Inviting Nature Home:
An Ecosystem-Based Approach to Nature in Cities

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Introduction

> "We shall solve the city problem by leaving the city"
>
> – Henry Ford (quoted in Mees 2010, 12)

> "It just may be the most radical act we can commit is to stay home."
>
> – Terry Tempest Williams (1994, 134)

The "city problem," unrecognized by Ford, is thinking that we really can leave – that there is somewhere fully separate where we can go. The "city problem" is that we perceive a separation between here and there, between the city and nature, between ourselves and the ecosystems that support us.

The history of our cities has generally been one of expelling nature and constructing a sovereign built environment exclusively for humans. We have assumed that cities are not only independent from nature, but that they should fully replace the "wild" landscape of nature with a more sophisticated, cultured, and advanced landscape. Cities are manifestations of our Quixotic battle to overcome nature, to separate ourselves from the cycles of the earth, and to insist on what William Cronon (1995) calls a fabricated "human-nature duality." In city building, this false duality has facilitated the impetuous tearing apart of nature in a hasty quest to sterilize our habitat at the expense of others.

The tragic assumption that we and our cities are separate from nature provides false comfort as we bury urban streams, fragment ecosystems, and disconnect ourselves from the cycles of life. This disconnection blinds us to the effects of our actions, and leaves us illiterate to read the signs from a nature in distress. Instead, we are engulfed in an urban landscape too frequently "depressing, brutal, ugly, unhealthy, and spiritually degrading" (Kunstler 1993, 10).

Rather than liberated by our imagined separation from nature, we suffer emotional, psychological, and physiological wounds, pay an unnecessary economic price, and leave our children missing something they have never known. Alienation from nature afflicts us with a "nature-deficit disorder" (Louv 2008) manifested in a wide range of maladies affecting all community members, but extracting its greatest toll from our children in the form of obesity, anxiety, depression and a disconnection from the living world. As children grow up in an urban landscape bereft of nature, we are gambling with the consequences of a generation uniquely severed from the earth's systems at the same time that those very systems are under more stress than any point in human history.

The cost of expelling nature is expressed in the billions of dollars necessary to repair the crumbling urban infrastructure we have installed to replace nature, in the annihilation of local ecosystems and the shifting of ecological burdens elsewhere, and in the disconnection from nature that stifles our capacity to affectively address urgent environmental problems.

But it doesn't have to be so. There is nothing essential about cities that precludes nature. Instead, another urban relationship with nature calls to us. Over forty years ago Ian McHarg implored us to listen: "Let us then abandon the simplicity of separation and give unity its due. Let us abandon the self-mutilation that has been our way and give expression to the potential harmony of man-nature" (McHarg 1969, 5).

The call is to invite nature home to our cities. It is to welcome nature as a co-designer of the urban landscape, and to embrace our connection to the earth rather than flee from it. The call is for a process of restoring ecological integrity that begins with restoring the integrity of our relationship with nature. We are not separate from nature. Our relationship with the ecosystems around our home is reflected back to us in our relationship with ecosystems across the planet, in our relationship with other species, and in our relationship with ourselves.

This paper suggests a three-part process for inviting nature home. The process rests on the conviction that the appropriate nature to invite back to any given city is the nature that existed in that particular location before the city did. The term "character" refers to "the *natural* composition, structure, and function of the ecosystem" and is the appropriate guide for restoration at all spatial and temporal scales across the city. The first part of the process is developing an understanding of natural ecosystem "character," as well as its current condition.

The second part, Ecosystem-Based Voluntary Action (EBVA), describes restoration actions that can be taken at the scale of individual properties, blocks, and neighbourhoods. These "bottom-up" efforts are, by definition, individually small, but the aggregate of these actions provides the essential "greening of the matrix," without which a healthy urban ecoscape would not be possible.

The third part, Ecosystem-Based Restoration Planning (EBRP), is based on the science and practice of Ecosystem-Based Conservation Planning, but applied to urban areas with the acknowledgement that inviting nature back into our cities is a process of restoration. The goal is to restore some level of ecological integrity by connecting the restoration work carried out through voluntary action at the site, block, and neighbourhood scales, to existing and new larger-scale patches and corridors across the urban landscape.

Inviting nature back into the human-dominated landscape of our cities requires innovative approaches to greening the matrix, and to creating new patches and corridors at multiple spatial scales. However, it also requires that we simultaneously increase the density of human use because higher density is needed to reduce the ecological footprint that might otherwise counter many of the benefits gained through restoring nature. Urban designers recognize that while there is an apparent paradox in being asked to build more while simultaneously conserving open spaces, it is possible to design a built environment that actually creates green space and makes density more liveable.

Approaches to this end include blurring of the lines between indoors and outdoors, incorporating wildlife passages into infrastructure systems, greening walls and roofs, planning for canopy-level connectivity, reducing road density and re-purposing alleys, daylighting streams, greening hydrological infrastructure, establishing ecology parks and linear corridors, reclaiming abandoned industrial landscapes, increasing urban agriculture, and generating biophilic momentum.

Successful reintegration of nature in our cities offers us innumerable benefits: urban dwellers become attuned to our global environmental challenges, and apathy is transformed into a lasting ecological ethic; citizens are connected to their place on the earth, communities are strengthened, and children are healthier; cities becomes more resilient, ecosystem services are secured and strengthened, and people experience greater physiological and psychological well being.

Committing Terry Tempest Williams' radical act of staying home sends out this invitation to nature. Staying home means recognizing that there is nowhere fully separate to go, and we must therefore take responsibility for healing ourselves, our planet, and our home. Inviting nature home to our cities will inspire citizens and communities to reconnect with what Harvard's Edward O. Wilson (1993) calls our "innately emotional affiliation" to nature.

At a time when 80 per cent of Canadians live in cities, the call to invite nature home is more urgent than ever. By inviting nature home, the "city problem" may yet become the "city solution."

Terminology

Urban Ecoscape

Cities are highly-modified landscapes dominated by human activities. Yet within the urban landscape, at many spatial and temporal scales, there is a mix of human and non-human elements, vibrantly engaged in a myriad of interactions, and challenging us to clearly define a line between what is natural and what is not.

Terms used to describe the more natural elements within cities include “green space,” “open space,” “parkland,” “natural areas,” “reserves,” and “stocks of natural capital.” All of these terms require specific definitions that recognize the range of elements that might be included as well as the interactions with elements that are not. For example:

> “Open-space systems are composed of a myriad of interacting and interdependent entities, from humans and wildlife to natural features and built structures. They inherently engage complex causal connections, both ecologically and socially…. Because the term “open-space” is an ambiguous one, scholars and practitioners have long devised schemes to understand the connection of open land to the built environment” (Erickson 2006, 11).

The schemes devised are frequently typologies organized according to a specific feature of interest such as scale, use, ownership, or ecological value (Erickson 2006). For example, stocks of natural capital within a city could be organized according to their potential to sequester greenhouse gas emissions, to support pollination services, or to manage stormwater runoff. Alternatively, parkland could be organized by scale from the neighbourhood to the region.

This paper concerns itself with ecological values across various scales, multiple uses, and the full range of ownership arrangements. In order to select an appropriate term that would capture all elements of the urban landscape that provide ecological value, the concept of “ecoscape” as proposed by University of California at Berkeley’s William Lidicker (2008) was embraced. Lidicker proposes the term “ecoscape” to refer to a fourth level of ecological organization, above the levels of organism, population, and community, that is defined as “an ecological system containing more than one community type” (Lidicker 2008, 71).

In this paper the term “urban ecoscape” (or “ecoscape”) refers to the entirety of elements within the urban landscape that provide some measure of non-human ecological value.

While there may not be a clear line between the “urban ecoscape” and all other components of the urban landscape, a few guidelines may help conceptualize approximately where the line might be drawn. First, elements of the urban landscape that provide little or no direct ecological value are not included in the ecoscape. While some non-human ecological activity undoubtedly takes place in these elements (such as the growth of mould on a bathroom wall), and these elements may provide benefits to non-human species (such as the preparation, in a restaurant’s kitchen, of food that may ultimately provide a meal for rats), these elements are primarily the results of human efforts and exist to provide primarily human benefit.

Second, what is obviously within or without of the ecoscape depends significantly upon scale. For example, a neighbourhood park may be understood to be part of the ecoscape at the neighbourhood scale, but at the scale of the park itself, elements such as a tennis court would not. Conversely, a building may not be obviously part of the ecoscape at the scale of the city, but a vegetated wall or an eagle’s nest on the building obviously would be part of the ecoscape at the scale of the building.

Third, humans are part of, and are dependent upon, ecosystems. Defining the term “ecoscape” in terms of “non-human ecological value” does not call these facts into question, but rather makes a distinction for the purposes of clarifying what is too frequently overlooked in our cities: the non-human elements. The focus on non-human ecological values is an intentional rejection of David Harvey’s assertion that: “In the same way there is nothing unnatural about an ant hill, so there is, surely, nothing particularly unnatural about New York City.” (2010, 85).
The definition of “ecoscape” used in this paper allows for a focus on the “ecology in cities” while recognizing the context of “ecology of cities” as distinguished by Grimm *et al* (2000). Ecoscapes represent the “ecology in cities” but are part of the “ecology of cities” and it is recognized that:

> "Cities and towns are composed of complex ecosystems, with many different processes acting to shape the ecology of the city. These include influences from social systems… economic systems… as well as the ecological systems, relating to the physical and chemical environment, the local climate, and the biota that inhabit these areas." (Hahs et al 2009, 594)

In other words, the urban ecoscape is influenced by human culture (including human economic and social systems, and the human built environment), and vice-versa.

Healthy Urban Ecoscape

An urban ecoscape can be either healthy or unhealthy. A healthy ecoscape is connected rather than fragmented; ecologically diverse rather than composed of a small number of species; reflective of ecosystems indigenous to the area rather than overwhelmed by introduced species; connected at multiple scales to the region rather than isolated from the surrounding landscape; and natural rather than manicured.

The concept of a healthy urban ecoscape is based on the concept of an "ecosystem-based approach" that has been pioneered in forest ecosystems in the context of competing uses of forests. The pioneer of an ecosystem-based approach to forest use, Herb Hammond, explains that such an approach focuses on "what to leave and not on what to take," operates at multiple and connected spatial and temporal scales, and recognizes that the natural ecological integrity indigenous to a particular place is the appropriate guide for ecosystem restoration (personal communication 2012).

The ecosystem-based approach advanced by Hammond and his Silva Forest Foundation has been implemented in forest communities around the world. It has been shown to create stronger human communities, longer-term economic benefits, and healthier and more resilient ecosystems. By planning over ecological time frames (hundreds of years), the ecosystems are diverse enough to adapt to threats (including climate change) while maintaining ecosystem services and providing benefits to human communities.

The approach is based on the science of landscape ecology and the process of ecosystem-based conservation planning:

> Landscape ecology considers "spatial patterns and ecological processes; spatial and temporal scales; heterogeneity effect on fluxes and disturbance; changing patterns; and a framework for natural resource management" (Forman 1995, 133)
>
> "Ecosystem-based conservation planning is a method of ecosystem protection, maintenance, restoration, and human use that, as its first priority, maintains or restores natural ecological integrity – including biological diversity – across the full range of spatial (from very large to very small areas) and temporal (from short to long periods of time) scales" (Hammond 2009, 23).

Applying the ecosystem-based approach to urban areas leads to a significant shift in understanding about what it means to have green space in the city. First, an ecosystem-based approach means that the nature that is restored and protected within urban areas is the nature that existed in that particular place before the city did. In other words, it is not manicured, non-native, and contained nature, but rather it is indigenous, wild, and ecologically-healthy nature. Second, nature is connected at multiple spatial scales. Rather than isolated green patches, nature is connected from backyards, to blocks, to neighbourhoods, to larger protected areas, and to the region surrounding the city. Third, nature is integrated throughout the city, rather than separated into distinct zones and parcels.

By applying the ecosystem-based approach to urban landscapes, we can expect that the ecosystems within urban areas will be ecologically stronger and better able to withstand the stresses placed upon them by human activity. We can also expect that ecosystems adjacent to, and dependent upon, urban ecosystems will also be stronger and more diverse. Connectivity will no longer end abruptly at the urban containment boundary, but will instead continue throughout and across urban areas. Species needing to pass through urban areas, such as salmon and migratory birds, will find sanctuary and protection rather than blockage and threats. Moreover, by applying an ecosystem-based approach to urban areas we can expect a markedly increased bounty of ecosystem services from both urban and adjacent ecosystems, including clean water, clean air, climate regulation, flood protection, waste treatment, pollination, species habitat, food production, recreation, and aesthetic and spiritual benefits.

Within the urban ecoscape, it is recognized that urban areas are human-dominated landscapes, that restoration of natural ecological integrity may not be fully possible, and that the extent of restoration will vary across the urban landscape (for example, the downtown core versus residential areas). Nevertheless, the goal of an ecosystem-based approach to inviting nature back to our cities is maximizing restoration in order to create a healthy urban ecoscape.

In this paper, the term “healthy urban ecoscape” (or “healthy ecoscape”) refers to an urban ecoscape that is characterized by the restoration of as much of the full range of natural ecosystem composition, structure, and function as possible, connectivity across all spatial and temporal scales, and biological diversity.

The Expulsion of Nature

> "…nature waits for us to bring her home… we have expelled it needlessly from our daily lives"
> —Edward O. Wilson (2012, xv)

The expulsion of nature from our daily lives is nowhere more evident than in our cities. The Western project of urbanization has generally proceeded by removing nature from where we live and work, and replacing it with the "concrete jungle" of a built environment designed almost exclusively for human activities carried out in perceived isolation from nature. This process of ousting nature typically results in the complete razing of local ecosystems, including disrupting hydrological and nutrient cycles, culverting and burying streams, polluting soils and waterways, shattering aquatic and terrestrial habitat, simplifying ecosystem structures, halting the process of ecological succession, fragmenting ecoscape components, isolating remnant populations, harbouring invasive species, reducing food web complexity, and disconnecting people from ecological feedback, knowledge, and wisdom. As Lewis Mumford noted, our efforts have created a "polluted, bulldozed, machine-dominated, dehumanized" civilization that calls for "a vision of organic exuberance and human delight, which ecology and ecological design promise to open up for us" (Mumford 1969, viii).

While it is true that urban areas, and suburban areas in particular, include patches of manicured greenspace, this is not a replacement for the functioning ecosystems that existed prior to urbanization. Rather, it is a capturing and sentimentalizing of nature. As Jane Jacobs wrote:

> "Nature, sentimentalized and considered as the antithesis of cities, is apparently assumed to consist of grass, fresh air and little else, and this ludicrous disrespect results in the devastation of nature even formally and publicly preserved in the form of a pet" (1961, 446).

What has been expelled from our cities is "wild" nature – nature that is unbridled enough to include a full range of natural ecosystems, to have connectivity across all spatial and temporal scales, and to support and include significant biological diversity. What has been dismissed from our cities is nature that is able to provide significant levels of ecosystem services, offer spiritual, psychological, and physiological benefits to urban residents, and foster the empathy and creativity necessary for humanity to restore ecological health across the planet. In his seminal *Design With Nature*, Ian McHarg wrote:

> "Clearly the problem of man and nature is not one of providing a decorative background for the human play, or even ameliorating the grim city: it is the necessity of sustaining nature as a source of life, milieu, teacher, sanctum, challenge and, most of all, of rediscovering nature's corollary of the unknown in the self, the source of meaning" (McHarg 1969, 19).

Witnessing the overwhelming expulsion of nature from our cities, begs the question: "why?" Why did we choose to create an urban habitat – one that for the first time in history holds the majority of humans (United Nations 2010) – that is so bereft of nature? To answer this we must recognize that it has been our choice to do so, and we therefore need to look to ourselves. The Latin word *civis*, meaning "citizen," is the root of both the word "city" and the word "civilization." Our conception of cities cannot be untangled from our conception of civilization, or of the aspirations of our culture. As Darko Radovic expounds: "As sensitive reflections of broad societal values, trends and trajectories, cities reflect the highs and the lows of human civilization" (Radovic 2009, 1). As such, the separation of our cities from nature is tied to the separation of our civilization, our culture, and ourselves from nature.

Environmental historian William Cronon points out that Western culture has fabricated a human-nature duality: "The place where we are is the place where nature is not" (Cronon 1995, 81). This duality is manifest in the development of cities where engineers have gone to great lengths to make urban existence as seemingly independent from local ecosystems as possible: the reliance on energy inputs from elsewhere, the homogenization of development irrespective of location or climate, the removal of vegetation and paving over of soils, the fabrication of infrastructure to replace ecosystem services, and the shielding of daily life from hydrological cycles, seasons, and weather. Our cities are "ecologically impoverished and imperilled, constantly requiring a technological fix to right the catastrophe prompted by a previous technological fix" (Hester 2006, 9), and urban planning literature is engaged with discussion of the "urban-rural gradient" that describes not only an intensity of human use, but also presumes an inescapable extirpation of nature as one moves toward the urban core. Anne Whiston Spirn writes that: "The belief that the city is an entity apart from nature and even antithetical to it has dominated the way in which the city is perceived and continues to affect how it is built" (Spirn 1984, 5). Nature is perceived as existing somewhere else beyond the exurban fringe. Nature is comprehended as the subject of documentaries, and the location of weekend adventures, but daily urban living is led in apparent isolation from it.

Sigmund Freud took it even further when he wrote that "…the principal task of civilization, its actual raison d'être, is to defend us against nature" (Freud 1927, 15). Freud's assertion reveals another layer to the human-nature duality that is expressed by urbanization. It is not just that nature is separate; it is also that Western civilization actively attempts to suppress, contain, and destroy nature. There has long been a perceived struggle through which cities overcome nature and keep it out, so that they don't become "ruined" or fall into neglect, meaning "overgrown" (Mason 2010, 187). Cities have been designed to succeed by making nature succumb: by "reclaiming" land from wetland ecosystems; by channelling rivers and levelling the earth; and by driving out most species and taming what nature is left. As University of California at Berkeley's Carolyn Merchant writes: "Civilization is the final end, the telos, toward which "wild" nature is destined" (Merchant 1995, 147). In this epic battle, cities represent the glory of civilization's victory over nature.

Of course the fabrication of a human-nature duality remains just that: a fabrication, a myth. Our cities, our civilization, and ourselves remain fully connected to nature and to the ecosystems of which we are a part. In the words of Harvard's E.O. Wilson:

> "The truth is that we never conquered the world, never understood it; we only think we have control… The prevailing myths concerning our predatory actions toward each other and the environment are obsolete, unreliable, and destructive" (Wilson 1984, 140).

Creating cities in service of a mythical human-nature duality costs us enormously. Expelling nature from where we live robs us of our full human potential, and divorces us from our innate affiliation with the living biosphere. It is well documented that this exacts a significant emotional, psychological, spiritual, and physiological toll, especially on our children. It also costs us economically by limiting our ability to understand and respond to ecological challenges, and by forcing us to rely on expensive constructed infrastructure that attempts to recreate the services that nature would otherwise provide for free.

In this section, the human, economic, and ecological costs are reviewed. The psychological and physiological costs of expelling nature are well documented, we are collectively experiencing "nature deficit disorder," and our children are growing up severed from the earth's systems at the very time that those systems are sending out dire warnings. The economic costs of expelling nature include our expensive reliance on manufactured and decaying grey infrastructure systems, as well as a "there-is-no-alternative" mindset that leaves us unable to creatively address our ecological challenges without further reliance on expensive built systems. The ecological costs, paid at multiple spatial and temporal scales across urban areas, include the concentration and degradation of water and the interruption of the hydrological cycle, the fragmentation and isolation of ecosystems and habitat areas, the substitution of manicured nature for functioning ecosystems, the colonization of urban areas by a small number of exploiter species, and the concomitant degradation of ecosystems adjacent to urban areas.

Human Costs

> "We need nature in our lives; it is not optional but essential."
> – Timothy Beatley (2011, 3)

Edward O. Wilson, Harvard's eminent Professor of biology and Pulitzer prize-winning author, developed the concept of "biophilia" – "the innate tendency to focus on life and lifelike processes" (1984, 1) – and concluded that "the degree to which we come to understand other organisms, we will place a greater value on them, and on ourselves" (1984, 2). It is this "innately emotional affiliation of human beings to other living organisms" (Wilson 1993, 31) that allows us to be fully human, and to reach our intellectual, emotional, and creative best. The full development of this connection with nature depends, in the words of Yale University's Stephen Kellert, "on sufficient experience, learning, and cultural support" (2006, 4). Yet our urban areas are too frequently devoid of nature, robbing us of our potential, and repudiating our inherent affiliation with life. A growing body of research is documenting the emotional, psychological, spiritual, and physiological toll this is taking on us all.

We are Less Human Without Nature

In his influential book *Last Child in the Woods*, Richard Louv (2008) argued that our alienation from nature has afflicted us with "nature-deficit disorder", as manifested through a wide range of maladies affecting children and adults, families, and entire communities. Louv chronicles three "frontiers" of our Western relationship with nature: "direct utilitarianism" (through the end of the 19^{th} century), "romantic attachment" (through the 1990s), and the current "electronic attachment." During the "romantic attachment" period of the 20^{th} century, there were relatively accessible forests and farmland on the edge of cities, and many people had "grandparents or other older relatives who farmed or had recently arrived from farm country during the rural-to-urban migration of the first half of the twentieth century" (2008, 19). The current "third frontier," populated by today's children, is characterized by five trends: "a severance of the public and private mind from our food's origins; a disappearing line between machines, humans, and other animals; an increasingly intellectual understanding of our relationship with other animals; the invasion of our cities by wild animals… and the rise of a new kind of suburban form"(2008, 19).

The "third frontier" of our relationship with nature has put our innate desire for nature at odds with the reality of our daily urban experiences. The average North American spends 95 per cent of his or her time indoors (Nicholson-Lord 2005), and when they do venture outside, it is frequently into an urban landscape dominated by pavement, buildings, and a fabricated and sentimentalized ecoscape of highly-managed lawns, gardens, and playing fields. This combination of features does not feed our innate need for real connections with nature.

"Far from desiring intensively managed and manicured landscapes which is often assumed by engineers… the public have shown a strong preference for: natural rivers banks and channels; trees and vegetational diversity" (House et al 1993, 320). A survey of American suburban and exurban residents found that when asked to rank conventional subdivisions, conventional agriculture, and ecologically-beneficial subdivisions in terms of perceived attractiveness, the ecologically-beneficial features were found to be most attractive (Nassauer et al 2004). University of Michigan psychologists Rachel Kaplan and Stephen Kaplan have extensively studied the effect of nature on people's health, and assert that human's "preferred environments" are green and natural settings with complexity and diversity (1982).

Without regular access to our preferred natural environments, we are foregoing many psychological and physiological benefits. Over a decade of research has revealed "how strongly and positively people respond to open, grassy landscapes, scattered stands of trees, meadows, water, winding trails, and elevated views" (Louv 2008, 43). Exposure to nature has been shown to reduce recovery time from injuries, reduce one's frequency of illness, reduces stress, and profoundly affects our mental and physical health (Louv 2008, 46).

Stephen Kaplan points out that "directed-attention fatigue" comes from the exhaustion associated with continually blocking out competing stimuli – a challenge ubiquitous in urban life – and leads to irritability, reduced inhibitions, a lessened ability to effectively solve problems, a lowered capacity for understanding the "bigger picture," a weakened capacity for following through on plans or taking action on difficult tasks, and a reduced inclination to assist others (Kaplan 1995). The antidote, according to Kaplan, is exposure to natural environments which "turn out to be particularly rich in the characteristics necessary for restorative experiences" (1995, 169), and such experiences are capable of both mitigating and preventing stress (Kaplan 1995, 180).

Toll on Children

The expulsion of nature from our daily lives may be taking its greatest toll on our children. While there is a complex set of factors that contribute to obesity, the dramatic increase of childhood obesity in the United States has led some paediatricians to warn that today's children may be the first generation since World War II that dies at an earlier age than their parents (Louv 2008, 47). Twenty percent of American children are clinically obese, up from five percent in the 1960s (Louv 2008, 48). Statistics Canada reports that fewer than 10 per cent of Canadian children and youth meet the current guidelines for moderate-to-vigorous physical activity, and that Canadian children spend an average of 7.6 of their daily waking hours engaged in sedentary activities (CBC 2012).

Paradoxically, at the same time that obesity has increased dramatically among children, the United States has seen "the greatest increase in organized children's sports in history" (Louv 2008, 48). Clearly organized sports are not a panacea, and highly-structured play at a young age does not provide the physical and psychological benefits available from unstructured play in nature. For example, studies comparing children "who played every day on typically flat playgrounds to children who played for the same amount of time among the trees, rocks, and uneven ground of natural play areas. Over a year's time, the children who played in natural areas tested better for motor fitness, especially in balance and agility" (Louv 2008, 48-49).

Children engage in open-ended activities when playing in nature, and "the way in which people interact, particularly children… is also directly influenced by the natural elements and design of a park or garden…" (Malone 2004, 59). Children also treat each other differently when playing in unstructured natural environments, valuing creativity and social skills over physical prowess. Studies of children in the US found that:

> "…when children played in an environment dominated by play structures rather than natural elements such as plants and bushes, physical competence was the means through which social hierarchy was established. The focus of the interaction with the environment and the play that ensured became competitive and little attention was paid to the environment as a space for learning or interaction. However, after an open grassy area was planted and became available for the children they played very differently I these "vegetative rooms." Fantasy play and socialization developed. More importantly the social hierarchy became based less on physical prowess and more on a "child's command of language and their creativity and inventiveness"" (Malone 2004, 59-60)

In fact, unstructured, imaginative, exploratory play – the kind of play encouraged by natural environments – "is increasingly recognized as an essential component of wholesome child development" (Louv 2008, 48). Researchers at the University of Illinois report that a growing body of evidence suggests "contact with nature is as important to children as good nutrition and adequate sleep…" (Andrea Faber Taylor and Frances Kuo quoted in Louv 2008, 110). While sedentary lifestyle also makes children depressed (Louv 2008, 49), children "prefer to play in natural or wild spaces where they can engage in direct contact with natural objects" (Malone 2004, 58).

Studies at Cornell University found that when children are faced with stressful events in life, exposure to nature reduces their psychological distress. Children with more nature near their homes had lower levels of behaviour conduct disorders, anxiety and depression. They also had higher levels of perceived self-worth. (Louv 2008, 50). Exposure to nature also helps children by stimulating their senses, and fostering imagination and creativity. Professor Robin Moore, director of North Carolina State University's Natural Learning Initiative, summarizes the broad range of developmental benefits children gain from exposure to nature:

> "The benefits of natural settings were found to be diverse, like nature itself. Natural settings stimulate all aspects and stages of child development through multi-sensory experience. They integrate informal play with formal learning in natural learning cycles and thus help build the cognitive constructs necessary for sustained intellectual development. They stimulate imagination and creativity in a special, boundless way, and supply construction materials for children's architecture and artefacts. They integrate children by age, ability, and ethnic background. They help children feel good about themselves. They enhance self-esteem and offer children a peaceful feeling. They focus the perceptions of children on the region of the Earth where they actually live. They help children understand the realities of natural systems through primary experience. They

> demonstrate natural principles such as networks, cycles, and evolutionary processes. They teach that nature is a uniquely regenerative process. They support interdisciplinary, environmental education curricula. They provide microclimatic comfort and flexible, forgiving settings that are aesthetically appealing to all people. By implication, these are some of the advantages to children that are becoming lost as their use of the outdoors diminishes." (Moore 1997, 208)

Taylor and Kuo found that when children diagnosed with an attention-deficit disorder, played in natural, green settings they were better able to focus and concentrate, and that activities that exacerbated ADD occurred in settings devoid of greenery (Louv 2008, 106). These findings are important in the context of disturbingly-high rates of attention-deficit disorders among children. The Globe and Mail reported that 7-10 per cent of Canadian children have ADHD, and that the condition is increasingly being viewed as chronic with expectations that 60 per cent of the afflicted will never outgrow it (Abraham 2010). In response, over two million Ritalin prescriptions were written in 2009 for Canadian children under the age of 17 – a rate that has been increasing over 10 per cent annually for a decade (Abraham 2010).

While a significant body of research points to the benefits of exposing children to nature, and that "natural settings stimulate children's development in ways not provided by other means" (Moore 1997, 207), urban life for children in the "third frontier" of our relationship with nature is often intentionally devoid of nature. Louv (2008) argues that direct contact with nature for children, in the form of outdoor play, is being deliberately restricted:

> "Countless communities have virtually outlawed unstructured outdoor nature play, often because of the threat of lawsuits, but also because of a growing obsession with order. Many parents and kids now believe outdoor play is verboten even when it is not" (Louv 2008, 28).

As this "third frontier" of children grow up in an urban landscape bereft of nature, we are gambling with the consequences of a generation more severed from the earth's systems at the same time that those very systems are under more stress than any point in human history. Families, communities, and colleagues are also burdened with the emotional, psychological, spiritual, and physiological wounds of an unfulfilled biophilia. Collectively we have handicapped our health, creativity, and resilience by removing life from the very place where we live.

Ecosystems Elsewhere

Perhaps the most subtle, yet potentially enormous, ecological cost of expelling nature from where we live is that our disconnection from nature increases the ecological burden we shift to other ecosystems, and decreases our capacity to effectively address environmental problems. By not having nature in our daily lives we fail to constrain our ecologically-damaging behaviour because we are insulated from the immediate effects and cannot read the signs of stress from the natural world. By seeing nature as something that exists somewhere else we create a disconnection that hampers our ability to effectively address the ecological crisis.

Hellmund and Smith, writing about the social ecology of landscape design, argue that "fixating on wild and beautiful places far from home makes it that much easier to avoid more difficult problems of the urban environment and the implications of consumptive behaviour" (2006, 169). Such an "emphasis on distant nature" – one that is outside our daily lives – has created serious problems, including: "a tendency to base international conservation on the wilderness ideal that is a vestige of colonialist thinking," and an understanding that the desirable life is outside of the city which "encourages further development and sprawl in the very places we cherish for their beauty and wilderness" (Hellmund and Smith 2006, 169).

If urban dwellers see the biodiversity problem at all, they generally see it as primarily occurring in another country (Beatley 2004, 116), or at least outside of the city in which they live. Disconnecting ourselves from environmental problems not only exacerbates the continued destruction of distant ecosystems, but also disregards the interdependence we have with a web of life that begins in our backyards. As Gregory Bateson reminded us: "The unit of survival is organism plus environment. We are learning by bitter experience that the organism which destroys its environment destroys itself" (Bateson 1972, 491).

Economic Costs

> "At the same time that we are altering our natural world one increment at a time, we are separating ourselves from this world. As a result, it seems less and less real, and we are less able to pick up the signals from our environment that would warn us of trouble; oblivious, we become yet more arrogant and sure of our powers. Arrogance distorts our ability to see which challenges around us really need our attention; and that, in turn, distorts the amount and kinds of ingenuity we supply."
>
> – Thomas Homer-Dixon (2000, 94)

Activist and author Dr. Vandana Shiva points to what she terms "monocultures of the mind" – a habit of thinking that excludes alternatives, discounts a diversity of approaches in favour of a single approach, and manifests itself in controlled technology instead of uncontrolled nature. As she writes, "monocultures first inhabit the mind, and are then transferred to the ground" (Shiva 1993, 7). By relying on a monoculture of manufactured systems and built infrastructure to support our cities, we have excluded the diversity of solutions available in nature while being simultaneously trapped in the expensive maintenance of our built infrastructure.

Thomas Homer-Dixon (2000) points out a two-part systemic limitation rooted in our expulsion of nature from where we live. The first part is that we are less able to recognize the signs of trouble, thereby foregoing the advantage of taking early action to avoid larger and more costly problems. The second part is that our disconnection leaves us flat-footed when the times comes to respond, thereby reducing the level of creativity and effectiveness we are ultimately able to provide.

Expelling nature also results in a perceived reduction in the available options for addressing our challenges – what Vandana Shiva calls the "there-is-no-alternative" mind set (Shiva 1993). If our environment is composed almost completely of human-made elements, then the answers to our challenges are frequently seen in the form of more, expensive, human-made elements: more roads to alleviate traffic, more medical facilities to help the ill, more sewers and treatment plants to manage water. With little connection to the natural world, we become stuck in a cycle of unsustainable and costly temporary solutions that make our long-term problems more acute and our cities ultimately unsustainable. As Darko Radovic, the Head of the University of Melbourne's Urban Design Program, argues: "…if our actions are based on values that respect the environment, then our cities will be sustainable: if our guiding social values are not sustainable, then our cities become unsustainable, too" (2009, 1).

Anne Whiston Spirn, Professor of landscape architecture at Massachusetts Institute of Technology, points out the breadth costs associated with the perception that cities are entities disconnected from nature:

> "This attitude has aggravated and even created many of the city's environmental problems: poisoned air and water; depleted or irretrievable resources; more frequent and more destructive floods; increased energy demands and higher construction and maintenance costs than existed prior to urbanization; and, in many cities, a pervasive ugliness." (2004, 115)

The "arrogance" identified by Homer-Dixon is particularly evident with the expansive urban infrastructure undertakings in which we simultaneously expel nature, and replace nature with constructed facsimiles. For example, urban riparian wetlands provide "…water quality maintenance, flood storage, carbon storage and sequestration, maintenance of biodiversity and wildlife habitat, maintenance of trophic structure and food webs, streambank stabilization, flood water storage and moderation of stream hydrographs, nutrient cycling processes, and the provision of recreational and aesthetic resources" (Stander and Ehrenfeld 2010, 254). Yet, such areas are frequently paved over and the benefits that were previously available for free are sought through an elaborate infrastructure of water filtration plants, stormwater management systems, stream channel diversion projects, flood protection structures, bank stabilization measures, and other related costs associated with the loss of the original riparian area, such as degraded soils, torn food webs, and the loss of recreational and aesthetic resources.

Cost of Grey Infrastructure

The expanse of urban infrastructure in Canada, built between the 1950s and the 1970s, is straining under increasing demands, and decades of under-investment. McGill University's Saeed Mirza (2007) has calculated the "municipal infrastructure deficit" in Canada to be over $120 billion. This figure represents the "total additional investment needed to repair and prevent deterioration in existing, municipally owned infrastructure assets" in Canada (Mirza 2007, 7), and has risen markedly over the past decade as all levels of government have deferred maintenance and repairs. In short, the level of investment "…has not met the annual rehabilitation needs of existing capital stock, or alleviated the backlog of maintenance and rehabilitation that accumulated" (Mirza 2007, 6). With continued deferral of maintenance, this figure could rise to over $2 trillion (in constant dollars) over the next 50 years (Mirza 2007, 17).

Since we are not keeping up with the maintenance costs associated with our existing built infrastructure, it is worth questioning why we are spending money on new infrastructure while failing to recognize what nature is able to provide for free. Optimistically, some cities are doing just that. For example, New York City compared a green infrastructure plan to meet their stormwater management objectives with a grey infrastructure plan, and found that the green infrastructure plan would cost $US 1.5 billion less ($US 5.3 billion for the green infrastructure, compared to $US 6.8 billion for the grey infrastructure) over 20 years, and would provide "significant sustainability benefits… not available through the grey strategy" (New York City 2010, 9). In attempting to quantify some of these benefits, New York's Department of Environmental Protection concluded that:

> "New Yorkers would receive between $139 million and $418 million in additional benefits through reduced energy bills, increased property values, and improved health. None of these benefits accrue through an all-Grey Strategy. Tanks, tunnels, and expansions are single-function items and lay dormant unless there is a storm of sufficient size. These large investments have long lead times for design and construction and are subject to intervening risks from changes in climate, labor, and economic conditions as well as regulatory requirements. Tanks, tunnels, and expansions also contain a significant amount of embedded energy – i.e., the greenhouse gas emissions and materials in their construction – involve significant amounts of construction-related air and other emissions, will require energy for pumping when in use, and are labor-intensive" (New York City 2010, 10)

Detroit, a city hard-hit by recent economic events, and a place where cost savings are paramount, recently cancelled plans for $1.3 billion in traditional grey infrastructure projects, and replaced them with $814 million in combined green and grey projects to meet the same needs (Berkooz 2011). Philadelphia has similarly committed to spending $1.6 billion on green stormwater infrastructure (Berkooz 2011), and studies in Toronto revealed that installing green roofs on only 6% of Toronto's roofs would affect stormwater retention to the same extent as building $60 million storage tunnel (Peck 2005). New York City has also recognized that protecting an urban watershed is less expensive than building water treatment plants. Over the past 20 years, NYC has contributed $US 1.5 billion to protect the quality of its source waters, and by doing so has avoided the need for a water filtration plant that would have cost at least $US 10 billion (New York City 2010).

New York's thinking in this regard takes an important step to address the arrogance identified by Homer-Dixon by proactively recognizing the value of nature and connecting its future with nature's abundance. In the same vein, a recent study for the David Suzuki Foundation estimated that the value of ecosystem services provided for free to BC's Lower Mainland by its existing stocks of natural capital to be $5.4 billion (Wilson 2010). Such an enormous figure, especially in the context of Canada's staggering infrastructure deficit, is a clear call to protect and enhance the ecoscape within cities as a much higher priority than building new grey infrastructure, especially at the expense of existing stocks of natural capital.

Ecological Costs

> "What is the significance of human habitat preference? Just this: Very few species like what we like. In fact, very few can even survive in the habitats we like."
>
> — Michael Rosenzweig (2003, 17-18)

The history of urban (human habitat) development has predominantly been one of expelling nature with such force that pre-development ecosystems are annihilated. Many cities have a legacy of planning and development that is, in the words of Ian McHarg, "the expression of the inalienable right to create ugliness and disorder for private greed" and has left "countless city slums and scabrous towns, pathetic subdivisions, derelict industries, raped land, befouled rivers and filthy air" (1969, 23). This has obvious and direct ecological costs at a local scale, and it also undermines our ability to deal with ecological challenges at the regional, national, and international scales.

While the specific ecological effects vary by location, and there are both linear and threshold relationships between urbanization and ecological effects (Roy et al 2010), the development of cities generally has a detrimental effect on water dispersion and quality, the hydrological cycle, the distribution of ecosystems within urban areas (including ecosystem fragmentation and isolation), the composition and structure of ecosystems within the urban area (including the preference for manicured ecosystems in favour of fully functioning ones), the diversity of species with urban areas (including the colonization of urban areas by a small number of exploiter species), and the health of adjacent terrestrial and aquatic ecosystems.

Where Does the Water Go?

The hydrological cycle - the cycle of water between the atmosphere, the land, and the ocean – is essential for life on our planet. By interrupting this natural cycle, and diverting water into manufactured culverts, pipes, and channels, urbanization has a profound effect on ecosystems. Urbanization replaces vegetated cover and pervious soils with impervious surfaces; replaces longer-term water flows that balance seasonal fluctuations, with rapid cycles of drought and flood; and replaces dispersed water with concentrated water. In short, "the degree to which water leaves land in the form of surface water runoff is the degree to which the area where it fell in the form of precipitation will be in deficit and downstream environmental will be surfeited (and generally adversely impacted)" (Patchett and Price 2008, 175).

Many urban streams are diverted into culverts and paved over, leaving storm drainage systems to collect water from impervious surfaces and force it through artificial channels, which are essentially biological deserts (Honachefsky 1999, 99) covered from sunlight and unable to provide any treatment or cleaning of the water. The concentrated water flows scour the bottom of streambeds upon entry, erode stream banks, and raise peak flow levels far beyond predevelopment levels (Honachefsky 1999, 101). The technological advancements in sanitation needed to combat disease (piped water and sewer systems), led to the "out-of-sight-out-of-mind" attitude that plagues us today (Hough 1990): "The benefits of sanitation and well drained streets are paid for by the costs of eroded and polluted rivers and a deteriorated larger environment" (Hough 1990, 15-16).

The increased area of impervious surfaces in urban areas alters the hydrology and geomorphology of streams, and severely reduces water quality. Studies have shown that catchments with only 2 per cent impervious surface have changes in their water quality, algal biomass, and diatom assemblages (Roy et al 2010). Impervious surfaces increase the runoff from urban surfaces, and when combined with industrial and municipal discharges, result in increased stream loading of nutrients, metals, pesticides, and other contaminants. Nearly all urban streams have increased levels of chemical contaminants including heavy metals (especially cadmium, chromium, copper, lead, manganese, nickel, and zinc), pesticides, petroleum products, and pharmaceuticals (Roy et al 2010, 344).

Even in areas without manufactured impervious surfaces, exposed urban soils are generally heavily compacted and are less able to absorb water, further increasing runoff and erosion (Burian and Pomeroy 2010, 285). The removal of trees and vegetation reduces rainwater interception and increases the amount of rain that reaches the ground surface

(Burian and Pomeroy 2010, 281), which heightens the erosive capacity of a given amount of precipitation. The deforestation of riparian zones reduces the food availability in the aquatic habitat, increases stream temperature, increases storm drain run-off into the stream, and increases the volume of sediments, harmful nutrients, and metals (Paul and Meyer 2001). Increased erosion increases turbidity in the water column thereby "…increasing fish gill clogging and the burial of bottom-dwelling flora and fauna" (Burian and Pomeroy 2010, 281). These changes result in urban streams experiencing a decline in the richness of algal, invertebrate, and fish communities (Paul and Meyer 2001).

Urban streams are generally characterized by a reduced diversity in channel morphology, and the destruction of adjacent habitats, which contributes to the loss of habitat in urban rivers and flood plains (House et al 1993). These streams typically have "homogenized fish assemblages, with high richness and abundance of tolerant, cosmopolitan, and nonnative species and relatively low richness and abundance of sensitive, endemic species" (Roy et al 2010, 345). Urban riparian communities are frequently more extensively invaded by exotic plants than nonurban riparian communities (Ehrenfeld and Stander 2010). Much riparian and salmonoid habitat has been lost or damaged in BC, and the most devastating impacts have been in the rapidly urbanizing areas (Rosenau and Angelo 2001).

Polluted waters conveyed in culverts and sewers are eventually discharged into receiving water bodies where they deposit an array of toxic pollutants that includes pesticides, pharmaceuticals, nutrients such as nitrogen and phosphorus. Combined-sewer overflows further affect receiving water bodies with elevated temperatures, high velocities, bacteria and floatable material, and toxic organic compounds (Burian and Pomeroy 2010).

The literature shows that pollution is understood as the most important effect that cities have on adjacent marine habitats, and mostly include the runoff of nutrients, heavy metals, and other toxins (Chapman and Underwood 2009, 66), but urbanization has other significant effects on marine and estuary environments. Urbanised estuaries, for example, are generally littered with large amount of material (Chapman et al 2009, 174), in spite of estuaries being one of the most ecologically productive ecosystems types on earth.

Fragmentation and Isolation

Approximately 25% of the urban landscape in Canada is committed to roads, parking lots, garages, driveways, and gas stations (Natural Resources Canada 2012). Beyond the impervious surface problems associated with roads, as discussed above, the ecological effects of roads can extend for more than hundreds of metres from the road itself, and include "the loss and fragmentation of habitat; input of pollutants (e.g. noise, chemicals and dust) into adjacent air, soil, vegetation and water; direct mortality; and the creation of barrier to wildlife movement" (van der Ree 2009, 185). Roads can also act as vectors for carrying weeds and pathogens (Lonsdale and Lane 1994), and it is estimated that up to 20% of the entire American landscape is directly affected ecologically by roads (Forman and Alexander 1998).

The effect of roads as barriers to movement is species-specific and may provide less of a barrier to highly-adaptable species compared with more sensitive species. For example, the highest density of woodchucks ever recorded was in the middle of a suburban highway interchange in Ottawa, possibly because of the lack of predators, abundant food, adequate burrow drainage, and the ability of the woodchucks to cross two-lane roads (van der Ree 2009). In spite of such examples, roads remain the greatest cause of mortality for many urban mammals (McCleery 2010, 91), especially for juveniles. The continual mortality of dispersing juveniles from habitat patches may decrease the vitality of local populations (van der Ree 2009), and the rate of loss does not need to be high for there to be a demonstrable impact. Experiments have shown that roads as narrow as 2.5 metres create an impassable barrier for smaller species such as carabid beetles and wolf spiders, and the application of salt to roads is a significant deterrent to crossing for amphibians (Forman and Alexander 1998, 215).

Roads contribute enormously to what may be the most challenging ecological problem facing the urban ecoscape: a pattern of extreme habitat fragmentation that isolates populations of species. Because of the high density of roads and other manufactured elements in the urban landscape, habitat patches tend to be small and isolated, which reduces biodiversity and threatens the survival of species in the patches. The isolated patches that remain are correctly classified as ecological “islands” – disconnected ecosystems surrounded by inhospitable terrain (pavement, concrete, etc.), and isolated in the same way that islands are isolated by the surrounding water.

Robert H. MacArthur and Edward O. Wilson developed the theory of “island biogeography” to explain what happens to ecosystems that can be classified as “islands.” The first observation they made is that there is “an orderly relation between the size of a sample area and the number of species found in that area” (1967, 8). This relationship holds both for a natural island surrounded by water, and an urban ecosystem island surrounded by pavement. For both, the smaller the island the smaller number of species that can be expected to be found. As acclaimed ecologist Reed Noss explains: “Island biogeographic theory predicts that small, isolated island (or patches of habitat that resemble islands) will experience higher extinction rates and lower immigration rates of species than large islands” (Noss 1993, 44). Extending the theory of island biogeography to terrestrial landscapes explains species decline and extinction resulting from fragmentation and isolation (Soulé 1991).

MacArthur and Wilson (1967) suggested that the two most significant effects of fragmentation are habitat loss and habitat isolation. Habitat fragmentation results in isolated populations with a shrinking gene pool that leads to the domination of recessive genes, resulting “congenital defects (both physical and reproductive), rising infertility, and weakening of each animal’s immune defence system” (Honachefsky 1999, 84). Reed Noss points out that isolated populations are susceptible to two detrimental genetic effects: inbreeding and random genetic drift (Noss 1993, 53).

Fragmentation limits the type of habitat available in the remaining patches, and interior habitat areas are rare in human-dominated landscapes (Thorne 1993, 29), especially in urban landscapes. This reduction in the number of available habitat types further reduces species diversity. Even if suitable habitat remains, the isolation of these patches still affects more species than may be initially obvious. For example, many birds have relatively poor dispersal abilities in spite of being able to fly (Noss 1993, 53), and the interactions between pollinator-friendly plant species and those species providing pollinator services is affected by the built environment between patches of plants (Henning and Ghazoul 2011). Overall, there is a decrease in species richness, and a degradation of the resilience of ecosystem services, which decreases the ability of natural systems to withstand future disturbances (Alberti and Marzluff, 2004).

In addition to the fragmentation of habitat patches, urban areas tend to provide very little connectivity between patches and the “matrix” between patches is generally not conducive to dispersal. As a result, even if urban habitat patches were enlarged and further protected, connectivity across the urban matrix would remain necessary as “…protecting green areas in isolation will not sustain the capacity of ecosystems to generate services” (Barthel 2006, 314) if the surrounding habitat continues to be fragmented and degraded.

Manicured Nature

Urban landscapes often feature manicured parks and yards with simplified ecological structures designed to fit a narrowly-conceived aesthetic. These simplified green spaces suppress the wilder and more uncontrollable aspects of nature, depend on high-energy inputs, and fail to provide diversity or a sense of place. Even if urban trees are indigenous, they are often contained in a manufactured environment that stunts their growth and disconnects them from complementary ecosystem functions. Ecosystems under strict human control are often not permitted to advance through various stages of growth and decay, and are unable to provide levels of habitat comparable to unbridled natural ecosystems.

Urban trees, while a highly visible component of the ecoscape, face numerous challenges in the urban landscape. Trees planted along urban streets are stressed by poor drainage and compacted soil, are exposed to air pollution and direct sunlight, and typically have only 15% of the space for their roots than is available in a forest setting (Cacik and Schaefer 1997, 83). Trees are often planted where there is insufficient spaces for canopy and root system growth, which leads to stunted growth (Volder and Watson 2010). Where there is space for trees to grow, such as in public parks, there is often high foot traffic which leads to very compacted soil causing “…reduced soil porosity, increased resistance to root growth, [and] reduced transmission of air and water, which can exacerbate the negative effects of both flooding and drought, and alter nutrient and carbon cycling” (Volder and Watson 2010, 228). Urban trees also face an interrupted nutrient cycle that makes them increasingly dependent upon imported nutrients in the form of fertilizer. A survey of urban tree trimming and landscape residue in the United States found that only 15% of wood residue is left or used on site (Whittier et al 1995). This means that 85% is removed from the site's nutrient cycle that would otherwise be available to build soil for future tree and vegetation growth.

Many urban habitats are perpetually kept at an early successional stage, limiting the diversity of species, reducing the variety of habitats, increasing the homogeneity of the ecoscape, and decreasing overall resilience. Urban mammal species are more susceptible to disease outbreaks and parasites because of their relatively concentrated natures of resources and the higher population densities in habitat areas (McCleery 2010). For example, densities of racoons in non-urban areas are generally below 20 per square kilometre, but in urban areas have been up to 333 per square kilometre (McCleery 2010, 90). In general, urbanization results in a reduction in mammalian diversity:

> "There is a clear relationship between mammalian diversity and the degree of urbanization of the landscape. As urbanization increases, mammalian diversity is lost. The loss of species in urban areas is generally attributed to habitat degradation and fragmentation, the loss of vegetation to impervious surface, and the simplification of vegetation" (McCleery 2010, 87).

In addition to reducing biodiversity, the urban landscape often features manicured parks and yards with simplified ecological structures designed to fit a narrowly-conceived aesthetic. Maria Hellström Reimer, Professor of Applied Aesthetics in Landscape Architecture, points out that there is a "tendency of environmental discourse to idealize nature" (2010, 28). When applied to ecoscape design, our approach to ecology "comes with a non-articulated and presupposed aesthetics of harmony and natural beauty, thus suppressing the wilder and more uncontrollable aspects of nature's performance" (Reimer 2010, 28). Simplified parks and open spaces depend on high-energy inputs and maintenance to create a manicured, generic landscape that fails to provide diversity or a sense of place. Such greenspaces do not provide the same level of ecosystem services as more complex natural systems, and more ecologically-complex greenbelt areas are often located on the edge of cities, presupposing automobile transportation for human access (Roelofs 1999, 246).

Exploiters, Adapters, and Avoiders

Habitat loss, fragmentation, isolation, and modification in urban areas results in specific types of habitats that are able to only support a relatively small number of species. McKinney (2002) categorized those urban habitats as the built habitat (building, roads, etc.), managed vegetation (residential and commercial green spaces that are regularly maintained), ruderal vegetation (cleared by unmanaged green spaces in empty lots, etc.), and natural remnants (islands of original vegetation, but often subject of substantial non-native species). With limited habitat, many native species are unable to exist in urban areas, and even fewer are able to thrive. In some cases, the species that are best suited to the urban landscape are non-native species which out-compete native species.

The categories of urban "exploiter, adapter, and avoider," introduced by Blair (2001) to describe birds and butterflies along the rural-urban gradient, provides insight into the transformation of species diversity brought about by urbanization. McKinney (2002, 887) explains that urban "exploiters" are "generally commensals that are almost entirely dependent on human subsidies;" "adapters" utilize human subsidies but also make significant use of "wild-growing" resources; and "avoiders tend to rely only on natural resources." Within these general categories, urbanization allows for the flourishing of "exploiter" species such as the European starling (an species introduced to North America), but severely stresses or extirpates populations of more sensitive "avoider" species such as many predator species and late-succession plants (McKinney 2002). The result is a significant reduction in biodiversity with a bias toward a smaller number of human-dependent species.

Even the "exploiter" and "adapter" species that survive (or thrive) in the urban landscape, frequently modify their behaviour to survive. For example, birds use vocalization to warn of danger, defend a territory, and attract a mate, but this vocalization in urban areas is forced to compete with elevated levels of noise from traffic and other urban sources (Shochat et al 2010, 78). In response, house finches, have altered the tone and length of their vocalization in order to compensate for urban noise (Shochat et al 2010, 78). Other species have modified their reproductive patterns in response to the challenges of urban living. Urban fox squirrels have more than one litter each year compared to non-urban fox squirrels that just have one (McCleery 2010, 91). Some other urban mammals have higher litter sizes, and others reach sexual maturity earlier (McCleery 2010, 91).

Adjacent Ecosystems

Urban areas not only effect the ecosystems within their containment boundaries, but also create conditions that have important effects on adjacent and surrounding ecosystems. These effects are felt by native terrestrial and aquatic species living near the urban area, as well as by transient and migratory species that move through or by the urban area.

Urban development has occurred in the places where it has, significantly because of ecological factors that made the location attractive to humans: healthy soils, access to water, protection from extreme weather, etc.. The ecological factors that make such locations on the planet attractive for human settlement, are often the same factors that made those locations attractive to countless other species before humans arrived. It should be of no surprise that the places where humans have settled were also once the home for many other species, and are now adjacent to what is left of those original homes for other species. Our cities have taken over some of the most ecologically-productive land on the planet, and the land that surrounds our cities is what remains of those original ecosystems.

The ecosystems adjacent to cities are often extremely productive. For example, Ontario's Greenbelt which surrounds the Greater Toronto Area is home to 78 of Ontario's over 200 provincially-listed species at risk (Cowie 2011, 5). The importance of these adjacent ecosystems underscores the importance of limiting urban incursion into adjacent areas (i.e. halting urban sprawl), minimizing the ecological contrast between urban and non-urban areas (i.e. providing ecological connectivity through urban areas), and reducing the detrimental effect of activities within the urban area on the surrounding ecosystem.

Unfortunately, our cities have generally not been successful at any of these three tasks. Between 1971 and 2001, Canadian urban areas encroached on an additional 15,200 square kilometres of land adjacent to existing urban areas (Canada Green Building Council 2011, xiii), which is an area three times larger than Prince Edward Island. At the same time, battles over urban containment boundaries have become more heated, resulting in dense development along the urban fringe which creates a marked contrast to the adjacent ecosystems, and allows for few connectivity paths for species moving into, or out of, the urban area.

Within the urban area, many activities have a detrimental effect on the surrounding ecosystems. These activities include interrupting the hydrological cycle, lighting up the night sky, blocking species movement corridors, increasing the ambient noise levels, altering the local climate, polluting the regional airshed, and fragmenting the regional landscape with dense transportation infrastructure. For example, the urban heat island effect – caused by the use of dark, non-reflective surfaces on roads, buildings, and other urban areas – results in urban temperatures up to 5.6˚C warmer than the surrounding exurban areas (USEPA 2003). This effect is detrimental to native habitat and species, impacts wildlife migration corridors, and increases the demand for energy and urban infrastructure (Canada Green Building Council 2004, 106). The heat island effect created by cities disturbs the adjacent microclimate and stresses species and ecosystems.

The effects of urban development are felt in aquatic areas as well as terrestrial areas. Urban harbours have, in general, been invaded by a large suite of exotic species, and urban structures have significantly altered the marine habitat around cities (Chapman et al 2009). Seawalls, for example, alter the intertidal zone by replacing it with a steeper slope and a more structurally simple surface than would naturally be present (Chapman et al 2009, 159). While habitats formed by urban structures (including marinas, piers, and wharfs) may provide some habitat, their success needs to be compared to the "types and numbers of fish similar to those on natural rocky habitats" (Chapman et al 2009, 170). Studies have shown that the "assemblages associated with artificial habitats differ from those living in natural habitats" (Chapman and Underwood 2009, 62).

Disturbances to marine habitats around urban areas include "pulse" disturbances (during the construction of a new waterfront structure), "press" disturbances (the long-term disturbance after construction), and "ramp" disturbances (repeated small disturbances without complete recovery between them)(Chapman and Underwood 2009). It may also be that marine habitats are susceptible to both habitat destruction, and also to fragmentation of the supply lines that connect habitat patches. Artificial structures that protrude into the water can change currents and alter the conditions for native species (Chapman and Underwood 2009, 60).

Nature in Cities

''The future of humanity lies in cities"

— Kofi Annan, former Secretary-General of the United Nations (quoted in Wu 2010)

In spite of our brutal record of expelling nature from our cities, nature awaits. Ultimately patient and undiminished in potential, nature is at the ready to be invited into the urban landscape. There is a "hidden, potential flora, and *idea* of a forest, not in competition with the city but existing alongside it, patiently, waiting to become manifest" (Mason 2010, 191). Allowing this potential to spring forth offers hope for a healthier, more sustainable future.

This hope emerged from the ashes in the months immediately following one of our most extreme annihilations of life in the city – the bombing of Hiroshima. The tenacity of nature in Hiroshima provided inspiration for people to move forward toward a better future. Just two months after the atomic bomb, "the ashen landscape was covered with pumpkin and morning glory, radish, mustard, fleabane, pars lane… New tree growth was seen everywhere. Many trees, burned on one side, continued to grow on the other, and even those trees that seemed to have been completely incinerated began to put out buds from charred trunks and underground roots and stalks. Today over a hundred such trees remain… you can ask any child about such a tree, and they will point the way" (Mason 2010, 191).

Realizing the hope offered by an emerging nature in our cities, depends on a fundamental rejection of the notion that cities should strive to suppress nature. Instead, as Jane Jacobs observed, we need to adopt of a view that has "mankind and nature as partners, with nature as the senior partner and humans being the apprentices" (Jacobs 2004). We need to radically break from the deeply-held conviction that we are in charge of nature, and instead allow nature to help us solve the problems we have created for ourselves and for nature.

Doing so offers us innumerable benefits: urban dwellers become attuned to our global environmental challenges, and apathy is transformed into a lasting ecological ethic; citizens are connected to their place on the earth, communities are strengthened, and children are healthier; cities becomes more resilient, ecosystem services are secured and strengthened, and people experience "stress reduction, greater physical health, a deeper sense of spirit, more creativity, a sense of play, even a safer life" (Louv 2008, 163).

For the ecologists, urban planners, and anyone that cares about the future of our cities, an opportunity awaits to help shape Annan's "future of humanity." An emerging discipline in ecology is looking at natural ecosystems in cities (Hochuli et al 2009), and the discipline of landscape ecology has recently directed its gaze on the urban landscape. The fact that a new species of frog was recently discovered in New York City (Toronto Sun 2012) illustrates that there is much more happening right outside our front door than meets the eye. Thankfully, a range of professionals are coming together to understand it. The green building community is moving beyond the building scale to embrace whole communities, urban planners are increasing seeking to understand their stocks of natural capital, and both disciplines are grappling with multiple spatial scales. Urban thinkers are calling for "a biodiverse city, a city full of nature, a place where in the normal course of work and play and life residents feel, see and experience rich nature – plants, trees, animals" (Beatley 2011, 45), activists recognize the treasured value of ecosystems close to home, and urban communities are demanding the justice of sharing their homes with nature. Together these various perspectives are contributing to healthy urban ecoscapes that are capable of moving from being the restored, to being the agent of restoration.

A healthy urban ecoscape includes a full range of natural ecosystem composition, structure, and function. It has connectivity across all spatial and temporal scales. It is biologically diverse. It includes connected patches and corridors at scales from the neighbourhood to the region, with ecological integrity restored in the matrix. It has small-scale ecoscape components, and nested levels of smaller-scales patches and corridors. Unique ecological features are included, and large "anchor" patches are restored to maximum natural ecosystem composition, structure, and function. Urban avoider species are supported, while exploiter species are given fewer advantages. Streams are daylighted, riparian areas are restored, and soils are exposed. Density is pursued in concert with creating a healthy urban ecoscape, and building surfaces are harnessed as contributors to the ecoscape: green walls, green roofs, and green overpasses between buildings. Structures are integrated with the living environment, roadways cede some territory to the ecoscape, and green infrastructure takes over from the crumbling grey stormwater system. Impervious surfaces are replaced with living ones, natural ecosystem functions are prioritized in parks, and new patches and corridors are created.

In this section, a glimpse is provided of what it looks like to invite nature home to our cities. Given the extent of our expulsion of nature, the starting place is necessarily restoration – restoration of the ecosystems that existed in a particular location before the city did. From an ecological perspective, restoration must focus on ecosystem patches and corridors, greening of the matrix between patches and corridors, and restoring connectivity at multiple spatial scales.

The challenge of inviting nature into our cities demands innovation, creativity, and a liberation from monocultures of the mind. Front and centre in this context is the challenge of marrying increased density with increased nature – a seemingly awkward union that must be embraced, and that has in its fulfillment a blessing for both. Innovation happens at all spatial scales, and includes a re-imagining of roads, a fundamental respect for the hydrological cycle and the need to disperse water, an ecology of parks, and a biophilic momentum, all supported by a system of monitoring and feedback.

Human communities are made healthier as nature is invited home, and they in turn catalyze further ecosystem restoration. A healthy urban ecoscape drives and benefits from an ecological ethic, which is inked to a sense of place. Nature's antidote for human woes is fundamental and powerful, the ecosystem services provided by nature in cities is a cornucopia of wealth, and nature's indifference to socio-economic patterns across the city necessitates a more equitable distribution of nature in all our communities.

Restoration: Healthy Urban Ecoscapes

The restoration of natural ecosystems is the way to create healthy urban ecoscapes. Restoration must lead to ecosystem patches of various sizes, shapes, and types, connected by corridors. Understanding that the current urban landscape between patches and corridors is generally inhospitable to most species, it is necessary to also restore or "green" the matrix (the rest of the urban landscape beyond the patches and corridors). Recognizing that ecosystems function at multiple and nested spatial scales, it is essential that restoration of patches, corridors and the matrix is carried out at multiple spatial scales as well. Like the Russian matryoshka dolls that are nested within each other, healthy ecosystems are found nested within each other at multiple spatial scales.

Patches, corridors, and connectivity across the matrix needs to be restored within backyards, across neighbourhoods, and across the entire urban area. Researchers have found that the principles used for managing or enhancing biodiversity in non-urban settings can be applied to urban ecosystems (Savarda et al 2000), and hence the well-established approaches of actions at multiple spatial and temporal scales are appropriate for urban ecosystem restoration efforts (Savarda et al 2000).

Patches & Corridors

Characteristics of urban habitat patches that are relevant to biodiversity include patch size and shape, as well as the composition, structure, and functions within the patch. In accordance with the theory of island biogeography, the size of a path correlates with biodiversity. Large patches tend to be more heterogeneous than small patches (Collinge 1996), and the ability of plant species to occupy urban patches has been shown to increase with site age, area, habitat number, and similarity of adjacent habitats (Bastin and Thomas 1999). Large patches reduce the impact of "edge effects" and lead to the restoration of species richness (Collinge 1996). Patches with highly irregular boundaries will likely have a greater exchange of nutrients, materials, and organisms with adjacent habitats (Collinge 1996), the importance of which depends on the matrix.

Research in the UK found that urban mammalian species richness within patches decreased with increases in barren ground, proximity to buildings, and patchiness in total vegetation cover (Dickman 1987). The same research also found that more species of mammals, amphibians and reptiles were found in two small patches than in one large patch equal to their combined area (Dickman 1987)

Unique features (e.g. ecological remnants/refuges or migratory bird stopover points) need to be identified and included within the ecoscape (Beatley 2011, 26). The peri-urban landscape is frequently highly modified, and as a result, remnant ecosystems within urban areas can be biological refuges of significant regional importance. A 2002 study at the University of British Columbia's Centre for Biodiversity Research found that the most urbanized areas of BC – the South Okanagan, south-east Vancouver Island and Lower Mainland regions – are "biodiversity rarity and richness hotspots… and should become the focus for increased and integrated biodiversity conservation planning" (Scudder 2002, 1). In contrast to the commonly-held assumption that habitats for species at risk are located far from where we live, the biodiversity hotspots are frequently right next to our cities.

Existing protected area, such as regional parks or protected watersheds act as "anchors" in the ecoscape. These large patches provide some measure of interior habitat, the potential for multiple successional stages, and relatively diverse species composition and structures. In addition to parks, greenways, and ravines, there are "special places" that have large open areas with relatively few buildings. These include cemeteries, airports, and institutional campuses. A study by the Douglas College Institute of Urban Ecology found that in Metro Vancouver these "special places" do provide wildlife habitat, and provide permeable surfaces for rainwater and nutrient cycling, but they do not necessarily maintain healthy ecosystems (2002). Cacik and Schaefer (1997) identified and described 38 different types of urban landscapes that provide some measure of urban wildlife habitat, including forests, shrub communities, wetlands, clearings, area neglected by humans, alleys, rights-of-way, private yards, and public parks. However, not all habitat types are of equal ecological value, and not all species play an equal role in natural ecosystem character.

Certain exploiter and adapter species have found plentiful habitat in urban areas. Rat densities in cities worldwide are often more than 3,000 per square kilometre (McCleery 2010, 90) and there are approximately 28,000,000 rats in New York City (Lapham 2010, 83). Three bird species – the House Sparrow, the European Starling, and the Rock Dove – have adapted exceptionally well to living in cities worldwide (Savard et al 2000), and there are currently about 33,000 foxes living in the cites of Britain (constituting 14 percent of the total British fox population)(Renzetti 2012). Urban areas tend to have higher bird abundances than adjacent exurban or rural areas, however only a few species contribute to the majority of this abundance (Shochat et al 2010, 76) since the exploiter species have been able to dominate the urban landscape. While the urban landscape already provides habitat for a number of exploiter and adapter species, it is habitat for urban avoider species – the more sensitive, native species that are no longer able to thrive – that should assume much higher priority in the ecoscape. Habitat values in the urban ecoscape are understood best through the lens of natural ecosystem character which would identify indicator species (e.g. Coho salmon, Douglas squirrel, pileated woodpecker, red legged frog), umbrella species, and keystone species whose habitat should be prioritized.

Urban woodland patches are particularly important for supporting a diversity of bird species (Savard et al 2000). Within the woodlands, bird species richness is associated with spatial heterogeneity of vegetation, complex vertical structure, and diverse vegetation species (Savard et al 2000). Urban riparian areas are also particularly important for biodiversity, and studies have found that urban protected networks which rely significantly on riparian habitat are better for providing habitat continuity and habitat quality for a variety of organisms (Ehrenfeld and Stander 2010, 114).

It's important for urban streams to have "ponds and slack water sections at intervals throughout their length to attenuate flow and reduce substrate mobility" and thus offer "biological refuge zones as well as hydraulic retention, primary sedimentation and clarification"(House et al 1993, 316). Vegetated riparian areas further contribute to the quality of aquatic habitat by cleaning water and attenuating runoff. Collinge points out that:

> "riparian vegetation along streams and rivers is critically important to prevent soil erosion, maintain high water quality and provide habitat for riparian specialists. Corridors of native

> vegetation which link remnants of similar vegetation may provide habitat and facilitate movement of plants and animals" (1996, 71).

Habitat patches do not thrive in isolation, but need to be connected through corridors and across the matrix. Metapopulation theory makes it clear that "the greater the number of patches and the closer they are, the better the colonization" and that "seed dispersal and wildlife movements are key processes in determining the survival of metapopulations. Such movements are directly related to the connectivity of the landscape" (Rudd et al 2002, 368). For example, connectivity between green patches is crucial for the continued movement of pollinators between plant patches (Hennig and Ghazoul 2001, 138).

Corridors connecting patches provide habitat, and serve as conduit for movement, including daily and seasonal movements, dispersal, and range shifts (Noss 1993, 44). Dispersal is especially important in fragmented landscapes (Noss 1993, 50) such as urban areas. Corridors also facilitate the appropriation of food resources, offer refuge from predators (Savard et al 2000), and promote diversity through "genetic exchange over wider temporal and spatial scales" (Colding 2007, 51).

The ecological efficacy of connectivity corridors is largely determined by width, connectivity, and quality (Thorne 1993, 26). Reed Noss explains that the most important goals for wildlife greenways are to "provide a high-quality corridor for native species… and to maintain enough functional connectivity along the entire length of the corridor to allow safe passage" (Noss 1993, 57). Width is especially important, and depends on "habitat structure and quality within the corridor, the nature of the surrounding habitat, human use patterns, the length of the corridor, and the particular species expected to use the corridor" (Noss 1993, 59).

Large protected patches in peri-urban areas can help strengthen urban wildlife species populations. Specifically, "connectivity between inner-city and peri-urban habitat patches enhances the contribution of peri-urban migrants to inner-city populations" (Snep et al 2009, 461). If habitat components are missing in the urban ecoscape, peri-urban ecosystems can fill the gap, and there is a great opportunity to strengthen both through appropriate connectivity.

It has been argued that:

> "Perhaps the strongest and most scientifically substantiated argument for greenways is based on their potential role in ameliorating the negative effects of landscape fragmentation. This argument is based on the benefits of connectivity as related to theories of island biogeography and metapopulations" (Ahern 1995, 136).

However, an urban ecoscape consisting exclusively of patches and corridors is not sufficient to provide the necessary connectivity. The matrix must also be "greened."

Matrix

The "matrix" refers to the landscape between established patches and corridors. The matrix can be either hospitable or inhospitable to the species found in the patches and corridors, and the more hospitable the matrix is, the more likely the species found in the patches and corridors will be able to thrive. On the other hand, if the matrix is inhospitable, the patches and corridors alone may not be able to support the species they were intended to protect:

> "Protected urban green areas offer no guarantee for successful biodiversity conservation. Many nature reserves in urban areas are unable to sustain their species over time. The surrounding landscape matrix needs to be taken into account for conservation of biodiversity and the sustenance of urban ecosystem services." (Colding et al 2006, 237)

As Herb Hammond points out, restoration in urban areas is about restoring ecological integrity in the matrix (Hammond 2011). This point became obvious in a connectivity analysis conducted in a 2,600 hectare area of Coquitlam, British Columbia. The study found 54 "green spaces" or habitat nodes (parks and recreation areas recognized by the municipality), ranging in size from 0.1 hectares to 174 hectares, with a combined green space of

636.5 hectares. It was determined that in order to achieve a high level of connectivity between half of the green spaces, at least 325 links would be necessary. Noting that creating 325 discrete corridors would be "unrealistic," the authors concluded that "increasing biodiversity in backyard habitat, boulevards, and utility rights-of-way can produce a matrix functional as 325 corridors for plants and animals in the zone" (Rudd et al 2002, 373). The authors of the study further concluded that:

> "…it is important to remember that preserving parks is only part of the solution. Without connections between them, isolation and loss of genetic diversity is imminent. Green corridors, utility rights-of-way, and backyard habitat are important parts of urban planning, because they increase biodiversity in cities and improve the quality of life for all residents" (Rudd et al 2002, 373).

As Reed Noss warns: "Do not allow greenway establishment to divert attention from managing the landscape as a whole in an ecologically responsible manner" (Noss 1993, 62). The importance of the surrounding matrix is well understood in the literature of landscape ecology: "habitat patches are not truly islands in a homogeneous sea. Rather, the matrix that surrounds habitat patches is a source of species... landscape ecology now takes the more realistic view of landscapes as heterogeneous mosaics" (Noss 1993, 44). Within many urban areas, however, the matrix is quite homogeneous and ecologically unproductive, and therefore a healthy urban ecoscape is predicated on restoration throughout the matrix.

Doing so increases the "functional connectivity," which is the "degree to which organisms or other elements are able to move across a landscape" and which "need not depend on distinct linear corridors." (Noss 1993, 51). In fact, creating a healthy urban ecoscape is not possible by relying exclusively on distinct corridors to connect patches across an inhospitable urban landscape:

> "Randomly connecting open spaces is inefficient at best, and, given two or more complex alternatives, it is difficult simply to guess which networks are more efficient, which links are most significant, which networks have higher levels of connectivity, and which networks would be the most cost effective" (Linehan et al 1995, 191)

Instead, providing connectivity through both corridors and across the matrix offers the only arrangement that is capable of producing a healthy ecoscape. Equally important, this connectivity needs to be available at multiple spatial scales, from across a backyard to across the entire city:

> "For maximum effectiveness, open-space networks need to be planned and created simultaneously at a range of scales, from the large metropolitan level down to individual towns and cities. At an even finer grain, work is done at the scale of particular features like a creek corridor. Important connections are sometimes only several yards long" (Erickson 2006, 286)

Multiple Spatial Scales

Connectivity at multiple spatial scales allows species multiple avenues for dispersal across the urban landscape, and is also reflective of the complex connections that exist in unmodified natural ecosystems. As Herb Hammond explains:

> "…landscapes, both large and small, consist of interdependent, interconnected clusters of ecosystems. These clusters of ecosystems are found in repeated patterns across regions, subregions, landscapes, and watersheds. Across large landscapes, the definition of patterns and ecosystems are broad and coarse. However, as the area becomes smaller the definition of patterns and ecosystems becomes narrower and finer. Hence, the interconnected, interdependent nature of ecosystems clusters is found at all spatial and temporal scales" (Hammond 2009, 41).

Ecological activity at finer spatial scales is essential for healthy ecoscapes. Many species, including terrestrial invertebrates, operate at a very small spatial scale and are sensitive to the effects of urbanization in their surrounding matrix (Hochuli et al 2009, 232). Biodiversity is also more than just the plants and wildlife we can see – it's "also the range of bacteria and fungi present in a healthy soil…" (Beer 2010, 435). E.O. Wilson points out that:

> "[e]ach cubic meter of soil and humus within it is a world swarming with hundreds of thousands of such creatures, representing hundreds of species…. In one gram of soil, less than a handful, live in the order of ten billion bacteria belonging to as many as six thousand species" (Wilson 2006, 18).

Small-scale patches and corridors constitute connections across the matrix at a larger-scale. As Hammond (2009) explains, "the interconnected, interdependent nature of ecosystem clusters" means that they need to be restored at all spatial and temporal scales. While the individual contribution of a backyard or single tree may not seem large in comparison to an entire urban landscape, the aggregate of many such contributions becomes the bulk of what constitutes an ecoscape. As such, it is critical to restore patches, corridors, and the matrix at all spatial scales.

Innovation

> "Our tragedy lies in the richness of the available alternatives, and in the fact that so few of them are ever seriously explored…. [O]ur age seems not merely tragic but tragic in the classical sense, that despite all possibility, we seem trapped in just that remorseless "working of things" that the Greeks saw as the core of tragedy."
>
> — Tom Athanasiou (1996, 307)

The burden of an expelled nature is heavy, yet the strength of our innovation can remove it. We need to start by tearing off the blinders of "there-is-no-alternative" and see the many opportunities to invite nature home. While the summons is as much to our will as to our creativity, innovative solutions do abound, have been tried in countless cities around the planet, and are waiting for our strength to pick them up.

Innovation can show us how to invite nature home into an urban landscape already seemingly bursting with human development. Inviting nature back into the human-dominated landscape of our cities requires innovative approaches to greening the matrix, and to creating new patches and corridors at multiple spatial scales. These innovative approaches address the challenge associated with accommodating both the many demands of humans and the requirements of a healthy urban ecoscape. Central among these demands is the need for increased density in our cities, contemporaneous with the call to invite nature home.

The sampling of innovative approaches outlined in this section illustrate how density is made feasible and appealing through the concurrent restoration of a healthy urban ecoscape. Innovation is needed at all spatial scales from backyards, to neighbourhoods, and to the entire urban area. The innovative solutions in this section sketch out what is possible by re-imagining roads, by respecting the hydrological cycle and the paramountcy of water, by restoring the ecology of parks, by establishing biophilic momentum, and by supporting innovation with monitoring and feedback.

In the words of Jennifer Wolch, Dean of the Berkeley School of Environmental Design, the goal is to "renaturalize cities and invite the animals back in, and in the process re-enchanct the city" (Wolch 1998, 124). To re-enchant our cities with nature we need to embrace these innovative alternatives and move them from ideas into action.

Density and Nature

Urban density (the number of people living in a given area of land) and a healthy urban ecoscape are not at odds with each other, but are rather complementary approaches that benefit people and ecosystems alike. It's not only necessary to invite nature home to the city, but also to simultaneously increase the density of human use and activity. This is so because higher density is needed to reduce the ecological footprint that might otherwise counter many of the benefits gained through restoring nature, and to halt the expansion of the urban containment boundary into the ecologically-valuable and relatively unmodified land adjacent to cities. Significant research has shown that "[d]ensity remains the core strategy for achieving emission reduction targets" (Campbell and Teed 2010, 21). Density is "a sustainability silver bullet, providing across-the-board reductions in per-capita resource use" (Farr 2008, 103), and should not be traded off in favour of "sustainable" greenfield development that merely extends the urban boundary. Rather, we are summoned to something greater: a healthy urban ecoscape in conjunction with increased densities.

A study of five UK cities found that while "most measures of ecosystem performance declined with increasing urban density, there was considerable variability in the relationships. This suggests that at any given density, there is a substantial scope for maximizing ecological performance" (Tratalos 2007, 308). Urban designers recognize that while there is an apparent paradox in being asked to build more while simultaneously conserving open spaces, they increasingly recognize that it is possible to design a built environment that actually creates green space (Richards 2011). Such an approach includes multi-functional land use in which ecological purposes and habitat requirements are incorporated into development plans (Snep et al 2009), and providing "small areas of nature near home and larger areas as natural boundaries" (Hester 2006, 328).

While there is undoubtedly a need to accommodate population growth in our cities, significant additional density can be added to cities without sprawling into greenfield areas or infringing on existing large habitat patches. For example, Metro Vancouver's Residential Development Capacity Study found that the existing development capacity in Metro Vancouver is 42% more than the expected demand over the next 30 years (Metro Vancouver 2009). As this density is added to existing urban areas, there are many innovative approaches to greening the matrix and creating new habitat patches and corridors at the same time.

For example, the City of Vancouver is considering a "thin streets" program which would take half of the road right-of-way in some residential neighbourhoods, and convert it into development space (Ditmars 2012a). Such an approach could be used to provide the additional density along with smaller-footprint dwellings embedded into ecoscape restoration. The result would counter fears of new "monster homes" that have led to some objections to Vancouver's plans, and would instead create new greenspace in the neighbourhood which would be a benefit to all residents.

Density done poorly results in small spaces devoid of nature. In contrast to large lots abundant with nature, it is clear that density is to be shunned. However, there is no requirement that density has to be free of nature. On the contrary, density done well incorporates nature to create appealing spaces, separates dwelling units by leafy green amenities, and rewards the choice of density with high-value shared green space and ecological connectivity.

Site Scale

At the building scale, examples include the "officeduct" which is a building designed with an urban wildlife overpass on the roof such that all the necessary functions of infrastructure, building, and ecology are able to co-exist (Snep et al 2009). Other approaches rest on designing buildings that invite wildlife into the building as opposed to treating wildlife as a nuisance (Archer and Beale 2004), and blurring the lines between indoors and outdoors so that people can live and work outside, adjacent to buildings (Beatley 2011, 119).

The winning design of a 2011 housing competition in Abu Dhabi was the "StairScraper," a vertical stack of cantilevered single garden houses, spiralling up around a central column so that each level has substantial sunlight exposure in support of extensive and stepped gardens reaching skyward. The designers explain that it "represents the idea of understanding a wider habitat, a system of complex social relationships with the environment in sear of enjoyment of life, mixing different ambits, different uses" (quoted in Green Place 2011, 21). The "StairScraper" offers significant density as well as far more greenspace than would have been available even if the entire building lot was made into a grade-level park.

Some designers have attempted to merge the built environment with the living vegetative environment. One such innovation, entitled "Launch," is "a combination of living and nonliving systems: a progression of vegetal growth and its correspondent structural scaffolding that is required to guide the plant's form and trajectory until it reaches stability (Margolis and Robinson 2007, 14). The "scaffold" may be a transitional structure (i.e. biodegradable), it may be permanent, or it may be designed to evolve symbiotically. In some cases, the plants will either eventually graft with the inorganic structure in a process of "allofusion," or "over the course of many years, the architecture and living materials are envisioned to swap structural roles: the architecture recedes, while conceding structural support to the living materials it originally supported" (Margolis and Robinson 2007, 34).

Green roofs are widely recognized for their significant ecological and economic benefits including:

> "stormwater management, energy conservation, mitigation of the urban heat island effect, carbon sequestration, increased longevity of roofing membranes, habitat for wildlife, mitigation of noise and air pollution, and a more aesthetically pleasing environment in which to work and live" (Rowe and Getter 2010, 391).

Green roofs can reduce runoff by 50-100%, depending on the type of system (Rowe and Getter 2010, 394), and provide habitat for microorganisms, insects, birds and other animals. A strategy for improving native plant survival on green roofs is to "amend the growing substrate with mycorrhizae fungi to more closely represent their native soil" (Rowe and Getter 2010, 404), a strategy that would be informed by information about natural ecosystem character. It has been shown that "…over time, substantial biodiversity can take hold on green rooftops, and in some cities ecological roofs can even help in re-establishing populations of endangered and threatened species" (Beatley 2011, 121). In fact, the strongest driver for recent green roof construction in Europe has been the attempt to reconcile biodiversity conservation with urban development (Frith and Gedge 2005, 120).

Green roofs contribute to returning the local climate and air quality to pre-urbanization conditions and this in turn assists in the restoration of native plants and ecological communities. Simulation models have shown that 50 per cent green-roof coverage, evenly distributed throughout Toronto would cool the city by up to two degrees Celsius (Oberndorfer et al 2007, 829). Green roofs are being used in contaminated and degraded settings to take up localized pollutants and help clean the local airshed.

In some locations, such as Basel, Switzerland, green roofs are mandatory on all new flat-roofed buildings, and wildlife habitat needs to be considered in their design (Rowe and Getter 2010, 402). Copenhagen has similarly adopted a policy requiring green roofs for all new buildings with roof slopes of less than 30 degrees, and officials hope that up to 5,000 square meters of new development each year will be covered with vegetation (Proefrock 2010). The largest green roof in Canada covers 2.4 hectares on top of Vancouver's Convention Centre, features 400,000 indigenous plants, and supports an apiary that produces 55 kilograms of honey each year (Green Places 2011e).

Green walls offer connectivity between vertical layers in the urban ecoscape, and are quickly becoming embraced by urban designers who see these vertical landscapes as "representing a conceptual shift toward a synthesis between landscape and architecture" and offer the chance to embed building facades "within emergent, active, and responsive skins." (Margolis and Robinson 2007, 15). The vertical gardens of Patrick Blanc (see verticalgardenpatrickblanc.com) are visually captivating, structurally diverse, and able to beautifully green the matrix by filling voids of all sizes in the urban landscape. The ViaVerde housing project in New York's South Bronx connected a multifunctional garden at street level, up through spirals of south-facing gardens, to a sky terrace (Beatley 2011, 22). A vertical farm is being installed on an under-utilized parking garage in downtown Vancouver in hopes of growing vegetables year-round (Brodie 2011). Europe's largest living wall, on London's Mint Hotel Tower, covers 350 square metres (3,767 square feet) and contains 184,000 plants. The installation cost on the Mint Hotel was "comparable to a standard curtain walling system," and offers a low-maintenance system that requires only annual pruning (Green Places 2011c, 17).

Green walls and green roofs are able to provide connectivity to adjacent trees which support canopy-level connectivity across inhospitable grade-level terrain. High levels of canopy cover has the potential to significantly green the matrix, but in order to achieve high levels, both public and private landowners need to be engaged. It has been found that strategies which target street trees and trees on public land are often successful, but are not sufficient to achieve high forest cover targets (Conway and Urbani 2007). Strategies to engage private landowners are also necessary, especially in lower-income neighbourhoods (Conway and Urbani 2007). Vancouver has embraced a range of canopy cover goals (15 per cent for commercial areas; 25 per cent for urban residential areas; 60 per cent for suburban areas; and 40 per cent overall), and is considering "programs for free or subsidized trees, adopt-a-tree programs, tree planting workshops, a festival that celebrates trees, and incentives for planting additional trees on private property" (Boyd 2009, 43).

Re-Imagining Roads

We need to shift the focus of 25 per cent of our urban landscape (the portion that is currently devoted to conveying automobiles) from cars to nature (Beatley 2011, 106), and many cities are starting to do this. The Montreal borough of Mercier-Hochelaga-Maisonneuve began in 2010 to support neighbourhood initiatives to "green" alleys by planting them with trees and other vegetation, and Montreal has now converted over 100 alleys to greenspace (CBC 2011). The City of Vancouver has a "Green Streets Program," and the German city of Freiburger has for centuries had a network of exposed narrow streams, collectively named the Bächle, that run through channels along urban streets. Chicago launched a "green alley program" in 2007 complete with a handbook to involve citizens and adjacent landowners. The renovated alleys focus on addressing stormwater management through the use of permeable pavement in the alleys, and encouraging adjacent landowners to install rain barrels, permeable pavement, detention ponds, bioswales, and trees and other vegetation (Chicago 2007). The use of permeable pavement need not be restricted to alleys either, as porous concrete and porous asphalt have been used successfully for over twenty years in numerous applications (Margolis and Robinson 2007, 160).

Many street trees lack the necessary soil volume for successful growth (Margolis and Robinson 2007, 158), but structural soils offer an engineered medium that can allow for root growth, and also meet load-bearing requirements (Margolis and Robinson 2007, 158). Canopy cover from trees lining both sides of streets adds to connectivity for some species, but grade-level connectivity is important for other species. Given the ubiquitous impact they have on the urban ecoscape:

> "streets must be reconceived as not only (or primarily) infrastructure for the conveyance of cars and traffic but as places that harbor native plants and biodiversity, that collect and treat stormwater, and where pedestrians can experience intimate contact with nature as part of their daily routine" (Beatley 2011, 99).

Reducing road density across the urban landscape is a function of both increasing alternative transit options so that the demand for road space for individual vehicles is reduced, and narrowing or re-purposing streets and alleys. Approaches to combining the movement of vehicles with components of the ecoscape include devoting some of the existing road surface to new roadside greenways (Li et al 2005), and building "varied wildlife passages (tunnels, pipes, underpasses, overpasses, underpasses) operating for animal movement" (Forman and Alexander 1998, 225). Multi-use landscaped bridges over roads have been successfully introduced to urban areas, such as to the Mile End Road in East London, UK. The negative ecological effects of roads may also be somewhat addressed by reducing road speeds, periodically closing roads, reducing traffic flow, erecting sound barriers, and reducing runoff through various stormwater management strategies (van der Ree 2009).

Water

Shifting some of the impervious road surfaces to permeable soils and vegetation, combined with the increased use of permeable road surfaces, are strategies at the heart of a "green infrastructure" movement that understands both stormwater management and water filtration are better handled by nature than by constructed human systems. The roots of green infrastructure dates back to the late 19th Century in Boston where Frederick Law Olmsted created an "emerald necklace" system of "linear parks and flood management features such as wetlands, ponds and river channel enhancements that formed an extensive, contiguous greenway right through the heart of Boston" (McGucking and Brown 1995, 230). Today, green infrastructure is understood to include "components such as hydrologically functional landscapes, bioretention, infiltration, bioswales, greenways, rainwater harvesting, pervious pavement, and neighbourhood-scale constructed wetlands, stormwater detention, retention, and infiltration systems" (Burian and Pomeroy 2010, 280). These approaches are also included as elements of "low-impact development" which is a land development approach that "mimics natural processes as a way to manage stormwater on site" and employs a variety of techniques to retain, detain, percolate, and evaporate stormwater (Li et al 2010, 416).

"Bioretention," "raingarden," and "bioswale" all refer to the use of permeable soils and vegetation to temporarily hold and treat stormwater runoff from impervious surfaces. They are not designed to be permanent water bodies. They are shallow and usually located in upland areas (rather than deep, downhill ponds) close to the source of the stormwater runoff, and the biomass is used to retain nutrients and other pollutants (Li et al 2010). These approaches are generally effective for removing heavy metals, petroleum products, and fecal coliforms, but only moderately effective for removing nutrients (Lie et al 2010).

Studies in Guelph, Ontario suggest that "landscape integrity could be increased, urban wildlife habitat enhanced, and opportunities for residential non-consumptive wildlife recreation improved" by designing and incorporating urban stormwater management facilities into a network of greenways (McGuckin and Brown 1995). The authors concluded that:

> "…the application of landscape ecological theory and concepts to the planning and design of stormwater management facilities is a suitable strategy for enhancing the wildlife and residential non-consumptive wildlife recreation potential or urban stormwater management facilities" (McGucking and Brown 1995, 244).

Many municipalities have embraced green infrastructure solutions to both increase the urban ecoscape, and to provide an ecologically-superior and cost-effective approach to managing stormwater and water quality. Those close to the industry, assert that "the popularity of micro-green infrastructure as flood management solutions is likely to increase significantly" (Deen 2011, 42). New York City's Green Infrastructure Plan calls for capturing "the first inch of rainfall on 10% of the impervious areas in combined sewer watersheds through detention or infiltration techniques over 20 years" (New York City 2010, 4). The SW 12th Avenue Green Street project in Portland, OR, includes a "networked sidewalk stormwater system" that connects a series of embedded planters designed so that water flows into one planter, and when it is full, flows out to the street, along the curb, and into the next planter, allowing for the use of smaller raingardens that are collectively able to handle significant volumes of stormwater (Margolis and Robinson 2007, 70). Seattle ran a "street edge alternatives" pilot that was completed in 2001 and was "designed to provide drainage that more closely mimics the natural landscape prior to development than traditional piped systems." (Seattle 2011). The project:

> "reduced impervious surfaces to 11 percent less than a traditional street, provided surface detention in swales, and added over 100 evergreen trees and 1100 shrubs. Two years of monitoring show that SEA Street has reduced the total volume of stormwater leaving the street by 99 percent" (Seattle 2011).

Green infrastructure approaches contribute to the ecoscape, provide terrestrial habitat, and also improve aquatic habitat by providing much cleaner water to the aquatic areas within, and bordering, our cities. The quality of aquatic habitat is determined significantly by both the adjacent level of impervious surfaces, and the size and quality of riparian buffers. Paul and Meyer (2001) concluded that riparian cover only acts effectively as a buffer zone in urban areas with less than 45 per cent imperviousness (2001). A study of the impact of urbanization on stream habitat found that:

> "[t]he amount of connected impervious surface in the watershed was the best measure of urbanization for predicting fish density, species richness, diversity, and index of biotic integrity (IBI) score; bank erosion; and base flow. However, connected imperviousness was not significantly correlated with overall habitat quality for fish." (Wang et al 2001, 255).

Instead, it is a combination of low connected impervious surfaces (less than 12 per cent in the watershed) as well as an undeveloped buffer along streams that is required (Wang et al 2001). Other studies have pegged the threshold at ten per cent impervious surfaces as critical for limiting stream impacts (Burian and Pomeroy 2010, 282). The overall conclusion is that urban stream restoration can only address part of the challenge through work at the riparian site scale because the problems associated with high urban peak flows will still remain. It is necessary that this work be complemented by basin-wide stormwater management improvements, including reducing impervious surfaces (Walsh et al 2005; Stander and Ehrenfeld 2010), and that both stream restoration and green infrastructure strategies be pursued.

Successful stream restoration efforts are based on an understanding of ecological processes and ecological theory, consider the food web structure and the life-cycle of key species, are carried out at the appropriate spatial scale (the larger the better), and seek to restore connectivity and refuges from disturbance regimes (Lake et al 2007). Stream restoration initiatives need to look at the entire watershed and attempt to reduce the negative watershed-wide human impacts on the stream (Kauffman 1997), and should include ongoing monitoring and assessment (Bash and Ryan 2002).

"Floating islands" have recently been pioneered as a way to introduce vegetated bodies into the water body to improve water quality. BioHaven Floating Islands, for example, "may be applied to a eutrophic water body, water garden, stream, river, or wastewater application, in order to remove excess nutrients, heavy metals, or hazardous substances" and research has shown such structures effectively remove nitrate and phosphate, provide wildlife habitat, and reduce biogas emissions (Stewart et al 2008).

In addition to stream restoration work, creating a healthy ecoscape includes bringing back to life the many streams that have been paved over, diverted into culverts, and buried over by our cities. The process of bringing them back to life is called "daylighting," and the Rocky Mountain Institute, after reviewing multiple such projects across the United States concluded there were multiple benefits associated with these efforts:

> "Daylighting can provide multiple benefits—tangible and intangible—for every dollar expended. These include improvements to the functional values of waterways and urban stormwater systems through increased hydraulic capacity for flood control, lowering of water velocities to reduce downstream erosion, removal of water from combined sewers, improvements to water quality, and more. Daylighting can improve aquatic habitat and provide "new" riparian corridors for wildlife. It can revitalize neighborhoods, increase property values, and benefit nearby businesses. It can be cost effective compared to the expense of repairing a failing culvert. Daylighting projects help educate children and adults alike about the workings and values of stream corridors and wetlands. In doing so, they foster stewardship of natural resources and energize people with a sense of "setting things right." What more powerful restoration project is there than recovering a buried, out-of-sight and out-of-mind waterway that seemed lost forever?" (Pinkham 2000, 55)

While urban stream daylighting and reclamation is a relatively new approach, there are thousands of such projects already slated in the United States (Buchholz and Younos 2007), and ambitious projects are being undertaken worldwide. A landmark project in Seoul, South Korea, consisted of the removal of an urban freeway in order to daylight five kilometres of the Cheonggyecheon stream that has since become the centre of a showcase new urban park (Revkin 2009). Mexico City has embarked upon a reclamation project that will result in the world's largest urban park, named Texcoco Lake Ecological Park and covering over 14,000 hectares. The waterscape will treat wastewater and help protect Mexico City from flooding, and restoration efforts will focus on recovering a lost wetland ecosystem (Green Places 2011b).

Daylighting streams adds new habitat to the ecoscape, something that is necessary but challenging to do in fully built-out urban areas. Adding new, large patches and corridors to the urban ecoscape has historically been accomplished by governments acquiring land to set aside as greenspace. As Metro Vancouver recognizes, this approach is increasingly difficult to pursue:

> "In the past, one of the primary strategies for protecting natural areas from urban development was to acquire it as public land for parks and/or conservation. However, public acquisition budgets are not keeping pace with the significant increases in land prices. Therefore, the amount of land that can be protected through acquisition in the future is small compared to the need. There are also relatively few remaining large, contiguous areas to be acquired." (Metro Vancouver 2007, 5).

Ecological Parks

Many cities are looking at their existing inventory of greenspace, and re-visiting the concept of a "park" in order to establish more natural ecosystem composition, structure, and function. "Ecology parks" are an attempt to apply ecological landscape design principles to urban open space, and Pollution Probe developed a demonstration "ecology park" in 1987, dubbed "Toronto's Ecology Park." London's Olympic parkland, the largest new park development there since Victorian times, is designed to promote sustainable living through a focus on food growing (orchards and urban farming), and wildlife habitat including wetlands, wooded valleys, and other habitat areas (Reimer 2010).

The search for new urban ecoscape patches and corridors has led some (post-industrial) cities to their abandoned industrial lands. While these lands are dormant in terms of human activity, they have "all sorts of spontaneous nature values" (Snep et al 2009, 463), and new greenspaces have been established along with artefacts of prior industrial activity. For example, Seattle's Gas Works Park incorporates the remnants of an old factory into an iconic urban park (Harnik and Donahue 2011). In other cases, the inoperative industrial infrastructure has been repurposed to support creative new ecoscape elements. Paris' Promendate Plantée, the world's first elevated park, which opened in 1989 after the repurposing of the former Bastille Railroad Line, offers over four kilometres of pedestrian walkway surrounded by trees, plants, and pools of water (Hurwitz 2012), and was the inspiration for New York's High Line. Taking stock of a similar dormant elevated rail line in New York City, members of Manhattan's Chelsea community banded together in 1999 to propose that the High Line not be torn down, as was planned, but instead be made into a park. Today two of the Line's three half-mile-long sections have been transformed into a greenspace and walkway, with the third section pending development (Goldberger 2011).The High Line, which includes trees, shrubs, and native plant gardens, ecological information about the landscape, art installations, and public events, has become a celebrated Manhattan landmark and inspiration for similar efforts elsewhere. Vancouver, for example, is currently considering re-purposing its Georgia Viaduct into a greenspace and pathway based on the High Line's success (Ditmars 2012).

Linear ecoscape corridors sited along existing infrastructure and boulevards, waterfronts, and urban streams and rivers, act as corridors, but can experience a very high edge effect depending upon the surrounding matrix (Kullmann 2011). Depending on the degree of lateral permeability, and the adjacent matrix, such linear greenspaces can act as peninsulas where the level of biodiversity is highest at the base and decreases towards the tip, but permitting multiple habitat zones for different species (Kullmann 2011). In North America, such thin parks have been typically designed to meet public health and recreation objectives, and are often implanted green spaces as opposed to emergent.

As new patches and corridors are created in the urban ecoscape, there may also be increased demands from human users that want to visit the parks. In order to limit the negative effects of human traffic in urban habitat patches and corridors, some park designers have employed slightly raised walkways, or erected minor barriers to guide people along paths instead of through sensitive vegetation and soils. For example, the Tanghe River Park in Qinhuangdao, China, features an innovative red steel bench that snakes its way for half a kilometre through the park. On one side of the bench is an elevated foot path, and on the other is sensitive natural vegetation and habitat. The red bench incorporates lighting, seating, and information related to ecological interpretation and orientation.

Biophilic Momentum

As new elements are added to the ecoscape, there is a potential "aesthetic conflict" wherein people may prefer manicured green spaces that provide significantly less ecological value, than diverse habitat patches where natural succession patterns are permitted to continue (Gilbert 1989). Some people are "…conditioned to equate the annual cycle of growth and decay with neglect" (Gilbert 1989, 313), and assume that un-manicured sites will attract crime or will become refuse dumping sites. This can be countered by providing information about the specific cycles of growth, by training parks department staff, and by educating the public about the ecological objectives.

This aesthetic conflict can also, perhaps most effectively, be countered by inspiring people to embrace nature in the city. This inspiration comes in part from education and communication, in part from innovative design and planning, and in part from exposing urban dwellers to nature and allowing biophilia to take over. As Timothy Beatley argues:

> "The power of biophilia suggests that everything we design and build in the future should incorporate natural elements to a far greater extent – indoors and outdoors (and indeed the need to overcome these overly artificial distinctions), green neighborhoods, integrated parks and wild areas, not far away but ideally all around us" (Beatley 2011, 6).

In order to create biophilic momentum in support of nature in cities, ecoscape planning approaches should follow the advice of Randolph T. Hester, the University of California at Berkeley's Professor Emeritus of Landscape Architecture & Environmental Planning and Urban Design, who suggests we ensure that nature is nearby, evokes calm and does not increase anxiety, provides natural distractions, inspires creativity, is kept elemental and understated, provides views, and offers settings for active, passive, private, and social relationships (Hester 2006). Nature in cities should also offer rich, textured, multisensory environments that include a variety of sounds (e.g. frogs, crickets, screech owls, running water)(Beatley 2011).

Another way to create biophilic momentum is to embrace those solutions that complement natural ecosystem restoration while providing tangible benefits to urban dwellers. Urban agriculture is an element of the ecoscape that enjoys significant public support, and which can be frequently used to green the matrix by filling in small patches of available land across the urban landscape. The many ways that food can be grown in the city include both site-scale approaches (rooftop gardens, household gardens, household greenhouses) and neighbourhood-scale approaches (community gardens, orchards, and greenhouses, urban aquaculture, edible landscaping, and community farms) (Peemoeller et al 2008). San Francisco encourages residents to plant in "sidewalk gardens" between sidewalks and street curbs. Detroit has been experimenting with urban farming to fill in the gaps in its urban fabric (Mostafavi 2010), and Burlington, Vermont, supports two Community Supported Agriculture operations, and several organic farms and related food enterprises, in an urban floodplain along the Winooski River (Wheeler and Beatley, 2004, 315).

Monitoring Progress

Many systems of metrics and indicators have been developed for quantifying and monitoring nature in cities. These include the Green Plot Ratio, which provides design flexibility in meeting minimum requirements for vegetated leaf-area, and is being considered by Beijing as a way to evaluate their ecoscape (Li *et al* 2005). Berlin has a Biotope Area Factor (BAF) which factors the minimum proportion of a site that must have green features (Beatley 2011, 132), and Seattle has a Green Factor which is "…a landscape requirement designed to increase the quantity and quality of planted areas in Seattle while allowing flexibility for developers and designers to meet development standards" (Seattle 2011a).

The Regional Vancouver Urban Observatory (RVu) is a member of the UN-Habitat Global Urban Observatory Network, and tracks some indicators related to natural capital including greenfield development, citizen involvement in environmental stewardship, and local food security. The objective of creating indicators is to negotiate and integrate values and ideals; inform, attract, and unite the widest range of citizens possible toward the goal of improving our common urban future; involve local policy-makers and organizations of civil society in dialogue; generate information on local themes and problems; and encourage policy responses to locally felt needs and priorities (Holden 2006). Nancy Olewiler at Simon Fraser University points out that the purpose of developing indicators is to assist in the assessment of conditions and trends, to provide input into the policy process, and allow for informed discussions among stakeholders (Olewiler 2006).

Attempts to quantify the ecoscape usually adds value, however experience from England's "Accessible Natural Greenspace Standards" has shown that a danger with a standards-based approach is the preference for quantifiable results, possibly at the expense of ecosystem quality or management success (Pauliet *et* al 2003). Clearly the vast range of benefits associated with a healthy urban ecoscape, or the countless factors that contribute to realizing these benefits, cannot be distilled down to a few indicators. Those indicators that are available are helpful proxies that may provide a sense of progress or direction, but the words of Sociologist William Bruce Cameron are worth remembering: "…not everything that can be counted counts, and not everything that counts can be counted." (Cameron 1963, 13).

As we grapple with the breadth of the challenge in inviting nature home, and explore countless innovative approaches, much can be learned through the cross-pollination of disciplines, the appreciation for Indigenous knowledge, and the perspectives of citizens, neighbourhoods, and communities within our cities. It has been argued that effectively rising to the challenges of nature in cities requires a trans-disciplinary approach that crosses the traditional divisions between architecture, landscape architecture, planning, urban design, environmental planning, and landscape ecology (Mostafavi 2010).

Healthy Human Communities

A healthy urban ecoscape helps people connect to the ecosystems that support us all, and anchors their urban existence in a place-specific identity. This sense of place further encourages protection of local ecosystems, and engenders a preference for the locally-specific and ecologically-valuable over the generic and disposable. Nature in cities connects us with the ecological history of the location, and of ourselves. By providing access to nature in our cities, we can again learn to read the environmental signals and look to nature for inspiration in addressing the many challenges ahead. This sort of "ecological literacy" is necessary to better design our cities, and builds support for the actions necessary to address our many global ecological challenges.

A healthy urban ecoscape benefits ecosystems across the planet because nature in cities encourages a strong and lasting environmental ethic among its residents, and because urban ecoscapes are a highly-visible proving grounds for the anthropocentric benefits of nature. The formative years of childhood appear to be particularly critical for the development of an environmental ethic based on direct experience with nature, and by providing our children with nature close to their homes we are investing future generations with a sense of environmental responsibility and empathy.

It has been well established that there is a link between people's health and the presence or absence of nearby greenspace. A healthy ecoscape cleans the air and water, quiets the urban landscape, offers direct psychological benefits, make us more civil, provides an antidote to the stresses of daily life, and initiates broader forms of social change. Humans are dependant upon nature for survival, and benefit directly, consistently, and in innumerable ways from healthy ecosystems. The wide variety of ecosystem services provided by nature have been assigned a significant monetary value in a number of recent studies, and by protecting the stocks of natural capital that provides these services urban dwellers are able to reduce the pressure that would otherwise be placed on more distant ecosystems.

Creating a healthy urban ecoscape – one that provides ecological connectivity across the entire urban landscape – may also help alleviate an often inequitable distribution of greenspace. From an ecological perspective, it matters not whether a particular part of the city houses low-income or high-income people, the connectivity requirements still must be met.

Ecological Ethic

A healthy urban ecoscape benefits ecosystems across the planet because nature in cities encourages a strong and lasting environmental ethic among its residents, and because urban ecoscapes are highly-visible proving grounds for the anthropocentric benefits of nature. As Timothy Beatley points out, ensuring urbanites are "immersed in nature" is the best way to address environmental apathy (2011, 10).

It has been shown that "direct and frequent experience with nature as a child "is necessary for concern for the environment in later life" (Johnston 1990, 237), that one's sensitivity to environmental issues is determined significantly by one's personal exposure to nature (Sebba 1991), and that "enhancement of biodiversity in urban ecosystems can have a positive impact on the quality of life and education of urban dwellers and thus facilitate the preservation of biodiversity in natural ecosystems" (Savard et al 2000, 131).

The formative years of childhood appear to be particularly critical for the development of an environmental ethic based on direct experience with nature. Professor Karen Malone of the Globalism Institute in Australia argues that urban green spaces and botanical gardens, what she refers to as "holding environments," are essential to children's environmental learning (2004). Her research supports the conclusion that people's eventual ability to "contribute to environmental sustainable development will be largely dependent on the quality of their childhood environmental experiences" and that "…there is a strong connection between a child's likelihood to develop a sense of empathy, belonging and responsibility to their environment and their direct experiences in it" (2004, 64). She concludes that "to participate in, and contribute to, global sustainability – our children need places and the opportunity to engage, connect and respond to nature" (2004, 53).

By providing access to nature in our cities, we can again learn to read the environmental signals and look to nature for inspiration in addressing the many challenges ahead. This sort of "ecological literacy" is necessary to better design our cities (Hester 2006, 334), connects us directly to the natural environment we're seeking to restore, and builds support for the actions necessary to address our many global ecological challenges. The urban ecoscape is both an end in itself, and a means to bring urban citizens along on a journey to restore ecosystems elsewhere:

> "A major opportunity exists in urban areas to demonstrate that ecosystem management principles – particularly those that focus on the protection and restoration of essential ecosystem functions – have practical applications that are beneficial to humans. If people see these concepts at work in their neighborhoods, restoring vacant lots, improving riparian areas, and making their lives better, they are more likely to trust the fact that similar actions can help conserve America's rural landscape and protect its public land heritage." (Lyons 1997, 77-78)

Green design pioneer William McDonough recognizes this spill-over effect of a healthy urban ecoscape: "And so we can begin to see the city not only as an elegant self-sustaining place, but as a revitalizing force in its region" (McDonough 2005, 15). It is likely that this revitalizing momentum includes support for ecosystem restoration and protection efforts beyond the region, and helps build support for restoration efforts around the planet.

Beatley (2011) suggests various ways that cities can catalyze an environmental ethic, including celebrations of locally-unique nature and biodiversity spectacles (e.g. running of salmon, or the return of migratory birds), environmental literacy and outdoor education programs for adults, citizen science and community-based monitoring programs, urban nature "rangers or coaches" that provide local ecological interpretation, gardening and bird-watching programs, swimming locations in natural waterways, outdoor/open-air commercial districts, and fostering a deep sense of the city's natural history through planning and designing in time-frames of hundreds or thousands of years.

Sense of Place

The German poet Rainer Maria Rilke observed over a hundred years ago that "the movements of most of the people who live in cities have lost their connexion with the earth; they hang, as it were, in the air, hover in all directions, and find no place where they can settle**"** (Rilke 1903, 13). Similarly, Doug Farr remarks that: "…most people live out of daily contact with natural systems. They have no idea where their water or food or energy comes from or where their liquid or solid wastes go. As they get no feedback regarding the enormous stress that their lifestyle places on nature, they conduct their daily lives largely unconstrained by concerns about it." (Farr 2008, 48).

In contrast, a healthy urban ecoscape helps people connect to the ecosystems that support us all, and anchors their urban existence in a place-specific identity. This sense of place further encourages protection of local ecosystems, and engenders a preference for the locally-specific and ecologically-valuable over the generic and disposable. Creating a healthy urban ecoscape involves "an investment in place, an emotional commitment that surpasses real estate and financial imperatives" (Hough 1990, 16). As Timothy Beatley (2011, 39) notes, nature in cities connects us with the ecological history of the location, and of ourselves.

Sean Markey of Simon Fraser University's School of the Environment argues that a "sense of place" is a critical pre-condition to people caring about where they live, which in turn leads to their demanding a healthy environment and wanting to be part of the restoration process (personal communication 2012). Stuart Chapin et al similarly concludes that a sense of place is necessary for ecological stewardship because it provides the "motivation for enhancing ecosystem resilience and human well-being of the region they frequent," motivates people to negotiate their political and socioeconomic differences, and "increase the likelihood of prioritizing long-term solutions over short-term benefits" (Chapin et al 2012, 16). These conclusions are encouraging in the face of the significant challenges associated with urban ecosystem restoration, and point to the possibility of momentum being built into the process once it is initiated. As urban dwellers start to focus on the ecological remnants in their neighbourhood, understand these remnants as essential to their sense of place, and begin work to protect and enhance a healthy ecoscape particular to their neighbourhood, there will be numerous positive feedback loops that encourage greater commitment to the process and stronger ecological outcomes.

It is the “sense of place” attachment specific to nature, as distinct from the civic “sense of place,” that is key to predicting pro-environmental behaviour (Scannell and Gifford 2010). However, in urban settings civic pride and visible nature are complementary rather than mutually exclusive. A more nuanced distinction among the various aspects of a sense of place reveals that while attachment to a place fosters place-protective behaviour, place satisfaction does not (Stedman 2002). If a community is generally satisfied with the status quo of their environment, they are less likely to be motivated to engage in ecosystem stewardship, even if they have a strong sense of place. On the other hand, people are more willing to fight for a place that is central to their identity if they feel it is in “less-than-optimal condition” (Stedman 2002, 577). As other research has revealed, the context of place identification and satisfaction is important to understand (Uzzell et al 2002). In other words, a sense of place is necessary to motivate urban ecosystem restoration efforts by members of the community, but an appreciation of the need for improving the ecoscape is also necessary.

The specific ways that an urban ecoscape provides a sense of place varies from city to city and needs to flow from the unique ecology and history of a particular city. In many cases, preserving original natural vegetation has been embraced by planning and design approaches aimed at uncovering a local “identity of place” (Florgård 2009, 384). The UK’s National Trust is campaigning to connect communities to their food heritage in general by focusing on their apple heritage in particular – an effort they argue has important ecological benefits by moving away from monoculture orchards to the integration of apple trees with other trees, vegetation, and habitats (Groves 2011). Singapore’s vast Gardens by the Bay, scheduled to open in June 2012 and covering 101 hectares of downtown waterfront land, is inspired by the orchid – a plant that is emblematic of Singapore and whose epiphytic nature parallels the reclaimed land upon which the park has been built (Green Places 2011d). When Minneapolis called for design proposals to transform an 18-kilometre stretch of urban waterfront, the design requirement was to simply “put the river first” (Armstrong 2011, 24). The history of Minneapolis has been tied to the river, and the winning proposal intends to “forge a harmonious and symbiotic relationship between the city’s people, river, wildlife and landscape…” (Armstrong 2011, 24). Calgary’s RiverWalk park centres around the Bow and Elbow rivers and attempts to connect people with their riverfront history and identity (Greco 2010). A similar approach has been taken by the City of Prince George, BC, as it recently embraced plans to re-introduce river access to the core of the City as a way to recognize and celebrate the long history of Indigenous and colonial settlement at the confluence of the Nechako and Fraser Rivers. The restoration experiences of Kakamigahara City, on the fringes of Nagoya, Japan, which received the 2005 Prime Minister’s Award for Greening Cities, showed that “reuniting nature and the man-made environment based on the ecological context in each locality was the fundamental method for regenerating the city for future generations” (Mikiko 2009, 102).

The elements of the ecoscape that provide a sense of place can be large or small. Historic grand contributions to urban ecoscapes, in the form of large public parks such as New York’s Central Park, Vancouver’s Stanley Park, and San Francisco’s Golden Gate Park, provide an enduring and “monumental” sense of place that is “woven into the identity, practices, and rituals of city dwellers” (Breckman 2010, 180). At the smaller end of the scale, Tony Burton, director UK’s Civic Voice, argues that “there is something in every neighbourhood that people value and which provides the starting point for developing a clear and compelling vision” (Burton 2011, 31). Finding such a starting point can support an ecological restoration effort that has significant momentum. As more of these places are restored, additional momentum is built that leads to further enhancement of the ecoscape.

Nature’s Antidote

As the ecoscape becomes healthier so do urban communities and their residents. Planning visionary Ebenezer Howard described the community benefits of bringing nature into cities:

> "Yes, the key to the problem how to restore the people to the land – that beautiful land of ours, with its canopy of sky, the air that blows up on it, the sun that warms it, the rain and dew that moisten it… is the key to a portal through which, even when scarce ajar, will be seen to pour a flood of light on the problems of intemperance, of excessive toil, of restless anxiety, of grinding poverty" (Howard 1902, 44).

Howard's insight has been reiterated by many other urban thinkers and researchers. Randolph T. Hester writes that: "Nature make us more civil… experiencing nature more increases our ability to listen to others, to empathize, and to be concerned about their needs as well as our own… Exposure to nature reduces our aggression and makes us less violent" (Hester 2006, 335). Anne Whiston Spirn argues that "[t]he social value of nature must be recognized and its power harnessed, rather than resisted" (Spirn 2004, 115), Richard Louv (2008) describes nature as an "antidote," and urban design professor Darko Radovic asserts that "environmental and cultural sustainability cannot be separated" (Radovic 2009a, 15).

Professor Paul Milbourne (2011), at UK's Cardiff University, finds that community garden projects initiate broader forms of social change, and that they are often started for different reasons including improving aesthetics, providing green space in highly built-up neighbourhoods, tackling social problems, catalyzing community cohesion, and creating meaningful relationships between people and the environment. In the US, research indicates that community gardens are often associated with providing inexpensive and high-quality food, building community pride and confidence, and fostering new spaces for public participation (Milbourne 2011). An organizer of a community garden project in an urban low-income community reflected that "[w]hat has been incredibly rewarding is the absolute enjoyment and enthusiasm the children display when they are experiencing the touch, smell and fun to be had during all stages of the growing cycle" (quoted in Abbott 2011, 28). This reflection fits with research findings that children prefer "natural landscape with trees, flowers, and things that grow; animals, ponds, and other living things; natural colour, diversity and change" (Malone 2004, 63), and that the vast majority of adults identify the most significant place from their childhoods as being in the outdoors (Sebba 1991).

Greenway designers Paul Cawood Hellmund and Daniel Somers Smith have grouped the social functions of greenways into three categories:

> "As both attractors of recreational use and conduits for the movement of people, greenways enhance *social connectivity*. Especially where they link together diverse populations, greenways can thus influence patterns of *social interaction* within and between neighbourhoods…. These effect, in turn, have the potential to help build *social capital* – the networks of social ties and interactions that provide a crucial basis for trust, cooperation, and successful social, economic, and political activity" (Hellmund and Smith 2006, 160).

The benefits of a healthy ecoscape accrue not only to communities but to individuals as well since access to nature has a positive effect on human health, makes urban areas more attractive to live in, can raise the quality of life, and can influence the human psyche and well-being (von Borcke 2003). New York City apparently understands these many benefits and has thus spent over $US 3 billion on parks since 2002 with the goal of ensuring that no resident lives more than ten minutes from a park (Greco 2010).

It has been well established that there is a link between people's health and the presence or absence of nearby greenspace (Beer 2010), since access to nature invites outdoor exercise. Vegetated roofs reduce the level of sound transmission in urban areas by absorbing sound to a greater degree than hard surfaces (Rowe and Getter 2010), thereby resulting in less noise pollution for urban dwellers. Studies have shown that green roofs are effective in reducing sulphur dioxide, nitrous acid, nitrogen oxide, sulphur oxide, and other pollutants and particulate matter in urban air (Rowe and Getter 2010). A healthy ecoscape cleans the air and water, quiets the urban landscape, and offers direct psychological benefits:

> "Greening the city makes it impelling because nature evokes our most fully human selves. Naturalness nurtures good health and heals us when we are sick, fatigued, and stressed. Naturalness spurs us to play with reckless abandon, frees us from artificial affectations and inhibitions, instils in us divergent ways of thinking,

and reawakens our naiveté. Naturalness helps us discover our fundamental character… Naturalness touches our hearts" (Hester 2006, 323)

Ecosystem Services

Humans are dependant upon nature for survival, and benefit directly, consistently, and in innumerable ways from healthy ecosystems. The benefits we derive from nature have been termed "ecosystem services," and include gas regulation, climate regulation, disturbance prevention, water regulation, water supply, soil retention, soil formation, nutrient regulation, waste treatment, pollination, biological control, refugium functions, nursery functions, food, raw materials, genetic resources, ornamental resources, aesthetic information, recreation, cultural and artistic information, spiritual and historic information, and science and education (de Groot, Wilson, and Boumans 2002). In summary, these services can be grouped into various provisioning services, regulating services, habitat or supporting services, and cultural services (TEEB 2010).

The demand for ecosystem services is very high per hectare in urban areas, as has been shown through the ecological footprint analysis (see Wackernagel and Rees 1996). The demand for services is satisfied significantly by ecosystems outside the urban area, and often by ecosystems located a great distance from the city itself. These "metropolis-satellite relations," using the words of Andre Gunder Frank (1966/1995, 27), result in many of the ecological costs concomitant with high levels of consumption being paid by ecosystems far removed from the location of consumption. The ecological costs associated with the consumption habits of urban dwellers if generally invisible to them. The lack of nature in cities removes a valuable sight line between consumption and its associated ecological costs. When urban residents do not see nature around them, it's easier for them to forget that ecosystems support all life and that their consumption habits have a cost that must be carried by an ecosystem somewhere.

In order to reduce the pressure on ecosystems elsewhere, and to connect urban dwellers with the ecosystems that provide them with necessary services, it is necessary to invite nature home to our cities, make nature visible, and restore functioning ecosystems that are able to provide significant ecosystem services in the very place where people live, work, and play. To this end, significant work has been carried out in recent years to identify and valuate the stocks of natural capital located in and near urban areas, and to identify the ecosystem services they provide.

For example, a recent study found that Canada's first urban national park, the Rouge National Park, located within the Greater Toronto Area, provides over $10 million worth of ecosystem services every year, and that the larger watersheds within which the Rouge National Park is located provide over $115 million worth of ecosystem services every year (Wilson 2012). Similar studies found that Toronto's Greenbelt provides approximately $2.6 billion in ecosystem services each year (Wilson 2008), and that BC's Lower Mainland in total provides about $5.4 billion in annual ecosystem services (Wilson 2010).

It is clear that by protecting and restoring ecosystems in and around urban areas, a significant portion of the ecosystem services demanded by urban dwellers can be provided close to home. A healthy urban ecoscape also provides a range of ecosystem services that provide community and individual economic benefit, including "air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values" (Bolund and Hunhammer 1999). Urban trees, for example, have been shown to provide services that include:

> "the removal of dust and air pollution, carbon sequestration, reducing energy use through cooling (in hot climates) or reduced wind velocity (in cold climates), cooling the urban landscape through evapotranspiration, improved neighbourhood and landscape aesthetics, and enhancing the psychological well-being of people living in urban areas" (Volder and Watson 2010, 228)

England's recently launched Green Infrastructure Partnership, established to help communities move on green infrastructure projects, is seen as a strategy that will attract new business, increase property value, promote sustainable development, and create new employment opportunities (Green Places 2011a). New York's High Line park, which cost the City of New York $US 150 million, is estimated to have a value to the City, in increased property values and taxes, of $US 0.5 billion (Abbott 2011). The Toronto Green Roof Infrastructure Research and Demonstration

Project, a three-year study of green roof potential in Toronto, found that putting green roofs on only six percent of the roofs in Toronto would reduce Toronto's overall heat island effect by 1˚C, reduce greenhouse gas emissions by over 2 megatons annually, reduce smog alerts by up to 10 percent, improve air quality, and retain over 3.5 million cubic metres of stormwater each year (Peck 2005, 128). Building a storage tank alone for this volume of water would cost $60 million and provide no additional benefits (Peck 2005, 128).

At the building level, green infrastructure and ecoscape components are broadly understood to provide long-term financial benefits for the owners. For example, William McDonough + Partners calculated that the green roof they designed for GAP Corporations' headquarters in California would, when compared with a conventional roofing system, pay for itself in 11 years through annual energy and operational savings (Earth Pledge 2005, 20). The Village Homes project in Davis, California utilized a series of "green fingers" to collect stormwater and provide community greenspace, along with fruit trees and edible landscaping. The natural stormwater system saved the project approximately $600 per home (Wheeler and Beatley 2004, 305). The shading of buildings by trees has been shown to reduce cooling energy costs (Volder and Watson 2010), and empirical evidence from the United States reveals an approximate 20 per cent increase in property values from adjacency to a passive park (Crompton 2005). Productivity returns to the workplace are also evident as studies of office workers have found that those with views of nature experienced less frustration and showed more work enthusiasm than those without such views (Louv 2008, 104).

Equity

Creating a healthy urban ecoscape – one that provides ecological connectivity across the entire urban landscape – may also help alleviate an often inequitable distribution of greenspace. From an ecological perspective, it matters not whether a particular part of the city houses low-income or high-income people, the connectivity requirements still must be met. As Randolph T. Hester puts it: "Every neighbourhood should have some primal landscape" (Hester 2006, 330).

Unfortunately, this is currently not often the case because "[n]ature has been seen as a superficial embellishment, as a luxury, rather than as an essential force that permeates the city" (Spirn 2004, 115). Urban forestry literature consistently finds lower levels of vegetation in low-income neighbourhoods (Conway and Urbani 2007), and tree cover in five UK cities was found to positively correlated with the social status of residents (Tratalos 2007). In the United States, higher urban canopy cover is positively correlated with higher education levels, older houses, larger house lots, greater slopes, and denser stream networks (Heynen and Lindsey 2003). Other researchers have found that wealth, institutional investment, and social capital are the factors with strong positive correlations to protected forest lands in urban and suburban communities, and wealthier towns are more likely to have long-standing and active land trusts that effectively protect forest land (Warren et al 2011).

Nature in the city increases property values and may lead to gentrification, so steps need to be taken to ensure the benefits are distributed equally and do not simply result in increased property values that force people out of neighbourhoods. At the same time, the protection of natural capital in wealthier neighbourhoods should not be used as a NIMBY justification for opposing density initiatives or rapid transit development. Once again, density and a healthy urban ecoscape need to be pursued simultaneously.

Inviting Nature Home

"Perhaps it will be the city that reawakens our understanding and appreciation of nature"
– Jane Jacobs (2004)

Jacobs' insight seems initially surprising, almost oxymoronic, but only because we have fully accepted the expulsion of nature as necessary for urbanization. Cities and nature are understood as occupying opposite positions on a spectrum: "poles of a continuum in the history and intensity of human intervention" (Spirn 1995, 113). While cities have been, and continue to be, sites of fierce landscape modification and deportation of nature, they do not have to be. There is nothing essential to urbanization that requires the expulsion of nature. Rather, cities devoid of nature are but one vision for the urban landscape – a myopic and timid vision that defrauds us and nature alike.

There is another vision. There is a vision in which nature is welcomed as a co-creator of the urban landscape, where urban dwellers are connected to the earth and not afraid of it, and where nature is celebrated rather than entombed. Lewis Mumford pointed out that this vision dates back over 2,000 years to "Hippocrates' famous medical work on Airs, Waters and Places [which was] the first public recognition that man's life, in sickness and in health, is bound up with the forces of nature, and that nature, so far from being opposed and conquered, must rather be treated as an ally and a friend, whose ways must be understood, and whose counsel must be respected." Unfortunately, as Mumford concluded, nature's counsel was generally not taken and Hippocrates' insight has not underpinned our general Western approach to development:

> "Despite nature's many earlier warnings, the pollution and destruction of the natural environment has gone on, intensively and extensively, for the last three hundred years, without awakening a sufficient reaction; and while industrialization and urbanization have transformed the human habitat, it is only during the last century that any systematic effort has been made to determine what constitutes a balanced and self-renewing environment, containing all the ingredients necessary for man's biological prosperity, social cooperation and spiritual stimulation" (Mumford 1969, vi-vii)

A minority voice in defence of nature began to speak as soon as urban planning began formally to be practiced. In the 1880s, Frederick Law Olmsted introduced the "natural scenery" of "wild" places into Boston's Fens and Riverway, and used native plants and his understanding of local ecological processes to guide restoration (Spirn 1995). At about the same time, urban planning visionary Ebenezer Howard recognized the shortcomings of cities without nature, and proposed that the benefits of nature be brought into the city. He envisioned a "marriage of town and country" (Mumford 1966, 34) to create a "Garden City" with a compact, walkable city centre surrounded by a circular park and houses with gardens. Howard argued in his seminal *Garden Cities of Tomorrow* that "[t]here are in reality not only, as is so constantly assumed, two alternatives – town life and country life – but a third alternative, in which all the advantages of the most energetic and active town life, with all the beauty and delight of the country, may be secured in perfect combination" (Howard 1902, 45-46).

Contemporaneous to these early "green" planning thinkers were environmentalist efforts that included Ralph Waldo Emerson's 1836 writing of the essay "Nature," Henry David Thoreau's 1854 writing of *Walden*, and John Muir's 1892 founding of the Sierra Club. The influence of environmentalism on urban planning has strengthened significantly since that time, notably after the flowering of the environmental movement that began after Aldo Leopold's 1949 *Sand County* Almanac, and Rachel Carson's 1962 *Silent Spring* with its explicit connection between environmental degradation and human health. As environmentalism mushroomed in the early 1970s, Richard Register founded Urban Ecology in Berkeley, an initiative that has been heralded as catalyzing contemporary "eco-city" activism (Roseland 1997). As Mark Roseland points out, however, the "eco-city" attempts to "green" cities has been influenced by numerous other movements and paradigms, including "…healthy communities, appropriate technology, community economic development, social ecology, the green movement, bioregionalism, native world views, and sustainable development." (Roseland 1997, 4).

Other observers agree that ecologically-focused urban thinkers have, especially in recent years, advocated bringing nature into cities for a variety of reasons:

> "…the past decade has witnessed an especially strong upsurge in research, publications, and demonstration projects that are laying the groundwork for a major reshaping of human habitat… Ecological systems are being examined for the lessons they hold for human systems. Producing a built environment that mimics and complements rather than conflicts with nature is emerging as the Holy Grail of this movement." (Kibert 1999 ,xv)

Significant among the recent efforts to mimic and complement nature through urban planning and development are the approaches of "Smart Growth," and Leadership in Energy and Environmental Design (LEED), as well as the place-specific efforts of municipalities around the world. Smart Growth is a practical approach that offers an alternative to urban sprawl in the form of mixed-use, walkable, and higher-density communities, and which generally embraces the principle of preserving "open space, natural beauty, and environmentally sensitive areas" (Smart Growth BC). The Smart Growth movement includes supporters, advocates, and practitioners in virtually every urban area across North America, and numerous examples of communities that have re-introduced nature in compelling ways at various spatial scales.

The Leadership in Energy and Environmental Design (LEED) programs of the US and Canada Green Building Councils recently expanded from the building scale to include the neighbourhood scale through its LEED for Neighbourhood Development (LEED ND) rating system which looks at the environmental effects of entire communities. They developed this rating system to outline an alternative to status quo sprawling development patterns which "fragment habitat, endanger sensitive land and water bodies, destroy precious farmland, and increase the burden on municipal infrastructure" (Canada Green Building Council 2011, xiii). The LEED ND rating systems has credits related to the preservation and enhancement of ecological communities, restoration and conservation of wetlands and water bodies, urban trees, local food production, stormwater management, native plants, and brownfield redevelopment. The LEED system has gained significant momentum, is active in at least 130 countries, and has engaged over 50,000 construction projects representing over 820 million square metres (8.9 billion square feet) of construction. Through this depth of activity, LEED has helped take the notion of valuing nature in urban development from the fringes to the mainstream.

At the level of specific municipalities, numerous planners and city councils have taken steps to invite nature home through various experimental and innovative projects. Vancouver's *Greenest City Action Plan* sets targets related to clean water, local food, access to nature, and a "spectacular urban forest" capable of providing the many ecosystem services offered by trees, including "cleaner air, lower temperatures… stormwater absorption, reduced erosion, increased property values, habitat and food for wildlife, the production of oxygen, improved water quality, lower energy costs associated with heating and air conditioning, safer streets, neighbourhood pride, mitigation of noise and dust levels, protection from sun, wind, and rain, and aesthetic value." (City of Vancouver 2009, 42).

Notwithstanding these notable movements, green-planning tools, and city-specific efforts, the general approach to urbanization remains hostile to nature, and the absence of an overall biophilic ethic in urban development caps the efficacy of strategies working within hostile systems. The fact that many small-scale invitations to nature are happening, often through the efforts of volunteers, attests to the intuitive importance citizens place on nature and to the un-extinguishable nature of our biophilia. Nevertheless, these efforts struggle against a systemic approach to development that expels nature, and are weakened by a lack of context in a larger commitment to inviting nature home. As Deborah Curran observes: "Projects such as in-stream work, public and staff education, protection of micro-habitat, and ecological rehabilitation are all part of the day-to-day operations of many municipalities. Much less integrated into daily practice are complete community approaches and long-term environmental protection at the planning stage of development." (Curran 1999, 5)

At the same time that local efforts are stymied by the lack of a holistic approach to inviting nature into cities, global environmental challenges have become more acute. Accordingly, the urban landscape is increasingly being recognized as ripe for the reconsideration of its various ecological footprints and the need to creatively bring nature back into our cities, and to "…construct discourses that undermine the artificial and culturally biased notion that society and cities are separated from nature and countryside, and instead view cities as reciprocal parts of regional ecosystems and dynamic landscapes" (Ernstson et al 2009, 541).

Forman (2008) argues that we need to mesh conservation planning with urban planning, and recognize ''natural systems in our place, our nourishment, our home range, and our future" (Forman 2008, 251). Honachefsky (1999) reminds his fellow planners that their profession is "about protecting our home and standing watch over the air, water, vegetation, and soil on the Earth's crust that makes life possible on what would otherwise be a planet as barren and inhospitable as our moon" (Honachefsky 1999, 1). Timothy Beatley eloquently makes the case for a "biophilic city" that "…puts nature first in its design, planning, and management; [and] recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural systems" (Beatley 2011, 45).

The call for inviting nature home to our cities has grown louder with the uncertainty associated with climate change, and with the associated recognition that planning for a predictable future is "not only insufficient, but it may, in some ways, also be destructive" (Ernstson et al 2009, 531). In response, local governments are seeking to plan for some measure of food, energy, and economic security. Increasingly, cities are looking at green infrastructure and the protection of natural capital as strategies to reduce costs, risks, and their ecological footprint.

All of this converges into considerable contemporary support for inviting nature home to our cities. Nevertheless, significant questions remain unanswered: what constitutes the nature we want to invite? How do we introduce nature to a landscape so thoroughly dominated by human activity? How can ecological communities exist across countless property, zonation, and jurisdictional boundaries? How do we coordinate efforts across a city, from individual property owners, to neighbourhoods, to regions?

The approach proposed herein attempts to address these questions through a three-part process of inviting nature home to our cities. The first part (character: the compass bearing) recognizes that the appropriate nature to invite back to any given city is the nature that existed in that particular location before the city did. This is a process of ecosystem restoration. The term "character" refers to "the *natural* composition, structure, and function of the ecosystem" (Hammond 2009, 34) and is the appropriate guide for restoration at all spatial and temporal scales across the city. The second part (Ecosystem-Based Voluntary Action) describes restoration actions that can be taken at the scale of individual properties, blocks, and neighbourhoods. These "bottom-up" efforts are, by definition, individually small, but the aggregate of these actions provides the essential "greening of the matrix," without which a healthy urban ecoscape would not be possible. The third part (Ecosystem-Based Restoration Planning) is based on the science and practice of Ecosystem-Based Conservation Planning, as developed by Hammond (2009), but applied to urban areas with the acknowledgement that inviting nature back into our cities is a process of restoration (Hammond 2011). The goal is to restore some level of ecological integrity by connecting the restoration work carried out through voluntary action at the site, block, and neighbourhood scales, to existing and new larger-scale patches and corridors across the urban landscape. Efforts at these larger scales is intended to inspire further small-scale voluntary action through an iterative process that reaches across all spatial and temporal scales as it creates a healthy urban ecoscape.

As a healthy urban ecoscape is created, and ecological integrity is restored, more ecosystem services will be available from these restored stocks of natural capital. It is imperative that these additional ecosystem services are not squandered by simply demanding more of them as urban ecosystem restoration efforts become more successful. Instead, these additional ecosystem services must be protected as a net increase in services that are then available to address the many ecological challenges we already face. In short, we must not only invite nature home to our cities, but we must also demand less of nature.

A Three-Part Process

A three-part process for inviting nature home to our cities is proposed here. The first part – "character: the compass bearing" - is an understanding of natural ecosystem "character" which is the composition, structure, and functioning of ecosystems in the location of the city, before the city existed. This natural character provides a directional heading that guides restoration work and describes a vision that will be obtained to a greater or lesser degree in different parts of the city. The second part – "ecosystem-based voluntary action" – consists of individual voluntary actions, taken at the site, block, and neighbourhood scale to provide some restoration at those scales, guided by the understanding of natural character. This second part is driven by very local initiatives, and requires little or no coordination from government or external institutions. The third part – "ecosystem-based restoration planning" – consists of more formal, institutional restoration actions that connect individual voluntary actions to each other and to larger-scale patches and corridors. This third part is driven by the process of ecosystem-based conservation planning, and is supported by government and institutional resources.

The proposed process recognizes that ecosystem character is the appropriate guide for restoration but that the urban landscape will remain human-dominated. Accordingly, restoration of natural ecosystem composition, structure, and function, and connectivity across all spatial and temporal scales, will be achieved to a greater or lesser degree in various parts of the city depending significantly on localized priorities. The proposed process also recognizes the large number of individual land tenures across the urban landscape and assumes that greening of the matrix will succeed only with significant voluntary action at the site, block, and neighbourhood scales. These efforts are then linked to each other, and to larger patches and corridors. As the scale of effort tips from individual volunteer initiatives to a greater need for coordination and public land planning, government and institutional resources are deployed to support an ecosystem-based conservation planning process that builds on what began at an individual scale.

The literature related to ecosystem restoration in urban settings recognizes that "the high degree of spatial heterogeneity… and the diversity of interests in every parcel of land in urban landscapes create extraordinary challenges for urban green-space planning" (Borgström et al 2006, 2). The literature also recognizes the need to address the scale and tenure challenges, and the importance of both bottom-up volunteer action and a broader-scale ecosystem-based planning process. Mohsen Mostafavi, Dean of Harvard's Graduate School of Design, calls for an "ecological urbanism" that provides "the necessary and emancipatory infrastructures for an alternative form of urbanism, one that brings together the benefits of both bottom-up and top-down approaches to urban planning" (Mostafavi 2010, 133). Environment Canada's Jean-Pierre Savard *et al* (2000) proposed a hierarchical approach to manage biodiversity across scales from backyards to local parks and vegetation corridors that provide multi-scale connectivity across the city and to greenbelts surrounding cities. The Cities Plus Project, a 2003 collaborative effort involving over 500 individuals and organizations, came together to create a long-term plan for Greater Vancouver. A key recommendation of this effort was creating a green web "that connects a hierarchy of green spaces, ranging from protected watersheds and agricultural land, right down to hedgerows and private gardens" (Cities Plus 2003, 29). Several research studies have suggested that the application of ecosystem principles to urban areas might be most effective at the sub-municipal scales (e.g. Barthel 2006; Colding 2006; Ernstson et al. 2008; Ernstson et al 2010), and that an integrative approach that bridges multiple scales and tenures is necessary (e.g. Borgström et al 2006; Ernstson et al 2010).

Architect Peter Gisolfi has proposed a spectrum of ecosystem reclamation project categories, ranging from "modest-scale landscape reclamation" to "reclamation of an entire ecosystem" (Gisolfi 2011, 24). He suggests that given the significant barriers to being able to reclaim entire ecosystems, that a "system-wide intervention is more realistic" in which the "overall objective is to apply landscape reclamation techniques to individual components of the compromised natural system, and thus create a more self-sustaining environment." (Gisolfi 2011, 24).

Scale mismatches – between management or political frameworks on one hand, and ecological patterns and processes on the other – are particularly pronounced in urban landscapes (Borgström et al 2006; Ernstson et al 2010). Researchers have found that cross-scale interactions are often neglected by planners, and that priority is generally not given to spatial and temporal meso-scales (Borgström et al 2006). In response, some have proposed the linking of government agencies and civil society, possibly through social networks, as a strategy to overcome these mismatches: "A specific type of brokerage position is needed in adaptive governance that bridges across ecological scales… a social network position that links otherwise disconnected social actor groups" (Ernstson et al 2010, 5).

The oversimplification of urban land classification (residential, industrial, commercial, and green spaces) shapes the perception of urban lands and "creates an unfortunate divide between urban areas for biodiversity conservation and areas used for other purposes"(Colding et al 2006, 240), when in fact landscape complementation functions should be considered so that ecological functions are built into lands assigned primarily for other purposes (Colding et al 2006). Missing connections between various actors exacerbates the challenges by limiting a common understanding of urban ecosystem complexity and dynamics (Borgström et al 2006), and therefore results in potentially less effective restoration efforts.

The three-part process proposed herein attempts to address the key process challenges identified in the literature: scale-mismatches, the need for communication between participants at all scales, the heterogeneity of land use, multiple tenure holders, and the need for both bottom-up and top-down approaches.

A key principle of ecosystem-based conservation planning is that planning and activities must take place at multiple spatial scales. This is because "landscapes, both large and small, consist of interdependent, interconnected clusters of ecosystems" and "multiple spatial scale networks of ecological reserves are needed to maintain ecological integrity" (Hammond 2009, 41). Understanding character, and embracing it as a guide, at multiple spatial and temporal scales allows for effective ecosystem restoration at multiple spatial and temporal scales across the urban landscape. Doing so necessitates as much information as possible about the composition, structure, and function of natural ecosystems. As Hammond explains, "composition" refers to "the parts of the ecosystem, e.g. the types and numbers of species that occur in the ecosystem;" "structure" refers to "how the parts of an ecosystem are arranged, e.g. the patterns of vegetation types across a landscape;" and "function" refers to "the processes that occur within an ecosystem and between ecosystems that depend upon their parts and how they are arranged, e.g. their composition and structure" (Hammond 2009, 34).

Landscape ecology uses the concepts of "patch," "corridor," and "matrix" to categorize every point in a landscape (Forman 1995, 135), and recognizes the aggregate of all these landscape elements as the landscape mosaic. Patches and corridors vary by size and shape, and the matrix varies from "extensive to limited, continuous to perforated, and aggregated to dispersed" (Forman 1995, 135). These terms have analogous ones in other disciplines (e.g. the urban planning term "district" is analogous to the landscape ecology term "patch"; and "node" is used similarly by both disciplines), thus facilitating their understanding across professions.

Ecosystem-based conservation planning – which builds on the science of landscape ecology, recognizes the significance of biodiversity, and is rooted in Indigenous knowledge and management systems (Hammond 2009) – is appropriate for application to urban areas (Hammond 2009). The principles of landscape ecology have also been shown to be applicable to cities (Breuste et al 2008; Wu 2010). Waldheim (2006) argues for an approach to urbanism that is a "disciplinary realignment in which landscape supplants architecture's historical role as the basic building block of urban design" (Waldheim 2006 ,37). Scientific literature suggests that "the theory of island biogeography could be an appropriate framework for urban ecological research as a first exploration of the relationship between species richness and characteristics of urban habitat patches" and "metapopulation theory appears to provide another promising framework for urban ecological studies" (Breuste et al 2008, 1139-1140).

Harvard's Richard Forman makes the case for linking urban planning with conservation planning, and argues that "the urban region is the unit and the scale where existing landscape ecology/urban planning principles apply especially effectively" (Forman 2008, 253). He elaborates thus:

> "Internal structure, function, and change, or pattern/process/dynamics, are also conspicuous. Structure is easily understood as the arrangement of patches, corridors and matrix that differ in size, shape and type. Diverse greenspaces and built areas, perhaps of equal overall importance, are the basic types present. Patches may be entire residential, market-gardening and wooded landscapes, and corridors are often created by rivers, railways and highways." (Forman 2008, 252)

Character: The Compass Bearing

Inviting nature home to our cities is a process of ecological restoration in the context of a human-dominated landscape. It starts with an understanding of the ecosystems that existed in a particular place prior to urbanization, and uses this understanding as a guide for restoration. Cities are not built on an empty landscape, but are the modification of a particular place – a place with a unique combination of biotic communities, landforms, climate, and indigenous cultures. Urban designer and landscape architect Christina von Borcke points out that urban development is:

> "...built on land and landform that is unique to its location, with its own natural landscape and its intrinsic sense of place. Recognizing this simple fact brings a completely different approach to the roles of landscape in the city… [It] suggests that the city is added to the natural setting and responds to it rather than the other way around… Shouldn't a city grow from its setting rather than be imposed on it?" (von Borcke 2003, 33)

The recognition of natural ecosystems being the appropriate guide for restoration and conservation efforts is well established in landscape ecology and in the practice of ecosystem-based conservation planning. Herb Hammond – forester, ecologist, and pioneer of ecosystem-based conservation planning – explains that the term "character" is used to describe the natural ecosystem prior to development:

> ""Character" refers to the *natural* composition, structure, and function of the ecosystem included within a planning area at a particular scale, while "condition" refers to how the natural ecological composition, structure, and function have been *modified* or impacted as a result of human activities…" (Hammond 2009, 34)

The starting place for ecosystem-based restoration in cities is the character of the ecosystem that existed where the city is, before the city existed. Contrasting this character with the existing condition provides a direction or vision for restoration, and each community is then able to decide how far it wants to go toward the restoration of full ecological integrity (Hammond 2011). Understanding character also teaches people what has been lost (Hammond 2011), and provides enormous value for educating citizens about the place where they live.

Understanding the natural character of the location where a city now stands provides a wealth of information about the restoration activities that are appropriate and most likely to be effective, offers a compelling sense of place, and establishes an unwavering benchmark against which current "condition" can be compared. While many urban areas share common features such as trees, gardens, parks, and lawns, and each city is unique in its environmental and historical context (Hahs et al, 2009), and recognizing this context is essential for inviting nature home in a meaningful way. As Timothy Beatley writes, a city's "forgotten ecology" is a good guide to what a biophilic city will look like (2011, 42).

MacDougal *et al* (2004) recognize that historical data provides "restoration insights unobtainable from current biological studies emphasizing the end point of long-term ecological change" and consequently argue that restoration activity must "target the ecosystems' former structural diversity and the ecological and cultural processes that maintained it" (MacDougal et al 2004, 455). Beer (2010) argues that before one even begins planning for greenspace and green infrastructure, it is necessary to understand the "pre-urban landscape." Michael Rosenzweig, the conceiver of "reconciliation ecology," holds that "to design effective new habitats, we must carefully study the old ones to find out what makes [them] so suitable" (2003, 7). In the context of using a similar approach for aquatic ecosystem restoration (dubbed "the Back to the Future" method), it has been pointed out that: "This is a fundamentally different process from the conventional use of sustainability as a policy goal, which, at worst, may serve only to sustain the present misery," and also that it "counters the tendency to use as a baseline the state of things as they were at the start of our careers" (Sumaila et al 2000, 2).

Ecosystem condition describes the magnitude of damage that urban areas have inflicted on pre-existing ecosystems. In the case of metropolitan Vancouver:

> "The area of coniferous forest changed from 71% prior to 1827 to 50% in 1930 to 54% in 1990. However, prior to 1827, only 27% of the forest would have been immature (<120 years old), while

> 40% would have been immature in 1930 and 73% of the forest was immature in 1990. The amount of wetland area decreased from 10% to 1% of the study area while urban and agricultural area increased to 26% of the study area by 1990. The changes in land cover have had adverse effects on soil, water, and air quality; aquatic life; and plant and animal populations. Estimates of changes in net primary production and organic soil carbon suggest a decline over the past 170 years, although the latter rate of decrease has slowed since 1930. As human populations in the Lower Fraser Basin continue to increase, the quality of air, water, and soil will continue to decline unless measures are taken." (Boyle et al 1997, 185)

> "The great majority of pre-settlement streams in the Vancouver area have been buried or culverted, and many are effectively lost… Most of the remaining streams in the Lower Fraser Valley have been altered in one or more ways, including channelization, diversion, removal or alteration of riparian vegetation, and by pollution." (Fisheries and Oceans Canada 1997)

Condition "identifies areas in need of restoration, [and] identifies the type and extent of restoration that is needed." (Hammond 2009, 37). Condition describes the existing and highly-fragmented ecoscape across the human-dominated matrix. The existing ecoscape, while likely lacking integrity and connectivity, may provide "anchors" in the form of large parks, greenways, and species at risk habitat (Hammond 2011). This information is important to guide restoration efforts aimed at providing multi-scale connectivity across the matrix, and connecting patch and corridor anchors.

Together, an understanding of character and condition informs restoration activities, and character provides the direction. However, the effort required to accurately and completely describe character and condition is clearly beyond the capacity of individual urban citizens, and must fall to governments and institutions. Dr. Nancy Olewiler of Simon Fraser University argues that governments have a role to play in providing "essential data on the physical quantities and attributes of natural capital and their changes over time" (Olewiler 2004, i). This information must be made accessible and easily understandable by lay people so that volunteer action can be effectively guided. "It is not enough that scientific information is known. It must be also available for all stakeholders and actors. This means that it must be easy to understand, and usually comprehensive" (Nilsson and Florgård 2009, 556).

The information made available about ecosystem character should be fine-grained enough to help individual land-owners determine the appropriate restoration efforts for their specific location, and have an informed conversation with their neighbours about doing the same. It should describe the composition, structure, and function of ecosystems in ways that will help volunteer efforts to contribute to restoring some pieces of ecological integrity, or at least create conditions for that to happen. Ideally the information about character should be presented in a compelling way that builds excitement, fosters wonder, and strengthens a sense of place.

It has been pointed out that restoration is not simply landscaping (Riley 2004), and character descriptions should help people approach restoration work from an ecological perspective. Guidance should be clear about appropriate vegetation for planting, and which invasive plant species to avoid or remove (e.g. those that provide minimal ecosystem services, and that aggressively compete with species that do, such as the English Ivey that has colonized 30 per cent of Vancouver's Stanley Park)(Clark 2010).

A description of character is not just a description of the past – it is also a description of what is possible. It is a vision for a healthy ecoscape, for a city deeply rooted in its ecological place, and for a restorative urban existence. Knowing the character of one's home is like knowing one's self. It reveals the direction necessary for healing, it resists the generic in favour of the appropriate, and it fosters the pride and confidence that allows real transformation. Character provides a description of what Timothy Beatley calls a biophilic city:

> "Biophilic cities cherish what already exists… but also work hard to restore and repair what has been lost or degraded and to integrate new forms of nature into the design of every new structure or built project" (Beatley 2011, 45)

Individual to Neighbourhood Scale: Ecosystem-Based Voluntary Action

Understanding the natural ecosystem character of a city informs two subsequent iterative steps: ecosystem-based volunteer action (EBVA) at small scales, and ecosystem-based restoration planning (EBRP) at larger scales. EBVA builds support for larger-scale EBRP, which in turn inspires further voluntary individual actions. Together these two, iterative steps create a healthy urban ecoscape based on the city's natural ecosystem character. Voluntary actions are taken by individual property owners at the site scale, and through voluntary collaboration between multiple property owners at the block or neighbourhood scale. As collaborations take place, momentum is built to support continuation at larger scales to provide connectivity to "anchor" features in the ecoscape such as large parks and corridors.

The processes must be "cyclical and iterative" (Tomalty et al 1994, xi), and must operate at multiple scales in order to overcome the challenges presented by the large number of small land-holdings across the urban landscape:

> "…it is the concerted efforts at various scales that produce the best results. It is essential that home-owners realise that their own local actions can contribute to the larger collective effort that would culminate in the creation of a real biological corridor that facilitates the movements of several species throughout the city." (Savard et al 2000)

EBVA is entirely voluntary and does not depend on a top-down planning process, but could be supported by incentives to provide restoration in line with natural ecosystem character. The municipality could offer small grants, such as Vancouver's Greenest City Neighbourhood Small Grants program which offers up to $1,000 per person for individual initiatives. Support could also take the form of property tax grants, development incentives (such as set-back leniencies, density bonuses, permit fee reductions, or permit fast-tracking), or amenities (such as the installation of vegetated traffic-calming devices). Transfers of development rights and density bonuses should also be considered (Searns 1995).

Tools need to be available for all types of land use including residential, commercial, and industrial, and to support various scales of initiatives from site to neighbourhood. Land parcels located on sites whose natural ecosystem character is of significant ecological value – such as an estuary, coastline, riparian zone, or wetland – may be provided with additional restoration incentives. Zones with an under-representation in the ecoscape, such as the downtown core or industrial land, may also be given additional incentives. As the ecoscape is slowly restored, the incentives may be shifted to encourage different types of individual action, or support action in different locations or zonations. As restoration takes place, tools should be in place to lock in the restoration as much as possible, such as covenants, zoning changes, or land transfers to a public land trust or non-profit owner.

Initiatives from a number of closely-located individuals need to be provided with options for leveraging their individual initiatives into greater connectivity at the block or neighbourhood scale. For example, if a sufficient number of home-owners on a block have pursued restoration on their own properties, they may be given the opportunity to transform the commonly-abutted laneway from a vehicle zone into an ecoscape patch that could include appropriate natural ecosystem vegetation, a section of daylighted stream, a community garden or laneway orchard, a bike and pedestrian path, or other ecoscape elements guided by natural character.

Researchers recognize that private yards and gardens are a major components of the ecoscape and have the potential to provide considerable biodiversity benefits (Rudd et al 2002; Rosenzweig 2003; Goddard et al 2010), but that there is a "scale-dependent tension" because each individual yard or garden is too small to retain viable populations of any given species. Suggestions to overcome this have included the creation of "habitat zones" so that private land-owners are encouraged to plan their specific landscape in accordance with defined characteristics and thereby create "wildlife friendly" management across collections of yards and gardens (Goddard et al 2010). Other approaches suggest public education related to natural character vegetation:

> "A very important component of network planning is the consideration of private and unprotected areas. Backyard habitat can be an invaluable food and habitat source for a wide range of urban species and is essential in developing the matrix that supports the large numbers of corridors required for connectivity. Public education on gardening with native plants and providing proper

> habitat is another tool to enhance the connectivity of the region and improve the viability of the corridors" (Rudd et al 2002, 374).

The approach of "reconciliation ecology" is "the science of inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, or play" (Rosenzweig 2003, 7). It proposes species-specific restoration efforts in urban areas that provide "the rich and subtle variety of habitats that allow so many species to flourish" (Rosenzweig 2003, 21). Recognizing that "[n]o single land parcel may be large enough to contain a self-sustaining population," this approach encourages "neighbours to join together to select a species and protect it" (Rosenzweig 2003, 8) and recognizes that to be successful, a collaborative effort among many landowners is necessary.

Karvonen and Yokom (2011) propose "civic environmentalism" which they describe as:

> "an alternative to conventional forms of environmental management, with an emphasis on inclusive democratic deliberation aimed at concrete action. Civic environmentalism emphasizes the complex hybrid relations between urban residents and their material surroundings, champions the local scale as the most promising venue for reworking these relations, and provides a model for deliberative and action-oriented forms of political engagement" (Karvonen and Yokom 2011, 1307)

Civic environmentalism "engages citizens at the local level but replaces protest with deliberation and action aimed at creating and maintaining more desirable conditions" (Karvonen and Yocom 2011, 1308), and is rooted in a "responsibility stemming from their embeddedness in place" (Karvonen and Yocom 2011, 1310). The state plays a "background role as supporter and facilitator, providing expertise, funding, and organizational assistance" (Karvonen and Yocom 2011, 1311). As such, these engaged citizens are supported and equipped to initiate EBVAs.

Engaging people in "citizen science" also has the potential to encourage participation, and can be directly tied to knowledge of natural ecosystem character. It should be supported by public outreach, training, education and a scientific data collection methodology so that individual residents can be involved. This approach has the potential to collect a large body of data, and is flexible enough to be applied at various temporal and spatial scales (Cooper *et al* 2007). Collecting data, and monitoring ecosystem health, also helps individuals to remain engaged in the restoration process even after they have done some initial restoration work and helped to build momentum beyond the specific place where they live or work. A "BioBlitz," which is a 24-hour intensive search for all forms of biodiversity in a defined area (Beatley 2011, 31), can occur on a regular basis and be used to help monitor and document ecoscape changes and improvements.

Voluntary action can also be initiated by local community groups or informal, interest-based "clusters" of people such as gardening clubs, neighbourhood associations, school groups, or business-improvement associations:

> "Such organizational clusters pool resources and experience and facilitate the dissemination of information and knowledge among participants and local organizations. They also constitute important arenas to exchange ideas, common projects, expertise, and knowledge and may entail workshops and events to involve and educate participants." (Colding et al 2006, 242)

Chapin et all offers a recommendation to develop the necessary sense of place at the outset of a process such as ecosystem-based voluntary action at a neighbourhood scale: "Identify broadly shared dimensions of sense of place with potential to motivate stewardship, and strengthen these through shared experiences, stories, or education that strengthens and shares personal and cultural attachment to place" (Chapin et al 2012, 16).

All of these approaches help to restore community at the same time that ecosystems are restored. As McGill's Ray Tomalty *et* al (1994) points out, a sense of community and commitment to place can be fostered through urban ecosystem restoration and "collaborative efforts will be easier when people have retained or developed a sense of community, and a commitment to a place" (Tomalty et al 1994, x). People's direct involvement in building a healthy ecoscape will also make it easier for them to accept changes at a larger neighbourhood and city-wide scale (Tomalty et al 1994, xi) as momentum builds.

Studies of experiences with voluntary civil society involvement with ecosystem restoration in Cape Town, New Orleans, and Phoenix, illustrate that community involvement in environmental stewardship encourages the social innovation necessary for ecosystem protection, and that "…urban governance need to harness social networks of urban innovation to sustain ecosystem services" (Erntson *et al* 2010, 531). Research from Stockholm suggests that management by a diversity of local actor groups "seems to sustain rich levels of alpha biodiversity and desired ecosystem services" (Barthel 2006, 315).

Involving citizen participation has been successful in Porto Alegre, Brazil where projects include citizen participation in the environmental management system, and allowing partner institutions to "adopt" green areas (Menegat 2002). Chicago's Save Our Urban Lands (SOUL) project engaged at-risk youth to GIS map the ecological resources of neighbourhoods. Their data was combined with other data sets to create a plan of action for each neighbourhood that includes actions such as community gardens, aquaculture, and tree planting (Lyons 1997, 82). A block-scale volunteer initiative in the UK, dubbed "Full Frontal" by the woman who pioneered it, successfully encouraged home-owners to green the fronts of their row-houses by instilling a sense of fun and community pride into the effort (Alder 2011). San Francisco's Nature in the City is a non-profit organization that supports individual-scale ecosystem restoration of the city's biodiversity and habitats (Beatley 2011, 30), and experience from stream restoration efforts in BC's Lower Mainland have shown that the most effective restoration efforts are those that take an inclusive approach based on collaboration led by citizens and community groups (Rosenau and Angelo 2001).

The community momentum built from small-scale EBVA prepares the community for an ecosystem-based restoration planning exercise at the neighbourhood to regional scale. Volunteer local initiatives start a process that is then handed-off to an EBCP, which in turn inspires further small-scale volunteer action. This cyclical and iterative dynamic between EBVA and EBCP continues to ratchet-up (green-up) what is possible as the overall urban escoscape health begins to improve.

Neighbourhood to Region Scale: Ecosystem-Based Restoration Planning

Ecosystem-based restoration planning (EBRP) in urban areas picks up where individual volunteer action leaves off, but inspires further individual action in a cyclical and iterative process. EBRP is the process of ecosystem-based conservation planning, as pioneered by Herb Hammond, but applied to urban areas with the understanding that the goal is restoration. The objective is to restore some level of ecological integrity by connecting the restoration work carried out through EBVA at the site, block, and neighbourhood scales, to existing and new larger-scale patches and corridors in the urban ecoscape.

The context for ecosystem-based restoration planning is the human-dominated urban landscape, including the assumption that such landscapes will remain human-dominated. As Herb Hammond (2011) points out, it is essential to recognize that in urban areas, humans will be the dominant organism, making the application of ecosystem-based conservation planning different than in relatively unmodified landscapes. As Snep *et al* (2009) argues: "Urban ecosystems can only be meaningfully understood if we see urban ecology in the context of the urban landscape, one that is designed, constructed and used by humans" (Snep et al 2009, 460).

The first principle of ecosystem-based conservation planning is to "focus on what to protect, then on what to use" (Hammond 2009, 23). Applying this to urban areas includes halting the degradation of whatever components of natural ecosystems remain, and protecting the existing network of ecoscape patches and corridors. "Anchors" are large-scale ecoscape patches and corridors such as parks, greenways, greenbelts, nature reserves, protected watersheds, and golf courses. While frequently in need of restoration, these "anchors" provide the largest city-wide and regional habitat areas to which small-scale restoration efforts are to be connected. As a first step in EBRP, these anchors need to be protected from any further degradation.

Ecosystem-based conservation planning "recognizes the hierarchical relationship between ecosystems, cultures, and economies" (Hammond 2009, 23), and ergo the need for EBRP to prioritize the ecological integrity of ecoscape "anchors." In some cases, such as watersheds surrounding drinking water reservoirs, or highly-productive ecosystems such as estuaries, very little if any human activity should be permitted. In other cases, human activity should be limited to specific trails, and in some cases limited human activity can co-exist along with ecosystem restoration in the anchor. Researchers have tracked the evolution of how the priorities for greenspace objectives have developed in planning theory over time, from "axes, boulevards, and parkways" prior to the 1960s, to "trail-oriented greenways" through the mid-1980s, to "multi-objective" spaces that have increasingly embraced objectives that include "habitat protection, flood hazard reduction, water quality, historic preservation, education, interpretation, and other purposes" (Searns 1995). Research has found that an urban design approach to greenways that attempts to impose landscape form and land use function is "no longer viable ecologically, socially, or politically" and that such an approach is being replaced with a trend toward "using natural systems as a primary determinate for greenway form" (Taylor et al 1995), and recognition that "biodiversity is a most important greenway goal" (Ahern 1995, 152). EBRP further pushes this evolution of priorities for ecoscape anchors to greater reflect the fact that:

> "Economies are part of human cultures, and human cultures are part of ecosystems. Therefore, protecting ecosystem functioning provides for healthy human cultures, and the economies that are part of these cultures" (Hammond 2009, 24).

In addition to halting the degradation of existing ecoscape patches and corridors, EBRP attempts to increase the number of new anchors if possible, and additional patches at all scales. Building on the momentum of individual voluntary actions at smaller scales, EBRP attempts to provide new patches and corridors by repurposing land or increasing the ecological functioning of multi-purpose land uses. For example, significant voluntary action at the block and neighbourhood level may lead to enough support for restoring an alley or section of a street into a component of the ecoscape, the daylighting of a neighbourhood stream, or the replacement of parking amenities with habitat features. The Cities Plus Project called for a "hierarchy of green spaces," including those at the block scale, that recognizes the importance of multi-scale patches in connecting "blue ribbons and green webs" (Cities Plus Project 2003, 29-30). A 2007 collaborative effort involving regional, provincial, and federal governments, as well as a multi-stakeholder panel from the non-profit and private sectors, proposed a framework for conserving biodiversity in Metro Vancouver through the achievement of three goals – "protect a regionally connected network of habitats for biodiversity; enhance and restore the quality of habitats across the region; and protect and recover plant and animal species and populations" – at multiple spatial scales (Biodiversity Conservation Strategy for the Greater Vancouver Region 2007).

A key principle of ecosystem-based conservation planning is to "protect, maintain and, where necessary, restore ecological connectivity and the full range of composition, structure, and function of enduring features, natural plant communities, and animal habitats and ranges" (Hammond 2009, 27). As Hammond explains, this principle "is implemented by establishing nested, interconnected networks of ecological reserves at multiple spatial scales" and the incorporation of "ecological time frames" rather than human time frames (Hammond 2009, 27). Noss (1993) similarly emphasizes the importance of multiple spatial and temporal scales. Savard *et al* (2000) proposes multiple management scales in order to protect and enhance biodiversity over multiple spatial and temporal scales, and provides specific actions for each scale: individual lots (select appropriate vegetation, avoid pesticides and herbicides, restrain pets); city departments (design/establish vegetation; restore vegetation; night blackout of tall buildings); municipal governments (establish vegetated corridors; extend protected areas; design parks; increase volume and diversity of vegetation); and regional governments (zone/identify protected areas; establish greenbelt).

When applying the nested, multiple-scale approach to cities, Hammond (2011) suggests that various levels of restoration should be assigned to different parts of the city, from complete restoration to partial restoration. Decisions about how much restoration to pursue will come out of the individual voluntary actions at small scales, and the EBRP that flows out of these voluntary actions. In other words, people will come together at various scales – from backyards, to blocks, to neighbourhoods – to determine how much restoration is appropriate, and where. In large patch and corridor anchors across the ecoscape, restoration of natural ecosystem composition, structure, and function should be the top priority in most cases.

Many other researchers also recognize the need to provide patches, corridors, and connectivity at multiple scales across the urban landscape (e.g. Savard et al 2000; Borgström et al 2006; Ernstson et al 2010). In spite of significant support for this approach, research has also shown that urban planners have most difficult applying the ecosystem-based principles related to scale and ecological integrity (Shandas et al 2008). The EBRP approach builds on the bottom-up momentum of individual voluntary action to maximize ecological integrity across multiple spatial and temporal scales. Instead of creating habitat patches or corridors in isolation, the EBRP approach builds on what happens at very small scales, and complements it with patches and corridors at the neighbourhood to regional scale. This approach is led by community momentum in order to facilitate the process of establishing ecoscape components at larger scales, and assisting urban planners in supporting innovative approaches.

At the interface of successful individual voluntary initiatives and EBRP, is the need for walkable communities. Making a community walkable encourages walking, which in turn fosters a connection to greenspace. It's been noted that "walking encourages people to take ownership of their outdoor space," (Buck and Ferrai 2011, 22) and this sense of ownership builds momentum for further voluntary action. EBRP recognizes that people's need for regular contact with nature must fit with their daily living patterns, and that patches should be less than a ten-minute walk from their home (Johnston 1990). Hellmund and Smith (2006) suggested that connecting greenways from deep in the city out to unmodified landscapes is important so that people do not have to drive to nature. Some European cities have accomplished this by emphasizing density along transit networks and thus allowing greenspaces to come into the centre of cities. For example, Copenhagen has a green "fingers" plan, and Helsinki has created green "wedges" (Beatley 2011, 87).

The network of ecoscape patches and corridors must, as much as possible, follow ecological rather than political boundaries. At small scales, this is accomplished through individual voluntary initiatives that connect with other initiatives on the block and in the neighbourhood, guided by an understanding of ecosystem character, and committed to providing ecosystem connectivity across property lines. At large scales, this is accomplished by through inter-jurisdictional co-operation and pursuing an inclusive planning process that brings all perspectives and interests into the conversation. By creating ecoscape patches and corridors that straddle the urban containment boundary it is possible to facilitate the movement of species across political boundaries. McGill's Ray Tomalty (1994) points out the importance of "basing planning units on natural boundaries" rather than political ones, as well as the need to "encourage inter-jurisdictional decision-making."

Inter-jurisdictional co-operation is not limited to co-operation between adjacent municipalities or within a regional government system. It can also mean co-operation between local governments and higher-level provincial, federal, and even international bodies. Strong federal species-at-risk legislation, for example, can provide significant support for the establishment of new habitat patches and corridors within an urban ecoscape. Research into experiences in the Netherlands (Tjallingii 2003) and Brazil (Frischenbruder and Pellegrino 2006) has shown how influential supportive national policies, such as riparian protection laws, can be in creating local green spaces. The national ratification of international agreements, such as the Convention on Biological Diversity, may further provide strength and support for urban ecosystem protection (Borgström et al 2006). If local ecosystem values are great enough, international recognition of them may also help secure greater local protection. For example, in Cape Town, South Africa, urban biosphere reserves became affiliated with the UNESCO World Network of Biosphere Reserves (Stanvliet et al 2004).

The Cape Town biosphere reserves have social inclusion and poverty alleviation objectives, as well as ecosystem restoration objectives, in their strategy. Such multiple objectives are becoming more common, since the late 1990s it has been broadly accepted that "all land classed as greenspace in and around a city is multifunctional" (Beer 2010, 434). Multi-functionality may help build the consensus necessary for new ecoscape patches and corridors. For example, including green infrastructure objectives related to stormwater management or water filtration may help attract the necessary funding, and the provision of bike or rapid transit corridors may help ease the transformation of roads or alleys to green space. In other cases, it may not be possible to immediately transform land into ecoscape components that have ecosystem restoration as the top priority, but it may be possible to provide some ecoscape elements along with less damaging human activities. For example, Quayle and van der Lieck (1997) conceptualized a greenway as a hybrid landscape that has as it's backbone "a pedestrian broadway through the neighbourhood, linking the locales of everyday needs" that could take "a position central in location and in the life of the community like the village or town square used to do" (1997, 104). Their approach seeks to create multi-use, hybrid urban landscapes based on the gradual transfer of responsibility and authority to the neighbourhood level. Such landscapes could include significant ecoscape components, even though human uses continue to dominate.

"Ecological land-use complementation theory" attempts to work within the reality that multiple objectives exist for greenspaces, and is built on the understanding that "land uses in urban green areas could synergistically interact to support biodiversity when clustered together in different combinations" (Colding 2007, 46). Such an approach could provide for increased habitat availability for species, promote landscape complementation/supplementation functions, and support emergent ecological functions (Colding 2007). By working within multi-use ecoscape patches and corridors, it may be possible to arrange multiple uses so that ecosystem restoration and functioning is maximized. Since the clustering of green spaces entails the involvement of many different land managers, such an approach may also support collaboration and multi-stakeholder participatory management (Colding 2007).

Ecosystem-based conservation planning includes applying "the precautionary principle to all plans and activities" (Hammond 2009, 23). In the context of urban areas, there is never any ecological justification for abandoning the precautionary principle or otherwise concluding that enough restoration has been achieved. So long as the urban landscape is human-dominated, there will always be an ecological rationale for further restoration. Given that urban areas are often located where unique and highly-productive ecosystems once existed, there is additional need for embracing the precautionary principle in an attempt to restore valuable and threatened ecosystems. Uncertainty demands the precautionary principle, and since our understanding of natural ecosystem character may be incomplete, significant uncertainty exists regarding when the full range of composition, structure, and functions have been restored at any given spatial or temporal scale, and therefore there is a continual need to err on the side of caution and continue to strive for additional restoration.

Change in natural systems can occur in abrupt and discontinuous ways, so it's important to consider thresholds in the relationship between urban patterns and ecological processes (Albertini 1999), which is another reason why the precautionary principle needs to be embraced. Observers in an urban environment often have trouble reading ecosystem signals of distress, and "…ecosystems themselves often "fail to signal" the long-term consequences of loss of resilience, continuing to function in the short term even as resilience declines" (Folke et al 1996, 1020). This lack of feedback from ecosystems is another reason why it is necessary to take a precautionary approach to urban ecosystem restoration.

Ecosystem-based conservation planning recognizes the need to practice adaptive management (Hammond 2009), a process that includes both "active" adaptive management that "includes deliberate, carefully designed management experiments that have scientific rigour, including replicated treatments, data collection, and sound statistical analysis" (Hammond 2009, 31), and "passive" adaptive management that "involves careful monitoring of the effects and outcomes of activities, and a subsequent comparison of these effects and outcomes to pre-activity predictions and conditions" (Hammond 2009, 31). Both of these approaches to adaptive management are applicable to EBRP in urban areas, although passive adaptive management is more appropriate for smaller-scale individual voluntary action, and active adaptive management should be the responsibility of local governments and institutions across all scales.

Researchers have pointed out that adaptive management needs to be properly integrated, and that:

> "…the process is continuous and cyclic; components of the adaptive management model evolve as information is gained and social and ecological systems change. Unless management is flexible and innovative, outcomes become less sustainable and less accepted by stakeholders. Management will be successful in the face of complexity and uncertainty only with holistic approaches, good science, and critical evaluation of each step. Adaptive management is where it all comes together" (Haney and Power 1996, 885).

Citizen science approaches can help with adaptive management by collecting data for compilation at multiple scales, and the adaptive management process can help maintain momentum for the continual improvement of ecoscape health. Many urban planners, such as McGill's Ray Tomalty et al (2004), echo this approach and support the need to "initiate long-term monitoring, feedback and adaptation of plans."

Demanding Less of Nature

> "Growing more efficiently does not address the problem. It merely makes us more efficiently unsustainable. Corollary: If your 'solution' does not result in an absolute reduction in energy and material consumption and waste production, then it is part of the problem."
> — William Rees (2009)

The three-part process outlined herein to restore healthy urban ecoscapes will result in more ecosystem services being provided. It is essential that we do not respond to these gains by simply increasing our demand for ecosystem services. Instead, these additional ecosystem services must be protected as a net increase in services that are then available to address the many ecological challenges we already face.

The Khazzoom-Brookes postulate, or the "rebound effect," predicts that the gains from making equipment more energy efficient may be overwhelmed by the increased use of the same equipment as the energy-efficient technology is embraced. For example, an energy-efficient car may be driven faster or more frequently than a gas-guzzling car, resulting in no energy or pollution benefits. In the words of J. Daniel Khazzoom, "increasing the fuel economy of new vehicles leaves the emission rate of the regulated pollutants unchanged" (Khazzoom 1995, 190).

This dynamic is essential to remember as we restore a healthy urban ecoscape that will provide more ecosystem services – cleaning air and water, supporting pollination, storing and sequestering carbon, etc. – than a fragmented and unhealthy urban ecoscape. These ecosystem services need to be available to address our many existing environmental challenges, and not be squandered by enlarging the ecological footprint of our cities in response to our success in inviting nature home. As we improve the health of our urban ecoscapes, we need to secure these gains by simultaneously increasing urban density, reducing automobile and fossil-fuel use, and generally asking less of nature.

According the World Wildlife Fund, in 1978 we crossed the threshold at which overall human demands for ecosystem services are greater than what the biosphere is able to provide over the long term, and our current demands are 50 per cent higher than this threshold while still rising. Providing more stocks of natural capital in the form of a healthy urban ecoscape contributes to the need for more ecosystem services, but is only half of the equation. We need to simultaneously reduce our demands on the very nature we are restoring. As University of Waterloo Professor Robert Gibson suggests, we need to ask whether a particular strategy is "helping us move closer to a desirable and resilient future, or is it just *slowing* our descent into ever deepening unsustainability" (Gibson, 2011, 38).

Unfortunately many urban strategies aimed at sustainability assume that we can continue to pursue our unlimited material desires, so long as we do so in a "green" fashion. New Urbanist pioneer Andrés Duany, for example, asserts that an approach to urban sustainability should avoid "the imposition of austerities and inconveniences" because "Americans will not voluntarily tolerate suffering" (Duany 2008, 9). What qualifies as "suffering" is relative to one's expectations, but should by no reasonable standard include forgoing sprawling greenfield development, reducing fossil fuel consumption, or taking responsibility for our own ecological debt.

As citizens of the Western world pondering the changes we are called to make close to home, we are reminded by columnist George Monbiot that "it is not the needs of the poor that threaten the biosphere, but the demands of the rich" (Monbiot 2012). Reducing our demands on nature within the carrying capacity of our planet is not "suffering" – it is a reasonable response to a very real threat, and it can be achieved in ways that make our lives more rewarding and fulfilling, not austere or inconvenient.

In an urban context, this means pursuing strategies that reduce our aggregate demand or ecosystem services, most importantly by increasing density while we restore a healthy ecoscape. Multiple studies have shown that there is a strong connection between urban form/density and greenhouse gas emissions (Campbell and Teed 2010, 18). The University of British Columbia's Urban Design Lab reports that current research on this relationship indicates that "[h]igher densities provide a foundation for urban form characteristics that together reduce a community's GHG emissions" (Senbel et al 2010, 6).

In addition to pursuing density, urban activities should seek other ways to reduce the stress they place on local, regional, and global ecosystems. The importance of this approach is obvious in local ecosystem restoration projects that are frequently less successful than participants hope because the ecosystem stressors continue unabated. Researchers have pointed out, for example, that stream restoration efforts should include "…controls on fertilizers and toxicants, septic and sewer management policies, dam management policies, water use regulations, and road and utility crossing regulations" (Roy et al 2010, 347), and not just the riparian and in-stream restoration activities. As one stream restoration researcher explains:

> "The first and most critical step in ecological restoration is passive restoration, the cessation of those anthropogenic activities that are causing degradation or preventing recovery… Unfortunately, structural additions and active manipulations are frequently undertaken without halting degrading land use activities or allowing sufficient time for natural recovery to occur. These scenarios represent a misinterpretation of ecosystem needs, can exacerbate the degree of degradation, and can cause further difficulties in restoration" (Kauffman et al 1997, 12)

Many green building innovations help reduce our demand for ecosystem services. For example, green roofs reduce carbon emissions by lowering the demand for running HVAC equipment, and sequester carbon through the photosynthetic activity of the plants (Rowe and Getter 2010). Rain barrels and rooftop collection systems, grey-water on-site recycling, and low-flow fixtures all reduce the demand for potable water that is provided off-site. On-site sewage treatment makes effluent available for on-site uses, such as irrigation and toilet flushing, and avoids the nutrient-rich discharges associated with centralized systems (Margolis and Robinson 2007, 112). Building and landscape strategies to reduce light pollution helps birds and nocturnal wildlife to survive in the urban environment.

Bringing nature into our cities also helps reduce demand my offering urban dwellers local experiences with nature without requiring automobile use for access. By connecting greenbelts and other large patches of the ecoscape, they can be transformed from greenbelts into a "green cloak" that offers more than defence against development pressure (Gibson 2011) – it provides direct contact with the very nature that our sustainability efforts are trying to restore. The resulting fabric of an urban ecoscape can be used to support local activities and food production, and can strengthen a local community economy as an alternative to increased energy-dependent consumption (Hellmund and Smith 2006). As Professor Gibson envisions: "We can begin to treat greenbelts and associated urban areas as places where every one of our decisions aims to reverse the prevailing trends towards deeper unsustainability" (Gibson 2011, 40).

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