RESTABILIZATION OF STREAM CHANNELS IN URBAN WATERSHEDS

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INTRODUCTION

Concern over the status of native salmon runs has brought renewed attention to the quality of urban streams in the Pacific Northwest. In an effort to bolster the survival of ever-fewer salmon returning to the local streams to spawn, land managers have begun extensive programs to rebuild or rehabilitate appropriate habitat that has been lost or degraded due to urban development. The channels themselves also suffer from numerous disturbances, commonly expressed by rapid erosion or deposition and changing channel from. Although rebuilt habitat in a stabilized urban stream may not provide the level of ecological integrity required to maintain endangered salmon and other stream biota, physical stability is likely one necessary component of a healthy stream.

The deleterious influences of urbanization on the hydrology and geomorphology of small streams have been extensively explored and documented (*e.g.* Hammer, 1972; Leopold, 1973; Arnold et al., 1982; Booth, 1990). The transition of a watershed from the natural, forested state to a predominantly urban condition encompasses removal of vegetation and canopy, compaction of soils, creation of impervious surfaces, and alteration of natural drainage networks. These actions result in increased surface runoff and changes to sediment budgets. These changes, in turn, induce a geomorphic response, commonly resulting in enlarged, unstable channels. However, any subsequent ability of the channel to restabilize over time is not well understood.

The purpose of this study was to determine whether channels in urban watersheds are capable of restabilizing over a period of years to decades. Based on a variety of field and historical data from several streams draining urban and urbanizing watersheds in the Puget Sound lowlands (PSL) of western Washington, we investigated the relationships between channel stability and watershed urbanization, and between stability and other factors that may also affect the timing or extent of geomorphic response.

STUDY AREA & METHODS

The study channels drain small (5-40 km^2), moderately sloped (0.5-3%) PSL watersheds, ranging from the suburban fringe (50% urban land cover) to urban core (>95% urban land cover). Studied response patterns were limited to the commonly reported cross-sectional adjustments to hydrologic change associated with urbanization, and they excluded channels that have experienced rapid incision. Despite these constraints, the seven study channels are representative of a large population of PSL streams, including many that are being considered for or are already part of local stream rehabilitation projects.

The current level of channel stability was assessed from field measurements and observations using two methods: (1) cross-sectional surveys and pebble counts were used to calculate relative bed stability (after Olsen et al., 1997), and (2) sites were grouped into four bank stability categories by visual observation of indicators such as bank erosion and vegetation extent. On three of the streams, current observations of bank stability were compared with monitored cross sections surveyed repeatedly over the past decade

(Booth and Henshaw, in press) to test the observational technique as an indicator of longer term stability. Overall channel stability was determined as an aggregate of the available stability measures at each site.

To relate channel changes to urbanization and land use in the watershed, changes in land cover in each basin tracked over time. Recent land cover data, from classified 25-meter resolution LANDSAT-TM images, were analyzed using GIS software. Historical (pre-1991) development levels were determined from aerial photographs.

RESULTS & DISCUSSION

Three of the study channels were determined to be stable, while the other four showed varying degrees of instability, from minor bank erosion to severe degradation. Stability ratings for 14 field sites on the seven study streams, as well as for five additional PSL streams reported by Konrad et al. (1998) are shown in Figure 1. Physical channel form was surprisingly resilient to urbanization pressures in the watershed, with major channel instability observed only in basins with greater than 90% urban land cover. This complements the results of a related evaluation of channel stability (Booth and Henshaw, in press), where the selected channels for that study showed locally severe erosion with only modest watershed development but again no systematic relationship between the degree of urbanization and the level of channel instability. The rate at which urban development is occurring in the study watersheds also has no systematic effect on channel stability.

If channel stability in developed watersheds is tied only loosely to the magnitude or rate of land-cover change, other factors must play significant roles in determining whether a channel will destabilize and/or restabilize over time. The potential for restabilization, in particular, depends on both how changes in the watershed affect the channel's flow and sediment regimes and to what extent the channel is capable of responding to these changes. Relevant factors must therefore exist at both the watershed and channel scales. At the watershed scale, channel stability is influenced by the effect of land-use change on the hydrograph, which is determined by both development intensity and watershed geology. At the channel scale, channel substrate has a strong influence on the magnitude and mode of channel adjustment. Results also suggest that grade control, and the condition of the riparian corridor, influence local channel stability.

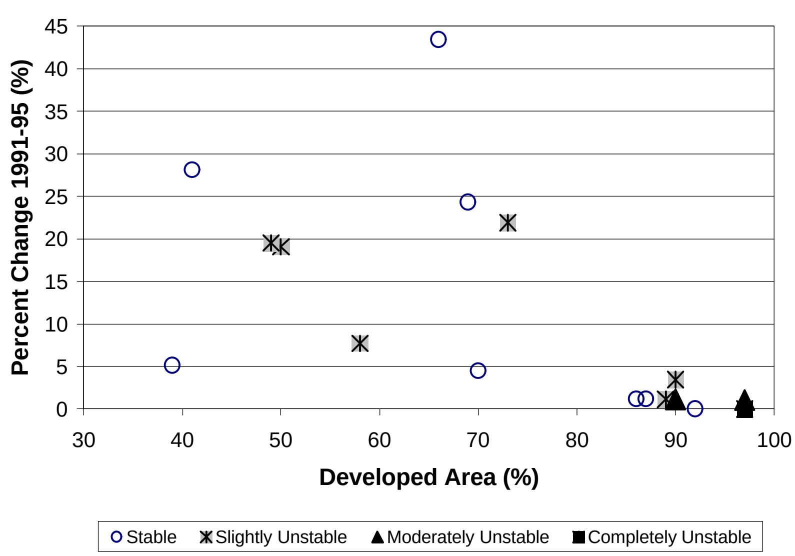

Figure 1. Channel stability as a function of developed area and change in development.

CONCLUSIONS

Hydrologic, field, and historical data were used to classify the stability of channel cross sections in seven watersheds and, where sufficient data existed, to determine the rate and extent of change in channel form over time. The results indicate:

1) Restabilization of urban stream channels in the PSL can, and commonly does, occur even in highly urbanized watersheds. However, the degree of stability is not well predicted by either the magnitude of developed area or the rate of recent development.

2) Most, but not all, PSL streams are likely to restabilize naturally within 10 to 20 years of constant land cover in the watershed, and possibly even more rapidly.

3) The likelihood that a channel will restabilize depends primarily on hydrologic and geomorphic characteristics of the channel and its watershed, not the magnitude or rate of development. The hydrologic regime and geologic setting appear to be important controlling factors; extent of grade control and the extent and condition of the riparian corridor may also play noteworthy, but less influential, roles.

Restabilization does not imply a return of the channel to its natural state. A restabilized cross section will typically be larger and less geomorphically complex than the pre-urbanization channel form. This change affects aquatic biology through loss of habitat and altered flow patterns, velocities, and organic inputs (*e.g.* May, 1996; Karr and Chu, 1999). Further assessment and rehabilitation will likely be required to restore the biological integrity of the stream, even when geomorphic stability is achieved, and the success of such additional efforts is by no means assured.

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