A hydrology-dependent method for delineating potential riparian areas

Sara A. Goeking¹, Carson Stam², Wendy Goetz², Greg C. Liknes³, Dacia Meneguzzo³, Mark Finco²

¹U.S. Forest Service, Rocky Mountain Research Station
²U.S. Forest Service, Remote Sensing Applications Center
³U.S. Forest Service, Northern Research Station
Problem statements

Problem #1:
The U.S. Forest Service’s Forest Inventory and Analysis program is “the nation’s forest census”...

...but the sample design does not adequately capture riparian forests.

Problem #2:
Most existing models for delineating potential riparian areas rely only on topography.
What is a riparian area?

- **Riparian**: Relating to or living or located on the bank of a natural watercourse (as a river)

*George Zaimes (2007)*
Objective

To compare multiple approaches for riparian delineation, with some key considerations:

- A definition of “riparian” that includes hydrology
- Acknowledgement that some “riparian” areas are degraded; distinguish potential vs. actual riparian vegetation
- Minimal errors of omission
- Potential for broad-scale application to diverse regions
Test areas

- The Utah portion of the Upper Colorado River basin
- The Nebraska portion of the Republican River basin
Evaluation criteria

- Stability & ease of use
- Documentation/defensibility
- Use of “best” input data
- Flexibility and scalability
- Minimal errors of omission
Comparison of 3 delineation methods

1. An existing valley confinement algorithm;
2. A cost-distance model based on fixed flood inputs; and
3. A cost-distance model based on variable flood inputs.

Height (meters)
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
#1: Valley confinement algorithm (VCA)

Confined vs. unconfined
#1: Valley confinement algorithm (VCA)

- **Platform:** ArcGIS Toolbox

- **Documentation:** Nagel et al. (2014)

- **Inputs:**
  - DEMs (10m)
  - NHDplus
  - Mean annual precipitation
  - User-defined parameters
#2: Cost–distance with fixed floods

- **Platform**: ArcGIS tools, Python scripts, R scripts

- **Documentation**: Abood & McLean (2012)

- **Inputs**:
  - DEMs
  - NHDplus
  - 50–year flood height (USGS gages)
    - a) One height for all streams
    - b) One height for each Strahler stream order
#2: Cost–distance with fixed floods

Stream order vs. 50-yr flood height

**UTAH**

**NEBRASKA**

- **50-yr flood height (feet)**
- **Stream order**
#3: Cost–distance with variable floods

- **Platform**: ArcGIS tools, Python scripts, R (or other stat software)

- **Documentation**: USGS publications (multiple)

- **Inputs**:
  - USGS peak flow equations
  - USGS streamflow data (gages)
  - NHD
  - DEMs
#3: Cost–distance with variable floods

1. Use published USGS equations to get peak flow rate for a particular flood recurrence interval (e.g., 50 years, 100 years).
2. Use gage data to get heights for peak flows.
## Comparison of inputs

<table>
<thead>
<tr>
<th></th>
<th>DEMs</th>
<th>NHDplus</th>
<th>NHD</th>
<th>USGS gage data</th>
<th>USGS peak flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Valley Confinement Algorithm (VCA)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2a) Cost–distance with 1 fixed flood height</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2b) Cost–distance with flood height by stream order</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3) Cost–distance with variable floods</td>
<td>Yes</td>
<td>Yes (but why?)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Results: UTAH

VCA classified the basin as a mix of confined and unconfined reaches.
Results: **UTAH**

1) Valley confinement

2a) 50-yr flood

2b) 50-yr flood, by order

3) 50-yr & 100-yr floods, by order, based on peak flow equations
Results: **NEBRASKA**

VCA classified almost the whole area as “Unconfined”. 
Results: **NEBRASKA**

1) Valley confinement

2a) 50-yr flood

2b) 50-yr flood, by order

3) 50-yr & 100-yr floods, by order, based on peak flow equations
**Evaluation criteria**

- **Stability & ease of use** → #1, except for defining input parameters
- **Documentation/defensibility** → #1/#3
- **Use of “best” input data** → #3 > #2 > #1
- **Flexibility and scalability** → #3 > #2 > #1
- **Minimal errors of omission** → #3 > #1 > #2

+ ???
Next steps...

- Apply variable-flood method to areas in both Utah and Nebraska & create multiple riparian masks:
  - Map existing riparian forests.
  - Identify potential restoration sites.
  - Identify current riparian forests that may be at risk due to alteration of flow regimes.
Contact:
Sara Goeking
sgoeking@fs.fed.us