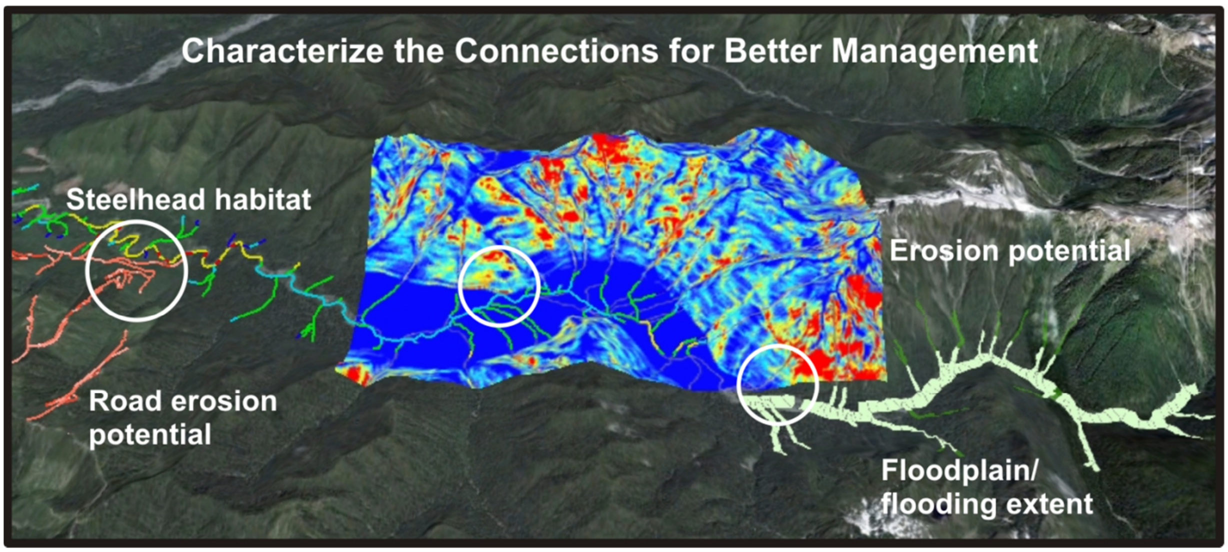
TerrainWorks (NetMap)

Watershed Assessment Packages: A Users Guide



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TerrainWorks Watershed Assessment Packages: A Users Guide

1.0 Introduction

A watershed assessment aids in planning involving resource use (forestry, grazing, mining, roads, and energy development), risk management (slope stability, other forms of erosion, wildfire, and climate change) restoration (watershed and in-stream), monitoring, and conservation. Watershed assessments can also inform pre- and post-wildfire planning efforts and climate change vulnerability.

The main components of a typical watershed assessment are (1) characterizing physical and biological features and processes in a watershed, (2) analyzing how past land uses have impacted natural watershed function, including the ecological integrity of river and terrestrial habitats and other values such as water quality and aesthetics, and 3) evaluating how current and future land use actions can impact watershed conditions. TerrainWorks Watershed Assessments, effectively a "desk top" analysis, rely on remote sensed data (digital elevation, climate, vegetation, roads, wildfire risk and climate change) and thus focus on the first and third components. The second component, an understanding of how land uses can impact watershed resources, is well established in the technical literature and does not have to be repeated in every watershed or assessment. Hence, the second component is encompassed in the Watershed Assessment Packages by utilizing the large body of information linking land use to watershed conditions and impacts.

The river network of a watershed, consisting of numerous headwater streams and a single river outlet, is the integrating unit of a watershed assessment, given that hierarchical and branching networks integrate and reflect, over space and time, the overall condition of a watershed in terms of flow, sediment and organic materials etc. Thus, the main objective of a watershed assessment is to inform how land uses can interact with natural watershed processes to achieve minimal negative consequences (Reid and McCammon 1993, USDA 1995, Montgomery et al. 1995, WDNR 1997, OWEB 1999, Benda et al. 2007).

Watershed assessments, also referred to as "watershed analyses", have become an organizing principle in the field of watershed or landscape management including by state governments and federal agencies (USDA 1995, WDNR 1997, OWEB 1999). Although watershed analyses have proven to be an effective planning tool, they are often expensive and time consuming and they can go out of date. TerrainWorks (NetMap) was designed to provide a comprehensive system of watershed assessment capabilities to diverse stakeholders including federal and state governments, NGOs and the private sector.

The Watershed Assessment Packages are underpinned by the "Digital Landscape". A Digital Landscape is an advanced terrain model that provides the numerical platform for characterizing watershed environments and processes, and human interactions with them. In addition to characterizing terrestrial attributes (erosion processes, floodplains, thermal energy), a Digital Landscape contains a digitally derived synthetic stream network. The synthetic stream layer is the primary integrating feature, just like in real watersheds and it supports analysis of connectivity and routing, including: 1) downstream, 2) upstream, 3) across floodplains and valleys, 4) downslope – upslope, 5) terrestrial – river and 6) atmosphere – land surface (**Figure 1**). Refer to www.terrainworks.com for additional information.

This users guide describes how each of the "watershed assessment packages" is used to evaluate watershed processes and how that understanding can help guide planning, including in forestry, fisheries, landslide hazards, watershed restoration, monitoring, conservation, pre- and post-wildfire analyses and climate change.

2.0 How to Use Watershed Assessment Packages

Brief discussions on the use of individual Watershed Assessment Packages follow. It is also recommended that users of the assessments refer to the full online Technical Help, Step Wise Guides and Tutorial Videos. Although these sources of technical help are designed primarily for users of NetMap tools, they provide information on how Watershed Assessment Packages are developed and provide reference materials for each watershed attribute in the assessments. In particular, users of Watershed Assessment Packages are encouraged to use the online information link to each of the watershed attributes here.

When a TerrainWorks Watershed Assessment Package is ordered, the client is sent a questionnaire and data requests so that certain assessments can be tailored to individual sites. Data requests include information on roads, aquatic habitats, slope stability and watershed classification needs.

There are eight "Watershed Assessment Packages": (1) watershed topography, (2) channel form/process, (3) aquatic habitats, (4) mass wasting/slope stability, (5) watershed classification, (6) road analysis, (7) wildfire risk and (8) climate change (Figure 1). Each of the assessment packages provides information necessary to evaluate watershed processes and patterns and to place them in spatial context with human activities (**Figure 2**).

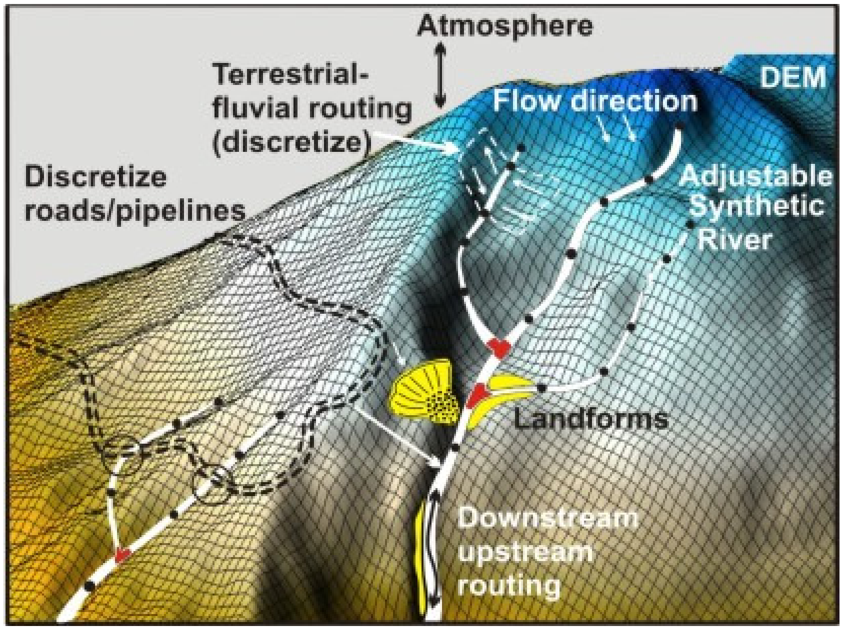

Figure 1. TerrainWorks (NetMap) comprehensive set of assessment support technologies. See www.terrainworks.com for more information.

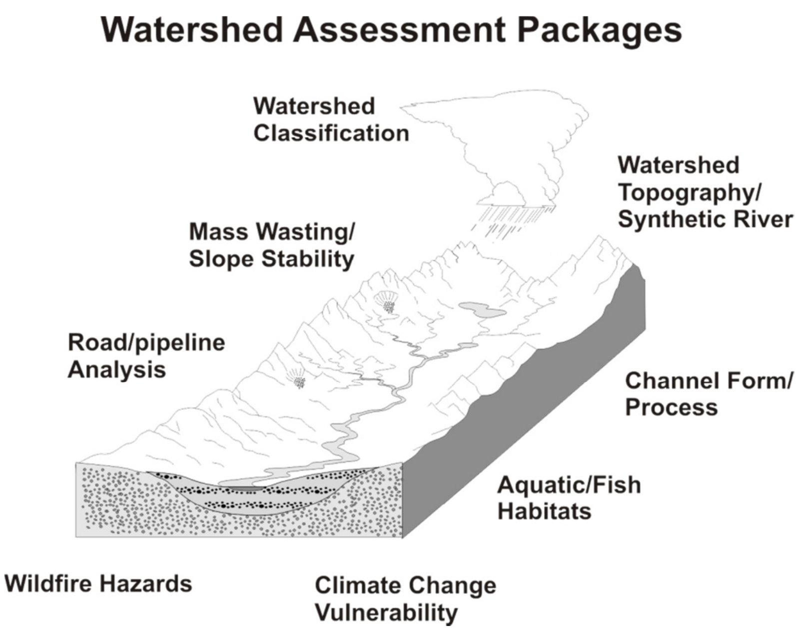

Figure 2. TerrainWorks eight Watershed Assessment Packages. For more information go here.

2.1 Watershed Topography Package

The Watershed Topography Package (WTP) consists of six attributes: 1) synthetic stream layer, 2) shaded relief, 3) elevation, 4) slope, 5) flow direction, and 6) flow accumulation. See here for more online information.

The WTP is designed primarily to provide the geospatial representation of topography (shaded relief, elevation) as well as a comprehensive mapping of all streams and rivers (stream layer). This is a key component of any watershed assessment. In particular, the synthetic stream layer derived directly from digital elevation models (typically 10 m) provides considerably more detail compared to the National Hydrography Datasets (NHD). In particular, there is a liberal densification of headwater streams to ensure, as much as possible, that small streams are not omitted. In NetMap Tools, there is a function to remove headwater streams, either individually or globally to tailor stream networks to individual landscapes.

The digital topography, combined with the synthetic stream layer and routing and connectivity functions, provides the "Digital Landscape, the fundamental analytical platform for all NetMap related analyses, such as, for example, linking streams to terrestrial environments, via "drainage wings" and the routing of in-stream information downstream or upstream (**Figure 3**).

2.2 Channel Forms/Processes Package

The Channel Form/Process Package (CFP) consists of nine attributes: 1) bankfull width, 2) bankfull depth, 3) mean annual flow, 4) channel gradient, 5) stream order, 6) stream power, 7) drainage area, 8) floodplain width and 9) channel classification. See here for more online information on each attribute.

The CFP is designed to provide baseline information on the physical characteristics of stream segments including hydraulic geometry, gradient, stream power and floodplains. This information is used to create customized habitat indices and stream classification systems. Classification systems include a channel response sensitivity index to identify which channel segments are most responsive to changes in sediment supply, flows and large organic debris.

The floodplain width attribute is both a channel reach attribute and a polygon. These data are useful for determining where, in a watershed, the best riparian and aquatic (fish) habitats are located and where flooding may impact resources such as roads and residences.

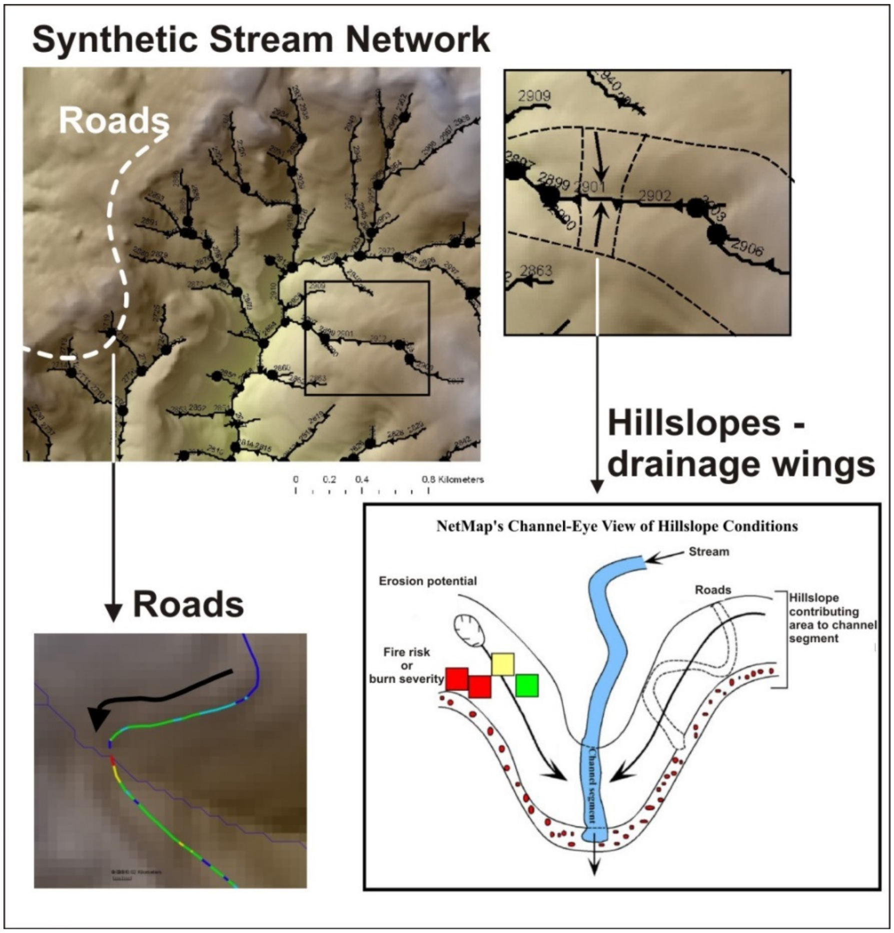

Figure 3. In Watershed Assessment Packages the local contributing areas located on both sides of individual channel segments ("drainage wings") are used to transfer terrestrial information (at the scale of wings) into their respective channel segments such as roads, vegetation, landslide potential, fire risk, climate change etc.. This provides a channel-eye or fish-eye view of terrestrial information and allows efficient spatial comparisons between terrestrial information (including land use related activities) and channel or habitat sensitivity or quality.

The other attributes in the Watershed Assessment Packages dealing with landsliding, debris flows, wildfires and climate change can be considered in the context of channel types and channel sensitivity; the Aquatic Habitat Assessment Package can also be used in this context.

Note that accessing NetMap tools via subscriptions allows one to create their own customized channel classification schemes (including applying a Rosgen classification) as well as customizing other attributes such as channel disturbance potential. Other NetMap tools include customized floodplain mapping, landslide channel interactions, tailoring channel heads, predicting wood accumulation types and predicting in-stream wood recruitment. For more information, go here.

2.3 Aquatic (Fish) Habitats Package

The Aquatic (Fish) Habitats Package (AHP) consists of six attributes: 1) coho salmon intrinsic potential, 2) Chinook salmon intrinsic potential, 3) steelhead trout intrinsic potential, 4) west slope cutthroat trout intrinsic potential, 5) beaver habitat, and 6) biological hotspots. See here for more online information on each attribute.

The AHP is used to map the spatial variation in aquatic habitat potential, particularly those of anadromous salmon and cutthroat trout. Fish habitat quality and abundance are not uniformly distributed across watersheds. Some areas of a watershed produce much better habitat than others based on the physical characteristics of channel networks and species preferences. For example, rearing coho salmon prefer low gradient and unconfined channels with off channel habitats and large organic debris. In contrast, steelhead trout prefer steeper and more confined channels. The intrinsic potential models for anadromous fish habitat are effective at characterizing the spatial variability in fish habitats for different species at the scale of watersheds to landscapes (Burnett et al. 2007).

A prediction of biological hotspots can be included in the AHP including combining attributes such as floodplain width, valley confinement, tributary confluences, substrate, wood recruitment and thermal energy. Fish habitat quality (using the intrinsic potential predictions) could be integrated within a biological production or hotspot index.

Similar to indices of channel sensitivity, fish habitat indices are used to understand where natural and human stressors, including landsliding, debris flows, roads, wildfires and climate change, pose the greatest threats and thus where special management, mitigation or restoration are warranted.

Accessing NetMap tools, via subscriptions, allows one to create their own customized aquatic habitat indices. For example, a user can modify the preference curves of the habitat intrinsic potential models. Other habitat characterizations can be created that include the attributes of floodplain width, substrate size, confluence effects, thermal loading and large wood. Other tools include core habitats, habitat diversity and a piscicide tool.

2.4 Mass Wasting/Slope Stability Package

The Mass Wasting/Slope Stability Package (MWP) consists of seven attributes: 1) shallow landsliding, 2) shallow landsliding, delivery to streams considered, 3) shallow landslide hazard proportion, 4) debris flow, 5) debris flow source areas, 6) debris flow-channel impacts and 7) gully erosion. In addition, see here for more online information on each attribute.

The shallow landslide model has two components: 1) a stability rating for all areas (sediment delivery to streams is not considered) and 2) instability of only those areas predicted to reach streams and rivers of a certain specified gradient threshold. The default channel gradient threshold is all channels.

Shallow landslide potential data are reported to stream channels (as reach segment data, see Figure 3) thus allowing users to compare predicted hillside erosion potential with other in-stream attributes such as channel sensitivity or response potential and fish habitat quality (see here for additional information). In addition, the channel reach scale erosion indices are aggregated downstream thereby providing a cumulative index of erosion potential at any spatial scale defined by the stream network (bottom of first order streams to bottom of seventh order rivers etc.).

Note, applying shallow landslide, gully, surface erosion and debris flow models and predictions requires careful consideration of other factors including the applicability of any model to diverse landscapes (e.g., is model appropriate), other important factors such as climate, vegetation characteristics, soils, land-use activities, wildfire history, and landslide history (at any particular site and across the larger landscape). Model users should have expertise in geotechnical disciplines in order to appropriately interpret landslide and debris flow hazards. See full warning.

The MWP information can be used in a variety of applications. For example, maps of shallow landsliding and debris flows can be used to search out locations of the most unstable areas in a watershed, particularly those that can impact fish habitats, roads, bridges, highways and residences. The shallow landslide proportion map allows one to identify locations of the highest percentiles of landslide risk, such as, for example, where the highest 20% of shallow landslide potential occurs in a watershed.

Slope stability maps are particularly useful for considering the existing and future locations of roads (for existing road locations, see the Watershed Assessment Package – Road Analysis). For future land use activities, road placement could be adjusted to reflect stability predictions (e.g., avoiding the highest potentially unstable areas or increasing engineering standards at those locations).

Note that the MWP does not address the potential for deep seated landslides or earthflows. However, subscribers to NetMap tools have access to functions that can be used to help identify *existing* deep-seated landslides and earthflows including using the attributes of floodplain and valley width, shallow landslide potential (certain spatial patterns of shallow landslide potential can be used diagnostically), and longitudinal and cross sectional profiling tools.

Also note that accessing NetMap tools, via subscriptions, allows one to create their own customized shallow landslide potential by modifying the delivery threshold. In addition there are tools for: 1) converting the index of shallow landsliding into sediment yield ($t/km^2/yr$), 2) calculating channel sedimentation potential, 3) identifying existing deep-seated landslides and earthflows, 4) predicting surface erosion using land cover vegetation, pre wildfire (predicted) severity, and post fire severity (using burned area reflectance classification maps) and 5) calculating erosion significance (of headwater streams).

2.5 Watershed Attribute Ranking Package

The majority of data in Watershed Assessment Packages is stream segment based or cell (raster) based and thus operates at the spatial scale of individual hillslopes (drainage wings, Figure 3) and individual channel reaches. This scale is appropriate for many types of applications where users want to see the details in specific areas. However, analysts may need to evaluate and summarize larger patterns of environmental attributes at the scale of entire watershed and landscapes. This is best accomplished by summarizing the various data layers at the scale of subbasins. Typically a TerrainWorks Watershed Assessment includes a set of subbasin polygons, usual Hydrologic Unit Code 6th field (12 digit); HUC 6 basin sizes are usually in the range of 10,000 to 15,000 acres (40 to 60 km^2). Note, purchasers of Watershed Assessment can opt to supply their own custom polygons during the TerrainWorks analysis.

In TerrainWorks analysis of watershed polygon ranking any aspect of the full distribution of values (distributions are calculated for each polygon), any aspect of the distribution can be used such as median, mean, or any percentile or percentile range. See here for more detail. Thus the Watershed Attribute Ranking Package (WACP) supports the creation of watershed- or landscape-scale classification systems. Attributes such as fish habitat potential (IP scores for various species), landslide and debris flow potential (different types), channel density, road density, road drainage, road erosion, fire risk and climate change can be used in the classification system (**Figure 4**).

Note that with a NetMap tool subscription, users can use the Subbasin Overlap Tool that allows one to quickly search for overlaps among subbasins. For example, where in a watershed does the highest landslide potential overlap with the best fish habitat or highest road density, at the scale of subbasins. Also note that the TerrainViewer supports this type of analysis.

2.6 Road Assessment Package

The Road Assessment Package (RAP) consists of seven attributes: 1) road density – subbasin scale, 2) road density – hillside/drainage wing scale, 3) road drainage diversion, 4) road surface erosion and sediment delivery to streams, 5) road stability (road landslide risk), 6) road-debris flow intersections, 7) roads in floodplains and 8) cumulative habitat length and quality above all road crossings. See here for more online information on each attribute.

RAP information can be used in a variety of applications. Road density (length of road/area in km/km^2 or mi/mi^2) is often used as a proxy for cumulative effects. Road density is commonly calculated at the scale of entire watersheds; values of 1 to 5 mi/mi^2 are common, particularly in areas with forest roads. However, calculating road density at the scale of individual hillsides (drainage wings, Figure 3) and channel segments reveals road densities that range from 1 to over 100 mi/mi^2. Thus, road density at the individual hillside – channel segment scale reveals significantly more spatial variation and is a useful attribute for locating areas in a watershed with the highest potential impacts from roads (Figure 4).

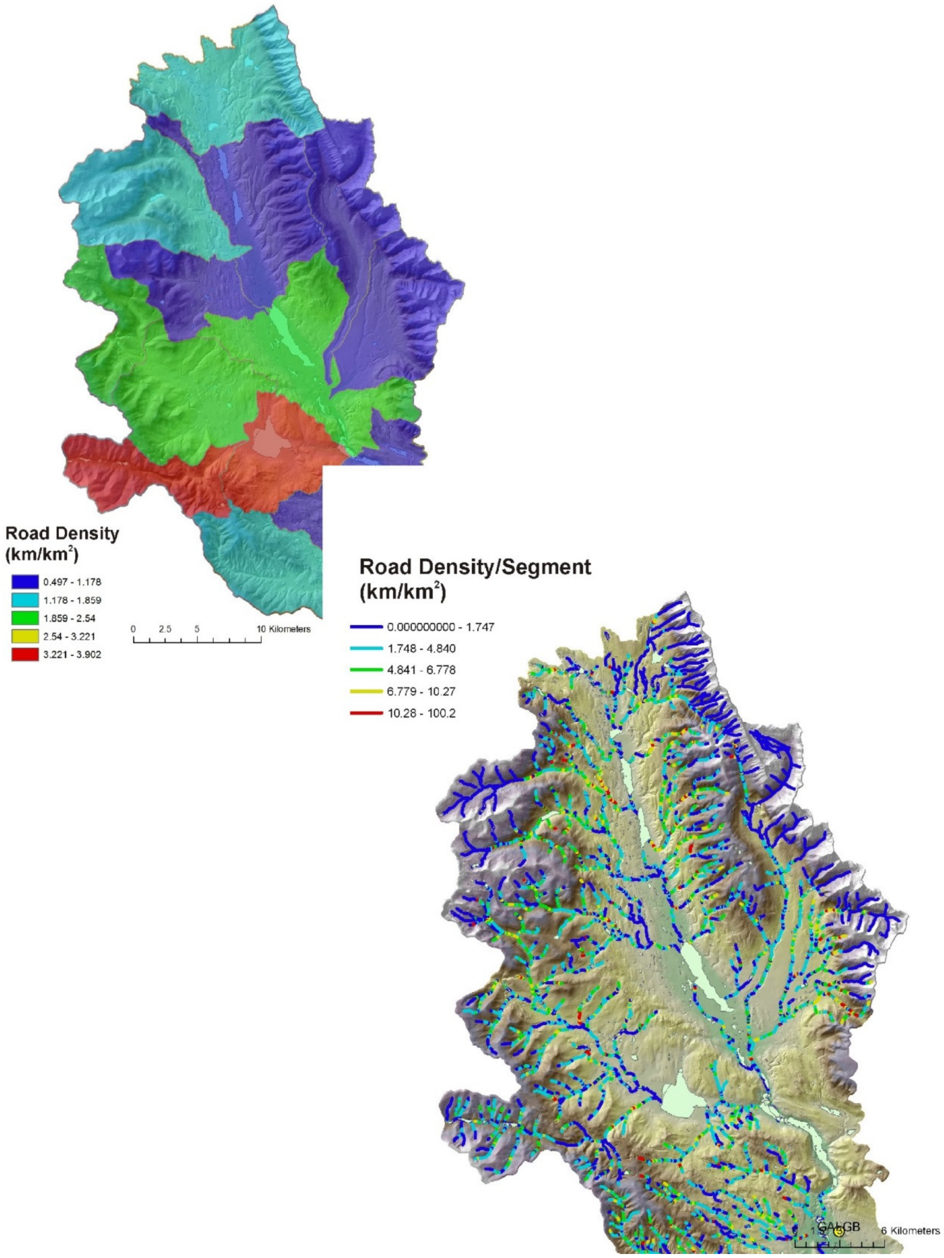

Figure 4. An example of watershed classification of road density is shown at the scale of HUC 6th using mean values and at the scale of individual channel segments and individual drainage wings (e.g., Figure 3). Note the much greater variation and higher values of road density when evaluated at the channel segment scale Any Watershed Assessment attribute can be classified (upper left panel).

The RAP information on drainage density and road surface erosion is particularly useful for considering which roads pose the greatest risk for fine sediment introduction to streams. Generally, only a small percentage of roads are the greatest producers of sediment. To see an example analysis in the use of road assessment attributes, go here. Also, during the development of a Watershed Assessment Package, GPS road drain points can be provided to make the analysis of road drainage and road surface erosion more accurate.

Roads that cross landslide prone hillsides are often at risk for failure and can represent a significant impact in watersheds. The road stability attribute classifies individual pixel-scale road segments by the underlying predicted hillslope stability (see the Watershed Assessment Package – Mass Wasting/Hillslope Stability). The stability road maps allow users to quickly identify hotspots where roads can contribute to failure. Of particular interest is where road related failures can intersect fish bearing streams, and this can be evaluated using the road-debris flow intersections attribute or by simply viewing the road stability maps in context with the fish habitat potential maps (using the Watershed Assessment Package – Aquatic [Fish] Habitats).

Roads in floodplains can be problematic because they are at greater risk from flood damage but they also threaten aquatic and riparian habitats because they can deliver runoff and increased fine sediment to streams and rivers. A user can display maps of road surface erosion and whether they intersect the floodplains. For this analysis, floodplain mapping is required (see Watershed Assessment Package – Channel Form/Process).

Roads often present constraints or outright barriers to fish migration either because culverts create impassable jumps or because they are velocity barriers. Restoration and road maintenance programs often target road – stream crossings to improve habitat access. Attributes contained within RAP include the cumulative habitat length and quality above every road crossing. An additional attribute is the total number of upstream (and downstream) crossings. These attributes could be used effectively to prioritize the crossings where restoration to improve fish passage would have the greatest positive benefits.

Note that a subscription to NetMap tools allows users to customize their road analyses. For example, new road layers can be imported and all analyses quickly repeated. Floodplains of different extents can be calculated (e.g., different elevations above the channel) and these can be used to search for road-floodplain interactions. In addition, users can calculate road drainage diversion and road surface erosion and utilize their GPS road drainage locations.

2.7 Wildfire Hazards Package

The Wildfire Hazard Package (WHP) consists of three categories and nine attributes: 1) fire severity, 2) fire probability and 3) post fire surface erosion. The three attributes categories are all represented on hillsides (rasters or grids) and in channels (individual channel segments and routed downstream), thus yielding nine attributes. See here for more online information on each attribute.

The predicted wildfire probability and fire severity (flame length in feet) uses data available from Western Wildland Environmental Threat Assessment Center (WWETAC). Post fire erosion (surface erosion using the WEPP model) is based on results from Miller et al. (2011).

Wildfires can represent a significant environmental stressor. High fire severity (large flame length) can lead to extensive areas of mineral soil, accelerated erosion (surface, gully, and landsliding), increases in channel sedimentation and large impacts on water quality and fish habitats. This is referred to as the "Wildfire Cascade" in NetMap (**Figure 5**). However, under certain conditions, wildfires and associated accelerated delivery of sediment and organic material to streams can provide long term net ecological benefits (Benda et al. 2003).

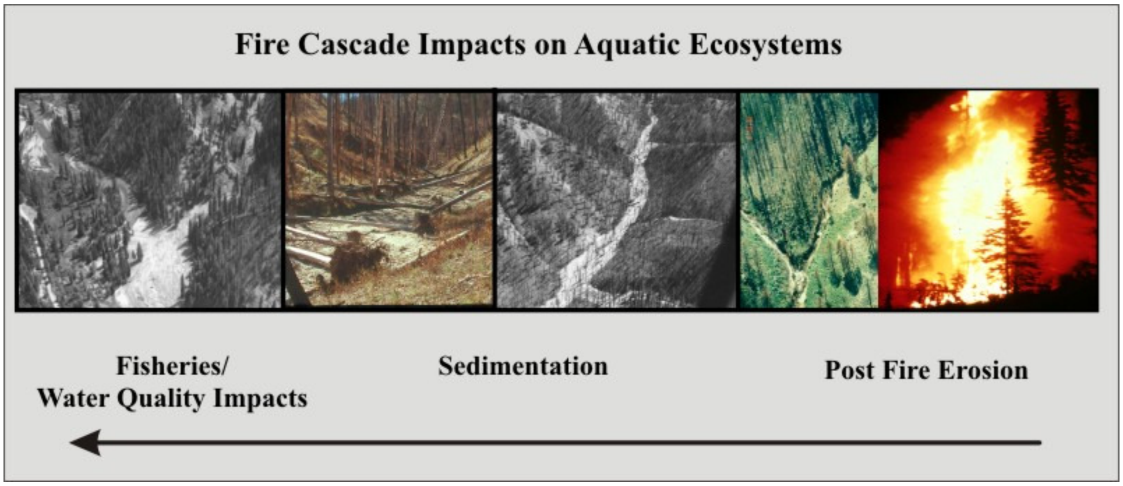

Figure 5. Wildfires often trigger a cascading sequence of events including erosion, sedimentation and impacts to channels, fish habitats and water quality.

The WHP can be used to quickly display the predicted fire severity, fire probability and post fire erosion on hillsides (as raster or grid) across large watersheds. These three attributes are converted to in-stream values, via drainage wings (Figure 3), thus providing a channel-eye or fish-eye view of wildfire hazards. Analysts, using the Watershed Risk Identifier Tool (WRIT), can quickly search for locations where the highest fire probability, severity or post fire erosion overlaps with the most sensitive habitats.

2.8 Climate Change Vulnerability Package

The Climate Change Vulnerability Package (CCVP) consists of six categories and 18 attributes. Climate change predictions include: 1) temperature, 2) precipitation, 3) snow accumulation, 4) summer runoff, 5) winter runoff and 6) snow-water equivalent. The six attributes categories are all represented on hillsides (rasters or grids) and in channels (individual channel segments and routed downstream), thus yielding eighteen attributes. See here for more online information on each.

Climate change predictions are reported in percent (%) change from historical (1916-2006) to forecasts in 2040 (positive and negative values); however, the temperature predictions are in absolute change in degrees C. Forecasts are from University of Washington Climate Impacts Group. For additional background information on how forecasts are made, see here and here. The climate change scenarios represent a composite average of ten global climate models (GCM) for the western US using four bracketing scenarios based on four GCMs (ECHAM5, MIROC_3.2, HADGEM1, and PCM1). Predictions are for one greenhouse gas scenario (A1B, a middle of the road scenario for future emissions).

The CCVP can be used to quickly display the predicted climate change attributes on hillsides (as raster or grid). These six attributes are converted to in-stream values, via drainage wings, thus providing a channel-eye or fish-eye view of climate change. Analysts, using the Watershed Risk Identifier Tool (WRIT), can quickly search for locations where the highest predicted changes in climate overlap with the most sensitive habitats.

3.0 Putting the Pieces Together

With all of the Watershed Assessment Packages available, an analyst can quickly perform analyses that will shed light on the spatial interconnectedness of different natural and land use related stressors and sensitive and or important habitats, inclusive of threatened and endangered fish species (**Figures 6 and 7**).

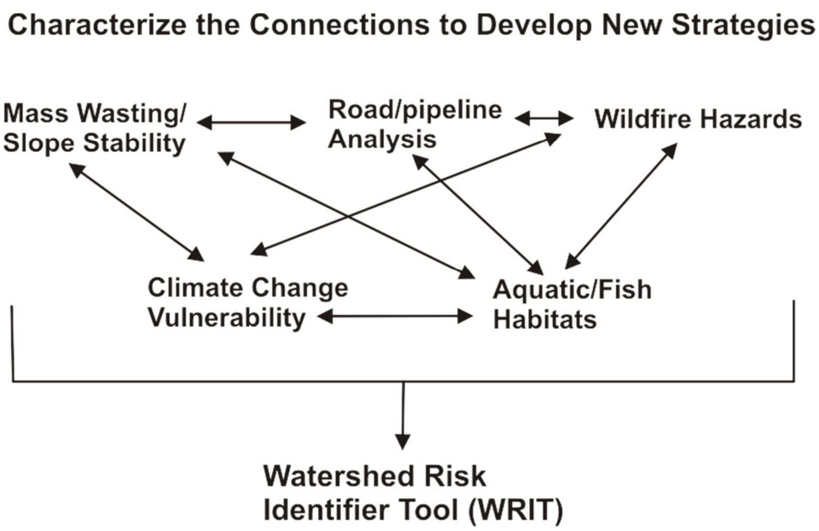

Figure 6. A major objective of TerrainWorks Watershed Assessment Packages is to quickly identify overlaps between single to multiple stressors (natural and land use related) and sensitive and valuable habitats.

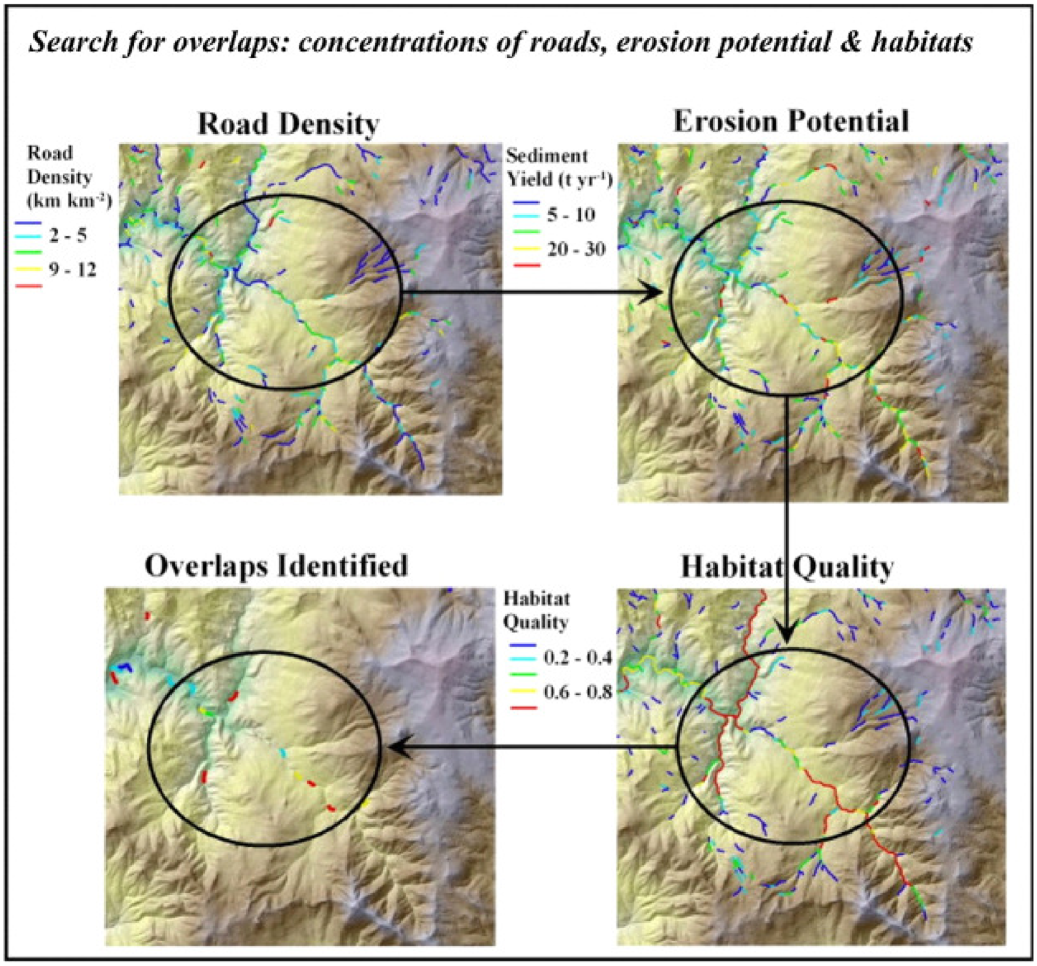

Figure 7. An illustration in the use of the Watershed Risk Identifier Tool (WRIT) shows how Road Density (calculated at the scale of individual channel segments, using Drainage Wings), is overlaid on the hillside erosion potential and which is further overlaid on fish habitat quality (Intrinsic Potential). A user selects threshold values for these three attributes (e.g., top 10%, top 5%, top 1% etc.) using WRIT and searches for where these thresholds overlap (and in this example, color coded by fish habitat quality). Hence, an analyst can quickly identify the locations of the highest potential for road related impacts on habitats. Field programs or restoration activities can be tailored to match these findings.

3.1 Step-Wise Guide to Watershed Assessment

One approach is to ask a series of questions related to natural and land use related stressors and aquatic habitats. TerrainWorks (NetMap) Step Wise Guide to Applications is designed specifically to use with NetMap Tools (coupled to digital landscapes) to help guide analyses. However, they can also be used in the context of Packaged Watershed Assessments because many of the analyses have been done (but not all, so not all questions will be relevant). To be able to answer all of the questions will require access to NetMap tools, via annual subscription.

To use the Step Wise Guide to Applications, simply follow the links. Remember that for those who do not have access to NetMap tools but to only the Packaged Watershed Assessments, particular reference to tool functions may not be useful, but the end product of many of the tools are included in the Watershed assessments. "*" indicates which questions are most applicable in the context of the Packaged Watershed Assessments.

Aquatic/Riparian Habitats

- Where is the best fish habitat located for different species (anadromous, resident)? *
- How can I locate areas of concentrated high quality fish habitats, e.g., habitat core areas?
- Where are my aquatic biological hotspots located? *
- Which channels would support beaver? *
- Where are the channels located with the greatest habitat diversity?
- Where are the largest and most productive floodplains located in my watershed? *
- Map estuary habitats.
- Calculate the cumulative length and quality of fish habitat upstream (or downstream) of any point in the river network (including all road crossings).
- Classify, by subbasins, aquatic or fish habitats across a large watershed or landscape. *
- Where in my watershed are channels with the greatest susceptibility to disturbances (or dynamics)?
- Identify where the best habitats intersect potential environmental stressors. **WRIT***

Channel Types, Channel Response, Channel Network

- What are the different channel types in my watershed and which ones are the most sensitive to land use impacts? *
- Which areas of the channel network are most prone to sedimentation and flooding? *
- How many stream orders do I have in my watershed? *
- What is my watershed's drainage density?
- What different types of channel geometry do I have in my landscape? *
- Which parts of my channel network are most prone to disturbance (floods, sedimentation, landslide impacts), an important consideration in the context of in-stream restoration? *
- What types of information can help with my in-stream monitoring program?
- What types of information will help with my floodplain restoration activities? How can I locate floodplains that have been obscured by development?

- How can NetMap help with in-stream restoration?

- How can I identify estuaries or portions of them that have been obscured by development and in need of restoration?

Erosion/Slope Stability

- Which hillsides in my watershed are most prone to landsliding? *
- Which headwater streams are most susceptible to debris flows or gullying? *
- Which fish streams are most susceptible to debris flow impacts?
- How can I identify large landslides and earthflows?
- Which areas in my watershed are most at risk from debris flows? *
- Which landslide prone areas are most sensitive to land uses?
- Which structures are at risk from landsliding and debris flows?
- What parts of my watershed are most likely to contribute sediment to river channels? *
- Where is the highest surface erosion potential with a high likelihood of sediment delivery to streams and rivers? *
- Classify watershed subbasins by inherent erosion potential? *
- What proportion of landslide potential originates from particular areas of my watershed? *

Roads/Pipelines

- Which subbasins across the landscape have the highest road density? *
- Which individual hillsides (approximately 0.1 km^2 [24 acres]) have the highest road density? *
- Create a fish-eye view of road density? *
- Which roads have the highest road drainage diversion potential? *
- Which road segments have the highest road surface erosion potential? *
- Which road segments/energy corridors are located on potentially unstable hillsides? *
- Which road segments/energy corridors are most likely to trigger debris flows in steep headwater streams? *
- Which road segments/energy corridors are most susceptible to damage from debris flows?
- Where do roads/energy corridors intersect floodplains? *
- Where do roads/energy corridors intersect quality aquatic/fish habitat? *
- What is the cumulative habitat length and quality above every road crossing (or below every road crossing)? *

Riparian Management

- Which streams are most sensitive to radiation loading if the riparian vegetation was altered or destroyed?
- In a snapshot in time (this year), how does variation in riparian conditions across my watershed affect in-stream wood loading?
- Using forest growth predictions, calculate how in-stream wood loading will vary over time (decades to centuries).
- What types of in-stream wood jams would I expect, given variation in riparian vegetation?
- Could predicted fish habitat quality influence the design of riparian management, including buffers?
- Should I consider erosion potential in the design of riparian management?

Pre Wildfire Planning

- Where in my watershed is the greatest chance of wildfire? Where is the highest 10% or 1% of fire risk located? *
- Where is the predicted highest fire severity located across the landscape? *
- Where does the highest chance of fire overlap with the highest fire severity? Where are those stressors located? *
- Where does the highest fire severity overlap with the highest chance of post wildfire erosion? *
- Where does the highest fire risk overlap with the highest fire severity, and where does that pair overlap the best aquatic habitats? *

Post Wildfire Planning (Burned Area Emergency Response, BAER)

- Where in my watershed is the highest burn severity located? Top 10%, top 1% etc.
- Where is the post fire surface erosion potential the most extreme?
- Where is the post fire landslide and debris flow risk the highest?
- At what locations does the highest fire severity overlap with the highest erosion potential, and where do those locations overlap with quality aquatic habitats?
- Where do roads intersect burned areas with the highest erosion potential?
- Which streams in the burned area have the highest exposure to increased thermal loading because of loss of riparian vegetation?

Climate Change Vulnerability

- Identify the largest predicted climate change in your watershed for temperature, precipitation, snow accumulation and summer and winter flows. *
- Where do the largest predicted changes in temperature and flow intersect the highest fire risk? *

- Where are the largest changes in summer flow predicted to occur and where do they intersect sensitive and valuable aquatic habitats? *
- Where are the largest changes in winter flow predicted to occur and where do they intersect valuable habitats and infrastructure, such as roads? *

3.2 Using the Watershed Risk Identifier Tool (WRIT)

This Watershed Risk Identifier Tools (WRIT) is designed to quickly identify spatial relationships between single to multiple environmental (and land use) stressors and sensitive and quality habitats. It can be used in conjunction with many of the questions outlined above. For example, where is the top 5% of salmon habitat located in your watershed? Or where is the top 10% of provisional biological hotspots? Where do those locations overlap with the top 1% of landslide risk; with the top 5% of debris flow hazards; with the top 2% of wildfire severity; with the top 20% of post fire extreme events (erosion); and with the top 10% of predicted climate change impacts? For example, **Figure 7** shows how WRIT identifies the overlaps between the top 10% of coho salmon habitat and the top 10% of road density (road density calculated at the scale of individual drainage wings – channel segments, Figure 3). Note that the Terrain Viewer is designed along the same lines but at a larger spatial scale, using HUCs 4, 5, and 6 (8, 10 and 12 digital respectively). See the Help Link on the WRIT tool for use of the tool within Packaged Watershed Assessments.

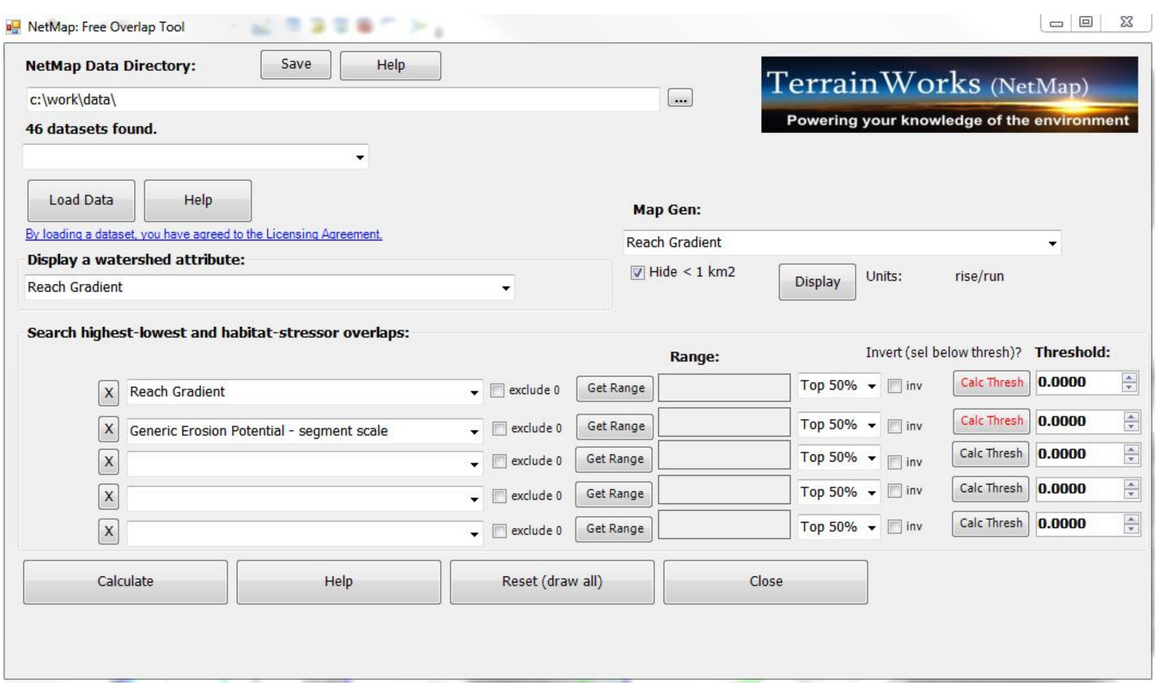

Figure 7. Use of the Watershed Risk Identifier Tool (WRIT) in the context of Watershed Assessment Packages is described ***here***.

References

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