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LAND COVER

Preclassification: An Ecologically Predictive Landform Model

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Introduction

The Southwest GAP Regional Land Cover mapping project faces the challenge of accurately mapping existing vegetation communities over a large (560,000 sq. mile) area by combining Landsat TM image classification techniques with GIS modeling. One of the most promising avenues by which a higher level of classification accuracy and community definition may be achieved, is to improve the modeling of biophysical parameters that predict potential vegetation. Mapping zones offer a way to partition the landscape into broad regions of similar spectral, ecological, and physiognomic characteristics (Manis et al. 2000). While mapping zones address stratification of macroclimate, microclimate and soil characteristics must be assessed to predict potential vegetation.

This article describes the development of a predictive landform model defined by slope gradient, slope aspect, landform position, hydrologic relationships, and microclimatic parameters. The ultimate objective of the model is to produce an ancillary GIS data set to assist imagery-based land cover classification.

Refining the Topographic Relative Moisture Index

The first step involves modeling parameters that influence surface and subsurface water movement and evaporative water loss versus water retention within local watersheds. For this step we modified and refined Parker's (1982) Topographic Relative Moisture Index (TRMI). The TRMI is a summed scalar index of four landscape elements derived from a Digital Elevation Model (DEM). These elements are *relative slope position*, *slope gradient*, *slope shape*, and *slope aspect*. The index works well in areas of moderate to high topographic relief. Parker (1982) acknowledges that the weighting of the elements is subjective, and different weighting schemes may be applied.

To refine the TRMI we incorporated two primary adjustments. First, we revised the original index to better assess the relationship between slope and aspect in affecting solar radiation and evaporation rates. The TRMI assumes a linear relationship between aspect and moisture availability independent of slope. Our refinement incorporates the assumption that soil moisture varies according to *both* the aspect and gradient of the slope. The greatest differences in soil moisture are between slopes of direct and opposite solar angles. To adjust for this range of solar angles we added an *aspect multiplier* based on the ranges of steepness of the slopes. This has the effect of assigning a more neutral index value to slopes that have less direct solar angles. The second modification involves rescaling the landform position, slope, and shape elements of the index with an aim toward building more discrete landform positions. Our revisions change the original TRMI scaling index of 0 to 60 (drier to wetter) to a more compact index ranging from 0 to 27 (drier to wetter). Figure 1 presents an example of the refined TRMI model.

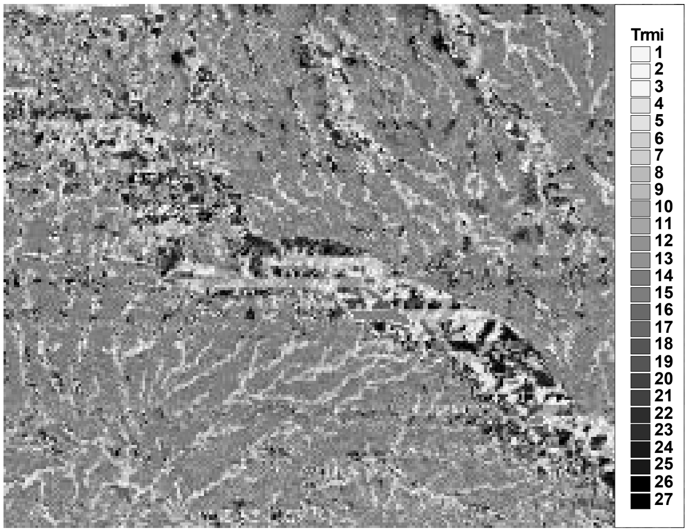

Figure 1. Refined Topographic Relative Moisture Index (TRMI) (1-27; drier – wetter).

Landform Position Model

Step two involves creating a landform position model that uses slope limits and TRMI values (Table 1). Landform Position Classes (LPCs) are therefore defined by topographic position, slope steepness, and relative moisture gradient. Landform classes are generic in nature, that is, no distinctions are made as to process or climatic zone. Flatter upland areas (i.e., plateaus, benches, divides, mesas, etc.) have medium TRMI values and low slope angles. Bottomlands, basins, etc. have a high TRMI and low slope angles. Similarly, other slope positions can be categorized in a range of steepness and relative moisture.

Slope limits for the landform position model were derived empirically, using The Nature Conservancy’s Ecological Land Unit (ELU) system’s slope limits as a first iteration guide (The Nature Conservancy, unpublished manuscript). Modifications were tested to “best fit” the DEM-derived slopes to natural slope breaks. The result is 10 LPCs suitable for the 2 ha minimum polygon size suggested for the GAP final cover type classification. Figure 2 is an example of mapped LPCs.

Table 1. Landform Position Classes

Landform Position Class		**Slope Limit**	**Refined TRMI**
1	Valley flats	lt 3 degrees	TRMI gt 22
2	Gently sloping toe slopes, bottoms, and swales	3-10 degrees	TRMI gt 18

3	Gently sloping ridges, fans, and hills	3-10 degrees	TRMI le 18
4	Nearly level terraces and plateaus	lt 3 degrees	TRMI le 22
5	Very moist steep slopes	10-35 degrees	TRMI ge 18
6	Moderately moist steep slopes	10-35 degrees	TRMI 11-17
7	Moderately dry steep slopes	10-35 degrees	TRMI 4-10
8	Very dry steep slopes	10-35 degrees	TRMI lt 4
9	Cool aspect scarps, cliffs, canyons	gt 35 degrees	TRMI gt 10
10	Hot aspect scarps, cliffs, canyons	gt 35 degrees	TRMI le 10

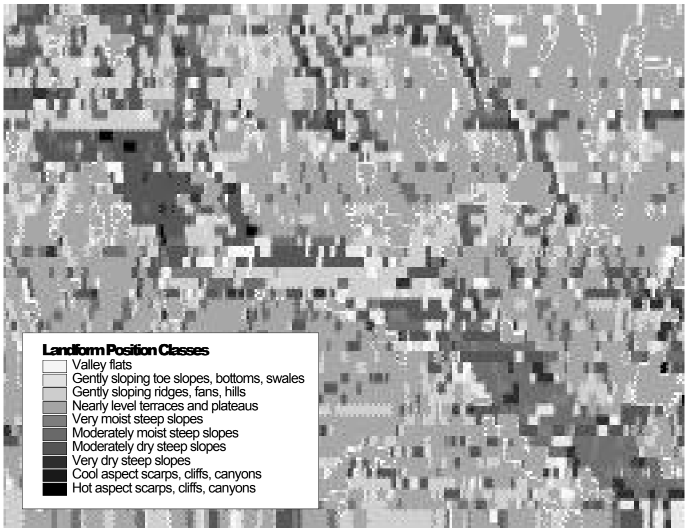

Figure 2. Landform Position Classes (LPC) showing southwest-facing escarpment.

Life Zone Stratification

In the final step, LPCs are reclassified into Ecologically Predictive Landform Classes (EPLCs) using a medium-scale, climatic zone (life zone) stratification. We experimented with elevation and STATSGO soil polygons, grouped by soil temperature, and other key criteria for a life zone stratification. While elevation data and STATSGO polygons hold some advantages, we ultimately chose a model by stratifying zones based on TM image-derived vegetation index as a superior strategy.

The Soil Adjusted Vegetation Index (SAVI) defines life zones by approximating vegetation leaf area from satellite imagery. This has important advantages over other methods but with at least two potential drawbacks. The most compelling advantage is that limits derived from a vegetation index do not appear arbitrary when applied to the landform model. Both the STATSGO and elevation-based stratification methods produced arbitrary life zone boundaries. We found that vegetation index values relate well to life zone (or life form) changes. Drawbacks to the method include the occurrence of "pixellated" zones near some stratification boundaries and incorrect classification of life zones due to recent fires or other large-scale disturbance features such as logging.

The pilot study area was the San Rafael Swell mapping zone, which includes the Capitol Reef and Henry Mountains. We used visual analysis of TM imagery, STATSGO, and elevation class to identify threshold SAVI values. These threshold values were classified to define four life zones. The lowest, driest zone is comprised of sparsely vegetated to barren, soft shale badlands. The second life zone is dominated by xeric dwarf shrubs and shrubs, low-cover xeric grasses, and low-cover pinyon-juniper on benchlands, slickrock plateau, and canyon country. The third zone represents the higher plateaus within the Swell, Capitol Reef, and the benches flanking the Henry Mountains that are dominated by high-cover pinyon woodlands and big sagebrush. The highest zone is the montane and subalpine communities on the slopes of the Henry Mountains.

Discussion

Thus, the output from the predictive landform model creates EPLCs based on topographic relative moisture, landform, and climatic zone (life zone). Steps one and two are created using a single ARC/INFO AML script. Step three utilizes an ERDAS Imagine EML script to combine the life zone stratification with the Landform Position Class model. After the stratification model is run, the initial output is filtered using ERDAS Imagine neighborhood analysis, majority filter, with a 3 x 3 window. This helps to smooth slope noise from the DEM, as well as remove isolated pixels. The number of life zone stratums can range from one to as many as five, depending on the complexity of the mapping zone microclimate. It is quite probable that all landform classes would not be present in some stratums. The number of life zone stratified landform classes or EPLCs is a multiplicative product of the number of life zones and the 10 LPCs. However, in some instances, it may be desirable to collapse similar landform classes if there is no essential difference in potential. For the San Rafael Swell mapping zone there are a total of 40 EPLCs.

Our EPLCs closely approximate the ELUs developed by The Nature Conservancy for conservation planning, as well as the Land Type level of ECOMAP (Cleland et al. 1997), and are easily cross-walked to those classifications-in-progress. We constrained our methodology to use only those data available regionwide to minimize processing time. The protocols described here for the EPLC model can be applied beyond the Southwest GAP land cover mapping effort. Other applications might include soil, habitat, hydrologic, and fire models.

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