[A Modeling Approach to Global Land Surface Monitoring with Low Resc

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THE PROBLEM - ACCURATELY ESTIMATING SPATIAL EXTENT OF FRAGMENTEl LAND COVER TYPES:

The effects of changing land use/land cover on global climate and ecosystems due to greenhouse gas emissions and changing energy and nutrient exchange rates are being addressed by federal programs such as NASA's Mission to Planet Earth (MTPE) and by international efforts such as the International Geosphere-Biosphere Program (IGBP). The quantification of these effects depends on accurate estimates of the global extent of critical land cover types such as fire scars in tropical savannas and ponds in Arctic tundra.

To address the requirement for accurate areal estimates, methods for producing regional to global maps with satellite imagery are being developed. The only practical way to produce maps over large regions of the globe is with data of coarse spatial resolution, such as Advanced Very High Resolution Radiometer (AVHRR) weather satellite imagery at 1.1 km resolution or European Remote-Sensing Satellite (ERS) radar imagery at 100 m resolution. The accuracy of pixel counts as areal estimates is in doubt, especially for highly fragmented cover types such as fire scars and ponds.

Efforts to improve areal estimates from coarse resolution maps have involved regression of apparent area from coarse data versus that from fine resolution in sample areas, but it has proven difficult to acquire sufficient fine scale data to develop the regression. A method for computing accurate estimates from coarse resolution maps using little or no fine data is therefore needed.

METHODS - MODELING STATISTICAL DISTRIBUTIONS

Modeling the distribution of fragment sizes: The distribution of fire scars and ponds is dominated by smaller sizes. Geographic features such as these are thought to be formed by processes that result in fractal (i.e. power or Pareto) size distributions where the proportion of sizes greater than x is bx^{-a} (Mandelbrot, *The Fractal Geometry of Nature*, W. H. Freeman and Company, New York, 1977). Quantitative and graphical analyses of sizes measured on maps developed from Landsat Multispectral Scanner(MSS), ERS-1 and Radarsat synthetic aperture radar(SAR) imagery indicate that these sizes are more accurately characterized by lognormal distributions.

A simulation study provides evidence that actual sizes may have a fractal distribution while observed sizes are lognormally distributed due to pixelation effects. Simulated points from a Pareto distribution were generated with pseudo-random numbers. Then sizes as observed on digital imagery were computed by simulating observation in a digital image - a box for each size (height x width = size) was "dropped" on a random location on a grid image pixels and the number of pixels overlapping the box by a sufficient fraction were counted. The resulting "observed sizes" were lognormally distributed.

Model-based area adjustment: Area is typically computed by multiplying pixel counts by per-pixel area. A method for adjusting this area:

1) estimates the parameters m and s of a lognormal distribution with an algorithm that compensates for missing data below the one pixel size T, and

2) estimates the total number of fragments N from the observed number N' and $P = $ probability$(x < T)$ computed with the lognormal model as: $N = N'/(1-P)$, and

3) computes the adjusted area estimate as N times the mean of the lognormal distribution with parameters m and s.

Simulated 'MODIS' and '100m SAR' maps were created by degrading the resolutions of maps developed from Landsat MSS and 12.5 m SAR imagery,
and used to test the area adjustment procedure.

RESULTS AND CONCLUSION

The distribution of burn scar sizes in tropical savannas (Figure 4) and ponds in Arctic tundra indicate the important contribution of small fragments to total area of highly fragmented types of land cover. These small fragments may be missed with coarse resolution satellite imagery so that total area is underestimated.

The table at right shows the results of applying the model-based area adjustment procedure to simulated coarse resolution maps. The adjustment compensated for 20% to 70% of the underestimation relative to the original maps, consistently providing a conservative improvement in the area estimates. The model-based approach therefore shows promise in improving areal estimates for fragmented cover types developed with low resolution imagery.