Final Report: Land Cover Characterization and Change in the Hunting Creek Pilot Watershed for the Period 1973-1991

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Introduction

Urban land development impacts biodiversity and watershed integrity. Disturbance and removal of natural vegetation reduces habitat for floral and faunal species, while the resulting fragmentation reduces the connectivity of remaining habitats. Urban development can increase soil erosion, sedimentation of wetlands and streams, and runoff pollution. However, not all urban development patterns have the same level of impact. Good planning may reduce impacts by integrating open space, greenways, and blueways to retain particular land cover types and natural connectivity.

The Hunting Creek watershed is located in the greater Alexandria/Washington D.C. area of Fairfax and Arlington counties. The Hunting Creek watershed is comprised of Tripps Run from the north and Holmes Run from the west, which are the 2 main tributaries for Lake Barcroft. Lake Barcroft then continues southward to form a tributary of the Potomac River in Northern Virginia. The watershed is highly developed by industry, commercial operations, and residential housing and is bisected by several highways and interstates. Several recent and ongoing studies are focused on the ecology of urban watersheds and are part of a larger, long-term project in the National Capital Region with primary emphasis on the effects of urbanization upon biological diversity.

For this project, CMI investigated historic and current land use patterns in the pilot watershed of Hunting Creek to assess land cover changes. Land use patterns may serve as the basis for future development decisions by providing historical and current information for users and stakeholders, including land owners, developers and designers, watershed and neighborhood groups, and local governments. The primary objectives of this study were to obtain and create historical and current land cover maps for the pilot area using the North American Landscape Characterization (NALC) dataset (http://edcdaac.usgs.gov/pathfinder/pathpage.html) and to report descriptive statistics of changes in land cover within the pilot area between years.

Methods

We used the NALC triplicate dataset for row 33 path 15 for this investigation. The image set consists of four different images taken on July 8, 1973; July 16, 1980; June 17, 1987; and June 28, 1991. Each image date provides information at a pixel resolution of 60m x 60m for 5 spectral bands.

These images were classified using an unsupervised, isodata clustering algorithm. The resulting cluster set was assigned a land cover classification by interpreting the imagery in a color-infrared representation on-screen. The classes used were:

Forested	Predominantly covered by deciduous or coniferous trees
Forested Residential	Large portion of the pixel covered with trees found with residential development such as buildings, lawns, and driveways

Residential	Mix of trees, buildings, pavement, and landscaping
Developed	Predominantly building, pavement, non-vegetated area
Park/Groomed	Treeless, grass-dominated areas; typically groomed; can include golf courses and cemeteries
Open/Mixed	Mixed tree, grass; vacant lot
Water	Open water (pond, river, and lake)
Road	Impervious road service; adjacent road areas
Residential Open	High density residential housing; nearly treeless consisting of open lawn and buildings

We observed significant confusion between spectrally similar classes from year to year. For example, a pixel classified as "residential" in 1973 would be classified as "residential open" in 1980, then be classified as "residential" again in 1987. After revisiting the imagery, we determined that much of this confusion was related to spectral noise and, in fact, no real change in land use/land cover was observed. This confusion was most pronounced between forested residential, residential and park/groomed classes.

We also observed some discrepancies in developed and residential classes from year to year. We decided to rectify this by disallowing a pixel to "change back" (or revert) from a developed class, as this is change is extremely rare and unlikely in this watershed. We started with the 1973 image and "burned-in" the developed class to the 1980 image, and so on. The result of this is an increasing amount of developed land through time. Although there may be some spatially explicit examples of where developed land has changed to a more vegetated state, we feel these are rare. For our purposes, the potential error introduced by this action is far less significant than the errors presented by mistakenly classifying developed areas as residential, or even forested residential.

We quantified landscape change by determining the total area of each class for each time period and comparing it to the total area of the same type determined for a later date. The observed confusion between the forested residential, residential, and open/groomed classes made it difficult to identify which types were actually changing from year to year, so we elected to combine these classes for analysis. The combined class was called "Residential Development". This class represents a disturbed vegetation class that can no longer be classified as "forested" but is not dominated by impervious surface as is "developed". This changed decreased our ability to make detailed assessments of land use change within these classes, but did allow us to make more general observations on the major changes observed on the landscape.

Results

Land cover imagery shows historical changes in land cover between 1973 and 1991 (Table 1). In general, the predominant land cover change observed was a reduction in forest and an increase in industrial development (Table 1 and Table 2). The watershed experienced a loss of 12.5 sq km of forest cover (over 50% of forest cover) between 1973 and 1991. However, from 1980 through 1987 and from 1987 through 1991, the rate of forest loss was greater than between 1973 and 1980 (Table 3). Industrial land cover increased approximately 8 sq. km within the watershed between 1973 and 1991 at a rate of 0.45 sq. km./year. A reduction of 53.42% of existing forest cover was lost between 1973 and 1991, while industrial cover increased 34.52% (Table 4).

Table 1. Historical land cover types and coverage (sq. km) in Hunting Creek watershed.

	1973		1980		1987		1991	
Class	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**	**Sq. Km**	**%**
Forested	23.43	19.7	22.93	19.2	16.53	13.9	10.91	9.2
Residential	72.05	60.5	69.23	58	70.66	59.4	74.25	62.7
Developed	23.60	19.8	26.27	22	30.15	25.4	31.75	26.8
Water	0.00	0	0.97	0	1.48	1.2	1.49	1.3

Table 2. Change in land cover (sq. km) between historical map images for Hunting Creek watershed.

	Change (sq. km.)				
Class	**1973**	**1980**	**1987**	**1991**	**1973 -91**
Forested	.	-0.50	-6.40	-5.62	-12.51
Residential	.	-2.82	1.43	3.59	2.20
Developed	.	2.67	3.88	1.59	8.15
Water	.	0.97	0.51	0.01	1.49

Table 3. Rate of change (sq. km./yr) between historical map images for Hunting Creek watershed.

	Rate (sq. km./yr) for each period			
Class	**1973 - 80**	**1980 - 87**	**1987 - 91**	**1973 - 91**
Forested	-0.07	-0.91	-1.41	-0.70
Residential	-0.40	0.20	0.90	0.12
Developed	0.38	0.55	0.40	0.45
Water	0.14	0.07	0.00	0.08

Table 4. Percent change in land cover for each land cover type between 1973 and 1991 for the Hunting Creek watershed.

	% Change in cover			
Class	**1973 - 80**	**1980 - 87**	**1987 - 91**	**1973 - 91**
Forested	-2.12	-27.90	-33.99	-53.42
Residential	-3.91	2.07	5.08	3.05
Developed	11.31	14.78	5.29	34.52
Water	0	52.23*	0.49	.

* the large increase is due to the creation of Lake Barcroft

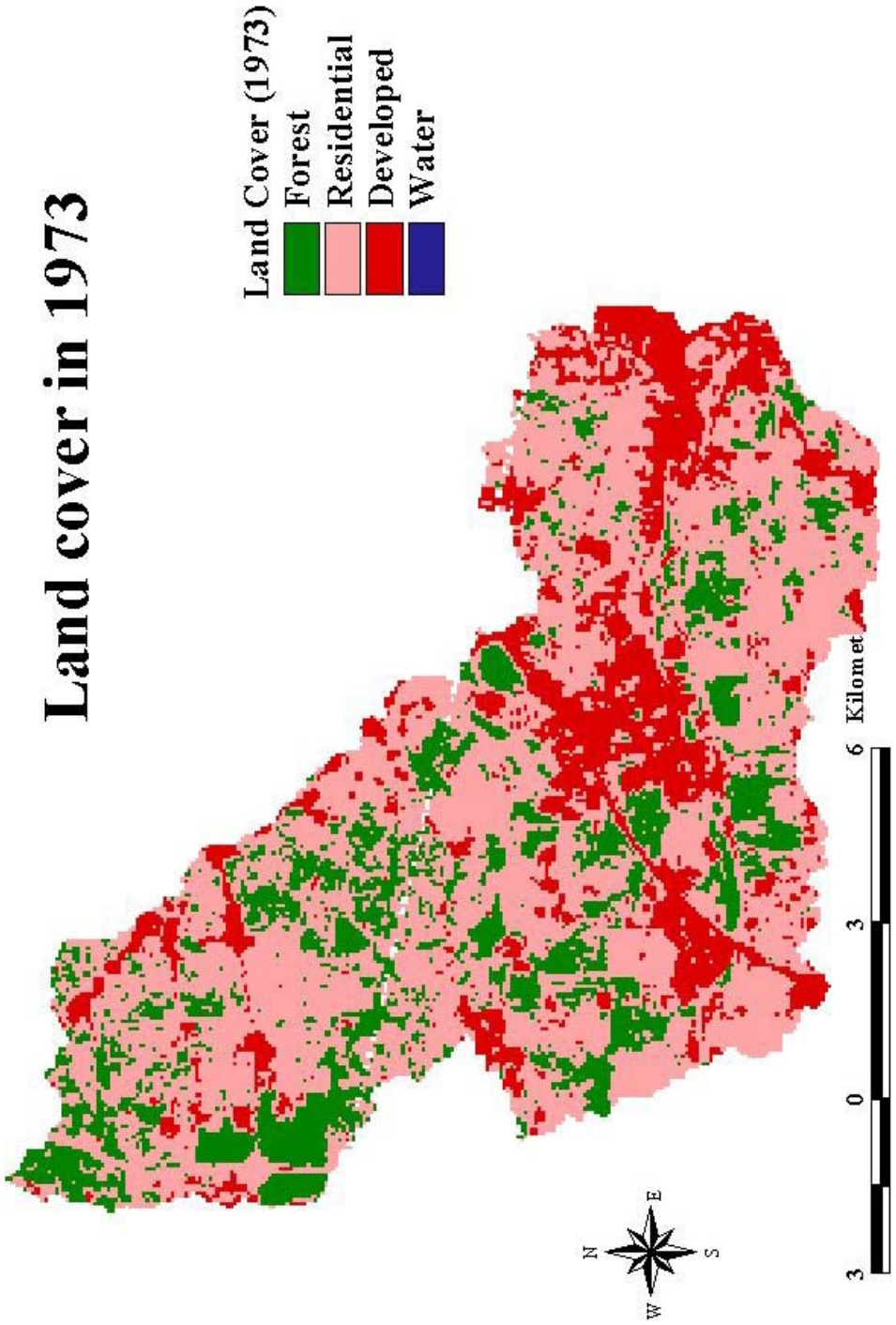
Discussion

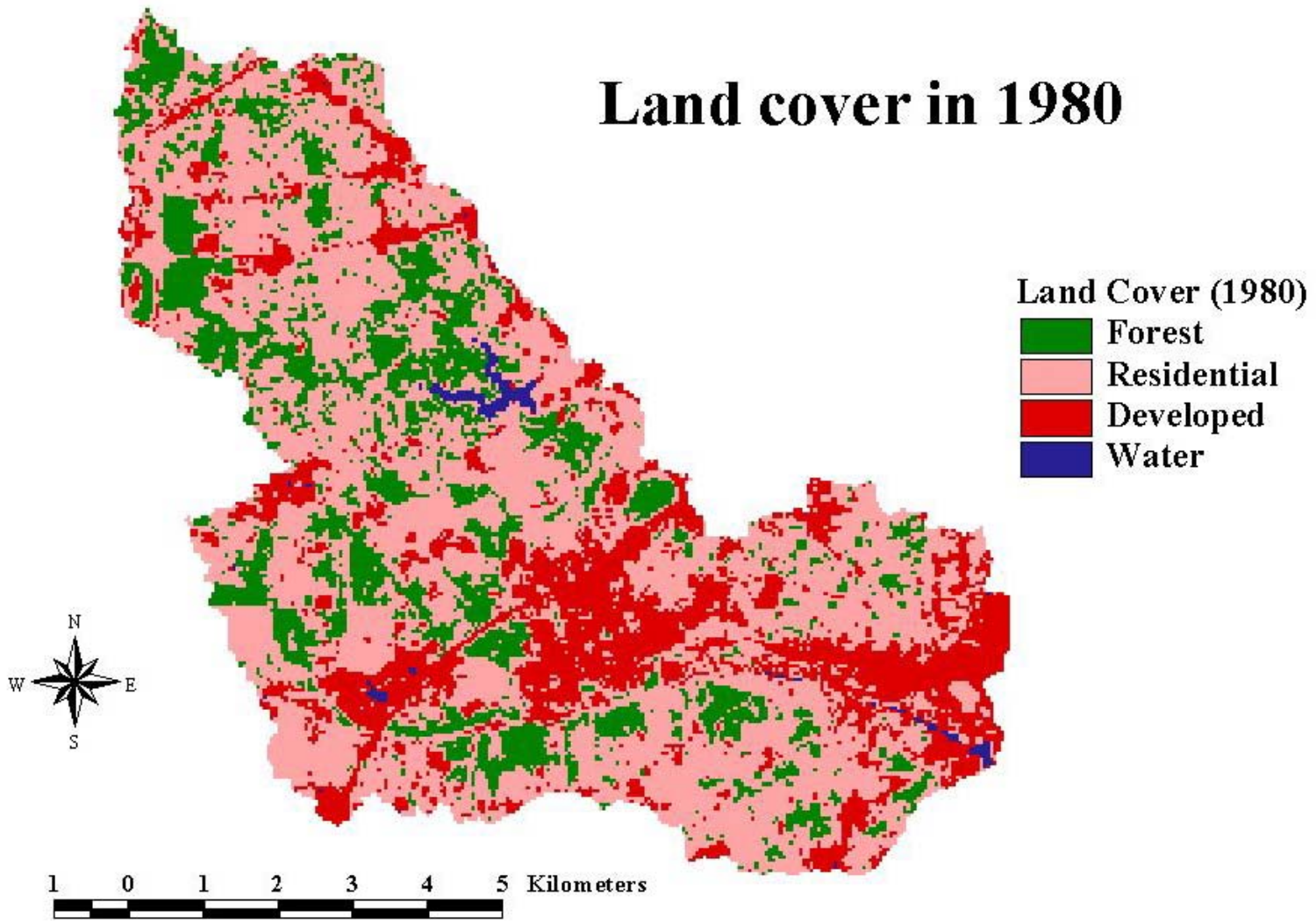
The changes observed in this study are consistent with the observed industrial development of the project area and a reduction of forest stands due to development and sprawl. Fairfax and Arlington counties, which administer the majority of the Hunting Creek watershed, has seen an 18.5% and 10.9% population increase from 1990 to 2000, respectively (http://quickfacts.census.gov). Accordingly, Fairfax and Arlington have seen dramatic increases in population densities, which are 2,455 and 7,323 people per square mile, respectively, as of 2000 (http://quickfacts.census.gov).

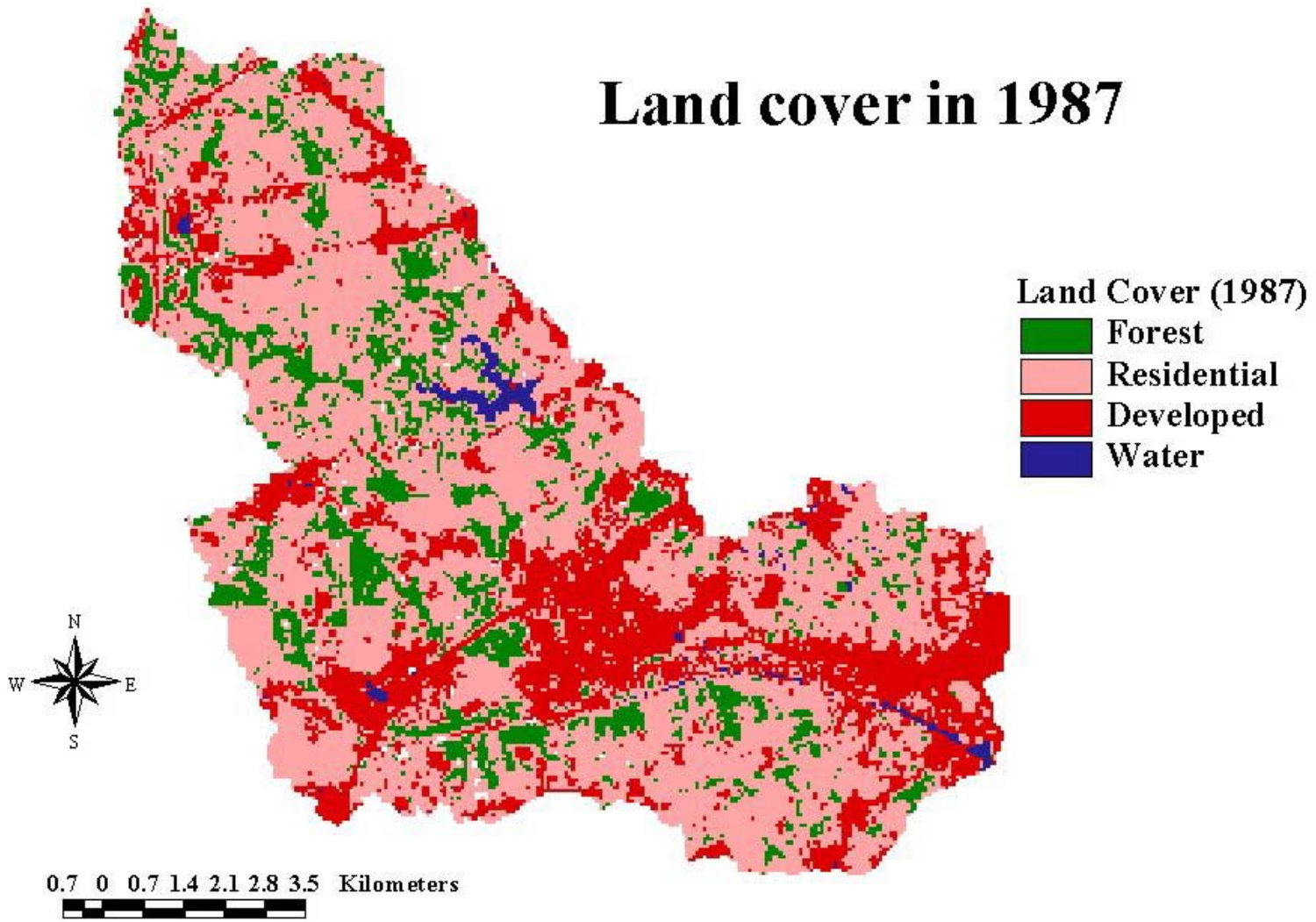
Although this analysis was fairly coarse, it does provide useful information for examining how much forested land is presently available, quantifying the rate of loss, and identifying what these lands are being converted to. Our study shows that most of the forested land is likely being converted to highly developed lands (industrial, commercial) rather than residential, since the relative change in this residential lands is relatively small compared to the increased area of developed lands.

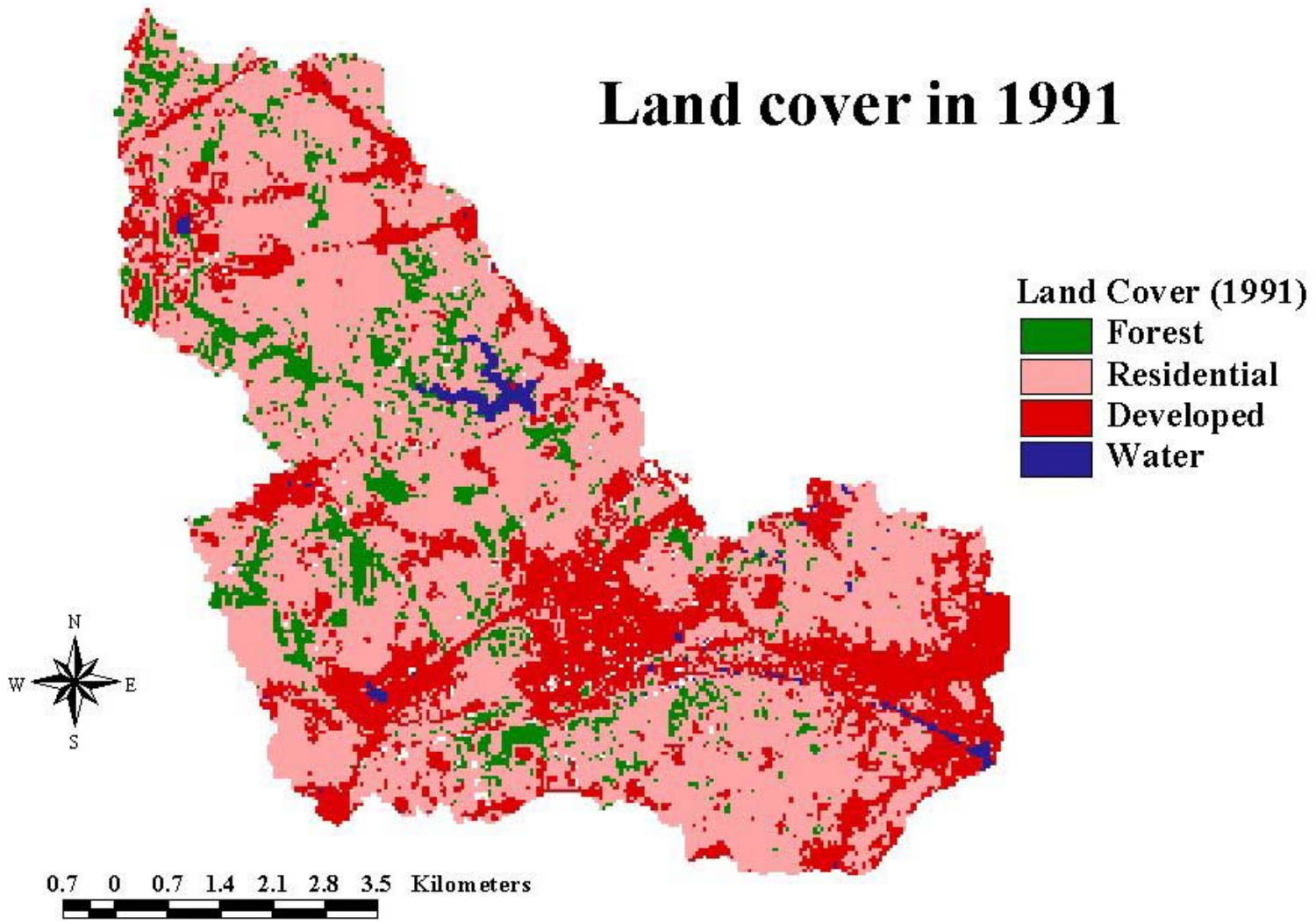
Further investigations into the Hunting Creek watershed may characterize historic and current land use controls and practices (e.g., zoning regulations); evaluate historic, current and future landscape and land use patterns in terms of biodiversity and watershed indicators; develop relationship between land use practices and landscape patterns; and develop guidelines based on these relationships for land users, managers, and other stakeholders to enhance urban biodiversity.

Appendix A. Land cover maps for each year




Land cover in 1980
Land Cover (1980)
Forest
Residential
Developed
Water
N
W
E
S
1 0 1 2 3 4 5 Kilometers


Land cover in 1987
Land Cover (1987)
Forest
Residential
Developed
Water
N
W
E
S
0.7 0 0.7 1.4 2.1 2.8 3.5 Kilometers


Land cover in 1991
Land Cover (1991)
Forest
Residential
Developed
Water
N
W
E
S
0.7 0 0.7 1.4 2.1 2.8 3.5 Kilometers