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Title:	Urban Stream Rehabilitation in the Pacific Northwest--Physical, Biological, and Social Considerations
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Objective(s) of the Research Project

The research assesses the consequences of urban watershed alteration on physical and biological channel functions, evaluates the degree to which rehabilitation efforts can recover lost functions, and determines the greatest impediments to successful rehabilitation in the urban environment. The objectives for this work are:

- What are the landscape processes that are critical in determining channel patterns?
- How does urbanization affects the rate, the magnitude, the frequency, and the spatial distribution of those processes?
- What are the changes in physical patterns that result from urbanization?
- What are the biological implications of those changes?
- To what degree can their undesired consequences be reversed?

Supplemental Keywords: watersheds, urbanization, ecosystem, indicators, rehabilitation, aquatic, habitat, integrated assessment, engineering, social science, ecology, hydrology, Pacific Northwest

Relevant Web Site: <http://depts.washington.edu/cuwrm/>

Summary of Findings

Our goal in this project has been to develop a robust approach to urban stream rehabilitation that blends knowledge from the physical, biological, and social sciences by:

- documenting the consequences of urban development on urban streams;
- understanding the causes of the resulting ecological degradation; and
- using that understanding to evaluate rehabilitation strategies and techniques.

We have focused on urban systems of the Puget Lowland region of western Washington, with the City of Seattle as its geographic and demographic center. We have taken a multidisciplinary approach because each element—physical, biological, and social—is a critical factor in stream degradation as well as a source of insight about how to accomplish meaningful protection and restoration goals.

Although stream conditions are not unambiguously correlated with urbanization, the multiple effects of urban development on stream systems make rehabilitation progressively more difficult at progressively greater levels of development. Rehabilitation success is *most* likely in those watersheds with relatively low levels of development that display paradoxically poor biological and/or physical conditions. This assertion is empirically based on examples where low watershed development and good in-stream conditions coexist. Rehabilitation, as classically defined, is *least* likely to produce improvements in highly developed watersheds, because the inverse state (high levels of development with very good biological and/or physical conditions) are simply not observed in this (or any previous) study, in the Pacific Northwest or elsewhere in the country.

Two critical elements in the urban environment are commonly omitted, and yet are crucial, in the pursuit of successful stream rehabilitation:

Hydrologic Changes. Hydrologic changes are often ignored in both new development and in postdevelopment stream "rehabilitation." Even where drainage regulations are in place and apply to the new development in a watershed they generally do not achieve genuine mitigation of urban-induced increases in runoff, because the mitigation is focused on hydrologic measures with little or no biological significance, such as peak flows or flow durations. In contrast, our study results show that annual and inter-annual flow patterns are closely related to in-channel disturbance frequency and biological health and are largely unaffected by traditional hydrologic mitigation.

The Effects of People. The actions of people influence stream health at multiple scales. In aggregate, human populations alter the hydrologic regime of a watershed through widespread changes to the landscape. Our work has also demonstrated, however, the equally important influence of *local* stream conditions, which in the urbanizing Puget Lowland is overwhelmingly determined by the behavior of streamside neighbors. Their effects are so influential because of their proximity and because they commonly abut most of the length of an urban channel network. Their actions may be benignly neglectful but are rarely restorative, and they are influenced by factors rarely addressed in a typical rehabilitation plan.

A consequence of our findings is an overall strategy for pursuing effective rehabilitation:

- Recognize and preserve high-quality, low-development watershed areas.
- Aggressively (and completely) rehabilitate streams where recovery of ecosystem elements and processes is possible. This condition is likely to be met only in low-development areas with relatively low to moderate levels of ecological health, because the agents of degradation are probably easier to identify and more amenable to correction.
- Rehabilitate selected elements of mid-range urban watersheds, where complete recovery is not feasible but where well-selected efforts may yield direct improvement, particularly in areas of public ownership.
- Improve the most degraded streams by first analyzing the acute cause(s) of degradation, but recognize that the restoration potential for populations of original instream biota is minimal.
- In the most highly developed watersheds, education and/or community outreach is not just appropriate but crucial. Here, the level of public interest is likely to be highest, streamside residents have greater direct individual influence over whether healthy stream conditions are maintained, and most of the riparian corridor is not under public ownership or control.

We also have some additional, more specific recommendations for urban stream rehabilitation efforts:

1. Make direct, systematic, and comprehensive evaluation of stream conditions in areas of low to moderate development. Reliance on any one metric, particularly land-cover statistics, will not yield a useful characterization or method for identifying promising rehabilitation candidates.
2. The hydrologic consequences of urban development cannot be reversed without extensive re-development of urban areas, which is infeasible in the near future. Likewise, the recovery of physical and biological conditions of streams is infeasible without hydrologic restoration over a large fraction of the watershed land area. This impasse can be resolved only if the specific, ecologically relevant characteristics of stream flow patterns can be recognized and targeted for management in urban areas.
3. Localized patches of riparian corridor are effective in maintaining biological integrity, but their value varies as a function of watershed-wide urbanization. Where overall watershed development is low to moderate, natural riparian corridors have significant potential to maintain or improve biological condition. At the same time, even small patches of urban land conversion in riparian areas can severely degrade local stream biology. As both a conservation and restoration strategy, protection and re-vegetation of riparian areas is critical for preventing severe stream degradation but these measures alone are not adequate to maintain biological integrity in streams draining highly urban watersheds.
4. Approaches must be developed to address the unanticipated, and unappreciated, consequences on channel conditions of human actions in the name of backyard improvements. Regional and national efforts now fall particularly short in this regard.
5. There is little evidence that in-stream projects can reverse even the local expressions of watershed degradation in urban channels.

6. Aggressive efforts at channel stabilization during the period of active watershed urbanization will probably achieve only limited rehabilitation gains at high and perhaps unnecessary cost, even though bank armoring projects are often constructed in the name of stream-habitat "improvement." Most lowland channels achieve a stable physical form some years or decades following urbanization, with or without human intervention. Their biological suitability, however, is likely to be low (and *also* unaffected by additional human intervention).

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