Riparian Area Mapping Model Overview

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RB2 Wetlands Regional Monitoring Effort (WRMP)
Wetlands Assessment Framework

- 3-year Prop 50 Coastal NPS project
- Region 2 demonstration of statewide monitoring and assessment tools
- Tools will be available to others to support statewide monitoring needs
- Cost-effective methods that are widely useable

Ultimate goal is to know where the wetlands are and how they are doing
WRMP Landscape-level tools: Map-based inventories and landscape analysis

- **Bay Area Base Map of Streams, Wetlands and Riparian features**
  - Mapping methods standardized. Standards reviewed for compatibility with NWI and NHD.
  - Extensive classification of mapped features
  - Stream Order and Stream flow direction
  - Based on 2005 NAIP imagery
  - Riparian model  
    
    "Our focus today"

<table>
<thead>
<tr>
<th>Number of Features in Sonoma Quad example:</th>
<th>NWI</th>
<th>NHD</th>
<th>WRMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streams</td>
<td>191</td>
<td>472</td>
<td>3,209</td>
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<tr>
<td>Wetland Polygons</td>
<td>211</td>
<td>166</td>
<td>2,691</td>
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<tr>
<td>Riparian Polygons</td>
<td>0</td>
<td>n/a</td>
<td>3,279</td>
</tr>
<tr>
<td>Total</td>
<td>402</td>
<td>638</td>
<td>9,179</td>
</tr>
</tbody>
</table>

- Wetland Tracker for tracking projects and habitat (www.wetlandtracker.org)
Riparian Areas

“They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems.”

- National Research Council

• Original model was developed to capture riparian extent as defined by the NRC

• Not intended to replace on-the-ground empirical evaluations
### Riparian Model Developmental History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>SFEI &amp; SCCWRP begin development through RHJV under technical advisory team.</td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>SCCWRP &amp; SFEI further methodology with regional mapping pilots under sister Proposition 50 grants (South Coast Byte and nine-county SF Bay Area).</td>
</tr>
<tr>
<td>2009</td>
<td>Initial riparian model review July 2009.</td>
</tr>
<tr>
<td>2010</td>
<td>SFEI Estuary 2100 proposal to add “potential riparian area module” to model.</td>
</tr>
</tbody>
</table>
Relationship Between Riparian Definitions and Modeling Approach

- **Riparian Buffer**: amount of riparian area needed to protect adjoining waterbody.

- **Functional Riparian Width**: amount of riparian area needed to provide a high level of a selected riparian function; is function-specific.

- **Full Functional Width**: amount of riparian area needed to provide high levels of all intrinsic functions; equals “riparian area” or “riparian ecosystem;” can vary with land use, vegetation type, waterbody type, hydrology, and geology (including topography and soil).
Relationship Between Riparian Definitions and Modeling Approach

- **Riparian Buffer**: protection of waterbody
- **Functional Riparian Width**: high level of a selected function
- **Full Functional Width**: high levels of all intrinsic functions

- This GIS model is based on the literature relating riparian width to riparian function, but does not discriminate between high and low functionality.
- The model describes existing *not potential* extent.
- **Modeled Riparian Width**: amount of riparian area calculated from user-selected riparian processes without consideration to level of function.
Riparian Profile
functions vary with distance from waterbody or…
…therefore, riparian width varies with function
Model is built on the relationships between available data, wetland processes and wetland function.

Examples:

**Functions**
- Flood control
- Pollution control
- Nutrient cycling
- Habitat and food web maintenance

**Processes**
- Fluvial processes
- Vegetation processes
- Hillslope processes

**Datasets**
- Vegetation maps
- Soils data
- Topography
- Hydrology info

NRC functions
### Vegetation Relationships

#### Functions
- Vegetative diversity
- Salmonid support
- Primary productivity
- Channel stability
- Habitat corridors

#### Processes
- Organic Matter Input
  - Leaf litter
  - Large woody debris
  - Organic C/nutrient exchange
- Shading & Temperature Control

#### Datasets
- Vegetation height
- Vegetation type
- Vegetation structure
- Vegetation patch size and connectivity

Examples:
## Hillslope Relationships

### Examples:

<table>
<thead>
<tr>
<th>Functions</th>
<th>Processes</th>
<th>Datasets</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sediment/nutrient supply</td>
<td>• Mass wasting</td>
<td>• DEMs</td>
</tr>
<tr>
<td>• Large woody debris input</td>
<td>• Allochthonous Input</td>
<td>• Stream Order</td>
</tr>
<tr>
<td>• Water supply</td>
<td>• Groundwater emergence</td>
<td>• Vegetation type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vegetation height</td>
</tr>
</tbody>
</table>
Fluvial Geomorphic Relationships

Examples:

<table>
<thead>
<tr>
<th>Functions</th>
<th>Processes</th>
<th>Datasets</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Channel maintenance</td>
<td>• Runoff</td>
<td>• DEMs</td>
</tr>
<tr>
<td>• In-stream habitat</td>
<td>• Sediment storage/transport</td>
<td>• Soil types</td>
</tr>
<tr>
<td>• Flood protection</td>
<td>• Degradation/aggradation</td>
<td>• Discharge</td>
</tr>
<tr>
<td>• Drainage</td>
<td></td>
<td>• Hydraulic curves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sediment load</td>
</tr>
</tbody>
</table>
# Software Architecture

## Software Platforms
- ArcGIS
- Visual Basic for Applications (VBA)
- ArcObjects
- ESRI geoprocessing tools

## Datasets used as input
- WRMP Base Map
- DEMs
- Vegetation layers
Software Design Approach: Modular Design

- **Modular design** subdivides a system into **smaller parts** (modules) that can be **independently created** and then used in different systems to drive **multiple functionalities**.
  - Cost reduction (lesser customization, and shorter learning time)
  - Flexibility in design
  - Allows for augmentation
  - Allows for exclusion
  - More adaptive to change

*Modular design combines the advantages of both standardization & customization

Adapted from Wikipedia
Stream Riparian Model Module Structure

Core Code
- Software that includes the common coded functions that may be needed by individual modules
- Pre-processing of layers and attributes to create inputs for modules

Modules
- Software developed to determine a riparian width based on appropriate data inputs using process-related calculations
- Outputs an module-specific individual GIS layer
Core Code

– Foundation code that modules build upon
– Pre-processes data used in different modules
– Single interface window
– User-defined parameters
– Data generated:
  • Strahler stream order
  • Channel width
  • Average hillslope
  • Vegetation type
– Can integrate module outputs
Core Code: Standard Channel Width and Stream Order

User defines widths based on Strahler stream order if channel banks cannot be mapped from aerial imagery.

SFEI defaults:
1\textsuperscript{st} 1 m
2\textsuperscript{nd} 2 m
\geq 3\textsuperscript{rd} 3 m
ditches 1 m
Core Code: Hillslope Calculation

Choose preferred DEM (USGS 10m, LiDAR)

Associates average adjacent slope with stream reach

Value taken 30m laterally

Independent values for Right and Left hillslopes (left hillslope shown in graphic)
Core Code: Vegetation

Model can accommodate various existing vegetation layers (e.g., CalVeg, Ca DFG, FRAP)

Associates vegetation type with left and right banks of the channel network
Core Code: Zero-Order Basins (variable source areas)

- Identify channel origin
- Core code assigns Slope and Vegetation
- Zero-order data fed into Functional Width Modules
Core Code: Model Output Visualization

Two alternative outputs

1. Maintain all attributes. Riparian Functional Width polygons are kept unique
   → Useful for analysis

2. Merge all attributes. Riparian Functional Width polygons become one feature
   → Useful for graphics
Vegetation Processes Module

Module Code
-Calculates Riparian Vegetation Functional Width based on:
  • Vegetation type (core code)
  • Slope (core code)
  • Vegetation height (user defined)
Vegetation Processes Module: Vegetation heights

Associates vegetation heights with vegetation types using lookup table

Input is a user-defined table of vegetation heights

SFEI default heights:
- Site-specific for trees
- 10 m for all shrubs
- 5 m for all grasses
- 1 m for all bare ground

<table>
<thead>
<tr>
<th>PI</th>
<th>MU_NAME</th>
<th>TreeHT</th>
<th>SBD</th>
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<td>1100</td>
<td>Winter Rain Sclerophyll Forests &amp; Woodlands Formation</td>
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<tr>
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<td>3121</td>
<td>Black Oak Alliance</td>
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<tr>
<td>3122</td>
<td>Blue Oak Alliance</td>
<td>6</td>
<td>-1</td>
</tr>
<tr>
<td>3123</td>
<td>Valley Oak Alliance</td>
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<td>-1</td>
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<td>3124</td>
<td>Oregon White Oak Alliance</td>
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<tr>
<td>4304</td>
<td>Leather Oak - California Bay - Rhamnus spp. Mesic Serpentini</td>
<td>-1</td>
<td>5</td>
</tr>
</tbody>
</table>
Allochthonous input

- Plant height: The taller the plants, the farther they can be from the channel and still interact.

- Slope: The steeper the slope, the narrower the riparian area.

- Tree will just hit the creek if tree height $h = c$

  $w = h \cos(A)$

- Studies document input from trees further away* so user can factor in additional width to capture full function (tree height factor).

*Reference: Reid and Hilton 1998
• For trees:
  “Allochthonous width” = Tree Height factor x Tree Height x Cos (0.0174 * Slope[rad])
  Tree height factor = 2 x SPTH

• For other vegetation (grasses, shrubs, emergent)
  “Allochthonous width” = default values
Vegetation Processes Module Output
Hillslope Processes Module

Module Code
- Calculates Hillslope Functional Width based on:
  - Average adjacent slope above 20%
Hillslope Processes Module Interface

Additional width begins at the edge of the Vegetation Process limit

Increase width 1 m for every 1% increase in slope > 20%

\[ W = (\text{Vegetation Processes Module width}) + \alpha(\text{slope}-\beta) \]

SFEI default: \( \alpha = 1, \beta = 20 \)
Hillslope and Vegetation Processes Output
Extent of Modeled Riparian Area

Vegetation Riparian Extent

Hillslope Extent

Material Flows, Habitat

Organic Matter Input, Shading

Bank Stability

Annual High-Water Mark

Waterbody

Zone of Influence
Riparian Full-Functional Width

- Hillslope Processes
- Vegetation Processes
- Channel Network
Interpretation and Application of Results:

What it is

• A statewide Level 1 tool (a map based on other maps and aerial images available statewide).
  – NRC definition of riparian
  – riparian width for selected functions
  – riparian buffer width for selected stressors

• A user-friendly tool that users can customize
  – Use local data
  – Adjust parameters for local understanding
  – Share workloads

What it isn’t

• A measure of actual riparian width (i.e., riparian delineation)
• A measure of riparian function (aka eco-service, beneficial use)
Thank you

Questions?
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