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A Study of Paired Catchments Within Peavine Creek Drainage in Atlanta

Most studies that have evaluated the relationship between impervious cover and stream quality were conducted by measuring dozens of catchments or subwatersheds. Fewer investigations have utilized the paired watershed study design, in which two nearby catchments of different levels of impervious cover are intensively studied over time to assess comparative conditions and impacts.

Recent work by Barrett Walker (1996) is an example of such a paired catchment study. The study, conducted in metropolitan Atlanta, provides further evidence that impervious cover is a good indicator of overall stream health. The study suggests that impervious cover as low as 5% within a catchment can be correlated to early signs of channel erosion and instability.

Differences Between the Two Catchments

For a paired catchment study to be most effective, it is important to choose catchments with nearly identical physical characteristics (e.g., order, slope, aspect, length, etc.). This makes it easier to detect differences in stream dynamics (such as biological diversity, flow, pollutant loads, and channel stability), in response to an independent variable (in this case, impervious cover). As can be seen from Figure 1 and Table 1, the two catchments in this study have remarkably similar physical characteristics.

The paired catchments are located within a larger urban watershed called Peavine Creek. The catchments are similar in size, aspect, slope, and soils and receive virtually identical rainfall. The major contrast is in impervious cover. The Fernbank Forest catchment (77 acres and 5% impervious) is protected as an urban forest preserve and serves as the reference catchment, while the Deepdene Park catchment (89 acres and 19% impervious) serves as the impacted catchment. The development that is present in the catchments is predominantly residential and relatively dated (i.e, older than 50 years); however, there is a small component of institutional land use in the Fernbank Forest catchment.

The Deepdene neighborhood was designed at the turn of the century by the eminent landscape architect Frederick Law Olmsted. Public sewer exists in both catchments, located within the street rights-of-way and away from the channels. Deepdene Branch is fed by a storm drain collection system that collects and conveys runoff from roofs, roads, and driveways before it is discharged to the stream. The Fernbank Branch, in contrast, has a relatively small number of homes and accompanying roads, and the majority of the runoff occurs as overland flow across the forest floor. Both catchments benefit from a well-established forested riparian buffer; however, the buffer width of the Deepdene Branch is significantly narrower than that of the Fernbank Branch (see Figure 1).

Study Methods

Biological, flow, suspended sediment, and channel geometry data were collected as part of the study. The sampling methods used were simple, rapid, and

Table 1: Summary of Catchment Characteristics

Descriptive Data	Deepdene Catchment	Fernbank Catchment
Watershed Area (acres)	89	77
Imperviousness (%)	19	5
Stream Length (ft)	2,297	2,625
Stream Slope (%)	3.3	3.4
Watershed Orientation	West	West NW
Drainage Infrastructure	storm drains outfall to stream	none - overland flow
Riparian Buffer	Good	Excellent

not the most sophisticated possible; however, they were adequate to observe the dynamics of urban stream catchments with relatively low impervious cover.

The macroinvertebrate analysis utilized a local Georgia *Adopt-A-Stream* protocol. The protocol generates a weighted index value based on the presence of "sensitive," "somewhat tolerant," and "tolerant" species. Qualitative ratings are assigned in the following manner: poor (<11); fair (11 - 16); good (17 - 22); and excellent (>22).

To estimate dry and wet weather flows, stream gauges were located at the lower ends of the two catchments to record stage. Discharge was then estimated based on channel geometry and velocity measurements. Suspended sediment samples were collected using a standard grab sample technique during stormflow events. The samples were collected at the same locations that the discharge estimates were made. Diagnostic channel stability data were collected with respect to substrate, slope, and cross-sectional geometry. These methods were able to qualitatively characterize the relative stability of the channels along different reaches and to relate them to catchment conditions such as impervious cover.

Macroinvertebrate Survey

Eight sampling events at a single sampling station on each stream occurred over a one-year period. The results of the macroinvertebrate sampling (Figure 2) indicate that the Fernbank Branch consistently scored in the excellent range (average score of 27), while the Deepdene Branch scored between fair and good (average score of 15).

Fish surveys were also conducted as part of a larger study. The Fernbank Branch survey found two species of fish and numerous salamanders, while the Deepdene Branch contained no fish and an occasional salamander. Lack of fish abundance and diversity may also be attributable to the small size of the streams and catchments.

Streamflow Analysis

Streamflow measurements were made in both drainages during wet and dry weather conditions. For the dry weather measurements, flows were recorded during 1994 (a wet year - about 60 inches of annual precipitation) and 1995 (an average year - about 53 inches of annual precipitation). In both instances, the base flows in the Deepdene Branch were about one third that of the Fernbank Branch. Differences in infiltration due to the export of runoff from impervious cover was suspected as the cause for the low base flow in Deepdene Branch; however, there are no historic flow data (i.e., prior to development in Deepdene Branch) to document this assertion.

Stream response to rainfall was evaluated on a limited basis in 1995. The events covered a broad range of rainfall depths (0.01 in - 1.3 in). The data indicate that the runoff response in the Deepdene Branch is 2.5 to six times greater than in the Fernbank Branch. This disparity is likely attributable to the amount of impervious cover in the drainages.

Suspended Solids

Total suspended solids (TSS) were used as an indicator of sediment movement. Suspended sediment concentrations in the Deepdene Branch increased proportionately with rainfall and yielded significant concentrations for all but light (i.e., <.0.02 in) rainfalls. The response pattern in the Fernbank Branch was much less extreme, where even moderate to heavy rainfalls yielded relatively low concentrations of suspended sediment. Diagnostic sampling within the Deepdene drainage indicated that the majority of the sediment load is

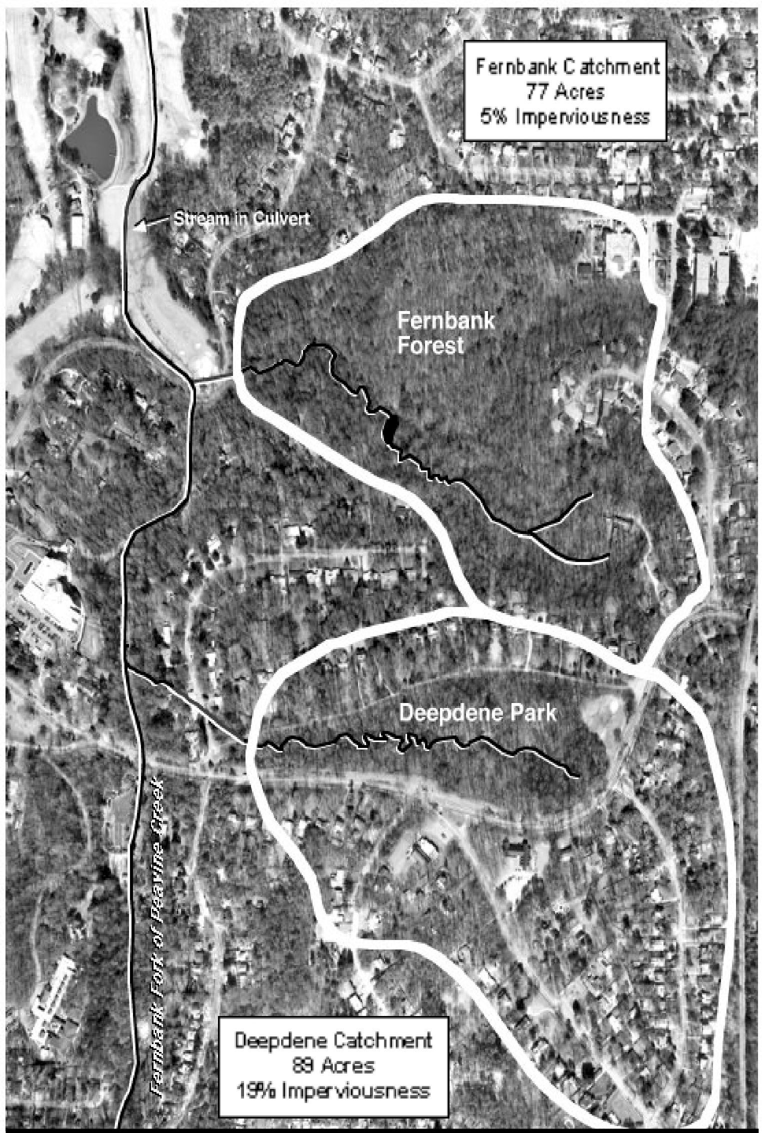


Figure 1: General Location of Catchments

Table 2: Summary of Findings		
Stream Indicator	**Fernbank**	**Deepdene**
Catchment Imperviousness	5 %	19 %
Macroinvertebrates	excellent	fair
Baseflow	3 times greater than Deepdene	one third that of Fernbank
Stormflow	2.5 to 6 times less than Deepdene	2..5 to 6 times greater than Fernbank
Suspended Sediment	>1,200 ppm in 1.3 inch rainfall	< 300 ppm in 1.3 inch rainfall
Channel Geometry	generally stable	significant downcutting visible along entire reach of stream

attributed to channel erosion as opposed to sediment being transported from impervious surfaces into the stream.

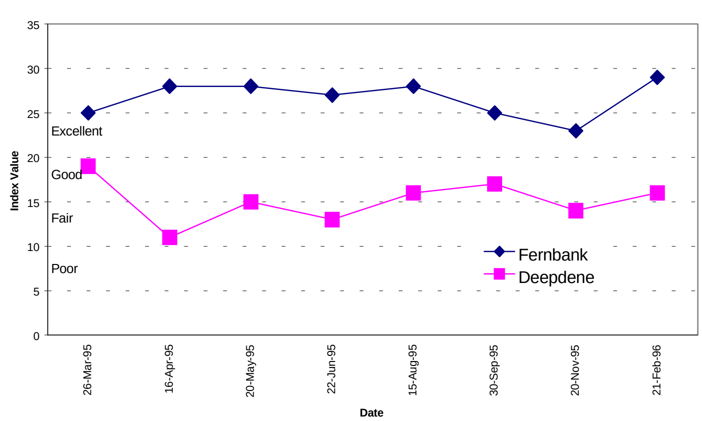
Stream Geometry

The amount of sediment generated from each catchment can generally be related to their relative channel stability. Channel geometry in the Fernbank and Deepdene Branches was evaluated along four reaches of stream in each drainage. The analysis was largely a qualitative assessment of the two catchments.

The Deepdene channel showed signs of significant downcutting, particularly at culvert outlet locations. The lower reach of the Deepdene channel was somewhat held in check by a road culvert which served as a hard control that prevents further downcutting. However, the culvert had itself been eroded by the increased volumes and frequencies of flow in the channel. In addition, the concentration of the increased flows by the culvert had exacerbated the downstream erosion.

The Fernbank channel was found to be much more stable than the Deepdene channel. However, there was recent evidence of channel erosion in the headwater reach of Fernbank channel. This is significant as it is this area of the catchment that is developed and recently experienced new residential construction. The construction resulted in the concentration of driveway and rooftop runoff from several area homes into a small V-shaped gully upstream from the source springs of the main channel. In just one year, the gully eroded into a scour hole and threatens to continue to downcut.

Figure 2: Macroinvertabrate Data (Using the Georgia Adopt-a-Stream Index)



Summary

A summary of Walker's findings are presented in Table 2. This paired catchment study provides further evidence that impervious cover is a good indicator of overall stream health. At 19% imperviousness, the Deepdene Branch shows multiple signs of impacts from urbanization. Base flow is diminished, stormflows are larger and more frequent, sediment loads are higher, and the channel is largely unstable. The headwater development within the Fernbank drainage, despite its small overall contribution to the makeup of the catchment, has the potential to greatly alter the current excellent stream health unless certain stormwater management measures are implemented. While the impact can largely be attributed to the small size of the catchment, the location of the disturbance within the catchment, and the absence of effective stormwater controls, it nonetheless suggests that, even at five percent imperviousness, receiving streams can be significantly impacted by increased runoff. - ***EWB***

References

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