FOREST SERVICE
REMOTE SENSING TIPS
FIRE AND ECOSYSTEM MANAGEMENT

Riparian Area Burn Analysis: Process and Applications

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Overview

Do riparian areas burn as hot as upland areas? By analyzing geospatial information at multiple scales analysts can better understand factors that make riparian areas susceptible to burning. In 2002 four large fires in the Western United States created the analysis area for the project. Practical analysis tools, including ArcInfo Arc Macro Language (AMLs), were developed to assess burns inside and outside of riparian areas. The project team discovered that: (1) riparian areas burn less hot than upslope environments; (2) while riparian areas burn less hot, riparian burn values relate positively to upslope burn values; and (3) lower order stream environments burn more like upslope areas, and as stream order increases, riparian area fires become less hot. The results of this study allow resource specialists to establish baseline data for future fuels planning, environmental analysis, and consultation under the Endangered Species Act.

Figure 1— Riparian burn in the Hayman fire in Colorado.

Introduction

The objectives of this project were to: (1) use available geospatial data to characterize factors that influence the intensity of riparian fires, and (2) develop tools that streamline the process of analyzing riparian burn patterns and trends. The National Fire Plan (NFP) provides direction for implementing sound land and fire-management planning. Scientifically supportable data are necessary to prioritize and plan projects that meet the NFP goals (http://www.fireplan.gov). Current fuel treatment and fire-planning efforts are based on models and assumptions that accurately assess broad landscapes but often overlook fine-scale features such as riparian areas (figure 1).

Little information exists about fire in riparian areas, which are some of the most productive, biologically diverse features of the landscape (Dwire and Kauffman 2003). This lack of data has resulted in an inability to integrate credible risks and opportunities into management prescriptions for riparian areas. It also limits a project team's ability to develop convincing purpose and need statements required in National Environment Policy Act (NEPA) analyses. Furthermore, failure to include riparian data for effects analysis often compromises the integrity of a proposal and

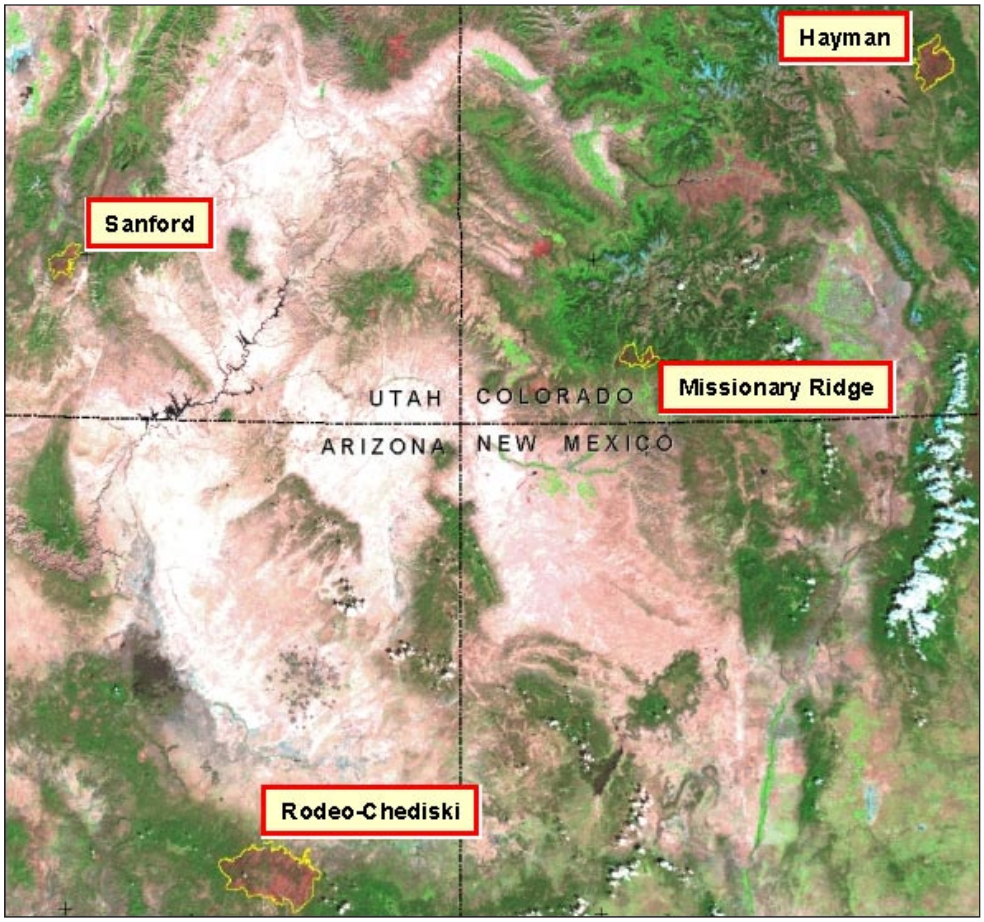


Figure 2—Fires included in the study were the Hayman and Missionary Ridge fires in Colorado, the Rodeo-Chediski fire in Arizona, and Sanford fire in Utah.

necessitates more work to implement a project and achieve NFP goals. Information on how, when, or why riparian areas burn is valuable for planning and directly supports NFP objectives. A large archive of remotely sensed data about past fires exists and can be investigated to shed light on the way fire and riparian systems interact.

Study Areas

Four major wildfires were selected for the analysis: the Hyman fire and Missionary Ridge fire in Colorado, the Rodeo-Chediski fire in Arizona, and the Sanford fire in Utah (figure 2). The Hayman fire burned approximately 137,760 acres within the Pike San Isabel National Forest. The Missionary Ridge fire burned approximately 73,391 acres in the San Juan National Forest. The Rodeo-Chediski fire burned about 462,614 acres in the Apache-Sitgreaves and Tonto National Forests and the Fort Apache Reservation. The Sanford fire burned around 78,000 acres in the Dixie National Forest.

Methods

Standard geospatial information on multiple fires was prepared and analyzed using a watershed-based sampling approach. The process was designed to take advantage of available datasets so that the method could be repeated for other fires across the country. Essential data layers included 10-meter digital elevation models (DEMs), available online at the USDA Forest Service Geospatial Data Clearinghouse, and 30-meter Burned Area Reflectance Classification (BARC) maps that were produced by the U.S. Department of Agriculture (USDA) Forest Service Remote Sensing Applications Center. BARC is a satellite-derived map of postfire conditions with four classes: high, moderate, low, and unburned.

Four ArcInfo AMLs were developed to streamline DEM and BARC map preprocessing, generate topographic and hydrologic models, and package the spatial database for analysis. The first two AMLs converted the raw DEMs and BARC imagery to grids and reprojected the spatial datasets into the same projection system (figure 3).

The third AML performed topographic and hydrologic modeling on the DEM and BARC datasets (figure 4). This AML produced slope, aspect, and multiple drainage-network parameters for each wildfire. Fire by fire, the user interactively selected pour points for all of the watershed basins to be sampled. Within a basin, the AML calculated Strahler stream order and gradient, and labeled stream routers by order. Once the hydrologic modeling was complete, the resulting drainage network was buffered 192 feet to capture the

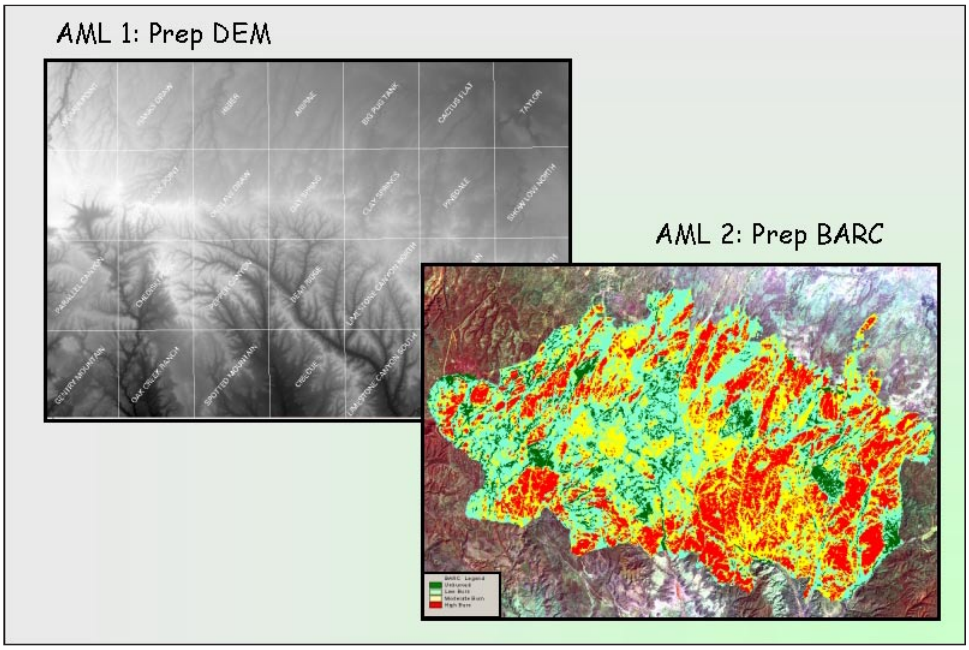


Figure 3— Examples of typical output from AML 1 DEM preparatopm and AML 2 BARC preparation.

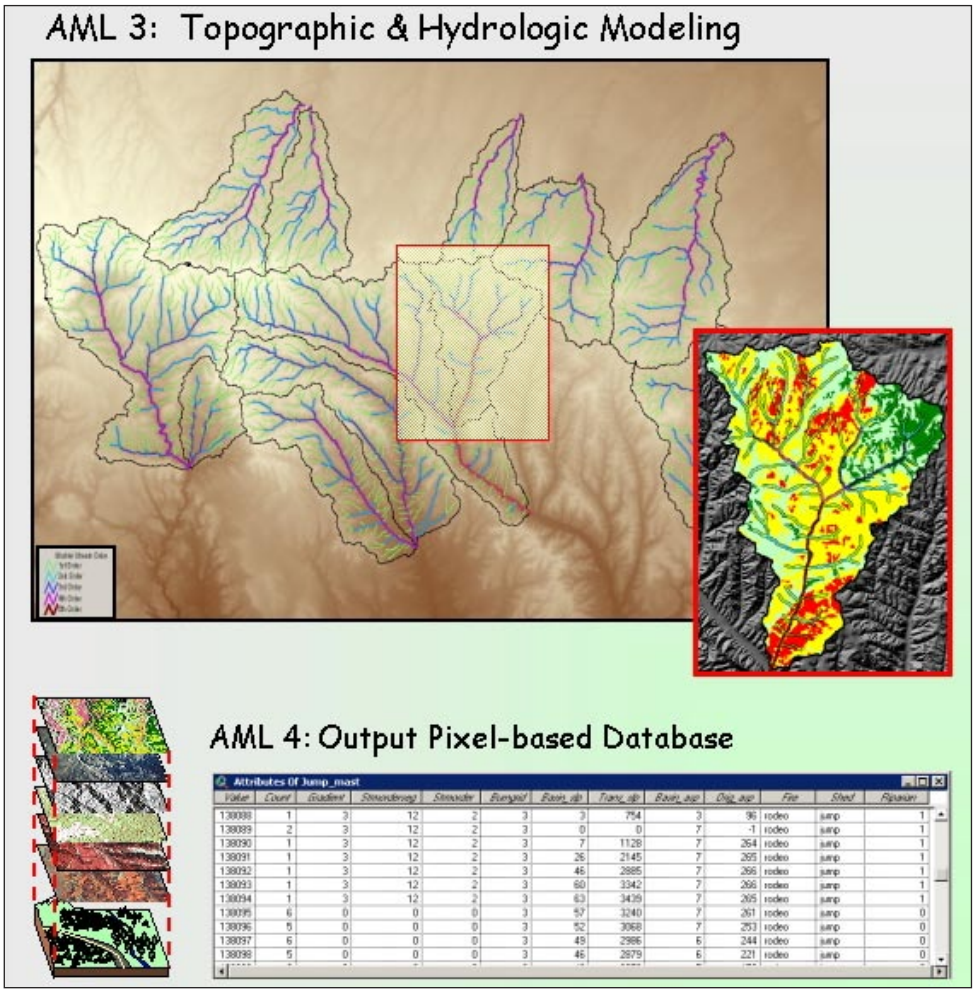


Figure 4— Examples of the output from AML 3 and 4.

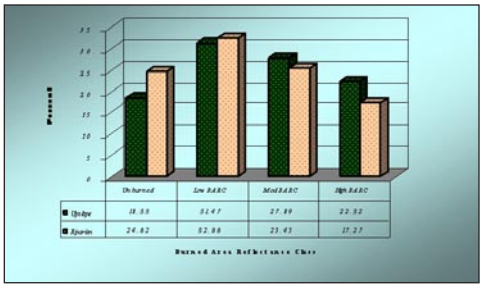


Figure 5—Summary of the upslope area versus the riparian area burn classes. When compared to the upslopes, a significantly higher percentage of riparian areas were in the unburned or low-burn classes while a significantly lower percentage of the riparian areas were in the moderate or high-burn classes.

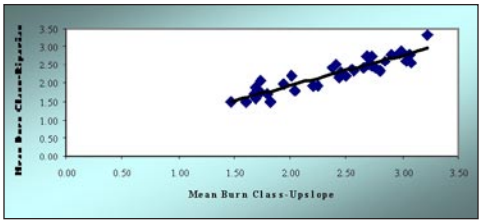


Figure 6—Correlation of individual watershed upslope and riparian burn class means. Resource specialists found that the hotter the watershed as a whole burned, the hotter on average the riparian area burned (r=.924).

riparian area within the watershed. All spatial-attribute information was converted to a raster format and combined with the burn and topographic layers. Fire and watershed names and X and Y pixel coordinates were also stored within the geospatial dataset.

A fourth and final AML prepared a pixel-based tabular database for analysis using SAS, a statistical software package (figure 4). Customized SAS analyses tested and assessed factors affecting BARC burn values at multiple scales: (1) all fires, (2) individual fires, and (3) individual watersheds. Each analysis compared burn values for upslope versus riparian areas using stream order and other factors. Analysts charted and graphed the results using desktop computer software.

Data Analysis and Results

A major conclusion of this four-fire analysis was that riparian areas burn significantly less hot than upslope areas (figure 5). However, correlating burn data between riparian and upslope areas indicated that while riparian areas burned less hot, they related positively (r = .924) to upslope burn values (figure 6). In other words, the hotter the watershed as a whole burns, the hotter on average the riparian area burns.

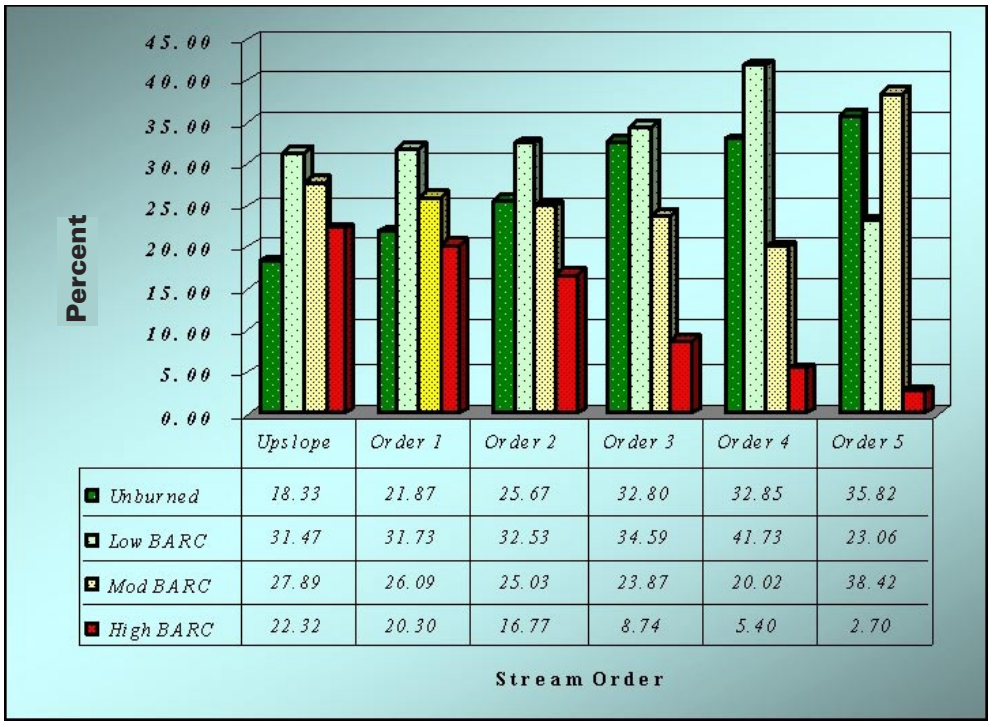
The results also indicated that drainages with a lower Strahler order (i.e., smaller streams) burned more like uplands, while higher-order (larger) stream riparian areas burned less like them. However, burn values for uplands and each individual stream order category differed significantly (figure 7).

Analysis of other factors demonstrated that within individual fires, burn patterns related to aspect and slope, but these patterns differed from fire to fire. Interestingly, stream gradient appeared to have no effect on the burn values within a stream order.

Applications

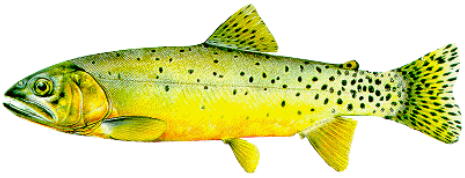
The project team identified several potentially useful applications. First, the process provides specialists with a set of practical tools for assessing and comparing the effects of wild or prescribed fire on riparian areas to those on uplands. These tools could help investigators prioritize postfire treatments, better understand the impacts to specific resources, and monitor the effects on specific watersheds or riparian areas.

Second, this analysis process would be useful in project planning and environmental document preparation. It provides a scientific basis for developing proposed actions, such as fuel treatment, and could be useful for resolving issues that arise during the scoping process. Improving the spatial precision and quality of baseline information about riparian areas offers a solid foundation for analyzing the affected environment, evaluating the environmental consequences, and understanding past wild or prescribed fires on similar landscapes. In addition, resource specialists could base and evaluate a proposal's risks and opportunities on credible scientific information. If desired, they could also estimate the probable risks to certain resources based on the analysis of other wildfires that previously burned in the surrounding area.



	Upslope	Order 1	Order 2	Order 3	Order 4	Order 5
Unburned	18.33	21.87	25.67	32.80	32.85	35.82
Low BARC	31.47	31.73	32.53	34.59	41.73	23.06
Mod BARC	27.89	26.09	25.03	23.87	20.02	38.42
High BARC	22.32	20.30	16.77	8.74	5.40	2.70

Figure 7—Summary of burn class by stream order. Lower order *(smaller)* stream segments burned more similarly to upslope areas and higher order *(larger)* stream segments burned less hot than upslope areas. Note: The 5th order stream data is not representative of "all fires" as the limited sample of 10-m pixels (44,960) were derived from only one watershed. The source of these moderate burn pixels is the location where a back burn was ignited during the firefighting effort.



The third application offers a method to integrate fuels planning with conservation approaches for listed aquatic-or riparian-dependent species on a broader scale. Managers can estimate the risks and opportunities of prescribed burns or wildfires present to riparian systems and aquatic species across their entire range. This information can generate spatially and temporally explicit plans for treating fuels that not only help restore fire-adapted ecosystems but also support the conservation and recovery of aquatic species in a mutually beneficial rather than an antagonistic way.

References and Suggested Reading

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