Natural Cities:
Urban Ecology and the
Restoration of Urban Ecosystems

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Abstract

The scientific community now embraces the emerging field of urban ecology as both valid and central to understanding the global environment. Given the concentration of human activity in urban centers, that humans are the dominant species in all ecosystems, and the pace of environmental change, urban ecology is a critical area for environmental research. Understanding urban natural resources and urban natural systems also has important implications for public health, economic development, education and community development in urban areas.

Since the late 1990s several cities have launched studies of their urban ecosystems. This paper presents a framework for urban ecosystem research that is accessible for community organizations and that includes a rapid assessment protocol that can link research to advocacy immediately. The paper also outlines specific legal and policy tools at the local, state and federal levels for protection and restoration of urban natural resources. The paper argues finally that by using the urban ecosystem as an organizing principle, urban residents can begin to reach across political and socio-economic divides to develop a cohesive vision for a metropolitan area.

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I. Introduction to Urban Ecology

The relatively young science of ecology attempts to forge a holistic understanding of the natural processes that take place within a defined system. The central idea is that a patch of the planet, a *natural community*, contains discrete living (biotic) and nonliving (abiotic) elements that interact in synergistic ways. These elements include the living organisms, the landscape patches, the parent geologic materials underlying the soils, and the local hydrologic and weather patterns. These patterns of interactions can be categorized and compared between and among various ecosystems. Energy flow (metabolism), food webs, predator-prey interactions and co-evolution are typical categories of investigation common to all ecosystems.[1] The scale of an ecosystem varies with the question being asked. Understanding the ecology of the Charles River, for instance, requires that the patch include at least 26 towns and cities. On the other hand, studies of the ecology of an endangered amphibian, such as the spadefoot toad, may be focused on a single vernal pool and its surrounding upland habitat.

Ecologists have been comfortable for over a century with the notion of natural ecosystems such as deserts, tundra, grasslands, old growth forests and estuarine salt marshes. Even animal societies such as honeybee colonies, termite mounds and wolf packs are routinely considered as ecological units.[2] However, the concept of the *natural city,* a human city functioning as an ecosystem on the scale of an estuary or a rain forest, is in its academic infancy.

Traditionally, the study of ecology has been applied to natural systems in such a way that the variable of human impact has been excluded from the biological equation. Our understanding of ecology, and its younger sibling science biodiversity, has been developed by sending researchers into pristine ecosystems in order to gather data on the intricate co-evolved relationships among organisms. Ecologists have focused on the interactions within the natural community. The new biodiversity scientists have tried to identify as many species as possible, and with those data, forge an understanding of species distribution and abundance. The studies have provided lucent images of nature and provide the infrastructure for the disciplines of biogeography (the mapping of species), behavioral ecology (the behavior of individuals and groups) and most recently, conservation biology (protecting those species from extinction). However, with the exception of those researchers interfacing with public health, the studies were conducted in remote areas where the human footprint was as small as possible. Those public health scientists who did work in cities were conducting research on the negative impacts of urban living and essentially trying to stamp out any remaining plant or animal populations that were deemed troublesome. Cities were not viewed as natural entities, but as foreign impositions upon the native landscape.[3]

The pervading perspective from the academic research centers was that true ecological research was possible only when one reached the wilderness. Here, the footprint of

human activity was small and had not yet destroyed the elements of a natural balance. The foundation of this approach to ecology traces its roots back to the transcendental writers of the late 19th century such as Thoreau and Emerson, who desired to escape the artificial environments of the city, and therefore wrote from solitary retreats where nature was encountered firsthand. The 20th century gave rise to many ecological pioneers bearing this aesthetic such as John Muir, Rachel Carson, and Aldo Leopold. Leopold's account of the natural history of his beloved Wisconsin wilderness in *Sand County Almanac* served as a manifesto to a generation of field biologists.

The dilemma posed by such approaches to studies in ecology is that while they provide beautiful and robust models of nature, they often lack the applicability to some of the most imposing challenges in human ecology, which lie in the management of our urban ecosystems. Nearly half of the world's population live in cities, many in mega cities like Mexico City that harbor nearly 30 million residents, most in abject poverty.[4] In the United States, nearly three-quarters of the population live in urban centers and that trend is increasing. The declining state, but increasing size and environmental importance of urban ecosystems, provides enormous opportunity for the application of ecological thinking and research. The heavy social burden of the injustices born of the urban environment demands that scientific talent be employed in the service of urban management. The ecological models developed in the remote beauty of national parks and wildlife refuges need to be tested and modified in order to provide guidance to those professionals struggling to solve problems and manage dwindling resources within the city landscape. The city as an ecosystem is a radical idea that challenges traditional scientists to think and behave in new ways.[5] There are indications that this urban perspective is grinding up and replacing some of the ecological dogma that currently exists.[6]

A revolution in science, viewed in real time however, is like watching the tide come in. Usually, the events are slow to unfold, and we need a marker from which to gauge the change. One notable indication that urban ecology has begun to achieve the status of legitimate science is the funding of two major projects by the National Science Foundation (NSF) that seek to reveal the ecological machinery of cities. Baltimore and Phoenix are urban research sites in the U.S. Long Term Ecological Research Network (LTER), a system of 1100 scientists working at 24 distinct sites across the world (http://lternet.edu/). Begun in 1980, the LTER program has attempted to research ecological phenomena on large temporal and spatial scales in order to identify and solve ecological problems. The philosophy has tilted towards the applied aspects of ecology, but the study sites have ranged from the polar ice of Antarctica to the rainforests of Puerto Rico. The inclusion of two urban ecosystems in this network represents a sea change in the discipline of ecology, and a recognition of the importance of understanding the ecology of our cities.

The development of ecological thinking about cities will have a broad and profound impact on all the issues of social importance to urban stakeholders. Public health, resource allocation, water quality, energy conservation, historical and natural preservation will all benefit from a revisionist approach that includes the biology of the system as the foundation for its understanding and management. The concept of the

natural city will have its roots in a series of scientific models that will be testable in a variety of urban environments.[7]

A. Why Should Cities Be Studied as Ecological Units?

The interest in urban ecology can be understood from four perspectives. First, human activity is concentrated in urban clusters. Even for those humans living outside of metropolitan centers in what are classified as rural landscapes, the productive activities of these people are often linked to resource requirements in nearby or distant cities.[8] Second, humans as a species dominate each of the earth's ecosystems, whether they are heavily populated or not.[9] Although this idea remains troubling to scientists, anthropogenic impact is an unavoidable variable in the study of ecology. Third, any modern model of ecology must include considerations of human impact in order to be of use as a predictive tool. Finally, developing an understanding of the ecological processes that occur within urban landscapes can be of great utility to those professionals charged with solving the social problems inherent in city life. We can examine these four elements in more detail.

Human demography has shown a steady increase in the percentage of people living in cities. Beginning with the advent of agriculture 5,000-10,000 years ago, humans have been developing bigger and more densely populated urban centers. The United Nations recognizes over 300 cities with population over 1 million people, with sixteen of these metropolises categorized as megacities (10 million or more inhabitants).[10] This pattern of urbanization is evident in both developed and developing nations. In the United States, the trend towards urbanization is accelerating.[11] Despite the migration to suburbia by middle class Americans after World War II, cities have continued to grow. This growth has occurred both as functions of density within the urban core and as urban sprawl. Over 75 million homes have been built in the United States since 1950, most within urban metropolitan areas. The expansion of urban areas since 1950 has gobbled up open space, doubling the physical footprint of cities to nearly 20% of the nation's land area (700,000 square miles).

As human population has increased, so has our species' impact on global ecosystems.[12] The fossil record points to five major periods of rapid extinction during the past 500 million years on the planet, all of which occurred prior to the evolution of our human lineage. These catastrophic events were triggered by rapid, un-buffered environmental change. The most recent complete cycle, triggered by an asteroid impact on the planet, occurred approximately 65 million years ago during the Cretaceous period and caused the extinction of at least 50% of all of the animal families on earth, including the last of the dinosaurs. Conservation biologists have detected the start of a sixth major period of rapid extinction, beginning in the past 200 years. This bout of biodiversity loss is directly linked to environmental degradation caused by human activity and over-exploitation of natural resources. The tremendous impact of humans on the biosphere is concentrated in urban areas where deforestation, soil erosion, pollution and exhaustion of natural resources is the most intense.

Ecological research has pondered the interactions of species in their natural setting for nearly 200 years. However, the shift from humans as a "confounding variable" to one that is a central element of scientific investigation is one that is in uncomfortable transition. The tension that exists between natural and social scientists is caused, in part, by this very issue. Although both camps embrace the scientific method, natural scientists and social scientists are separated by a methodological rift that runs along the axis of humans as a research variable. Natural scientists, such as physicists, chemists, geologists and biologists study natural phenomena in which human impact is minimized, or at least controlled for. Social scientists, such as psychologists, sociologists and economists embrace the human variable and make it the focus of original research. The city as a subject forces all the practitioners of science to cross the rift and work with a shared acceptance of the human factor as a legitimate subject of controlled study.[13]

Finally, bringing an ecological perspective to the challenge of urban management provides a new set of tools for addressing the problems of our cities.[14] Social injustice, poverty, public health and pollution are all societal problems with deep ecological and environmental roots. One of the tremendous advantages of science as a lens for viewing the world is that it brings with it a sense of dispassionate neutrality that can provide a fresh perspective on these problems. The teaming of science with social concern has spawned the relatively new field of environmental justice, which has proven to be a robust approach to such problems as toxic waste management and brownfields reclamation.

B. What Should the Scientific Protocols for Urban Ecology Look Like?

Once the decision is made to tackle ecological questions within the urban landscape, we are confronted with the challenges of designing relevant protocols that address the human social needs. The historic absence of the human dimension in traditional ecological study has forced urban ecologists to redefine the way in which they frame their questions. The old idea that cities are an imposition on the landscape leads an investigator to pose only certain types of ecological questions. They tend to be organized around ecological measurements *in* the city that can be compared to conditions outside of the urban setting, in "undisturbed" areas. These kinds of questions are potent sources of good science, but they provide only a limited understanding of the city as an ecological entity in itself. Urban ecology requires the establishment of a doctrine of ecological knowledge *of* a city, recognizing the legitimacy of the urban ecosystem.[15]

Emerging in the literature is a dichotomy between studies that have addressed the ecology *in* a city[16] and those that are describing the ecology *of* a city. With the exception of seminal research on the ecology of Hong Kong[17], researchers doing work in the urban context have posed *ecology in* questions. These questions ask about conditions *within* cities compared to those *outside* of the urban landscape. The city infrastructure, viewed as an imposition, modulates the natural processes in many complex ways. Popular topics include plant and animal distribution patterns, edge effects such as roads and fences, before and after construction effects, and pollution impacts. A more holistic approach to understanding cities requires the formulation and investigation of questions regarding the *ecology of* the urban landscape.

Ecology of research topics that recognize the city as a legitimate ecosystem include the ecological effects of land-use change, the spatial distribution of resources (abiotic) or populations (biotic) and whole system metabolism (energy flow). Using a watershed approach is an approximation of the type of perspective necessary to achieve the scale necessary for *ecology of* questions.[18] In a watershed model, all of the metabolic (energy & nutrient) inputs and outputs to the system are defined by the boundaries of the land that is drained by a single river or stream. As the science matures, the appropriate application of ecological science to city systems will require both a shift in perspective and the addition of new tools of investigation.

One particularly important addition to the urban ecologist's toolbox will be a set of research protocols that calculate the human social component. Standard ecological models[19]suggest three biophysical forces or drivers that stimulate and modulate the nature of any ecosystem: 1) The flow of energy, 2) the cycling of matter and 3) information flow among humans. These forces are seen to exert influence on ecosystem patterns and processes in relatively pristine systems. These forces lead to five major processes in ecosystems; primary productivity (energy captured by plants through photosynthesis), populations (growth and decline), organic matter (the raw "stuff" of food), nutrients (available food) and disturbance (climatic, geological or human). In standard ecological models, the human dimension is generally categorized as "disturbance." The new paradigm for studying *ecology of* questions requires that the researchers' toolkit be packed with a way of calculating socioeconomic "drivers" to the urban ecosystem. These drivers must be considered just like the three biophysical drivers mentioned above.

The socioeconomic drivers include information flow as mentioned before, but add cultural values and institutions that create a suite of additional patterns and processes that contribute to ecosystem dynamics. Grove and Birch (1997)[20] suggest that additional patterns include the economic system, the power hierarchies, land use and management, the demographic patterns and the designed or built environment. The integration of these socioeconomic drivers into the ecological equation requires cooperation among natural and social scientists, as well as urban planning professionals.

The biggest challenge to creating robust scientific models of the natural city is to try and find ways to blend the ongoing requirements of the city with the needs of the scientists to collect information. Typically, when scientists are conducting ecological research, the site at which they're working is essentially shut down and isolated from human disturbance. For example, if a team of scientists were conducting biodiversity studies of a local bird population in a rain forest, they would include as part of their methodology assurances that no other humans had entered the study area during the time they collected their data. In this way, scientists would be confident that the data they collect would represent the most accurate picture of the avian community structure. However, when scientists are working in the city, and the subjects include humans, this type of approach is essentially impossible. Avian biodiversity studies conducted in the urban context need to accept human presence as part of the model and actually find a way to quantify and understand the character and quality of human presence. In an urban setting, humans should be viewed a "keystone species" whose own ecology has dramatic and integral

impacts on all other species within the system being studied. Sociologists have known this for decades and have found ways to gather information that is both scientifically robust and whose methodologies are non invasive to the peoples that they're studying. Urban ecologists will need to adopt similar strategies.

A second important hurdle to clear is the obstacle of arbitrary political boundaries. Cities are often characterized by delineation along county, town, ward and precinct lines. While these boundaries may make sense in the context of the management of human behavior, they are typically meaningless to the plants and animals that constitute the natural community. Ecological studies must be rooted in solid methodologies, one of which is the recognition of the functional boundaries that have an impact on the migration or dispersal of the organisms being studied. In the emergent science of urban ecology, the watershed boundary has become the coin of the realm.

Watersheds represent the total land area drained by a river or estuary and present a reasonable unit of study. From a water pollution perspective, a watershed will contain both the source of a polluting chemical, such as the factory or sewer pipe, as well as the bodies of water most directly affected by the discharge. Thus, from a public water safety perspective, the watershed represents the local "vessel" from which water is both withdrawn and recharged. There is an inherent sense, therefore, to studying ecological process at the watershed level, despite the fact that a given city's limits might include more than one watershed, or a given watershed might include more than one city.

Protocols for studying urban ecology and focusing on *ecology of* questions are being adopted at a variety of sites around the United States. Two of the most notable current urban ecology projects are located in Phoenix and Baltimore. Heavily funded by the National Science Foundation, these two projects are part of the Foundation's efforts to support long-term ecological research. These research programs are part of an organized network of ecologists whose studies are designed to last at least 30 years. The goal of this integrated program is to provide a research framework that is applicable to any urban ecosystem.

Although long-term studies are preferable, they are not always possible in the urban context. Sites of interest within the natural city may be under pressure for development with associated changes in their land use. In addition, long-term ecological research is expensive, and local municipalities cannot afford to support projects for extended periods of time. These kinds of pressures select for a more rapid assessment of the ecological value of the site. This poses an additional challenge to scientists, as the luxury of time has been removed from the research methodology.

In response to the need for more tools to analyze urban ecosystems, The Urban Ecology Institute is coordinating a collaborative project that places the task of ecological research of urban resources into the hands of local stakeholders. This scholarly, but grassroots, approach is needed because Boston, like most cities, does not have the resources associated with an LTER designation by the NSF. Instead, we will have to be frugal, and investigate the city's resources using local talent and resources. With modest funding from the U.S. Forest Service, the goal of this collaboration is to establish a rapid

assessment methodology that both describes and evaluates the ecological or biodiversity value of a given patch within the city. The program provides a mechanism to directly link the fieldwork of scientists to the action steps of open space protection and restoration.

The underlying principles of the program require that the field component be relatively inexpensive to undertake and that the methodologies be completed in one day. Frugality and speed are required, due in large part to the scope of the work. Extrapolation from the initial review of the possible sites in a two square mile section of both East Boston and Medford suggest that the Boston metropolitan area may contain 500, *or more*, viable parcels worthy of protection and restoration!

The initial work products of this pilot program are; 1) the development of novel field protocols that will be used by scientists to characterize appropriate patches, 2) the application of these protocols to a sample of open space patches within the Boston metropolitan area, and 3) an ecological review of the assessed lots that have been ranked for further economic and political analysis.

The project will proceed in three phases. First, a map of suitable sites is created using existing G.I.S. maps and overlays, along with the associated satellite photographs that were used to create the original digital overlays. Second, using the maps, the sites of interest are investigated with on-site visual reviews. A field study team will perform the rapid assessment protocols at each of the sites that look promising. Finally, after the field data have been collected, the sites can be ranked according to their ecological value. This ranked list of suitable sites provides the basis for their protection and potential restoration.

The success of this project is contingent upon two novel aspects of the research methodology. One of these contingencies is the ability of the research team to accurately select the universe of possible sites from the G.I.S. maps that are available. Using the data layers of the Massachusetts G.I.S. system, potential sites are identified both by their size and connectivity to existing biodiversity megasites, such as the Middlesex Fells, Mystic River Reservation, Franklin Park, Logan Airport and the Lynn Woods. The minimum size that a site must be in order to be eligible for inclusion varies according to the population density of the area and proximity to one of the megasites. For example, a small isolated site (less than one acre) might be passed over in Medford, where open space is relatively abundant. However, a similar site in the densely populated East Boston area, near to an anchor site such as Logan airport, would most likely be selected for the full assessment program. Certain map designations such as wetlands, rare species habitats, vernal pools and forested areas suggest obvious locations for further investigation. Other data layers, when used in conjunction with the preceding list, can reveal a surprising number of additional possibilities. Patches designated as municipal lands may contain vegetated school grounds or cemeteries. Areas of open space may harbor significant tracts of vegetation or forested canopy. Even those areas defined as industrial may contain suitable sites, especially if they help connect other areas to the biodiversity megasites. The ability to use satellite photographs (orthophotos) in conjunction with the digital maps helps to reveal these sites that are suggested by the confluence of the data layers. Ultimately, access to persons with local site knowledge,

such as members of community groups or conservation commissions, will prove invaluable for fine tuning this process so that potentially valuable sites are not excluded from the initial review.

The Rapid Assessment Program was initiated in the summer of 2001 and the exact nature of the protocols are still being developed. However, the biotic assessment will include four categories of biodiversity analysis: breeding and migratory birds, Odonates (dragonflies), terrestrial insects and plant community structure. Each of these taxonomic groups of organisms provides a window into the ecological processes that are occurring at the site. The presence or absence of certain species can serve as indicators of environmental degradation or stress. The choice of dragonflies, birds and insects reflects the cosmopolitan distribution of these species. They are found at almost all survey sites and can be readily located and identified. The observations can be made directly, or videotaped for later identification by specialists. The choice of plant community structure is another fundamental measure of biodiversity that can be accessed throughout most of the year. These data can be analyzed to provide multiple levels of ecological structure at the sample sites. The various measures of biodiversity that can be applied to the data set will provide both a qualitative measure of ecological health at the site and a relative measure of biological value among sites.

The critical idea being explored here is that the data collected has a novel purpose. They will not used to compare urban sites to some rural standard that suggests that these urban sites are degraded beyond repair. Inevitably, if the standard is a pristine ecosystem, than an analysis of urban sites could yield no other result. Instead, these data are useful in the context of measuring the diversity of many urban sites and developing a relative sense of their biological value. The sites will be analyzed for additional characteristics such as connectivity to other open spaces, proximity to water, potential benefits for watershed health and function, ease of restoration, patchiness of the natural community and overall size. These analyses will result in a value system that is nested within the context of an urban system and recognized for both its biogeophysical and socioeconomic drivers. The true efficacy of this approach will be realized when these value systems are linked to urban restoration projects that maximize the existing resources of the city and link them to the surrounding ecosystem.

C. Conclusion

The development of a new perspective on the ecology of urban systems requires considerable effort on the part of the scientific community, but the potential payoff on the investment is enormous. If one accepts that science should be in the service of humanity, than the needs of urban dwellers worldwide provide a compelling challenge to natural and social scientists. Many conservation biologists agree that densely populated urban centers represent the most likely scenario for a sustainable planet. Understanding the ecology of cities is the first step towards improving the quality of life for all of its living inhabitants. Livable natural cities increase the probability that sprawl can be minimized, and the remaining open spaces outside the city limits can be preserved. The promise of science done well is that its findings provide the basis for rational solutions to human

problems. The application of ecological thinking to the vexing problems of the world's cities provides tantalizing opportunities for science to do more good work.

II. Legal and Regulatory Tools: Introduction

Just as the science of urban ecology is in development, regulatory efforts to protect and restore urban ecosystems are in their infancy. Urban ecology as a field of research and advocacy is unique in several ways, each of which has implications for regulatory efforts.

Advocacy to protect urban ecosystems proposes that environmental resources are to be studied and understood in a systemic context. That is, natural resources are to be understood and managed within the context of a regional ecosystem, not as individual media (land, water or air). In other words, the resources are managed on the basis of a specific place, as defined by scientific boundaries (an ecosystem) rather than by political boundaries (a town) or regulatory boundaries. Insofar as the environmental regulatory scheme is based on statutes that focus on specific media, these statutes must be utilized in creative ways to manage resources on a systemic basis.

In this regard, urban ecological research and advocacy can draw on the recent commitment at the state and federal levels to place-based environmental protection. The foremost examples of this approach to environmental protection and management are the watershed management programs implemented over the past five to ten years in many states and at the federal level. These programs are based in the realization that environmental impacts cannot be limited to a particular geo-political area and they assess an entire watershed when devising regulations to deal with issues such as land use and effluent limits (limits on discharge of pollutants).

Secondly, of course, urban ecology is a departure from traditional environmental advocacy in that the focus is on places that have long been considered the antithesis of the environment or of nature: urban areas. As noted in the introduction, urban areas are important focal points for environmental protection because of their enormous impact on natural communities and resources. Urban areas, although not typically thought of as important to environmental protection, may be the most important environmental challenge of the next century. The wisdom of focusing attention on healthy urban environments is clear. Demographic trends are putting an ever-increasing percentage of our population in urban centers, and metropolitan areas are growing at an alarming rate. In Massachusetts, there was a 21.7% increase in developed land from 1982-1992. In the greater Boston area, the population increased 24.3% between 1950 and 1990, while the urbanized area grew 158.3%.[21] Massachusetts is the thirteenth most populated state, with 96.1% of its population in metropolitan areas.[22] These data reflect trends that are occurring across the country. Urban population is indeed growing. However, the amount of land being consumed by development far exceeds this population growth. These statistics are leading many in the environmental movement to think about environmental protection in cities, including topics such as sustainable development, smart growth, and sprawl. With more people living in cities, and urban areas expanding beyond their current boundaries, ensuring that these areas are ecologically healthy presents a great challenge

to the environmental movement. Indeed, many environmentalists are coming to the conclusion that developing more sustainable, healthy cities may be the key to saving the overall environment.[23]

Although the legal and policy tools that will be discussed in this section are not specific to urban areas, they must be modified and used in innovative ways to address the unique challenges of urban natural resource protection. The goal of all of these strategies is to improve the ecosystem functions of an urban area. The city is an ecosystem in its own right, with energy and resources flowing into and out of the system, and with human beings as the keystone species. The goal of the application of these legal tools in an urban area is to improve the ecological health of urban environments and surrounding ecosystems, and to improve the quality of life for urban residents by linking urban ecosystem restoration to public health, economic development, educational opportunity and community development.

III. Local and State Regulatory Programs for Urban Ecosystem Protection and Restoration

A. Zoning/Local Regulation

> "If you want to make your community better, begin at once by throwing out your zoning laws. Don't revise them—get rid of them. Set them on fire if possible and make a public ceremony of it; public ceremony is a great way to announce the birth of a new consensus." James Kunstler, *Home From Nowhere*, Atlantic Monthly, 278, No. 3, 43 (1996).

Urban form affects habitat, ecosystems, endangered species, and water quality through land consumption, habitat fragmentation and replacement of natural cover with impervious surfaces. At the local level, urban form is dictated primarily by a municipality's zoning code. Zoning has been defined as "the division of a municipality or other local community into districts, and the regulation of buildings and structures according to their construction and the nature and extent of their use, and of the regulation of land according to its nature and use."[24] There is, however, a growing feeling that zoning codes in the United States have created an urban environment that lacks a sense of place or community. Pedestrian friendly, mixed use neighborhoods have been sacrificed to the separation of cities into use districts, with resulting increasing American dependence on the automobile, which in turn increases air pollution and the amount of impervious surfaces. Urban landscapes have changed little since Ian McHarg described them as "the expression of the inalienable right to create ugliness and disorder for private greed."[25] Environmentalists are now looking towards revising and rewriting zoning codes to create more sustainable, healthy environments. Further, there is a movement towards providing a sound ecological basis for zoning decisions. Although environmental concerns are not the primary focus of zoning today, this movement can be seen as the natural extension of the environmental concerns upon which the first zoning decisions were based.

Land use regulations based on nuisance have existed in the United States since the seventeenth century.[26] When urbanization began to occur, the need for a comprehensive system of land use control to avoid overcrowding and separate uses became evident. Residential uses needed to be separated from the odor and noise of slaughterhouses and other noxious uses. In 1924, the U.S. Department of Commerce promulgated the Standard State Zoning Enabling Act, which provided a model for states to follow in delegating police power to municipalities to prepare, adopt, and administer zoning codes. In the following years, many cities and towns adopted comprehensive zoning ordinances. Although the act required that zoning regulations be made "in accordance with a comprehensive plan," it failed to detail exactly what was to be included in a comprehensive plan. Devising environmentally sensitive land use schemes may depend on basing decisions on an underlying map of a municipality's sensitive areas in order to reach its full potential to protect natural resources. The comprehensive plan could provide the basis for reorienting zoning codes on the basis of ecological systems and goals.

The constitutionality of a comprehensive municipal zoning ordinance was first tested before the United States Supreme Court in 1926 in the case of Euclid v. Ambler Realty Company, 272 U.S. 365 (1926). In Euclid, the Supreme Court upheld a municipality's right to divide itself into residential, industrial and commercial districts. Here, the court was required to determine whether the ordinance at issue was a valid exercise of the police power or an unreasonable and arbitrary exercise of the powers of self-government and an impairment of the rights guaranteed by the U.S. Constitution. In upholding the ordinance, the court reasoned that the exclusion of industrial and commercial uses from the residential district bore a rational relationship to the health and safety of the community and was therefore a permissible exercise of the police power. For the past seventy-five years, the police power has served as the basis for a community adopting zoning ordinances.

Traditional zoning of the kind that was upheld in the Euclid case divides a municipality into districts based on economic and social values. Uses are separated and land use designations are made in order to further economic interests of landowners and social goals. This type of zoning rarely reflects an understanding of, or an interest in protecting, the underlying natural resources, instead increasing landowners' economic expectations based on density allocations. Once a density allocation is established, it is difficult to persuade a developer not to build-out to capacity, regardless of the harm to the community or the underlying natural resources. There are, however, mechanisms whereby ecological values can be incorporated into the zoning process. Traditional zoning, overlay zoning, and ecologically based municipal land use planning will all be discussed as local tools available to protect a municipality's natural resources.

B. Euclidean (traditional) Zoning

The Act which forms the basis for the current Massachusetts Zoning Act, 1975 Mass. Acts c. 808, suggests the following as some of the possible objectives which a municipality might seek to achieve through zoning laws:

- To lessen congestion in the streets;
- To conserve health;
- To secure safety from fire, flood, panic and other dangers;
- To prevent overcrowding of land;
- To avoid under concentration of population;
- To encourage housing for persons of all income levels;
- To facilitate the adequate provision of transportation, water supply, drainage, sewage, schools, parks, open space and other public requirements;
- To conserve the value of land and buildings, including the conservation of natural resources and the prevention of blight and pollution of the environment; and
- To encourage the most appropriate use of land throughout the cities or towns, including consideration of the recommendations of the master plan, if any, adopted by the planning board and the comprehensive plan, if any, of the regional planning agency.

1975 Mass. Acts 808, §2A.

Obviously, it was anticipated that zoning could contribute to the protection of environmental values. To a large degree, zoning has failed to protect natural resources, focusing instead on economic and social values. It will take a paradigm shift to get municipalities to plan based on an understanding of their underlying natural resources. Community groups must be at the forefront of advocacy for such a change.

Methods for zoning to incorporate environmental values will be discussed later in this section. Short of such a shift in focus, however, traditional zoning ordinances can be formulated in such a way as to have positive impacts on air pollution as well as land use in an urban environment. Often included in a zoning ordinance are provisions for parking spaces associated with particular types of development. By limiting the number of parking spaces required, a zoning ordinance can provide a disincentive for people to drive to the site, thereby improving air quality in the area. Further, by requiring fewer on-site parking spaces, there will be a decrease in the amount of impervious surfaces, and a corresponding improvement in water quality and amount of runoff.

A zoning ordinance can also be used to protect wetlands, which represent one of the most valuable urban resources. In Massachusetts, zoning has come to have a broader meaning than just dividing a municipality into use districts. In the Zoning Act, zoning is defined as "ordinances and bylaws, adopted by cities and towns to regulate the use of land, buildings and structures to the full extent of the independent constitutional powers of cities and towns to protect the health, safety, and general welfare of their present and future inhabitants."[27] This definition does not differentiate between a zoning ordinance and any other land use regulation adopted by cities and towns. Any land use regulation can therefore be considered a zoning regulation as long as it is within the constitutional powers of the municipality and is adopted pursuant to the Zoning Act. Therefore, sign and earth removal regulations, as well as floodplain and wetlands construction, are often carried out through zoning ordinances that are applied uniformly throughout a

municipality, without differentiation from district to district.[28] Regulating what can be done in a wetland area by way of a zoning ordinance is an effective local management tool, as the only route for appeal of a permitting decision is to Superior Court, where the level of deference to a municipal zoning decision is high. However, permitting decisions made under a zoning bylaw are not made by a conservation commission, which is the only local body devoted exclusively to protecting the environment.[29]

As noted, zoning maps currently bestow economic value on private property through density allocations. These allocations are not based upon any analysis of the carrying capacity, health, structure or function of the community's natural resources. Furthermore, it can be expected that the owner/developer will build the property out to maximum density, thereby optimizing profit for the parcel. Zoning bylaws dictate the uses to which a certain piece of property may be put. Indeed, property law often collides with zoning and other local land use regulations when a property owner challenges the effect that a particular regulation has on the economic benefit of his property through a takings claim.

In addition to traditional zoning tools, other local regulations can be used to effect positive environmental change in an urban setting. Reducing the amount of impervious surfaces and the number of cars on the roads can have a positive impact on the urban environment. Toward that end, the Boston Air Pollution Control Commission had adopted regulations limiting the number of off-street parking spaces for cars in downtown Boston, and providing for the granting of permits for such spaces. The court upheld this regulation, noting that "[m]unicipal regulation by a combination of zoning controls and other statutorily authorized means is proper."[30]

Local permits can be conditioned on the dedication of a certain amount of property to improving the environmental condition of a city, as long as the regulation does not go "too far" and affect a taking. One case of particular relevance in an urban setting was the Supreme Court decision in Dolan v. City of Tigard, 512 U.S. 374 (1994). There, the city gave petitioners a discretionary permit to expand their store and parking lot, but required that they dedicate roughly ten percent of their land within the 100-year floodplain for a recreational low-density "greenway" flood area and improvements for storm drainage, and that they dedicate a fifteen foot strip of their land for a bike path. The conditions were justified on the basis of promoting flood control and minimizing traffic congestion. The Supreme Court held that the City did not make sufficient findings to justify these conditions. The city must "make some sort of individualized determination that the required dedication is related both in nature and extent to the impact of the proposed development."[31]

The Dolan case provides guidance to municipalities and community groups working to condition local permits in order to improve urban environmental health. Grassroots environmentalism is needed to keep track of development projects that will impact neighborhood quality of life. In order to ensure that projects are appropriately structured, it is necessary for community groups to keep apprised of, and get involved in, local permitting processes.

This vigilance is particularly important in urban areas where "white flight" and disinvestment have left a large low-income, minority population in the inner city. These often disenfranchised communities have suffered disproportionately from noxious uses being located in their neighborhoods, raising environmental justice concerns. Zoning codes, while appearing neutral on their face, may be perpetuating the cycle of siting environmentally harmful uses in these neighborhoods. For instance, in Boston, the Boston Zoning Enabling Act asks whether a conditional use such as an asphalt plant is "appropriate" for the surrounding neighborhood.[32] A heavily polluting industrial use will be appropriate in an area where property values are low and similar uses have previously been located. Further, there is currently no mechanism whereby cumulative impacts of polluting industries are taken into account when permitting decisions are made. Therefore, a large number of relatively small polluting industries may be located in a particular neighborhood. Although each use is not in and of itself a major health problem, in the aggregate there is a great impact on the residents of the neighborhood. Thus, without a holistic look at zoning codes and local permitting decisions, unhealthy environmental conditions are likely to continue in the urban core.

Environmental justice advocates in Massachusetts have begun to address this issue with a bill currently pending in the state legislature. The Environmental Justice Act (S. 1145) would create a new program to identify Areas of Critical Environmental Justice Concern—a new "ACEJC program" to protect people where they live, work, and play. The bill directs the state Office of Environmental Affairs to develop statewide regulations for the protection and use of areas of critical environmental justice concern. Once the bill is passed, details of how it will work will be decided through a public process to develop regulations. Citizens of polluted areas could direct their own future by applying for ACEJC status. The bill would increase the level of protection afforded environmental justice communities, in the same way that projects in Areas of Critical Environmental Concern are currently scrutinized more carefully. In this way, cumulative impacts could be considered when analyzing proposed projects in already overburdened neighborhoods.

C. Ecologically-Based Land Use Planning

In order to force local zoning to take natural resources into account, community groups must advocate for a local process that starts with a natural resource inventory. In this way, zoning decisions can be made with the complete knowledge of the community's resources, and planning can occur prior to making these decisions. Initially, zoning was expected to be subordinate to a master plan.[33] This type of planning gives the community an opportunity to determine its long-term interests by consensus. Only with a full understanding of the underlying natural resources can a community make informed decisions that protect the environment.

This type of planning based on natural resources has been called ecologically-based municipal land use planning, environmental zoning, and watershed-based zoning. Whatever the name, the concept remains the same—growth and development should be directed to those areas that can best manage the impact—those areas that contain comparatively less sensitive ecological resources. In an urban area, there may not be a great deal of choice as to where to locate development, but the principles can be used to

improve site design by integrating open space and placement of buffers, as well as by minimizing the amount of impervious surfaces. In addition, local design codes could even be drafted to encourage biodiversity of different sorts. It is not inconceivable, for example, that all new development in a given area might be required to include vegetation of a particular density and type that would provide habitat for birds and butterflies. This might turn all new development into habitat islands in a sea of concrete. With an understanding of how an urban area functions ecologically, it may be possible to write zoning codes with an eye towards increasing tree cover in a particular section of town. This type of ecologically sensitive design has been found to increase property values. A study conducted in Atlanta found that the presence of trees and natural areas measurably increased the residential tax base. [34] Such a change in zoning requirements would therefore be both sound ecological and sound economic policy.

The Charles River Watershed Association (CRWA), a nonprofit organization located in Newton, Massachusetts, has piloted the innovative use of zoning to protect environmental values. CRWA has undertaken an environmental zoning project in conjunction with the Town of Holliston, Massachusetts. This project seeks to turn the planning paradigm on its head, starting with an analysis of the town's water resources—local water supplies, stream flow, and capacity for wastewater treatment and storm water management—and designing zoning ordinances and directing growth to minimize impacts on those resources. CRWA undertook an analysis of Holliston's groundwater recharge areas, combined with determining which lands were unprotected and undeveloped, in order to create a hierarchy of lands that needed to be protected as open space to protect recharge areas. CRWA then drafted model zoning ordinances to direct the town's future growth in ways that protect these high priority lands from harmful development. In this way, a municipality's zoning code can be used to protect beneficial environmental resources.

D. Overlay Zoning/Interim Planning Overlay Districts

As previously discussed, traditional Euclidean zoning, the division of a municipality into use districts, does not take environmental values into account, focusing instead on economic and social values. In addition to not focusing on environmental values, Euclidean zoning is often too inflexible to accommodate the irregular boundaries of environmentally sensitive areas and resources. Therefore, another method is needed to provide additional protections for these areas. Overlay zones use performance standards to protect environmental resources, whether they be reservoirs, aquifers, forest or beach areas. Performance standards are criteria established to control and minimize offensive by-products of land uses, such as noise, odor, pollutants, and runoff. These requirements do not take the place of traditional zoning controls, but impose additional requirements on all properties within sensitive environmental areas. Overlay districts are subject to the same type of judicial scrutiny requiring a connection between the standard and the governmental objective that were discussed with respect to the Dolan case. For example, a performance standard that regulated dust and "objectionable noise" coming from a coal operation was upheld because the ordinance was reasonable and closely related to the legitimate state goal of protecting the public from offensive land uses.[35]

Finally, cities can use interim planning overlay districts to protect areas from development under current zoning when necessary to prevent unwanted environmental and social consequences. Such an interim planning district was used in an urban context to control development on a large, abandoned brownfield site in Chelsea, Massachusetts. The site, a 38-acre commercial parcel that abuts an urban creek, is currently a sea of parking, along with several small retail shops and a now out-of-business large, anchor store. The city discovered that a "big-box" retailer was looking to move onto the site, against the wishes of both the city government and a very active environmental community group, the Chelsea Green Space and Recreation Committee. With the support of the Green Space Committee, the city adopted a Shopping Center Interim Planning Overlay District, suspending the current zoning on the parcel until a planning study was completed. The overlay district prohibited the building inspector from issuing any permits to "use, alter, construct, reconstruct, or expand any building or structure" within the study area "unless such use, alteration, construction, reconstruction, or expansion is equal to or less than a total gross floor area of eight thousand (8,000) square feet." As justification for this overlay district, the city stated that it was necessary in order to manage the visual, traffic, and noise impacts on residential neighborhoods and historic resources; the desires of the City's residents not to be subject to poorly planned large-scale development; the intent of the City's residents to reclaim reasonable public and visual access to its waterfront resources; the need to preserve and protect the City's natural resources; and the need to encourage an economically sound mix of commercial, residential, and light industrial uses. (Citation to Shopping Center Interim Planning Overlay District, Chelsea Zoning Ordinances) Obviously, not all of these interests are environmental. However, it is important when using zoning ordinances to effect positive ecological change, to remember that quality of life in an urban setting includes economic as well as environmental prosperity.

E. Other Local Tools

Zoning is only one way for municipalities to protect and improve the conditions of their ecosystem. In Massachusetts, the State Executive Office of Environmental Affairs has given municipalities tools to plan for and improve their local environment. Signed into law by Governor Cellucci on September 14, 2000, the Community Preservation Act is statewide legislation that enables cities and towns to exercise control over local planning decisions. The Act provides new funding sources, through a surcharge on real property, which can be used to address three core community concerns:

- Acquisition and preservation of open space
- Creation and support of affordable housing
- Acquisition and preservation of historic buildings and landscapes

Ten percent of the money raised through the surcharge on real property must be used on each of the above priorities. The remaining seventy percent of the money raised may be divided between these as the community sees fit. A community preservation committee is established in each town that votes to accept the provisions of the Community Preservation Act in order to study the needs, possibilities and resources of the community

regarding community preservation. This committee then makes recommendations to the legislative body for the acquisition, creation and preservation of open space, for the acquisition and preservation of historic resources, for the acquisition, creation and preservation of land for recreational use, for the creation, preservation and support of community housing and for rehabilitation or restoration of such open space, historic resources, land for recreational use and community housing that is acquired or created as provided in this section. In this way, decisions are made on the basis of a complete knowledge of both the natural and historic resources that exist within a municipality.

The Community Preservation Act is a state law that authorizes municipalities to raise local money and to plan for open space acquisition, historic preservation, and the creation of affordable housing. Each community may develop a needs assessment procedure under the act, and can develop a plan to respond to the identified needs. Combining this approach with true planning based on natural resources would complete a municipality's ecological land use planning.

In the first five months after the CPA became law, 52 Massachusetts communities held ballot votes on the issue, with 31—or 60 percent—voting to adopt it. Recently, North Andover, a town just north of Boston, became the first community in the Commonwealth to use CPA funds to preserve land. The town purchased a 27-acre tract of land that will contribute to water quality in the town by providing a buffer for the town's sole source of drinking water.

F. State Environmental Law: Wetlands Protection Act

Urban natural resources can also be protected using state laws that apply without the requirement of local adoption. The protection of wetlands in Massachusetts is an example of a combination of state oversight and local implementation. The state Wetlands Protection Act (M.G.L. c. 131, §40) establishes a permit system where the state sets uniform standards which local conservation commissions are empowered to implement. A municipality may also choose to adopt its own wetlands ordinance, which must be at least as stringent as the state act. Having a uniform statewide standard avoids problems which may occur in the context of zoning, where one municipality can adopt radically different standards than a neighboring town in order to manage growth and resources differently (exclusionary zoning).

The authority of local conservation commissions derives from a delegation of the state police power to cities and towns. In Massachusetts, "[a] city or town may, by the adoption, amendment, or repeal of local ordinances or by-laws, exercise any power or function which the general court has power to confer upon it, which is not inconsistent with the constitution or laws enacted by the general court in conformity with powers reserved to the general court…, and which is not denied, either expressly or by clear implication, to the city or town by its charter."[36] This article gives local governments authority to exercise broad police powers over local matters, including environmental and land use law.

Thus, local governments can protect wetlands using a general ordinance that is more protective of natural resources than the Wetlands Protection Act (discussed in more detail later). A municipality may "impose more stringent controls than those established [by the WPA], and, in proper cases, may even 'prohibit outright any disturbance of covered lands.'"[37] Allowing a town to regulate wetland use by means of a local bylaw eliminates the opportunity for Department of Environmental Protection review of its decision. If a decision made under a local by-law is appealed, the only recourse is to the Massachusetts courts. Indeed, towns must be careful when adopting wetlands protection bylaws. If the local bylaw simply reproduces the Wetlands Protection Act, the final arbiter of any dispute will be the Department of Environmental Protection. If, however, the local bylaw is more stringent in some way than the WPA, the local commission will make the decision, which can be appealed only in the courts.[38]

In addition, regulating wetlands by way of a non-zoning by-law is sometimes preferred because zoning acts do not allow a conservation commission to administer zoning by-laws. These by-laws allow a town to customize protection to its own needs, such as adding protection for aesthetic beauty, limiting exemptions found in the Wetlands Protection Act, or requiring contractors to post a bond as insurance against a permit violation. A non-zoning bylaw could potentially also address non-point source pollution.[39]

The rate of wetlands loss in Massachusetts has slowed. Although we are still losing wetlands, primarily due to urbanization, the rate of loss has slowed in the last twenty years. This indicates that the Wetlands Protection Act is having some influence over land use decisions and has been somewhat effective in controlling wetlands loss. Because urbanization is the largest contributor to wetlands loss in Massachusetts, it is particularly important to be vigilant in the application of the act to projects in cities and at the edges of urban sprawl.

The Wetlands Protection Act requires a permit for any work in a resource area that is named in the Act.[40] The Act has a larger scope than just the protection of wetlands. It is intended to protect those resource areas that contribute to the following interests: "protection of public and private water supply; protection of ground water supply; flood control; storm damage prevention; prevention of pollution; protection of land containing shellfish; protection of fisheries; and protection of wildlife habitat."[41] These resource areas are protected through performance standards that have been promulgated by the Department of Environmental Protection. The performance standards ensure that projects proposed in these resource areas will not have a significant adverse impact on the resource area.[42]

A developer wishing to complete a project in any of these resource areas must apply to the local conservation commission for an Order of Conditions. The developer submits a Notice of Intent, describing the project and the safeguards in place to protect the resource area. After notice and a public hearing, the conservation commission can either permit the project as proposed, decline to permit the project, or permit the project with conditions designed to protect the functions of the resource. Regulations promulgated by the Department of Environmental Protection provide performance standards,

environmental criteria that must be met to minimize the impact of the project on the resource area, which the conservation commission uses in making its permitting decision. Decisions of the conservation commission can be appealed to the Department of Environmental Protection, as well as to the Superior Court.

As stated above, urbanization is the leading cause of wetland loss in Massachusetts. This dynamic suggests that the Wetlands Protection Act should be used to slow the rate of sprawl, and that conservation commissions in communities on the urban fringe should be diligent in protecting wetlands in their communities. Further, there may be an opportunity to create a wetlands banking program at the state level, allowing a developer who wishes to proceed with a project on wetlands to purchase and protect wetlands at some other location in the watershed so that there is no net negative impact as a result of the project. This type of program would need to be implemented very carefully to ensure that there is no resulting loss of capacity for wetlands to perform important ecological services such as flood control and water quality protection.

G. Chapter 91—The Public Trust Doctrine

Another state law that can be used to promote healthy urban environments is the Chapter 91 Waterways program. Chapter 91 is the codification in Massachusetts of the Public Trust Doctrine. Under this doctrine, "the sea and with it the shore of the sea" are the common property of all people. The public has the right to fish, hunt waterfowl, and navigate in or on the land between high tide and low tide. In Massachusetts, the government acts as trustee for the citizens of the Commonwealth. All decisions made by the government with respect to land that is subject to Chapter 91 are therefore made for the benefit of the public.

Chapter 91 and its regulations set forth standards for development projects that occur on areas that are currently, or were in the past, tidelands. Much of Boston was created by filling in marshland. Filling in a piece of property does not take away the public's interest in that property. A key purpose of the law with respect to uses on filled tidelands is to "promote the public use and enjoyment of such land to a degree that is [consistent with the public's rights to such land], and which ensures that private advantages of use [of such land] are not primary but merely incidental to the achievement of public purposes…"[43]

In order to fulfill this objective, the regulations provide for open space and public access on all projects located on tidelands or former tidelands. They also set specific limits on the height of buildings, as well as mandating setbacks from the water. In order to determine how much open space is required, one must determine how much of the property is subject to Chapter 91 jurisdiction. The process for determining Chapter 91 jurisdiction requires looking up old licenses that have been issued for particular sites, or, if none exist, finding historic maps which show the historic high water mark on the site. This mark determines how much of the site is subject to Chapter 91's requirements. Once this is known, the regulations provide specific requirements for open space and public access.[44]

Chapter 91 encourages the owners of waterfront property to develop "water-dependent uses," which need to be located on the water. These uses are generally considered to serve a proper public purpose. The leverage point for a community group trying to create open space in its community comes when a project proponent wants to build a non-water-dependent use on property subject to Chapter 91. When a project proponent wants to build on tidelands, a Chapter 91 license must be secured from the Department of Environmental Protection. For a non-water-dependent use project, a proponent submits an appropriate application to the DEP, which holds a public hearing and issues a license after making a written determination that:

- The project serves a proper public purpose;
- The benefits of the project for the public outweigh the detriment to the public that is caused when tidelands are used for non-water-dependent private development; and
- The project is consistent with a series of policies that the Massachusetts Coastal Zone Management program has adopted governing the use and management of the land and water that make up the state's coastal zone.

Given Boston's proximity to the water, and history of creating property by filling in historic tidelands, there are many projects in the Boston area that are subject to the requirements of Chapter 91. Community groups can use this statute to leverage open space and more ecologically sensitive designs for such projects. For example, former tidelands located along small waterways are not generally susceptible to water-dependent use. Therefore, developers are likely to propose a nonwater-dependent use for these sites, thereby triggering Chapter 91's most generous open space and public access requirements. [45] Community groups can use the licensing process to ensure that the access and open space requirements are met when new developments are proposed.

H. Massachusetts River Protection Act

Governor Weld signed the Massachusetts Rivers Protection Act into law on August 7, 1996. The Act regulates virtually all activities along rivers and other flowing bodies of water. In Massachusetts, this means that roughly 9,000 miles of riverbank are covered. The Act operates by adding a new resource area to those already protected by the Wetlands Protection Act, thereby expanding the jurisdiction of that Act. This new resource area is called the "riverfront area." The Act is the result of a six-year debate among environmental groups, legislators, land trusts and watershed associations, and is very explicit. It describes a 200-foot riverfront area as its jurisdiction, makes the permitting procedures predictable, announces clear approval criteria, and makes the Act effective immediately. The Act protects drinking water and recreational areas.

Any activity within the new resource area (dredging, filling, or altering) requires an Order of Conditions from a local conservation commission after the filing of a Notice of Intent. Appeals are to the regional DEP office upon request for a Superseding Order. An adjudicatory hearing, in Boston, is available after the matter is considered by the regional DEP office.

An applicant for an Order of Conditions must prove, by a preponderance of the evidence, that there will be no significant adverse impact on the "Riverfront Area." The riverfront area is protected for the following purposes: "to protect the private or public water supply; to protect the groundwater; to provide flood control; to prevent storm damage; to prevent pollution; to protect land containing shellfish; to protect wildlife habitat; and to protect fisheries." Further, an applicant must show that there is no practicable and substantially economically equivalent alternative to the proposed project with fewer adverse impacts on such purposes.

For purposes of its application in urban areas, the Rivers Protection Act defines the riverfront area as the land situated between the river's mean annual high water line and a parallel line located 25 feet away. In addition to the ecological value derived from protecting riparian corridors, such as increased wildlife habitat and buffers for surface water and flood protection, studies have shown that a shoreline buffer can increase the value of adjacent property. For example, housing prices in Colorado were found to be 32% higher if they were located next to a greenbelt buffer.[46] Having riparian corridors in an urban area can contribute to wildlife habitat as well as improved water quality. Depending on the adjacent land uses, it may be important for the riverfront area to be increased from 25 feet in order to have the desired impact on water quality or habitat. A complete understanding of how an urban area functions is important in helping community groups advocate for these types of policy changes.

I. Brownfields

The Environmental Protection Agency defines brownfields as "abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination." Since 1980, when Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), contaminated properties, particularly those in urban centers, have been accumulating and sitting idle. CERCLA created a "strict liability" scheme for hazardous waste sites—imposing liability on virtually anyone associated with a site, no matter how tangentially.[47] A party in any one of the four statutory categories is liable regardless of whether its actions were unlawful or negligent. Courts have also interpreted CERCLA as imposing "joint and several" liability unless the defendant can show that its contribution to the harm is divisible. Therefore, any party can be held responsible for the entire cost of the cleanup.

These liability rules are practically mirrored in many states' hazardous waste laws, including Massachusetts'. Massachusetts created its own "superfund" statute in 1983, the Massachusetts Oil and Hazardous Material Release Prevention and Response Act (Mass.Gen.L. c. 21E). This statute sought to promote the cleanup and redevelopment of contaminated areas in Massachusetts, many of which are located in urban centers. However, many of its provisions, including strict liability on "potentially responsible parties" and lack of clarity in designating cleanup duties and standards, discouraged potential owner, investors, and lenders from developing contaminated lands.[48] In fact, the Massachusetts statute is even more broad than the federal act, imposing liability for releases of oil and hazardous materials (where the federal act exempts petroleum

products) and including in the category of potentially responsible parties those who "caused or [are] otherwise legally responsible" for the release.[49]

The broad liability schemes in the federal and state superfund statutes were intended to create a regime that ensured that all parties that benefited from the improper disposal of hazardous waste were held liable for the cleanup. In fact, the current owner or operator of the site could be held liable even if he or she were not a contributor, on the theory that he or she would benefit from the cleanup. Unfortunately, the strict liability imposed on virtually any party associated with a contaminated site had the unintended consequence of providing a disincentive to owners and developers to get involved with these sites.[50] Further complicating the cleanup problem is the fact that there were no clear standards in the state hazardous waste law for declaring a site "clean" and terminating potential liability associated with the site. This uncertainty as to continuing liability rendered many sites unmarketable, and they sat idle and abandoned in the inner city. Difficulty in quantifying the extent of contamination and liability has led developers to purchase and develop "clean" sites at the edges of current development, thereby contributing to urban sprawl.

It has been estimated that there are more than 500,000 brownfields sites nationwide. In a report released by the U.S. Conference of Mayors, lack of funds, liability stemming from Superfund legislation, and requirements for expensive environmental assessments were listed as the three major obstacles to redeveloping these sites.[51] Despite these obstacles, the benefits of brownfield redevelopment are clear: creation of new jobs, increased tax revenues, the ability to support an increase in population without stressing existing infrastructures, and creating "extra" green space by preserving existing farmland and open space. Brownfields present challenges for trying to apply the statute in order to advance the goals of healthy urban ecosystems. A contaminated site that is left dormant may develop into high quality habitat by virtue of being that rare commodity in an urban area: a site that is left to nature. It is critical to use brownfields laws in the context of ecological restoration by linking redevelopment to ecological goals through overlay zoning, permitting and so forth—so that as sites are redeveloped they are redeveloped to achieve at least some ecological goals. Nonetheless, redevelopment can contribute to creating a healthy urban ecosystem. Encouraging brownfield redevelopment to achieve these goals was the purpose of brownfields legislation in Massachusetts and other states.

Chapter 206 of the Acts of 1998, "An Act Relative to Environmental Cleanup and Promoting the Redevelopment of Contaminated Properties," ("the Brownfields Act") significantly amended Massachusetts' hazardous waste law. The Brownfields Act seeks to facilitate the redevelopment of urban industrial and commercial sites that have been contaminated by oil or other hazardous materials in order to stimulate economic growth in distressed areas of the Commonwealth and reduce urban sprawl in the suburbs.[52] Specifically, the Brownfields Act seeks to establish requirements and procedures for preventing contamination; notifying the DEP of contamination; assessing the extent of contamination; evaluating alternatives for remedial action; promoting public involvement in response actions; and recovering cleanup costs paid by the Commonwealth.[53] Finally, the Act attempts to infuse more clarity and flexibility into the assessment and cleanup process by allowing the cleanup process to be directed and managed by private Licensed

Site Professionals (with audit oversight by the DEP) and by offering different standards for cleanup depending on the intended use of the property.

The Brownfields Act employs two main tools in its efforts to promote the cleanup and redevelopment of contaminated properties: liability relief and financial incentives. The act creates a class of "eligible persons" who are exempt from liability, provides for activity and use limitations on the property, and creates a "Covenant Not to Sue" program in coordination with the state attorney general's office. These programs are designed to clarify and reduce the liability associated with owning a contaminated site. Such initiatives are emerging in many states as interest in brownfield redevelopment increases.

The financial incentives created by the act are intended to alleviate the costs of environmental cleanup of brownfields and encourage redevelopment. Incentives include a loan program under which the borrower and lender contribute equal amounts to a reserve fund, and the state makes a matching contribution to the fund. There are also low-interest loans and grants to developers that can be used in economically distressed areas. By encouraging the redevelopment of these contaminated sites, not only is the health of the urban ecosystem improved, but sprawl is contained by creating a disincentive towards development of "clean" parcels on the urban fringe.

In addition to these state programs, the federal government (EPA) has a Brownfields Economic Redevelopment Initiative that is designed to empower states, communities, and other stakeholders in economic redevelopment to work together to prevent, assess, safely clean up, and sustainably reuse brownfields. EPA funds pilot programs and other research efforts, enters into partnerships, conducts outreach activities, develops job training programs, and addresses environmental justice concerns. Communities with brownfields sites often face other concerns such as unemployment, substandard housing, outdated or faulty public infrastructure, crime, and a poorly-skilled local workforce, which might be of higher priority than thinking about redeveloping contaminated property. Therefore, the Brownfields Initiative provides an opportunity for Federal agencies to work together in a more integrated fashion toward sustainable redevelopment.

Through the Brownfields Initiative, communities can leverage both public and private sources of capital and technical support that can ensure successful redevelopment. Brownfields assessment and cleanup activities can be linked to health and workforce development programs through the creation of temporary and permanent jobs. Brownfields projects can be coordinated with transportation planning, ensuring access to transportation for new workers in redeveloped areas. Reuse options can include not only new economic and industrial opportunity, but also development of urban agriculture and green spaces. Close cooperation from the beginning of a Brownfields pilot may also decrease the likelihood that agencies will duplicate efforts, work at cross purposes, or confuse community leaders and civic groups.

J. Massachusetts Watershed Initiative

The Massachusetts Watershed Initiative is an innovative state program that protects and restores natural resources and ecosystems on a watershed basis. The Massachusetts

Watershed Initiative is a broad partnership of state and federal agencies, conservation organizations, businesses, municipal officials and individuals. The state has been divided into 27 watersheds, each represented by a watershed team, and having its own team leader. These watershed teams coordinate the watershed protection activities in each of the state's 27 watersheds. The stated goals of the Massachusetts Watershed Initiative are to: improve water quality; restore natural flows to rivers; protect and restore biodiversity and their habitats; improve public access and balanced resource use; improve local capacity to protect water resources; and promote shared responsibility for watershed protection and management.

The Watershed Initiative achieves these goals by: finding the sources of pollution and taking cooperative action to clean them up; teaching and helping groups and communities to protect and restore their local waters; expanding communication among local, private and public partners so everyone works together to solve water resource problems; improving coordination among government agencies; and directing resources to critical needs so that limited dollars go further to resolve the most important problems. The Watershed Initiative has been important in helping to restore urban systems by creating a team of representatives from state, local and federal agencies working together to tackle the issues that arise in the urban context. In addition to providing much needed funding for specific watershed improvement projects, the Watershed Initiative provides technical expertise and knowledge of state and federal regulations that can be applied in the urban context. Having a team of professionals from different agencies working together on the same problem is invaluable to resolving issues efficiently and effectively.

IV. Federal Regulatory Programs: Introduction

As with the state and local regimes, the role of federal regulatory schemes in protecting and restoring an urban ecosystem is defined by the unique elements of urban ecological advocacy: the commitment to systemic research and management, and the city's status as a forgotten environmental zone. Though each unique attribute creates challenges in utilizing federal environmental regulations, neither is ultimately a roadblock. Creative use of existing federal regulatory schemes can result in advocacy specifically tailored for urban places and urban systems.

The federal environmental regulatory structure is built on statues that focus on specific media. The relevant statutes for our purposes are the Clean Air Act and the Clean Water Act. These two schemes share a common general architecture: the federal government (Environmental Protection Agency (EPA)) establishes national standards for clean air and clean water, and then states propose regulatory programs for achieving those standards. Once the federal government (in the form of EPA) approves a state program, the state is primarily responsible for the regulatory landscape. The state must report to the federal government on its progress, and the federal government shares the power and authority with the state to enforce environmental laws.

Within each of these federal schemes are specific tools or mechanisms that can be used to protect ecological systems in the urban context. Environmental agencies at both the

federal and the state level have been working for some time to manage environmental resources systemically. The state and federal watershed programs provide a model for using media-focused statutes to protect regions, places and environmental systems.

V. Clean Water Act

A. Clean Water Act Overview

Though the federal efforts to prohibit dumping in navigable waters trace back to the Rivers and Harbors Act of 1899, [54] the 1972 amendments to the Federal Water Pollution Control Act provide the modern framework for managing water pollution in this country. The goal of the Clean Water Act is the restoration and maintenance of chemical, physical and biological integrity of the Nation's waters.[55] The interim goal is to achieve water quality throughout the country that provides for the protection and propagation of balanced populations of fish and wildlife and supports recreation in and on the water.[56]

The Clean Water Act's regulatory scheme provides discrete programs for different sources of water pollution. The Act establishes a mechanism for managing pollution from "point sources," that is, entities that purposefully discharge into the waters of the United States.[57] Over time, amendments to the Act have established regulatory mechanisms for managing spills of oil and hazardous waste,[58] non-point source pollution (in its simplest terms, runoff of rain water from a place on which it may pick up pollutants),[59] and sewers that are combined with storm water.[60] The Act also establishes a water-quality system for all water bodies. Under this system, each state must designate uses for all water bodies within the state.[61] The EPA will review these designations every three years.

Each of these programs will be discussed in more detail below. Each provides some opportunities for input from local governments, organizations and individuals concerned with the protection and restoration of urban natural resources. A threshold question, however, may be how water quality affects urban ecology as a whole. In other words, why might we care about water quality in the context of restoring and protecting urban ecosystems?

B. Urban Water Quality and Healthy Urban Ecosystems

Urban communities across the country have begun to restore and revitalize their rivers and riverfronts. There are large-scale projects underway in Los Angeles, New York City, Milwaukee, Boston, Detroit, San Antonio and many other cities.[62] Revitalized urban rivers provide a number of benefits to urban ecosystems, and for both human and non-human populations in that ecosystem.

With respect to the non-human communities within the ecosystem, improved water quality of course means increased biodiversity within the rivers themselves. Decreases in the central pollutants governed by the Clean Water Act improves the quality of the river as habitat for fish and shellfish, obviously, and this improves the quality of this element of the urban ecosystem.

Focusing on water quality can have important implications for the quality of the upland portions of the ecosystem as well. Controlling, managing or improving the quality of runoff will have an effect on the quality of the plant communities on any particular site. Similarly, strategies for managing and controlling runoff may well lead to improvements in the riparian corridor. The riparian corridor is the habitat along the edge of a river. This habitat, along with wetlands, may be the most important habitat in an urban region. From an ecological perspective, these are very rich communities.[63] These areas also may provide the greatest opportunity for creating habitat corridors in an urban context, for the banks of rivers may be under-developed or may be already preserved. Such corridors can improve the value of otherwise isolated pockets of habitat by providing a natural highway through which species may travel from one urban pocket to another.[64]

Improvements in urban water quality can also provide a series of important benefits to the human communities in the ecosystem. These improvements to the quality of life of the dominant human species can be highlighted to encourage human communities to protect and restore urban water quality in ways that benefit the other species in the ecosystem.

Specifically, improved water quality has implications for public health, recreation, economic development and over all well being of urban communities. The link to public health is neither illusory nor attenuated. In July 2001 scientists at Johns Hopkins reported that more than half of all waterborne disease outbreaks in the United States in the last half-century followed a period of heavy rainfall and subsequent runoff.[65] With respect to recreation, there is little doubt that rivers and riverfronts may be the most important recreational resources in the urban context, for they provide opportunities for fishing, boating, passive and active (e.g., sports fields for example) green spaces and, potentially, swimming. Improving public health and increasing recreational opportunities improve the overall quality of life in an urban area--which can increase the economic success of that urban community. Corporate Chief Executive Officers surveyed ranked quality of life as the third most important factor in locating a new business.[66] Protecting rivers and their riparian zones can increase adjacent property values, reduce maintenance costs for landowners, and provide opportunities for small business development.[67] The potential for small business development may be greater than is presently understood. Improved water quality in the urban context could lead to water-based businesses such as fishing and boating operations, could improve tourism and could also lead to valuable improvements in businesses that abut an urban river.

For all of these reasons, a number of urban communities have launched programs to improve conditions in and along their urban rivers. Nonetheless, conditions in urban waterways remain poor.

C. Urban Water Quality

Section 305(b) of the Clean Water Act requires states, tribes, territories and interstate commissions to report on the quality of their rivers, lakes, wetlands, estuaries, coastal waters and ground water.[68] The twelfth biennial *National Water Quality Inventory,* completed in 1998, indicates that about 40% of U.S. streams, lakes and estuaries assessed are not clean enough to support fishing and swimming. The most prevalent pollutants are

siltation, bacteria, nutrients and metals. The primary sources of these pollutants are urban runoff and runoff from agricultural lands.[69]

Studies performed by the EPA under the Nationwide Urban Runoff Program found that storm water runoff from urban areas contributes heavily to the impairment of aquatic ecology, chemical makeup and physical characteristics of local waters.[70] According to the 1998 study, urban runoff and municipal point sources were responsible for 25% of the impaired river miles, and a similar percentage of the impaired lake acres, in the United States.[71] Taking the Charles River in Boston, Massachusetts as an example, before the EPA launched a concerted effort to improve conditions in that river through its Clean Charles 2005 Initiative (an effort to make the Charles River fishable and swimmable by the year 2005) the River met water quality standards for swimming 19% of the time and water quality standards for boating 39% of the time.[72]

Perhaps most disturbing is the effect that municipalities are having on the nation's estuaries. There are 90,465 square miles of estuaries in the United States. Estuaries are where rivers meet oceans and include bays and harbors. As with any edge between habitats (in this case between salt water and fresh water), estuaries are extremely rich ecological zones, and serve as nursery areas for many commercial fish and for virtually all the shellfish populations in the United States.[73] According to the EPA, 44% of the country's estuarine square miles are impaired, with urban runoff, municipal point sources and storm sewers as the primary sources of the degradation.[74]

As outlined above, urban rivers, estuaries and lakes are critical to the overall health of an urban ecosystem. At the same time, urban communities are a primary source of degradation for these resources across the country. Clearly, there are challenges ahead in improving urban water quality and therefore for protecting and restoring urban ecosystems. The Clean Water Act provides municipalities and community organizations with a number of tools that can be utilized in unique and creative ways in the urban context to begin the process of restoration.

D. The Clean Water Act in the Urban Context

Each of the Clean Water Act's central elements can be or has been modified such that it can be an effective tool in the fight to restore urban ecosystems. Central to creative use of federal statutory schemes is the data to support unique and creative applications of national regulatory tools. Certainly the rapid assessment model outlined in the first section of this paper is a crucial starting point for urban ecological advocacy that uses the Clean Water Act regulatory scheme.

Controlling Water Pollution Through the National Permit Program

The National Pollution Elimination Discharge (NPDES) system is the centerpiece of the regulatory system for controlling pollution from "point sources." Point sources include sewage and industrial pipes, of course, but courts have also classified as point sources such things as channelized storm water runoff, bulldozers pushing fill into a wetlands,

unintentional overflow from a hazardous waste site lagoon and a culvert from a landfill leachate pond.[75]

Under the Clean Water Act, no person may "discharge" any pollutant into the "navigable waters" of the United States without a permit under the National Pollution Discharge Elimination System program.[76] All of the terms under the Act have been given broad interpretation, and thus the phrase *navigable waters* has never been limited to waters that are, strictly speaking, navigable. The term includes tidal zones, and also wet meadows, wetlands or any other water body that can be used for recreation, tourism or may generate commercial activity.[77] NPDES permits set limits on discharges to receiving waters such that the discharges do not threaten human health or the environment.[78] Permit holders must report on their discharges to the EPA, and violations of the permits are enforceable under the Clean Water Act. Under the Act, the EPA may authorize states to operate their own NPDES program, as long as the state program meets certain minimum standards. As of February 1998, 42 states have authorized NPDES programs.[79]

Over the past thirty years, through a combination of federal enforcement and rigorous citizen enforcement under the citizen's suit provisions of the law, this system has produced a dramatic improvement in water quality.[80] Standing alone, however, the NPDES program is not an effective strategy for restoring urban ecological integrity, for the obvious reason that the permit system examines each discharge on its own terms. In order to harness the NPDES program to the larger goal of restoring an ecological system in an urban area, the permit program must be incorporated into a regional watershed-wide or ecosystem-wide strategy. Under this approach, responsible agencies, and/or local residents, examine all the permits in a particular ecological system. By coordinating enforcement and inspections within an ecosystem, an agency can have a significant impact on the underlying resource. In addition, such action can create a community of interest among permit holders in a particular ecosystem. As this occurs, that community of interest may become a collective stakeholder in the restoration and protection of the ecosystem.

The framework for such an approach already exists. In the early 1990s, EPA embarked on a Watershed Protection Approach, which represented a "renewed emphasis on understanding and addressing all surface water, ground water and habitat stressors within a geographically defined area, instead of viewing individual pollutant sources in isolation."[81] In 1994, the EPA committed to integrating its NPDES Program with the watershed approach.[82]

EPA-Region I's success in the Charles River provides an excellent example of the potential impacts of bringing an ecosystem-wide perspective to an enforcement program. As a part of its campaign to make the Charles River fishable and swimmable by 2005 (Clean Charles 2005), the regional EPA undertook an enforcement sweep of all the major corporations and institutions along the River, with a particular focus on those corporations and institutions that held permits to discharge into the River. The sweep generated some specific enforcement outcomes, such as Supplemental Environmental Projects in lieu of fines, and as such certainly reduced pollution into the River. But perhaps much more exciting is the impact that the enforcement sweep and the ongoing

Clean Charles project had on this community of stakeholders. As a result of the sweep and the larger project, these institutions launched the Clean Charles Coalition. As of 2001, the coalition has sixteen members, and their general goals are to work within their member institutions to heighten appreciation for the Charles; to help bring public attention to the efforts of others in restoring the Charles; to participate in various small scale cleanup efforts; to promote better storm water management by member institutions; and to educate smaller institutions in the watershed on storm water management.

Thus far, the Coalition has established a web page through which it has disseminated general information on the Charles, as well as a series of storm water management best management practices summarized by coalition members.[83] The coalition hosted a series of meetings to develop storm water management strategies for each of their facilities. Using their shared knowledge, the Coalition is planning a series of workshops for the regulated community in the Charles watershed, including small businesses, to provide strategies for storm water management.

The Coalition is also working with EPA to develop a voluntary pollution prevention program that will target companies in the Lower Charles and provide technical assistance through workshops and instructional materials. The Coalition will also encourage businesses to adopt specified water quality practices to improve pollution prevention abilities and provide participants with public recognition for their participation through certificates and decals, website listing, and a clean business directory.

In sum, the Clean Water Act's enforcement provision, while not designed for urban ecosystem restoration, can be a powerful tool when married to a watershed-wide or ecosystem-wide perspective.

Water Quality Standards

Section 303 of the Clean Water Act requires that each state establish water quality goals for all water bodies in the state.[84] One purpose of this provision of the Act is to ensure that, wherever possible, water bodies are or will be used for fishing and swimming. In addition, the Act requires that each NPDES permit include necessary limitations to ensure that these water quality goals are met.[85] These standards are thus an important element of the overall permitting process. The process by which a state proposes these goals, and by which the EPA reviews them, can be an opportunity for a community group or local government to participate in establishing aspirations for an urban ecosystem and its water bodies.

Specifically, each state develops water quality standards applicable to each of its water bodies. The state must review those standards every three years, and must provide for public notice and a public comment period any time it revises its water quality standards.[86] Perhaps most importantly, any segment of a water body that is not classified as fishable or swimmable must be re-examined every three years. Furthermore, if a state decides that the fishable/swimmable standard is not attainable in a particular water body or segment of that water body, then the state must prepare a scientific analysis to justify this determination.[87] In addition, each state must establish an "antidegradation policy,"

such that it will maintain and protect existing uses and maintain and protect any water that is fishable and swimmable.[88]

Finally, the Clean Water Act requires that states provide the EPA every two years with a prioritized list of all their waters that are not meeting water quality standards (also known as "impaired waters").[89] For the highest priority water bodies, states are required to establish Total Maximum Daily Loads ("TMDLs"), which is a calculation of how much of a pollutant a water body could receive and still meet the water quality standard. For an impaired water body, the TMDL will represent a reduction in the pollutant load, and will allocate pollution reduction across all the sources in a watershed.[90] This powerful restoration tool has not been fully implemented across the country. In June 2000 the EPA issued a rule to revise the TMDL program in order to implement it more broadly. That rule is the subject of some controversy and is the target of a number of lawsuits. While it was scheduled to go into effect in October 2001, the EPA suspended the rule for 18 months, effective August 2001. The National Academy of Sciences and the EPA are reviewing the June 2000 version of the rule. In whatever form it takes, however, it is clear that the TMDL program will encourage and in fact require an ecosystem approach to both data collection and pollution prevention. Community groups and local governments will want to ensure that crucial urban resources are included on the Section 303(d) priority lists and that these crucial resources are included in the TMDL program.

Any program to protect or improve an urban ecosystem will want to take account of the regional water quality standards in that ecosystem. The water quality program will have developed significant data on the status of crucial water resources. In addition, to the extent that urban water quality standards are below fishable/swimmable, these standards, as set by the state, and approved by the EPA, will serve as a limitation on the future improvements in the ecosystem. Providing for the level of water quality necessary for a fully functioning ecosystem may require advocacy in favor of fishable/swimmable standards for all crucial water resources during the triennial state review.

Non-point Source Pollution Control: Storm Water Runoff

Although the original NPDES program helped to improve water quality around the U.S., studies done in the 1980s indicated that storm water runoff—especially in urban areas—contributes heavily to the impairment of the aquatic ecology, chemical makeup, and physical characteristics of local receiving waters.[91] Responding to this, Congress amended the CWA in 1987, authorizing EPA to create a comprehensive program to manage storm water runoff. EPA decided to implement its program in two phases.

EPA enacted the first phase of the storm water program, "Phase I", on November 16, 1990.[92] In essence, Phase I expands the Clean Water Act's coverage. The Program is an effort to manage pollution coming not simply out of pipes but also from precipitation that runs off and over the land and into receiving waters. Whereas the original NPDES permits cover only industrial and municipal *wastewater*, Phase I focuses on *storm water* runoff from "medium and large" municipal separate storm sewer systems ("MS4s") (sewer systems located in an area with 100,000 people or more) and runoff from eleven categories of industrial activity, including "large" construction activity (construction that

disturbs five or more acres of land).[93] The Phase I permitting system requires these groups to work with their local NPDES permitting authority[94] to develop and implement storm water management programs ("SWMP") for MS4s, or storm water pollution prevention plans ("SWPPP") for the specified eleven industrial activities. The primary purpose of these plans is to determine and implement best management practices ("BMPs") for each operator that will reduce pollutants in the operator's storm water runoff to the maximum extent practicable ("MEP"). The permit process is strict to ensure nationwide uniformity, but also allows a degree of flexibility so that local operators and permitting authorities can customize permits to meet the specific needs of their situation and surrounding watershed.[95]

The expansion of the Act under Phase I did not adequately address all of EPA's storm water management concerns, however. EPA inventories and local watershed studies done in the 1990s (including one involving the Green River in Massachusetts) showed that waterways were still being impaired in significant numbers as a result of small MS4s and construction activities that were not covered by the Phase I permits.[96] Also, in a 1992 federal court case, the Ninth Circuit Court of Appeals held that EPA had acted arbitrarily and capriciously by not including construction activities that disturb less than five acres in its Phase I program. The court held that EPA had not shown justification for regulating large construction activity (i.e., disturbing five or more acres) under Phase I, while excluding small construction activities from regulation, and remanded the case so that EPA could amend its regulations accordingly.[97]

EPA then developed Phase II of the storm water regulations, which was implemented on December 8, 1999.[98] Like Phase I, Phase II is a further expansion of the permitting system, this time reaching out to cover "small" MS4s (regulated sewer systems not already covered by Phase I) and "small" construction activities (construction disturbing less than five acres of land).[99] In keeping with Phase I, Phase II attempts to allow local operators a great degree of flexibility in complying with the NPDES permit requirements. To that end, Phase II requires operators of MS4s to develop and maintain six types of programs (called Minimum Control Measures ("MCMs"))[100] in order to satisfy the NPDES permit national standards. These six programs are: Public education/outreach; Public involvement; Detection & elimination of illicit discharge; Construction site runoff control; Post-construction runoff control; and Municipal pollution prevention/good housekeeping.

To assist operators, EPA has promulgated a "Menu of Best Management Practices" ("BMPs") for each program, suggesting ways in which operators can best meet the goals of the Minimum Control Measures within a designated time frame.[101] Similarly, operators of small construction sites must develop and implement a SWPPP to satisfy the NPDES permit national standards. To help the operators, EPA has again promulgated a menu of BMPs, detailing ways in which the operators can best attain an effective SWPPP before, during, and after construction activities.[102]

Although it has many characteristics in common with Phase I (e.g., flexibility, use of BMPs, development of SWMPs for MS4s, development of SWPPPs for construction activities), Phase II is different in several respects. Perhaps most importantly, Phase II has

a special focus on small MS4s and small construction in "urbanized areas" ("UAs"), as designated in the most recent U.S. census.[103] This program is therefore specifically designed to foster the protection and restoration of water bodies in urbanized areas.

Cities subject to Phase I of the Program have developed a number of interesting and potentially powerful tools that could both reduce runoff in urbanized areas and protect or restore urban habitat. The deadline for compliance with Phase II is March 10, 2003. Accordingly, urbanized areas in the process of developing their Phase II Programs have a number of sample projects from which to choose. Community organizations and local governments will want to learn about the various programs that Phase I cities have implemented and may want to advocate for certain types of Phase II programs in each category, specifically those programs that combine landscape and habitat protection and runoff control. Even after the March 2003 deadline has passed, the Phase II program provides an explicit regulatory link between landscape management and water quality. The program will therefore be a unique opportunity to combine habitat protection and water quality improvement. As an urbanized area launches an urban ecosystem study, and begins to identify priority resources, local community organizations will want to share that data with the local Phase II permitting authority, in the hopes that Phase II permits can be drafted, or redrafted, to utilize habitat restoration as an important tool for water quality improvements.

With respect to public education and outreach, for example, there are certain model programs that may be of particular interest. A number of cities launched storm drain stenciling projects, developing kits for volunteers and working with local community groups and schools to stencil a "Don't Dump" message on the city's storm drains.[104] Sacramento, California focused its efforts on those industry sectors likely to have the largest impact on storm water quality, such as auto cleaning operations, car lots and carpet cleaners. While these are innovative and potentially quite effective programs, there are other model programs that offer a greater opportunity to combine habitat restoration with runoff control through public education and outreach. With voter approval of over 60%, Portland, Oregon passed a $135.6 million bond bill to acquire up to 6000 acres of land to protect its urban waterways from runoff. Implicit in this ambitious undertaking is the link between the protection and restoration of riparian (riverfront) habitat, the resulting natural filtering of runoff and improved water quality.[105]

Similarly, with respect to the public involvement components of a Phase II plan, the options range from a more generalized citizen outreach program and workshop series,[106] to a program such as the one developed in Milwaukee that targets riparian landowners. The Milwaukee project works with riverfront landowners to improve their management and care of riverfront property in order to minimize erosion and improve the ecological values of the waterway.[107] Again, the Milwaukee program integrates the storm water runoff goals with efforts to understand and to improve the ecological values of the city's rivers.

A third element of the Phase I and Phase II programs is the identification and elimination of illicit connections to the storm sewers. Cities across the country have launched inspection programs, using both city personnel and volunteers, to identify illegal

connections of wastewater pipes into the storm sewer system.[108] Eliminating such cross connections can significantly improve water quality in the urban context.[109] Undertaking these programs against the backdrop of an ecosystem-wide study of natural resources will allow cities to quantify the ecological gains of these programs, will encourage targeted enforcement to protect critical water bodies and will perhaps provide incentives for continued improvements.

The construction and post-construction elements of the storm water programs also provide significant opportunities for habitat restoration and for integrating ecosystem restoration and protection with management of runoff. The bulk of the construction programs center on education and training of contractors and developers and increased inspections. Community groups and local governments will want to advocate for complete training programs and for increased inspections at constructions sites.

More promising still are model programs developed to manage runoff from new development or redevelopment. Grand Traverse County Michigan adopted an ordinance requiring on-site retention of all storm water for all commercial developments and new subdivisions.[110] The city of Maplewood, Minnesota avoided high assessments for new gutters and storm sewer systems and improved habitat at the same time by developing a system of swales planted with native species to control storm water.[111] In Austin, Texas developers can either install on-site water quality controls to manage runoff, or they can pay an ordinance fee calculated on the basis of the amount of impervious surface (surfaces that water cannot penetrate) they will create. The city is using these funds to develop a series of restoration programs to improve storm water control, including a series of interconnected ponds that will reduce pollution from runoff.[112] Prince George's County, Maryland and Portland, Oregon are developing new site design processes called Low-Impact Development ("LID"). LID programs seek to protect the local stream ecology by maintaining the watershed's pre-development hydrological patterns.[113] In short, the design process centers on avoiding runoff altogether by limiting impervious surfaces, and on limiting the impact of runoff through on-site infiltration of storm water. The net effect of this approach could be to create or improve green space in the context of development or redevelopment and thus it could link upland ecological restoration with storm water control.

Even the municipal good housekeeping section of the Phase II program provides opportunities for innovative programs that can protect or restore habitat and other upland ecological values. For example, the Howard County, Maryland Parks and Recreation Division found that wildflower meadows are twenty times less expensive to maintain than conventional turf. This new approach reduces storm water pollution by drastically reducing the amount of pesticides and fertilizers on county land. The ecosystem effects of this approach to park design and maintenance are profound, as meadows will attract and support significantly more complex animal, bird and insect communities.[114]

Every element of the storm water pollution program launched by EPA thus provides opportunities to improve and protect both urban water quality and urban habitat and biodiversity. Local community groups and local governments that undertake an urban

ecosystem study and restoration program will want to integrate Phase I and Phase II storm water projects with the larger ecosystem restoration program.

VI. Clean Air Act

A. Clean Air Act Overview

The Clean Air Act operates in many ways on the same model as the Clean Water Act. As a general matter, the Act establishes a level of air quality that the states are required to achieve. That level of air quality is meant to be protective of human health and the environment. A state then has the authority to allocate emissions to individual sources (which collectively represent the commons) such that the total emissions meet the air quality goal.

Specifically, the Clean Air Act establishes National Ambient Air Quality Standards (NAAQS) for certain "criteria pollutants"(namely those pollutants that Congress found to be of greatest concern).[115] The Act over time has then established various mechanisms for achieving those standards, depending on the type of pollution source that is being regulated: stationary sources (basically smokestacks), mobile sources (cars and trucks), and new sources (stationary sources built after the Act came into effect). As of 1990, the Act also stepped up regulation on sources of hazardous air pollution.[116]

With respect to stationary sources, the Act requires each state to submit for approval by the EPA a State Implementation Plan ("SIP"). The SIP is a prescription for how the state will regulate stationary sources in such as way as to achieve the NAAQS. The EPA must approve the SIP or draft its own Federal Implementation Plan.[117] In order to avoid a race to the bottom, with states seeking to entice industry through lax air quality laws, the Act requires that new sources of pollution (built after the regulations for a specific pollutant go into effect) use the best available technology for air quality control.[118]

In addition, each state is divided into a series of Air Quality Control Regions ("AQCR"), each of which must achieve the NAAQS. Over time, since the first Clean Air Act in 1970, Congress has modified the system to a certain extent in recognition of the fact that meeting NAAQS would be virtually impossible in certain regions of the country, in certain AQCRs. In such areas, termed "non-attainment areas," the state has to achieve "reasonable further progress" by requiring all new stationary sources to offset their new pollution by an even greater reduction from existing pollution sources.[119] Furthermore, in areas that have achieved NAAQs, states must regulate new sources in such a way as to achieve Prevention of Significant Deterioration.[120] In order to avoid the chaos of having each state regulate mobile sources in a different way, the Clean Air Act provides direct federal management of mobile source pollution. As such the Act authorizes the EPA to establish across-the-board standards for tailpipe emissions from motor vehicles.[121]

As scientists and ecologists have provided a clearer picture of the specific environmental and public health effects of air pollution, Congress has modified the Clean Air Act to tackle specific environmental problems that stem from air pollution. Perhaps the best

examples of this targeted regulatory approach are the so-called "acid rain" provisions of the Clean Air Act. These provisions actually target acid deposition in all forms of precipitation (rain and snow) that contain elevated levels of chemical contaminants, primarily Sulfur Dioxide (SO2) and Nitrous Oxide (NOx). These chemical contaminants react with water and oxygen in the atmosphere to form acidic compounds (sulfuric acid and nitric acid) that result in a mix of sulfuric acid and nitric acid. About 2/3 of the SO2 and ¼ of the NOx in this country come from electric power plants that burn fossil fuels, and especially from those that burn coal.[122] Acid rain can damage soil, fish, forests, human health and even buildings on which it falls. Precipitation with elevated levels of chemical compounds can have profound and complex impacts on ecosystems far from the source of the pollution. For example, research in the Rocky Mountains has linked acid rain to the steep decline in the bighorn sheep population through a complex chain of reactions in soil and plant life that deprives baby sheep of a crucial nutrient.[123] With respect to public health, the acid rain itself is not a threat, but the particulates that cause it have been linked to illness and death from heart and lung disorders, asthma and bronchitis.[124]

The EPA's acid rain program tackles the problem through a combination of a cap on emissions and an emissions allowance trading system. Specifically, EPA's program caps SO2 emissions nationwide at 8.95 million tons. Each source of SO2 pollution is given a permit that includes an allowance of a certain number of tons of emissions. Sources of pollution can trade or sell those allowances, with entities that come in under their allowance able to sell their excess allowances to those entities that fail to meet their limits.[125] A similar system operates for NOx emissions.[126] Any person can participate in this market, as school groups and environmental organizations have bought emissions allowances and simply mothballed them to prevent the pollution from occurring. This market-based approach has worked extremely well, as SO2 emissions have been cut 30% faster than expected.[127]

As with the Clean Water Act, and for that matter the state and local regulatory schemes discussed above, the Clean Air Act must be utilized in innovative ways for the restoration and protection of urban natural resources. Under close scrutiny, however, the Clean Air Act's regulatory scheme does provide some specific tools that can be part of an urban ecosystem protection program.

B. State Implementation Plans

One area for further study is the State Implementation Plans themselves. Whenever the EPA finds that an existing plan is inadequate, or in response to revisions in the NAAQs, and/or new technologies for meeting NAAQs, the EPA may require a state to revise its SIP.[128] The state must provide an opportunity for public comment on any revisions. Community groups and local governments armed with data on the ecological resources in an urban area, and on those pollutants for which a city is a non-attainment zone, could advocate for certain types of emissions control plans and goals. The mechanisms that a state uses to meet the NAAQs may also have an impact on the local ecosystem. For example, some states have implemented parking bans in certain cities in an effort to meet

NAAQs. Such transportation-based mechanisms could affect land use and development and may offer opportunities to protect critical resources.

In addition, community groups and local agencies concerned with urban ecological resources will want to research whether a city is a non-attainment area for certain of the criteria pollutants. Where a city is a non-attainment area, the existing air quality conditions will certainly have an impact both on public health and on the local ecology. Researching those impacts will allow community groups and cities to work with states to bring the state into compliance with NAAQs. For example, Massachusetts is a nonattainment area only for ozone. Pending the final approval of a new ozone standard by EPA, the Commonwealth has developed, and continues to develop, specific strategies to address the ozone problem, each of which may have implications for urban ecosystems. The Commonwealth is working to meet the ozone NAAQs by:

- Reducing VOC (Volatile Organic Compound) emissions from industrial sources
- Reducing the VOC content of certain products
- Implementing more stringent emissions standards for cars and increasing inspections for trucks
- Reformulating gasoline
- Reducing vehicle miles traveled by encouraging employee rideshare programs
- Improving mass transit, adding HOV lanes, and funneling transportation dollars to those projects that provide quantifiable air quality improvements.[129]

Some of these strategies have no apparent benefits for the larger urban ecosystem. In fact, a number of these strategies seek to meet the ozone standard not by limiting or reducing the number of cars on the road or the number of roads built (which would limit runoff, fragmentation of habitat and destruction of landscape), but by reducing the impact of each car or truck. Other strategies on the list would help to meet the Ozone standard while at the same time protecting ecological resources and habitat. Chief among these are incentives for mass transit and programs that reduce vehicle miles traveled.

The relatively recent permitting program launched by the 1990 Clean Air Act amendments provides a specific vehicle for such coordinated efforts. The 1990 amendments added a Title V to the Act that is similar to the NPDES permits under the Clean Water Act. Specifically, the regulated major sources of pollution are now subject to a mandatory permits that include emissions standards, as well as monitoring and reporting requirements.[130] Organizations working on urban ecological restoration can now review permits and emissions monitoring data for a particular area and thereby participate in the efforts to manage air pollution impacts. Providing information on the urban ecosystem effects of non-attainment will be an important element of these efforts.

C. Particulate Pollution: The Link to Public Health

Particulate matter is one of the criteria pollutants for which the EPA has established NAAQs. The term describes a wide variety of liquid droplets or solids of different

chemical compounds, but include especially sulfur oxides, nitrous oxides and volatile organic compounds.[131] Particulate matter has natural and human sources, including especially combustion of fossil fuels such as diesel fuel.

EPA had established NAAQs for particulates in 1987, but a host of new epidemiological studies published in the early 1990s convinced the EPA of the need to review the 1987 standards. Specifically, a number of community epidemiological studies have illustrated serious health effects, including increased mortality and morbidity for respiratory and cardiovascular disease, exacerbation of chronic diseases such as asthma, and increased hospitalizations, linked to ambient levels of particulate pollutants below those allowed by the 1987 standards in many urban areas.[132] The greatest risk seems to be to children, the elderly and asthmatics.[133] EPA's review of health data for two test cities found that for those two cities alone, "the risk remaining after attaining the current 1987 standards was on the order of hundreds of premature deaths each year, hundreds to thousands of respiratory-related hospital admissions, and tens of thousands of additional respiratory related symptoms in children."[134]

The earlier standards set limits on relatively large particles (PM10), and as the studies showed that smaller particulate matter is of greatest concern, the proposed 1997 NAAQs revised the PM10 standard and set new standards for smaller particulates (PM 2.5).[135] At the same time, the EPA Administrator revised the NAAQs for ground level ozone. The Administrator's announcement came after intensive lobbying from all sides of the issue, and as expected the new standards were challenged in court. A federal appeals court struck down the new standards, but ultimately the Supreme Court upheld the new particulate standards against a number of challenges, thought it struck down the new ground level ozone NAAQs, stating that the Agency's interpretation of the Clean Air Act was unreasonable.[136] In addition, the Bush Administration announced plans to continue stringent new standards for diesel trucks and buses first proposed under the previous administration. As of the summer of 2001, the EPA is reviewing the new rules in order to establish a timetable for implementing them.

States will be required to revise their SIPs to meet the new NAAQs, and this will provide an opportunity for community groups and city governments to link this public health effort to urban ecological restoration. As noted, revisions to SIPs are subject to extensive public review and comment. Community groups and local governments will want to present data regarding critical urban ecological resources, so that proposals for meeting the new NAAQs can promote both ecological and public health goals. For example, cities and states will most probably implement a variety of transportation-based proposals to manage particulates-these proposals will want to take account of how urban ecological resources could support the achievement of the NAAQs and also how the proposed revisions to the SIP might affect critical ecological resources.

D. Global Warming

There is a general agreement at the turn of the 21st Century that human activities are contributing to changes in the global climate. Specifically, weather data indicates that the average surface temperature of the globe has increased by 1 degree Fahrenheit since the

late 1800s, and suggests that temperatures will increase between 2 degrees and 10 degrees Fahrenheit by 2100.[137] Research indicates that emissions of greenhouse gases (such as Carbon Dioxide (CO2)) from human activities are contributing significantly to the warming trend.[138] Due in large part to the burning of fossil fuels, and especially coal, the amount of CO2 in the atmosphere has increased 25% since the late 1800s.[139]

Climate change is likely to have a significant effect on ecosystems, water supplies, coastlines and tropical agriculture, for it will change weather patterns and could affect the availability of water.[140] Changes in weather patterns and the water cycle could mean more extreme weather events, water shortages, increased flooding in coastal areas, and increased drought in dry areas.[141] Climate change will lead to substantial increases in sea levels along the coastlines of the United States.[142] In addition, increases in average global temperatures could have significant public health effects by increasing air pollution (ground level smog occurs more readily in hot temperatures), heat-related stress, and water and vector-borne diseases.[143]

All of these changes will of course have a dramatic impact on urban ecosystems, especially in coastal cities. The climate change itself will have a dramatic impact on terrestrial ecosystems through changes in plant composition and differential rates of adaptation to changing ecosystem structure.[144] By the same token, cities will be central in the struggle to manage global greenhouse gas emissions.

The 1997 Kyoto Protocol set out to tackle global climate change by requiring developed countries to limit their emissions of greenhouse gases. In July of 2001, 178 countries signed an accord agreeing on the rules for the implementation of the Kyoto pact. The United States did not sign this Bonn agreement on the grounds that it does not set emissions targets for developing countries and that compliance with the accord would damage the U.S. economy. The Bonn agreement calls for 38 industrialized nations to cut their greenhouse gas emissions by a combined 5.2% below 1990 levels by 2012.[145] The Bonn version of the treaty provides credits for emissions reduction for protecting or planting trees, on the grounds that trees absorb CO2. The Bonn version provides for recognizable sanctions for failing to meet the targets, and also envisions an emissions trading system like the one established under the Acid Deposition Program. Countries or companies could purchase emissions credits from countries that meet their targets.[146]

As noted, the United States has not joined the Bonn agreement and the Senate has never ratified the treaty. Nevertheless, a strong bipartisan contingent in the United States Congress is considering legislation that would set limits in this county on CO2 emissions.[147] These limits would most likely take the form of NAAQs, to be implemented through the SIPs, permit limits on major sources of CO2, and a trading system. Despite the U.S. refusal to join the accord, U.S. multinational companies have already launched large-scale forestry projects around the world on the hopes that the CO2 absorption capacity of replanted forests might provide CO2 credits tradeable on the international CO2 emissions trading market, or applicable in markets that have adopted the Kyoto accord.[148]

All of this may seem tangential at best to planning, researching and protecting an urban ecosystem. Consider, however, the importance of cities to the problem of global climate change. Burning coal generates 56% of the country's electricity.[149] Combustion of other fossil fuels for electricity and from cars, as well as burning solid waste, accounts for a significant additional percentage of the nation's greenhouse gas emissions. Tree cover, on the other hand, can serve as a sink for CO2 emissions, absorbing tons of CO2 emissions every year. The concentrated resources use, transportation needs and solid waste disposal systems of the average American city are at the center of the global climate change problem. At the same time, as noted above, coastal cities especially have a great deal to lose over the next century.

A community group or a city government could engage the global climate change debate, and could participate in both the search for a solution and for that matter in the international emissions trading market, by establishing an annual citywide CO2 budget- an accounting of the city's contributions to both CO2 emissions and to CO2 emissions absorption or reduction. Every planning decision, from the decision to clear trees, to transportation programs, to solid waste disposal and handling, could be and perhaps should be assessed for its impact on the city's CO2 budget. A city could set for itself a goal for CO2 reductions, either through systemic changes or through planting and protecting urban forests. It is not inconceivable that some of those decisions could be rewarded with CO2 emissions credits that could be sold or traded to fund the city's parks department. At a minimum, providing a city's residents with a concrete sense of their collective contribution to the problem of global climate change may be a crucial first step towards local advocacy on this issue. As it stands, the issue is seemingly too complex and too international in scope to be the subject of individual or even regional action. Establishing a regional CO2 footprint, and better yet establishing a local annual CO2 reduction target, provides a focal point for local advocacy and environmental education. Local numbers bring the problem home, and could provide a city with additional resources in the bargain.

VII. Conclusion

In the past several years the scientific community has embraced the emerging field of urban ecology as both valid and central to understanding the global environment. Given the concentration of human activity in urban centers, that humans are the dominant species in all ecosystems, and the pace of environmental change, urban ecology is arguably one of the most important areas for environmental research for this century. In addition, understanding the ecological processes in, and ecological history of, an urban center can provide a slate of new and exciting tools for addressing the social and economic challenges endemic in most large urban centers. Understanding urban natural resources and urban natural systems has important implications for public health, economic development, education and community development in urban areas.

A number of groundbreaking research projects are ongoing that will develop a comprehensive understanding of the city as an ecological unit. While these long-term studies continue to unfold, community groups, universities and environmental

organizations are developing community-based methods for stakeholder-driven urban ecological research and restoration. Together these various efforts will provide a baseline methodology over the next five to ten years for understanding the city as an ecosystem and for linking research to advocacy and restoration in the near-term.

As with the research protocols, urban ecological policy and advocacy tools are in their infancy. In developing specific legal and policy tools for use in the urban context, community groups and their partners must address the unique nature of urban environmental advocacy: its focus on place and not on specific media, and the contingency of the science and the research. Despite these challenges, however, many local, state and federal legal and regulatory schemes (most of which focus on a specific environmental media) can be modified as tools to restore and protect urban natural resources. Perhaps the most exciting nature of this work is that it requires leadership and participation from urban residents and community groups. Almost all of the legal and regulatory tools that might be used to restore urban natural resources require some significant level of community involvement.

Using the urban ecosystem as an organizing principle, urban residents can now begin to reach across political and socio-economic divides to develop a cohesive vision of a metropolitan area. The very architecture of advocacy for urban ecosystems (its focus on a regional environmental system) pulls together community groups across traditional divides, and provides the opportunity for community-based coalitions that transcend neighborhood-level parochialism. Furthermore, understanding an urban area as an ecological system provides such coalitions with a unifying theory for managing and restoring an urban area. Decisions about where and what to build, how to manage private and public land, whether and how to restore contaminated property and the like that in the past community groups would have addressed without an underlying scientific basis and without an alternative proposal, can now be assessed from the perspective of a regional vision or blueprint: the healthy urban ecosystem. The emerging science and advocacy of urban ecology are thus exciting in their implications for the global environment, in their implications for the social dynamics of metropolitan areas, and in the strength and power they could provide to urban residents for creating a world, a neighborhood and a city of their own choosing.

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[41] 310 CMR 10.01(2).

[42] 310 CMR 10.21-60

[43] 310 CMR 9.53

[44] The Department of Environmental Protection interprets this to mean the historic mean high water mark.

[45] For nonwater-dependent use projects located on tidelands, Chapter 91 regulations require that there be one square foot of open space for every square foot of building within tideland area containing non-water-dependent uses. 310 CMR 9.51(3)(d).

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[51] *Recycling America's Land: A National Report on Brownfield Redevelopment*, U.S. Conference of Mayors, February 2000.

[52] See M.G.L. c. 21E, §19.

[53] 310 CMR 40.0002(a)(1-7).

[54] 33 U.S.C. §§ 401-466n

[55] 33 U.S.C. §1251(a)

[56] 33 U.S.C.§1251(a)(2)

[57] 33 U.S.C. §1311

[58] 33 U.S.C. §1321. This section was amended by the Oil Pollution Act of 1990, 33 U.S.C. §2701.

[59] 33 U.S.C. §§1208, 1329

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[61] 33 U.S.C. §1313(c)

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[123] Gary Polakovic, *Deaths of the Little Bighorns*, L.A. Times A1 (August 29, 2001)

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[126] 42 U.S.C. §7651f

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[143] Id. at 5-6. There is some evidence that the public works infrastructure in U.S. cities will be capable of managing or minimizing the water-related public health impacts. See also Epstein, PR, *Climate and Health*, Science 285/5426, 347-348 (1999).

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[148] Foroohar, *The New Green Game,* Newsweek at 62. Two native American tribes in Montana received money from a London company to replant forests devastated by forest fire. In exchange, the company received the rights to the 47,972 tons of CO2 that the forests will absorb over the next 80 years. At a projected $70 per ton, those rights could be worth more than $3 million. Id.

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42 U.S.C. §7651

42 U.S.C. §7661

42 U.S.C. §7407

42 U.S.C. §7409

42 U.S.C. §7410

42 U.S.C. §7411

42 U.S.C. §7412

42 U.S.C. §7470

42 U.S.C. §750

42 U.S.C. §7521

55 Fed. Reg. 47990

64 Fed. Reg. 68722, 68725, 68726-32 (codified at 40 C.F.R. 9, 122-124)

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