Mapping Valley Bottoms for Resource Management

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Overview
Riparian areas are critical elements of healthy forest and rangeland ecosystems. Mapping riparian areas is often cost prohibitive and does not sufficiently delineate actual ground conditions. This report presents a practical and repeatable method for making riparian-area maps more accurate. We recommend using the valley bottom-mapping tool (VBMT) in combination with other methods to map riparian corridors across large land areas. This model incorporates user-defined terrain characteristics to stratify land areas into valley bottoms and uplands. The valley-bottom map corresponded reasonably well to ground conditions when validated within the Chattahoochee-Oconee National Forests. The VBMT can prove beneficial for resource management, structural maintenance, and flood management.

Introduction
Healthy riparian areas reduce erosion, improve water quality, enhance biological diversity, provide habitat for fish and wildlife, and are vital components of forest and rangeland ecosystems (figure 1). The 2004 Chattahoochee-Oconee National Forests Land and Resource Management Plan defines riparian areas as those “associated with the aquatic ecosystem and that portion of the terrestrial ecosystem that is substantially affected by the presence of surface and ground water.” (p. c-4) Riparian-area widths vary according to ecological factors that include landform, hydrology, soils, and vegetation. Understanding how these riparian areas function is crucial for resource managers. This knowledge provides specialists with vital information for restoring vegetation communities, eradicating invasive species, providing recreational opportunities, and undertaking structural repairs.

Methods for mapping riparian areas, such as field investigations and GIS analyses, have their drawbacks. Site-specific field investigations may define accurate riparian boundaries; however, they are often costly and time consuming and require interdisciplinary teams to make professional judgments. Traditional GIS-based buffer techniques can produce inaccurate delineations that often include upland features in the landscape.
A pilot project, sponsored by the Remote Sensing Steering Committee and the San Dimas Development and Technology Center, explored using topographic GIS modeling techniques within the Chattahoochee-Oconee National Forests. This report describes the way the valley bottoms were mapped, discusses the methods for validating the map, and highlights potential uses of such maps for resource management.

Riparian Area Mapping

Riparian areas can be mapped through an iterative, multiphase process. Such a mapping process provides a practical, repeatable, and effective method for accurately delineating riparian areas (Kish 1965). The mapping process described in this paper includes two phases: 1) stratifying land areas consistently into valley bottoms and uplands; 2) using remote sensing imagery to map existing vegetation within the valley bottoms. An example of phase two is highlighted in the Potential Applications section, later in this paper.

Valley-Bottom Mapping Tool (VBMT)

The VBMT generates maps of valley bottoms by using a flood-fill algorithm to analyze 10-meter digital elevation models (DEMs). Hydrologic modeling techniques and existing models provide the basis for the VBMT (Goetz, 2001; Fisk and others 2004). The analysis uses three topographic parameters that are defined by the technician and governed by Strahler stream order: 1) buffer distance; 2) change in height; and 3) slope threshold. These parameters simulate a flood on the DEMs and create a variable-width delineation of the valley bottoms. ESRI’s ArcGIS, Leica Geosystem’s ERDAS Spatial Modeler, and 10-meter DEMs are required to operate the model.

Figure 2 provides conceptual depictions of the three terrain-modeling parameters. The darkening shades of blue indicate increasing levels of Strahler stream order. First, the buffer distance from the channel marks the outer limits of analysis for the valley-bottom delineation (2A). Second, the buffered zone is further defined by the maximum height above the channel (2B). Finally, the size of this area is reduced by eliminating sections that exceed the maximum allowable slope (2C). These parameters produce a valley-bottom map that excludes uplands and retains key riparian areas. Once the model has been run, the user should examine the results to determine whether to modify the terrain parameters and rerun the flood-fill algorithm.

Case Study

Problem—Riparian Area Delineation

Managing riparian areas along streams containing threatened and endangered species or designated as state-listed impaired waters, are two top priorities within the Chattahoochee-Oconee National Forests in Georgia. Before now, the best way to detect riparian areas involved a combination of variable-width and fixed-width GIS buffer techniques along streams. Riparian area boundary could be increased or decreased by incorporating other stream properties. Nonetheless, this approach often over- and underestimates the actual riparian areas. More accurate methods for widening or narrowing the buffer zone require expensive interdisciplinary field reviews.

Solution—Multistage Mapping Process

Modeling the Valley Bottom

The VBMT, was applied to a 19-7.5-minute -quad section of the Chattahoochee- Oconee National Forests (figure 3). The project area encompassed the Chattooga and Upper Piedmont watersheds. Forest resource specialists generated the valley-bottom map for each watershed by specifying the topographic parameters and running the model. The resulting maps were initially assessed in a GIS environment by overlaying them with DEM hill shade derivatives, percent slope maps, and available vector layers.

Figure 2—Conceptual depictions of terrain parameters used to map the valley bottom: A) buffer distance, B) change in height, and C) slope threshold.

Figure 3—Location of the project area (red) and Little Toccoa Creek in the Chattahoochee-Oconee National Forests.
Potential Applications

Although not evaluated in this pilot study, efforts to map riparian areas have been conducted throughout the Forest Service (Evans and others 2002, Laes and others 2004). These projects employed a variety of methods such as field surveys, aerial-photo interpretation, and image classification. Figure 5 shows existing vegetation mapped within a similarly-derived valley bottom in Custer National Forest, in Montana (Laes and others 2004). In this example, the valley-bottom map established a spatial reference point for remote sensing and data-mining techniques to predict eight general types of riparian vegetation.

The VBMT can benefit a variety of resource-management tasks, including vegetation and flood-zone mapping, recreation planning, and structural maintenance and repair (figure 6). For example, mapping valley bottoms can help land managers make plans to restore riparian hardwood communities, canebrakes, and streams, as well as address concerns about invasive species such as privet and hemlock woolly adelgids. Resource specialists can identify roads, trails, campsites, and structures that exist within valley bottoms and assess whether to maintain, decommission, or relocate them to a more suitable and sustainable setting.

Validating the Maps

Validating the maps involved designing a strategy to select valley-bottom sample units, collect field data, and compare the map product to the reference information. A total of 16 valley-bottom sample units were identified for field verification. Field data collection involved traversing the valley-bottom boundary on foot using GPS equipment. The boundary of each valley bottom was roughly two to three miles long and extensive bushwhacking was required to complete the survey. Only 7 sample units were actually visited due to budget limitations and an erratic GPS signal that worsened under the thick vegetation cover (leaf-on conditions existed). Nonetheless, these surveyed sites provided reference information to assess the valley-bottom model.

Results and Discussion

Valley Bottom Map

The VBMT provides a good starting point for creating more intensive riparian and flood-zone maps. A study of Little Toccoa

Figure 4—Valley-bottom map (green) compared to GPS field survey (white line) and overlaid on a 1-meter color infrared digital orthophoto image along Little Toccoa Creek in Georgia.

Project Costs

Producing a consistent and continuous valley-bottom map of the 19-quad project area cost very little. The first stage of the process took less than a day to complete. It involved acquiring 10-meter DEM data, preparing geospatial data layers, running the valley-bottom model, assessing the output visually, refining user-defined topographic parameters, rerunning the model, and visually assessing the valley-bottom map in a GIS environment. The second step of the process took an additional week to complete. This involved collecting the reference information from seven sample units and using it to validate the model output.

Figure 5—An example of phase two: riparian vegetation mapped within the Custer National Forest in Montana.
Conclusions

Resource specialists can easily, inexpensively, and consistently delineate valley bottoms using the VBMT in just a few days. This initial stratification helps focus more intensive mapping efforts like riparian vegetation. The riparian-project in the Custer National Forest estimated the cost as seven to nine cents an acre, which may even decrease as the size of the study area increases.

For More Information…

To learn more about the VBMT or delineating riparian areas using the process outlined in this report, please contact your regional remote sensing specialist or the Remote Sensing Applications Center (RSAC). To obtain a working version of the VBMT, along with user instructions, visit the RSAC FTP site at ftp://fsweb.rsac.fs.fed.us/pub/R8-Riparian/programs/

Suggested Readings


