B61C - 0739: ASSESSMENT OF LANDSCAPE FRAGMENTATION ASSOCIATED WITH URBAN CENTERS USING ASTER DATA **ABSTRACT RESULTS AND DISCUSSION** ^{1,2} William L. Stefanov 1. Albuquerque 17-June-00

The role of humans as an integral part of the environment and ecosystem processes has only recently been accepted into mainstream ecological thought. The realization that virtually all ecosystems on Earth have experienced some degree of human alteration or impact has highlighted the need to incorporate humans (and their environmental effects) into ecosystem models. A logical starting point for investigation of human ecosystem dynamics is examination of the land cover characteristics of large urban centers. Land cover and land use changes associated with urbanization are important drivers of local geological, hydrological, ecological, and climatic change. Quantification and monitoring of urban land cover/land use change is part of the primary mission of the ASTER instrument on board the NASA Terra satellite, and comprises the fundamental research objective of the Urban Environmental Monitoring (UEM) Program at Arizona State University. The UEM program seeks to acquire day/night, visible through thermal infrared data twice per year for 100 global urban centers (with an emphasis on semi-arid cities) over the nominal six-year life of the Terra mission. Data have been acquired for the majority of the target urban centers and are used to compare landscape fragmentation patterns on the basis of land cover classifications. Land cover classifications of urban centers are obtained using visible through mid-infrared reflectance and emittance spectra together with calculated vegetation index and spatial variance texture information (all derived from raw ASTER data). This information is combined within a classification matrix, using an expert system framework, to obtain final pixel classifications. Landscape fragmentation is calculated using a pixel per unit area metric for comparison between 55 urban centers with varying geographic and climatic settings including North America, South America, Europe, central and eastern Asia, and Australia. Temporal variations in land cover and landscape fragmentation are assessed for 9 urban centers (Albuquerque, New Mexico, USA; Baghdad, Iraq; Las Vegas, Nevada, USA; Lisbon, Portugal; Madrid, Spain; Riyadh, Saudi Arabia; San Francisco, California, USA; Tokyo, Japan; and Vancouver, Canada). These data provide a useful baseline for comparison of human-dominated ecosystem land cover and associated regional landscape fragmentation. Continued collection of ASTER data throughout the duration of the Terra mission will enable further investigation of urban

INTRODUCTION AND OBJECTIVES

The role of humans as integral components of ecosystems, both driving biogeophysical change and effected by these same changes, has only recently been accepted into mainstream ecological thought. The logical starting point to gain **v** understanding of ecosystem processes in human-dominated systems is investigation of urban centers and their dynamics (Grimm et al. 2000).

The Urban Environmental Monitoring (UEM; elwood.la.asu.edu/grsl/UEM/) project at Arizona State University seeks **A** to investigate urban ecosystem processes by acquiring biseasonal, day/night data collected by NASA EOS sensors (primarily the Advanced Spaceborne Thermal Emission and Reflection Radiometer, or ASTER) for 100 urban centers during the projected six-year mission of the Terra satellite (Stefanov et al. 2001a).

The current research assesses the degree of landscape fragmentation associated with 55 urban centers using land cover classifications as input to calculate Pixel Per Unit Area (PPU) index values. These index values are recast into percent area (for each ASTER scene) to allow comparison between urban centers located on all of the major continents.



Figure 1. ASTER visible-near infrared (321 RGB) scene of the San Francisco metropolitan area acquired 14-June-00. Vegetation is red, urban areas are blue-green, and water is blue-black.



Figure 2. NDVI (Normalized Difference Vegetation Index) data derived from the visible-near infrared ASTER data in Fig. 1. Brightness corresponds to vegetation abundance (bright = high, dark = low).

Vavelength region	<u>Band</u>	<u>Bandwidth (m)</u>
Visible to near infrared	1 2 3	0.52 - 0.60 0.63 - 0.69 0.76 - 0.86
Shortwave infrared	4 5 6 7 8 9	1.60 - 1.70 2.145 - 2.185 2.185 - 2.225 2.235 - 2.285 2.295 - 2.365 2.360 - 2.430
Mid- (thermal) infrared	10 11 12 13 14	8.125 – 8.475 8.475 – 8.825 8.925 – 9.275 10.25 – 10.95 10.95 – 11.65



Urban areas appear bright due to high edge density resulting from buildings, streets, etc.

Grimm, N.B., J.M. Grove, S.T.A. Pickett, and C.L. Redman, 2000. Integrated approaches to long-term studies of urban ecological systems. Bioscience 50: 571-584.

An expert system approach to land cover classification of semiarid to arid urban centers. Remote Sensing of Environment 77: 173-185.

Figure 8. Percent landscape fragmentation level by ASTER scene for urban centers. Fragmentation index values correspond to calculated values presented in Fig. 6; higher index values represent higher levels of landscape fragmentation per unit area. Urban centers are grouped according to location: A - North America; B - Middle East; C - South America; D - Europe; E - Asia/India; F - Africa; G - Australia.

















Urban Centers

Figure 9. Comparison of fragmentation levels for urban centers over approximately one year. In general, fragmentation levels are comparable for each individual city. Major differences in fragmentation levels are due to variation in ASTER scene coverage over the urban center (i.e. Vancouver).

> Table 2. Urban Centers with over 50% Area Fragmentation Indices 5 and Higher

<u>Region</u>	<u>total n</u>	<u># of Cities</u>	<u>%</u>
All Regions	55	37	67
North America	19	13	68
South American	5	3	60
Africa	5	4	80
Asia/India	8	6	75
Europe	8	7	87.5
Australia	2	1	50
Middle East	8	3	37.5

Results of the fragmentation analyses of 55 urban centers suggest that relatively intense landscape fragmentation (defined as fragmentation indices of 5 or higher per unit area) of the urban/exurban region is present in over half of the metropolitan areas examined (Fig. 8 and Table 2).

European, African, and Asian/Indian urban centers exhibit the highest degrees of landscape fragmentation relative to other continental areas. A This result reflects the high population densities in the selected cities, as the majority of cities in this grouping are "megacities". The impact of large human populations, and associated landscape alteration, on ecosystem connectiveness is well illustrated and quantified by the current work.

The results presented here are based solely on ASTER data. The high spectral and spatial resolution allows for increased classification accuracy (estimated at 75-80% overall) of both built and natural materials, however spatial and temporal coverage of the data is not uniform. This difficulty is illustrated for several cities in Fig. 9. Future work will involve the incorporation of other datasets (such as Landsat Thematic Mapper, Enhanced Thematic Mapper Plus, and Advanced Land Imager data, and astronaut photography) to create a more uniform temporal and spatial dataset for each city.

Incorporation of additional ancillary geospatial data (i.e. land use, geologic, and vegetation maps; agricultural or water use data; and zoning information) for each city could be used to further refine the classification algorithm

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