# Interaction Between Scientists and Nonscientists in Community-Based Watershed Management: Emergence of the Concept of Stream Naturalization

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ABSTRACT / Watershed management, although dependent on science and engineering, is first and foremost a social process. Given the current emphasis on community-based approaches to environmental decision making, scientists must, more than ever before, understand, appreciate, respect, and immerse themselves within local social contexts. Only by doing so will they be able to ensure that their opinions and information are fairly and meaningfully considered by nonscientists.

The authors' personal experience in watershed planning and decision making in the agricultural Midwest is described to illustrate how: (1) formalization of the process of community-based management is not sufficient to guarantee that local people will meaningfully consider scientific information and opinion when making decisions about watersheds, and (2) genuine social interaction between scientists and nonscientists requires a considerable investment of time and energy on the part of the scientist to develop personal relationships with nonscientists based on trust and mutual exchange of information. This experience provides the basis for developing a general conceptual model of the interaction between scientists and nonscientists in community-based watershed management in the agricultural Midwest.

An important aspect of integrating science effectively into community-based decision making is the need to revise existing concepts to accommodate place-based contexts. Stream naturalization is introduced as an alternative to stream restoration and rehabilitation, which are viewed as inappropriate management strategies in human-dominated environments. Stream naturalization seeks to establish sustainable, morphologically and hydraulically varied, yet dynamically stable fluvial systems that are capable of supporting healthy, biologically diverse aquatic ecosystems. This general goal is consistent with the types of stream-management practices emerging from community-based decision making in human-dominated, agricultural landscapes. Further research on the linkages between geomorphological and ecological dynamics of human-modified agricultural streams over multiple spatial and temporal scales is needed to provide a sound scientific framework for stream naturalization.

Over the past two decades, gradual change has occurred in the philosophy and practice of environmental management at regional, national, and international scales. This change involves a shift away from top-down strategies, in which planning, policy formulation, and regulation is conducted primarily by centralized government agencies, towards a bottom-up approach, which involves all relevant parties, especially local communities, in the process of environmental management and decision making (Merkhofer and others 1997; Moote and others 1997; Vasseur and others 1997; Smith and others 1997). In the United States, community participation underpins the concept of integrated environmental management (IEM), which currently is being widely and enthusiastically embraced within academic, professional, and political circles (Born and Sonzogni 1995). More specifically, it is an essential element of the Watershed Protection Approach (WPA)—the US Environmental Protection Agency's (USEPA) ecosystem-based perspective on watershed management (US Environmental Protection Agency 1995).

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The broadened scope of public involvement inherent to IEM and the WPA has heightened interest in the role of social processes in environmental management. Cooperation, collaboration, conflict resolution, and social negotiation are emerging as central issues in the community-participation paradigm. Recent literature has emphasized both the importance of including local citizens in the decision-making process and the need for effective communication between local people and scientific / technical ''experts'' (Crance and Draper 1996; Maser 1995; Selin and Chavez 1995). Despite this progress, detailed empirical studies of the social processes of environmental management within specific communities in the United States are lacking. As a result, the social mechanisms of community-based environmental decision making are poorly understood. Knowledge of these mechanisms is essential if the outcomes of community-based decision making are to be properly explained and anticipated by environmental managers.

Research on international development has shown that conflict and negotiation in community-based management often derive from different valuations of the biophysical environment by local people and technical experts (e.g., Western and Wright 1994). This work has emphasized the degree to which scientific knowledge, local knowledge, and differences in the empowerment of various stakeholders influence social negotiations in participatory approaches to environmental management (Thompson and Scoones 1994; Thrupp and others 1994; Proon 1995). It emphasizes that conceptions of nature, environmental quality, and sustainability are value-laden social constructions that cannot be derived from or made absolute by scientific inquiry (Gale and Cordray 1994; Greider and Garkovich 1994; Simmons 1994; von Maltzahn 1994). The lesson to be learned from this research is that truly participatory approaches to environmental management must fully respect the knowledge, experiences, values, interests, and resources of various participants. Conversely, the participatory process often fails if it adopts a coercive stance in which one type of knowledge or valuation is intrinsically privileged relative to others at the outset of the management process.

This paper draws upon our personal experience as participants in local watershed planning and decision making in the agricultural Midwest to advance a fundamental proposition about community-based watershed management in this part of the United States. Although this proposition is directed toward the agricultural Midwest, related work suggests it may have broad applicability beyond this specific regional setting (Andersen and Polkinghorn 1996). Our central proposition maintains that watershed management, although dependent on science and engineering, is a process that is fundamentally social in nature. It also asserts that whenever environmental scientists and technical experts fail to overtly recognize the social nature of watershed management, a truly participatory approach to environmental decision making can be hindered in several ways. First, environmental scientists and technical experts, especially those who live outside the local community, may implicitly privilege their own knowledge, yet at the same time be ignorant of or insensitive to the place-based knowledge of nonscientist stakeholders. Second, scientists may fail to distinguish clearly between their knowledge and their values, and, in fact, convey the impression that their values derive directly from their knowledge. This confusion, while innocent in nature, nevertheless can lead to the presumption among scientists that their values also are privileged. As a consequence of this implicit privileging of their knowledge and values, scientists may discount the importance of the knowledge and values of nonscientists, whereas nonscientists may perceive that they are being cast as ignorant and wrong—a situation that can generate feelings of mistrust and resentment among nonscientists. Moreover, because scientists and technical experts rarely take the time to understand the social–cultural lifeworlds of nonscientists, they often do not communicate effectively with them—a problem that only exacerbates feelings of mistrust and resentment. The perception among nonscientists that scientists are insensitive to their values and knowledge may prompt them to ignore scientific information, which they perceive as tied to a value system with which they do not agree. Together, these factors impede decision making based on shared information and a common understanding of this information, a concept that lies at the very core of community-based environmental management. The challenge for scientists is to: (1) improve their self-awareness of the distinction between their knowledge and their values; (2) recognize that their knowledge and values are not necessarily viewed as privileged by the rest of the community; (3) acquire an understanding of the values and knowledge of nonscientists and, in the process, learn how to communicate effectively with other members of the community; and (4) develop place-specific representations of scientific knowledge that are sensitive to the sociocultural lifeworlds of nonscientists and that are divorced from scientists' personal environmental values.

The paper first provides a brief historical summary of human interaction with watersheds in the agricultural

Midwest to provide a context for the discussion of contemporary issues. It then illustrates how the central proposition about watershed management as a social process has emerged from our experience as participants in a community-based watershed project in east-central Illinois. The central proposition is elaborated by developing a conceptual model of the interaction among scientists, scientific information, nonscientists, and local knowledge in community-based approaches to watershed management. The paper also describes the concept of stream naturalization, which provides an overarching framework for accommodating the full range of diverse outcomes of community-based decision-making about stream management in the agricultural Midwest.

## Human Modification of Watersheds in the Agricultural Midwest

The recent emphasis on community-based approaches to environmental decision making has important implications for watershed management in the agricultural Midwest. In rural Illinois the primary local stakeholders are farmers, who are concerned about maintaining high levels of agricultural productivity, but who also have a land-based appreciation of environmental quality. These farmers, besides having a major influence on hillslope processes through farming activities, also have been invested, via the Illinois Drainage Code, with substantial authority to modify streams; thus, they are key agents in community-based efforts to manage watersheds (Rhoads and Herricks 1996).

The prevailing attitude toward stream management in many parts of the Midwest has emerged out of a historical social/cultural context centered on artificial drainage of a landscape, which, at the time of settlement, was too wet for agriculture. In east-central Illinois interaction with the landscape initially was driven by perceptions of wetness and by lived experiences about how wetness affects crop production (Winsor 1987). At first, the need for drainage was met by individual farmers; however, in the late 1800s the Illinois state government authorized the formation of local political consortiums known as drainage districts (Rhoads and Herricks 1996). Over time, an ethic centered on land drainage became embedded in the social fabric of rural communities in east-central Illinois. This ethic was reinforced by engineering research and technology aimed at developing improved methods and machinery for land drainage.

The statutory laws that have developed to support drainage activities vary from state to state throughout the Midwest (Sandretto and Massey 1987; Beck 1991a), but in general drainage districts are invested with substantial power to modify small, headwater streams (Beck 1991b). In Illinois, drainage districts are authorized by state statutes to ''alter, enlarge, extend, improve, deepen, widen or straighten'' any natural watercourse for the purpose of drainage (Illinois Drainage Code, Act 605, Article 4-16b). This legal authority has produced widespread channelization of agricultural streams throughout the state; over 23% of the total stream length in Illinois has been channelized (Mattingly and others 1993). This figure probably grossly underestimates the total effect of human modification on the fluvial landscape because it does not include routine maintenance activities, such as clearing and dredging, which are more commonplace than channel straightening. The greatest extent of channel modification has occurred in the headwaters of agricultural watersheds, where in some cases 100% of the total stream length has been channelized. The adverse effects of channelization and channel maintenance on downstream flooding, on habitat quality, and on stream-channel stability have been well-documented (Griswold and others 1978; Schlosser 1982; Simpson 1982; Brookes 1988). Available evidence indicates that ecological degradation has been pronounced and the quality of stream ecosystems in Illinois remains severely compromised (Illinois Department of Energy and Natural Resources 1994).

## Social Aspects of Community-Based Watershed Management in east-central Illinois

Despite an increase in concern about ecosystem-based watershed protection within society at large over the past 20 to 30 years, the land-drainage ethic is still strong in east-central Illinois. The predominance of this ethic was evident during social negotiations associated with a community-based watershed project in the upper Embarras River basin of east-central Illinois (Rhoads and Herricks 1996). This local project revealed first-hand the strong social resistance to incorporating environmental information into the watershed planning process. The organization of the Embarras River watershed project conformed in many respects with the guidelines put forth in the EPA's Watershed Approach (US Environmental Protection Agency 1995, 1996): it was initiated and supported locally; brought together the public, citizen groups, researchers, and government agencies; had an organizational structure consisting of a main oversight committee and several technical subcommittees (environmental, engineering, legal, and resource information); involved personnel from multiple organizations in a decision-making role throughout the life of the project; and included public meetings to inform and educate the citizens of the watershed (Rhoads and Herricks 1996). In the planning phase of the project, rural stakeholders played a passive role, appearing reluctant to interact with the technical experts and scientists on the various subcommittees. During interactions with the environmental subcommittee, which consisted mainly of scientists from universities and government agencies, rural stakeholders tended to disregard information on the geomorphology and ecology of streams in the watershed. This reaction appeared to reflect an ingrained perception of streams and their function by the farmers and their engineers. When asked to vote on various management alternatives proposed by the technical subcommittees, local stakeholders preferred the option with which they were most familiar, i.e., dredging of streams to remove accumulated sediment. Because the planning process emphasized the primacy of community-based input, the final plan for management of streams in the upper Embarras River watershed focuses mainly on the need to maintain adequate land drainage (Upper Embarras River Basin Planning Committee 1996). A statement focusing on environmental conservation was inserted in a top-down manner by the main steering committee after technical experts on the environmental subcommittee objected that the penultimate version of the management plan ignored their recommendations.

Regardless of the outcome of watershed planning, implementation of specific stream-management strategies in the agricultural Midwest depends largely on the cooperation of drainage-district commissioners, who for the most part are farmers. Ultimately, it is these commissioners who have the legal authority to modify stream channels. Recently, the authority of drainage districts to conduct channelization and maintenance has been curtailed by a ruling on the Clean Water Act Regulatory Program (Section 404) issued by the US Army Corps of Engineers (USACE) and the US Environmental Protection Agency (Department of Defense and Environmental Protection Agency 1993). Interpretation and enforcement of this ruling vary substantially among district offices of the USACE. As a result, the ruling has not been applied uniformly to drainage-district activities in Illinois. Drainage-district commissioners greatly resent this top-down regulatory restriction on their authority and often feel they do not need to apply for a USACE permit when conducting channel maintenance. Should federal policy become less restrictive, these commissioners most likely will return to business as usual. Lasting change in the way streams are managed by local people requires a fundamental transformation in the prevailing community ethic toward the environment—a change that will occur only via social processes, if it occurs at all.

An important challenge for scientists and technical experts is to develop a sincere, genuine understanding of the perspective of local stakeholders. Doing so will build partnerships based on trust, cooperation, and collaboration. Our experience indicates that developing such partnerships is difficult, but not impossible. One factor that cannot be ignored by environmental scientists is the emphasis that farmers in the Midwest place on the need to maintain adequate drainage of their fields. Any approach to stream management that ignores this factor, such as ‘‘do nothing,’’ most likely will be ignored by drainage-district commissioners. Similarly, any management recommendation proffered by scientists that ignores or discounts local valuations undoubtedly will be disregarded or viewed scornfully by local stakeholders.

We have had some success in working with drainage-district commissioners and their engineers to develop innovative approaches to land drainage that include environmental-quality components (Rhoads and Herricks 1996). In 1994, the Embarras River Mutual Drainage District (ERMDD) proposed to straighten several sections of the river within the district. In coordination with the local district conservationist of the Natural Resources Conservation Service, we began to discuss alternatives to straightening with the district commissioners. Although the commissioners were not opposed to suggested alternatives, they decided it was best to proceed with the original plan and then implement alternatives after receiving a Section 404 permit from the USACE. In the course of the permitting process, the US Fish and Wildlife Service, USACE, and local environmental organizations raised concerns about the project. The USACE encouraged the commissioners to work with us to develop an alternative plan and, after a second independent application was deemed unsatisfactory by the USACE, the commissioners did turn to us for advice. After several meetings, we developed a relationship of trust with the commissioners, which in turn led to the formulation of an alternative plan that included a habitat preservation component and that precluded realignment of the stream course, yet fulfilled the drainage concern of the district commissioners (Rhoads and Herricks 1996).

Our interaction with the ERMDD commissioners exemplifies disparities between local knowledge and scientific knowledge and how resolution of differences between scientists and nonscientists requires sensitivity to place-based knowledge on the part of the scientist. By listening carefully to the commissioners and their consulting engineer, we developed an understanding of specific concerns and of the relative importance of these concerns. The commissioners were most concerned about maintaining adequate drainage of farmland adjacent to the stream. Land drainage systems in east-central Illinois consist of networks of subsurface tiles that drain into stream channels. Many tile outlets along the Embarras River had become submerged during baseflow conditions, decreasing the rate of drainage of the adjacent farmland. The commissioners viewed exposure of the tile outlets during periods of baseflow as the most important objective of the project. A secondary concern was the perceived loss of land along meandering sections of the river and the effects of this erosion on water quality and channel sedimentation. Finally, the commissioners were sincerely interested in exploring ways in which they could be good environmental stewards and promote the quality of fisheries resources in the Embarras River.

Subaerial exposure of tile outlets traditionally is accomplished by deepening and straightening the stream channel. Straightening exposes outlets that cannot be located precisely prior to the project and also has the added benefit of increasing the hydraulic efficiency of the stream. The commissioners wanted the stream deepened, but began to understand the environmental benefits to be gained from not straightening the stream. They agreed to develop a plan that would involve deepening the stream channel, but not straightening it.

A key issue in the deliberations with the ERMDD commissioners was the perceived need to modify a meandering section of stream, which the commissioners viewed as an erosional eyesore that was removing precious topsoil and threatening nearby fields through lateral migration. This concern derived from their perception of vertical streambanks on the outside of meander bends and the gradual movement of the bends over time. We informed the commissioners that these properties were part of the natural form and function of meandering streams and were also important ecologically. We also conducted a detailed GIS-based analysis of channel change along the reach using historical aerial photography. This analysis demonstrated that rates of lateral movement over the previous 30 years were negligible ($<1$ m/y) (Rhoads and Urban 1997). It also showed that the direction of movement of the bends was down valley, along the axis of a riparian buffer strip, and not toward the farmland adjacent to this buffer strip. The commissioners correctly perceived that erosion was occurring, but scientific analysis revealed that this erosion was not an imminent threat to their farmland.

The results of the GIS-based analysis were not presented to the commissioners in a way that cast them as wrong and us as right. Instead, an atmosphere of mutual cooperation was cultivated by empathizing with the commissioners' concerns and by discussing these issues in the field during visits to the site. The commissioners seemed to genuinely appreciate our interest in their concerns and commitment to formulating a solution that would both enhance drainage efficacy and preserve environmental quality. Although they agreed to leave the meandering portion of the river untouched so that it would function as a ''habitat island'' within the system, this decision was a difficult one for them. A few days before the final plan was submitted to the USACE, the commissioners asked us to meet with them in the field to explain once more the rationale behind preservation of the meandering reach. The meeting illustrated clearly the extent to which the drainage ethic had become engrained in the lifeworld of the commissioners. Left with no rational arguments of their own to support modification of the reach, the commissioners were looking merely for someone they trusted to assuage their doubts. A few days later the final plan was submitted to the USACE, which, two months later issued a permit for the project.

The upper Embarras River watershed project illustrates that institutional decrees calling for stakeholder involvement and the specification of formalized protocols to facilitate stakeholder involvement are not sufficient to guarantee that community-based decision making will be based on meaningful interaction among stakeholders. Genuine social interaction cannot be ensured by formal prescriptions. Sincere dialogue requires effective communication, which in turn must be based on relationships characterized by mutual understanding, respect, and trust. Because scientists usually are a minority in the context of community-based decision making, the onus is on them to properly situate their knowledge and opinions within the prevailing sociocultural context of the local community. Those who refuse to do so should not be surprised when their knowledge and opinions are discounted in the decision-making process.

## A General Conceptual Model of Interaction Between Scientists and Nonscientists in Community-Based Watershed Management

Our experience in watershed planning and decision making in rural east-central Illinois suggests that the interplay among scientific knowledge, scientists, local knowledge, and nonscientists is a crucial component of community-based watershed management in the agricultural Midwest. This experience provides the basis for a bottom-up conceptual model of the social dynamics of

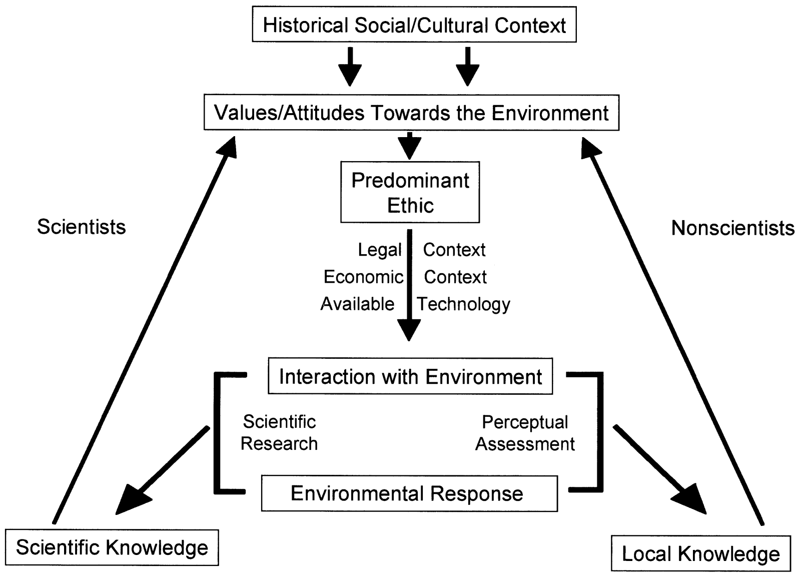


**Figure 1.** Conceptual model of interaction between scientists and nonscientists in community-based watershed management in the agricultural Midwest.

community-based watershed management (Figure 1). This conceptual model includes diverse aspects of the nonscientific and scientific worlds—values, attitudes, ethics, historical inheritance, local knowledge, and scientific information—situated within specific sociocultural settings. It integrates contextual and locally rich factors into a general conception of social interaction between scientists and nonscientists within a community of local stakeholders. The model represents community-based watershed management as an unbroken cycle of interactions involving diverse actors and institutions with differing and sometimes competing agendas and stocks of knowledge.

The central focus of the model is the collective set of values / attitudes towards the environment within a community composed of nonscientists and scientists. This set of values, which includes concerns both about economic viability and about environmental quality, emanates in part from the place-based historical social / cultural context that shapes the current fabric of stakeholder perceptions, beliefs, and involvement with watersheds. Out of the historical social / cultural context emerge the values and attitudes that certain individuals or groups of stakeholders take for granted, as well the skills and knowledge, including scientific and technical knowledge, which various stakeholders have acquired and employ. Local stakeholders, individually and collectively, thus have a consciousness, or worldview, shaped both by science and by society. On the one hand, a constellation of meanings about the watershed emerges that forges competing visions of its utility and value. On the other hand, an array of meanings about watershed actors and institutions also emerges—about farmers, engineers, lawyers, government officials, scientists—that fashions a vision of the importance and proper role / conduct of these actors in local life. Both clusters of meanings—about the watershed and about the range of interactive participants—are crucial aspects of what the watershed is and what it will become in the future.

As a community of stakeholders negotiates this milieu of competing meanings and values, a predominant community ethic about the local environment emerges. A community ethic, as defined here, embodies the norms that govern interaction of local people with the surrounding biophysical environment. Through this interaction, the raw biophysical environment is transformed into a landscape—an entity that is as much cultural as it is biophysical in the sense that the landscape embodies and expresses the collective set of transformative practices deemed ethically appropriate by the local community (Cosgrove 1989; Greider and Garkovich 1994). The concept of a community ethic is distinct from that of an environmental ethic. Whereas the latter prescribes normative ideals about how people should interact with the environment, the former is grounded not in ideals, but in the everyday practices through which local people actually do interact with the environment. The community ethic and an environmental ethic are commensurate only when people act in a manner consistent with a prescribed set of normative ideals.

Because the prevailing community ethic derives from a socially negotiated weighting of competing meanings and values, it has a complex, fluid content. The ethic is complex because components of the biophysical environment may be valued in different ways by different people within the community. The ethic evolves because the same individuals may value certain modes of environmental interaction differently at different times. The complex, evolving nature of the community ethic implies that even though the community as a whole assigns precedence to certain types of interaction with the environment, other types of interaction are not viewed as valueless, but merely are not weighted as strongly. The joint concern of farmers in east-central Illinois about economic gain and about stewardship of the land serves as an example of competing valuations held by local stakeholders in the agricultural Midwest. The prevailing community ethic defines behavioral preferences only at a particular time and under specific sets of circumstances. Change in the prevailing ethic is always possible through social processes that result in a shift in the weightings assigned by the community as a whole to particular values.

The community ethic, by defining place-based standards for human interaction with the biophysical environment, shapes a community's approach to watershed management. However, while providing an internal set of constraints on community behavior, the ethic also gets filtered through prevailing societal rules and resources that define allowable and possible kinds of interaction with the biophysical environment (Figure 1). These external rule and resource configurations—legal, economic, political, and technological—constrain and enable the way in which a community of stakeholders can act toward the environment. For example, as was pointed out in the discussion of the upper Embarras River watershed project, drainage district activities, although authorized by the Illinois Drainage Code, are now restricted to some extent by federal regulations, namely, section 404 of the Clean Water Act.

Patterns of stakeholder interaction with watersheds are recursive, ongoing and always generating immediate outcomes that initiate and influence future rounds of interaction. Stakeholders are reflexive agents, people purposefully negotiating their interaction with watersheds based in part on current and evolving stocks of knowledge. Nonscientists commonly evaluate their interaction with the environment through their perceptions derived from everyday lived experience, which in turn shape their local knowledge. Scientists, on the other hand, rely not only on their personal perceptions, but also examine the response of the environment to human actions through scientific inquiry, a process that transcends ordinary perceptions of environmental response (Figure 1). Through a series of recursive iterations, these two types of knowledge, over time, continuously inform the ceaseless negotiations about the weightings and meanings of the valuations that underpin the community ethic, resulting in reinforcement or modification of this ethic.

The interplay between the local knowledge of nonscientist stakeholders and the scientific knowledge of scientist stakeholders is a key element of the social negotiations that shape the community ethic. In some instances, the two types of knowledge may inform the same valuations, in which case negotiation of competing valuations is muted. However, when scientific knowledge informs different valuations than local knowledge, especially those with low weightings within the community of stakeholders, or ascribes new meaning to certain valuations in a way that challenges the prevailing ethic, negotiation of competing valuations is likely to intensify. This inevitable confrontation of different value systems, types of knowledge, and opposing viewpoints initiates a context of contestation that draws upon relations of power between scientists and nonscientists. Scientists, who often are convinced of the superiority of scientific knowledge, may attempt to overtly wield this knowledge as a source of power in the clash of values. The danger of this stance is that it often leads to ineffective top-down intervention-oriented negotiation strategies in which the scientist attempts to formally educate the ignorant or wrong-minded nonscientist. Such strategies can stiffen existing social barriers, generate feelings of mistrust, reinforce the image of the scientist as an outsider, and most importantly, cause nonscientist stakeholders to disregard scientific information in the social negotiations that define the content of the community ethic. Discounting of scientific information may be especially detrimental to environmental-management initiatives if local nonscientists have the political authority and desire to modify the landscape. To effectively situate scientific information within community-based social negotiations, scientists must not only develop an understanding of the value-bound perceptions, forms of discourse, and place-based knowledge of local people, but must also foster interpersonal relationships based on trust and mutual respect. Only by developing such relationships can scientists hope to have their opinions and the information they offer listened to and considered and, at the same time, understand and appreciate the knowledge and concerns of nonscientists.

## Stream Naturalization: A "Bottom-Up" Concept for Watershed Management in Human-Dominated Environments

As local communities assume increasing responsibility for the management of watersheds, the outcome of decision making is likely to reflect, at least in the short term, the importance of traditional practices through which these communities have shaped the surrounding landscape. In resource-rich settings, such as the agricultural Midwest, where traditional practices have led to widespread, radical transformation of the biophysical environment, intensive human use of the biophysical environment is unlikely to decline dramatically in the foreseeable future. This particular perspective on watershed management may differ substantially from community-based viewpoints in other portions of the United States, and, more importantly, from national trends.

Scientists and technical experts are best equipped to interact effectively with local people when they make a serious attempt to recognize, understand, and work within place-based perspectives. Our experience suggests that place-sensitive approaches to incorporating scientific opinion and information in local decision making can produce a gradual shift of the community ethic toward a position of increased concern about environmental quality. This shift occurs not by scientists imposing their values on the community, but by all stakeholders, including scientists, mutually reconsidering competing valuations and the extent to which these valuations are informed by alternative types of knowledge. The concept of stream naturalization serves as an example of how scientifically based prescriptions about environmental practice, in this case about stream restoration, can be tailored to local settings. We have formulated this concept to accommodate the full range of stream-management objectives emerging from community-based decision making in the agricultural Midwest.

Over the last several years, restoration of biophysical systems, such as wetlands and streams, has garnered increased public interest at the national level. The term restoration has been used to describe a wide range of environmental practices, but the most precise and perhaps well-known definition is the one proposed by the National Research Council (NRC) (1992). According to this definition, restoration is the complete structural and functional return of a biophysical system to a predisturbance state. Related concepts defined by the NRC (1992) include rehabilitation, a partial structural or functional return to the predisturbance state, and enhancement, any functional or structural improvement, a definition that is inherently tautological and therefore not useful in any practical sense. To effectively restore a biophysical system, adequate information on the predisturbance state must be available or obtainable. In addition, restoration requires that reestablishment of the predisturbance state is possible technologically and that the local community desires and supports restoration.

Restoration or rehabilitation of the geomorphological and ecological conditions of streams in the agricultural Midwest is unlikely for several reasons. First, transformation of the fluvial environment, which largely occurred prior to the collection of detailed environmental information, has been so widespread and so fundamental that the predisturbance condition of streams is largely unknown. Thus, any attempt to reproduce or even to approximate the predisturbance state of streams will be misinformed. Second, environmental conditions, especially land cover, have been transformed throughout entire watersheds; therefore, it is unlikely that the pristine state, even if it could be determined, would be sustainable given the current regime of water and sediment delivery to the stream system. Third, restoration of land-cover conditions at the watershed scale is impractical because most rural communities have a primary concern about maintaining high levels of agricultural productivity. The land, almost all of which is in private ownership, is simply too valuable for large tracts to be taken out of production. The economic importance of farming to rural communities and the deeply ingrained importance of farming practices to the sociocultural milieu of these communities imply that the predisturbance condition has little or no relevance to sustainable, community-based approaches to stream management in the agricultural Midwest. This conclusion is not merely hypothetical; it derives from our experience as participants in community-based watershed projects in east-central Illinois.

Naturalization is an alternative to restoration and rehabilitation that defines a viable management goal for watersheds situated in landscapes characterized by intensive human modification of the biophysical environment. It implicitly acknowledges that the concept of ‘‘natural’’ is a social construct and that each community socially negotiates an appropriate mix of human and biophysical components in the local landscape (Evernden 1992; Potts 1996). The goal of naturalization is to establish sustainable, morphologically and hydraulically varied, yet dynamically stable fluvial systems that are capable of supporting healthy, biologically diverse aquatic ecosystems. This goal is not a product of our idealized conception of an appropriate approach to environmental management; instead, it characterizes the salient content of an emerging community-based shift away from purely utilitarian perspectives on stream management toward scientifically informed views that acknowledge the importance of environmental considerations. Sustainability, as used in this context, refers to system insurance sustainability (Gale and Cordray 1994), in which management addresses social and economic concerns, yet also preserves or enhances existing biophysical diversity. Naturalization thus embraces the idea that human intervention in biophysical systems may be

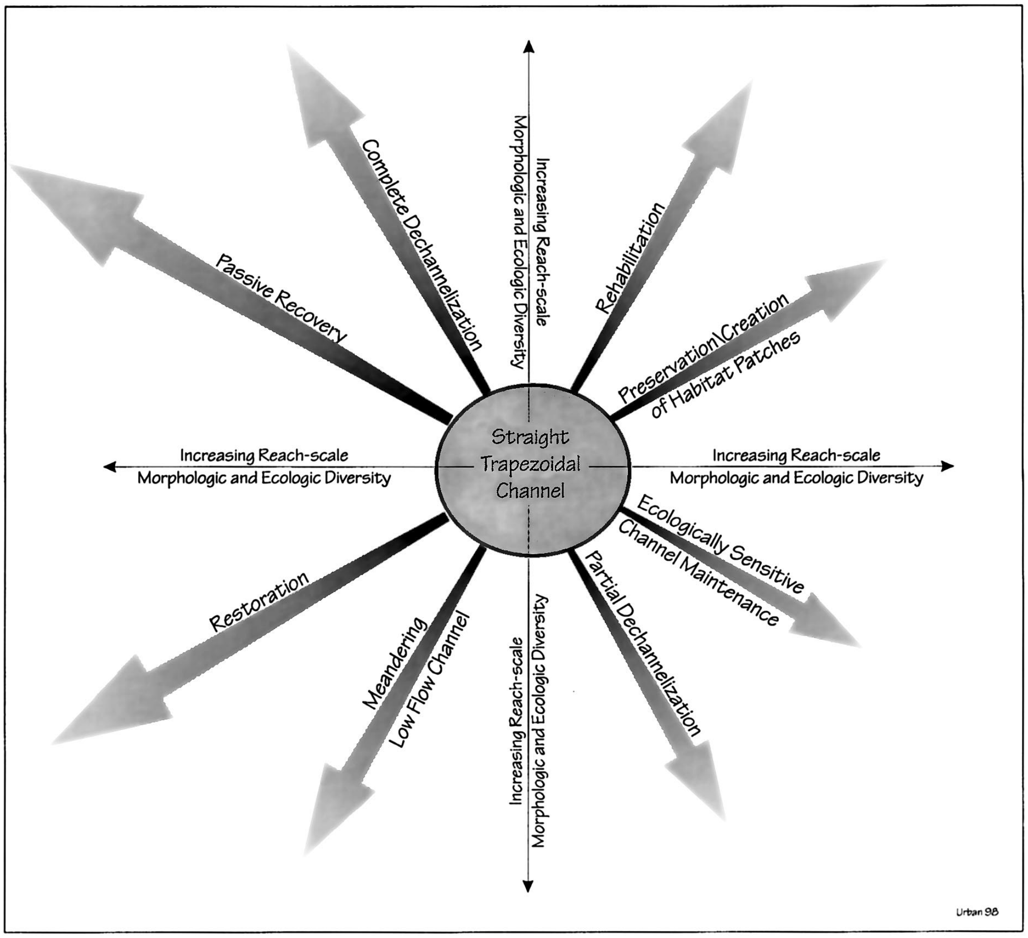


**Figure 2.** Diverse range of management practices for streams in the agricultural Midwest encompassed by the concept of stream naturalization. All of the practices increase reach-scale morphological and ecological diversity (arrows) relative to the reference state (straight trapezoidal channel).

part of the current "natural" dynamics of this system. The key is to identify morphological and ecological configurations that accommodate this intervention, but that also preserve or enhance morphological, hydraulic, and ecological diversity. The latter consideration necessitates that specified configurations must be compatible with contemporary rates and magnitudes of fluvial processes in the watershed.

Naturalization is aimed at the watershed as a whole, but in most watersheds will be accomplished gradually through a series of reach-scale projects. The target state of naturalization is not fixed a priori, as is the case in restoration/rehabilitation. Instead, naturalization accommodates a broad spectrum of management options, each of which can emerge via open-ended, recursive interaction among local knowledge, scientific knowledge, and competing valuations of the environment within specific communities (Figure 1). In highly modified systems, the predominant configuration of stream reaches, rather than the pristine state, becomes the frame of reference for the development of naturalization strategies (Figure 2). For stream reaches in east-central Illinois, the reference state is a straight, uniform trapezoidal channel. Relative to this frame of reference, the broad scope of naturalization can encompass the entire range of management options for enhancing morphological, hydraulic, and ecological diversity (Figure 2). In reaches that are unmodified or that have recovered from modification, naturalization focuses on preservation of existing diversity. Enhancement and preservation of diversity within individual reaches, when implemented in a manner that properly accounts for linkages with upstream and downstream reaches, will lead to an overall enhancement of geomorphological and ecological diversity throughout the watershed.

Most fluvial systems in the agricultural Midwest, while modified structurally, still function naturally in the specific sense that erosional and depositional processes are unconstrained by artificial structures, such as dams or human-reinforced channel boundaries. Thus, channels are free to adjust in an unrestricted fashion to imposed modifications. Over time such adjustments slowly lead to an increase in morphological and hydraulic diversity within the modified stream environment (Rhoads and Herricks 1996; Rhoads and Urban 1997). One naturalization option is to allow streams to passively recover from past channelization activities, eventually assuming a form and function generated by and compatible with the prevailing environmental conditions (Figure 2). Current knowledge of adjustment rates of low-energy agricultural streams suggests that this type of management may not yield tangible environmental benefits for decades or even centuries (Barnard and Melhorn 1982; Rhoads and Urban 1997). Moreover, it may not be compatible with the farmers' concern about preserving the integrity of tile-drainage systems. Despite these limitations, it is conceivable that some communities in the Midwest may view this management strategy as the preferred approach to naturalization. Other communities may favor a proactive approach, wherein portions of the stream system are dechannelized or otherwise reconfigured in an effort to accelerate the rate at which environmental benefits are realized (Figure 2). Another strategy might involve conducting frequent maintenance of stream channels for the purpose of drainage, but devising innovative, ecologically sensitive approaches to maintenance that preserve or enhance morphological, hydraulic, and ecological diversity (e.g., TerHaar and Herricks 1989; Rhoads and Herricks 1996). In this case, recurring human intervention may play an important role in assuring that the form and function of the system are sustainable. Finally, it is important to note that the ideas of restoration and rehabilitation, as defined by the National Research Council (1992), are subsumed by the concept of naturalization (Figure 2). If a rural agricultural community decides it is in their best interests to partially or wholly return a watershed to a predisturbance state, and adequate information and technology are available to allow the community to attain this goal, the result will be an increase in the hydraulic, morphological, and ecological diversity of the system, i.e., a form of naturalization. In a general sense, naturalization recognizes that the concept of ''natural'' is defined by the community relative to the modified state of the system and that the goal of naturalization is to drive the system as a whole toward a state of increasing morphological, hydraulic, and ecological diversity, but to do so in a manner that is acceptable to the local community and sustainable by natural processes, including human intervention (Figure 2).

## Conclusion

The basic argument put forward in this paper is that because community-based watershed management is fundamentally a social process, scientists and technical experts must develop an understanding of the place-based social worlds of local communities. Only by doing so will scientists be able to effectively situate their experience, information, and opinions within the process of community-based decision making. Our experience as participants in local watershed projects in the agricultural Midwest suggests that local people often discount or ignore scientific information if they perceive the bearer of this information as an outsider who is insensitive to the rituals and practices that constitute their shared cultural identity. On the other hand, when scientists invest the time and energy to establish relations of trust and mutual cooperation with members of a local community, effective partnerships can be forged between scientists and nonscientists. Through this process, scientists and nonscientists will begin to listen to, understand, and consider each others' opinions and information in community-based decision making about management of the biophysical environment. As part of this process, scientists must be prepared to revise general concepts to accommodate specific place-based contexts. The concept of naturalization, as described in this paper, illustrates how general notions about environmental practice, in this case restoration and rehabilitation, can be adjusted to encompass the broad range of potential outcomes of community-based decision making in watersheds characterized by intensive human modification of the biophysical environment.

Once scientists have positioned themselves to be heard by the community at large, they must be prepared to provide meaningful input to the decision-making process. In part, the value of this input will depend on the quality of scientific information (i.e., certainty, reliability). In an ideal management environment, a holistic naturalization plan first would be devised by mutual interaction between scientists and nonscientists and then implemented concurrently throughout a watershed. In reality, both planning and implementation are likely to occur incrementally because of fiscal, political, and technological constraints. Therefore, the development and implementation of sustainable naturalization strategies in the agricultural Midwest should be based on sound knowledge of the biophysical dynamics of low-energy, warm-water agricultural stream systems over a variety of scales (Rhoads and Monahan

1997). At present, attempts to naturalize streams are largely trial-and-error approaches that draw upon limited, general knowledge in geomorphology and ecology (Brookes and Shields 1996). Further scientific research is needed to develop an improved understanding of the geomorphological and ecological dynamics of human-modified agricultural streams at multiple spatial and temporal scales. This type of research will provide a reliable scientific framework for successful stream naturalization in the mid-western United States.

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