RipZET

The Riparian Zone Estimation Tool

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SAN FRANCISCO ESTUARY INSTITUTE
4911 Central Avenue, Richmond, CA 94804
p: 510-746-7334 (SFEI) • www.sfei.org

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For more information please contact:
Scott Dusterhoff, scottd@sfei.org
510-746-7350

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Purpose

The Riparian Zone Estimation Tool (RipZET) was produced by the San Francisco Estuary Institute and Aquatic Science Center to help the California community of riparian interests visualize and characterize riparian areas as habitat unto themselves as well as their capacity to support the ecosystem services of the state's lakes, streams and wetlands.

General Description of RipZET

RipZET is a tool used with a Geographic Information System (GIS) to estimate the extent of riparian areas based on the concept of "functional riparian width." According to this concept, the kinds of functions that a riparian area can provide depend on its structure, which includes topographic slope, types of soils, density and height of vegetation, and plant species composition. Furthermore, for any given structure, the levels of specific functions within a riparian area depend on its width and length. Wider and longer riparian areas tend to support higher levels of more kinds of functions than shorter and narrower areas (Wenger 1999). The concept of functional riparian width is central to the riparian definition recommended by the National Research Council (NRC 2002) and is integral to many riparian design and management guidelines (e.g., Johnson and Buffler 2008).

RipZET has three main components: core code, modules, and output. The core code prepares the input data used by the modules. Each module generates an estimate of riparian width for a different set of riparian functions within a geographic area defined by the user. The output of each module is a unique visual display (GIS coverage) of the estimated functional riparian area. The displays are not regarded as riparian maps *per se* because they do not depict areas with definite boundaries based on field indicators. Instead, they depict areas where the riparian functions represented by the individual modules are likely to be supported. The modules can be run separately or together, and the outputs from different modules can be conflated to estimate the maximum likely riparian extent for all the functions represented by all the modules. The modules can be revised, and new modules can be added to cover more functions.

At this time, RipZET consists of the Hillslope Processes module, the Vegetation Processes module, and the Hydrological Connectivity module. Modules to estimate channel entrenchment, shading and thermal loading, wildlife habitat extent are being planned.

Technical Description of the Hillslope Processes Module

The Hillslope Processes module (or Hillslope module) is designed to incorporate mass wasting into estimates of functional riparian extent. The processes of particular interest are landsliding and dry raveling that deliver sediment to an aquatic feature. The effects of sediment input can be positive or negative. For example, inputs of coarse sediment are generally expected to have positive effects on in-stream habitats, whereas the inputs of fine sediment are generally expected to have negative effects. In any case, the inputs are riparian in nature. The module also accounts for the effect of hillslope steepness on inputs of organic allochthonous material, especially large woody debris (LWD). For example, the riparian width defined by the maximum distance a tree can be from a stream and still fall into it decreases as hillslope steepness increases. This module is therefore especially applicable in steep terrain. It is also designed to estimate the minimum likely headwater source areas for rivers and streams (i.e., the zero-order basin). These areas are typically uphill of the ends of surface channels as mapped using LiDAR or aerial imagery.

The Hillslope module estimates functional riparian width according to a series of simple analytical steps. First, the module calculates the area-weighted average hillslope gradient from a digital elevation model (DEM) over a distance of 40 m perpendicular to the stream bank or wetland edge. For hillsides with an area-weighted average gradient less than 20%, the riparian width relating to hillslope processes is assumed to be zero, and the headward source areas for streams and rivers is assumed to be the same as the channel ends evident in LiDAR or aerial imagery. Second, where the hillslope gradient is greater than 20%, the functional riparian width is estimated as 1 m for each 1 percent increase in average hillslope gradient above the 20% threshold value. For example, the functional riparian width for a stream reach bounded by a hillslope having an average gradient of 27% would be 7 m. The size of the headwater source area of a river or stream is similarly estimated. For example, if the area-weighted gradient around the end of a mapped channel is 27%, the diameter of the circular area created to represent the source area would be 7 m. The default threshold value of 20% that triggers the module and the increase in functional riparian width above that value were determined from a literature review (Trimble 1957, Swift 1986, Wegner 1999), and can be adjusted by the user to better reflect site-specific conditions. This module can be run for any selected watershed or other area of interest.

Example RipZET Hillslope Processes Module

Technical Description of the Vegetation Processes Module

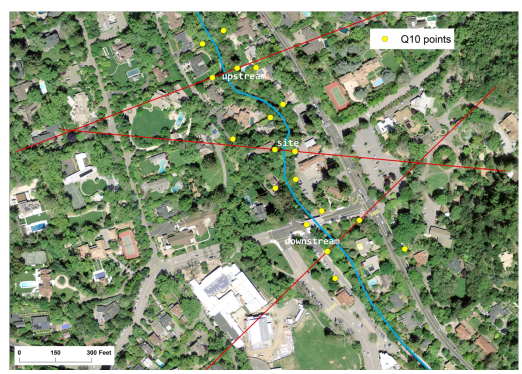
The Vegetation Process module (or Vegetation module) is designed to estimate the functional riparian area associated with filtering non-channelized surface runoff and providing plant debris, plant exudates, invertebrates and other allochthonous materials to surface waters. This module generates estimates of functional riparian width based on the intersection between user-provided digital maps of vegetation, topography, and surface waters. The preferred map of surface waters is the California Aquatic Resource Inventory (CARI), but the user is free to use any dataset of his or her choosing. CARI is consistent with the mapping standards of the National Wetland Inventory (NWI) of the US Fish and Wildlife Service, and the National Hydrological Dataset (NHD) of the US Geological Survey, but provides more detail. Readily accessible vegetation data that can be used for this module include CALVEG produced by the U.S. Forest Service and VegCAMP produced through the California Department of Fish and Wildlife. The VegCAMP data are preferred because of their greater spatial resolution and accuracy, but the user can use any vegetation dataset.

The module starts by identifying vegetation as trees, scrub-shrub, grasses and forbes, or bare ground base

Example RipZET Vegetation Processes Module on the user-supplied vegetation data. For the non-tree classes, the module assigns a standard buffer width (SBW) that is based on vegetation type (bare ground and pavement receive a value of 1 m). For the tree classes, the module calls up default values of expected heights for mature trees present by species. The levels of particular riparian functions are positively related to mature tree height. For each bank, the module then calculates the product of twice the mature tree heights and the cosine of the adjacent hillslope or floodplain angle (determined from a DEM) to estimate functional riparian width. Essentially, the functional riparian width for a flat floodplain is two tree heights and decreases as floodplain angle becomes steeper. The underlying concepts behind this equation are that: 1) LWD input is often driven by the trees at a distance of around two tree heights from the bank hitting the trees closer to the channel (Reid and Hilton 1998); and 2) the steeper the floodplain, the greater the momentum driving LWD delivery and the lower the required functional width (Vannote et al. 1980, Fox 2003, May 2003). The user can edit the default tree height multiplier and floodplain or hillslope values as needed to represent local conditions. This can be necessary to account for allochthonous input from trees at different distances away from aquatic features. Functional riparian width is not estimated where the aquatic portion of one feature intersects that of another kind, such as where the flow from a river or stream enters a lake. Similar to the Hillslope module, the Vegetation module can be run for any selected watershed or other watershed area of interest.

Technical Description of the Hydrologic Connectivity Module

The Hydrologic Connectivity module (or HydCon module) is designed to estimate the likely extent of flooding along low-gradient alluvial rivers and streams as a way of estimating functional riparian extent. The functions of particular interest within this module are storage of flood waters, de-synchronization of flood stage, recharge of shallow aquifers, filtration and storage of fine sediment, production and input of allochthonous material, and support and maintenance of riparian vegetation.



Example RipZET HyCon Module output.

To estimate the likely lateral extent of flooding, the module uses site-specific physical data, a simple hydraulic equation (Manning's equation), and flood frequency information. The module begins by determining cross-section topography and channel slope derived from high-resolution LiDAR or from field surveys at three locations within the selected study reach. The user then assigns roughness values for the floodplains and the channel using field observations (e.g., Arcement and Schneider 1989), literature values (e.g., Chow 1959) and aerial photographs, or a combination. These data are then used with Manning's equation to determine cross-sections specific relationships between discharge and flow stage (or rating curves). Rating curves are then combined with flood frequency information and the cross-section topography to determine the out-of-bank flooding extents for larger storm events, which are generally considered reasonable estimates of functional riparian extents in undisturbed alluvial valleys (Ilhardt et al. 2000). The module maps the estimated flooding extent of the 10- and 50-year floods, but the user can choose to show other flooding extents if they are more appropriate for site-specific conditions. The mapped flooding extents within a study reach can then be connected to estimate functional riparian extent.

The HydCon module is best suited for the middle and lower reaches of watersheds, where appreciable floodplains tend to form. It is also well-suited for streams that lack rating curves or other empirical flow data. At this time, the HydCon module can only be run for individual stream reaches.

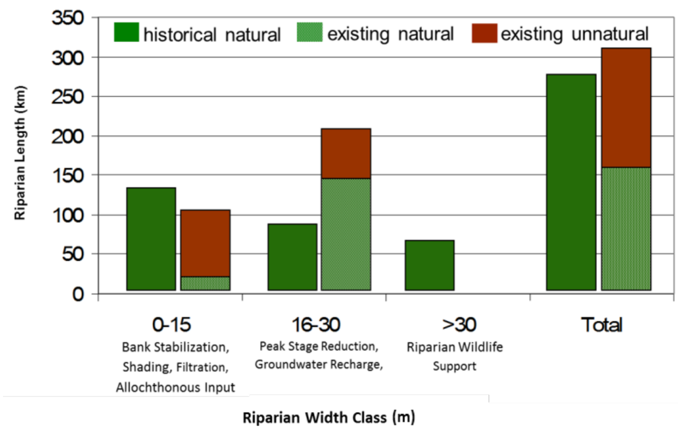
Visual and Analytical Output

Each module of RipZET generates a display of functional riparian areas and a summary chart of basic statistics developed from the display. The summary chart includes total riparian area by aquatic feature type for each module and for all modules combined, and the total riparian area shared by two or more types of aquatic features. All the data used to generate the final displays and summary statistics are maintained in the GIS. This includes the numerical estimates of riparian width, the names of associated aquatic features, the Strahler order of associated channels (Strahler 1952), the types of associated vegetation, and the values for hillslope gradients.

Intended Uses of RipZET

The main intended use of RipZET is to assess the capacity of existing riparian areas to support desired riparian functions. To complete this kind of assessment, the user might employ published relationships between width and function (e.g., Wenger 1999). Wider areas will tend to support all the functions of narrower areas plus additional functions. Widths can be grouped into classes based on the functions they support. The RipZET tabular output can then be used to calculate the relative abundance of the different classes of riparian width. Based on these calculations, the user can estimate spatial and temporal differences among riparian areas in terms of their likely capacity to support the desired functions.

The RipZET outputs have many additional uses. For example, they can be used to prioritize riparian restoration opportunities and to test the effects of alternative restoration scenarios on the total extent of riparian area by functional width class. They can also be used to create graphics that depict riparian areas in relation to other landscape features and land cover, as needed to educate the public about the locations and values of riparian areas.



Example analysis of the relative abundance of different classes of functional riparian width.

Additional Modules Being Considered

New RipZET modules can be recommended by its user community. Three additional modules that have been suggested by management agency partners are being planned at this time.

- Thermal Loading Module. A module to calculate thermal loading as a function of tree shading of the channel has been prioritized for development. Its main purpose would be to help estimate decreases in thermal loading due to increases is shade. The module would also determine the percent of shading that is due to hillsides, stream or wetland banks, riparian vegetation, or built structures. It is also envisioned that this new module could be used to test various riparian restoration scenarios on thermal loading.

- HydCon Module 2.0. Two sub-modules of HydCon module are being planned. One sub-module will enable the basic approach of the current module to be applied automatically to entire watersheds. Another sub-module will estimate the degree of channel entrenchment throughout a drainage network. Entrenchment could be calculated as the ratio between bank height, as derived from LiDAR, and maximum bankfull depth, as derived from regional hydraulic geometry curves (Dunne and Leopold 1978). The outputs from these sub-modules would help identify where flooding is likely and where floodplain restoration is most needed and feasible.

- Wildlife Support Module. The diversity of wildlife supported by a riparian area and the level of support for any particular riparian wildlife species is related to the width of the area and its structure as habitat (NRC 2002). This new module would use LiDAR to estimate the width of riparian forest canopy up to a maximum width that is greater than the minimum width for any key riparian wildlife species. The user would be able to select minimum widths for individual species to generate an estimate of the extent of their riparian habitats. It is also envisioned that this new module could be used to test various riparian restoration scenarios on habitat extent.

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