

Land Use and Impervious Cover in the Paradise Creek Watershed: An Initial Assessment

Report To:

Paradise Creek Watershed Assessment and Protection Plan

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Introduction

Land uses within the Paradise Creek Watershed, particularly those that create impervious surfaces such as asphalt, compacted earth, and rooftops are being increasingly monitored as concern over the integrity of this watershed grows. There is growing evidence that when impervious cover comprises more than 10% of a watershed, water quality and quantity begin to be affected¹. Aside from an increase in imperviousness, land use such as residential development also causes fragmentation and destruction of habitats². To assist in the Paradise Creek Watershed Assessment and Protection Plan, an estimate of impervious cover and an analysis of land use within this watershed are needed. Several types of data exist that allow land use classification and direct estimates of the amount of impervious cover including ground surveys, aerial photography, and satellite remote sensing; usually in conjunction with a Geographic Information System (GIS)³. This analysis attempts to quantify impervious cover and land use in this watershed using GIS to apply an existing land use classification based on aerial photography.

The Collaborative Environmental Monitoring and Assessment Program (CEMRI)⁴ recently sponsored low-level aerial photography of the Delaware River Basin (including the Paradise Creek Watershed) to quantify land use, impervious cover and forest fragmentation. CEMRI provided their impervious estimation results and land use classification to the Pennsylvania Spatial Data Access (PASDA) website (<http://www.pasda.psu.edu>; Access Data, New Data Additions, September 2002) as a free GIS dataset available for download. A key advantage to this dataset is that the goal of the project was to overcome the limitations of existing satellite imagery and aerial photography complicated by the extensive forest canopy of this region. (see Appendix I).


Methods

The CEMRI land classification is a vector-based dataset, a commonly used image format in GIS that is comprised of contiguous geometric shapes (polygons), each containing information on such parameters as area and land use (Figure 1).

Legend

 Delaware River

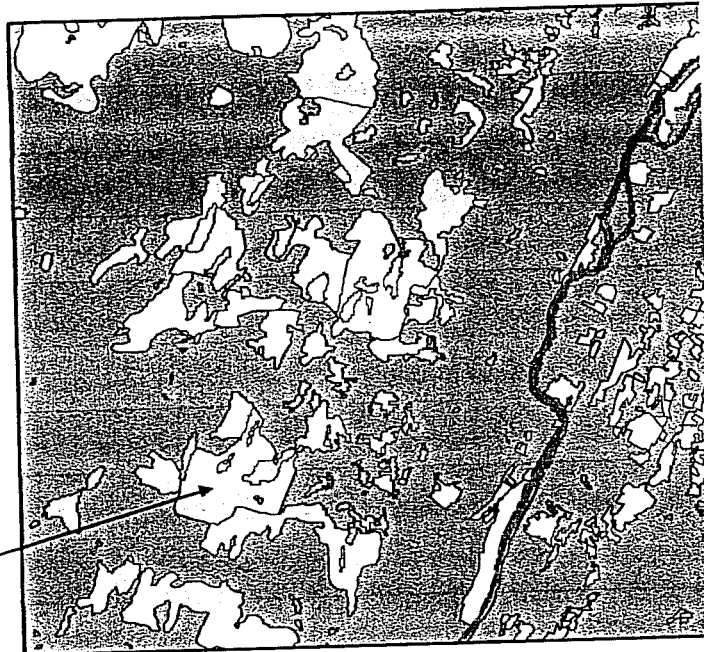
LANDUSE

 Residential and Commercial

 Forest

 Water

 Other



Area = 378.84 hectares

Land Use = Residential

% Tree Cover = 86

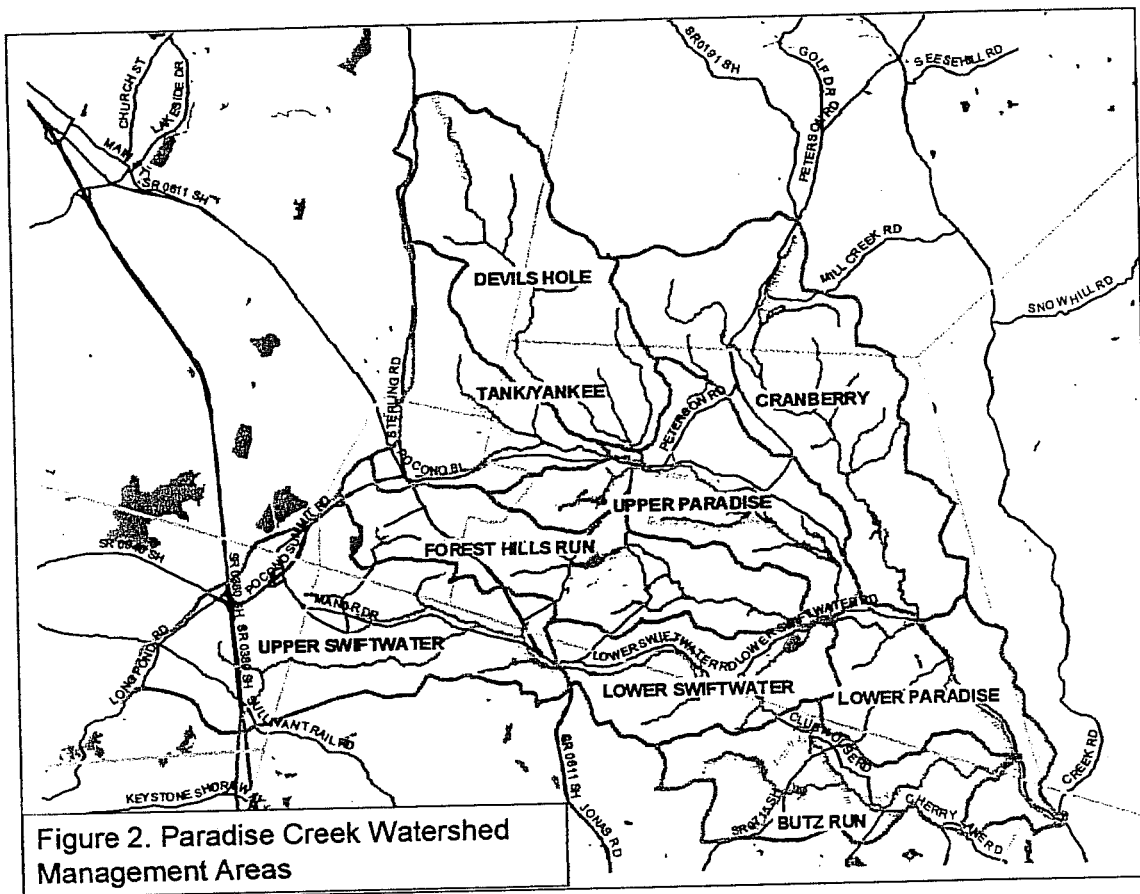
% Road = 6

% Building = 6

% Grass = 2

Figure 1. Portion Of CEMRI Land Use Polygons for the Delaware River Basin

Using a GIS, this image was clipped to the entire Paradise Creek Watershed and proposed management units within the watershed (Figure 2.).



The polygons within each clipped area were summarized according to the types and coverage of land use. CEMRI also estimated the percent area occupied by buildings and roads, forest, and grass cover for residential polygons. This allowed residential impervious surface area and forest cover to be calculated for each clipped area.

One problem with the CEMRI dataset needed to be overcome. Some polygons within the watershed were not classified due to occasional cloud cover obscuring the ground. These polygons were overlaid on 1999 flight file USGS digital orthophotos (available from PASDA) in the GIS, and classified according to their resemblance to CEMRI classified ones. For each of these polygons classified as residential, impervious percent cover values derived from averaging the entire CEMRI dataset were used (Table 1.). In order to determine impervious cover for other anthropogenic land use polygons (e.g. retail and industrial areas, roads) a value of 50% imperviousness was applied based on values described in the literature^{1,5} and visual inspection of these polygons overlaid on the orthophotos. This value is conservative with regard to literature recommendations for some of these land uses but is considered more applicable to this analysis based on the visual assessment.

Table 1. Land Use Polygon Codes and Values Used For Impervious Cover Estimation.

CEMRI ¹ Polygon Code	Description	CEMRI Impervious Cover Polygon Values (%) ²	Impervious Cover Values Used For Unclassified Polygons (%) ³
1101 1111 1112	Low Density Residential	Range: 4 – 18	CEMRI Mean: 10.597
1121 1122	Medium Density Residential	Range: 4 – 18	CEMRI Mean : 12.862
1130	High Density Residential	Range: 8 – 35	CEMRI Mean : 15.661
1140	Multi-family (apartments)	--	CEMRI Mean : 34.154
1210 1220	Commercial/industrial	--	50
1300	Urban open	--	50
1400	Transportation	--	50
1500	Powerlines	--	--
1600	Recreation	--	--
2100	Pasture	--	--
2200	Crop	--	--
4000	Forest	--	--
5200	Lake	--	--
5300	Pond	--	--
5500	Wetland	--	--
7200	Bare Soil/mining	--	--

1. Collaborative Environmental Monitoring and Research Initiative (CEMRI).

2. Impervious cover was provided for each residential class polygon by CEMRI except when photo interpretation was precluded by cloud cover.

3. For Commercial/industrial, Urban open, and Transportation polygons, values were based on visual inspection of 1-meter resolution 1999 digital orthophotos from the USGS and the literature. Means derived from the entire Delaware River Basin CEMRI classification were applied to residential class polygons with no data.

Results

Impervious cover for the Paradise Creek Watershed is estimated at 3.63% (Table 2).

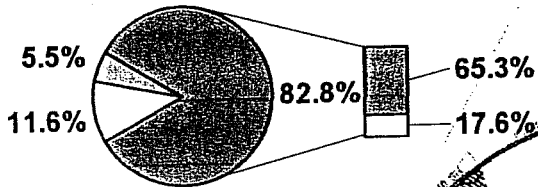
Table 2. Summary of Results From Impervious Cover and Land Use Analysis

Watershed Management Unit	Area in Hectares	Land Cover Percentages		
		Impervious Cover	Other Land Use	Forest Cover
LOWER PARADISE	1010.97	0.85	4.14	95.01
CRANBERRY	1910.18	1.96	3.90	94.14
BUTZ	951.43	2.63	12.51	84.86
DEVILS HOLE	1590.97	2.93	1.85	95.22
FOREST HILLS	1233.65	3.68	16.21	80.11
LOWER SWIFTWATER	863.81	3.81	13.71	82.48
UPPER SWIFTWATER	1782.63	5.51	11.65	82.85
UPPER PARADISE	1172.80	5.54	11.48	82.98
TANK-YANKEE	828.30	6.31	4.22	89.46
Calculated for Entire Watershed:	11344.78	3.63%	8.47%	87.91%

The Tank-Yankee, Upper Paradise, and Upper Swiftwater management units had the highest impervious cover values (5.51 to 6.31%) and the Lower Paradise and Cranberry management units had the lowest (< 2%). In general, the opposite trend is observed for percent forest cover, although the proportion of other land uses is more variable, resulting in the unit with the most impervious cover, Tank-Yankee (6.31%), having the fourth highest forest cover (89.46%). Forest cover is notable in that it is consistently high, with a value of more than 87% for the entire watershed, and ranging from approximately 80% to 95% for the management units.

Figure 3 shows individual management unit maps summarizing the types of land uses present (see Table 1 for code descriptions) and graphically illustrating the proportion of land cover types. A detailed assessment of all land use present in these management units is beyond the scope of this research; however, some general trends are evident. Diversity and types of land use vary across management units. Forest Hills is diverse, with 12 land use categories while Lower Paradise has only four. Management units such as Devils Hole and Lower Paradise are largely contiguous forest; Butz Run and Upper Paradise have more agricultural use; and Tank-Yankee, Forest Hills, and Lower Swiftwater have the most area allocated to residential and commercial use. It is important to note that while Tank-Yankee is dominated by residential development, these areas contribute almost 25% to the overall forest cover of this unit. The distribution of land use relative to waterways is also varies. Most of the

Upper Swiftwater



- Other
- Impervious Cover
- Total Forest
- Residential Forest

Legend

upper_swiftwater.lu

- 1101
- 1121
- 1140
- 1210
- 1220
- 1300
- 1500
- 1600
- 4000
- 5200
- 7200

