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Effects Of Urbanization On Small Streams in the Puget Sound Ecoregion

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The Pacific Northwest, like many areas of North America, is experiencing an increase in urban development that is rapidly expanding into remaining natural aquatic ecosystems. In the Puget Sound lowland (PSL) ecoregion, the natural resources most directly affected by watershed development are small streams and associated wetlands. Stream ecosystems are critical spawning and rearing habitat for several species of native salmonids including coho and cutthroat trout and many salmon species. These fish, especially the salmon, hold great ecological, cultural, and socioeconomic value to the peoples of the region. Despite this value, the wild salmonid resource is in considerable jeopardy of being lost to future generations. Over the past century, salmon have disappeared from about 40% of their historical range and many of the remaining populations (especially in urbanizing areas) are severely depressed (Nehlsen, *et al.* 1991). There is no one reason for this decline. The cumulative effects of land-use practices including timber-harvest, agriculture, and urbanization have all contributed significantly to this widely publicized "salmon crisis."

The effects of watershed urbanization on streams are well-documented (Leopold, 1968; Hammer, 1972; Hollis, 1975; Klein, 1979; Arnold, *et al.* 1982; Booth, 1991) and include extensive changes in basin hydrologic regime, channel morphology, and water quality. The cumulative effect of these alterations have produced an instream habitat structure that is significantly different from that in which salmonids and associated fauna have evolved. In addition, development pressure has a negative impact on riparian forests and wetlands that are essential to natural stream function. Considerable evidence about these impacts exists from studies of urban streams in the Pacific Northwest, although most previous work has fallen short of establishing cause-effect relationships among physical and chemical impacts of urbanization and the response of aquatic biota.

The most obvious manifestation of urban development is an increase in impervious cover and the corresponding loss of natural vegetation. Land clearing, soil compaction, riparian corridor encroachment, and modifications to the surface water drainage network all typically accompany urbanization. Watershed urbanization is most often quantified in terms of the proportion of basin area covered by impervious surfaces (Schueler, 1994; Arnold and Gibbons, 1996). Although impervious surfaces themselves do not generate pollution, they are the major contributor to changes in watershed hydrology that drive many of the physical changes affecting urban streams. Basin imperviousness and runoff are directly related (Schueler, 1994). In previous studies, measures of total impervious area (%TIA) of about 10% have been identified as the level at which stream ecosystem impairment begins (Klein, 1979; Steedman, 1988; Schueler, 1994; Booth and Reinelt, 1993). Recent studies suggest that this potential threshold may apply to wetlands as well.

Stream Study Design

A key objective of the Puget Sound lowland stream study conducted between 1994 and 1996 was to identify the linkages between watershed conditions and instream environmental factors, including defining the functional relationships between watershed modifications and aquatic biota. The goal was to provide a set of stream quality indices for local resource managers to use in managing urban streams and to minimize resource degradation resulting from development pressure. For example, one study objective was to determine the conditions for maintaining a given population or community of organisms (such as native salmonids) at a specified level. This requires sustaining a certain set of habitat characteristics, which in turn depend on an established group of watershed conditions. A part of this overall objective was to identify any thresholds of watershed urbanization as related to instream salmonid habitat and aquatic biota. The study was designed to establish the linkages between landscape-level conditions, instream habitat characteristics, and biotic integrity. A conceptual model of this design is illustrated below:

Watershed and Riparian Characteristics => Instream Habitat Conditions => Aquatic Biota

A subset of 22 small-stream watersheds was chosen to represent a range of development levels from relatively undeveloped (reference) to highly urbanized. Researchers controlled for physiographic variability by