MAPPING THE DISTRIBUTION AND DENSITY OF GREEN COVER IN LOS ANGELES COUNTY

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Introduction

Parks, open space, and green vegetation are fundamental to the livability of cities and their neighborhoods (Longcore et al. 2004; Wolch et al. 2004). The provision of parks and recreation facilities was promoted for their help in combating such social problems as poverty, crime and poor health in the first half of the twentieth century (Young 1995). More recently, research has shown how outdoor play is critical to younger children's social and cognitive development (Hart 1979; Proshanski and Fabian 1987; Nabhan and Trimble 1994) while for older children and youth, park-based activities are vital alternatives to passive pastimes, such as computer games and television, and to juvenile delinquency (Burgess et al. 1988). Similarly, a large and healthy vegetation cover provides several of nature's services, such as cooling and shading, carbon sequestration, air pollution removal, noise suppression, and reductions in urban storm runoff (Longcore et al. 2004).

The lack of access to parks and open space is especially acute in the Los Angeles Basin. Most of the cities in this region were historically conceived as places of low density homes each with its own private garden and, as a consequence, civic leaders set aside extraordinarily modest amounts of land for open space and park/recreational purposes. Concern about the lack of adequate park and recreation space for residents has grown rapidly in recent decades as the region has grown and become increasingly dense. Several studies have documented large variations in the distribution and density of green cover (Miller and Winer 1984; Brown and Winer 1986), while others have documented large variations in access to parks and open space (Wolch et al. 2002, 2004) and the important contributions of green infrastructure to residential real estate prices across the region (Conway et al. 2002).

The current study used satellite imagery and the Normalized Difference Vegetation Index (NDVI) to describe the distribution and density of green cover in Los Angeles County, California. The variations in NDVI across this study area were compared with variations in population density, land use, and median household income to identify those communities and residents with large green cover endowments and those with poor endowments. The first group experiences more shading and cooling, less noise, better air quality, and better access to natural flora and fauna in contrast to the latter group, which is forced to endure large expanses of commercial, industrial and other buildings; roads, parking lots and other impermeable surfaces; and brownfields.

Past Work

Miller and Winer (1984) and Brown and Winer (1986) classified common plant species with color-infrared imagery and measured emissions of reactive organic gases to determine the range of photochemical pollution in the South Coast Air Basin. The Los Angeles Basin was defined by the Santa Monica and San Gabriel Mountains to the north, Santa Ana Mountains and San Joaquin Hills to the east and southeast, respectively, and Pacific Ocean to the west for both of these studies. The boundaries included the ridgeline of the Santa Monica Mountains and 1,100 m contour of the San Gabriel and Santa Ana Mountains (this elevation was assumed to be above the average height of the summer temperature inversion layer).

Miller and Winer (1984) divided this study area into 20 land cover polygons based on reflective characteristics of color-infrared images obtained from a 1972 NASA U-2 over-flight. Ground measurements in 20 randomly selected 182 ha (450 acre) plots identified a total of 184 plant species distributed among six structural classes: broadleaf trees, conifers, palms, shrubs, grasses, and ground covers. Shrubs occurred most frequently (71 species; 67% of specimens counted in sample plots) followed by broadleaf trees (64 species; 15%), ground covers (35 species; 10%), conifers (8 species; 6%), and palms (4 species; 2%) in the sampled plots; although large differences were noted in percent ground cover and species composition between residential and non-residential (commercial, commercial-industrial) areas.

Brown and Winer (1986) used the same data and described the vegetation cover differences by land use type in much greater detail. Their results confirmed the good agreement between the field measurements and photographic estimates of vegetation cover, and showed that the percent of vegetation cover varied greatly between sample sites, ranging from 4% to 58%. Low values of about 10% occurred in two polygons dominated by commercial/industrial areas, and these areas were contrasted with a heavily vegetated residential neighborhood (47%) and a site which included a golf course (58%). Most values of total vegetation cover fell in the 20-30% range for urban residential areas with the largest percentages occurring in affluent coastal areas (Palos Verdes, Pacific Palisades, Santa Monica) and the lowest values occurring to south-central Los Angeles and a series of communities along Interstate 10 to the east of Downtown. These results may not be indicative of the current green cover given the age of the photography (> 20 years) and changes in human settlement patterns that have occurred during the past two decades.

The next pair of papers by Wolch et al. (2002, 2004) reported the results of an equity-mapping analysis of access to parkland for children and youth in the City of Los Angeles. Their results show that low-income and concentrated poverty areas as well as neighborhoods dominated by Latinos, African Americans, and Asian-Pacific Islanders, have dramatically lower levels of access to park resources than white-dominated areas of the city. Further, a mapping of park-bond funding allocations by location revealed that funding patterns often exacerbate rather than ameliorate existing inequalities in park and open-space resource distributions. They noted the lack of large parcels for park acquisition, and concluded that these results indicate that creative strategies for providing open space—such as utilizing vacant lots, alleys, underutilized school sites, public or utility-owned property, unnecessarily wide streets, and abandoned riverbeds—will be required in the city's older neighborhoods to redress existing inequities in access to parks and open space.

The results of these past studies show that low income households and communities of color in the City of Los Angeles are apt to be relegated to 'park-poor' neighborhoods, while wealthier districts are more likely to boast plentiful parks and greenbelts provided by public funding. Since more parks and green space translates into higher property values, this inequity also translates into growing wealth disparities (Diamond 1980; Conway et al. 2002). On an everyday basis, however, children and youth relegated to concrete sidewalks for playgrounds are arguably the greatest victims of this type of environmental inequity. Wolch et al. (2002) argued that this deficit in parklands is particularly problematic for older, high density, low income communities where children tend to utilize park resources more intensively than kids in newer, suburban areas where most housing units have gardens and there are more recreational opportunities in the environment (Loukaitou-Sideris 1995). This state of affairs also helps to explain why the issue of parks and recreation is often cited as one of the most critical among residents of the region's low income communities of color (Wolch et al. 2002, 2004).

Methods and Data Sources

Two LANDSAT Thematic Mapper (TM) scenes with 0% cloud cover captured on 3 February 2003 were purchased from the United States Geological Survey EROS Data Center. These two scenes covered most of Los Angeles County and were combined with population density and median household income information taken from the 2000 Census to examine the linkages between land use, population density, wealth, and green cover.

The Normalized Difference Vegetation Index (NDVI) was calculated in ArcGIS using Band 4 (which corresponds to the near infrared wavelengths) and Band 3 (red wavelengths) from the two LANDSAT TM scenes and the following equation:

$$NDVI = \frac{Band4 - Band3}{Band4 + Band3} \quad (1)$$

The infrared and red wavelengths measure the amount of chlorophyll present and the computed values of NDVI range from -1 (which indicates that few photosynthesizing green plants are present) to +1 (showing that large numbers of photosynthesizing green plants are present). The choice of LANDSAT TM as the source data meant that the final greenness maps included 12,602,675 pixels measuring 28.5 m on a side.

The maps and charts reproduced in the next section show these data combined with land use, population density, and median household income. A polygon layer showing parks, recreation areas, cemeteries, and other designated open space in Los Angeles County was compiled from a variety of data sources and used as a mask for the comparisons of population density, median household income and green space.

The population density layer recorded this variable in raster cells measuring 424 m on a side and was acquired from Oak Ridge National Laboratory. This unique one-of-a-kind national data set—which utilized high resolution imagery to reallocate population counts from the 2000 Census for census tracts and blocks to 424 m raster cells—depicts fine-grained variations in residential population densities. The population densities were assigned to a series of user-defined classes and the NDVI values were aggregated to 424 m cells to examine how greenness varied with population density across the Los Angeles Basin and San Fernando Valley. Lancaster and Palmdale were excluded from these comparisons because the northeastern part of the county differs substantially from the remainder of the county in terms of both climate and land cover (see Figure 1 for example). Median household income data at the Census tract level was compared to NDVI greenness values.

Results

Figure 1 shows the variation in NDVI values across Los Angeles County along with park and designated open space boundaries. Most of the dark green pixels, which indicate NDVI values greater than 0.3, occur inside the Angeles National Forest, Santa Monica Mountain Recreation Area and several large regional parks. The dark brown pixels, which indicate NDVI less than -0.15, are concentrated in the northeast quadrant immediately north of the Angeles National Forest and east of the Cities of Lancaster and Palmdale, in the northeast San Fernando Valley, and in a broad zone extending from Downtown Los Angeles to the South Bay and Long Beach. The mean NDVI value for pixels located inside the park and designated open space boundaries (0.13) shown in Figure 1 was 4.33 times higher than the equivalent value for the remainder of Los Angeles County.

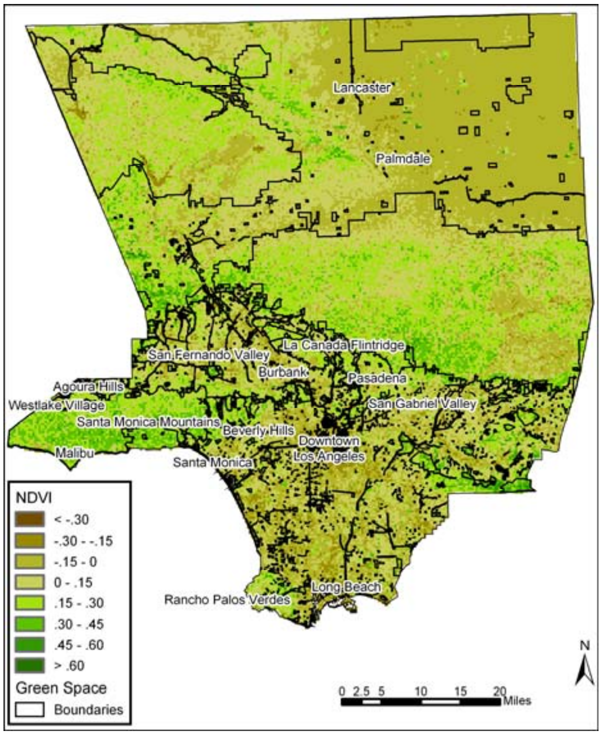

Figure 1: Map showing variations in NDVI in Los Angeles County.

Figure 2 shows the park and designated open space areas (in light green), major highways (for reference only), and variation in population density. The yellow shades that dominate various parts of this map show very low densities (0-3 residents per acre) and surround smaller orange areas with densities (3-10 residents per acre) typical of residential areas composed mostly of single family dwellings. The dark brown area with densities exceeding 10 residents per acre show neighborhoods dominated by medium density row houses, apartments and high rises.

The population densities summarized in Figure 2 were then divided into nine classes and mean NDVI values were calculated for the pixels in each of these classes. The graph of NDVI versus population density class reproduced in Figure 3 illustrates that NDVI (greenness) values tend to decline slightly with increasing residential population density. The relatively weak trend evident in the whole county (r=-0.14) was substantially improved when analysis was restricted to the portion of Los Angeles County south of the 118 freeway (r=-0.32).

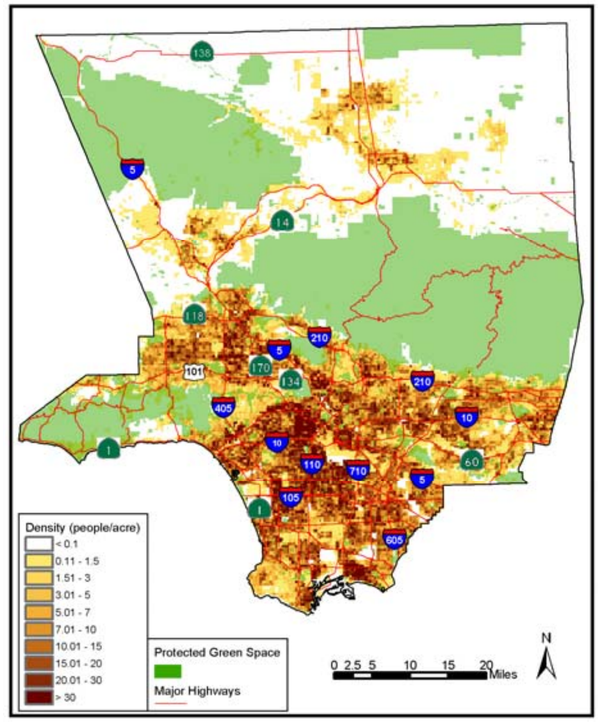

Figure 2: Map showing variations in residential population densities in Los Angeles County.

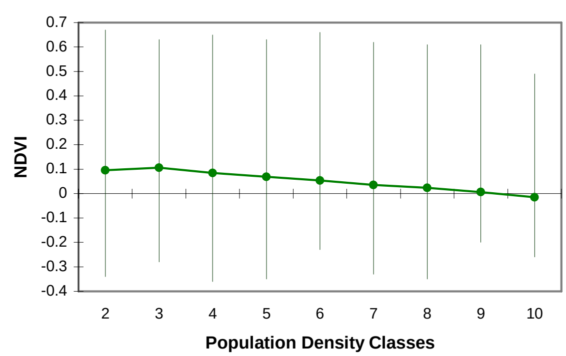

Figure 3: Graph showing mean NDVI by population density class.

The second graph, reproduced in Figure 4, shows mean NDVI values for ten median household income classes. The general trend showing mean NDVI values increasing with increasing median household income reaffirms the results reported nearly 20 years earlier by Brown and Winer (1986). However, these results also show that the mean NDVI values declined from class 1 (median household income < $16,895; the federally designated poverty threshold) to class 2 ($16,895-$30,000 median household income) and from class 9 ($150,000-$200,000 median household income) to class 10 (median household incomes > $200,000). The largest mean NDVI values were computed for the eighth and ninth income classes, which correspond to median household incomes ranging from $100,000 to $200,000. Hence, 15-25% of the variation in NDVI was explained by the variability in median household income (r=0.49 for the southern half of the county and r=0.38 for the county as a whole).

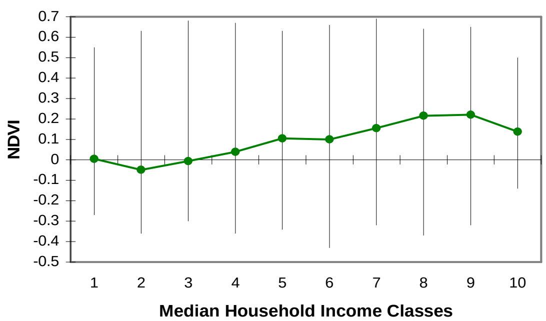

Figure 4: Graph showing mean NDVI by median household income class.

The final map reproduced in Figure 5 shows the variation of greenness for several cities and neighborhoods in the Los Angeles Basin and the San Fernando and San Gabriel Valleys. This larger scale map confirms the tendency for high greenness values to be associated with wealthy cities and neighborhoods. This map shows high greenness values clustered in Westlake Village, Agoura Hills, along the western and southern margins of the San Fernando Valley, in Pasadena and La Canada, and on the Westside and the Palos Verdes Peninsula.

Conclusions

The NDVI maps point to relatively large variations in green cover that are a function of climate and land use (e.g. semi-arid areas in northeastern portion of county; Figure 1), population

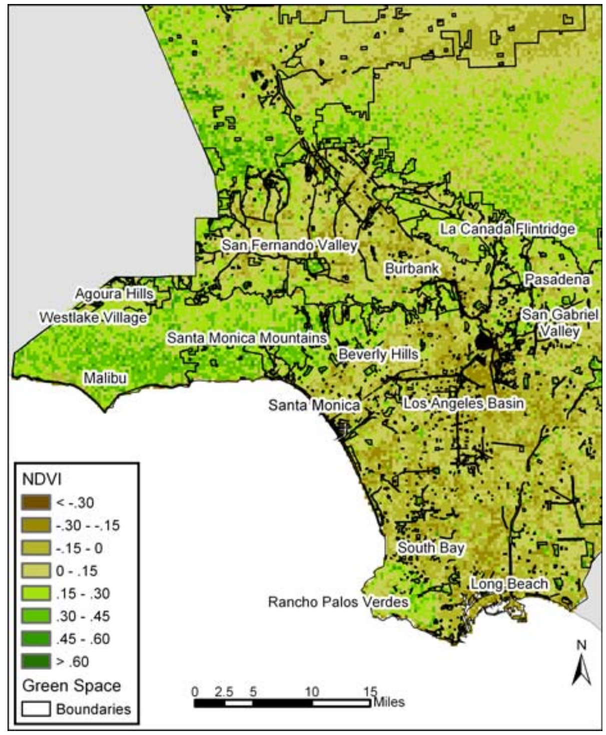

Figure 5: Map showing variation in NDVI in Los Angeles Basin and San Fernando and San Gabriel Valleys.

density (Figures 2 and 3), and median household income (Figure 4). The tendency for higher greenness values to be associated with the wealthiest cities and neighborhoods exacerbates the environmental inequities identified by Wolch et al. (2002, 2004) because these areas also boast plentiful parks and greenbelts. This overall pattern—the tendency for parks, designated open space and high greenness values to occur in tandem in some parts of the county and not others—help to explain the tremendous variations in access to nature's services, parks and designated open space in different cities and communities in Los Angeles County.

This outcome suggests that parks and recreation will remain critical issues among residents of the region's low income communities of color unless the various state, county and local park/open space bond issues can be used to redress existing inequities in access to nature's services, parks, and open space. This, in turn, will require more creative strategies for providing parks and open space—such as utilizing vacant lots, alleys, underutilized school sites, public or utility-owned property, unnecessarily wide streets, and abandoned riverbeds—because of the lack of large parcels for park acquisition and lack of existing parks and open space resources in the city's older neighborhoods.

Acknowledgments

The research support provided by the University of Southern California Lusk Center for Real Estate is gratefully acknowledged. This manuscript was initially published as Working Paper No. 2004-1001 by the Lusk Center for Real Estate (http://www.usc.edu/schools/sppd/lusk/research/papers/ for additional details).

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