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PRIORITIZING FUEL MANAGEMENT ACTIVITIES USING WATERSHEDS AND TERRAIN UNITS.

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1. ABSTRACT

We used watersheds and terrain units to demonstrate a procedure for prioritizing fuel management activities. As part of the Southern Utah Fuel Management Demonstration Project (SUTAH), we examined several, 4th code watershed units within southern Utah. Here, we chose to examine a single 4th code watershed unit, the Beaver Bottoms-Upper Beaver sub-basin located near the town of Beaver, UT. Within this 4th code unit we analyzed the nested 6th code units and developed on average 50 terrain units per watershed. These terrain units were developed by combining categories of slope, aspect, and elevation for delineation of unique biophysical environments; e.g. steep, southerly facing slopes. Managers may use these units for implementing fuel activities and for evaluating the impact that such activities will have on ecological processes. Terrain units may assist managers in evaluating the effect their management activities will have on the structure, composition, and function of the biological and physical components of the system. In addition to demonstrating the development of terrain units we present a GIS database with data summaries for both watershed and terrain units. This database includes information on roads, population, vegetation, soils, climate, and fire ignitions. Questions asked by mangers to locate landscapes at risk can be queried using this database. Using the terrain units as a guide, managers can use the database to evaluate the additional impacts that fuel management activities might have on the biological and physical components of the watershed.

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2. INTRODUCTION

We investigate the use of watershed and terrain units to address the question of prioritization. That is, where on the landscape can we define management units that will be useful in both the planning and in the evaluation of fuel management activities on ecological processes? Although managers are confronted with multiple issues surrounding the implementation of activities including land history, public perceptions, political agendas, ecological improvements, recreational enhancement, etc, the use of land units that can be understood, on-the-ground, and constrain ecological processes may improve the implementation and assessment of management activities. To begin addressing these questions, we present data summaries for a few variables and we examine these variables at two scales, the watershed and terrain unit scales.

Watershed units provide a hierarchical framework for understanding ecosystem processes (Maxwell et. al., 1995; Nemani, et. al., 1993). Watershed units have been used to address scale in designing management activities (Hann and Bunnell, 2001), evaluate management impacts (Omi et al., 1979) and in developing appropriate modeling units (Blaszczynski, 2000). , Watersheds are also valuable in terms of constraining ecological processes such as nutrient fluxes, sediment deposition, and flows (USDA, 1995). We will use the watershed database that was developed for the Southern Utah Fuel Management Demonstration Project (USDA, 2002). Here, the finest units available consistently across the study site, were 6th code watershed units. These watershed and sub-watershed units were mapped at a 1:100,000 scale.

In addition to the use of watershed units for understanding and prioritizing management efforts we also investigate the development and use of terrain units. The use of topography and terrain indices have been used by researchers to improve vegetation classification and distribution (Manis, et. al., 2000; Moore et. al., 1991; Davis and Goetz, 1990; Bolstad et. al., 1998; Franklin, 1995; Lynn et. al., 1995; Iverson et. al., 1997), to guide landuse planning (Omi et. al., 1997), and to develop proxy indices for evaluating other less tractable variables (Parker, 1982, Zheng, 1996). Here, topographic variables provide a mechanism for further dividing the available 6th code watershed units. That is, within the 4th code sub-basin, regions were divided based on slope steepness, slope direction, and elevation within 6th code watershed units. This process provided a rule set and a repeatable mechanism for dividing the land in an ecological manner. In particular, we will investigate the use of these units with respect to the prioritization of fuel management activities. For example, some activities may affect ecological components such as soils, water quality, and nutrient flows. Terrain units may help to address the ecological processes acting at multiple scales to predict impacts from treatments to the larger watershed or landscape. In addition to prioritizing regions for management activities, these units may also direct the application or implementation of different fuel management activities. For example, certain applications on regions of steep slope and on southerly aspects may produce greater negative impacts to ecological processes if the land receives more intense management. However, an investigation of the these possible scenarios within terrain units may begin to address this potential and support the application of particular management practices across the varied landscape.

3. METHODS

We used the 6th code watershed units developed for the SUTAH project to summarize variables of road densities, habitable land area, and percent of pinyon-juniper vegetation:

- road density- the length (km) of all road types (U.S. Census, 2001a; U.S. Census, 2001b) by the area (km^2) of each unit.
- habitable land-includes land under either tribal or private ownership (USGS, 2001a) and where forested regions within these ownerships possess slopes of <30% (Holloway et.al., 1997; Weiss, 2002)
- vegetation- we chose to examine the percentage (%) of pinyon juniper vegetation (USDA, 2002) within each unit

Previous work on the SUTAH project targeted identifying and mapping variables of concern or values of interest to local communities within 6th code watershed units. Here, we will explore the use of both watershed and terrain units, in displaying some of these variables of concern and for prioritizing management activities. In particular, we are interested in comparing the data summaries between these two units.

3.1 Watershed Units

We examined 6th code watersheds within the Beaver Bottoms-Upper Beaver sub-basin. Watershed units, including 4th, 5th, and 6th code units, were assembled for the SUTAH Project. Data was developed and downloaded from the USGS water resources program (USGS, 2003). Standard watershed terminology used by both the EPA and USGS includes regions, sub-regions, accounting units and cataloging units (Seaber et. al., 1987). The 4th, 5th, and 6th code descriptors were used in describing the various cataloging unit divisions. All of these units categorize surface hydrological features. Within the Beaver Bottoms sub-basin there exist 57, 6th code watershed units with a mean size of 7,845 ha (figure 1).

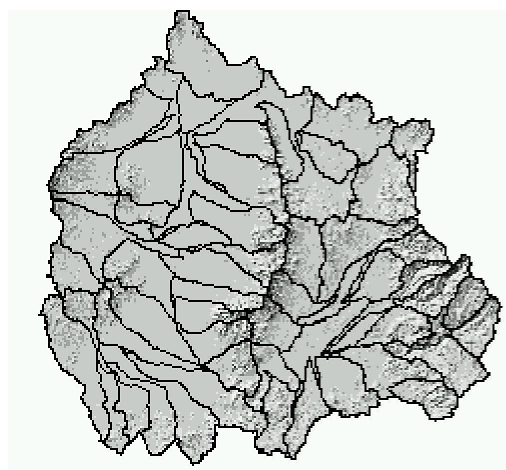

Figure 1: Beaver Bottoms Sub-basin displaying 6th level watersheds and underlying topography.

Watersheds were also used as the basis for dividing the landscape into finer terrain units.

3.2 Terrain Units

Terrain units were created from topographical data using both standardized and relativized categories of slope, aspect, and elevation. We used the following rule set to divide each watershed:

- Elevation- Watersheds were iteratively divided into five equal area elevation classes representing low, medium, high, and very high areas. For example a very flat region with few elevations would still be divided into several elevation classes. This relativized method was chosen due to the large amount of extremely flat areas within the study site.

- Slope- Across the entire study area five slope classes were calculated:
  - Flat- representing 0% to 10% slope
  - Gentle- representing 11% to 30% slope
  - Moderate- representing 31% to 50% slope
  - Steep- representing 51% to 100% slope
  - Very Steep- representing >100% slope

- Aspect- Across the entire study area three aspect classes were determined:
  - Flat- includes those areas without aspect
  - North- includes aspects of 200°-360° and 0°-19°
  - South- includes aspects of 20°-200°

To create the terrain divisions each 6th code watershed was processed using Arc/Info 8.1.2 (ESRI, 2001). Additionally, Digital Elevation Models (USGS, 2001b) were used to divide the landscape into five elevation categories as well as calculating the standardized categories of slope and aspect. These three variables were then combined to create unique topographic or terrain regions (figure 2)

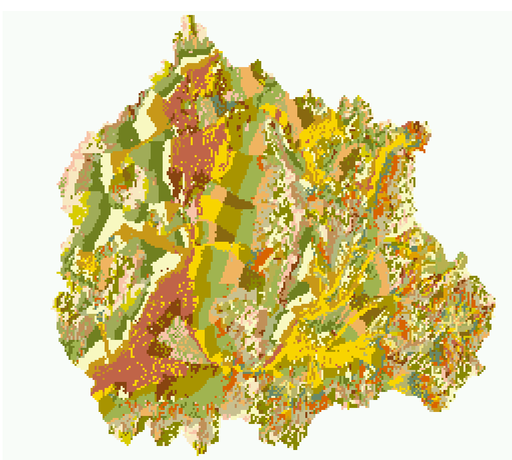

Figure 2: Terrain regions within the Beaver Bottoms Sub-basin

With five categories of elevation, five categories of slope, and three categories of aspect each sub-basin could possess up to 75 topographic classes. However, these classes can further be divided by both the watersheds in which they reside and then spatially as non-contagious units. That is, terrain units within a watershed may share the same topographic signature but be separated spatially. These can be considered unique regions that can be evaluated and managed differently. We will explore the use of these units for producing summaries and demonstrating the on-the-ground choice of appropriate land divisions for management. Initial analyses will primarily be of a qualitative and visual nature. Future work may hold promise for more stringent and quantitative analyses.

4. RESULTS

We chose three datasets to examine differences between the 6th code watershed units and the developed terrain units. Data sets included habitable land, road density and amount of pinyon/juniper vegetation. Figure 3 displays each of these data summaries within both the terrain and the watershed units of the Beaver Bottoms sub-basin. There exist 57 watersheds and 2,614 terrain units within this area.

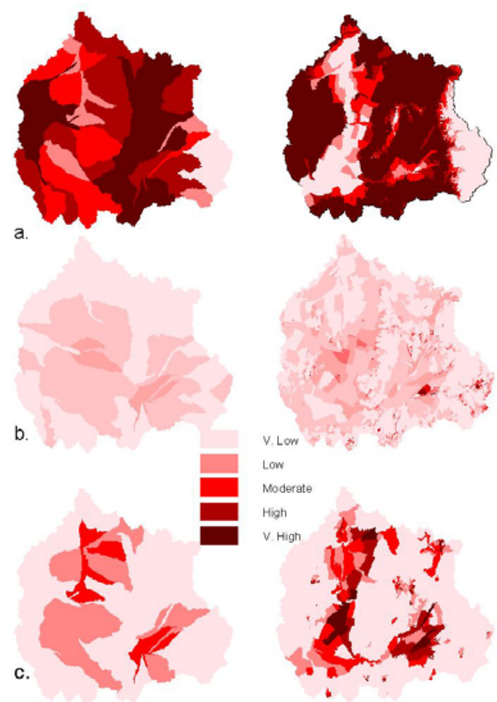

Figure 3: Comparison of 6th code watersheds and terrain units. Percent of pinyon juniper (a), Road density (km/km2) (b), and Percent of habitable land (c). Watershed units are on the left and terrain summaries on the right.

Examination of the results for the three datasets reveals similar patterns with respect to the densities and percentages of each variable for both the watershed and terrain units. For example the examination of percent of pinyon juniper vegetation shows similar patterns of density (Figure 3a). However, for the three datasets we also see regions of particularly high amounts of each variable within the terrain unit that were less prominent in the watershed. This is expected since the smaller terrain units were more likely to capture regions of pure pinyon juniper, extremely roaded, or intensely populated areas.

5. DISCUSSION

An examination of the use of terrain units was pursued to address the importance of scale in evaluating areas for prioritization. This preliminary analysis was used to explore the implementation of physical, topographic land units in planning and evaluating management activities. Analysis show that units can be easily produced using topographic data and that watersheds can be assessed at a finer scale. However, the work of evaluating these units with respect to actual management activities or with respect to various fuel management and fire behavior or effects models still needs to be investigated. Although priorities may change from the watershed to the terrain scale, it is possible that the terrain unit does not provide any advantage over working within the watershed or within finer systematic units applied to the watershed. Evaluation of the effect of management activities and the future planning of activities may not be improved by using ecologically derived units. Also, the question of scale in examining various datasets should also be further investigated.

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