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Using Green Infrastructure to Alleviate  
Poverty and Promote Healthy  
Communities: Legal and Policy Solutions  
for the Urban Environment

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## **ABSTRACT**

### **Using Green Infrastructure to Alleviate Poverty and Promote Healthy Communities: Legal and Policy Solutions for the Urban Environment**

**Alexandra Dapolito Dunn**

Around the world, green solutions are being used to enhance environmental health, aesthetics and human well-being in communities. “Green solutions” may manifest as physical green infrastructure improvements such as green roofing, rain barrel and rain garden installations and the use of permeable street paving materials, as well as green socio-political policy innovations such as open space preservation, investment in alternative energy sources as well as the development of sustainable buildings and sustainable communities. These important investments in green infrastructure, however, are often not concentrated in areas with distressed and income limited populations. This Article explores the benefits of and barriers to green infrastructure implementation in under served urban areas, and discusses how green investments can improve quality of life in all communities. In particular, this Article demonstrates how green urban investments can help alleviate poverty by providing green jobs and reducing economic and social burdens associated with urban living, such as high food costs and crime. This Article advocates for policy and institutional changes to maximize the use of green infrastructure in new and retrofit development, and stresses the advantages of concentrating a portion of these environmental and aesthetic investments in low-income areas.

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# **Using Green Infrastructure to Alleviate Poverty and Promote Healthy Communities: Legal and Policy Solutions for the Urban Environment**

**Alexandra Dapolito Dunn<sup>1</sup>**

Around the world, green solutions are being used to enhance environmental health, aesthetics and human well-being in communities. “Green solutions” may manifest as physical green infrastructure improvements such as green roofing, rain barrel and rain garden installations and the use of permeable street paving materials, as well as green socio-political policy innovations such as open space preservation, investment in alternative energy sources as well as the development of sustainable buildings and sustainable communities. These important investments in green infrastructure, however, are often not concentrated in areas with distressed and income limited populations. This Article explores the benefits of and barriers to green infrastructure implementation in under served urban areas, and discusses how green investments can improve quality of life in all communities. In particular, this Article demonstrates how green urban investments can help alleviate poverty by providing green jobs and reducing economic and social burdens associated with urban living, such as high food costs and crime. This Article advocates for policy and institutional changes to maximize the use of green infrastructure in new and retrofit development, and stresses the advantages of concentrating a portion of these environmental and aesthetic investments in low-income areas.

## **I. Introduction**

### **1. Urban Environmental Challenges**

Most urban and suburban waterways around the world are polluted. As rain comes into contact with streets, parking lots, and rooftops, an environmental chain reaction occurs. Especially near urban

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areas, and particularly after a rainfall event, streams, lakes, or coastal waters can be rendered unsafe for swimming or other direct contact. Development creates impervious surface coverage, increasing runoff and altering prior drainage and water uptake patterns. Rain picks up oil, grease, and toxins, as well as pathogens, nutrients, and other pollutants, and deposits them into lakes, streams, and coastal waters. High volume, high velocity flows can cause additional adverse environmental consequences, including flooding, streambank scouring, riparian habitat loss, increased stream temperatures, and, because the rainwater can not soak into the ground, depleted groundwater resources. Rainfall events carry trash, toxins, and bacteria into waterways, increasing the risk of illness for swimmers and subsistence fishers, and making these waters unhealthy for fish, amphibians, and birds.

Polluted waters are a health hazard as well as an eyesore, diminishing property values, and detracting from community revitalization efforts. These problems will only continue to grow as our world's population increases and, even more importantly, as development continues to spread across the landscape – in the United States for example, at twice the rate of population growth.<sup>2</sup> Add to this the projected adverse impacts of global warming on water resources and shorelines, increased magnitude and frequency of flooding and sewerage overflows,<sup>3</sup> and decreased snowpack.<sup>4</sup> These environmental challenges exist throughout the developing world, but are exacerbated by concentrated populations in urban centers. Dense, developed urban centers often have more impervious surfaces<sup>5</sup>

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<sup>2</sup> U.S. Census Bureau Population Profile of the United States, *National Population Projections*, <http://www.census.gov/population/www/pop-profile/natproj.html>.

<sup>3</sup> For example, the U.S. EPA reports that while data are inconclusive, some models predict that global warming will increase the frequency of combined sewer overflows by up to 12 percent, as well as the volume and velocity of stormwater flows. *E.g.*, T. Johnson, *Factoring the Impacts of Climate Change into Combined Sewer Overflow Mitigation*, U.S. EPA National Center for Environmental Assessment, New England Climate Change Forum June 2008, <http://www.epa.gov/region1/climatechange/pdfs/johnson.pdf>.  
See also, *A Screening Assessment of the Potential Impacts of Climate Change on Combined Sewer Overflow Mitigation in the Great Lakes and New England Regions*, EPA Draft Report (2007) <http://www.epa.gov/fedrgstr/EPA-RESEARCH/2007/March/Day-29/r5803.htm>.

<sup>4</sup> *See, e.g.*, Natural Resources Defense Council, *In Hot Water*, 4-16 (July, 2007) <http://www.nrdc.org/globalwarming/hotwater/hotwater.pdf>.

<sup>5</sup> “Impervious surfaces alter the natural hydrology, prevent the infiltration of water into the ground, and concentrate the flow of stormwater over the landscape. ... As the imperviousness of a watershed increases, the greater volume of stormwater increases the possibility of flooding and reduces the potential for pollutants to settle out; meaning that more pollution is delivered to drinking water streams and aquifers.”

G. Kauffman & T. Brant, “The Role of Impervious Cover as a Watershed-based Zoning Tool to Protect water Quality

and less open spaces, leading to heat island effects and reduced air quality. These conditions impact the environment and can create human health risks.

## 2. Urban Health Challenges

Increased environmental burdens in urban settings are associated with adverse human health impacts. International data suggests that morbidity and mortality rates are higher in densely populated urban centers.<sup>6</sup> For example, cancer<sup>7</sup> and “[a]sthma morbidity and mortality are disproportionately high in urban centers,”<sup>8</sup> and some studies suggest that overall life expectancy and healthy life

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in the Christina River Basin of Delaware, Pennsylvania, and Maryland;” University of Delaware, Institute for Public Administration, Water Resources Agency, Watershed Management Conference (2000)

<http://www.wr.udel.edu/publications/imperviouscoverchristinabasin.pdf>.

See also Arnold & Gibbons "Impervious Surface Coverage, The Emergence of a Key Environmental Indicator" APA (1996), where the The American Planning Association explored the use of impervious cover as a measurable environmental indicator and growth management tool.

<sup>6</sup> C. van Hooijdonk et al., *Higher mortality in urban neighbourhoods in The Netherlands: who is at risk?* Netherlands National Institute for Public Health and the Environment, *Journal of Epidemiology and Community Health* 62:499-505 (2008) <http://jech.bmj.com/cgi/reprint/62/6/473>;

M. Stafford et al., *Neighbourhood characteristics and trajectories of health functioning: a multilevel prospective analysis*, *The European Journal of Public Health*, 18(6):604-610 (2008) (suggesting a link between mental and physical health inequalities and locale) <http://eurpub.oxfordjournals.org/cgi/reprint/18/6/604>;

Z. Luo et al., *Infant mortality among First Nations versus non-First Nations in British Columbia: temporal trends in rural versus urban areas, 1981-2000*, Departments of Epidemiology and Biostatistics, British Columbia, *International Journal of Epidemiology* 2004 33(6):1252-1259 (2004) (suggesting a greater decline in infant mortality in rural areas than urban areas.)

<http://ije.oxfordjournals.org/cgi/reprint/33/6/1252?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=1&andorexactitle=&and&titleabstract=urban+health+mortality&andorexactitleabs=&and&andorexactfulltext=&and&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT>;

T. Harpham, *Health and the urban poor*. Evaluation and Planning Centre for Health Care. *Health Policy and Planning*, 1(1):5-18 (1986) <http://heapol.oxfordjournals.org/cgi/content/abstract/1/1/5>.

<sup>7</sup> P. Nasca et al., *Population density as an indicator of urban-rural differences in cancer incidence, Upstate New York, 1968-72*, Johns Hopkins University School of Hygiene and Public Health, *American Journal of Epidemiology* Vol. 112, No. 3: 362-375 (1980) (identifying a statistically significant linear trend of increasing incidence with increasing population density for cancers of the buccal cavity and pharynx, esophagus, bronchus and lung, stomach and colon.) <http://aje.oxfordjournals.org/cgi/content/abstract/112/3/362>.

M. Wake, *The urban/rural divide in head and neck cancer-- the effect of atmospheric pollution*, *Clinical Otolaryngology*, Vol. 18:4, 298-302 (2007); <http://www3.interscience.wiley.com/cgi-bin/fulltext/119313817/PDFSTART>

L. Minelli et al., *Urban-rural differences in gynaecological cancer occurrence in a central region in Italy, 1978-82 and 1998-2002*, *European Journal of Gynaecology and Oncology*, 28(6):468-72 (2007) <http://www.ncbi.nlm.nih.gov/pubmed/18179138>;

A.C. Monroe, et al., *Cancer in rural versus urban populations: a review*, *Journal of Rural Health* 8(3):212-20 (Summer 1992)

[http://www.ncbi.nlm.nih.gov/pubmed/10121550?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed\\_Results\\_Panel.Pubmed\\_DiscoveryPanel.Pubmed\\_Discovery\\_RA&linkpos=4&log\\$=relatedreviews&logdbfrom=pubmed](http://www.ncbi.nlm.nih.gov/pubmed/10121550?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_Results_Panel.Pubmed_DiscoveryPanel.Pubmed_Discovery_RA&linkpos=4&log$=relatedreviews&logdbfrom=pubmed)

Varying degrees of association are reported between cancer incidence and urban/rural environments, but the association between atmospheric pollutants and cancer rates is fairly well established, to the extent that it can be argued that increased exposure to pollution can have significant health impacts. Green infrastructure implementation can decrease pollutants in the air and the water, likely having positive impacts on human health.

<sup>8</sup> F.J. Malveaux & S.A. Fletcher-Vincent, *Environmental risk factors of childhood asthma in urban centers*, *Environ. Health Perspect.* 103(Suppl 6): 59-62, (Sept. 1995) <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1518936>

expectancy “decreased steadily as area of residence became more urban.”<sup>9</sup> In 2001, the U.S. Department of Health and Human Services reported that “Americans who live in the suburbs fare significantly better in many key health measures than those who live in the most rural and most urban areas,” in a study that showed that “people who live in the most rural and most urban areas have higher mortality rates for working age adults than suburban residents.”<sup>10</sup> While these reports are not definitive, and the factors affecting health disparities in rural and urban environments are multifarious, increasing data indicates that varying socio-economic and environmental conditions associated with urban development can negatively impact the health of urban residents. Reducing exposure to pollutants in the air and water can be beneficial to human health and social wellbeing.

## II. Green Infrastructure

### 1. Defining Green Infrastructure

The term green infrastructure does not just mean “green” as in environmentally sound, but also green as the color of the vegetation that it relies upon as its principal waste and stormwater treatment mechanism. The term “green infrastructure” has many definitions because it is used on a variety of scales – watershed or subwatershed, neighborhood, or site. In this paper it applies to natural systems or designed or engineered systems that use soil and vegetation to mimic natural processes to protect and enhance environmental quality and public health. This paper references green infrastructure applications on several scales.<sup>11</sup> Green infrastructure in cities, where stormwater induced pollution is most severe, includes green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket

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<sup>9</sup> [Scottish Public Health Observatory, Health Life Expectancy: Urban Rural Classification, \(2001\)](http://www.scotpho.org.uk/home/Populationdynamics/hle/hle_data/hle_rurality.asp)  
[http://www.scotpho.org.uk/home/Populationdynamics/hle/hle\\_data/hle\\_rurality.asp](http://www.scotpho.org.uk/home/Populationdynamics/hle/hle_data/hle_rurality.asp)

See technical paper at <http://www.scotpho.org.uk/nmsruntime/saveasdialog.asp?IID=4717&SID=4075>

See also O'Reilly et al, *Urban and rural variations in morbidity and mortality in Northern Ireland*, Dept of Epidemiology and Public Health, (2007) <http://www.biomedcentral.com/1471-2458/7/123>.

<sup>10</sup> M.S. Eberhardt, et al., *Urban and Rural Health Chartbook*. Center for Disease Control National Center for Health Statistics., Health, United States, 2001. <http://www.cdc.gov/nchs/PRESSROOM/01news/hus01.htm>.

<sup>11</sup> Green infrastructure development ranges in scale from residential rain barrel installations to city, state, and even national land use and storm and waste water design practices. “Green” socio-political policies may be implicated by, or even prerequisites to green infrastructure design, development and implementation.

wetlands, infiltration planters, and vegetated median strips – essentially soil and vegetation worked into the urban landscape.

## 2. How Green Infrastructure Helps Alleviate Poverty

Green infrastructure offers the advantage of managing rain where it falls, often preventing it from flooding the sewer system. Less water in the sewer system means less pollution is discharged in sanitary and storm sewers, reducing treatment costs at wastewater treatment plants. Cost savings have also been gained from either avoiding the addition of new infrastructure or diminishing the size and scope of capacity improvements. Green infrastructure is often accompanied by other decentralized storage and infiltration approaches, including the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets. All of these have the benefit of keeping rainwater out of storm and sewer systems so that it does not cause overflows, allowing it to be absorbed and cleansed by soil and vegetation, and then re-used or allowed to flow back into groundwater or surface water resources. Additional examples of good green infrastructure practices are the restoration of existing wetlands in highly urbanized areas, as well as the creation of new wetlands, for stormwater management.

Physical green infrastructure improvements directly benefit water quality, preserving valuable drinking water resources, ecosystems and recreational areas, but the benefits of introducing green infrastructure are not confined to water quality. Green infrastructure design innovations such as rain barrels, green roofs, community gardens, water retention ponds, and green space preservation and creation increase vegetative cover, filtering airborne pollutants, helping to offset urban heat island effects, uptaking carbon, and reducing the heating and cooling demands of buildings.<sup>12</sup> Additional affects of green infrastructure that are difficult to quantify but which can be critical for thriving and

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<sup>12</sup> For example, temperatures above a green roof on City Hall in Chicago, IL, U.S. average 10-15°F lower than a nearby black tar roof, with the difference being as much as 50°F in August. The associated energy savings for the building are estimated to be \$3,600 US annually. C. Kloss & N. Stoner, *Controlling Urban Runoff with Low Impact Development*, Urban Water Management (July, 2007).  
[http://www.pennnet.com/display\\_article/303870/130/ARTCL/none/none/1/Controlling-Urban-Runoff-with-Low-Impact-Development/](http://www.pennnet.com/display_article/303870/130/ARTCL/none/none/1/Controlling-Urban-Runoff-with-Low-Impact-Development/)

sustainable communities are the aesthetic benefits gained from trees and vegetation.<sup>13</sup>

### 3. How Green Infrastructure Addresses Societal and Environmental Challenges

Green infrastructure has both environmental and public health benefits. These benefits include improved water quality, expanded wildlife habitat, enhanced drinking water supplies, protected open space and parks, energy savings, smog reduction, decreased flooding, improved aesthetics, higher property values, reduced crime, and a greater sense of community. Green infrastructure can save taxpayers money by not only reducing sewage and stormwater pollution, but also by minimizing the amount of water that needs to be conveyed to centralized treatment facilities, thereby making those facilities more cost-effective to operate. Use of green infrastructure approaches in addition to modernization of aging, decaying treatment plants, collection systems, and distribution systems can forestall the need for even more costly approaches and investments in the future. And both the clean waterways themselves and the green infrastructure that keeps them clean increase property values, revitalize blighted neighborhoods, enhance street life and community aesthetics, and provide free recreation.<sup>14</sup>

Green infrastructure can help to alleviate poverty and promote healthy communities by mitigating environmental burdens that disproportionately impact poor people. These burdens commonly come in the forms of air and water pollution, increased asthma and cancer rates, stagnant water and reduced drinking water quality, lower groundwater tables, and more. Green structures can reduce these societal and environmental burdens, yielding healthier environments and healthier

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<sup>13</sup> Studies suggest that ready access to “green spaces” has positive correlations with longevity and quality of life. E.g. J.R. Aston, *Health and greening the city*, Journal of Epidemiology and Community Health 56:896 (2002), <http://jech.bmj.com/cgi/reprint/56/12/897>;

T. Takano et al., *Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces*, Health Promotion/International Health, Division of Public Health, Graduate School of Tokyo Medical and Dental University, Tokyo, Japan Journal of Epidemiology and Community Health, 56:913-918 (2002) <http://jech.bmj.com/cgi/content/full/56/12/913>.

<sup>14</sup> Natural Resources Defense Council, *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows* (June 2006)(Report on green infrastructure strategies employed by U.S. communities, documents how storm and sanitary infrastructure investments achieve more by focusing on multi-benefit approaches, leveraging private and public investment, and weaving green infrastructure controls into a broad range of municipal activities, such as repair and rehabilitation of roads. <http://www.nrdc.org/water/pollution/rooftops/rooftops.pdf>

communities.<sup>15</sup> In addition to physical health benefits associated with improved air quality and living environments, green structures can improve psychological well-being in individuals and society, improving a community's self image and fostering a sense of pride in the community.<sup>16</sup> On a larger scale, sustainable, "low impact" development<sup>17</sup> patterns that employ land use methodologies such as "smart growth"<sup>18</sup> or "transit oriented development"<sup>19</sup> can further the implementation of green infrastructure innovations, creating open spaces, reducing impermeable coverage, and even reducing total vehicle miles traveled, reducing carbon emissions associated with the increased commutes of traditional sprawling communities. Open, green space draws people out of their homes<sup>20</sup> and with more families present in the community, crime can be reduced.<sup>21</sup> <sup>22</sup> <sup>23</sup> Many types of green infrastructure

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<sup>15</sup> For example, the City of Winnipeg, Canada, is conducting analyses on optimizing efficiency of energy use in flat-roofed buildings and abilities of green roofs to improve urban air quality, especially plant uptake of greenhouse gases and metals. <http://www.greenroofs.org/resources/GRIM-Winter2002.pdf>

<sup>16</sup> "When San Francisco Mayor Newsom announced in August 2005 that all city-supported affordable housing developments would be required to include holistic environmental standards based on the Green Communities Criteria, he emphasized children's health: Children in low-income neighborhoods often suffer from childhood diseases like asthma or lead-poisoning that are exacerbated by unhealthy housing. By signing up to be the country's first citywide Green Community, we'll prove that it's possible to build affordable housing and to build it green." San Francisco Green Initiative, <http://www.greencommunitiesonline.org/green/benefits/sf.asp>

<sup>17</sup> Sustainable development means, not only green building development, but also shifting development patterns. Sustainable land use patterns are also essential to sustainable development, and, in the United States, local zoning authority is a powerful mechanism that can shift development patterns so that more compact and energy efficient buildings are constructed, distances between residences and work or shopping/recreation locations are reduced, and more undisturbed vegetated areas and agricultural lands are preserved. J. Nolon, *Shifting Ground to Address Climate Change: The Land Use Law Solution*, Government Law and Policy Journal (2008), [http://www.law.pace.edu/files/landuse/Shifting\\_Ground\\_Penultimate.pdf](http://www.law.pace.edu/files/landuse/Shifting_Ground_Penultimate.pdf); See also J. Nolon, *Well Grounded: Using Local Land Use Authority to Achieve Smart Growth*, Environmental Law Institute, (2001).

For examples of twelve U.S. cities that have successfully adopted sustainable development principles, see <http://www.sierraclub.org/sprawl/report05/buildingbetter.pdf>

<sup>18</sup> Smart growth generally refers to "anti-sprawl development that is environmentally, fiscally and economically smart, and includes land-use planning and mixed use development." <http://www.smartgrowth.org/about/default.asp>

See also, *Growing Smarter: Achieving Livable Communities, Environmental Justice, and Regional Equity*, (Bullard, Robert D. ed. 2007); additional resources at <http://www.smartgrowth.org/library/default.asp>.

<sup>19</sup> A form of sustainable smart growth design focusing high-density mixed use development in areas with transit accessibility, encouraging pedestrian accessibility and discouraging urban sprawl development.

<http://www.transitorienteddevelopment.org/>. See also <http://www.todadvocate.com/>; <http://www.todadvocate.com/todresources.htm> for additional resources.

<sup>20</sup> "The simple act of planting trees provides opportunities to connect residents with nature and each other," says Dr. Greg McPherson, director of the USDA Center for Urban Forest Research. "Neighborhood tree plantings and stewardship projects stimulate investment by local citizens, business and government in the betterment of their communities." Wisconsin Natural Resources Magazine (2006), <http://www.wnrmag.com/supps/2006/aug06/green.htm>.

<sup>21</sup> Recent research indicates that the presence of trees actually reduces the incidence of crime. This may, in part, be due to the higher natural surveillance of well-used greenspace, as sites with trees have been found to attract more people than those without. Research has also linked the presence of vegetation to mitigation against mental fatigue, often "a precursor of outbursts of anger and violence. E.g. C. Hastie, *The Benefits of Urban Trees - A summary of the benefits of*

innovations can address numerous environmental and social issues- for example, basketball courts with permeable pavement are cooler in the summer,<sup>24</sup> and, similarly, green roofs reduce the urban heat island effect.<sup>25</sup> Green infrastructure design, in all of its forms, can help to alleviate many urban environmental problems, such as the Urban Heat Island effect, erosion, water runoff and pollution, carbon emissions, and inefficient energy use, as well as social problems, such premature mortality associated with elevated particulate matter concentrations (which often disproportionately effects poor communities living closer to pollution sources), and even psychological well being.<sup>26</sup> Poor communities that are often disproportionately impacted by environmental and social problems can be greatly benefited by green infrastructure design.

The installation of green infrastructure also can yield safe and reliable jobs, which with training can be made available to local low income individuals.<sup>27</sup> Green infrastructure certainly creates demand for highly skilled jobs such as for architects, designers, and engineers, as well as other low “green

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*urban trees* (accompanied by a selection of research papers and pamphlets) Warwick District Council (July 2003). As cited in: <http://bristolparks.inovem.com/inovem/gf2.ti/f/52194/1111461.1/pdf/-/Discussion%20paper%20%20Balanced%20and%20sustainable%20communities%20%20Trees.pdf>.

- <sup>22</sup> The study by University of Illinois researchers Frances E. Kuo and William C. Sullivan explored how well residents of the Chicago Robert Taylor Housing Project were doing in their daily lives based upon the amount of contact they had with trees. Kuo and Sullivan found that trees are a canopy against crime. Trees have the potential to reduce social service budgets, decrease police calls for domestic violence, strengthen urban communities and decrease the incidence of child abuse. Buildings with high levels of greenery had 52 percent fewer total crimes than apartment buildings with little or no greenery. Residents of buildings with more vegetation knew their neighbors better because they were more apt to come outside. Based on study findings, the city of Chicago spent \$10 million to plant 20,000 trees as a means of social change. “A green workforce”, Wisconsin Natural Resources Magazine (August 2006) <http://www.wnrmag.com/supps/2006/aug06/green.htm>.
- <sup>23</sup> But extensive research as well as experience in Los Angeles suggests that it is possible to create small green public spaces of extraordinary quality and value to the community that are safe (and are perceived as such). For example, Bimini Slough Ecology Park (built on a vacated street) is located in a poor, high-density East Hollywood community plagued by many problems including crime and gangs, yet it is intensely used by community members without incident. Similarly, Augustus Hawkins Natural Park, in South Los Angeles, built on a small brownfield, is extraordinary because of its superior design and security features that create a sense of protection and calm. [http://college.usc.edu/geography/ESPE/documents/alleyreport\\_final\\_reduced.pdf](http://college.usc.edu/geography/ESPE/documents/alleyreport_final_reduced.pdf).
- <sup>24</sup> B. Linder reporting “Philadelphia Tackles Rainwater Runoff Pollution” NPR Morning Edition, 09/29/06 (using permeable pavement, rain gardens and urban farming to reduce rainwater runoff, improve water quality and stormwater systems, and community wellbeing) <http://www.npr.org/templates/story/story.php?storyId=6165654>
- <sup>25</sup> U.S. EPA, *Heat Island Effect Mitigation - Green Roofs*, <http://www.epa.gov/heatisland/mitigation/greenroofs.htm>
- <sup>26</sup> Bristol City Council, Parks & Greenspace Strategy - Balanced & Sustainable Communities, (June, 2007) <http://bristolparks.inovem.com/inovem/gf2.ti/f/52194/1111461.1/pdf/-/Discussion%20paper%20%20Balanced%20and%20sustainable%20communities%20%20Trees.pdf>.
- <sup>27</sup> “By their nature, green jobs are local jobs, ... The green-collar economy includes all 'green jobs' like construction work on green buildings, organic farming, solar panel manufacturing, and bicycle repair. Cognizant of Oakland, California's 'literal do-or-die struggle to build a sustainable local living economy strong enough to lift people out of poverty,' community leaders under the banner of the local Alliance are committed to “job creation for the low-income and people of color in the green, sustainable economy.” M. Burkett, *Just Solutions to Climate Change*, 56 Buffalo Law Review 169, 226 (2008).

collar” jobs in construction, maintenance, installation. And, with large green infrastructure projects come a variety of small businesses engaged in designing and building green roofs, rain gardens, tree boxes, and other types of green infrastructure.<sup>28</sup> Green infrastructure approaches can achieve cleaner bodies of water, create a greener environment, stimulate the economy and improve overall quality of life.

#### 4. Obstacles to Green Infrastructure Investment and Implementation

As beneficial as green infrastructure investments are, there are key obstacles to green design implementation. First, while green solutions are becoming more and more common in cities around the world, their application frequently is not concentrated in poverty stricken areas. For purposes of this paper, poverty is characterized broadly to include not only traditional elements of poverty such as reduced family income, but also poverty exacerbating indicators such as lack of productive assets (e.g., clean water and land), lack of access to sanitation and water supply, and lack of access to employment.<sup>29</sup> Second, there are legal barriers to widespread green infrastructure implementation. Third, green infrastructure innovations are often perceived as cost prohibitive or more costly than traditional grade and pave approaches to urban development. This paper explores these obstacles, advocates for policy and institutional changes to maximize the use of green infrastructure in new and retrofit development, and stresses the advantages of concentrating a portion of green investments in low-income areas.

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<sup>28</sup> Tree People's Natural Urban Systems Group, <http://www.treepeople.org/vfp.dll?OakTree~getPage~&PNPK=206> (projects creation of 50,000 new jobs from green infrastructure initiative)

<sup>29</sup> Key U.N. reports have adopted a necessarily broad definition of poverty which support the approach taken in this paper to include environmental conditions. In *Development as Freedom*, Amartya Sen defines poverty as the deprivation of basic capabilities that provide a person with the freedom to choose the life he or she has reason to value. These capabilities include good health, education, social networks, command over economic resources, and influence on decision-making that affects one's life. Income is important because money allows a person to develop his or her capabilities, but it is only a means to live a valuable life. From this perspective, poverty is a condition with many interdependent and closely related dimensions which can be summarized in three broad categories: (a) Lack of regular income and employment, productive assets (such as land and housing), access to social safety nets; (b) Lack of access to services such as education, health care, information, credit, water supply and sanitation; (c) Lack of political power, participation, dignity and respect.”

Office of the United Nations High Commissioner for Human Rights, *Human Rights and Poverty Reduction: A Conceptual Framework* (HR/PUB/04/1), quoting A. Sen, *Development as Freedom*, (1999)) [http://www.unescap.org/pdd/CPR/CPR2007/English/CPR4\\_4E.pdf](http://www.unescap.org/pdd/CPR/CPR2007/English/CPR4_4E.pdf).

## 5. Green Infrastructure Success in the United States

### A. Municipal Examples

The U.S. has had significant success in the green infrastructure arena. These investments have had dual benefits in that they have improved the aesthetic value of neighborhoods while also yielding key environmental benefits. An \$8 million subsidized downspout disconnection program in Portland has saved \$250 million in infrastructure improvements by diverting 1 billion gallons of rain annually from the combined sewer system and allowing the rain to soak into the ground. Seattle's first Street Edge Alternative (SEA) pilot project has retained 99 percent of the rain that has fallen during the five years of monitoring and prevented it from being discharged to sensitive receiving waters that are home to salmon. Seattle also has encouraged developers to incorporate environmental principles through its SeaGreen program since 2002. The city frames its green affordable housing goals in terms of environmental sustainability and justice.<sup>30</sup>

In the Rouge River area of Michigan, the Inkster Wetlands demonstration project uses 14 acres of wetlands (approximately nine of which are constructed) adjacent to the River to naturally treat stormwater before it enters the River. Prior to the project, "hard infrastructure" discharge pipes routed stormwater past the existing wetlands and directly to the River; however, the demonstration project rerouted stormwater through the existing wetlands which were supplemented with new, constructed wetlands. The project was completed in 1997 at a cost of \$465,000. The results of a subsequent five-year monitoring study evaluated the effectiveness of the project at improving the quality of the

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<sup>30</sup> "Greening affordable housing is part of Mayor Nickels' agenda to help promote more sustainable approaches to managing the built environment in a socially equitable way so those in our communities who can least afford it will benefit from healthy, high-quality affordable housing." Enterprise, Green Communities, <http://www.greencommunitiesonline.org/green/benefits/cities.asp>.

The SeaGreen Program's guiding principles for affordable housing are that they are: Cost-effective to build, durable and practical to maintain; Results in a high quality, healthy living environment; Reduces utility costs to residents; Enhances the residents' connection to nature; Protects the environment by conserving resources, including energy, water and materials; Advances the health of local and regional ecosystems." City of Seattle Office of Housing, <http://www.seattle.gov/housing/SeaGreen/default.htm>.

[www.aaa.com](http://www.aaa.com) See also "City of Seattle Sustainable Building Program: 5-year Report 2000-2005, Building a Better City" [http://www.seattle.gov/dpd/static/5-year\\_report\\_LatestReleased\\_DPDP\\_009930.pdf](http://www.seattle.gov/dpd/static/5-year_report_LatestReleased_DPDP_009930.pdf).

stormwater runoff and found that in addition to dampening stormwater flows, the wetlands also reduced concentrations of total suspended solids by 80 percent total phosphorus by 70 percent, and both oxygen depleting substances (BOD) and heavy metals by 60 percent.

These cities that have shown innovation adopting green practices have also been at the forefront of the policy and institutional changes necessary to encourage new programs. Public funding has been critical to the adoption and acceptance of green infrastructure. Public financing has been used directly to install pilot projects and subsidize community programs and provide grant money for private efforts. Chicago's Department of the Environment announced that it would provide 20 \$5,000 grants in 2006 for small-scale commercial and residential green roofs and received 123 applications. Policy changes have required that green infrastructure be the first option for new development and offered financial incentives for green infrastructure retrofits. Several cities have revised their stormwater regulations to place an emphasis on on-site retention and treatment and state a preference for green infrastructure approaches. Cities have also structured their utility fees to provide a fee discount when green controls are installed.

#### B. Green Jobs

Green infrastructure brings green collar jobs. With training, disadvantaged individuals can become part of the green economy. "The campaign for green-collar jobs is just as much about economic and social recovery for EJ communities as it is about environmental dividends. ... The green-collar economy includes all "green jobs" like construction work on green buildings, organic farming, solar panel manufacturing, and bicycle repair."<sup>31</sup> Green infrastructure creates sustainable "green collar" jobs, which in turn have environmental advantages. Examples of green design innovations creating green collar employment opportunities fusion include community gardens created by the New York Restoration Project that fund green improvements and continuous upkeep in economically and environmental burdened areas in New York. One project, the New York Restoration Project's Target

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<sup>31</sup> M. Burkett, *Just Solutions to Climate Change*, 56 Buffalo Law Review 169, 225 (2008).

East Harlem Community Garden on 117<sup>th</sup> Street, installed solar panels and wind turbines to power the LED lighting and drip irrigation system in the garden.<sup>32</sup> Similarly, in a housing development in Stamford, Connecticut, green design guru Jonathan Rose Companies' Metro Green Apartments project "integrates features that enhance the urban environment, promote better health for residents, are energy efficient, and save residents money" while creating green collar construction jobs.<sup>33</sup> Green features of the Metro Green Apartments project include "a high performance roof and insulation system . . . that reduces [the] heat island effect," "operable double hung windows" that reduce heating and cooling costs, and "a rainwater harvesting system that will funnel water from the roof into storage tanks to be used for drip irrigation and filtered for use in washing machines."<sup>34</sup> Such green innovations elevate poverty directly by reducing food, heating and cooling bills, as well as stimulating the local economy by creating local, green collar jobs. Some researchers have suggested that placing green roofs on publicly-owned buildings can be an effective way of establishing an educated roofing industry and experienced installers for future green roof construction.<sup>35</sup> Green infrastructure design can greatly benefit the environment and the job market. Additionally, the energy efficiency of green buildings can reduce skyrocketing energy costs for poverty stricken families and yield more affordable energy bills.<sup>36</sup>

## C. Green Living

### 1. Eating Green and Food Accessibility

Green infrastructure can also create a place to grow small quantities of food in the urban center.

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<sup>32</sup> A. Raver, *Healthy Spaces for People and Earth*, N.Y. Times, November 05, 2008

<http://www.nytimes.com/2008/11/06/garden/06garden.html?scp=3&sq=&st=nyt>.

<sup>33</sup> Rose Network, *Jonathan Rose Companies breaks ground on MetroGreen Apartments at Stamford Transportation Center: Joint Venture with Malkin Family to Bring New Life to Urban Transit Hub*, June 11, 2008

<http://ahdc.com/news/Articles/METR-stamfordplus-080611.pdf>.

<sup>34</sup> Rose Network, *Jonathan Rose Companies breaks ground on MetroGreen Apartments at Stamford Transportation Center: Joint Venture with Malkin Family to Bring New Life to Urban Transit Hub*, June 11, 2008

<http://ahdc.com/news/Articles/METR-stamfordplus-080611.pdf>.

<sup>35</sup> T. Carter & L. Fowler, *Establishing Green Roof Infrastructure Through Environmental Policy Instruments*, *Environmental Management*, Vol. 42, N. 1, 151-164 (July 2008)

<http://www.ingentaconnect.com/content/klu/267;jsessionid=59m3wxu1g4p1.alice>.

<sup>36</sup> A study of Chicago's urban forest found that increasing tree cover by 10 percent (three additional trees per building) would reduce total heating and cooling energy use by up to 10 percent. At a national level, researchers estimate that planting three additional trees per building could cut more than \$2 billion in energy costs. *Wisconsin Natural Resource Magazine*, (2006) <http://www.wnrmag.com/supps/2006/aug06/green.htm>.

Urban hunger and hungry city dwellers is a growing problem.<sup>37</sup> In some countries food insecurity is more serious among the urban poor than among the rural poor.<sup>38</sup> In fact, “given prices and income, the ability of a poor urban household to buy food may be less than that of a poor rural household, because the urban poor must buy most of their food. In many cases, the urban poor pay up to 30 per cent more for their food than the rural poor, and spend 60 per cent or more of their total expenditure on food. Transport costs and post-harvest losses are the main causes of the higher cost of food in urban areas.”<sup>39</sup> Exacerbating these disparities, “food markets that are located in low-income neighborhoods are often smaller, with less selection in general and less and lower quality produce,”<sup>40</sup> making it more difficult for low-income families to achieve balanced food intake necessary for a healthy diet. Community gardens are an emerging green solution to environmental and socio-economic burdens associated with urban living. In addition to encouraging permeable garden spaces that reduce water run-off, and decreasing the food delivery distances, which decreases transportation-related carbon output, community gardens can improve “nutrition, physical activity, community engagement, safety, and economic vitality for a neighborhood and its residents.”<sup>41</sup>

## 2. Green Housing

Development has enormous environmental implications. In the United States, building materials account for 40 percent of all raw material use,<sup>42</sup> while housing and related transportation account for

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<sup>37</sup> Food and Agriculture Organization of the United Nations, “The State of Food Insecurity in the World 2004” (Rome, 2004).

<sup>38</sup> United Nations Economic and Social Commission for Asia and the Pacific, *The Millennium Development Goals: Progress in Asia and the Pacific 2007*, (2007). The World Food Summit, held in Rome in November 1996, defined food security, as access by all people at all times to enough food for an active and healthy life. Food security involves three components: availability, access and utilization. Availability refers to the total amount of food in supply per person; access refers to the economic ability of individuals to purchase food; utilization refers to the body’s ability to absorb necessary nutrients (See The World Food Summit Plan of Action <http://www.fao.org/docrep/003/w3613e/w3613e00.HTM>).

<sup>39</sup> United Nations Economic and Social Council, Committee on Poverty Reduction, *Urban Poverty and the Working Poor, Facing the Challenges of Urbanization and Urban Poverty in Asia and the Pacific* (2007). [http://www.unescap.org/pdd/CPR/CPR2007/English/CPR4\\_4E.pdf](http://www.unescap.org/pdd/CPR/CPR2007/English/CPR4_4E.pdf)

<sup>40</sup> [M. Valliantatos, et al., \*Transportation and Food: The Importance of Access\*, \(2002\), \[http://departments.oxy.edu/uepi/cfi/publications/transportation\\\_and\\\_food.pdf\]\(http://departments.oxy.edu/uepi/cfi/publications/transportation\_and\_food.pdf\).](http://departments.oxy.edu/uepi/cfi/publications/transportation_and_food.pdf)

<sup>41</sup> Local Government Commission, *Cultivating Community Gardens: the Role of Local Government in Creating Healthy, Livable Neighborhoods*, [http://www.lgc.org/freepub/PDF/Land\\_Use/fact\\_sheets/community\\_gardens.pdf](http://www.lgc.org/freepub/PDF/Land_Use/fact_sheets/community_gardens.pdf); See also Municipal Research and Services Center of Washington, *Community Gardens*, <http://www.mrsc.org/Subjects/Parks/comgarden.aspx>.

<sup>42</sup> U.S. Green Building Council, *Green Building By the Numbers*,

close to 40 percent of global-warming emissions.<sup>43</sup> In addition to environmental impacts, how built environments are constructed can have serious human health implications.<sup>44</sup> “Green building” is development that reduces the short-term and long-term impacts on the environment, using new design technology to improve the quality and performance of buildings.<sup>45</sup> While green development may use cutting edge technology, green development can be implemented in a way that is no more costly than typical building development.<sup>46</sup> Moreover, green development consumes less energy and water resources, making green building more cost efficient in the long run.<sup>47</sup> In part to demonstrate the benefits of green development, Enterprise Community Partners and the Natural Resources Defense Council entered a five-year, \$555 million dollar “green communities initiative” to build more than 8,500 environmentally health, affordable homes across the United States.<sup>48</sup> Not only can green housing greatly reduce the carbon impact of housing development and upkeep - green homes can make home ownership more affordable.<sup>49</sup> Green affordable housing “is simply part of a healthy city infrastructure both on the human and physical capital side” – in the words of Enterprise founder James

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<http://www.usgbc.org/ShowFile.aspx?DocumentID=3340> Citing Lenssen and Roodman *Worldwatch Paper 124: A Building Revolution: How Ecology and Health Concerns are Transforming Construction*. Worldwatch Institute (1995).

<sup>43</sup> U.S. Green Building Council, *Green Building By the Numbers*,

<http://www.usgbc.org/ShowFile.aspx?DocumentID=3340> Citing *Energy Information Administration Assumptions to the Annual Energy Outlook : Electricity consumption* (2008).

<sup>44</sup> NRDC (Natural Resource Defense Council) links “standard” low-income housing developments with increased asthma rates, increased exposure to lead paint, and increased food, energy and transportation costs. *NRDC, Green Business: Green Building, Affordable Green Housing*, (2006) <http://www.nrdc.org/cities/building/fhousing.asp>.

See also US Green Building Council factsheet on affordable housing at

<http://www.usgbc.org/DisplayPage.aspx?cmspageID=1718> ; Green Communities, Why Go Green,

<http://www.greencommunitiesonline.org/green/why/> (linking increased asthma, cancer, and lead poisoning rates to low-income housing).

<sup>45</sup> A. Paul, *Building Green and Living Green*, (2007) <http://www.greenandleeds.com/building-green-living-green/>

See also NRDC Green Business:Green Building <http://www.nrdc.org/cities/building/fhousing.asp>.

<sup>46</sup> R. Suttell, *The True Costs of Building Green: The cost premium for green buildings is nominal over that of traditional, ‘to-code’ structures*, Buildings, (April 2006) <http://www.buildings.com/articles/detail.aspx?contentID=3029>.

<sup>47</sup> R. Suttell, *The True Costs of Building Green: The cost premium for green buildings is nominal over that of traditional, ‘to-code’ structures*, Buildings, (April 2006) <http://www.buildings.com/articles/detail.aspx?contentID=3029>.

<sup>48</sup> Enterprise Resource Database: Green Communities Initiative

<http://www.practitionerresources.org/showdoc.html?id=56006&topic=Affordable%20Housing&doctype=Website>.

<sup>49</sup> “Mayors around the country are advancing bold visions for making their cities more environmentally sustainable through strategies to reduce greenhouse gas emissions, manage water and energy resources and create more livable communities greenhouse gas emissions, manage water and energy resources and create more livable communities. Green affordable homes are a vital part of the new sustainable city.” [Enterprise Community Partners, Green Communities Tools: Sustainable Cities](http://www.greencommunitiesonline.org/green/benefits/cities.asp) <http://www.greencommunitiesonline.org/green/benefits/cities.asp>.

Rouse, creating “gardens for growing people.”<sup>50</sup>

### III. Removing Identified Legal and Policy Barriers to Green Investment

Given these many success stories, why don't we see more green investment in needy communities around the world? What can we do to eliminate obstacles to green infrastructure solutions? What can we do to target these investments towards communities in distress?

#### A. Quantification Models to Raise Acceptance

First, we need to refine and make readily accessible user-friendly models to quantify effectiveness of green infrastructure solutions and its life-cycle cost, and tools for measuring economic and environmental benefits realized from the use of green infrastructure. Measurement of small scale projects can be done with general ease. For example, to address localized flooding caused by runoff from one alley, the City of Chicago removed the asphalt from the 630 foot long, 16 foot wide area and replaced it with a permeable paving system. The City then measured that, instead of generating stormwater runoff, the alley will infiltrate and retain the volume of a three-inch, one-hour rain event. The permeable pavement requires little maintenance and has a life expectancy 25 to 35 years. In other areas of the country, studies in Maryland and Illinois show that new residential developments using conservation design approaches saved \$3,500 to \$4,500 per lot (quarter- to half-acre lots) when compared to new developments with conventional stormwater controls. These developments were conceived and designed to reduce and manage stormwater runoff by preserving natural vegetation and landscaping, reducing overall site imperviousness, and installing green stormwater controls. Cost savings for these developments resulted from less conventional stormwater infrastructure and paving and lower site preparation costs. Importantly, in addition to lowering costs, each of the sites discharges less stormwater than conventional developments. Adding to the cost savings, developments utilizing green infrastructure normally yield more lots for sale by eliminating land-consuming conventional

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<sup>50</sup> [Enterprise Community Partners, Green Communities Tools: Sustainable Cities  
http://www.greencommunitiesonline.org/green/benefits/cities.asp](http://www.greencommunitiesonline.org/green/benefits/cities.asp)

stormwater controls, and lots in green developments generally have a higher sale price because of the premium that buyers place on vegetation and conservation development. Methods for predicting the effectiveness of large scale or large area green infrastructure projects prove more challenging and are still evolving, but absolutely exist today. For example, researchers at the University of California at Davis have estimated that for every 1,000 deciduous trees in California's Central Valley, stormwater runoff is reduced nearly 1 million gallons—a value of almost \$7,000. EPA in fact, now has gathered in a single location a variety of accepted predictive models and calculators for green infrastructure, putting these tools in the hands of city managers and planners nationwide and helping to debunk the myth that the effectiveness of green solutions can not be measured.<sup>51</sup>

#### B. Increase Sources of Funding

Second, we need to identify and create sources of Federal, state, and local funding for green infrastructure projects. Various efforts are being taken to develop green infrastructure funding programs, both in the U.S. and in other nations.<sup>52</sup> The billions of dollars necessary to mitigate water pollution simply and absolutely cannot be found at the local level alone. Experience shows that when public financing is on the table, entities will pick up the green infrastructure ball and run with it. As just one example, in 2006 Chicago's Department of the Environment announced that it would provide twenty \$5,000 grants for small-scale commercial and residential green roofs –and received 123 applications. EPA recently cataloged a variety of federal programs where funding for green infrastructure projects may be available.<sup>53</sup> Meaningful funding for such projects at the state and local

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<sup>51</sup> U.S. EPA National Pollutant Discharge Elimination System: Green Infrastructure Models and Calculators <http://cfpub.epa.gov/npdes/greeninfrastructure/modelsandcalculators.cfm>.

<sup>52</sup> See, for example, Winnipeg example, Federation of Canadian Municipalities' "Green Municipal Enabling Fund", Enterprise Community Partners & Natural Resource Defense Council's "Green Communities Initiative", Habitat for Humanity & Home Depot Foundation's "Partners for Sustainable Building Program". In the U.S., major Federal and State funding sources include EPA, Department(s) of Energy, Housing and Urban Development & Health and Human Services.

<sup>53</sup> For professional green building grant service provider in U.S., see <http://www.fundinggreenbuildings.com/>.

<sup>53</sup> U.S. EPA National Pollutant Discharge Elimination System: Green Infrastructure Funding Opportunities, <http://cfpub.epa.gov/npdes/greeninfrastructure/fundingopportunities.cfm>.

levels remains generally elusive, but is starting to become more common.<sup>54</sup>

There are a variety of other ways to create funding for, and to incentivize, green solutions. For example, a key element of the Comprehensive Energy Security and Consumer Protection Act (H.R. 6899) passed by the U.S. House of Representatives in September 2008, is the Green Resources for Energy Efficient Neighborhoods (GREEN) Act. GREEN Act measures make energy efficiency practices more affordable, accessible and achievable by consumers, businesses and government entities. The bill promotes green building by nonprofit affordable housing developers by requiring the creation of grants to nonprofit organizations to increase low-income community development capacity;<sup>55</sup> authorizes an energy efficiency and conservation demonstration program for project based Section 8<sup>56</sup> multifamily housing developments; and establishes a loan fund to allow states and tribes help home and apartment building owners improve energy efficiency via renewable energy and related methods.

A water focused approach to green infrastructure implementation is to create stormwater utilities, similar in function to water and wastewater utilities, which then allow for the assessment and collection of user fees dedicated to a stormwater management program. The dedicated funds can then be applied in part to green infrastructure solutions or they can include incentives to encourage voluntary use of green infrastructure. For example, Portland's River Rewards program provides a credit of up to 35 percent of the standard stormwater fee for properties that retain stormwater on site. Another option is dedicating a certain portion of collected local tax revenues to a stormwater fund, thereby removing stormwater management from volatile and competitive general revenue funding at the local level. These dedicated stormwater funding sources could identify a preference for green

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<sup>54</sup> State Environmental Resource Center: Green Infrastructure State Activity  
<http://www.serconline.org/grInfrastructure/stateactivity.html>

<sup>55</sup> [Text of H.R. 6078 \[110th\]: GREEN Act of 2008 http://www.govtrack.us/congress/billtext.xpd?bill=h110-6078.](http://www.govtrack.us/congress/billtext.xpd?bill=h110-6078)

<sup>56</sup> Section 8, or the Housing Choice Voucher Program, is a Federal housing program which provides housing assistance to low-income renters and homeowners. This assistance comes in the form of rental subsidies, limiting the monthly rent payment of the assistance recipient. Affordable Housing Online,  
[http://www.affordablehousingonline.com/section8housing.asp.](http://www.affordablehousingonline.com/section8housing.asp)

infrastructure or establish a funding scale based upon the relative use of green management techniques. Frankly, the organizational structures and possibilities are many – but they have to be entertained and seriously considered, and existing revenue collection mechanisms may need to be abolished or changed. And while change can be hard, it is far from impossible – especially when the environment stands to benefit.

### C. Reform Regulatory Requirements to Promote Green Infrastructure

The role of regulatory requirements must be explored in terms of how they facilitate and also hinder the use of green infrastructure. In the category of facilitation, research shows that a common driver among many cities using green infrastructure is, in fact, the need to assure compliance with regulatory requirements. For example, a catalyst for Portland, Oregon's active green infrastructure program is a need to satisfy a number of environmental regulatory requirements, including limitations on combined sewer overflows, discharges into groundwaters used as drinking water supplies, and total maximum daily load (TMDL) allocations.

Washington, D.C. passed a law requiring private developers to meet U.S. Green Building Council LEED standards for commercial projects and Green Communities Criteria for housing. The stated goal of the legislation is to "help mitigate the environmental, economic and social impact of built structures in the District." These same regulatory requirements, however, have shown themselves to hinder opportunities for creativity and willingness on the part of municipal decision makers to actively promote and introduce green infrastructure. For example, models have shown that trees with mature canopies can absorb the first half-inch of rainfall – but trees can't be planted with mature canopies. In contrast, a pipe can capture water as soon as it is installed and on-line. Because our regulatory and enforcement system revolves around compliance and immediate results, and because green solutions can take time to come into their own, green infrastructure can be snubbed in favor of a tried and true hard infrastructure solution that can produce measurable results to regulators. For example, many cities are reluctant to use green infrastructure as part of their CSO remediation programs because

enforcement officials generally prefer to see water quality benefit realized expressed in traditional terms, such as percent capture. Percent capture through green solutions is seen as unreliable – and thus, possibly less enforceable.

We need to ensure that green infrastructure projects become an acceptable alternative to hard infrastructure solutions in federal, state, and local permitting and enforcement contexts– even if they may take more time to become fully effective. For example, a tree can take 20 years or more to develop a full canopy that will maximize its stormwater retention and other environmental benefits, which makes regulators reluctant to include them in long term control plans for combined sewer overflows, but it can take almost as long to design and build underground storage tunnels to retain wet weather flows, and those tunnels provide no benefits until they are completed. At least trees provide some stormwater retention, shade, property enhancement, air quality benefits, and aesthetics while they are growing. Regulatory and enforcement officials should focus on the big picture and ensure that the remedies they seek are the most beneficial over the long haul.

Many stormwater regulations focus on peak flow rate control and flood control, and not on retention of stormwater and recharge of groundwater resources. Revision of these regulations to require minimizing and reducing impervious surfaces, protecting existing vegetation, maintaining pre-development runoff volume and infiltration rates, and providing water quality improvements can encourage green infrastructure because it can meet these objectives. New Jersey’s stormwater management standards require 300-foot riparian buffers and stipulate a preference for non-structural best management practices (BMPs). These standards also institute water *quantity* as well as *quality* regulations. The water quantity standards require no change in groundwater recharge volume following construction and that infiltration be used to maintain pre-development runoff volumes and peak flow rates. Any increase in runoff volume must be offset by a decrease in post construction peak flow rate. Water quality standards require a reduction in stormwater nutrient loads to the “maximum extent feasible” and total suspended solids reductions of 80 percent. If the receiving water body is a

high-quality water, the required total suspended solids reduction is 95 percent.

Further, existing local zoning requirements and building codes often inadvertently discourage the use of green infrastructure. Provisions requiring downspouts to be connected to the stormwater collection system prohibit disconnection programs and the use of green space for treatment of rooftop runoff. Mandatory street widths and building setbacks can unnecessarily increase imperviousness. Stormwater treatment requirements that favor centralized collection and treatment and prescribe treatment options offer little opportunity or incentive to use green infrastructure. Jurisdictions should review their applicable stormwater and wastewater ordinances and revise them to remove barriers to green infrastructure use and encourage more environmentally friendly regulations. Those looking to see what other jurisdictions have done can consult a variety of resources, such as the comprehensive, publicly available compilation of ordinances maintained by Pace University School of Law's Land Use Law Center in its *Gaining Ground* database. This resource contains local ordinances on all subjects, including low impact development and stormwater management, and groups them by state, EPA region, and topic.<sup>57</sup>

It is also critically important to recognize that some of the most significant barriers to incorporating green infrastructure into existing urban areas are the costs and challenges associated with retrofitting these systems into built-out and space constrained urban areas. For example, green infrastructure solutions may be more appealing to developers and cities when they are part of a large investment of capital for new projects that are projected to substantially overhaul and upgrade existing infrastructure. For example, it is often less expensive to install a green roof when an existing roof needs to be replaced, and rain gardens or trees in road median strips are often installed along with other street improvements when a street is already likely to be torn up and construction crews are on site.

#### D. Raise Public and Policy Makers Awareness

Fourth, we need to increase the public's and policy makers' awareness and acceptance of green

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<sup>57</sup> See <http://www.landuse.law.pace.edu/>; look under "browse resources," no password needed.

infrastructure options. Although green infrastructure is in many cases less costly than traditional methods of stormwater and sewer overflow control, it often is easier to continue the habit of investing in existing conventional controls rather than trying an alternative approach. It is incumbent on local decision makers, leaders, and citizens to promote and publicize cleaner, more environmentally attractive methods of reducing the water pollution that reaches their communities. Green infrastructure presents an opportunity for community outreach and education. Downspout disconnections, rain barrels, rain gardens, and green roofs may individually manage a relatively small volume of stormwater, but collectively can have a significant impact. Green infrastructure can be introduced into a community one lot or one neighborhood at a time.

A commonality among cities that have incorporated green infrastructure is a commitment from city personnel. Whether elected officials or professional staff, these city leaders have recognized the benefits of green infrastructure and have successfully communicated its value to the public. These cities have also been innovative with their regulations and environmental policies, looking for existing and alternative avenues to encourage adoption of new stormwater and CSO control strategies. These efforts are often popular because of the public's positive response to the "greenscaping" that accompanies the programs. As many local leaders have found, using green infrastructure in place of or in combination with less effective conventional methods of managing water pollution and stormwater runoff can have benefits beyond just economic cost savings and reduced pollution.

#### IV. Conclusion

Finding an effective approach to achieve urban water quality has been elusive. Finding ways to benefit distressed urban economies is also challenging. However, it should be clear now that many cities are developing a track record of success in the green infrastructure arena. These cities are demonstrating convincingly that green infrastructure is an economically and environmentally viable approach for water management and natural resource protection in urban areas. So with that, let us do what it takes, city by city, country by country, to promote a concentration of green investment in urban

communities, so that the people who call these places home may reap the environmental and quality of life benefits that green infrastructure delivers.