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Urban Watershed/Water Body Restoration – The Driving Forces

Vladimir Novotny, David Clark, Robert J. Griffin

Abstract

Urban streams are used for several purposes. Some uses are conflicting and some are complementary. The use of urban water bodies and the resolution of conflicts is driven by anthropogenic and biocentric/ecocentric interests that must be optimized and the conflicts resolved.

This article examines and analyzes land ethics (biocentric) and socio-economic (anthropocentric) drives for stream restoration of urban watersheds located in the Milwaukee (WI) metropolitan area. The basins experienced increased flooding, significant degradation of sediment and water quality, and loss of aquatic species, all due to urbanization. It was found that the primary drivers for restoration of urban streams are the ethical attitudes of population towards the ecocentric benefits of restoration in combination with a desire for flood control. A Contingent Valuation Survey of citizens residing in two Milwaukee watersheds revealed that those who see the watershed in ecocentric terms appear to have a greater Willingness to Pay for watershed/water body improvements than those who see the benefits solely in anthropogenic terms of reduction of flood damages.

Keywords: stream restoration, flood control, benefits evaluation, contingent valuation, urbanization

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Introduction

Urbanization in most cases results in downgrading the integrity of water bodies and watershed in urban and urbanizing areas. The root causes of degradation are well known and include hydrological changes such as increased peak flows and flooding at one end and loss of base flow on the other. Water quality is degraded by contaminants in urban runoff and, in some cases, by overflows from combined and even sanitary sewers (CSOs and SSOs). An ultimate degradation of an urban stream is to line it with concrete or riprap, straightening the channel, and sometimes covering it, essentially converting the stream to an underground sewer. These modifications could be categorized, based on a definition in Section 5 of the Clean Water Act, as pollution. However, the only tool available currently to agencies to initiate stream restoration, the Total Maximum Daily Load process (Section 303(d) of the Act), is ineffective to bring about compliance of the goals of the Clean Water Act of urban streams affected by “pollution” that does not involve discharges of pollutants.

Urban streams are used for a variety of purposes, including : (1) flood conveyance; (2) disposal of urban runoff and overflows from sewer systems; (3) aesthetic enjoyment by the urban population; (4) aquatic life propagation; (5) contact and noncontact recreation (sailing and fishing); (6) potable and nonpotable water supply (e.g., golf course irrigation); (7) other uses that may include cooling, navigation, and groundwater recharge. Some uses are conflicting with one another. For example, fast conveyance of floods interferes with aquatic life propagation and recreation, potable water use typically restricts contact recreation. Some uses complement each other; e.g., the use of the urban water body for water supply or for contact recreation necessitates a healthy ecology of the water body. The uses of the urban water bodies are driven by anthropogenic and biocentric interests that may conflict; therefore, the conflicting uses must be optimized.

Rationale

The research described in this paper was part of a large interdisciplinary research sponsored by the USEPA/NSF/ USDA STAR (Science to Achieve Results) watershed program. The relatively small urban watersheds analyzed in the research (Novotny et al. 2001) and the paper are

- the Menomonee River and Oak Creek in Milwaukee County (WI)
- Lincoln Creek in Milwaukee County (WI)

Other notable examples of restoration of a stressed urban water body are the Rouge River in the Wayne County (MI) and the Muddy River in Boston/Brookline (MA).

The partially urbanized Menomonee River and fully urbanized Lincoln Creek in the Milwaukee metropolitan area have been undergoing substantial restoration efforts, with approximately the same cost (more than $70 million each). The restoration of the urban Muddy River in Boston/Brookline is in the final planning stages. Oak Creek in Milwaukee County is undergoing rapid urbanization/transition from rural to urban. None of the analyzed water bodies receives significant point inputs from wastewater effluents.

The three urban watersheds (Menomonee River, Lincoln Creek and Muddy River) are experiencing increased and more frequent flooding, degradation of sediment and water quality, and loss of aquatic species, all due to the impact of urbanization. In Milwaukee's Menomonee River and Lincoln Creek watersheds, the annualized tangible benefits of flood control amounted to only a fraction of the cost. Because most ecological benefits are intangible, the ecocentric uses are in a distinct disadvantage. However, societies and agencies, today, may not accept nor finance flood control and stream restoration projects that would have negative net benefits.

Because restoration of the water bodies and riparian floodplains and development of storage oriented best management practices for storage and treatment of runoff (e.g., ponds and wetlands) also have significant flood control benefits, accomplishing both goals is possible in the investigated watersheds. Implementing abatement of urban diffuse pollution, stream habitat restoration, and remediation of contaminated sediments is a problem because the solution cannot be mandated and only minimum federal government funding is available for water body restoration (with the exception of Rouge River that is a pilot project with significant federal funding). Most funding must come from local sources and from citizen's initiatives. Thus the ecocentric attitudes of the citizens of the watersheds, originally defined fifty years ago by Leopold (2001) play an increasingly important role. Watershed/water body restoration will not happen if citizens do not exercise their land (environmental and biocentric) ethic attitudes. However, until recently, the biocentric and environ-mental attitudes were demonstrated only by citizens' organizing into "friends of the river" committees, public pressure on developers and legislators, and court action. However, quantitative measures of attitudes (willingness to pay) were sparse.

Problems of urban water bodies

Multiple and conflicting uses of urban water bodies without reconciling conflicts, leads to short term resolution of the most publicized problem (e.g., flooding), often with long term adverse consequences. In the past, urban engineers tried to resolve the problem of increased floods by increasing the velocity and flow capacity of urban streams. Such conveyance oriented flood control approaches did not improve water quality, were detrimental to habitat and dangerous during flooding to citizens. Moreover, they passed flood control problems downstream. At the same time, development continued to encroach on floodplains, exacerbating flooding problems. Traditional cost-benefits evaluations often revealed negative net benefits as cost far exceeded the flood control damage reduction and the tangible benefits were frequently limited to citizens residing in floodplains.

In contrast, storage oriented approaches enhance flood storage by including infiltration, storage ponds and wetlands both throughout the watershed and in existing and reclaimed floodplains provide numerous ecological benefits and are the necessary prerequisite of revitalization of urban streams. Such best management practices are also an integral part of solving the diffuse pollution problem of urban streams. In addition, contaminated sediment remediation should be part of the overall plan.

Measuring and evaluating benefits of urban diffuse pollution control and water body/watershed restoration is difficult and the standard benefit-cost approaches do not work nor would be applicable. Improving the ecological quality of the resource generates private and public benefits that are direct and indirect, tangible and intangible. Among those residents who use the water resource for recreation activities such as hiking, sailing, fishing or swimming, an improvement in ecological quality can improve or even reinstate a recreational experience. Such benefits are direct. However, even local residents who are not currently users may want to improve the environmental quality of the water resource for themselves or their children's private future use (known as option value). Existence values are benefits that an individual receives from knowing that a resource is preserved or enhanced even though the consumer never intends to use the resources (Krutila and Fisher 1975, Mitchell and Carson 1989). Such existence benefits are divided into vicarious consumption (by significant others, relatives or close friends, and by general public), stewardship values (preservation or bequest) or even enhanced sense of civic pride resulting from improving or restoring a local environmental resource. These are direct benefits to consumers, even though the good is public in nature. A typical current practice of evaluating benefits is to count only active users of the water resource, for example, by estimating the number of recreational users and assigning a numeric value of a benefit to each user.

Measuring benefits associated with flood control projects by traditional cost/benefit analysis wherein the reduction of tangible flood damage is the benefit are incomplete for several reasons. First, they are based on the false premise that the only benefits of flood protection are those experienced by residents in the floodplain. Second, they fail to fully recognize some ecological benefits that may be derived from some ecologically enhancing storage oriented flood control projects. Third, they are incapable to include the intangible external cost of the ecological damage done to the stream corridor by channel modifications and floodplain development.

Socio-economic conflicts

It is important to briefly overview the numerous and often conflicting actors and interests that are affected by urban watershed management and seek to influence it.

First, federal, state, regional and local governments and supporting institutions (e.g., regional planning commissions, regional drainage agencies) are the most obvious and powerful agents of management. However, because watersheds and floodplains do not fall exactly within the geographical jurisdictional boundaries, problems arise. Also, different governmental organizations and units may have conflicting objectives, depending on their constituencies, interests, funding sources, relationship to other agencies, etc.

Second, due to the large expense associated with watershed management and preservation/restoration projects, many policymakers are hesitant to initiate proactive policies, especially those that may present a financial burden on population. Policymakers usually react to what they perceive to be the demands of their voting public and derive their policy concerns from stakeholders, public meetings, and media coverage of flooding and stream bad quality calamities. Without the intelligence of an unbiased and valid public opinion survey their perception of public concerns can be erroneous, since only motivated people will voice their concerns directly to policy makers or attend a meeting. News media coverage usually include salient events (e.g., flooding) rather than trends (e.g., progressive worsening of water quality and loss of the ecological value of a water resource due to urbanization). Thus concerns with flooding, driven by policymakers' perceptions of the media and public concerns, generally drive urban watershed projects. This was the primary driver of the Menomonee River, the Muddy River and Lincoln Creek projects. However, in the 1980s and before, citizens' participation on watershed (primarily flood control) projects was minimal and restricted mostly to citizens' advisory committees with few members. In the case of Lincoln Creek, in the early 1990s, the flood protection only project relying on fast conveyance ran into stiff opposition from the public and environmental groups that virtually stopped the project while trucks with concrete were being delivered. Without proactive environmental communication and knowledge of environmental benefits of stream corridor preservation/ restoration, the linkages between the ecological status and use of the water body for conveyance (and by the same reasoning for other purposes requiring hydraulic modification such as navigation or excessive water withdrawals) are blurred.

Finally, it was recognized at the end of the last century that efficient watershed management involves more than a reduction of the flood risk. It incorporates issues as diverse as ecological integrity, water quality, public health and safety, urban and rural development planning, and aesthetic/quality of life concerns. Watershed management encompasses a number of social, economic, ethical and environmental issues. Consequently, effective watershed management planning and policy formation require knowledge on the benefits and costs of management actions and public acceptance.

Ecocentric and anthropogenic values

Environmental values of urban watersheds are a special form of basic views about how things should be in the world and what should be done to make urban areas a better place (Norton 1995, Leopold 2001). They can be anthropocentric or biocentric. In the case of anthropogenic values, environmental improvement should be undertaken only for the material benefits of people. For biocentric environmental values, ecological improvements should be undertaken for the sake of nature itself apart from any material human benefits. The ecological restoration of a watershed, for example, should be undertaken if it benefits the species present whether or not there is any material benefit to human beings. As Leopold (2001) noted, out of 22,000 species of birds, fish and animals in Wisconsin only a few percent have any economic value, yet they deserve protection. This means that individuals with environmental and biocentric values could support ecological restoration even if neither they or anyone else experience added material benefits such as improved recreation opportunities, higher market values for riparian and near stream properties, or cleaner drinking water.

One of the major objectives of the research conducted at Marquette University (Milwaukee, WI), described in this article, was to investigate the role and extent of land ethic defined by Leopold (2001) (or environmental perspectives) as evident in the beliefs and attitudes of citizens in urban and urbanizing watersheds, in particular as related to conservation and ecological restoration under the threat of increased flooding caused by urbanization. The research estimated the citizens' willingness to pay to support stream restoration and sound flood protection as well as communication, attitudinal belief, and other psychological factors that may affect that support.

Method

A two wave phone scientific survey of more 1000 citizens residing in the watersheds of the Menomonee River and Oak Creek was conduced during the 1998-2001 period (Figure 1). The survey was preceded by several focus group sessions that tested the survey and significance of questions included in the questionnaire. The measure of the citizens' attitudes was the willingness (WTP) to pay for flood control and environmental restoration projects. A comprehensive research report (Novotny et al. 2001) also addressed the hydrologic impact of urbanization and developed measures of water body integrity – ecological risks that were then, in a simplified form, conveyed to the respondents of the survey. Given that residents in the Milwaukee metropolitan area have experienced several large (more than 100-year) flood events in the last 15 years (1986, 1997 and 1998), the issue of flood control has had a high public profile. Since flood control projects focus primarily on mitigation of flood risks or they may employ techniques that also improve the ecological integrity of the watershed, an understanding of the relative importance of these two objectives of watershed management is needed. The socio-economic study developed and conducted by the second and third author employed Contingent Valuation Method (CVM) to evaluate community support for watershed management practices. The CVM was used to estimate value for environmental improvements and flood control, relying on individual responses to hypothetical circumstances. A parallel analysis utilizing models of risk communication and testing at a more micro level of psychological variables that correlate to willingness to pay was also conducted. Finally, the survey also contained questions related to environmental ethics and its relation to WTP.

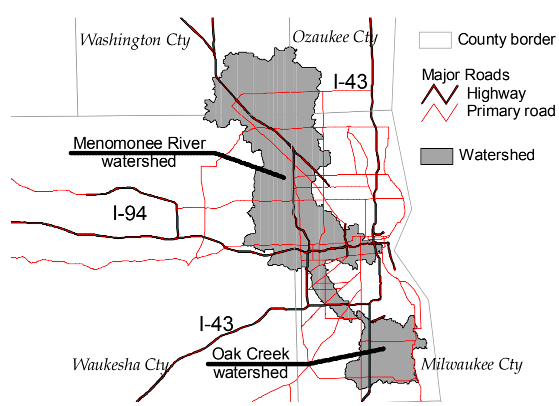

Figure 1. Menomonee River and Oak Creek watersheds.

The generalized model for the analysis of the survey is given by equation

Ln(WTP) = f(*demographic, residence controls, survey controls, attitude/value, risk,* ε)
where *demographic, residence controls, survey controls, attitude/value* and *risk* are vectors of variables contained in the model, and ε is the random error variable.
The surveys were conducted along three paths: (a) environmental path where respondents expressed their views and WTP for environmental restoration and preservation projects, (b) flood control path, and (c) combined path.

Results

Until recently, WTP studies have neglected psychological foundation of WTP and, instead, narrowly focused on demographic variables (Ajzen and Driver 1992). Our study found that the primary socio-demographic variables (respondent income, race/ethnicity, gender, age, dwelling location within the floodplain, and the number of inhabitants in the dwelling) bear weaker relationship with WTP for flood control projects than do variables based on the Theory of Planned Behavior (Ajzen and Driver 1992), specifically subjective norms ($r = 0.29$, $p<0.001$) and an overall index of cognitive structure ($r = 0.4$, $p<0.001$; $r = 0.46$, $p<0.001$, when the belief-evaluation compound items are also multiplied by a separate self-report measure of the importance of the outcome to the decision.

The findings from the survey in the flood control path revealed that:

- There is some evidence that WTP is higher among those at a higher risk of flooding, especially those living in the downstream portions of urban watersheds and those currently residing near but outside of the 100-year floodplain
- Demographic factors (especially income) and measures of environmental attitudes are important determinant of WTP, even after accounting for differential risk factors
- Potential problems with embedding suggests that voters in a hypothetical referendum on flood control may not carefully scrutinize the features of the flood control project when determining their level of support. Rather, given the existing perception at the time of the survey on the flooding problems in Milwaukee County, they may believe that it is important to take some action.

Ethic research

The survey evaluation revealed that strictly economical values such as income, play a comparatively minor role in WTP regression equations relative to psychological variables such as cognitive structure and subjective norms. Cognitive structure is in turn strongly related statistically to environmental attitudes and values. The research focused on evaluation of two types of ethical attitudes: environmental ethic and duty oriented ethics. Results of Griffin's research found that residents' perception of the actual efficacy of the project in bringing about the physical goals ("…help improve the health of the river" in the environmental path, and "…help hold the line against flooding" in the flood control path) were among the most important considerations, especially if they produced enduring benefits such as "…help support a long-term solution" and "…help future generations." Less salient was consideration of whether a flood control project might help people who live in the floodplain. Similarly, respondents on the average rated only as moderately important (i.e., roughly around the middle of a 0 to 10 scale of importance) economic considerations as to whether the project would be personally expensive and whether it would add significantly to one's taxes.

Environmental perspectives can play a significant role in determining cognitive structure and WTP. Not only is a broad measure of environmental beliefs an important influence on cognitive structure, but so is a measure of perceived taxpayer duty toward urban river cleanup as well. Thus key theoretical concepts from the environmental ethic play an important role in formulation of the public's WTP for urban watershed restoration. Those who see the environment in ethical terms appear to have a greater WTP for environmental improvement, at least in the case of urban watersheds.

Economic outcome

The regression results of the Marquette University research revealed that the models explained about 40% of the variation of the latent WTP variable. Clark found that for the ecological restoration value, respondent income does not have a statistically significant influence on real WTP. "Years of education" does positively affect the real WTP, and older respondents have lower real WTP, other factors being equal. Homeowners have higher WTPs, but the coefficient is significant only at the 10% level on one-tailed test. In the protest vote, respondents were unwilling to spend their own funds. The "subjective norms" index, as well as both cognitive structure measures, are positive and significant.

The habitat risk score was positive and significant. In the habitat test the responses were correlated to the quality of the habitat expressed by the index of physical integrity of the nearest section of the water body for which the index was available. This implies that a higher level of habitat quality leads to a higher WTP to pay for reducing ecological risk. This at first seems counterintuitive, since one may believe that higher ecological risk (and lower habitat quality) areas need more clean-up. However, an alternative interpretation is that respondents believed that less environmentally damaged areas require more funding to preserve their environmental integrity than did more damaged areas. That is, WTP is higher before an area is damaged than after the damage has occurred. Finally, the more the respondents visit the river, the higher is the WTP.

Two additional measures were included in this category: *an awareness of consequences,* a Likert-type question related to the belief that taxpayers have a duty to share the cost of improving the health of urban rivers (*taxpayer duty*) and a belief that nature should be preserved for its own sake apart from any human benefits (*biocentric ethic*). Only "taxpayer duty" was statistically significant and was positive. It is an expression of environmental duty rather than biocentric ethics, which apparently is less significant in the urban environment dealing with degraded rivers and favoring restoration rather than nature protection.

Given approximately equal positive valences to the project outcome that would result in flood protection or environmental restoration project, the survey yielded a significantly more heavily weighted compound for beliefs about the efficacy of environmental projects as compared to the flood control projects. This was confirmed by the actual present values calculated by Clark from the willingness to pay that yielded much higher WTP for environmental restoration than flood control. Willingness to pay for environmental restoration was 2.4 times higher than for flood control benefits.

The WTP model developed in the research is transferable to other location, at least in the same geographical region (Alp et al. 2002).

Conclusions

Although the primary drivers for urban stream management for policy makers is primarily flood control, projects that would focus solely on flood control may have negative net benefits and may not be acceptable to the public that appreciates more ecocentric values of stream restoration and preservation. However, because restoration of the water bodies and riparian floodplains and development of best management practices for storage and treatment of runoff (e.g., ponds and wetlands) have also significant flood control benefits, accomplishing both goals has been possible and met (or are proposed to be met) in the investigated watersheds.

Acknowledgments

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