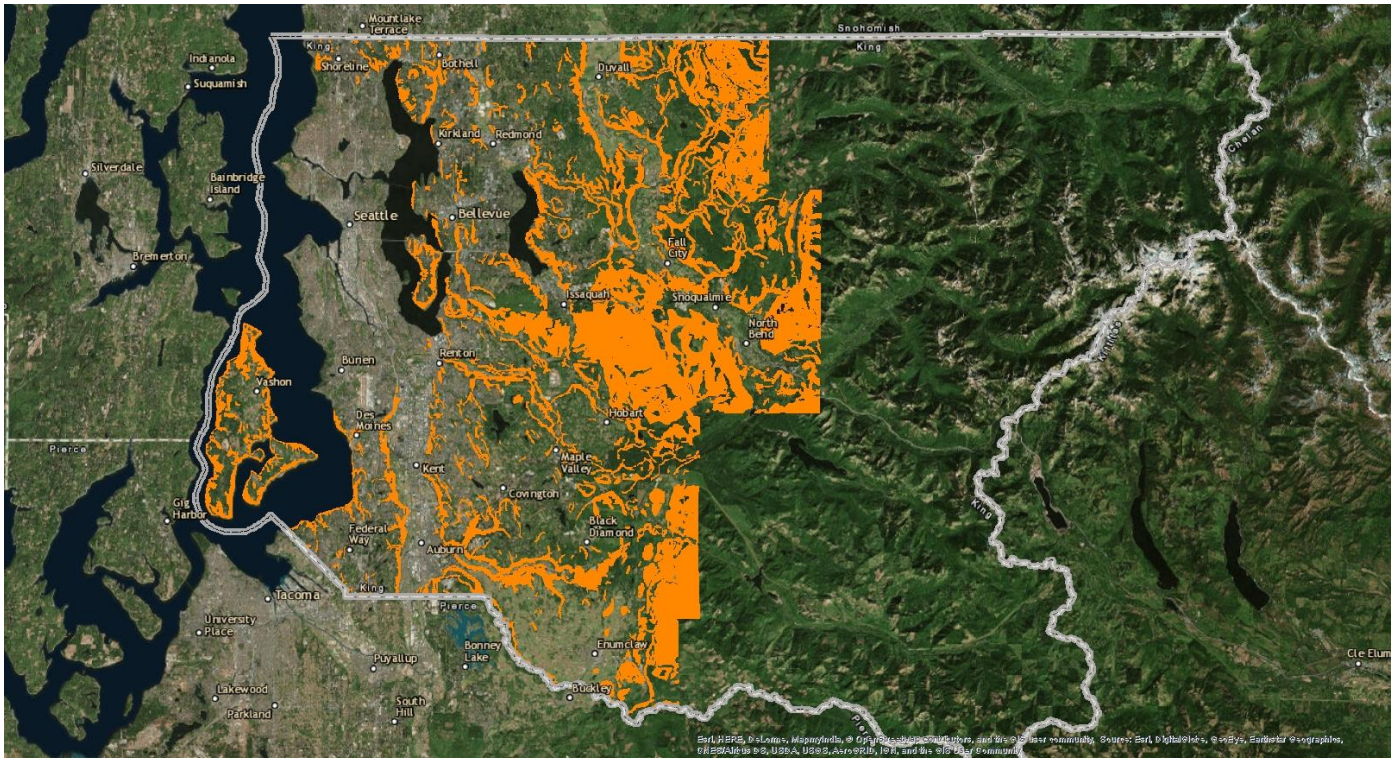


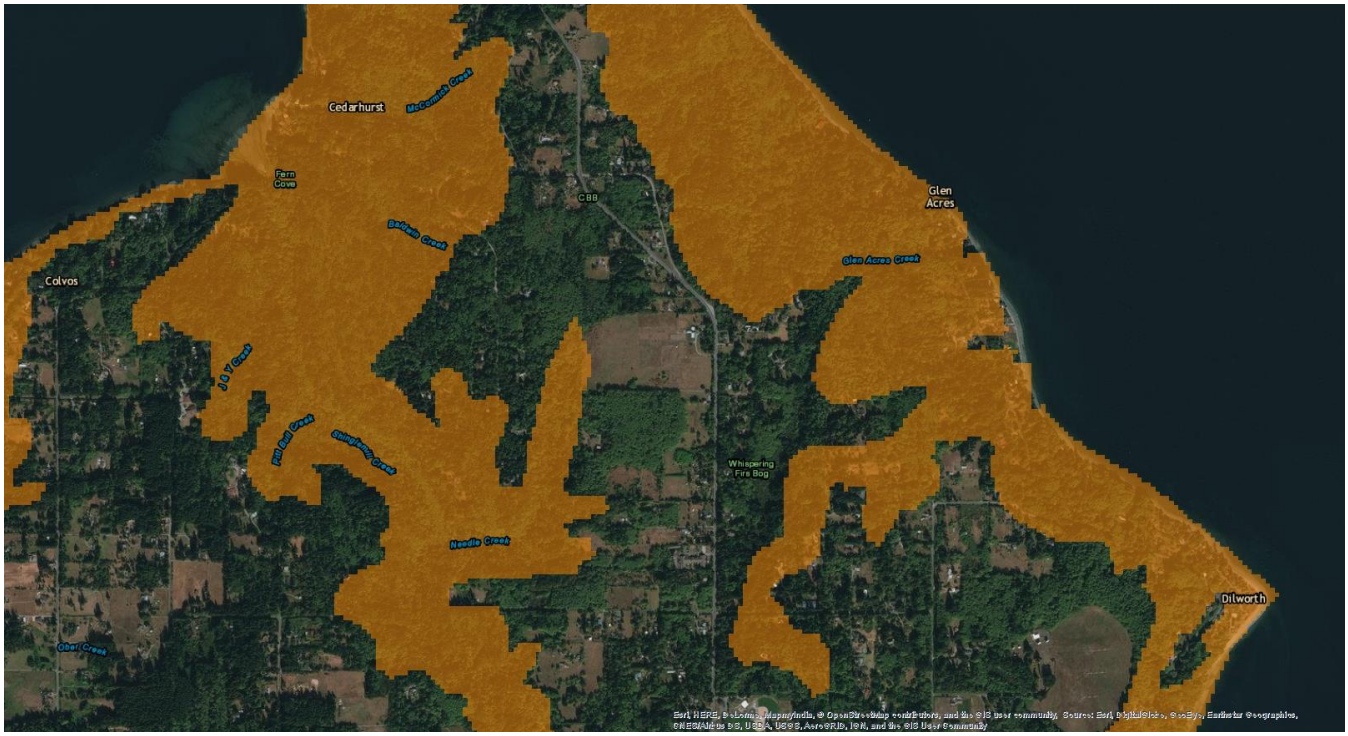
9. Erosion Hazard Areas

The Sensitive Areas Ordinance (SAO) defines significant erosion hazard areas as those soils in King County that may experience severe to very severe erosion hazard. The SAO adopts the soils definition in the U.S. Department of Agriculture Soil conservation Service (SCS) 1973 King County Coil Survey and the Snoqualmie Pass Area Soil Survey (ND).

Suitability rating assigned is based on location “in or out” of the erosion hazard area.

- areas within the hazard were assigned a 4 (High Suitability for Tree Planting Benefits);





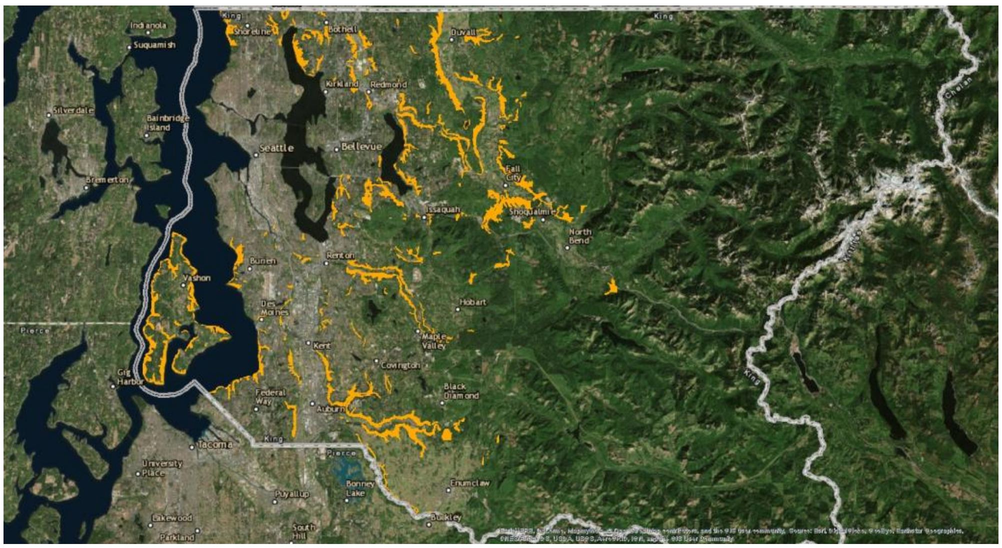
10. Landslide Hazard Areas

Areas subject to severe landslide risk. A. Any area with a combination of: 1. Slopes greater than 15 %; and 2. Impermeable soils (typically silt and clay) frequently interbedded with granular soils

(predominantly sand and gravel); and 3. Springs or groundwater seepage. B. Any area that has shown movement during the Holocene epoch, or that is underlain by mass wastage debris of that epoch. C. Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action. Any area that shows evidence of, or is at risk from, snow avalanches. E. Any area located on an alluvial fan, subject to or potentially subject to inundation by debris flows or stream-transported deposits.

Suitability rating assigned is based on location "in or out" of the landslide hazard area.

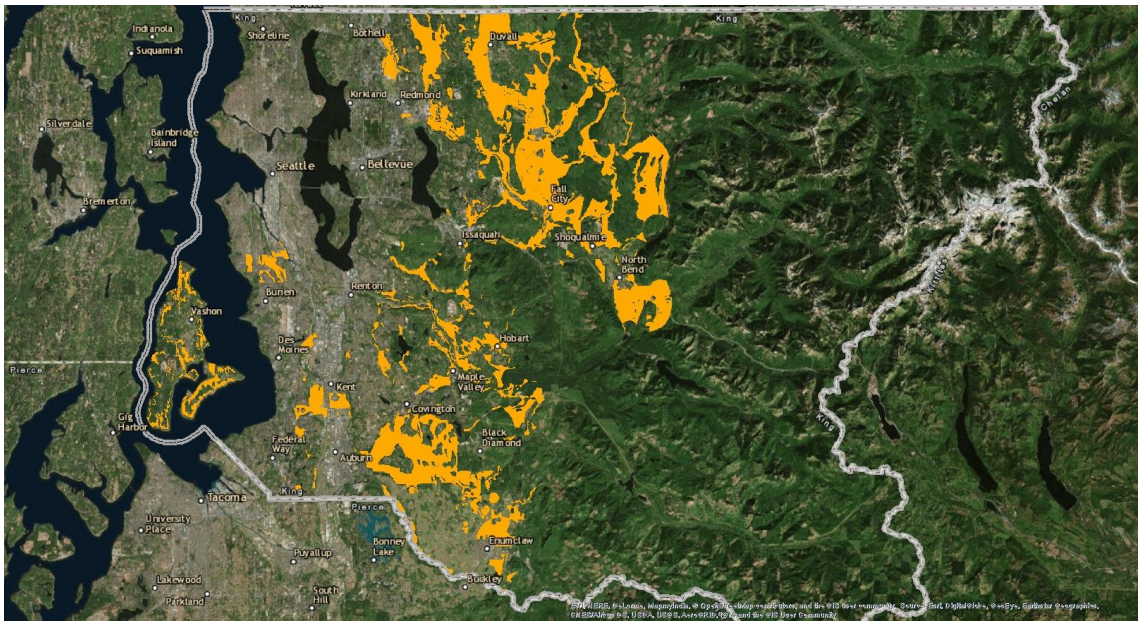
- areas within the hazard were assigned a 4 (High Suitability for Tree Planting Benefits);



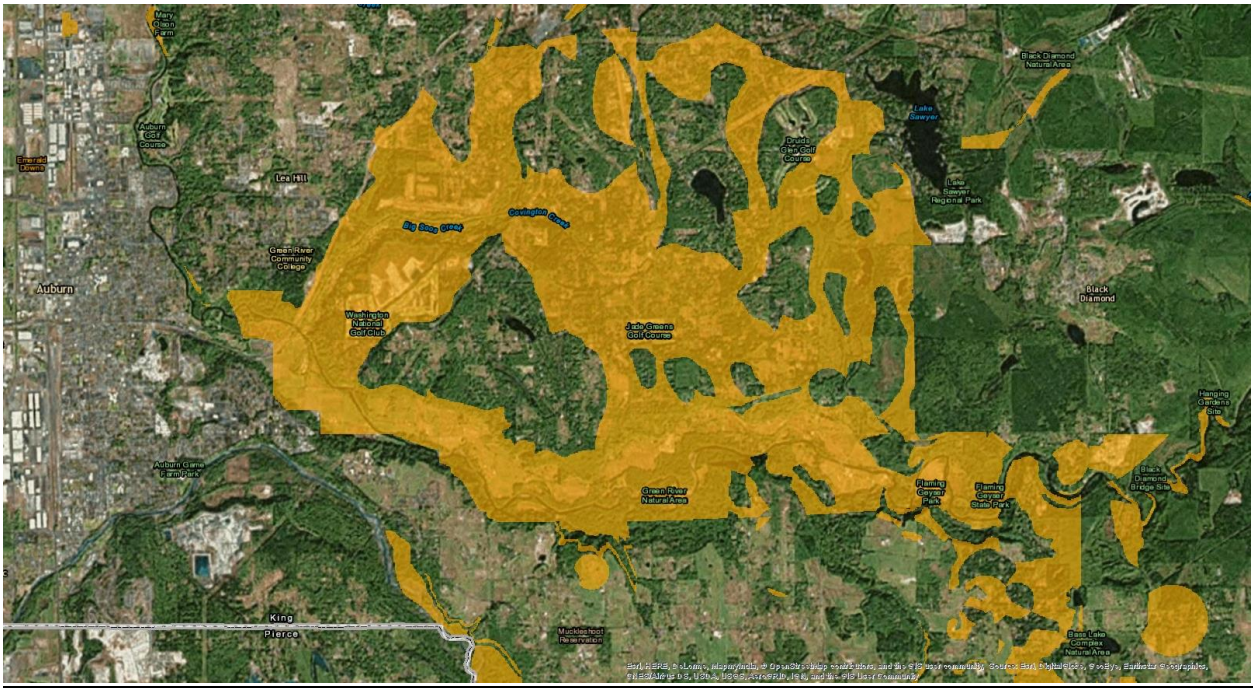
11. Critical Aquifer Recharge Areas CARA

The GMA defines CARAs as "areas with a critical recharging effect on aquifers used for potable water." Aquifer recharge occurs where rainfall, snowmelt, infiltration from lakes, wetlands and streams, or irrigation water infiltrates into the ground and adds to the water underground that can supply a well. Areas with a critical recharging effect on aquifers used for potable water are areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water.

Suitability rating assigned is based on location "in or out" of the CARA.



- areas within the CARA area were assigned a 2 (Lower suitability for trees).

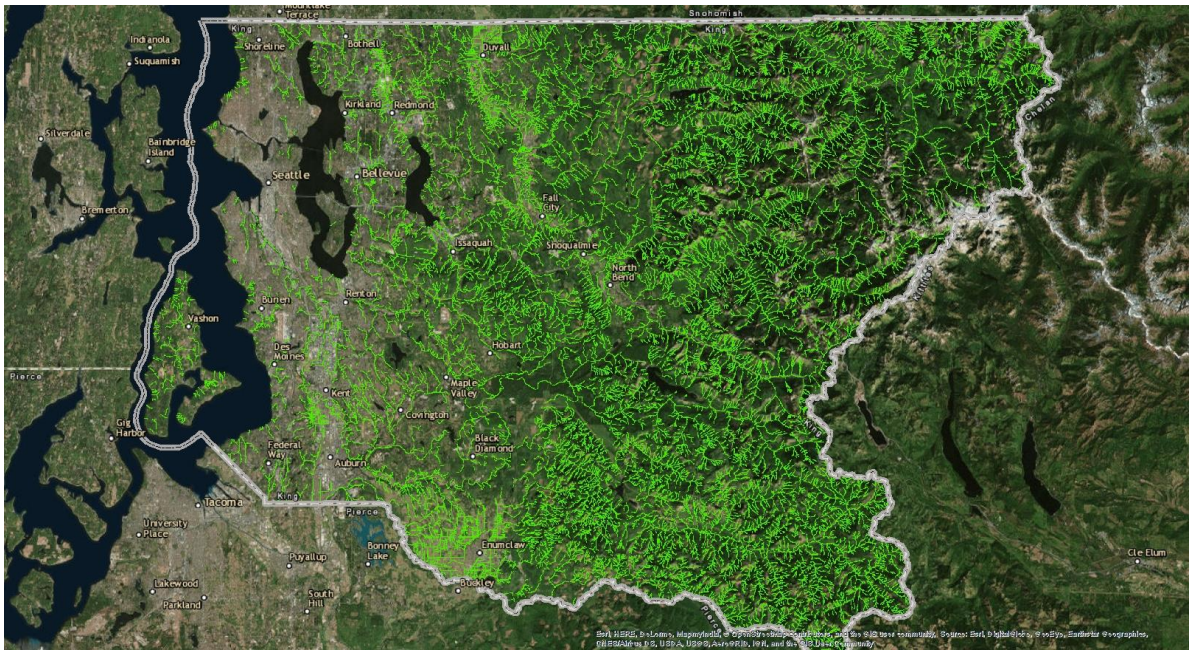


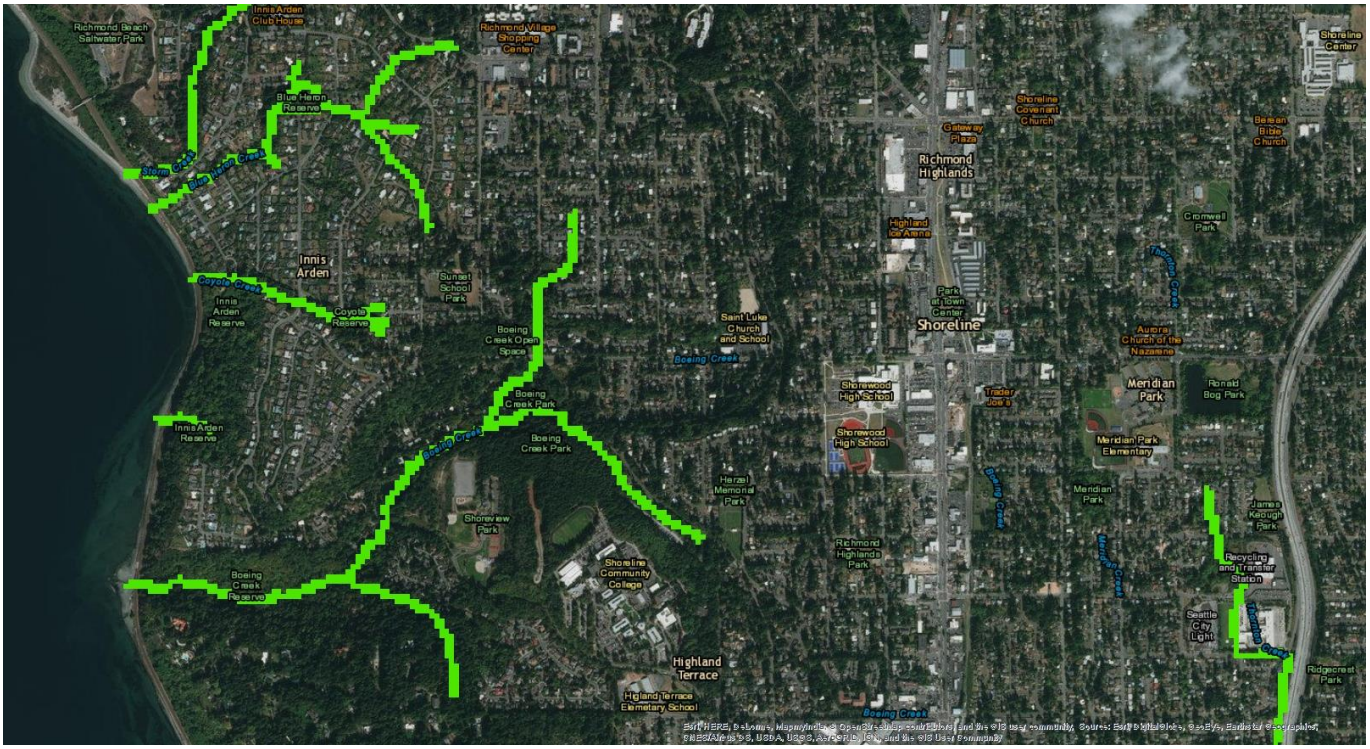
12. Areas within 50 feet of Watercourse (rivers and streams)

Streams of King County. Purpose to enhance shading and stormwater filtering opportunities with new tree plantings along watercourses.

Suitability rating assigned is based on proximity to the shoreline.

- areas within 50 feet of the stream were assigned a 3 (Medium Suitability for Trees).





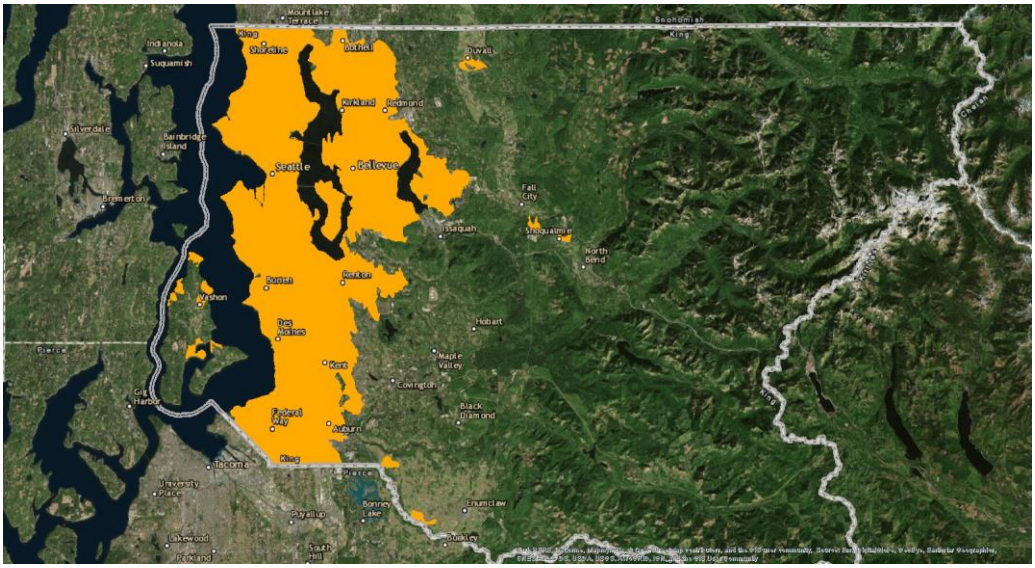
Optional Additional Data Sets

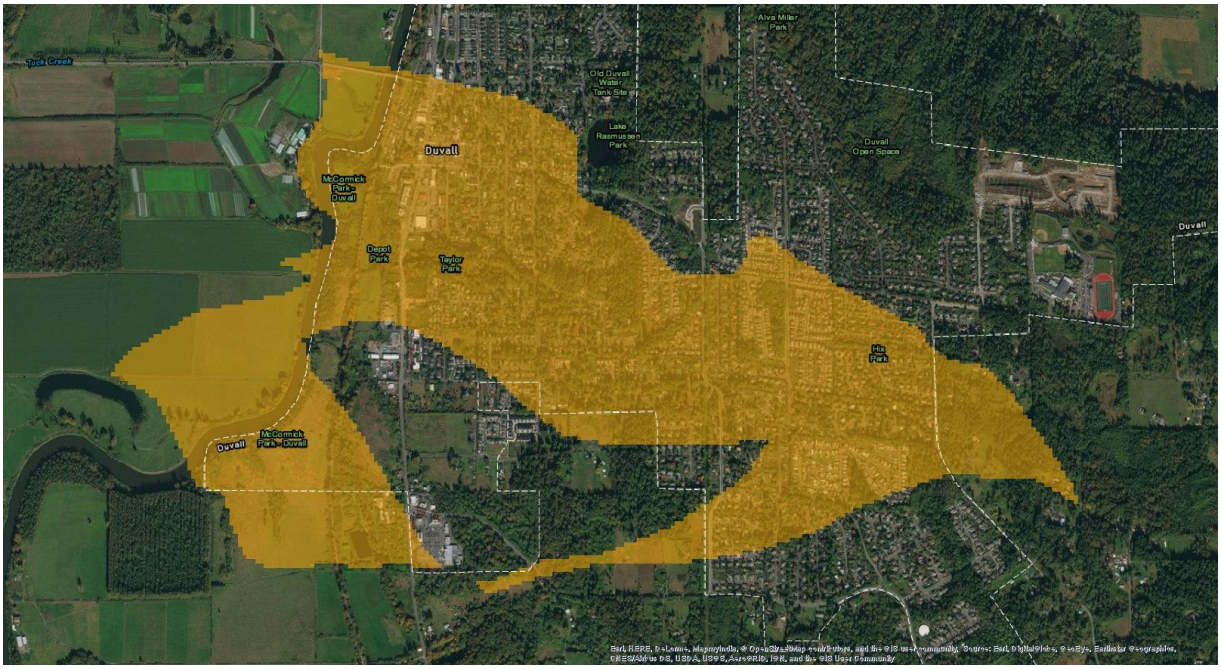
13. Drainage Basin Condition of Low

Environmental conditions of Drainage Basins. Used as a tool to regulate land use according the 2005 King County Critical Areas Ordinance.

Suitability rating assigned is based on location "in or out" of the Drainage Basin with a Low Condition Ranking by DWQ.

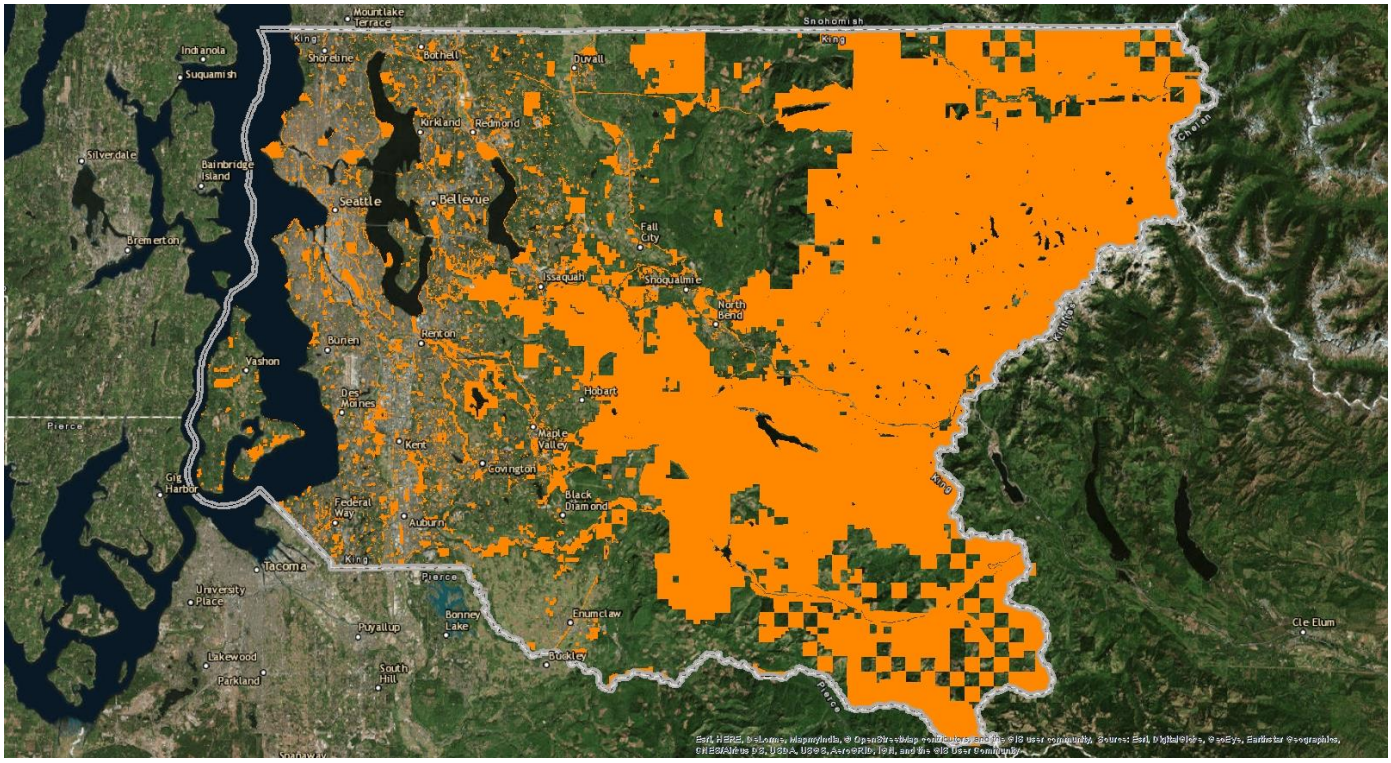
- areas within the basin were assigned a 1 (lowest suitability for trees).

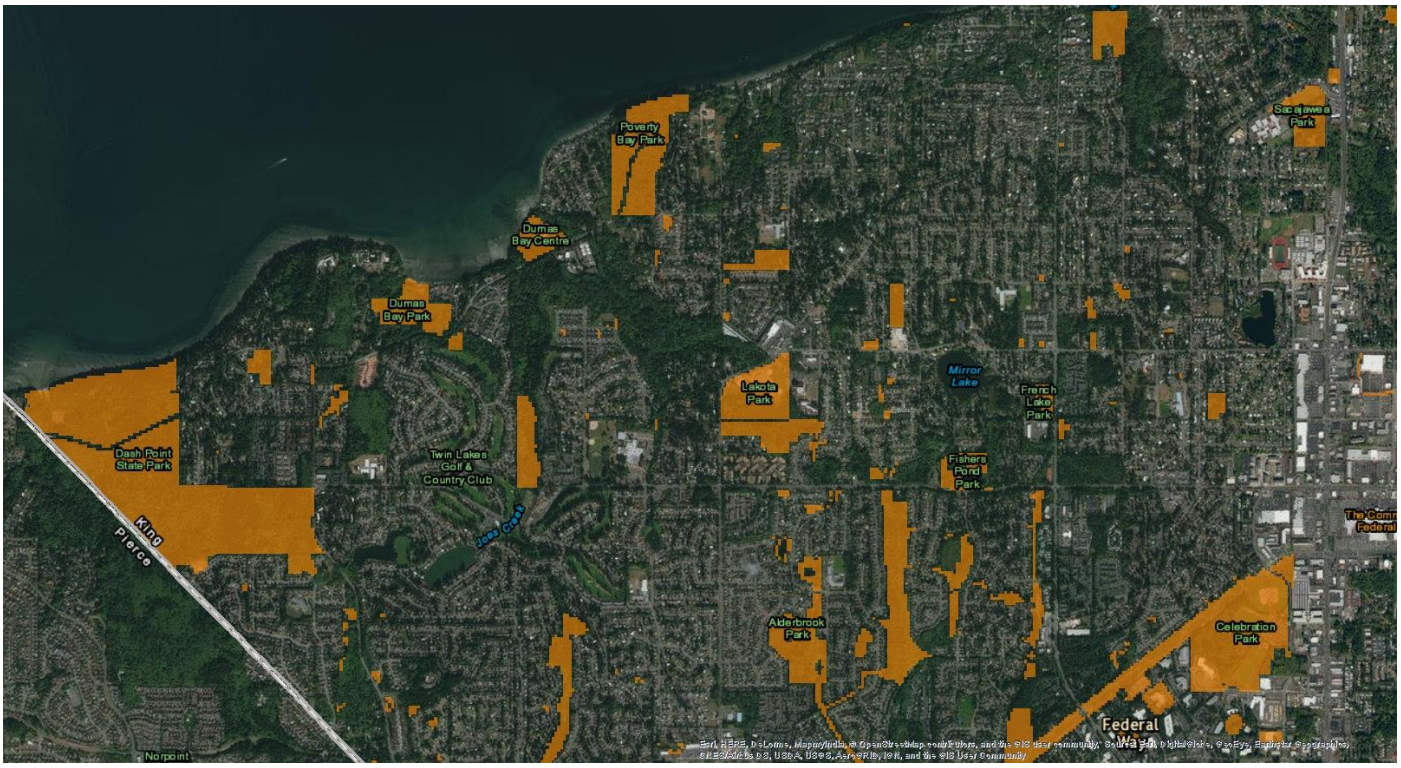




14. Public Lands

Publicly-owned parcels derived from the SDE spatial view PARCEL_COMMONDATA_AREA_VIEW by selecting taxpayer names that indicate the parcel is publically owned. Property owned by <u>any</u> public agency.


Mountlake Terrace
Snohomish
King
Indianola
Suquamish
Shoreline
Bothell
Duvall
Kirkland
Redmond
Silverdale
Bainbridge Island
Seattle
Bellevue
Fall City
Bremerton
Issaquah
Snoqualmie
North Bend
Renton
Burien
Vashon
Des Moines
Hobart
Pierce
Kent
Maple Valley
Covington
Gig Harbor
Black Diamond
Federal Way
Auburn
Tacoma
University Place
Bonney Lake
Enumclaw
Puyallup
Buckley
Lakewood
Parkland
South Hill
Cle Elum
Chelan
Kittitas
Yakima



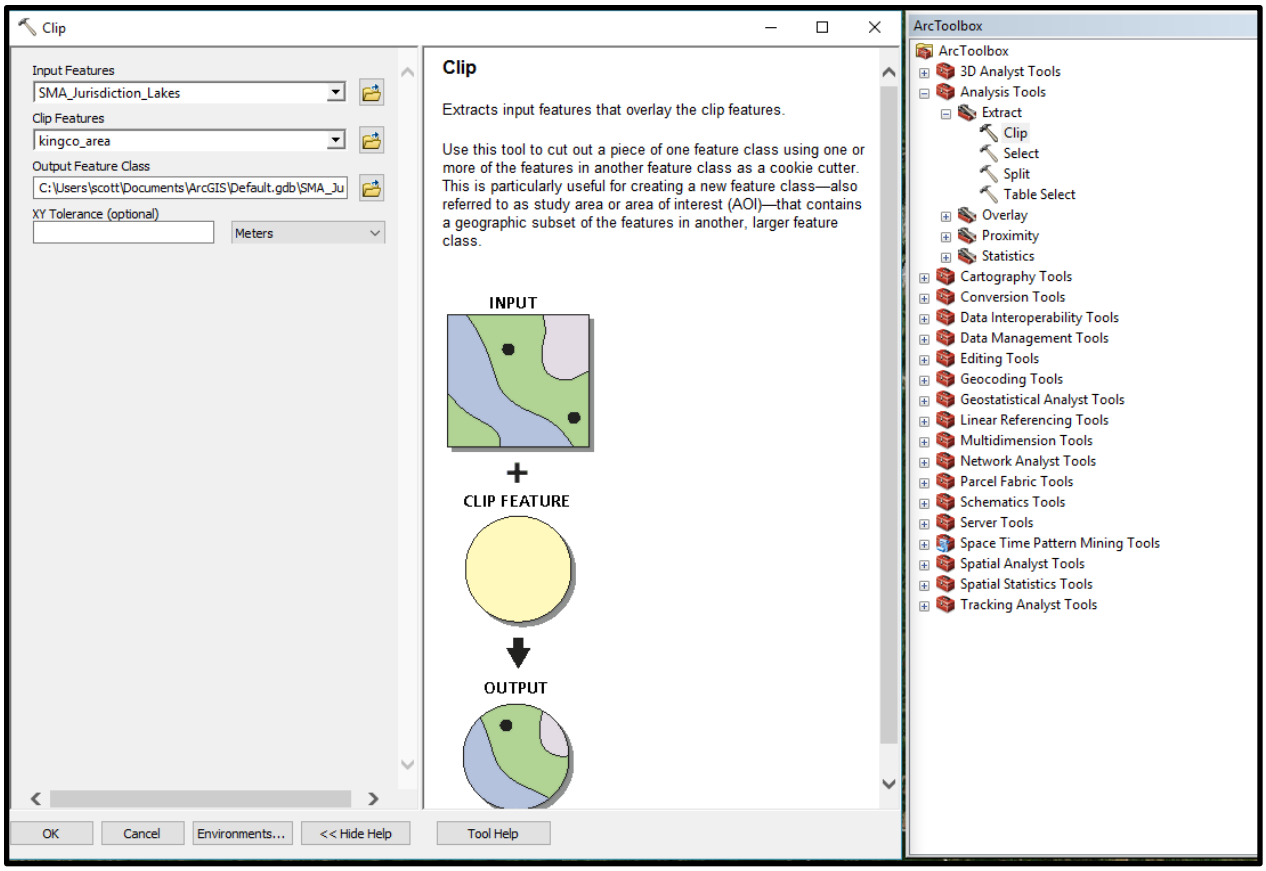
Pre-processing of Environmental and Ecological Datasets:

STEPS

1. Data sets Clipped to Focal Area (King County)

All data sets obtained outside of the King County data portal needed to be clipped to the King County boundary for efficiency and easier processing and viewing. Data clipped included:

a) DOE DWQ Shoreline Management Act - marine shoreline and freshwater waterbodies (over 20 acres).
b) StreamNet fish identification waters.
c) DOE DWQ Drainage Basin Condition.

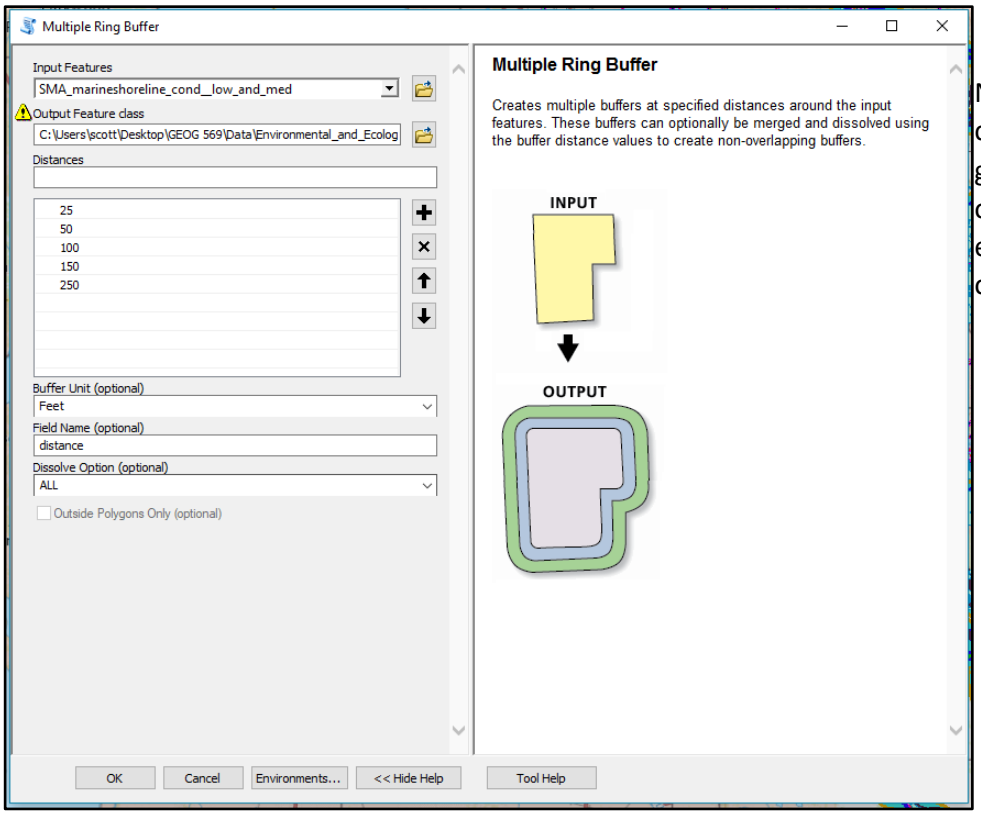


2) Multiple Buffer Distance Values Assigned

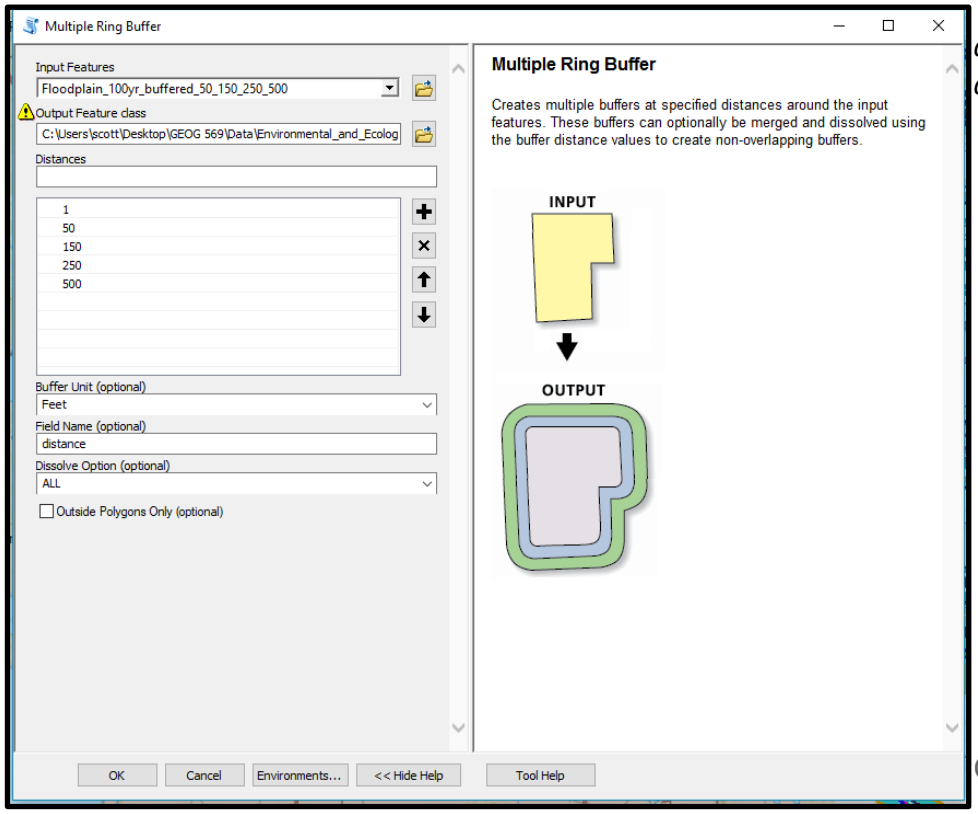
All Data sets that were polyline features, as well as a few key polygon features were processed to assign 5 unique graduated distance values which were needed to eventually assign a suitability ranking based on proximity to the underlying target feature of the dataset. Graduated (or ordinal) distance values assigned ranged from 25 feet for the first buffer area to 250 feet for the outer buffer area. These distance values were generally used for buffering areas around streams, rivers and shorelines datasets that were created with a high degree of resolution. However, the buffered distance values can vary widely depending on the nature and resolution of the underlying feature data set. The Wildlife Habitat Network buffered areas ranged from 250 feet to 2,000 feet due to the more generalized nature of the data set and its lower resolution and scale of accuracy confidence. The specific distance values assigned to all datasets can be found in the listing and description of the 13 data sets preceding this section.

The 5 graduated distance values were created using the multiple ring buffer tool, as shown in the graphic below.

Polyline Feature with 5 distance buffer values assigned



Note: Polygon features chosen for buffering were given a fist buffer ring value of 1 foot as the first ring was essentially merged with the original area of the polygon.



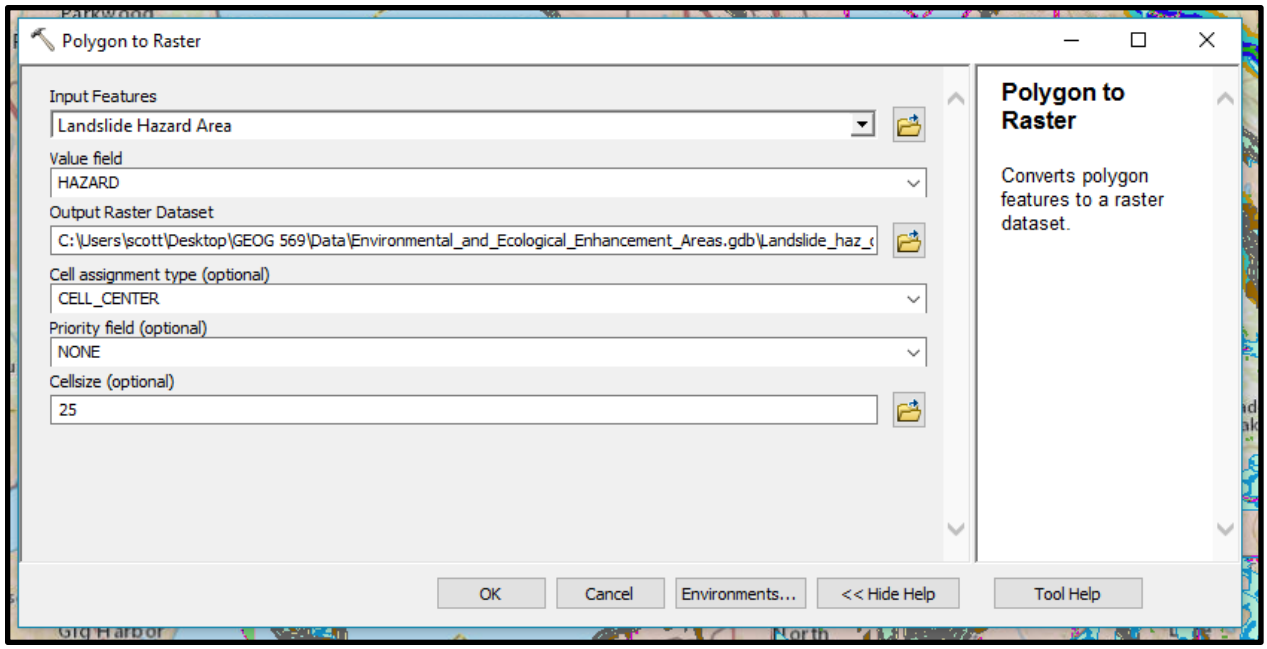
Polygon Feature with 5 distance buffer values assigned

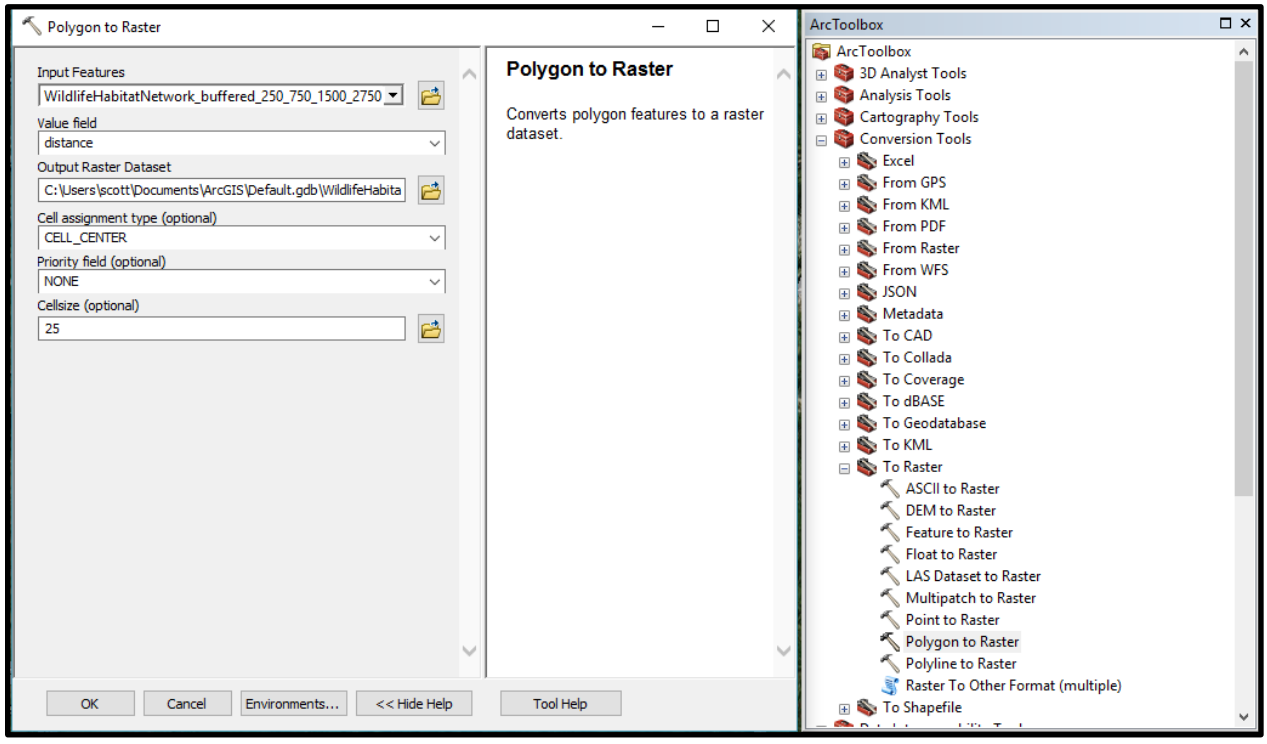
3. Raster Data Sets Creation

Polygons and polylines that were assigned 5 values based on graduated distance from the target feature were then converted to rasters with 5 unique values. Each of the 5 unique distance values will be assigned a weight (or score) based on the distance from the target feature. For example, areas in the first buffer ring value will be given the highest weight because it is closest to the desirable feature.

Cell size of the rasters was set to 25 feet squared to capture as much resolution of the original feature classes as possible.

Example: Polygon Feature Converted to a Single Value Raster with 25 foot Cell Size





Example: Polyline Feature Converted to a Single Value Raster with 25 foot Cell Size

Note: The Value field is set to "distance" which contains the 5 buffer values (distances) created with the Multiple Buffer Ring Tool as shown previously.

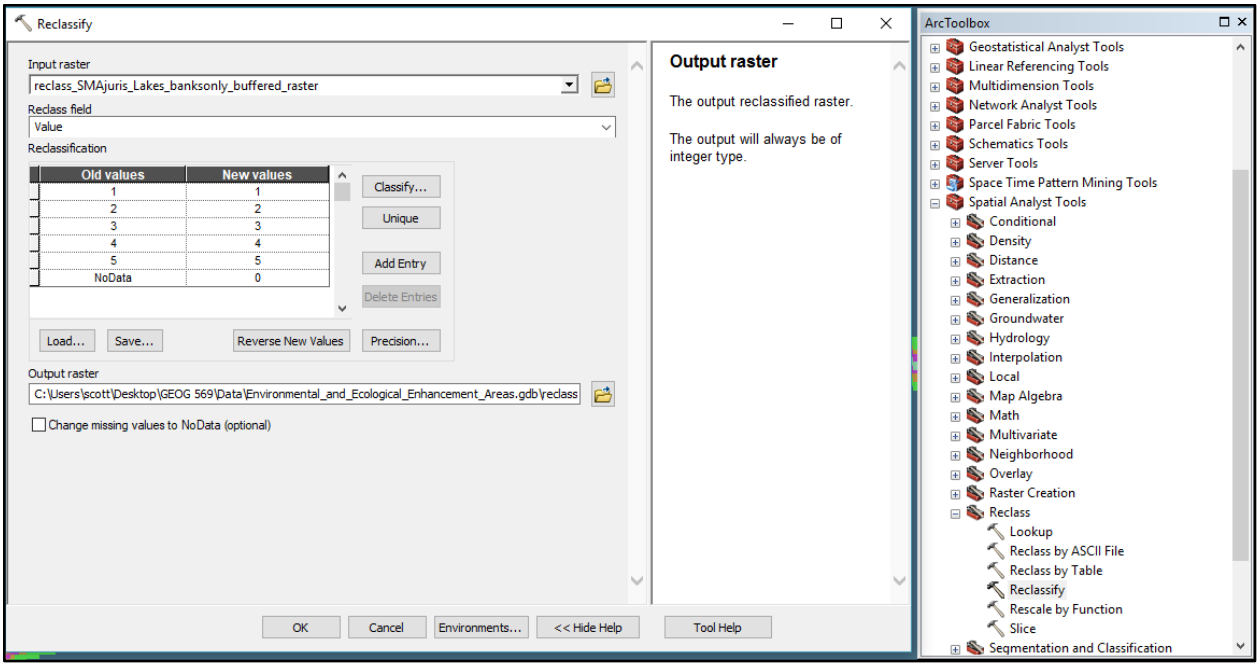
4. Raster Processing

All 12 Raster data sets identified as critical to the Environmental and Ecological Enhancements goal were reclassified using the Reclassify Tool to assign a suitability score of 1 through 5 that corresponds with the distance values of the multiple feature buffer areas created before. The suitability reclassification was necessary step before conducting overlay analysis. A score of 5 signifies the most suitable or desired areas for tree planting to enhance the underlying enviro/ecological feature of the data set. A score of 5 signifies that the area is part of the enviro/ecological feature or is within the closest buffer area ring.

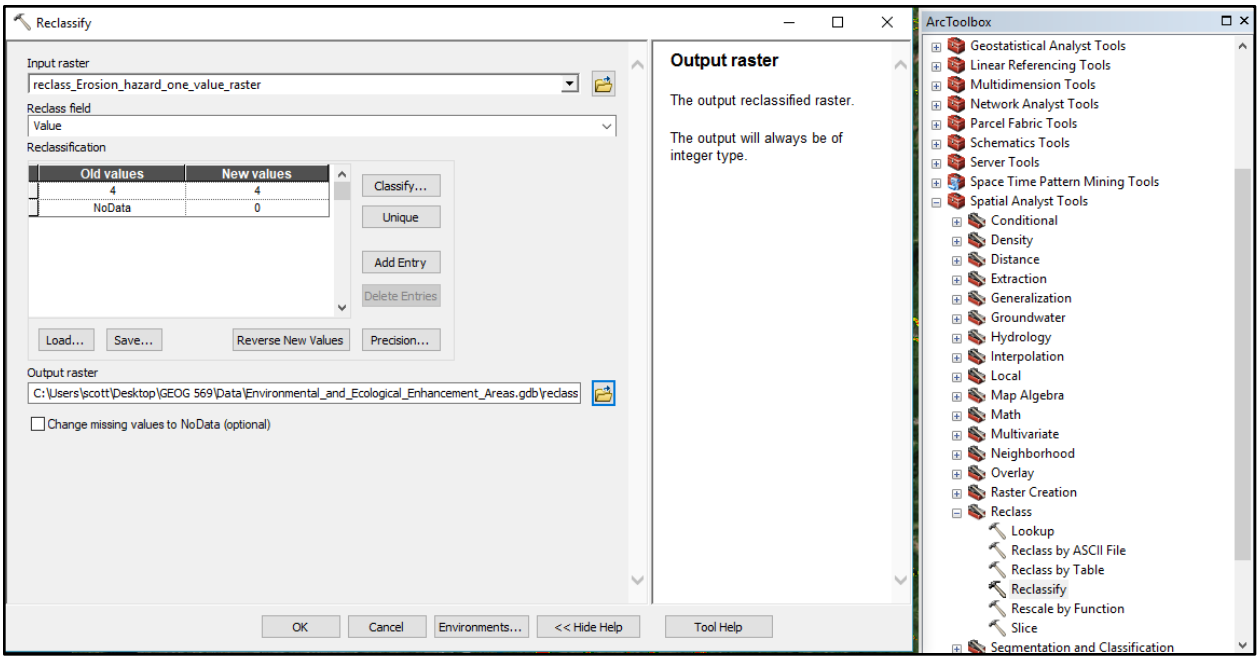
Below shows the Reclassify Tool within the Spatial Analyst Toolbox, as well as an example of the Reclassify dialog box showing the "marine shoreline low/medium condition areas" reclassified to a suitability score of 1-5. The classification of the suitability scores is as follows:

5 = Highest Suitability (to achieve Enviro/Eco Enhancement with Tree Plantings)
4 = High Suitability (to achieve Enviro/Eco Enhancement with Tree Plantings)
3 = Medium Suitability (to achieve Enviro/Eco Enhancement with Tree Plantings)
2 = Lower Suitability (to achieve Enviro/Eco Enhancement with Tree Plantings)
1 = Least Suitability (to achieve Enviro/Eco Enhancement with Tree Plantings)
0 = No Data/Not Applicable

Polyline Feature Reclassified to Suitability Scores 1 through 5, A value of 0 was for NoData.

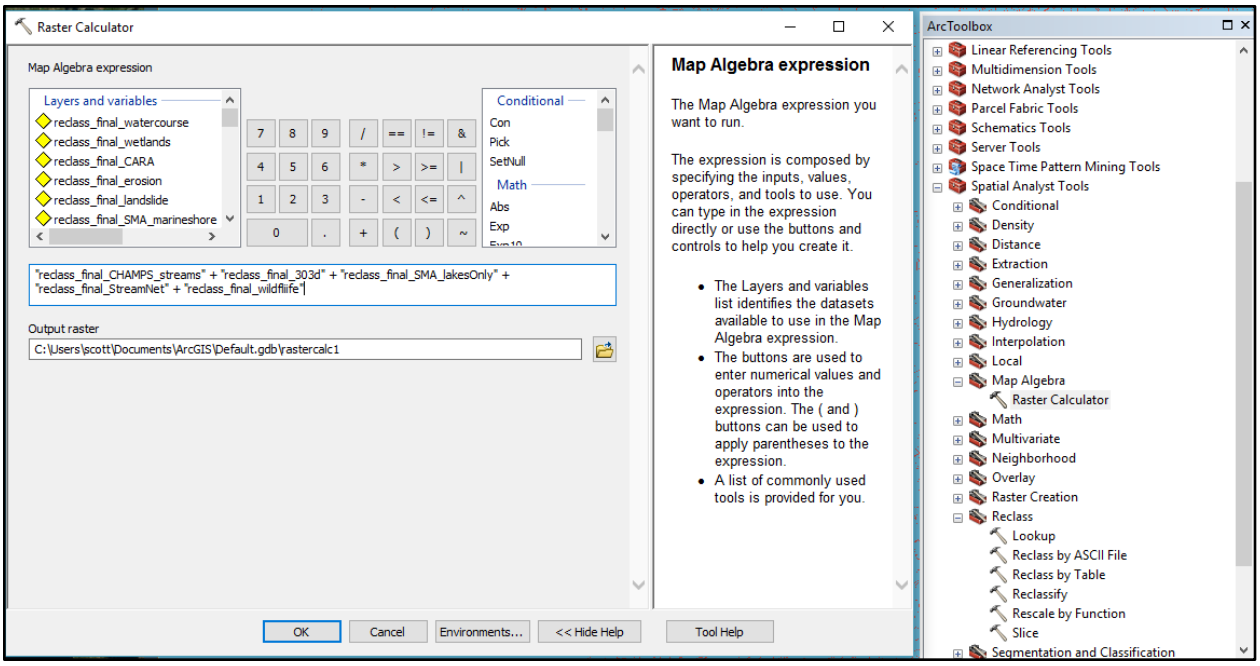


Polygon Feature Reclassified to Suitability Score of 4, A value of 0 was for NoData.



3. Raster Data Sets Run Through Spatial Overlay Analysis

The Raster Calculator tool was used to create and execute a Map Algebra expression that will output a comprehensive raster which adds the cumulative suitability scores of all the individual raster data sets that make up the environmental and ecological enhancement category.



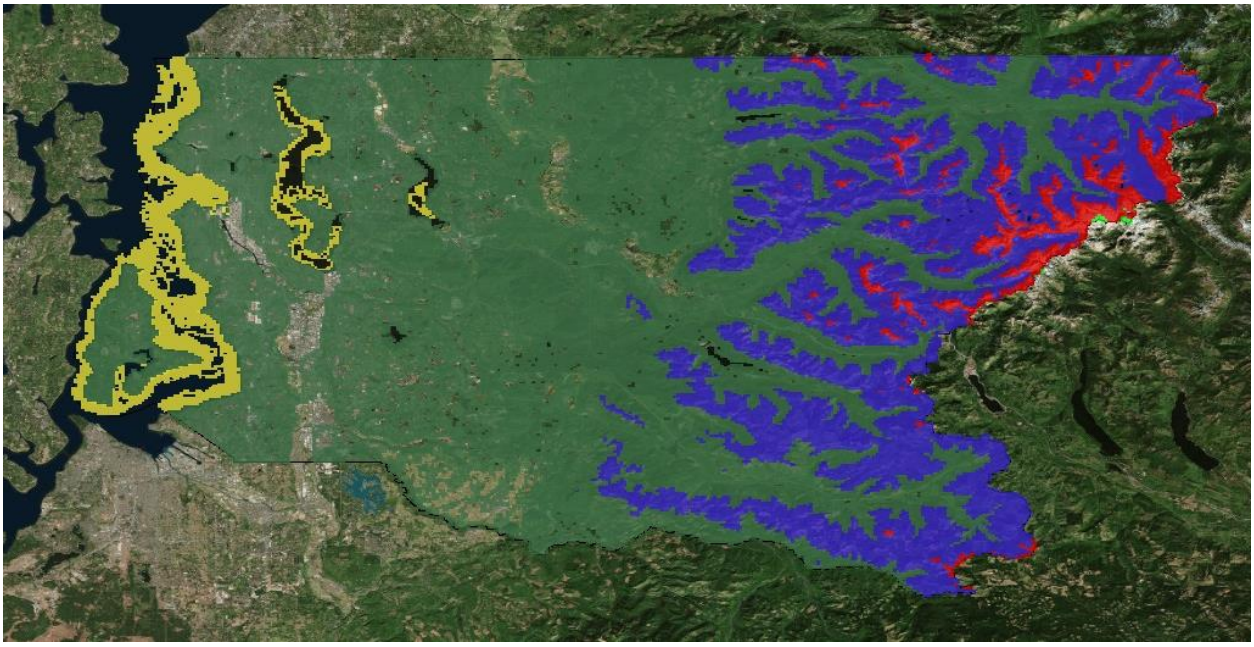
The result of the raster calculator is a composite overlay of all the input features which includes summed totals of each cell in the raster output based on the occurrence of a feature or features intersecting or being contained in the cell.

Tree Survivability

The survivability of native trees in King County can be a long and never ending analysis if the individual or team has the time to spend doing so. According to the King County Native Plant Guide, there are twenty- seven (27) species of trees which are native to King County. The analysis that provided clarification to the survivability of native species of trees in King County ended up being the result of a raster calculation of reclassified King County soils and elevation data. 50 meter contour elevation data was readily available for download from the King County GIS Data Portal, and the soils data was provided by query search within the NRCS (National Resources Conservation Service).

Elevation Analysis (Elevation_Reclass)

The elevation data was available directly from the King County GIS Data Portal and I chose to use the 50ft contour shapefile because it can be utilized for large and small scale maps and still retain its meaning for the purpose of the project. Using the Clip tool in the Analysis toolbox via Extract, I was able to clip the contour shapefile to the extent of King County. After that was complete, I manually reclassified the elevation data into 5 new groups within the shapefile table. The 5 categories were classified on a scale of 1 (least likely) to 5 (most likely). I chose to classify everything below sea level as least likely, along with the highest 2,000ft of elevation. Then, starting at 0ft elevation, I grouped the elevation data every couple 1,000ft based on some general research of the native species of trees in King County and roughly their preferred elevation. Once the classification is complete, then the shapefile is converted into a raster file using the Conversion toolbox-- To Raster-- Feature to Raster.

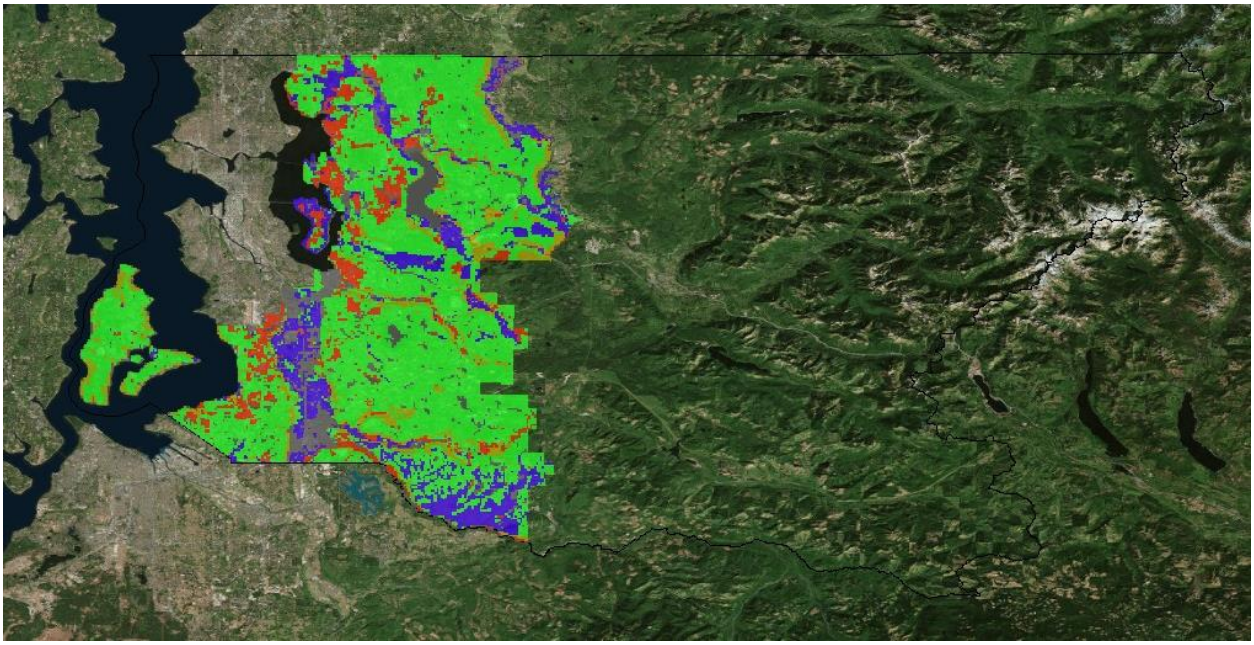


Raster representing elevation reclassified on a scale of 1 (less) to 5 (most) suitalble for Tree Survivability.

Soils Analysis (Reclass_Soil1)

The soils data within the NRCS web page provided three (3) data files of soil survey within King County. While they were all separate soil surveys provided by varying survey companies, two (2) of the soil samples covered the same area and one (1) covered the remaining area of the state. Of these three (3) soil surveys, I was able to utilize one (1) of them. This is because the one (1) that I was able to utilize, allowed me access to a Microsoft Access database that held a text file explaining the numerals which represented the MUSYM or MUNAME column of the GIS shapefile. This allowed me to read textual information about the soil when I needed to reclassify the shapefile for preparation of creating a raster. The remaining two (2) shapefiles/ soil surveys did not provide any textual files that represented the numbers in the same column which would allow a thorough understanding for manual reclassification.

I was then able to use the text file to relate to the table of the one soil shapefile, so that I could obtain some relevant information about the type of soils I was looking at and also looking for. After looking through the table, I was able to manually classify all of the different soil profiles into 5 different categories on a scale of 1-5 with 1 being the least likely and 5 being the most likely suitable soils for tree survivability. Once the classification is complete, then the shapefile is converted into a raster file using the Conversion toolbox-- To Raster-- Feature to Raster.



Raster representing soils in King County classified from 1 (less) to 5 (most) suitable for Tree Survivability.

Tree Survivability Composite (Tree_Survivability)

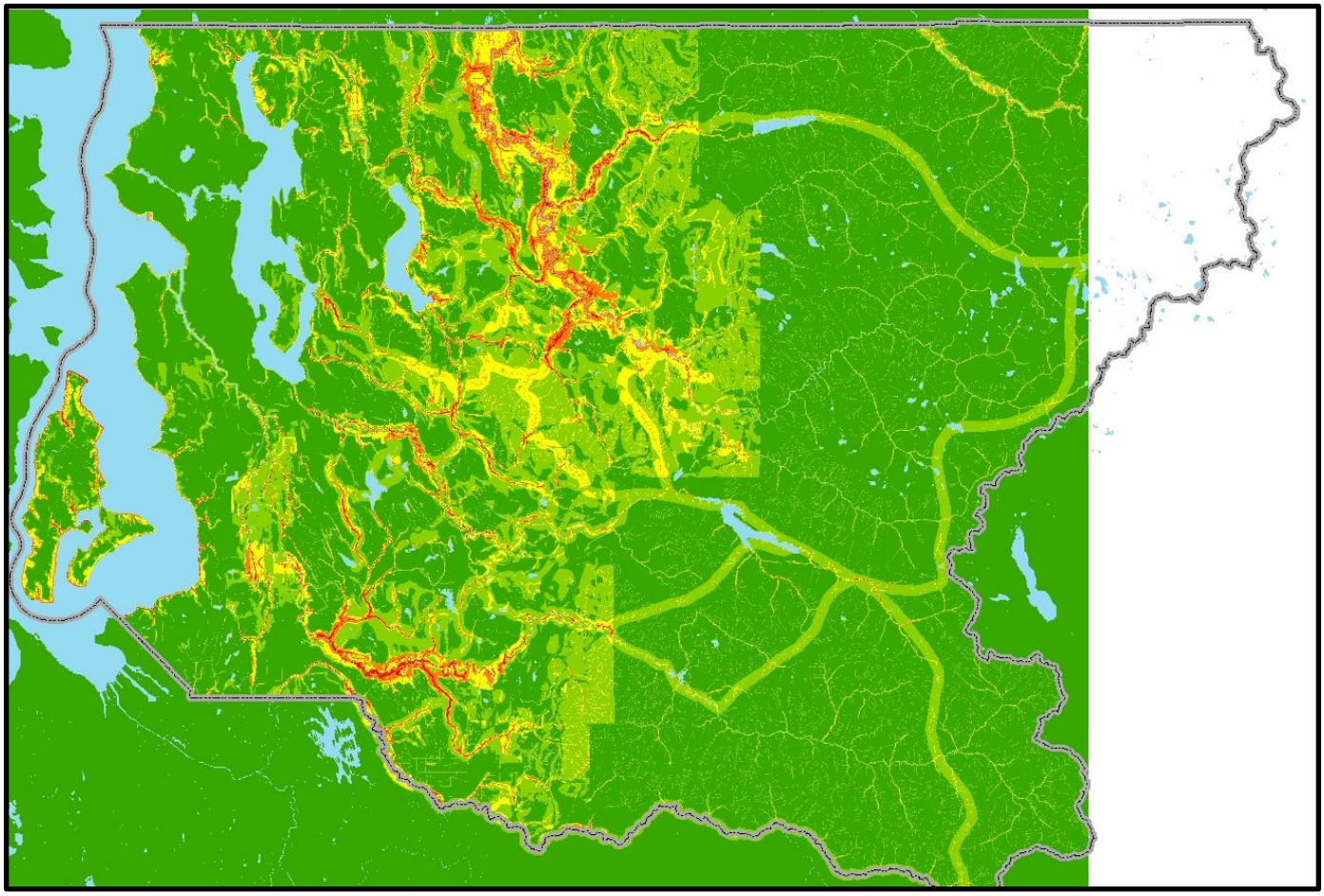
After both the Elevation and soils layers were reclassified manually, I then turned the shapefiles into rasters. After that, I used the Reclassify tool within the Spatial Analyst--Reclass Toolbox to make sure that the classifications of the two new raster datasets are classified the same for the final computation. The final step, then, is to input the two rasters into the Raster Calculator and, using equal weights, compute the two layers into a single raster file to represent Tree Survivability.

Raster representing Tree Survivability in King County.

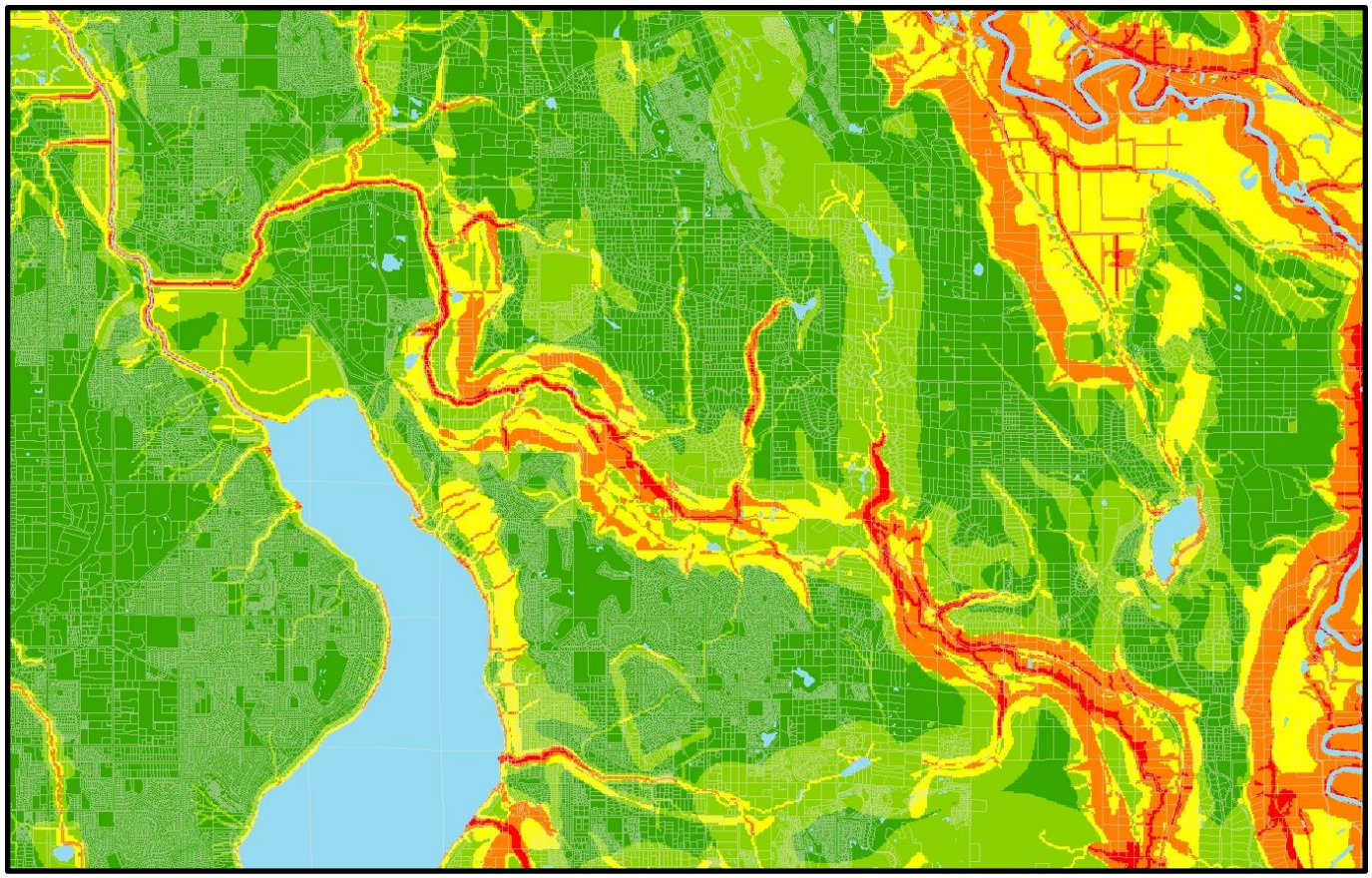
Results

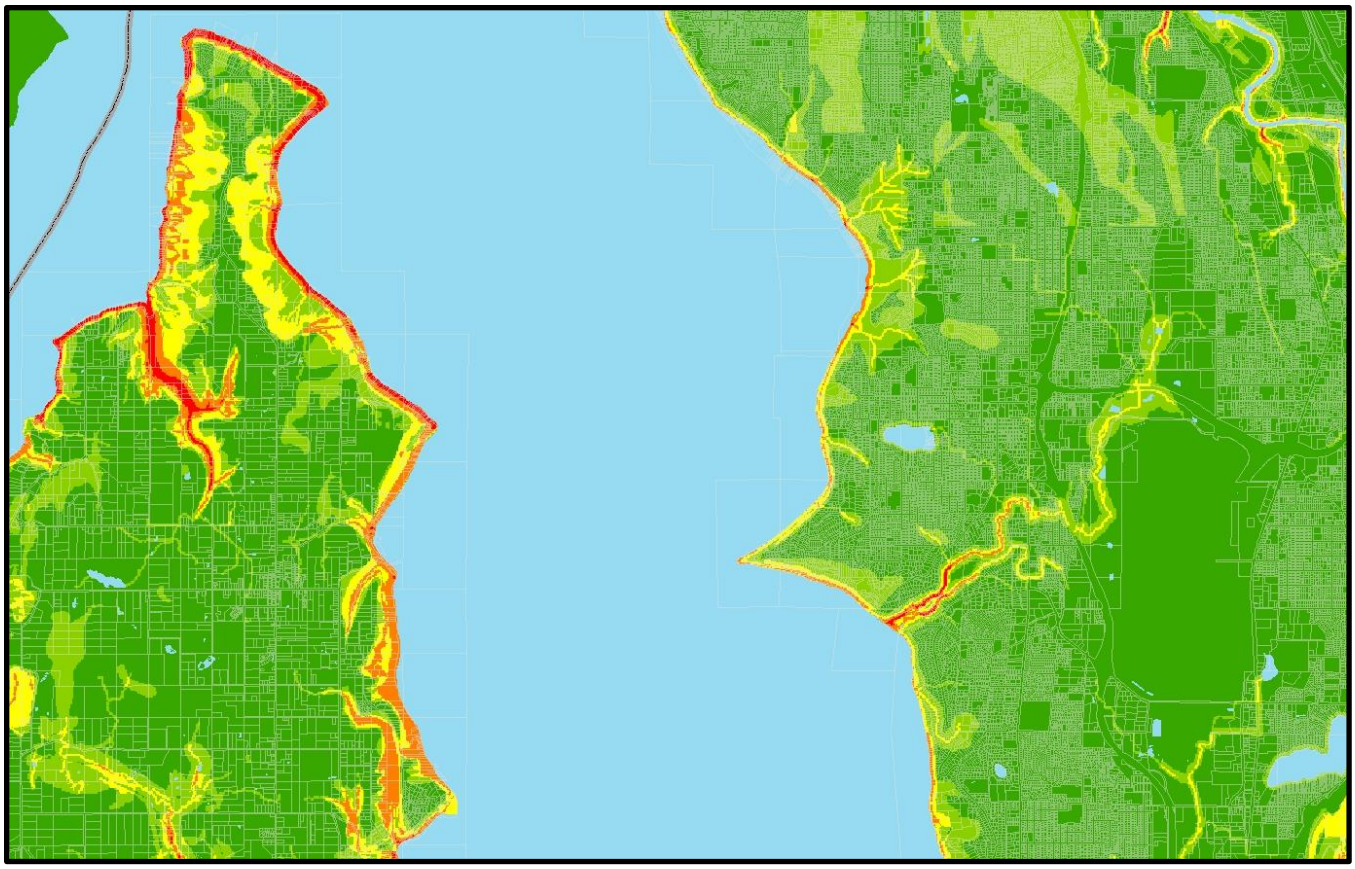
Insert overlay analysis results via map images

Example of Environmental and Ecological Enhancements composite overlay analysis. Areas in red signify the highest suitability, with orange to yellow being high to Medium suitability and dark green signifying lower suitability or lower priority.



Example of Environmental and Ecological Enhancements composite overlay analysis. Areas in red signify the highest suitability, with orange to yellow being high to Medium suitability and dark green signifying lower suitability or lower priority.





Discussion

- Areas that have potential for rooftop planting or the potential to convert impervious surfaces to planting surfaces
- The accuracy and timeliness of data inputs used in this analysis should be updated periodically to reflect ongoing tree planting initiative as well as potential losses to existing tree canopy.
- Another LiDAR-based assessment should be planned to determine changes to the tree canopy in Seattle within the next five years. Such assessment can provide information on how effective tree planting and preservation efforts have been, in addition to understanding how other factors (e.g. development, drought, pests, etc.) may be impacting tree canopy. Future assessments will only be made possible if continued investments in high-resolution remote imagery and LiDAR data acquisition are made. Undertaking LiDAR-based assessments in the future will allow for trend analysis with comparable tree canopy data to be made.

Business Case and Implementation Plan

Recommended Use:

A web based mapping tool that allows government, nonprofit and private users to explore lands throughout the county to assess potential sites for tree installation and green space creation. The user's assessment and resource investment decisions can now be made in accordance with their specific personal or organizational goals and objectives (i.e. socioeconomic equality, climate resilience, fisheries protection, habitat enhancement, natural hazard reduction, community beautification, etc. etc.).

In coordination with similiar City of Seattle efforts, the study data can be used to establish localized canopy goals and targeted plantings and conservation efforts to maximize limited resources. Selecting a specific benefit to build an engagement campaign can increase the success in tree planting and conservation actions, particularly when an audience is already galvanized around a particular issue (e.g.engaging residents concerned about air quality issues in a specific neighborhood in tree planting efforts in that area).

Similar to the recommendations in the City of Seattle's 2009 Tree Canopy Assessment and Siting Plan, in future countywide mapping projects, potential tree planting sites and associated attributes used for queries & prioritization can be improved upon to include watershed boundaries, soil types, above & below ground power line locations, demographic data (income, public health data) and other GIS overlays similar to the proof of concept analysis found in this report and methodology. Such data would increase the accuracy and utility of the results. However in order to maximize use across varied audiences, a web-mapping service (WMS) such as ArcGIS online or customized GoogleEarth interface, where both technical and non-technical map-users can access, query, display and share the information for their particular purposes would be useful.

An ecosystem benefit study could be conducted for the County. There are several studies out and various groups attempting to update known effects of watershed runoff, contaminant loading, air pollution, carbon sequestration, and costs associated with each and to improve existing databases of baseline data and techniques for processing the data. One of the most well known and widely used tree canopy benefits analysis software packages is CITYgreen. Produced by the organization known as American Forests, it utilizes decades of research conducted and refined by well-known institutions and experts to analyze not only current tree canopy benefits but also modeled tree canopy benefits useful for guiding urban forest public policy. CITYgreen software analyzes and places a dollar value associated with air quality pollutant removal savings, total carbon storage capacity in tons, and because trees also impact storm water runoff in a number of ways, CITYgreen software analyzes possible savings to the city as a result of reduced storm water runoff.

Considerations, Limitations and Opportunities

- More effort should be made to identify the legal suitability of property for tree planting
- More effort should be made to identify tree species suitability based on utility of the environment and the value of tree planter
- More uniformity should be attempted when collecting soils data. There is a difficulty with understanding the correlation between the soil number and the soil description.
- A more in depth analysis of native tree species' suitability could be researched and analyzed, given more time is provided. Each individual tree pretty much has a different set of ecological requirements that make their unique environment most suitable for their survival. Factors such as sunlight, minerals in the soil, proximity to water/ how much water does the tree need to survive, oxygen requirements, unique and specific soil profiles, are just a few suggestions for a more in depth analysis. It would make more sense to do 27 unique analyses (one analysis for each tree species) because there are so many factors which are only specific for certain trees (not taking into account the different sub-species of these trees which also might contain a different set of unique preferences for their survival as well).
- When creating rasters from the shapefile data, it might be beneficial to provide a set pixel requirement so that when the final raster calculation is done, then the pixelation is appropriate for the goals that have been set.

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