Watershed Restoration: Optimizing Site Selection

(Nehalem Prototype)

Prepared for:
NOAA, ODFW & Nehalem Watershed Council)
by:
TerrainWorks (NetMap)/www.terrainworks.com
February 2014

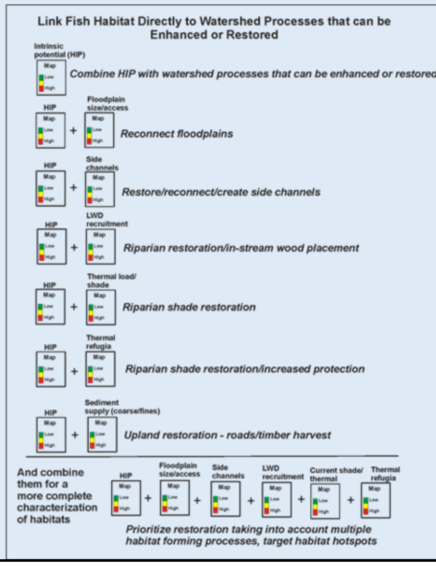
This powerpoint contains some examples of the Watershed Restoration Analysis, Oregon Coast Range (NOAA & ODFW)

Project completed February 2015
TerrainWorks Digital Landscapes and Analysis Tools are being applied in a demonstration analysis for using NetMap in support of creating watershed restoration strategies for independent populations of coho salmon in the context of delisting strategies (Coho Recovery Plan). One objective is to create rigorous, objective and consistent analyses across all effected watersheds. This project is conducted in conjunction with NOAA-Fisheries, Oregon Department of Fish and Wildfire (ODFW), Oregon Watershed Enhancement Board (OWEB) and the US Forest Service, Pacific Northwest Research Station.

For full PPT-PDF, go here.

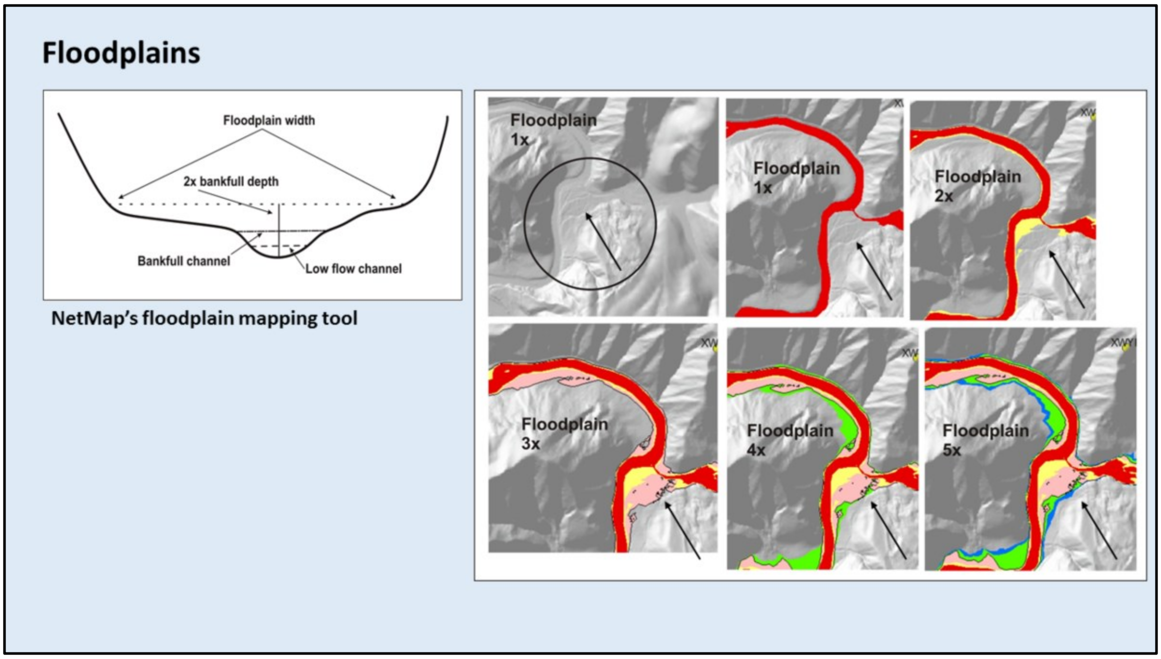
For MP4 webinar presentation, go here.

Fish habitat modeling, such as 'habitat intrinsic potential' for salmon does not include parameters that can be directly restored or enhanced. Habitat intrinsic potential modeling can be linked to other landscape attributes:

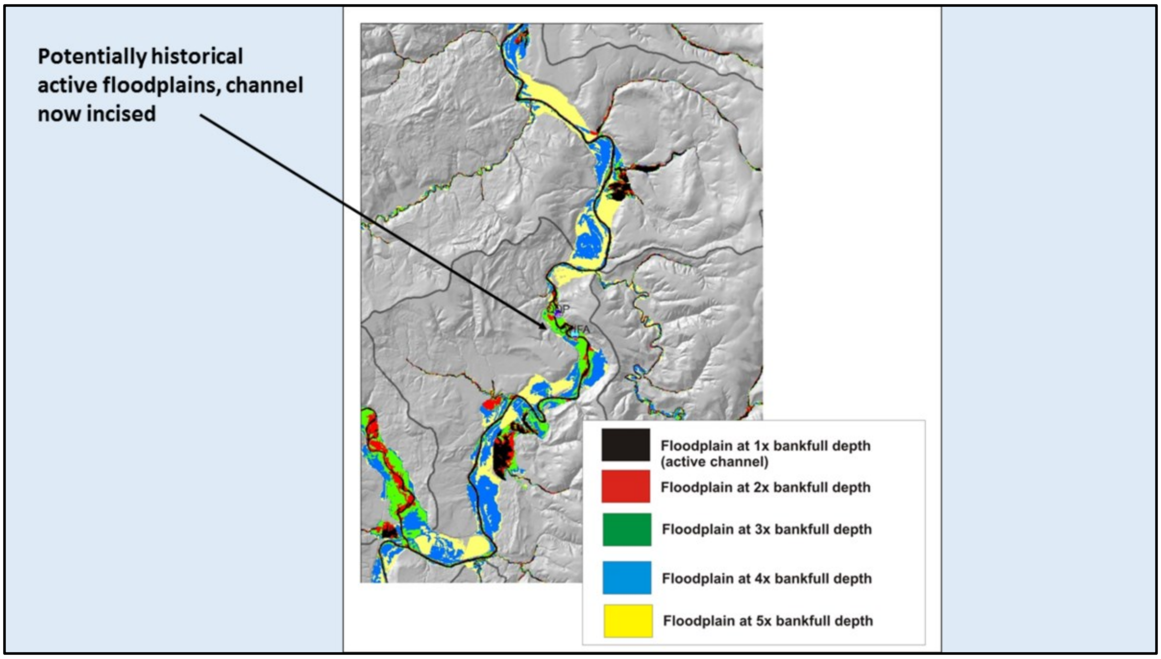


Floodplains
Side channels
Riparian wood recruitment
Riparian shade
Upland (road) restoration

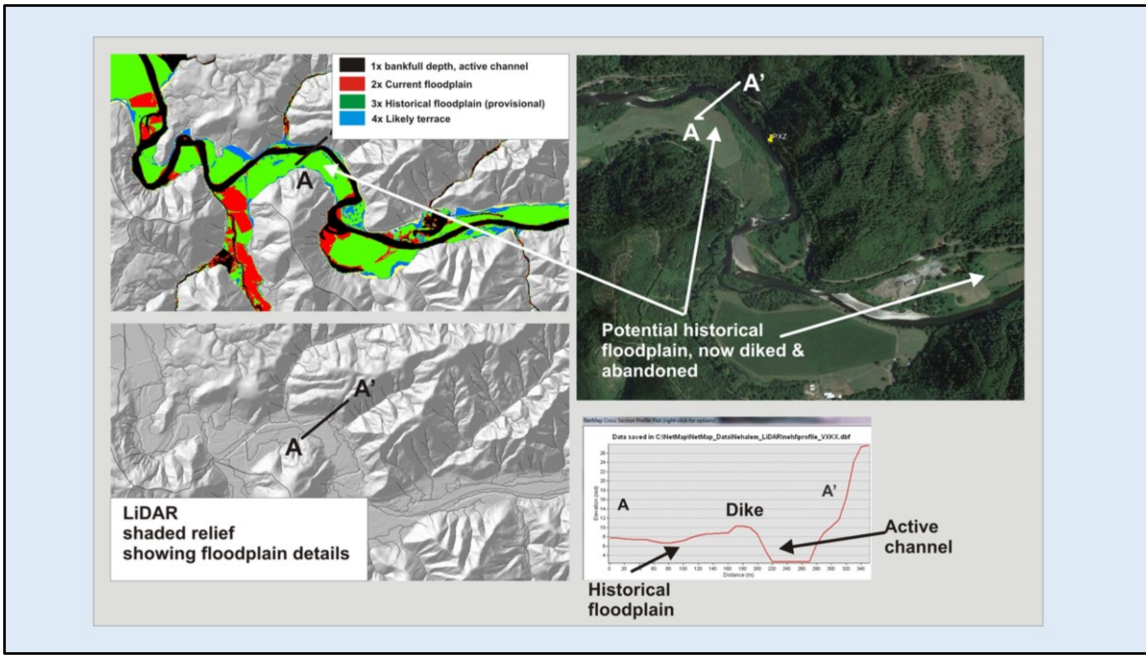
Examples follow



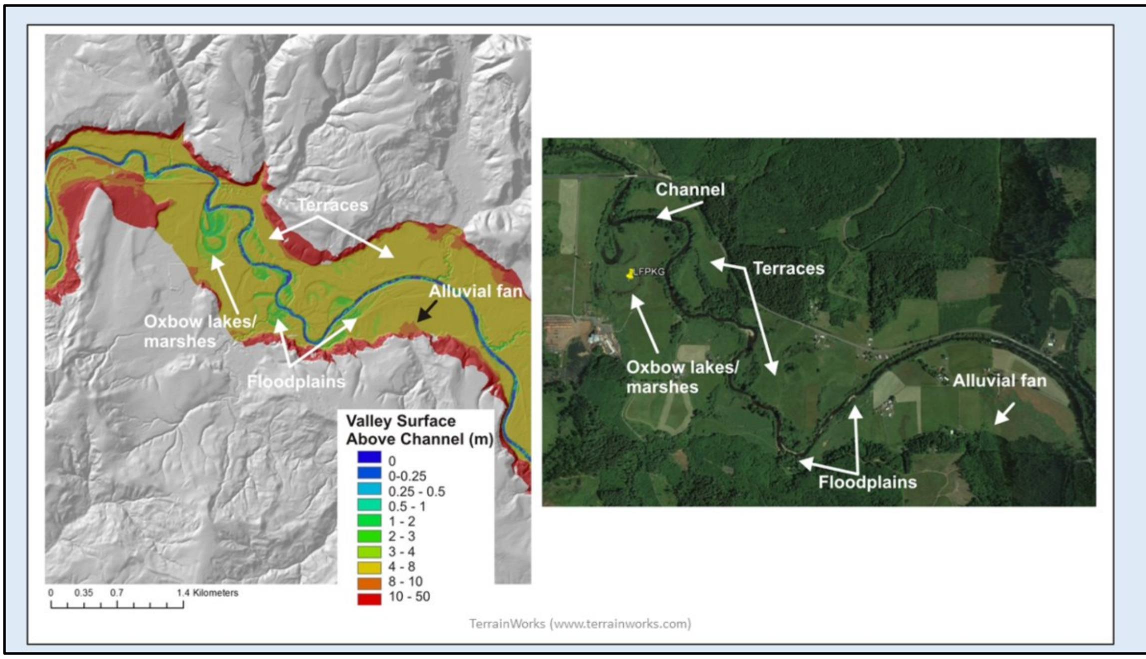
Floodplains are an important constituent of coho habitats and can be targeted for restoration. NetMap's advanced floodplain mapping tool calculates floodplains based on multiples of bankfull depths above the channel. This graphic (right panel) illustrates this using a 2.5 m LiDAR DEM in the Nehalem. Floodplains at 1x bankfull depth defines the active channels; floodplain at 2x defines the current active floodplain; floodplain at 3x defines the higher current floodplain and or the historically active floodplain in channels that have incised; floodplains above 3x are likely terraces that do not get inundated.



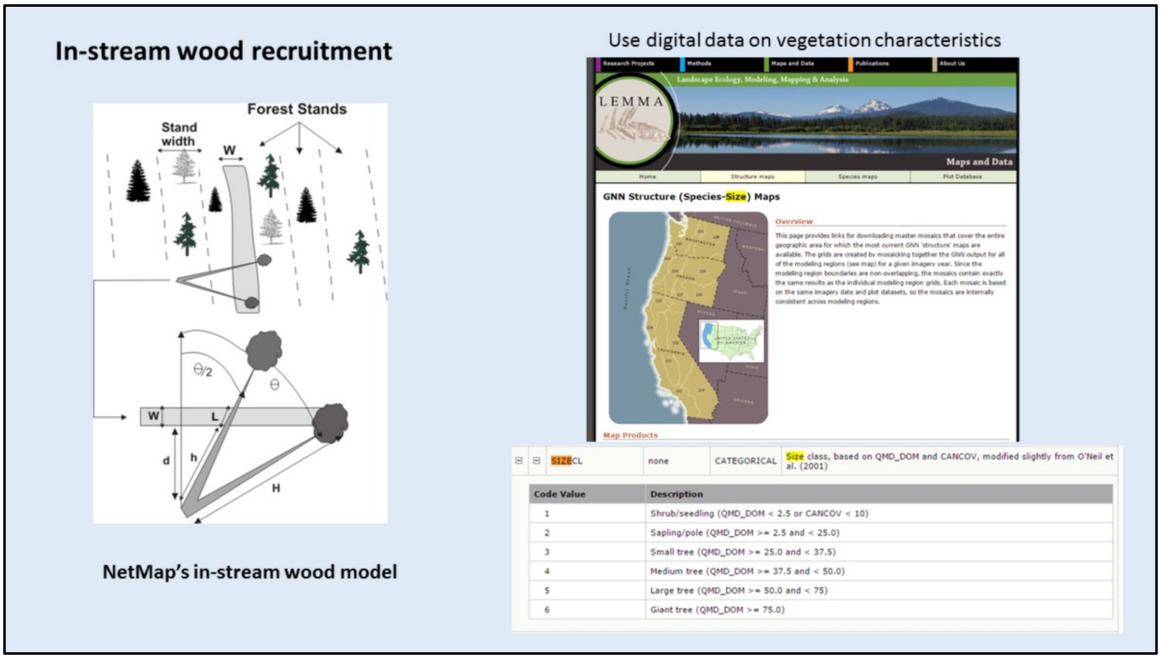
NetMap’s floodplain mapping tool can be used to identify current floodplains and abandoned floodplains, those that were once active but currently are non functioning because of dikes and other land uses.



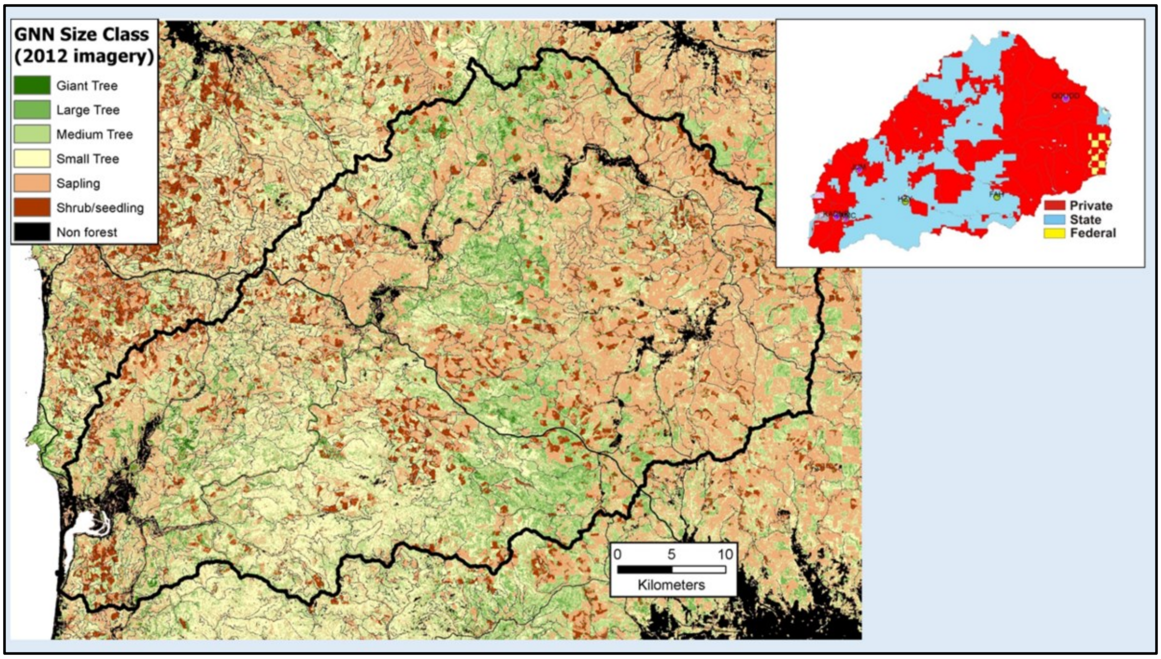
The floodplain mapping tool can be used to detect the effects of dikes in isolating floodplains from their river systems, as illustrated above.



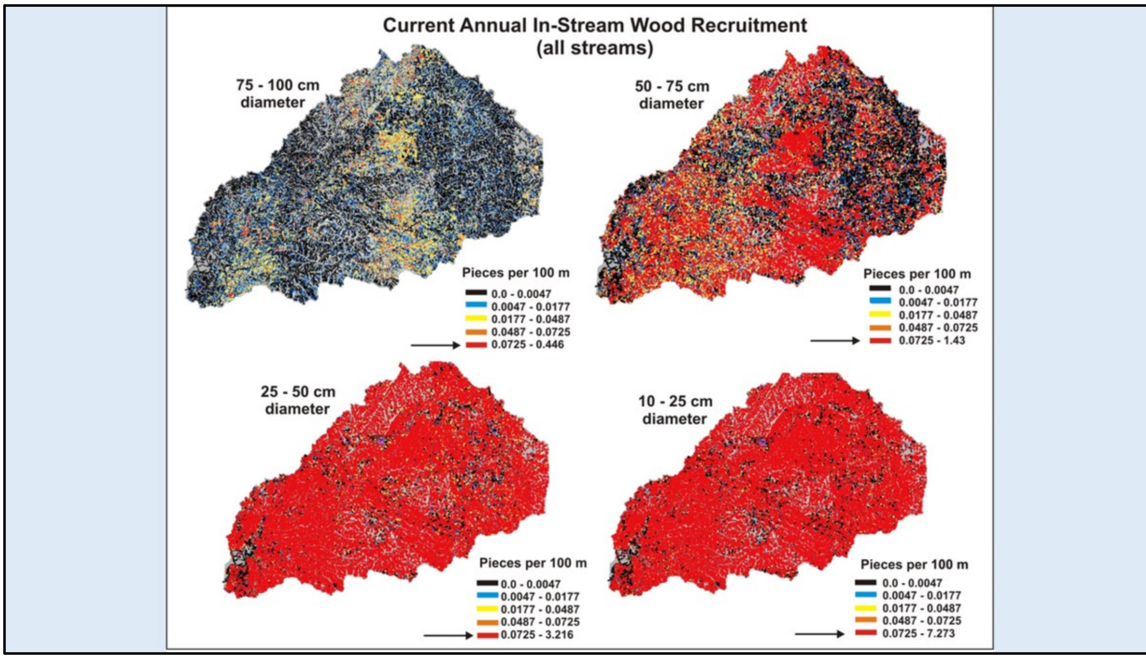
NetMap's valley floor mapping tool can identify landforms including channels, floodplains, oxbow lakes, marshes, terraces and alluvial fans. This information could be used to help prioritize restoration projects, particularly those designed to reconnect channels with their floodplains.



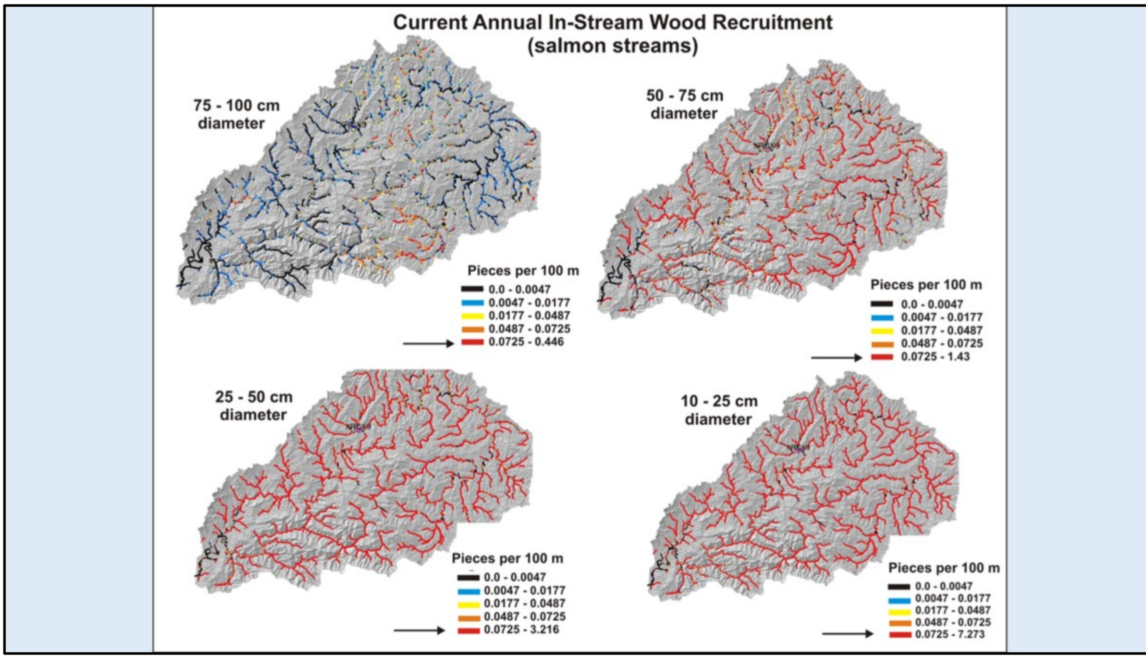
Another important fish habitat component is in-stream wood recruitment



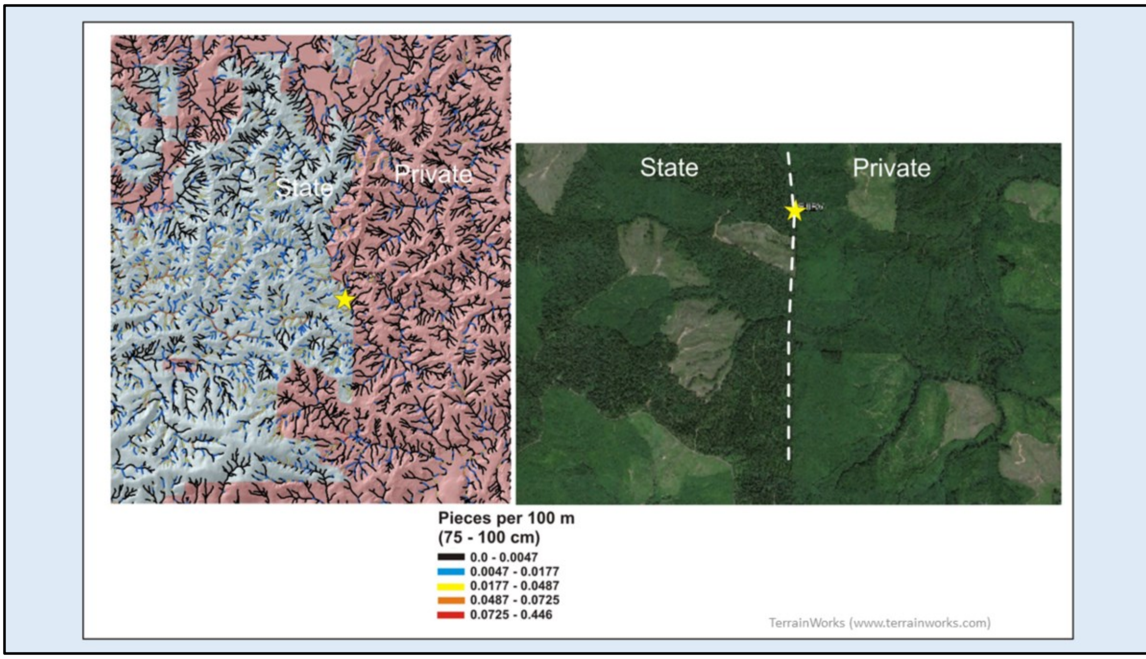
Remote sensing data from LEMMA is used in NetMap's watershed scale wood recruitment tool. Here we can see the distribution of vegetation/tree sizes across the Nehalem watershed. The ownership map in the top right corner that shows the distribution of private and public (state) lands corresponds in large part to the distribution of tree sizes. The dominance of small trees and saplings is concentrated in the private lands. However, many streams, particularly fish bearing, do have vegetation buffers that include larger trees (not easily seen in the watershed scale map).



NetMap's watershed scale wood recruitment tool reveals patterns of potential in-stream wood loading from headwaters to salmon streams. All legend classes are the same across all four diameter classes, with the exception of the highest values (denoted by arrows). Darker colors (black/blue) indicate low wood loading for size classes and the warmer colors (orange/red) indicate higher wood loading (pieces/100 m). Wood recruitment of larger size classes (75-100 cm) is low in many areas of the watershed but there are areas of higher recruitment in some local areas (e.g., patches of larger trees). Overall, there are much greater amounts of wood recruitment in the moderate to small diameter classes. Such information could be used to help prioritize restoration site selection.



NetMap's watershed scale wood recruitment tool reveals patterns of potential in-stream wood loading for salmon streams. All legend classes are the same across all four diameter classes, with the exception of the highest values. Darker colors (black/blue) indicate low wood loading for size classes and the warmer colors (orange/red) indicate higher wood loading (pieces/100 m). There are patches of higher wood recruitment for the larger diameter classes (upper left). Many fish streams have higher levels of recruitment but of the smaller diameter classes. Areas of high to low recruitment of large to small wood could be matched up with higher intrinsic potential (IP) scores and used to help prioritize restoration site selection.



Zooming in on predicted annual wood recruitment of the largest size classes show a distinct difference in wood loading potential. For the largest piece size class, headwaters in private lands have very low values because very few buffers are required. State lands have some buffers in headwaters, leading to higher predicted wood recruitment in some locations, but some headwaters on state lands also can have low wood loading due to historical and present day timber harvest. Along fish bearing streams overall, private lands have low to moderate
levels of wood loading for the largest piece sizes while state lands wood loading varies from lower to higher values, depending on the history of land use activities, including timber harvest.

Add Shade/Thermal Loading

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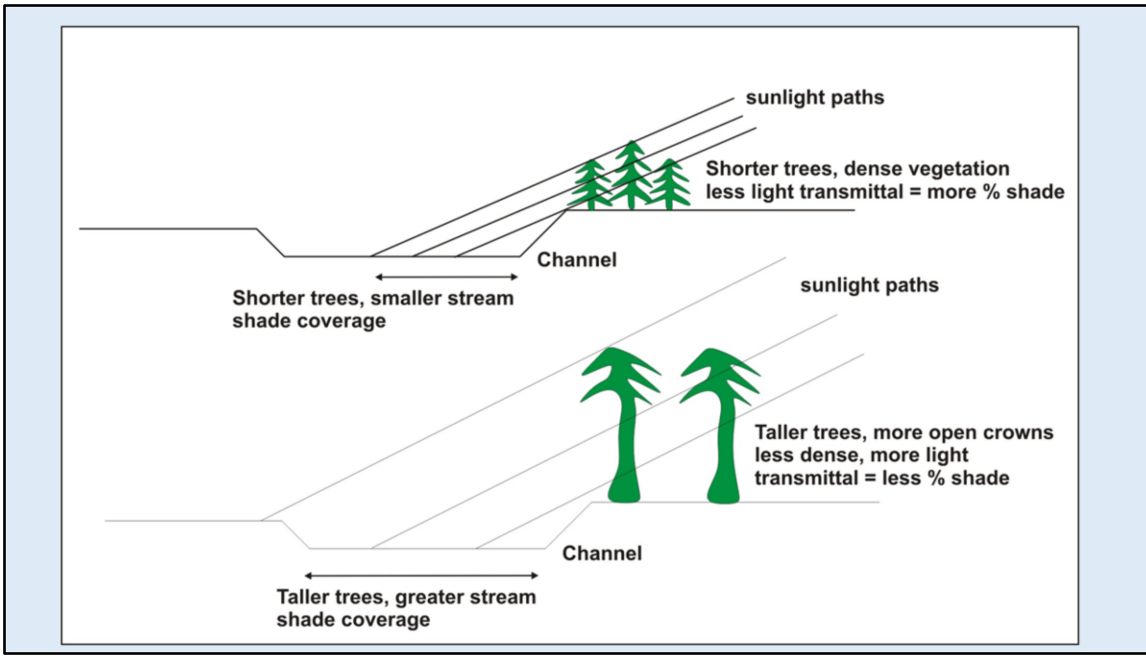
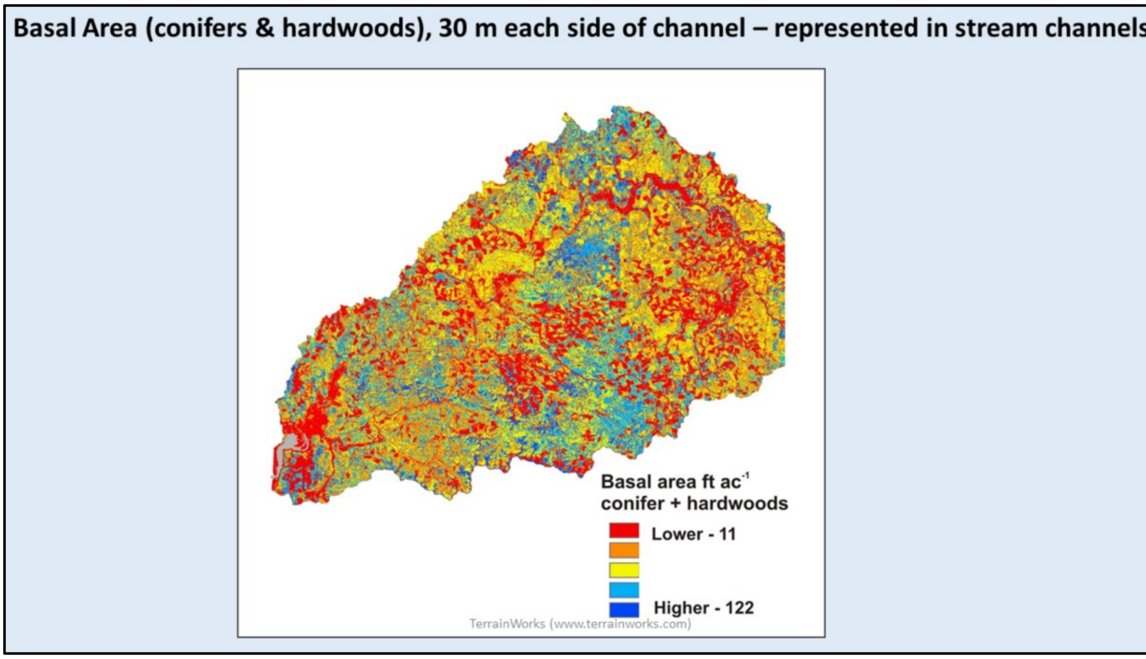
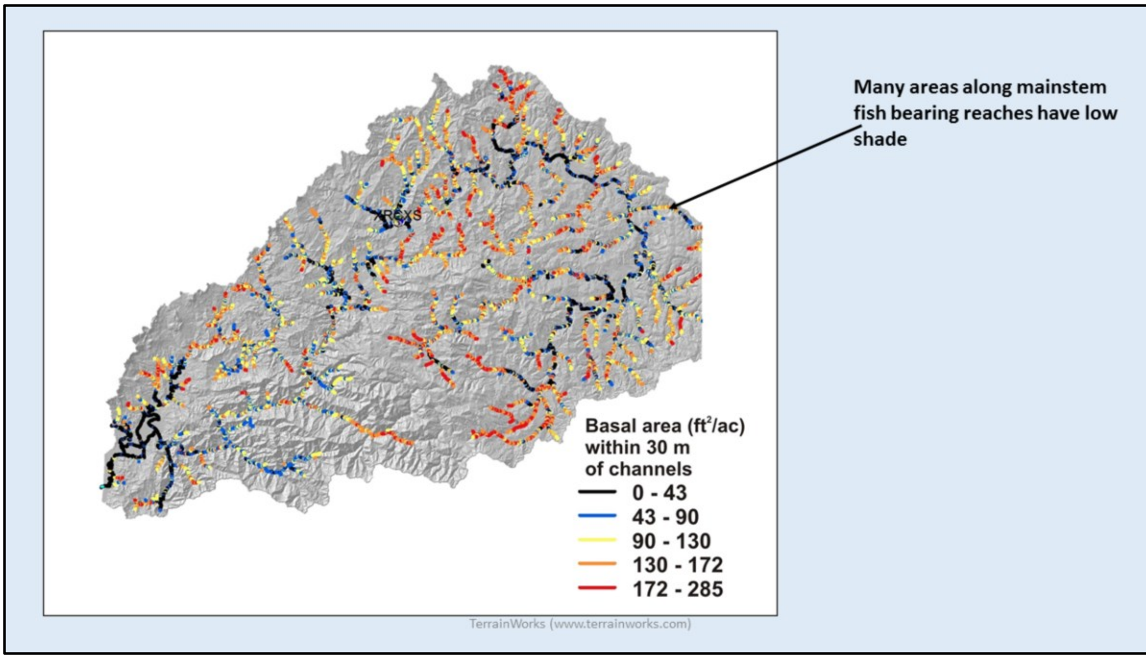


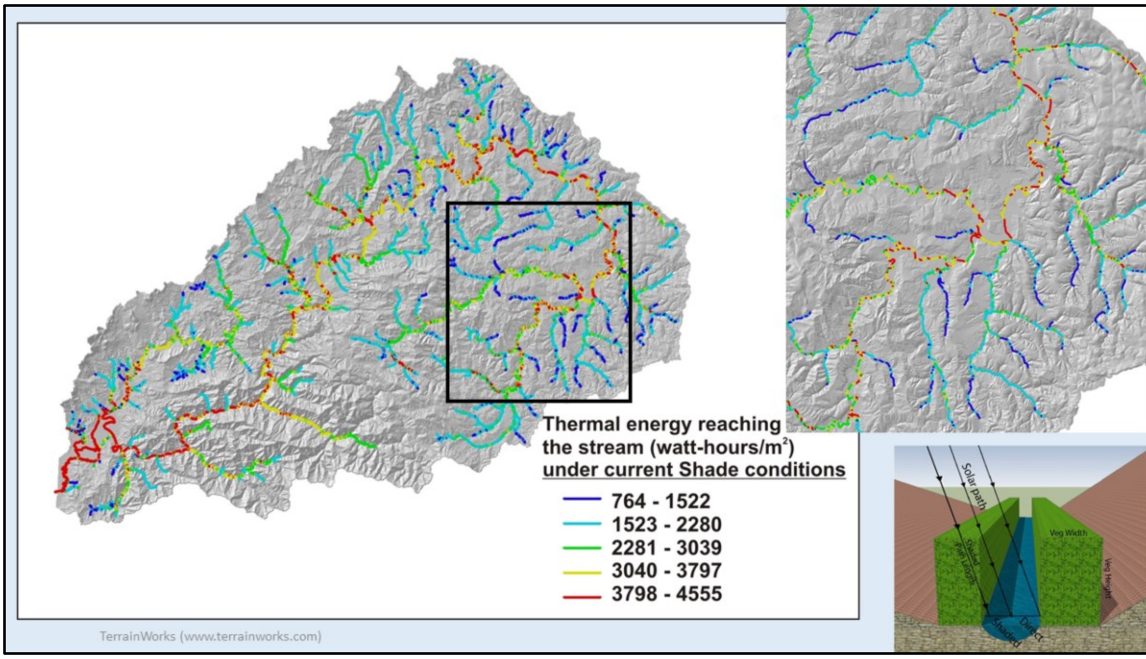
We combined NetMap's physically based thermal loading tool with a model to predict percent shade using basal area and tree height (shade model by Groom et al. 2014). The diagram above illustrates how the shade model works. Percent shade is positively correlated with basal area (think vegetation density) and negatively correlated with tree height (e.g., more light gets through taller trees that have less dense vegetation and more open canopies compared to shorter vegetation with dense vegetation). However, as trees get taller they shade an increasing proportion of the channel width, so taller vegetation equals greater shading also. Keep that in mind as we examine the predictions about how basal area and tree height, combined with natural thermal loading, affect streams in the Nehalem watershed in the next couple slides.



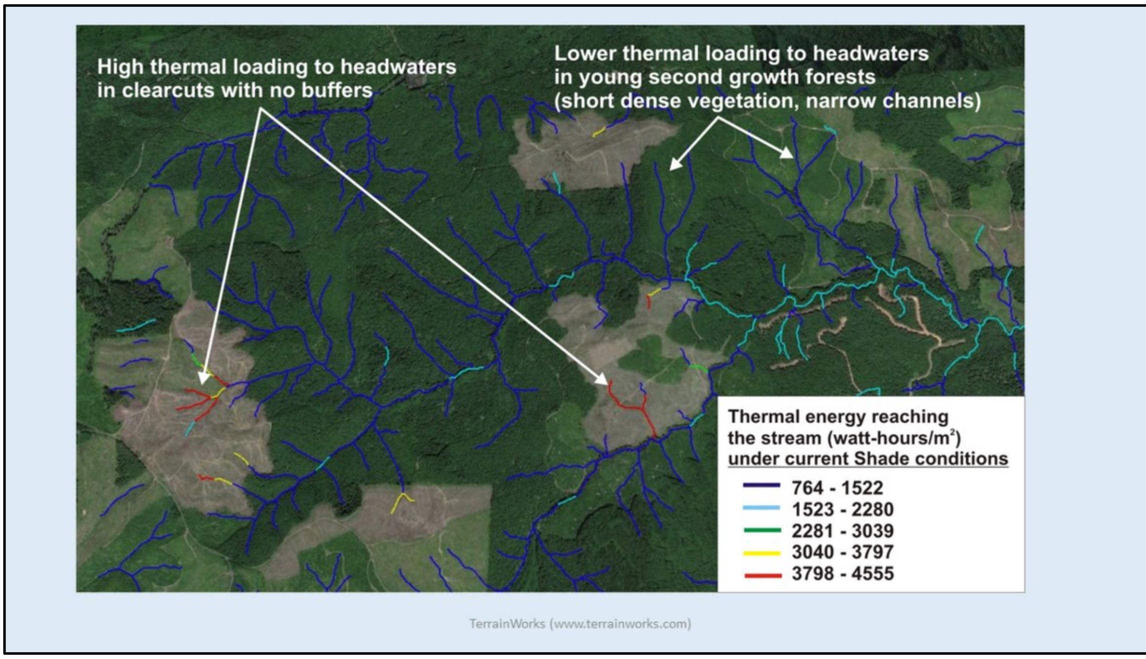
Here is the LEMMA/GNN data on basal area, conifer and hardwoods combined for the Nehalem watershed.



Here is a map of coho salmon bearing streams only revealing areas of high to low shade. Certain areas stand out as having low shade including the larger valley floors that are developed including for agriculture.

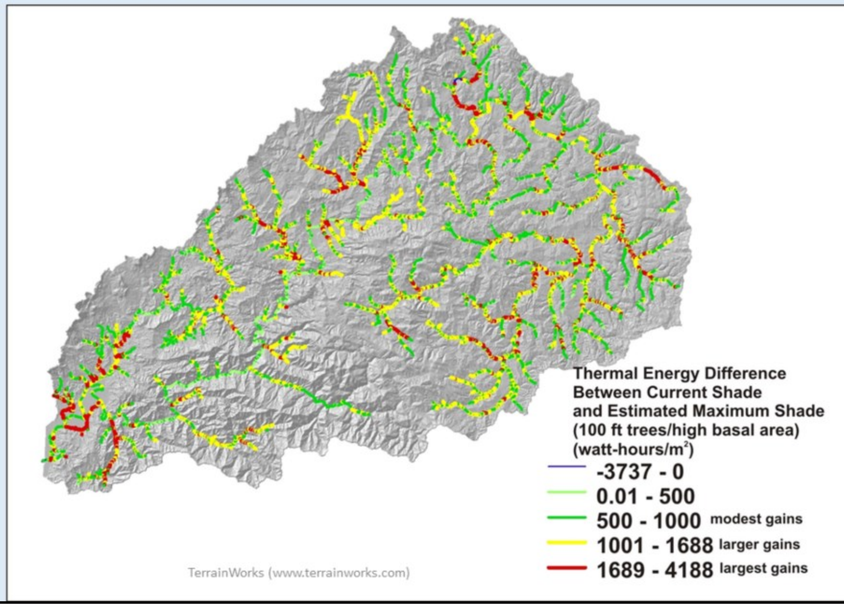


We now evaluate how current shade conditions (basal area combined with tree height) affects thermal loading along streams in the Nehalem watershed. The warmer colors in the map indicate channels that have higher thermal loading due to present day shade, combined with natural patterns of thermal loading controlled by channel width, orientation, topography and solar angles.

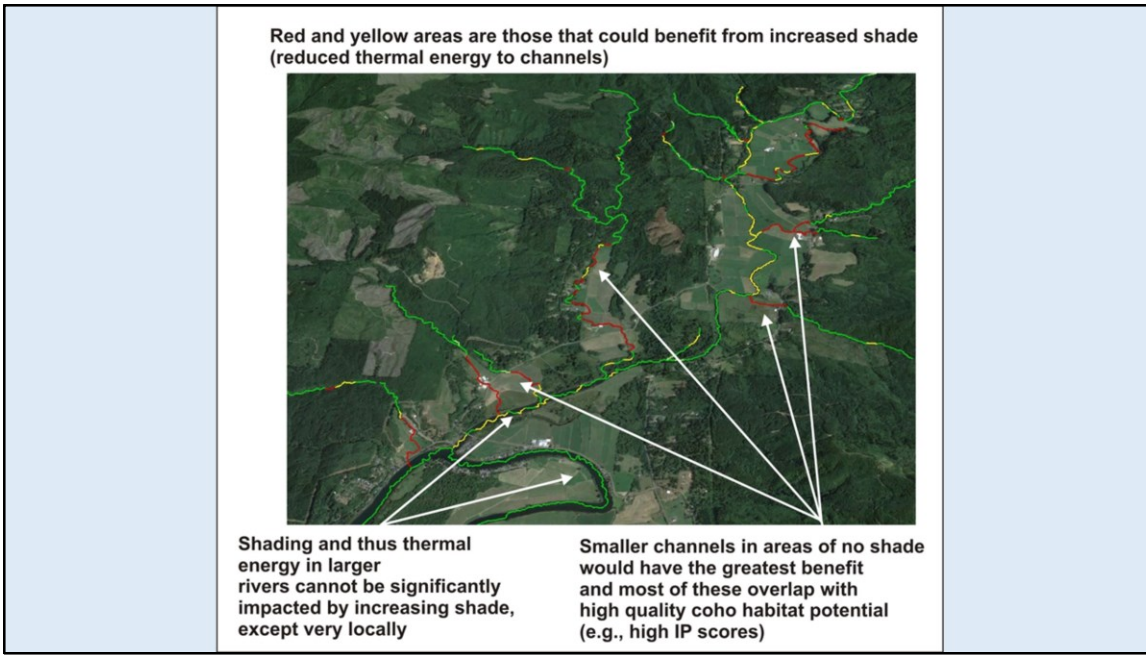


NetMap's predicted current shade-thermal loading conditions including for small headwater channels. Recent clearcuts have the highest thermal loading potential because of the absence of stream side vegetation and buffers. However, younger second growth forests do provide significant shade and thus lower thermal loading, including because of narrow (1-2 m wide) channels. Recall that shading is positively associated with basal area but negatively correlated with tree height (see slide 52).

Where is increased shade needed most?



We can estimate, based on Nehalem specific vegetation conditions, a likely maximum shade condition, combining basal area and tree height. A maximum shade condition is calculated using a high basal area (122) and a 100 ft tree height. The current shade condition (previous) slide is subtracted from that. The result is a map that shows where increasing shade by vegetation manipulation would have the largest potential benefit on water temperatures. The yellow and red areas in particular may be areas where increasing shade would be an improvement. See also next slide.



As would be expected, small high value coho streams located on floodplains and terraces, but under current agriculture, are most sensitive to current low shade levels compared to larger rivers where shade is proportionally less important in reducing thermal loading.

Calculating Potential Thermal Refugia and Thermal Hot Spots
Four types:

1) **Along channel (reach scale) thermal refugia created by a combination of natural landscape controls on thermal load (topographic shading, stream size & orientation, and current stream side vegetation conditions;**

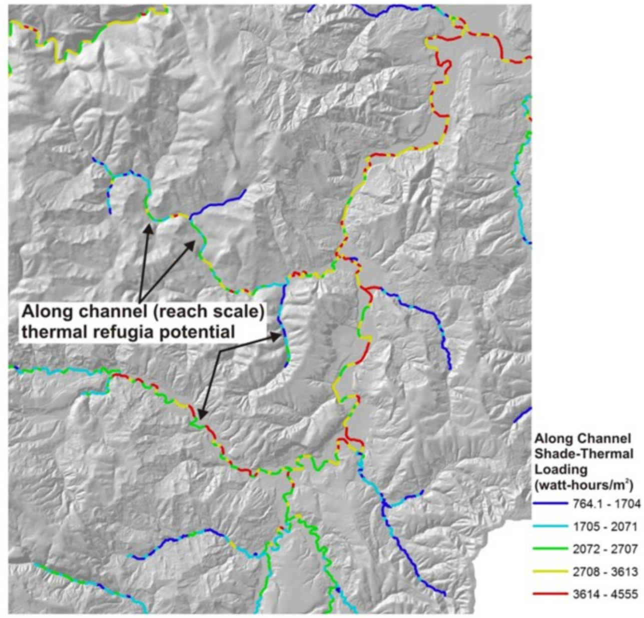
2) **Tributary scale thermal refugia, same as #1 but aggregated (averaged) over individual tributaries;**

3) **Tributary confluences that show the relationship between accumulated landscape thermal load plus shade in mainstem channels compared to intersecting tributaries (provisional cold and hot spots)**

4) **Downstream spatial variation in floodplain magnitude (widths). Floodplain narrowing enhances upwelling of cooler hyporheic water.**

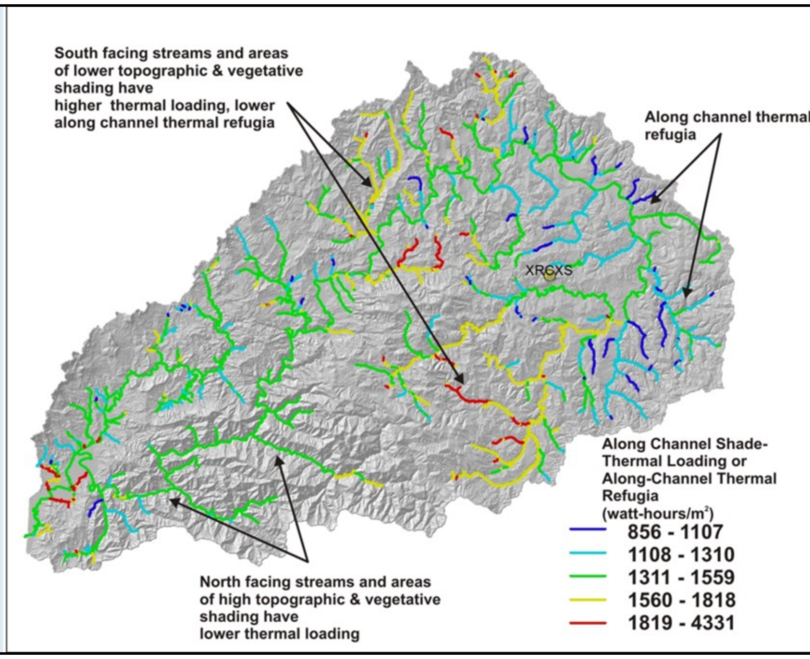
NetMap contains a tool for predicting provisional thermal refugia in streams and rivers including related to tributary confluences and floodplains. See next couple of slides.

Along channel thermal refugia



Based on natural controls on thermal loading (topographic shading, channel width, orientation and solar angles) and on current shade conditions along streams (basal area and tree height), NetMap can be used to predict provisional areas of thermal refugia, and alternatively, areas of warmer water landscape conditions. And see next slide.

Tributary scale thermal refugia



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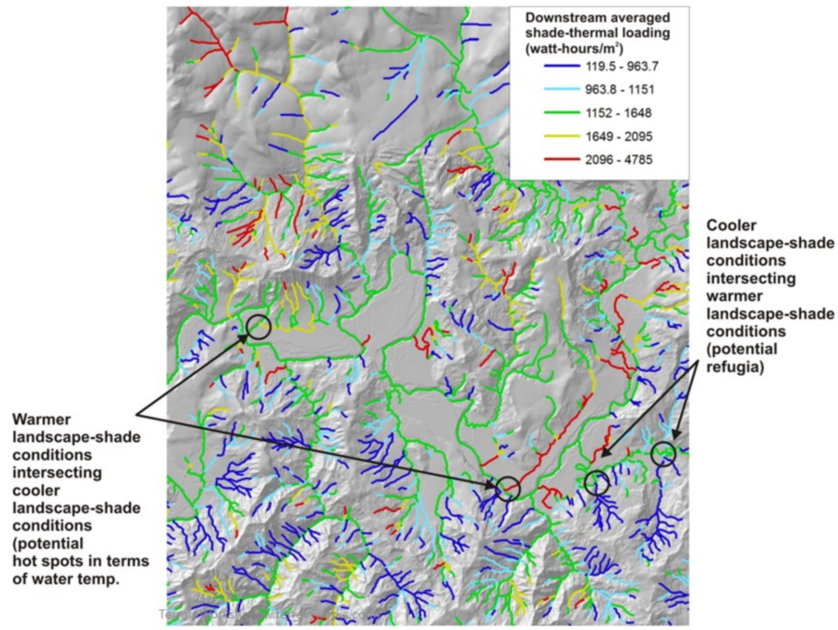
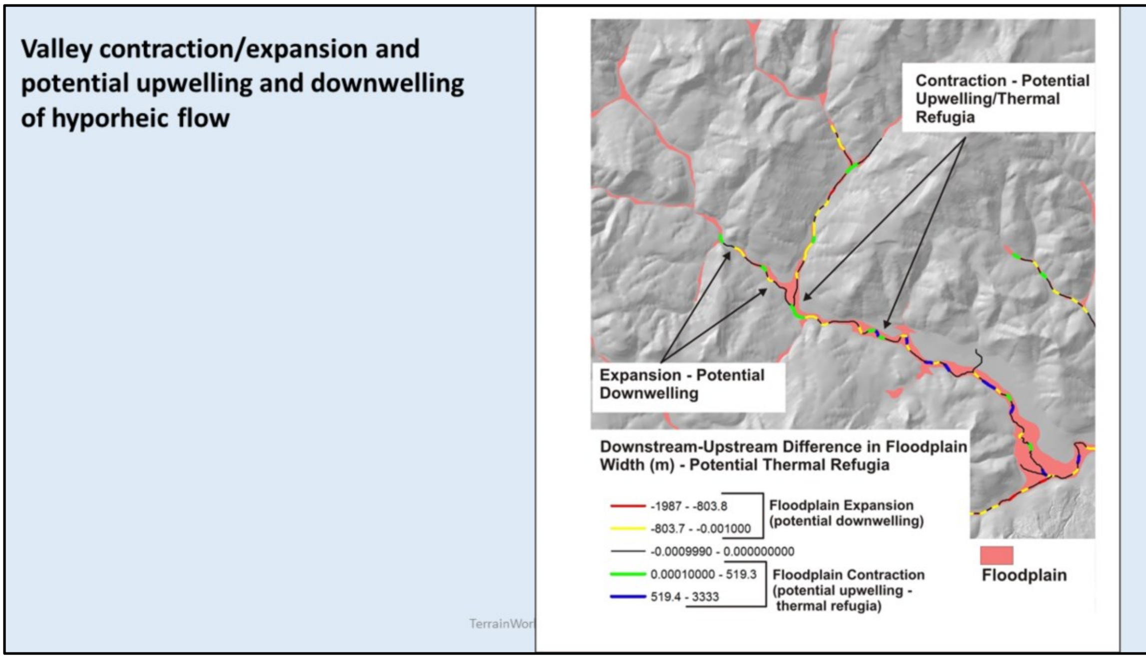
The combined condition of current shade (tree height and basal area) and landscape controls on thermal energy (topographic shading, stream orientation, stream width, solar angle) can be aggregated downstream producing tributary basin averages. This results in tributary scale predictions of thermal refugia.

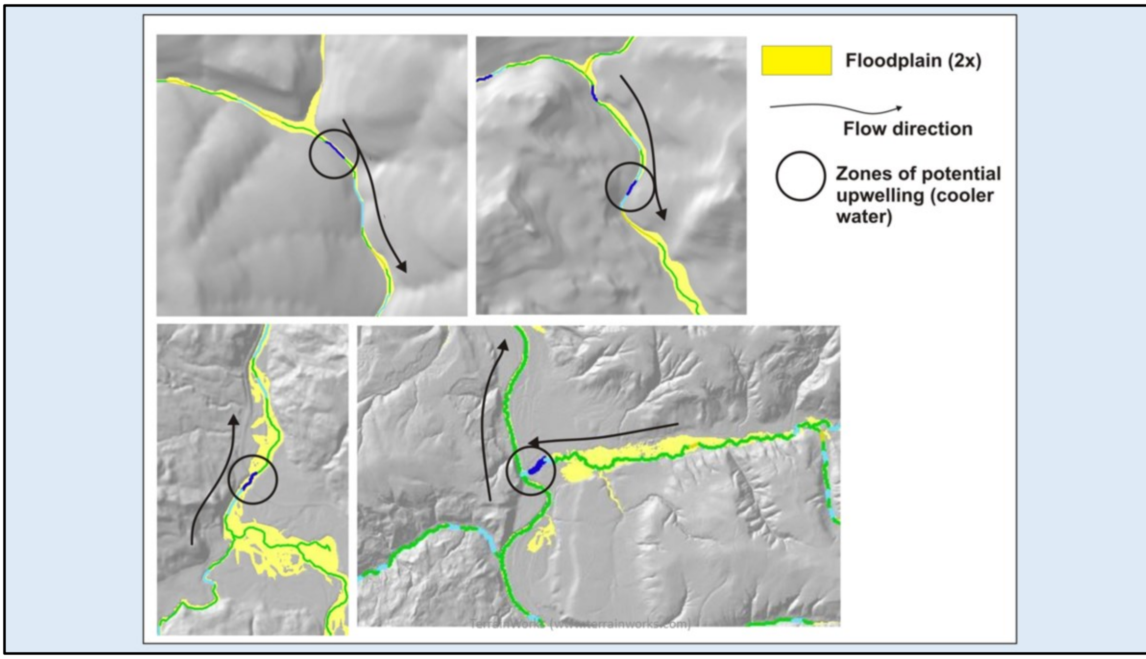
Thermal relationship between tributaries and mainstem channels



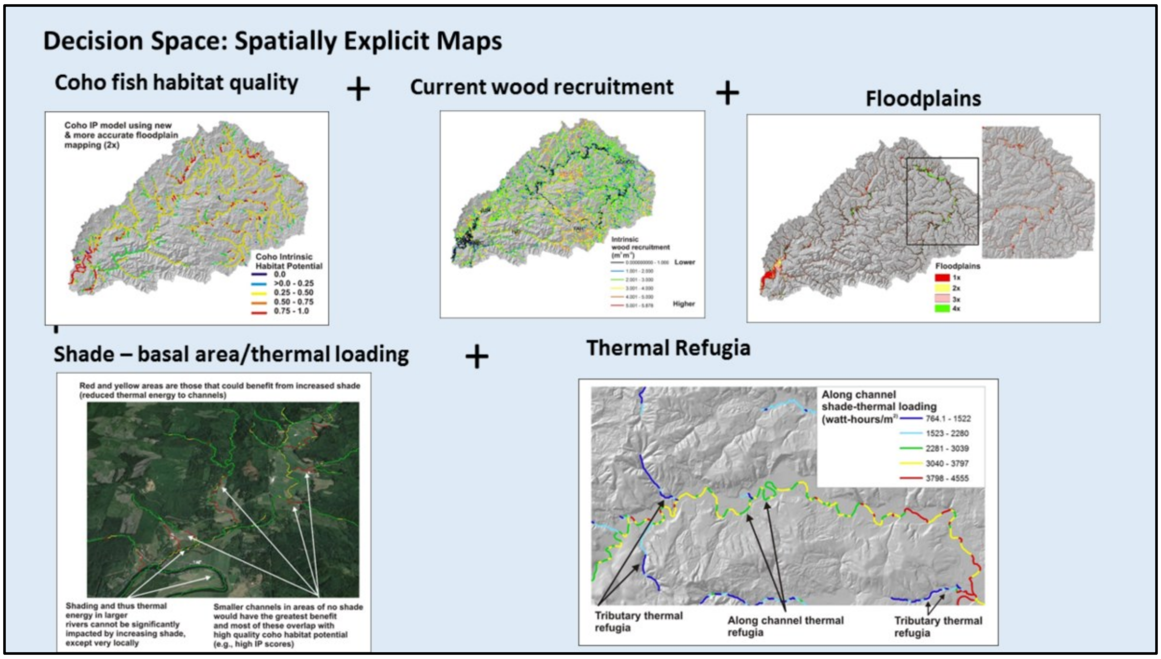
Another way to examine tributary scale thermal energy conditions is to view them at confluence locations (tributary locations with mainstem channels). Juxtapositions between tributaries and mainstems can be used to examine areas of provisional cold and warmer water landscape conditions and whether tributary mouths might be functioning as thermal refugia from the perspective of warmer mainstem conditions.



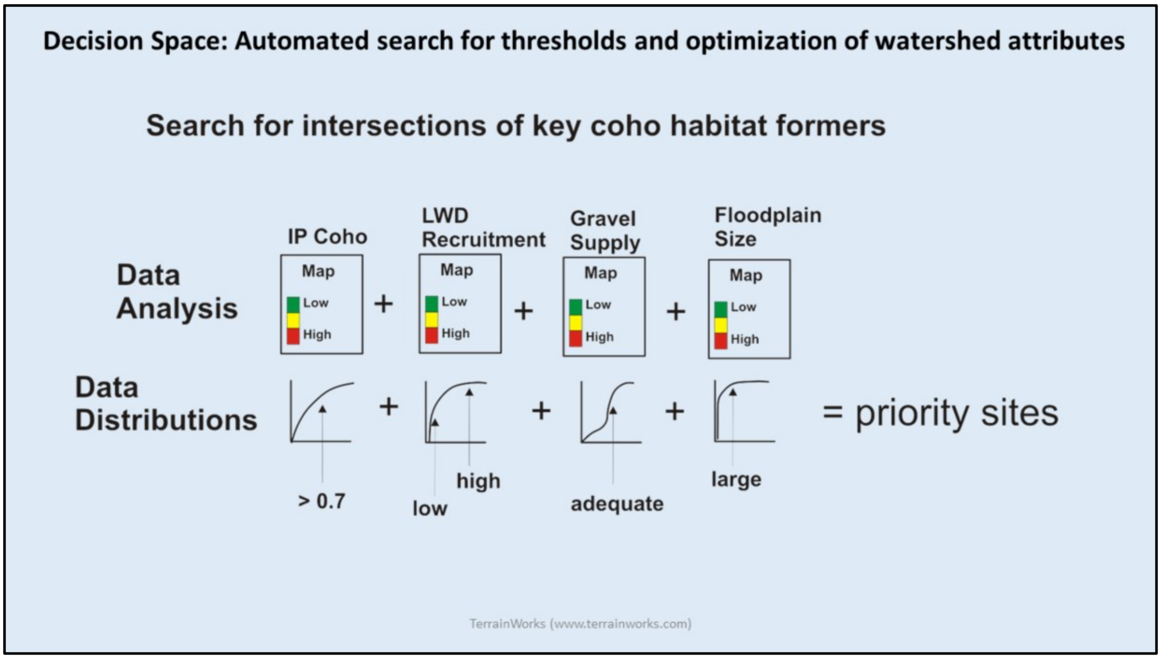
The fourth type of potential thermal refugia is where floodplains (or terraces or higher elevation valley floors) contract abruptly downstream, often causing hyporheic upwelling of cooler water. NetMap's thermal refugia tool calculates this type using reach to reach downstream changes in floodplain width, as shown in this slide for areas in the Nehalem watershed.



Another example of identifying potential areas of hyporheic upwelling, as thermal refugia.

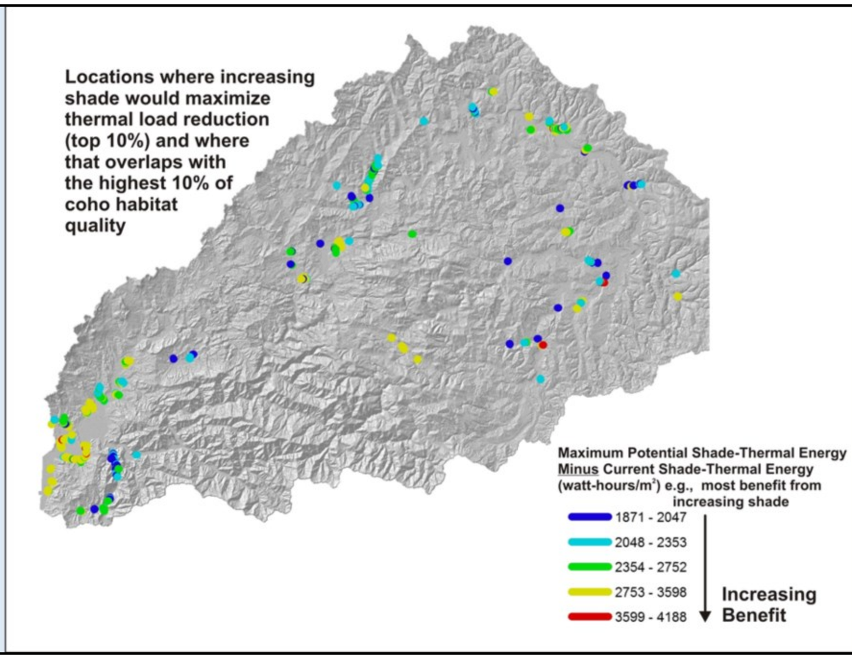


Recall one of the restoration planning decision spaces, involving overlaying maps of habitat forming processes. The issue of gravel supply has been omitted in the current presentation but see PPT addendum (at the end of this presentation) to review results from the sediment (gravel) supply analysis.

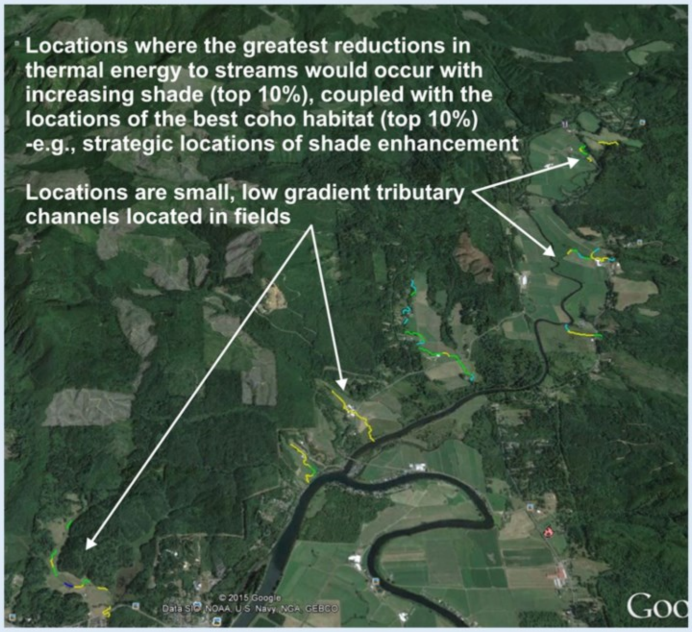


A second type of restoration planning decision space: using data distributions for all relevant habitat forming processes, select habitat condition thresholds for each of them and let NetMap quickly search for and locate spatial intersections between the various attributes. For example, where does the highest 10% of coho quality habitats (IP) intersect with the lowest wood recruitment potential and the widest floodplains? How many sites are there and where are they located. Use these data to prioritize restoration. Some examples follow.

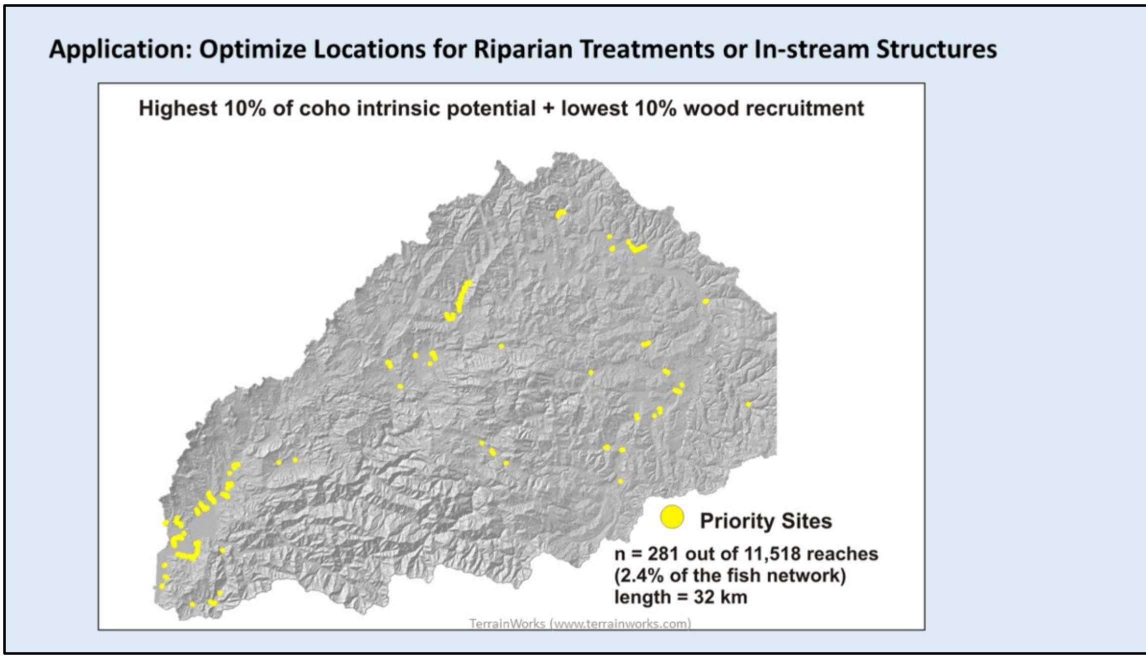
Identify strategic locations where increasing shade would have the greatest benefits



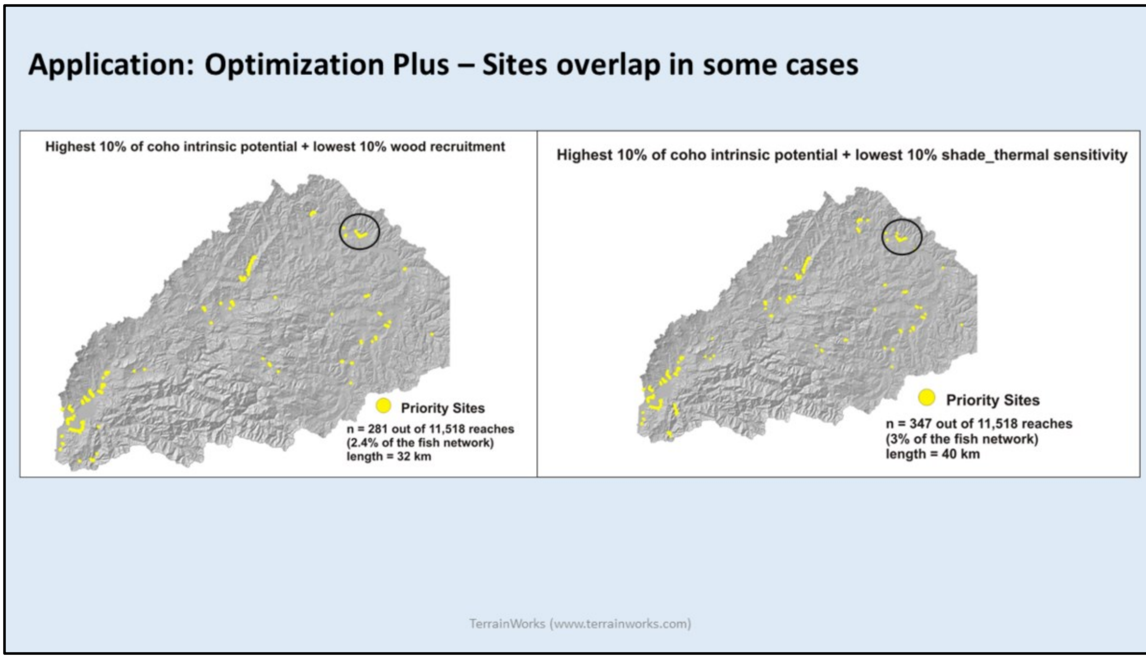
Use NetMap's overlap tool to quickly identify the locations where shade would have the greatest effect at reducing thermal energy to streams and where those locations overlap with the best fish habitat.



Export results to Google Earth

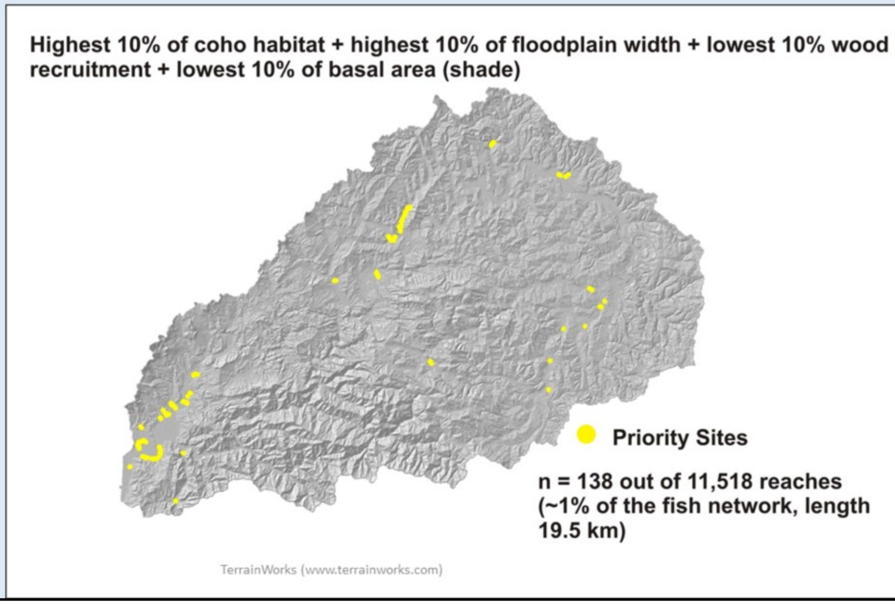


Using NetMap's tool, we quickly identified the locations where the highest 10% of coho habitat quality (IP) overlaps with the lowest 10% of wood recruitment. 281 sites were identified out of the total of 11,518 reaches in the virtual watershed (2.4% of the fish bearing network, with a total length of 32 km). Analysts, using the tool (previous slide), can change the threshold values (e.g., top 5%).

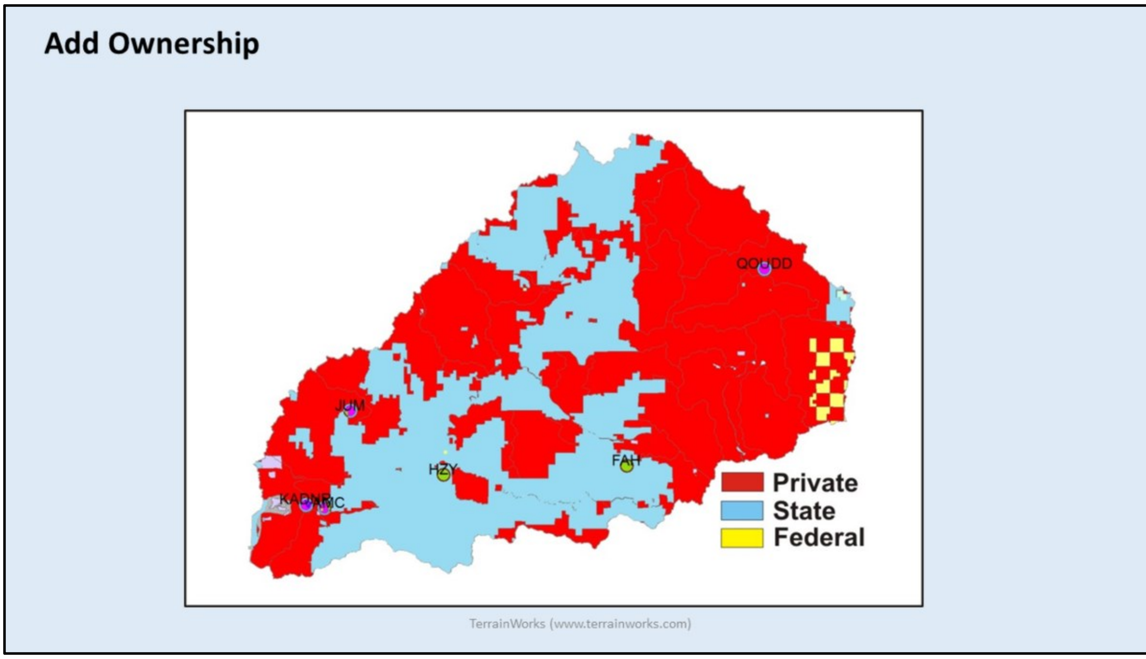


Sometimes, priority sites will overlap, yielding a bigger bang for your buck! Here there is commensurability among the best coho habitats (IP) and low wood recruitment and shade-thermal sensitivity. Use these types of maps to prioritize restoration actions.

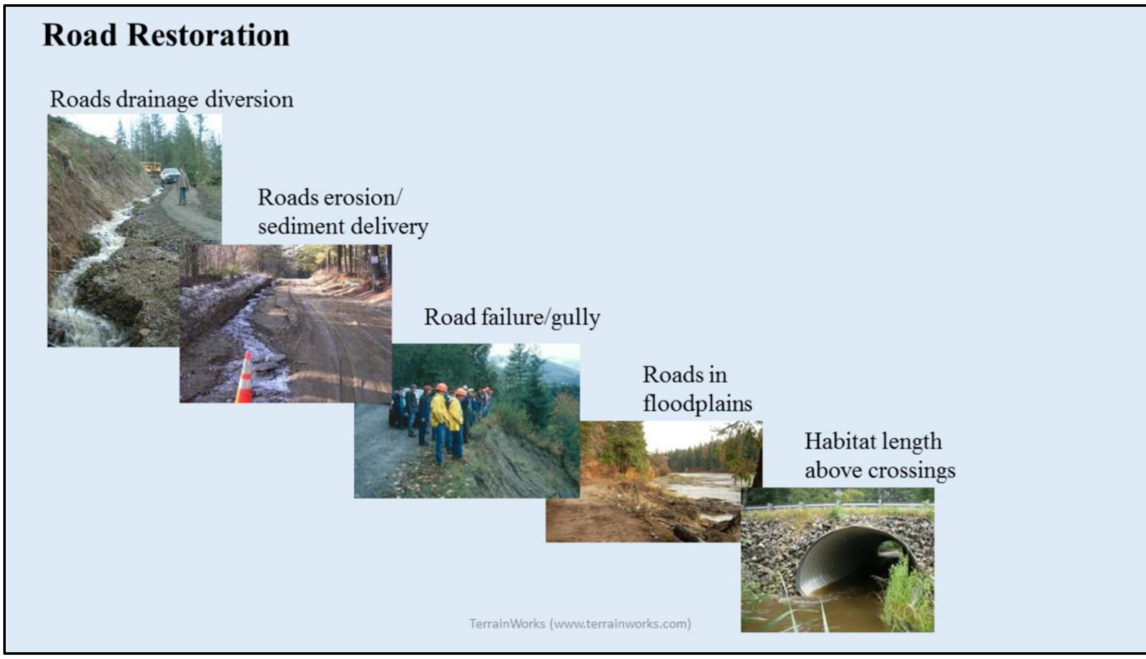
Application: Impaired habitat hotspots as restoration targets



In NetMap, you can search for five levels of intersections or overlaps among habitat forming conditions (or lack thereof). This example shows how four factors were overlaid: highest 10% of coho habitat, highest 10% of floodplain width, lowest 10% of in-stream wood recruitment and the lowest 10% of shade, conditioned by thermal sensitivity. Only about 1% of the fish bearing network meets these criteria; use this type of information to inform restoration planning.



Ownership (federal, state, local, private) can be an important determinant in selecting restoration sites. See how ownership varies across the



Watershed restoration activities can include road upgrades, maintenance and abandonment, as well as new construction. In NetMap and as applied in the Nehalem, road restoration can address: 1) drainage diversion, 2) road erosion and sediment delivery to streams, 3) road failure and gully potential, 5) roads in floodplains and 6) habitat length above road-stream crossings.