GREENING WHERE PEOPLE GATHER

Conserving biodiversity and creating habitat in the Cambie Corridor

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November, 2010

Greening Where People Gather:

Conserving biodiversity and creating habitat

in the Cambie Corridor

by

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A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS (PLANNING)

in

THE FACULTY OF GRADUATE STUDIES

School of Community and Regional
Planning

We accept this project as conforming
to the required standard

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THE UNIVERSITY OF BRITISH COLUMBIA
NOVEMBER 2010

TABLE OF CONTENTS

PHOTO: CREATIVE COMMONS

1.0 ABSTRACT

Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul. ~John Muir

Conditions are not great: streams, rivers, and forests are degraded beyond repair and species extinction rates are higher than ever before. The first priority for improving ecosystem health is to save and restore the intact ecosystems on which we so depend. But no matter how complete and connected these wild places are, they will still feel the impact of human activities and settlements nearby.

Not only are cities usually located in species rich areas such as on flood plains or river estuaries, but in the process of development, nature is culverted, levelled, piped and replaced with skyscrapers, pavement and landscapes with introduced plants.

People in cities are then separated from the natural world, leading to what some researchers suggest, nature deficit disorder, depression, impeded development and a lack of desire to protect the environment in the future, adding to the threat of further decline.

While the normal practice is to separate nature from cities and relegate it to protected areas, there is a growing movement that is suggesting that nature should be integrated into the built environment. With thoughtful planning and design that considers natural systems and local ecology, research shows that cities can support wildlife species, even those endangered and threatened, while purifying the air, water, mitigating heat island effect and providing that much needed opportunity for people to connect to nature.

This project explores how habitats can be integrated into our cities through a literature review, precedent studies, and design principles explored in the Cambie Corridor in Vancouver BC. Perhaps the most important learning from this project is that first, we must always protect and restore remnants of nature in the city, second, enhance and protect existing biodiversity. Third, weave nature into the urban fabric through high quality ecological designs such as greenroofs, stormwater management and food gardens. Finally, to ensure biodiversity success, these protected, restored, enhanced and integrated habitats must be connected to ultimately create an ecological network throughout the city.

2.0 ACKNOWLEDGEMENTS

I would like to express my sincere thanks to the following people who provided support and contributed expertise to this project:

Dr. Maged Senbel, Project supervisor for his contributions, technical advice, support and innovative ideas.

Scott Hein for his eye for design, encouragement and support at the City of Vancouver.

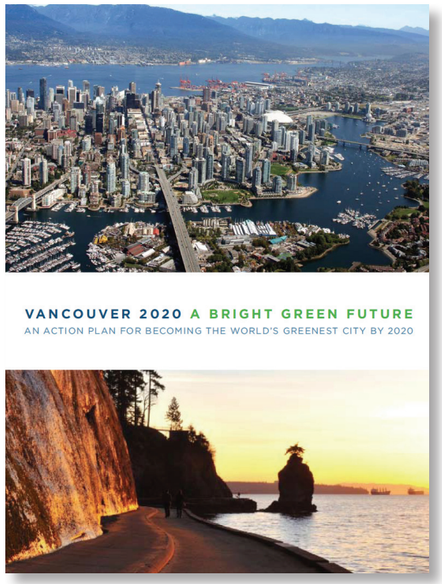
Jim Bailey, Matthew Roddis, and the City of Vancouver's Cambie Corridor team for their technical support and interest in my project. Alan Duncan of the Vancouver Parks Board for sharing his insights into the Vancouver Parks Board role as stewards of the the cities greenspaces.

Bruce Clark from the Department of Fisheries and Oceans, for taking the time to share his valuable knowledge about the Fraser River.

Mark Holland who helped me develop the framework for my project and provided key insights into it's direction going forward.

Finally, I would like to take this opportunity to extend my deep appreciation to Jacqui Thomas for her design expertise and Jane Ritchie for her constant support and second set of eyes.

3.0 PROBLEM STATEMENT



In this time of environmental decline and climate change there is a response among many cities to rise to the challenge of being exemplary in the quest for sustainability. Along with this quest, a number of typical scenarios unfold for good reason: reducing CO_2 emissions, encouraging green-building and green industries and increasing infrastructure for walking, cycling and transit. What seems to be consistently missing from the table is the concept of habitat and biodiversity.

Scientists, health practitioners and decision makers alike are also emphasizing the need to focus on urban ecosystem health and biodiversity as a city's growth and activity not only heavily degrade surrounding ecosystems but also rely on ecosystem services to support the health and functioning of the city (MA, 2005). These ecosystem services go beyond providing clean air, water, food clothing and shelter to also being vitally important for human health and well being.

In 2009, the City of Vancouver BC, joined in this quest, with their Greenest City Initiative (GCI). Outlined in the document "*Vancouver 2020, A bright green future*", were ten goals to help realize this vision. In the whole discussion of becoming the greenest city, the focus is mostly on the larger, global scale impacts of green industry and reducing greenhouse gasses in response to climate change (GCI, 2009).

Although the document emphasizes the importance of bird song and references the peregrine falcon in the opening address, the concept of local ecology is not well developed except for, to some extent, Goal #6 "increase access to nature" (GCI, 2009 pg. 41).

At the same time, it could be argued that successes most celebrated in Vancouver are related to its natural beauty and wildlife. Besides being celebrated for it's natural settings, wildlife in the city are also showcased. Recently, the herring return after building, South East False Creek's Habitat Island was a proud achievement for the development, and the herring rookery in Stanley Park supporting hundreds of nests year after year is protected and coveted by locals. The continued return of these species, proving their resilience in what seems like the toughest time for the planet, can become a yardstick for success for the GCI. Weaving habitat into the urban fabric, especially through urban redevelopment is also an approach that could support local species, enhance ecosystem services and increase access to nature. Vancouver, rich in natural capital, is well positioned to showcase urban nature as the new green.

The Cambie Corridor, as a test site presents a tremendous opportunity to elevate Vancouver to the next level and in so doing, show leadership and successes that are often most measurable and meaningful.

PROJECT GOAL

The goal of this project is to introduce the importance of biodiversity and ecosystem health in the planning process. Through precedents and the design process, I also hope to emphasize the possibilities and interesting design challenges that can come with prioritizing biodiversity and ecosystem health in the urban context.

PROJECT OBJECTIVE

The objective of this research is to realize the above goal using a literature review, precedent studies and design principles.

Literature Review:
The literature review aims to explore previous research addressing ecosystem health, the impact of cities on local ecosystems, and connections between people and nature. Further, it will help develop the habitat integration approach through scientific evidence of best practices and current thinking around ecosystem restoration and protection and urban ecology.

Precedent Studies:
Precedent studies explore case studies, mostly at the site scale, of habitat integration around the world, highlighting particular features that can be applied or considered for local applications.

Design Principles:
Design Principles will be developed using current ecological principles applied to landscape ecology and scientific approaches defining urban wildlife and habitat

4.0 LITERATURE REVIEW

BIODIVERSITY

Defined by the UN, biodiversity "*is the term given to the variety of life on Earth and the natural patterns it forms. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend.*" (U.N., 2010)

Biodiversity includes the plants, animals and microorganisms that inhabit the earth. Approximately 1.75 million species have been identified, however, scientists suggest there could be about 13 million species. Biodiversity also includes the genetic diversity within each species. Biodiversity is found in the wide variety of the earth's ecosystems including wetlands, forests, deserts, lakes, oceans, prairies, savannahs and mountains. Ecosystems support living organisms and together they form a functioning unit interacting with each other, and the surrounding air, water and soil (CBD,2006).

ECOSYSTEMS

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit. In this functioning unit, every organism plays a role (CBD, 2006). The ecosystem can only function for as long as the food, water and shelter can sustain the organisms within it. There is no designated scale for ecosystems as the functioning unit can range from a small pond to the planet itself (UN, 2010).

Examples of ecosystems include forests, wetlands, meadows and rivers or riparian habitats.

ECOSYSTEM SERVICES

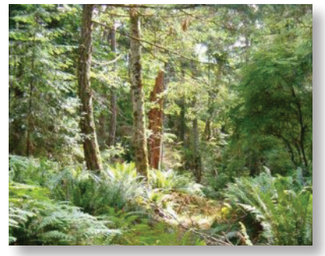
Humans are fundamentally dependent on ecosystems and their services. The human species has been sustained by the bounty of the earth's ecosystems for thousands of years, not only by the ecosystem services that support basic needs such as food, clothing and shelter but by the cultural services, substance, experience and backdrop on which to inspire culture, spirituality, recreation and innovation (MA, 2005).

As defined by the Millennium Ecosystem Assessment "ecosystem services" are the benefits provided for humans by ecosystems and include:

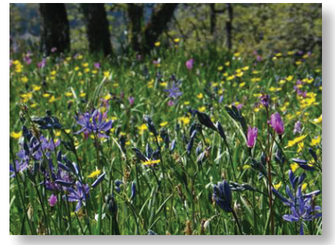
- Provisioning services such as food, water, timber, fiber, and genetic resources;
- Regulating services such as the regulation of climate, floods, disease, and water quality as well as waste treatment;
- Cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and
- Supporting services such as soil formation, pollination, and nutrient cycling. — (MA, 2005)

In 2010, the United Nations Environmental Programme (UNEP), released a document that attempted to quantify ecosystem services. In total, the planet's ecosystem services are reported to be worth "*over USD 72 trillion a year, - comparable to World Gross National Income, for food security, drinking water, climate regulation, medicine, recreation, culture, health*" (2010). Canada's National Parks, for example, store 4.343 gigatonnes of carbon, providing a service worth between 11 billion and 2.2 trillion USD (UNEP, 2010). UNEP stressed that loss of ecosystem services could result in up to 25% of the world's food production by 2050 and current losses are contributing to natural disasters (UNEP, 2010).

ECOSYSTEMS



Forest



Meadow

Wetland

River

THE NATURE/CULTURE CONNECTION

There is a strong argument that humans have an innate, psychological connection to the natural world, a condition E.O. Wilson defines as "Biophillia" – "love of life or living systems" (Wilson, 1986). Wilson suggests that there are connections that humans subconsciously seek with the rest of life and that these deep affiliations for nature are rooted in our biology (1986). He also contends that nature is one of the most information-rich environments that people will ever encounter (1984). This theory is supported by a growing number of studies across disciplines that document the benefits of nature to people for a range of conditions; recuperation from illness, stress reduction, improving cognitive functions, reducing symptoms of behavior disorders and positively contributing to social cohesion (Kaplan 1995, 1998, 2005; Pyle, 1993; Ulrich, 1991).

One study showed that cancer patients who experienced nature-based activities for twenty minutes, three times a week, for three months after surgery, were more likely to recuperate faster, return to work full time and had overall higher quality of life ratings at the end of the three month study period, then the control group (Kaplan, 1995). In a ten-year study of gallbladder surgery patients, those who had a view of a grove of trees from their room went home faster than those with a view of a brick wall. In a similar study, prison inmates with a view from their cells of a farmland had 24% fewer cases of illness than those with a view to between a decrease in domestic violence and increase in tree planting in public housing projects (Sullivan et al, 1996). It has also been found that the presence of green space near one public housing complex contributed to stronger ties among neighbours in public housing compared to a similar housing complex without trees or grass (Kuo et al 1998).

ECOSYSTEM DECLINE

In 2005 the Millenium Ecosystem Assessment (MA), was released, revealing that, "over the past 50 years humans have altered ecosystems more rapidly and extensively than any comparable period of time in human history to meet the demands of food, fresh water, timber, fiber and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth." (MA, 2005. pg. 2). In 2010, The United Nations Environment Programme reported that, "*nearly two-thirds of the globe's ecosystems are considered degraded as a result of damage, mismanagement and a failure to invest and reinvest in their productivity, health and sustainability*" (2010. Pg 5).

Also according to the MA 2005, approximately 70% of the original temperate forests, grasslands and Mediterranean forests had been lost by 1950, mostly through conversion to agriculture, which covers about 24% of the earth's surface. Of the species assessed, either the population size or the majority of species is declining, and between 10-30% of the bird, mammal and amphibian species are threatened with extinction (MA, 2005).

The most direct threats to ecosystems are habitat change (land use change and physical modification or water withdrawal from rivers), overexploitation, invasive species, pollution, and climate change. Collective research suggests that of these, the biggest threat is habitat loss through land transformation and development (MA, 2005; UNEP, 2010; LPR, 2008).

CITIES AND ECOSYSTEM DECLINE

Although agriculture and town settlements contribute to land transformation, cities, taking up only 2% of the earth's surface could potentially have the most impact on the earth's ecosystems (MA, 2005; UNEP, 2010). The growth and evolution of cities in conjunction with human activity and consumption patterns affect ecosystem processes both directly (inside and close to the city) and remotely through displacement, resource use and through required inputs and outputs (i.e. waste) (Alberti, 2003).

Cities impact local ecosystems in a number of ways:

1. Cities are most likely to be located in areas of high biodiversity where resources are most abundant (Luck, 2007).
2. Urban growth leads to highly fragmented and isolated ecosystems, habitat loss and homogenization of remaining natural areas (MA, 2005; Miller, 2005).
3. Urban outputs such as waste, stormwater and pollutants degrade nearby intact ecosystems and their services (MA, 2005; UNEP, 2010).
4. Urbanization disconnects humans from the natural world, not only impacting human health and well-being but reducing urbanites knowledge of their natural heritage and therefore desire to protect it now and into the future (Miller, 2005; Pyle,1993).

1. Cities are located in areas of high biodiversity

Cities are most likely to be located in areas of high biodiversity and species richness such as estuaries and flood plains where the resources are most abundant (Luck, 2007). Biologists have identified 25 regions, dubbing them biodiversity hotspots, these cover about 12% of the earths land base and where nearly 20% of worlds population were shown to be settled by 1995 (Cincotta et al, 2000). Throughout history, these areas have experienced the most intense settlement (Luck, 2007; Cincotta et al, 2000).

2. Urban growth leads to highly fragmented and isolated ecosystems, habitat loss and homogenization of remaining natural areas

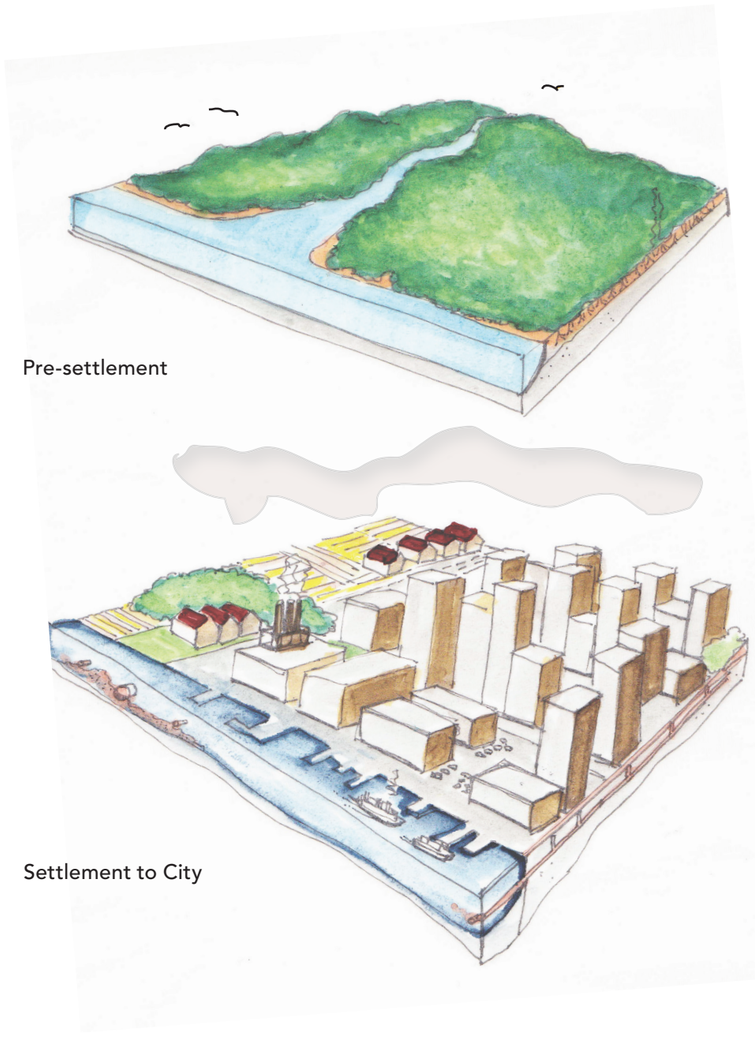
As cities evolve from settlement to town to city, ecosystems are first perforated then fragmented then isolated (Marzluff et al, 2001). The remaining ecosystems become vulnerable to human impact and limit connectivity, leading to species isolation and decrease in habitat, not to mention profound alterations to remaining species breeding, feeding and evolution patterns (Alberti, 2003). The systems required for a city to function often results in homogenization of the region, as nature is replaced with skyscrapers, roads, residential development and suburbs. Urbanization is also said to compromise net primary productivity, micro climates, air quality, and geomorphological and hydrological processes (Alberti, 2003).

Evidence shows that as the built environment intensifies, biodiversity declines. A study of bird diversity in four major metropolitan areas revealed that of 4.4 million people in all cities combined, 33.1% lived in low diversity neighbourhoods, a condition that the researchers claim is reflective of most of the urbanized world, and as a result, most of the earth's population is living in "biological poverty" (McKinney, 2006). Another study mentions that urban areas without natural parks, experience reduced beta diversity meaning that few new native species are available to populate the area over time (Blair, 2001).

3. Urban outputs degrades nearby intact ecosystems and their services (MA, 2005; UNEP, 2010).

When ecosystems are fragmented from urban development the quality of biodiversity and ecosystems declines as well as the quantity (Dobson, 1999). Roads cutting through natural areas for example, create an edge, the area of a natural area where most species prefer to avoid. In fact many species won't even cross the road for breeding or foraging. The more patchy a natural area is, the more vulnerable these species become (Dobson, 1999).

Streams, rivers, oceans and lakes, closely integrated through the hydrological cycle are significant ecosystems that are naturally species rich and serve as important water purifying systems, a function that is



CITIES AND ECOSYSTEM DECLINE *CONTINUED*

particularly important in urban environments. In the US, urbanization is the second biggest cause to stream impairment after agriculture (Paul and Meyer, 2001). Urban streams that have not been buried or paved over have been blocked by culverts that can severely limit fish flows and spawning and aquatic ecosystem functioning (Paul & Meyer, 2001).

Cities are predominantly paved over with impermeable surfaces. Precipitation runs into streams and rivers as surface flow, collecting pollutants along the way. Water enters the river or stream in short flashes causing stream bank erosion and degrading water quality. Evidence shows that nitrogen, phosphorous, metals, and pesticide residue are frequently carried into urban streams through surface runoff. Some research suggests that these pollutants can be the primary cause of degradation of urban catchments (Paul & Meyer, 2001). In fact, research has shown that urban nitrogen inputs can affect streams and rivers for hundreds of kilometers. Research in both France and the US shows that pesticides (frequently from home lawns and golf courses) are more prevalent in urban streams and biota than areas of intense agriculture (Paul & Meyer, 2001).

In a 1997 report,86 per cent of the Fraser Valley's 779 streams classified (excluding the Fraser River mainstream and estuary) were lost, endangered, or threatened (DFO, 1997).

Remaining open spaces displace native flora and fauna with highly manicured landscapes dominated with plants from other parts of the world, often without habitat value and in some cases highly invasive to remaining natural areas. In Vancouver, 30% of Stanley Park has been invaded by English Ivy, a vine that is predicted to grow one meter a year (SPES, 2010). This is just one of many invasive plants that are degrading remnant areas. Unfortunately many are still cultivated and sold in nurseries as garden plants (Evergreen, 2006).

4). The Nature/Culture disconnect:

"What is the extinction of the condor to a child who has never known a wren?" (Pyle, 1993).

In the last two decades, much has been written about the direct and indirect outcomes of a growing population that is experiencing a disconnect from the natural world, this has been related to of disappearing ecosystems, urbanization and a growing tendency to stay indoors.

Pyle claims that as fewer people have the opportunity to access nature "as they become surrounded by human-created landscapes composed largely of nonliving materials and void of species diversity and habitat" there is a collective "extinction of experience" that threatens future conservation (Pyle,1993). One study in England showed that children were able to identify more names on Pokemon trading cards (a series of Japanese characters) than local native species such as otter, oak and beetle (Louv, 2005). Another study revealed that on average, less than half an hour in a day is spent in purposeful outdoor activity (Hofferth & Sandberg, 2001). Research in the US suggests that the average American spends 95 per cent of his or her time indoors (from Nicholson-Lord, 2005).

In his book, "The Last Child in the Woods", Richard Louv suggests that emerging child development issues such as obesity, depression and behavior disorders are symptoms of what he calls "Nature Deficit Disorder" A disorder that could be associated with a shrinking of natural play areas where children can experienced unstructured play and build their own connections with the natural world (2005). His book further reveals that American children, ages six to eleven spend an average of thirty hours a week watching a TV or a computer monitor. Two out of ten American children are obese and the population of overweight children between two and five has increased almost 36% between 1989 and 1999. This is despite one of the largest increases in organized sport in history. Louv suggests that one thing that organized sports lack is the opportunity for play in natural settings (Louv, 2005).

There is also an increase in cases of depression found in young children. A 2003 study found that the rate at which American children are given antidepressants almost doubled in five years and 66% of children being prescribed antidepressants were preschool aged children (Louv, 2005; Luby, 2003). At the same time, a number of studies show that children living near natural areas experience less anxiety, behavior disorders and depression (Wells et al, 2003).

A Note on Lawns

Lawn is another culprit in the urban landscape that impacts natural areas and widens that gap between people and nature. Lawns dominate parks, cemeteries, school grounds, boulevards and yards. These "lawn" scapes are not representative of nature, in fact they can be detrimental to human and environmental health. Lawns, originating in Fifteenth Century England, where wealthy landowners replaced productive land with closely shorn ground cover as a status symbol, then hired human labour to clip it by hand (Jenkins, 1995).

Lawn arrived in North America sometime in the early 1800's with European immigrants. As chemicals and lawn mowing equipment became more readily available it became a household feature (Jenkins, 1995). In recent times, regardless of the climate, a well-manicured green lawn is the expected standard: an effort that requires regular watering, mowing and in most cases chemical pesticides and fertilizers are applied (Jenkins, 1995).

Watering lawn throughout the summer drains local watersheds. The Metro Vancouver web site states that "one lawn sprinkler uses as much water in 1 hours as 25 toilet flushes, 5 loads of laundry and 5 dishwasher loads combined" (MV, 2010).

Studies report that lawn-care pesticides can lead to chronic illness, including brain cancer, prostate cancer, kidney cancer, pancreatic cancer, skin disease neurological diseases and can affect reproductivity and children are particularly vulnerable to exposure both because of their small size and because they tend to play on lawn (Sanborn et al, 2004). As previously mentioned, pesticides and fertilizers are often found in high concentrations in urban rivers and streams, disrupting the natural balance of the water systems and entering the aquatic and terrestrial food chain, disrupting breeding and development of local species.

Lawn equipment, including mowers, leaf blowers and weed eaters, emit smog-forming pollutants such as hazardous air pollutants (HAPS), particle pollution (dust), and volatile organic compounds (VOC), hydrocarbons and nitrogen oxides, pollutants that contribute to the formation of ozone (EPA, 2009). The Environmental Protection Agency reports that Lawn and garden equipment made before 1997 produced as much as 5% of the total man-made hydrocarbons that contribute to ozone formation, 1,000 gasoline-powered mowers can produce as much as 9. 8 tons of volatile organic compound (VOC) emissions per year, equivalent to 230 cars (2009). Another source states that mowing for 100 hours (the average time a resident spends mowing per year) with a 3.5 horsepower gasoline mower can emit pollutants equivalent to driving a new car for approximately 55,000km (from MV, 2005). These pollutants can also contribute to health problems. Particle pollution can cause respiratory problems, cardiac arrhythmia (heartbeat irregularities), and heart attacks, affecting the most vulnerable populations such as the young, elderly and people with existing respiratory conditions (EPA, 2009).

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The Planning Process and Ecosystem Health

"There clearly is a need for professionals who are conservationists by instinct, but who care not only to preserve but to create and manage" (McHarg 1969)

When it comes to planning, natural areas are most often separated from other land uses and often become managed by a se per ate organization or department. For example, in Vancouver, many natural areas are managed by Vancouver Parks Board and stewardship groups. It could be said that as a result, the planners dealing with development and urban systems are often not prioritizing or even aware of local ecology in the planning process.

Research suggests that one of the main barriers is poor communication between "ecologists on the one side and the public and decision makers on the other." (Yli-Pelkonen & Niemelä, 2005). One researcher suggests that scientific data and language can be too complex for the public or decision makers to decipher (Niemelä, 1998). Another issue is that biologists or ecologists are rarely part of the planning process. One study suggested that municipalities that had biologists on staff had more conservation efforts in place (Miller, 2008)). If they are involved they rarely stay through the entire process (Lovell, 2009; Yli-Pelkonen & Niemelä, 2005). Researchers emphasize a need for planners to become more aware and educated in the field of ecology and in turn ecologists need to recognize the importance of the designed landscape and become involved in the planning process (Miller, 2008).

In the work "*Ecology and Urban Planning*", Neimela suggests that three issues must be addressed for ecology to be incorporated into planning (Neimela, 1998):

1. Knowledge of local ecology must increase through mapping and inventory

2. There needs to be a better understanding of urban nature vs wild nature and how city functions affect urban nature.

3. Ecosystem based management must be incorporated. For example certain areas could be left un-managed to allow natural processes to occur, likely increasing biodiversity.

Stokes et al emphasize the importance of educating the public about local biodiversity, especially flagship species such as those threatened or endangered, and how preserving these species benefits people. As well, there should be more collaboration in biodiversity conservation among different jurisdictions and between scientists and urban professionals (Stokes et al, 2009).

Addressing Ecosystem Decline

PROTECTING AND RESTORING URBAN ECOSYSTEMS

"*They will always be the greatest reservoirs and most interesting places to visit*" (Erlich, 2008)

Most experts agree that the top priority should always be protecting intact ecosystems as they are irreplaceable and the most inexpensive option for maintaining ecosystem services (MA, 2005; UNEP, 2010; Erlich,2008). Protecting intact urban ecosystems has the potential to preserve urban wildlife, maintain native flora and fauna stock and provide urbanites with a context to their natural surroundings, raising awareness of their local natural heritage. Depending on scale these remnants may also serve to mitigate heat island effect, filter air and water pollutants and sequester carbon (Elmqvist et al,2008). Protection may not only mean preserving intact ecosystems but limiting pollution through air and water sources, fragmentation from intense human activity and invasive species introduction.

Emerging evidence shows that protection alone is not enough. Globally, reserves only cover 13% of the earth's surface, coastal reserves 6% and ocean areas is less than 1% and most are not managed effectively (UNEP, 2010; MA, 2005). Of the ecosystems not protected, almost one-third are already directly converted for human activities, cultivation and development and those not converted have been degraded to some extent (UNEP, 2010; MA, 2005, Erlich, 2008). Not only are these protected areas vulnerable to degradation, but there are also fewer available to preserve.

In concert with protection, scientists are emphasizing a need for large scale efforts to restore ecosystems (UNEP, 2010; Sinclair et al, 1995). In 2010 the United Nations Environmental Programme (UNEP) released the report "*Dead Planet, Living Planet, Biodiversity and Ecosystem Restoration for Sustainable Development*". This report emphasized the need to restore the globe's ecosystems, and that although restoration costs are often significantly higher than conserving intact ecosystems, the numbers are "dwarfed compared to the long-term estimated cost of losing these ecosystem services" (UNEP, 2010).

The report involved surveying ecological restoration case studies. The results showed that most projects were successful in increasing biodiversity and restoring ecosystem services to some level. It also emphasized that ecosystem restoration proved to be economically viable:

"*Well planned, appropriate restoration, compared to loss of ecosystem services, may provide benefit/cost ratios of 3–75 in return of investments and an internal rate of return of 7–79%, depending on the ecosystem restored and its economic context, thus providing in many cases some of the most profitable public investments including generation of jobs directly and indirectly related to an improved environment and health. Ecological restoration can further act as an engine of economy and a source of green employment.*" (UNEP, 2010 pg. 7).

HABITAT INTEGRATION

Protection and restoration of remnant ecosystems are of utmost priority; at the same time there are strong arguments for integrating natural systems and creating, in effect, new habitats within the built environment. Although this concept has been around in various forms in the science and design fields, there has been no standardized approach, so, for the purpose of this paper it will be called "habitat integration".

Biologist and educator, Paul Erlich recommends integrating nature into human modified landscapes, emphasizing the importance of maximizing biodiversity in areas where humans can experience it in their day-to-day lives, which could increase ecosystem service delivery and increase bioliteracy (2008).

Michael L. Rosenzweig a professor of Ecology and Evolutionary Biology at the University of Arizona, founded a concept called Reconciliation Ecology, in which people "reconcile" with nature in places they live work and play" (Miller, 2005). Rozenzweig contends that efforts should also be focused on designing human surroundings in ways that meet habitat requirements such as using native species in landscape design (Miller, 2005; Rosenzweig, 2003). Some examples might include constructed ponds and Meadows in Golden Gate Park in San Francisco and the green rooftops of Berlin (Miller, 2003). Reconciliation Ecology could be applied to endangered or threatened species such as the constructed ponds in the UK that support an endangered toad (*Ibid*).

Clarkson et al., notes that cities create unique opportunities for what he calls restorative ecology, because the population density provides a solid volunteer base, lack of grazing supports growth of the herb layer, and potentially rare species, and the closeness of people to these natural areas offer increased opportunities for awareness and education (Clarkson et al, 2007).

Biodiversity in Cities

Despite the contested nature between urban space, habitat and wildlife, urban habitat patches do have value and can maintain surprisingly high biodiversity (Miller, 2005).

In 2001, the City of Chicago, created a green roof on top of their City Hall with the aim of combating rising local temperatures. Although wildlife habitat was never a primary objective of the project, by 2003 the roof had seen a 12% rise in the number of birds using the roof, and an increased variety of species. The roof has also provided a habitat for a wide variety of insects including native honey bees (Chicago Wilderness Magazine, 2004).

Barnes Elm Wetland in London, England consists of 150 acres of reclaimed reservoirs that support 190 species of birds and is a significant oasis to Londoners (WWT, 2008).

A study in Sheffield England assessed urban garden flora in 61 yards and found 4,000 invertebrates, 80 species of lichen and over 1,000 plant species (Smith et al, 2006).

Dockside Green in Victoria incorporated a natural stream, which, shortly after being completed, became home to a local otter a now celebrated feature of the site (http://docksidegreen.com).

Maplewood flats in North Vancouver, was once a dump site for the fill from the construction of the West End, after years of restoration efforts it is now a bird sanctuary that supports amphibians and over 200 species of birds including owls, eagles and raptors there is also a large following of birders and an active conservation group (www.wildbirdtrust.org).

Addressing Ecosystem Decline *continued*

The City of North Vancouver has protected Mahon Park, a 24-hectare remnant forest that is home to amphibians, eagles, owls and piliated woodpeckers. This forest has become an outdoor classroom for thousands of visitors including school groups, youth, organizations and a dedicated stewardship group that has been volunteering to preserve the park since 2003 (CNV, 2008).

In many cases it is simply biodiverse landscapes, water sources and native food sources that supply the habitat necessary for species to forage and breed. These same landscape qualities can also provide important ecosystem services for the human inhabitants of the city.

BENEFITS OF URBAN HABITAT

Ecosystem Services
Urban vegetation can reduce heat island effect, improve air and water quality, reduce noise and enhance recreation.

In a study of Stockholm County, it was assessed that the region's ecosystems could accumulate about 41% of the CO_2 generated by traffic and about 17% of total anthropogenic CO_2. Wetlands in cities can lower spending on sewage treatment and in some cases up to 96% the nitrogen and 97% of the phosphorous can be filtered by plants and animals (from Elmqvist et al, 2008).

Studies report that street trees can filter up to 70% of the surrounding air pollution and 1 ha of mixed forest is estimated to remove 15 tons of particulates annually from the air, (spruce forests are capable of twice as much). In the Chicago region, trees were found to remove some 5500 tons of air pollutants per year (Bolund & Hunhammar,1999).

Ideally, habitat integration will not only create healthier local ecosystems in cities, but the paradigm shift required to design and manage or steward urban habitats could effectively shift ecology to the top of the priority list in planning and land management processes. It could also result in a behavior shift as the impact of human activity (a local bird population declines in a community park for example) is now experienced first hand as opposed to a news report on the decline of an environment far away.

Habitat integration, in sink with protection and restoration of remnant ecosystems could lead to healthier communities, improve ecosystem services, connect people to nature and lighten urban impacts on local and regional ecosystems. If cities could do this collectively then global ecosystems may also improve, especially in conjunction with sustainable development.

Restore hydrological processes:
Urban nature can purify water before it returns to oceans, rivers and drinking water sources and increase fish population health (Cook, 2000). A recent study of the habitat quality, ecological function, and fish composite of urban gully streams in Hamilton, NZ., found that positive outcomes were associated with streams that had vegetative cover, low instances of stormwater inputs and presence of woody debris. The authors emphasize the important role urban streams play in biodiversity conservation. They recommend some key interventions including as restoring riparian habitat to shade streams, disconnecting stormwater piping, mapping key opportunities of high biodiversity and using a catchment systems approach for urban stream restoration (Collier et al, 2009).

Re-connect people to nature:
As the world becomes more urban and density becomes the norm, parks and open space prove more vital to residents, as a reprieve from the stress of the city and a source of light, open air and ideally, nature.

This notion is centuries old, starting when cities first experienced miasma from crowding and unsanitary living conditions. In the late 1800's John Rauch, a Chicago Physician wrote his influential report "*Public Parks: Their Effect upon the Moral, Physical and Sanitary Conditions of the Inhabitants of Large cities; with special reference to the City of Chicago*" arguing that miasma and poor human health can be relieved by the presence of public parks. This report not only influenced the construction of large public green space in Chicago, but Frederick Law Olmsted and Calvert Vaux and the building of Central Park (Martensen, 2009). Frederick Law Olmsted is known for his perspective that open space provided light and clean air, social interactions and sanctuary from the cramped, stressful and miasmic state of the city (Frank, 2003; Martensen, 2009).

While surmising that open space contributes to physical and mental health, especially in more dense urban centers, it is important to note that certain attributes of open space are proven to benefit human and ecosystem health more than others. Evidence shows that people consistently prefer open space with more biodiversity and natural amenities, particularly water features, large trees or woodlands, irrespective of culture or nationality (Irvine et al, 2010; Kaplan & Kaplan,1989). A survey of 310 park users in Sheffield, England, a city of over 500,000, showed that the psychological benefit of the park was positively related to species richness of plants and to a lesser extent of birds. Plant and bird richness had a stronger correlation to psychological benefit than park size. 69% of the interviewees used local parks to "be in a natural environment", 55% to see local wildlife, and 36% to feed ducks. They also strongly emphasized the importance of nature in the park, and at least two-thirds reported that flora and fauna diversity is valuable (Irvine et al, 2010).

A Swedish study asked 953 Swedish city dwellers to rank the sensory dimensions of open space in correlation with stress reduction. The eight perceived sensory dimensions of open spaces in question included: Nature, culture, prospect, social space, rich in species, refuge and serene. The combination of "*Refuge, Nature and Rich in Species, and a low or no presence of Social*", was the most preferred urban green space, and as the researchers suggest, "*could be interpreted as the most restorative environment for stressed individuals*" (Grahna & Stigsdotterb, 2010).

Another study showed that natural park features were more strongly correlated with physical activity and suggested the most effective park design promoting physical activity would be a "*system of attractive natural parks interconnected by trails*" (Kaczynski et al, 2008).

5.0 HABITAT INTEGRATION - DESIGNING URBAN HABITATS

As urban environments are completely altered from the natural heritage that came before, habitat integration does not suggest restoring urban neighbourhood into complete ecosystems such as old growth forests, instead it suggests weaving high quality ecological landscapes, or "biodiversity building blocks" into the built form using natural analogs. Bioswales in streets, food gardens in parks, habitat on rooftops are all examples of these building blocks. A far cry from the typical lawn dominated urban landscapes, it is hoped that collectively these landscapes can benefit local ecosystems and urban citizens.

Guidelines
The following are some key principles that are fundamental to habitat design:

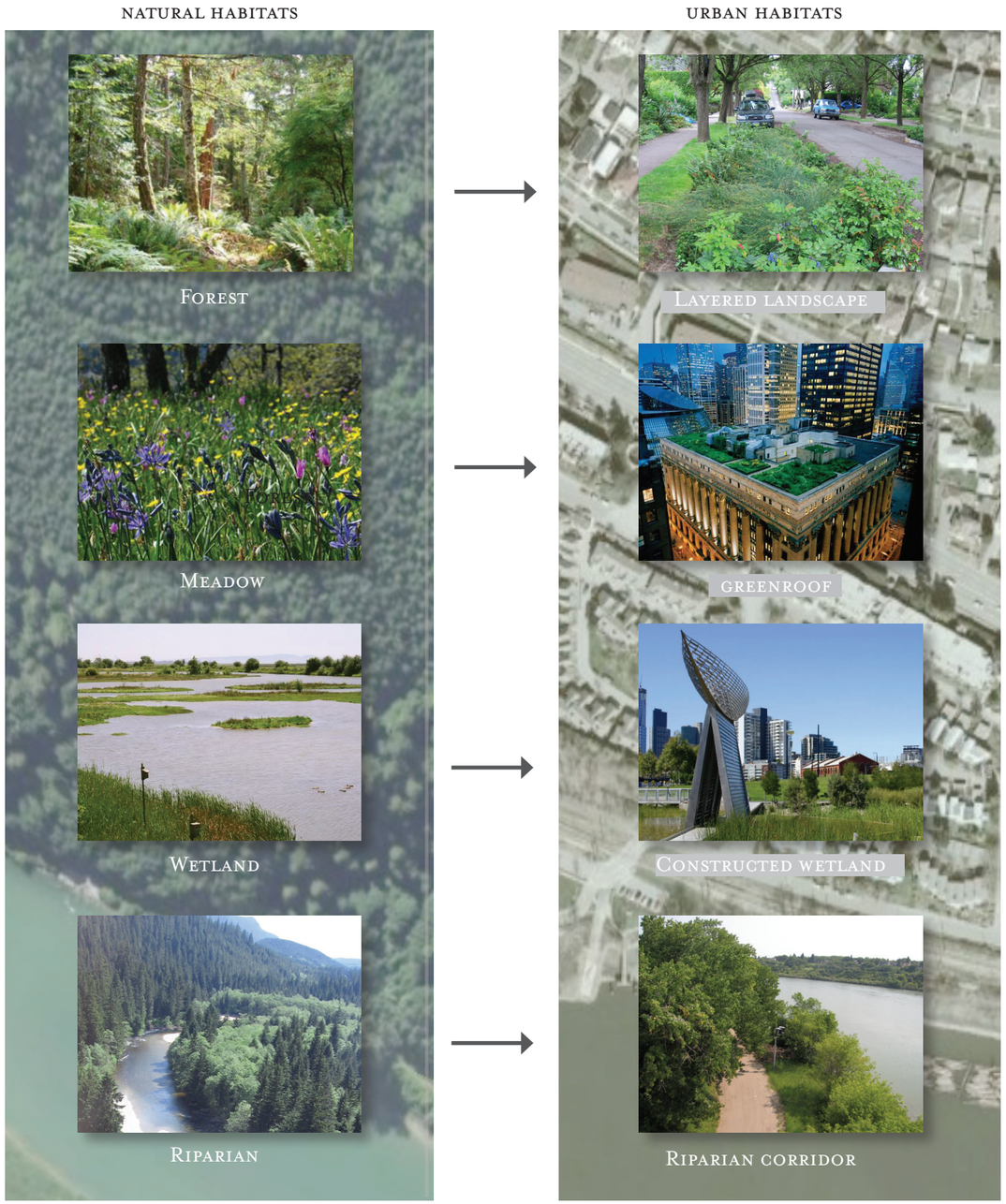
1. All landscapes are designed and managed without environmental impact.

2. All urban landscapes benefit the environment in some way and have some degree of functionality, whether for food production, purifying water, supporting pollinators or connecting habitats.

3. All scales are considered simultaneously and ranked with the same importance as everything is linked from site to region. As each is part of the whole system.

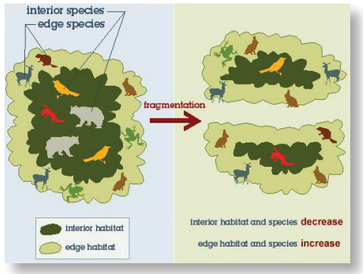
Ecological Principles:
Lessons can be learned by the work of scientists and researchers who have studied urban habitats. Three important concepts include:

- Connectivity: Patch Corridor Matrix
- Urban Wildlife: Avoiders/Indicators; Adapters and Exploiters
- The bare necessities: Food Water and Shelter

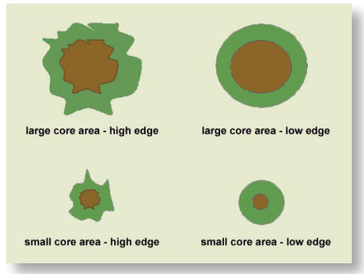


Habitat Requirements > Regional & Neighbourhood Scale

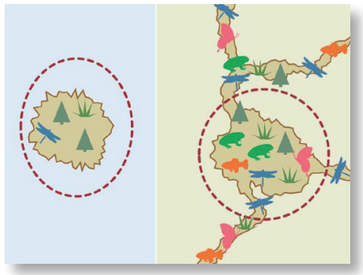
Connectivity: Patch, Corridor, Matrix



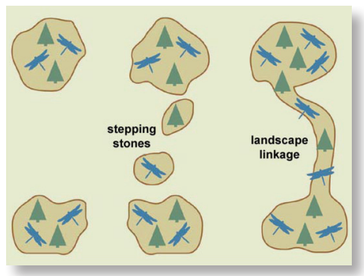
Larger patches support more interior species. Fragmented habitats support more edge species.



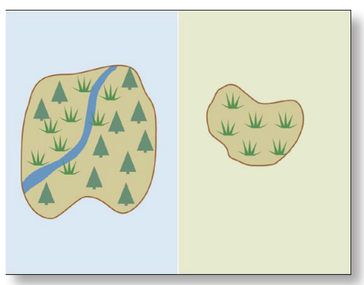
Patches with less uniform edges support more biodiversity than those with smooth edges.



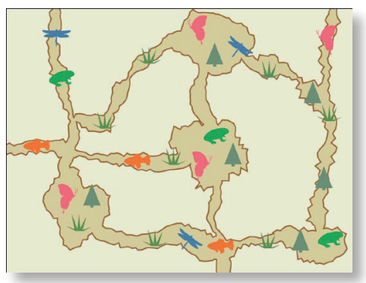
Isolated patches are more vulnerable to species extinction and degradation than large patches



Species movement is facilitated through stepping stones or linkages between patches



More habitat type diversity in large patches



Higher ecological success comes with more connections between patches

- Image Source: Defenders of Wildlife www.defenders.org/, 2008

CONNECTIVITY: PATCH, CORRIDOR, MATRIX

Landscape Ecologist T.T Forman defined land patterns as mosaics comprised with patch, corridors and matrices. These can occur at multiple scales. Patches, like nodes, can be large or small, corridors, the connections between patches can be wide or narrow and can be continuous or take the form of small patches as stepping stones. The matrix, is the land form that provides the background to the patch and corridor and is often of a different landscape type than the patch or corridor (1995).

Forman outlined a number of principles for optimum ecological health within the patch, corridor, matrix system (right).

Principles for the Patch, Corridor and Matrix (T.T Forman, 1995):

- *The arrangement or structural pattern of patches, corridors, and a matrix that constitutes a landscape is a major determinant of functional flows and movements through the landscape, and of changes in its pattern and process over time.*
- *[Large natural vegetation patches] are the only structures in a landscape that protect aquifers and interconnected stream networks, sustain viable populations of most interior species, provide core habitat and escape cover for most large home range vertebrates, and permit near-natural disturbance regimes.*
- *An ecologically optimum patch shape usually has a large core with some curvilinear boundaries and narrow lobes, and depends on orientation angle relative to surrounding flows.*
- *For sub-populations on separate patches, the local extinction rate decreases with greater habitat quality or patch size, and recolonization increases with corridors, stepping stones, a suitable matrix habitat, or short inter-patch distance.*
- *A coarse-grained landscape containing fine-grained areas is optimum to provide for large-patch ecological benefits, multi habitat species including humans, and a breadth of environmental resources and conditions.*
- *Top-priority patterns for protection, with no known substitute for their ecological benefits, are a few large natural vegetation patches, wide vegetated corridors protecting water courses, connectivity for movement of key species among large patches, and small patches and corridors providing heterogeneous bits of nature throughout developed areas.*

Quoted from: Some general principles of landscape and regional ecology, T. T. Forman, 1995

Additional considerations for habitat connectivity include:
Natural corridors between 10m² patches show more success for recolonization and reducing species loss compared to corridors between 1m² patches (Lee & Rudd, 2003).

In a natural environment, the wider the corridor the better, for example, a corridor 50m wide supports movement for generalist species where 100m² corridors are more suitable for specialist species, corridors 200m² are more effective for breeding and feeding (Lee & Rudd, 2003). This could also be applied to an urban environment, where the corridor is competing with other uses such as streets and backyards. A wider corridor allows for more biodiversity and opportunities for food and shelter.

Riparian corridors help facilitate movement of both terrestrial and aquatic species. They also are shown to improve water quality (Marsh, 2010; Lee & Rudd, 2003).

Habitat Requirements > Site Scale

Food, Water, Shelter

Naturescape BC is a resource developed by naturalists, biologists, and conservation groups, to promote the caring and enhancement of residential wildlife habitat. Naturescape emphasizes the importance of providing the basic necessities of food, water and shelter for wildlife our built environment (1995).

Food: Food sources for urban wildlife predominantly come from plant selection. To support native species, native plants with seeds, nectar, berries and nuts are the best source. Some plants provide nectar and berries for multiple species. In some cases, specific ornamentals can also provide suitable food sources. Selecting a range of plants suitable to the site can feed a wider range of species. Diversity in vegetation can also provide food for insects, which alternatively feed wildlife, adding to the food chain (NBC, 1995).

Shelter: Shelter is necessary for rest, escape from danger, shelter from the weather and breeding. To create shelter for a number of different species, layered, undisturbed areas of mixed vegetation are the most suitable. This will accommodate ground feeders and canopy foragers. Shelter should also provide protection from domestic predators, chemical pollutants and human activity (NBC, 1995). Hedgerows and shelter-belts provide food and shelter for a variety of song birds, insects and small mammals and aesthetic versions could replace the coniferous hedges that dominate many urban landscapes.

Water: Water is a basic necessity for drinking, bathing and in some cases (the dragonfly for example), breeding. In urban environments, sometimes clean accessible water sources may not be available. The best sources of water are moving, and sheltered from domestic predators (NBC, 1995).

Food

Butterfly feeding. Source: Creative Commons

Cedar Waxwing feeding on Hawthorne berries Source: author

Water

Kokanee Source: Creative Commons

Bird drinking from tap Source: Creative Commons

Shelter

Hummingbird Source: Author

Tree Frog hiding Source: Creative Commons

Urban Wildlife > Avoiders, Adapters, Exploiters and Indicators

Types of flora and fauna species change dramatically from natural, to rural to urban areas. Blair categorized these species as urban exploiters urban avoiders and urban adapters, terms he used for bird, butterfly and lizard studies. Urban exploiters are typically non-native species that have not only adapted but thrived in urban settings. Examples of urban exploiters could include pigeons, and starlings. Urban adapters adapt to urban settings in a way that mimics how they would survive in nature, for example blue herons and urban avoiders are more sensitive to disturbance, rely mostly on natural resources and/or tend to be out-competed by adapters and exploiters, these could include most amphibians, typically sensitive to air and water pollution (From Mckinney, 2002).

An indicator species is "*an organism whose characteristics are used as an index of attributes too difficult, inconvenient or expensive to measure for other species or environmental conditions of interest*" (Landres et al., 1988).

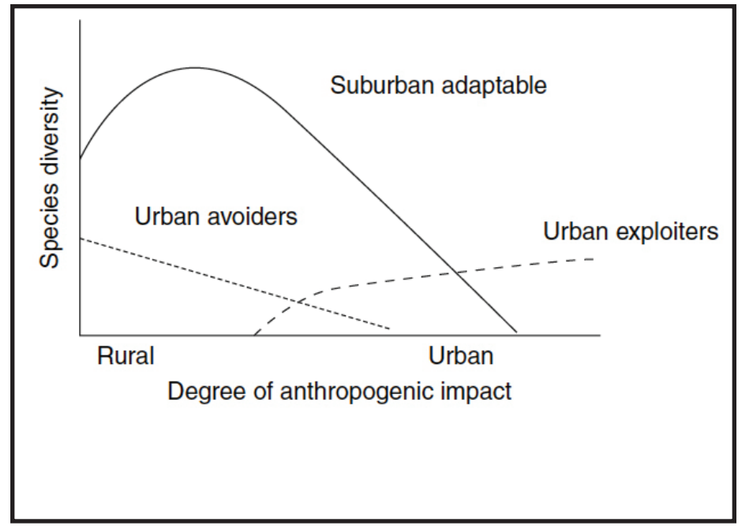
Indicator species are commonly used to assess environmental conditions. Plants and animals are used to assess air and water quality, classify communities and measure habitat suitability for other species (the canary in a coal mine would be an extreme example) (Lee et al, 2003). Indicator species of the lower mainland could include fish such as the white sturgeon and coho salmon, amphibians such as the red legged frog and red backed salamander, birds such as the great blue heron and the piliated woodpecker and mammals such as the river otter and the Douglas squirrel.

Cities typically have low native species diversity, especially in the most intensely urban environments such as the urban core where vegetation is reduced. Studies on butterflies, insects, mammals and birds show that populations are reduced to more than half in the urban core compared to rural areas (Mckinney, 2002). This is correlated with vegetative cover. Amphibian, bird and insect populations seem to increase with the amount of plants in an area (Mckinney, 2002).

In Vancouver, there are enough cases of highly sensitive species or urban avoiders close to the urban core such as the flying squirrels in UBC's botanical garden and amphibians in VanDusen Gardens to not only indicate already healthy biodiversity in some parts of the city, but also to prove that habitat integration is possible.

For the purpose of this project, habitat integration's ultimate goal is to achieve quality habitat at all scales that will result in enough biodiversity to attract and decrease extinction rates of urban avoiders, species that will also be indicators of success. For this reason, urban avoiders and indicators are one in the same.

Major challenges to many urban avoiders are human disturbance, fragmentation and pets (Marzluff & Rodewall, 2008). Efforts could be made to designate areas as habitat zones, areas that limit access using creative fencing or walkways. Also raising awareness about pets as predators should also be an important priority.



(Elmqvist et al, 2008)

Urban avoiders tend to decline with urbanization, with population densities highest in the most natural settings. Urban exploiters increase and potentially thrive with urbanization, and their populations peak in the urban core. Urban adapters, respond and adapt to some degree of urbanization but populations peak at around the intermediate levels of urbanization. (Elmqvist, et al 2008)

AVOIDERS/INDICATORS

Douglas Squirrel

Piliated Woodpecker

Rough skinned Newt

ADAPTERS

Coyote cubs, VanDusen Gardens

Peregrine Falcon, New York City

Blue Heron, Stanley Park Rookery

EXPLOITERS

English Ivy

Rock Pigeon

Eastern Gray Squirrel

6.0 URBAN LANDSCAPES

Urban landscapes are "new to the earth" (Marsh, 2010). They are almost entirely manufactured and almost completely altered from the natural landscape they displace (Marsh, 2010). Complex land patterns such as gridded street systems, houses, skyscrapers and industry make up the urban form. Open space within these land use configurations can provide habitat from greenspaces and streets to rooftops, empty lots and plazas of the urban core.

The quality of habitat and the number of species that could be supported depend on a number of factors including: size of open space, presence of native soil, presence of native plants that provide food or shelter, existing biodiversity and proximity to water.

Remnant ecosystems for example, could be considered the highest quality habitat, considering it is closer to it's natural form.

Neighbourhood parks provide opportunities to integrate high quality landscapes in some parts of these parks. Commercial areas, although they have a higher ratio of paved surfaces, still provide opportunity for biodiversity on rooftops which have proven to support a range of birds and insects, and landscape features in plazas, streetscapes and even on balconies.

Although these land uses are often considered separate, they are all connected from site to region. If designing for habitat becomes a key feature in open space design and planning at all scales than collectively, these habitats could form an ecological network throughout the city, connecting to natural remnants while increasing urban ecosystem services.

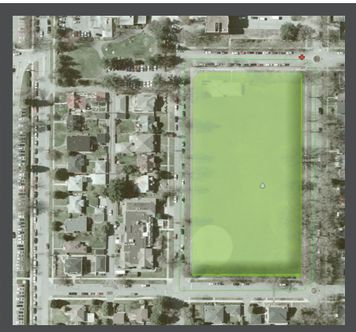
For this project, five qualities of habitat integration were chosen depending on the size of the urban landscape, existing biodiversity and land use. (see following page)

Biodiversity building blocks were developed using natural analogs or components of riparian habitats, forests, wetlands and meadows, all natural habitats typically found in temperate rainforests. These biodiversity building blocks are landscape models that can be integrated into a range of urban landscapes to collectively form the ecological network.

The Habitat Spectrum for Urban Landscapes

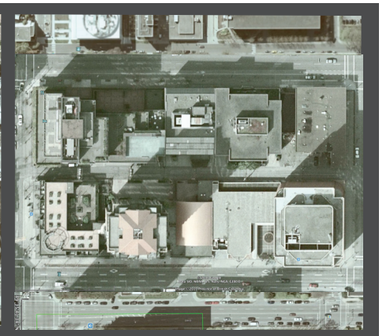
Remnant Ecosystem

Large Parks

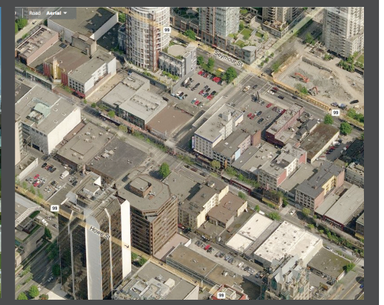


Neighbourhood Parks

Institutional Greenspace



Commercial Open Space



LEVEL I REMNANT ECOSYSTEMS
PROTECT & RESTORE

Remnant ecosystems, forests, streams, rivers and shorelines left behind, are of the highest priority and policy, strategies and resources should be dedicated to their protection and restoration.

Species: Large mammals, small mammals, fish, amphibians, birds, invertebrates songbirds, pollinators.

LEVEL II LARGE PARKS
ENHANCE AND PROTECT

Large parks such as botanical gardens and golf courses can support multiple high quality habitat types. Biodiversity should be enhanced and protected from pollutants and invasive plants. Ideally a large area is set aside that has minimal disturbance, with access limited to boardwalks and viewing platforms can provide access while avoiding disturbance and fragmentation.

Species: Small mammals, amphibians, birds, invertebrates.

LEVEL III NEIGHBOURHOOD PARKS (left) AND
INSTITUTIONAL GREENSPACE (right) INTEGRATED HABITAT

Neighbourhood parks include sports fields, playgrounds and pocket parks. Institutional parks can include hospital grounds, school grounds and campuses. Although these parks have many uses, their are plenty of nooks and crannies that can support habitat. Natural landscapes in these greenspaces can connect more children to the benefits of nature and patients can benefit from the healing properties of nature. These greenspaces also serve as stepping stones between larger habitat refuges.

Species: Small mammals, amphibians, songbirds, birds of prey, invertebrates.

LEVEL IV COMMERCIAL OPEN SPACE
INTEGRATED HABITAT

Commercial open space includes plazas, pedestrian walkways, streetscapes, balconies and rooftops. Habitat in these highly urban spaces can be microhabitats for a variety of species, provide an oasis for busy urbanites while filtering pollutants that often accumulates from intense urban activity.

Species: invertebrates, songbirds.

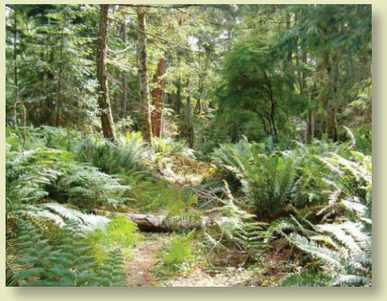
CONNECTIONS STREETS AS HABITAT CORRIDORS

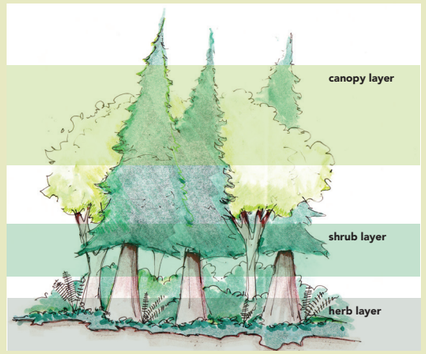
Residential streets, greenways and pedestrian walkways can all be used as important wildlife corridors connecting these habitat patches. Continuous tree canopy, shrub layers and underplantings along the streets can provide habitat for songbirds, invertebrates and even some native small mammals.

Spectrum of habitat qualities for urban landscapes:

The most complete, native and biodiverse habitats start with remnant ecosystems (level I). As land uses become more urban, habitats come in the form of greenspaces dotted with biodiverse landscapes, stormwater treatments such as bioswales and enhanced urban forest in streets. In the most urban landscapes (level IV), habitats are highly designed landscapes, integrated into plazas, streetscapes, buildings and rooftops as formal raingardens, sophisticated native landscapes and greenroofs.

INSPIRED BY NATURAL FORESTS

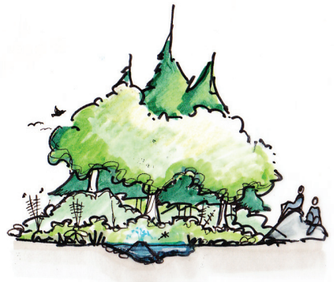




Habitat typology—forest grove

- Natural analogs: mixed canopy, shrub and herb layers
- Mix of native conifer and deciduous trees
- Shrub and herb layer provides ample food through plant selections with berries, seeds and nectar
- Healthy soil layer rich in organic matter, needles, leaves and vegetation are left on site for decomposition
- Include natural water features
- Designated trails and seating areas allow for experience while vegetation, fencing or boardwalks limit disturbance.
- Potential indicators of success depending on scale and location: Owls, piliated woodpecker, Douglas squirrel, songbirds
- Monitor for overgrowth and invasive plants

URBANIZED VERSIONS



THE WILD CORNER

Forest grove for corners and perimeters of green-space

WHERE Neighbourhood parks, large parks, plazas, school grounds, hospital grounds

FEATURES

Canopy Layer: 1-3 Native Conifer Trees, 3-5 Small - Medium Deciduous Trees

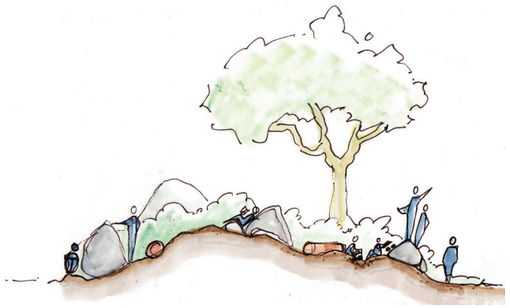
Shrub layer: Native shrubs with seeds, berries, nectar

Herb layer: 75% Native herbs and ground covers, 25% Non-native herbs and ground covers with habitat value

Water feature with moving water, seating

POTENTIAL SPECIES

birds, insects.



NATURAL PLAY SPACE

Natural habitat for children

WHERE Neighbourhood parks, large parks, plazas, school grounds, hospital grounds

FEATURES: Rocks, logs, dirt, sand, trees and shrubs, water for play and exploration.

Can be in a small corner or spread out through a large park.

POTENTIAL SPECIES

birds, insects (pollinators, beneficial insects)

HEDGEROW

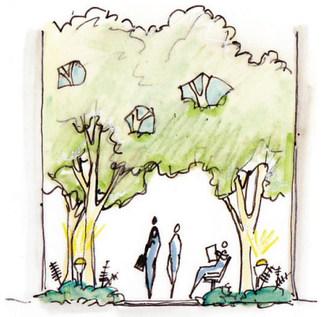
A natural version of the traditional hedge

WHERE Residential yards, streetscapes, commercial landscapes

FEATURES: Mixed Shrubs with seeds, berries, nuts, nectar

POTENTIAL SPECIES

birds, insects (pollinators, beneficial insects)



PEDESTRIAN WALK THROUGH

Natural connections

WHERE Commercial areas between buildings, or pathways mid-block in a residential neighbourhood

FEATURES

Canopy layer: A mix of small to medium deciduous trees

Shrub layer: small shrubs with habitat value

Herb layer: Woodland plants, native ferns and perennials, mixed with non-native perennials if necessary for the site.

Lighting and site lines for safety, Seating

POTENTIAL SPECIES

birds, insects (pollinators, beneficial insects)

URBAN OASIS

Layered habitat for small spaces

WHERE Commercial plazas

FEATURES

Canopy layer: A mix of small to medium deciduous trees

Shrub layer: small shrubs with habitat value

Herb layer: Woodland plants, native ferns and perennials, mixed with non-native perennials if necessary for the site.

Lighting and site lines for safety

Seating, Water feature

POTENTIAL SPECIES

birds, insects.

INSPIRED BY NATURAL PONDS, STREAMS AND RIPARIAN HABITAT

Habitat typology—ponds and streams

Natural analogs: Running water , mixed riparian trees and shrubs.

Potential indicators of success depending on scale and location: amphibians, fish, songbirds, insects

Designate trails along bank far enough away from waters edge to prevent fragmentation of riparian habitat.

Provide access points with viewing platforms, large boulders, where possible provide opportunities for play in the water (wading, floating boats)

Monitor for: garbage, invasive species (plants and amphibians), overgrowth of shrubs over time.

URBANIZED VERSIONS

RIPARIAN TRAIL
A trail along a riparian streambank

WHERE Waterfront park, neighbourhood development, commercial waterfront

FEATURES
Complete riparian edge with marsh, shrubs and tree canopy not fragmented by linear walkways

Walkway set back to allow for complete riparian edge with access along the trail through lookouts and sand beaches.

POTENTIAL SPECIES
Birds, insects, amphibians fish, waterfowl

URBAN CREEK
A creek designed to meander through an urban space

WHERE Neighbourhood parks, Large parks, plazas, school grounds, hospital grounds, streetscapes

FEATURES
Layered vegetation around all or part of the creek.
Circulating all or part of the year (often turned off for winter)
Meandering
Depth depending on safety and access
Seating, Bridges, Boardwalk

POTENTIAL SPECIES
Birds, insects, amphibians

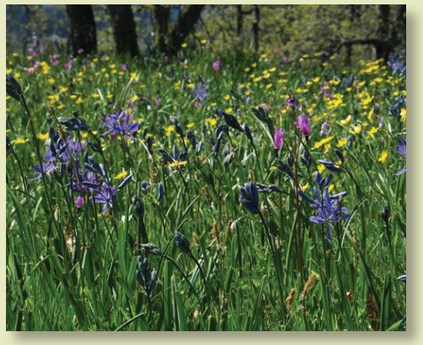
URBAN POND
A water feature, with year around water and habitat

WHERE Neighbourhood parks, Large parks, plazas, school grounds, hospital grounds

FEATURES
Vegetation around all or part of the pond for habitat
Depth depending on safety and access
Seating
Bridges
Boardwalk
A fountain or circulating creek to keep water moving

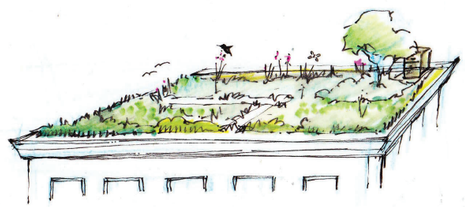
POTENTIAL SPECIES
Birds, insects

INSPIRED BY NATURAL MEADOWS (GARRY OAK MEADOW OR FOREST CLEARING)



- Natural Analogs: mixed perennials/wildflowers, native grasses and some trees. Can be wet in winter and dry in summer
- Grasses and perennials provide food for birds, insects and small mammals
- Meadows can increase stock of threatened or endangered wildflowers
- Monitor for invasive plants

URBANIZED VERSIONS



GREENROOF
Designed for habitat

WHERE
Commercial, schools, hospitals, residential

FEATURES
Mixed perennials, shrubs, some trees depending on roof. Choose native plants, plants with nectar, seeds, berries. Provide some shade
Provide easy access for maintenance. Monitor species health.

Seating, shade, water features if intensive

POTENTIAL SPECIES
birds, insects (pollinators, beneficial insects)

URBAN AGRICULTURE
For people and pollinators

WHERE
Commercial, schools, hospitals, residential, parks

FEATURES
Raised plots or garden beds with vegetables, berries, orchards and herbs
Rain capturing features for watering
Water features for habitat and placemaking

POTENTIAL SPECIES
Birds, insects (pollinators, beneficial insects)

ECOLOGICAL LANDSCAPE
Mixed ornamental plants with habitat value

WHERE
Neighbourhood parks, large parks, plazas, school grounds, hospital grounds

FEATURES

Any ornamental landscape with plants of some habitat value

Mixed native and non-native shrubs and perennials designed for aesthetics, seeds, nuts, pollen and nectar.

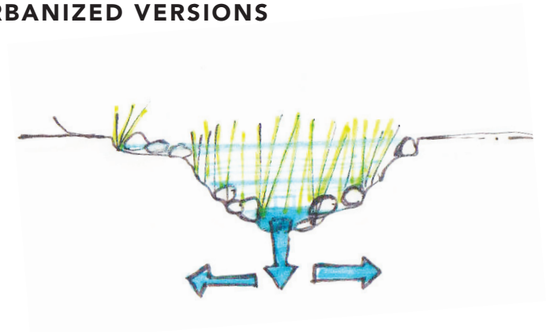
Gardens are all managed without chemicals and use no invasive plants

POTENTIAL SPECIES
Birds, insects (pollinators, beneficial insects)

INSPIRED BY NATURAL WETLANDS

- Natural analogs: Fluctuating water levels, aquatic plant species, water filtration and drainage.
- Multiple types for various applications and scales
- Designate trails outside of wetland, provide viewing platforms
- Limit public disturbance with boardwalks and fencing
- Filter water before entering wetland if for habitat
- Potential indicators of success depending on scale and location: amphibians, red wing blackbirds, dragonflies and other aquatic insects
- Monitor for water quality, overgrowth of some plants such as cattails, invasive species: yellow flag iris, purple loosestrife, invasive bullfrogs

URBANIZED VERSIONS



BIOSWALE
Habitat and stormwater management

WHERE
Neighbourhood parks, large parks, plazas, school grounds, hospital grounds, streets

FEATURES

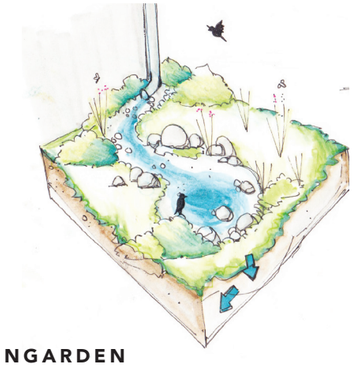
Drainage channel to slow stormwater overflow and filter pollutants before the water reaches streams, rivers and lakes.

Engineered to avoid standing water

A range of vegetation along swale including trees, grasses and perennials.

Can be creatively designed with sculptural features for interaction and aesthetics.

POTENTIAL SPECIES
Birds, insects (pollinators, beneficial insects)



INFORMAL RAINGARDEN
Habitat and stormwater management

WHERE
Neighbourhood parks, large parks, plazas, school grounds, hospital grounds, streets, residential

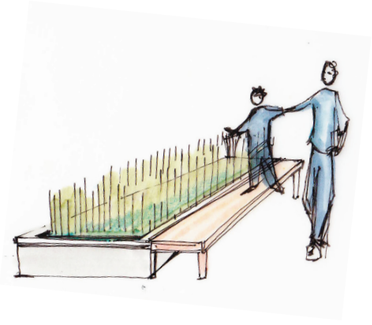
FEATURES

A planted depression collecting water from surrounding land and/or buildings

Designed with proper drainage to avoid standing water

Can be creatively designed with sculptural features for interaction and aesthetics

POTENTIAL SPECIES
Birds, insects (pollinators, beneficial insects)



FORMAL RAINGARDEN
Habitat and stormwater management

WHERE
Plazas, streets

FEATURES

A contained depression often in a raised bed or planter.

Designed with proper drainage to avoid standing water

Usually planted with grasses, moisture loving perennials and some trees

Can be creatively designed with sculptural features for interaction and aesthetics

POTENTIAL SPECIES
Birds, insects (pollinators, beneficial insects)

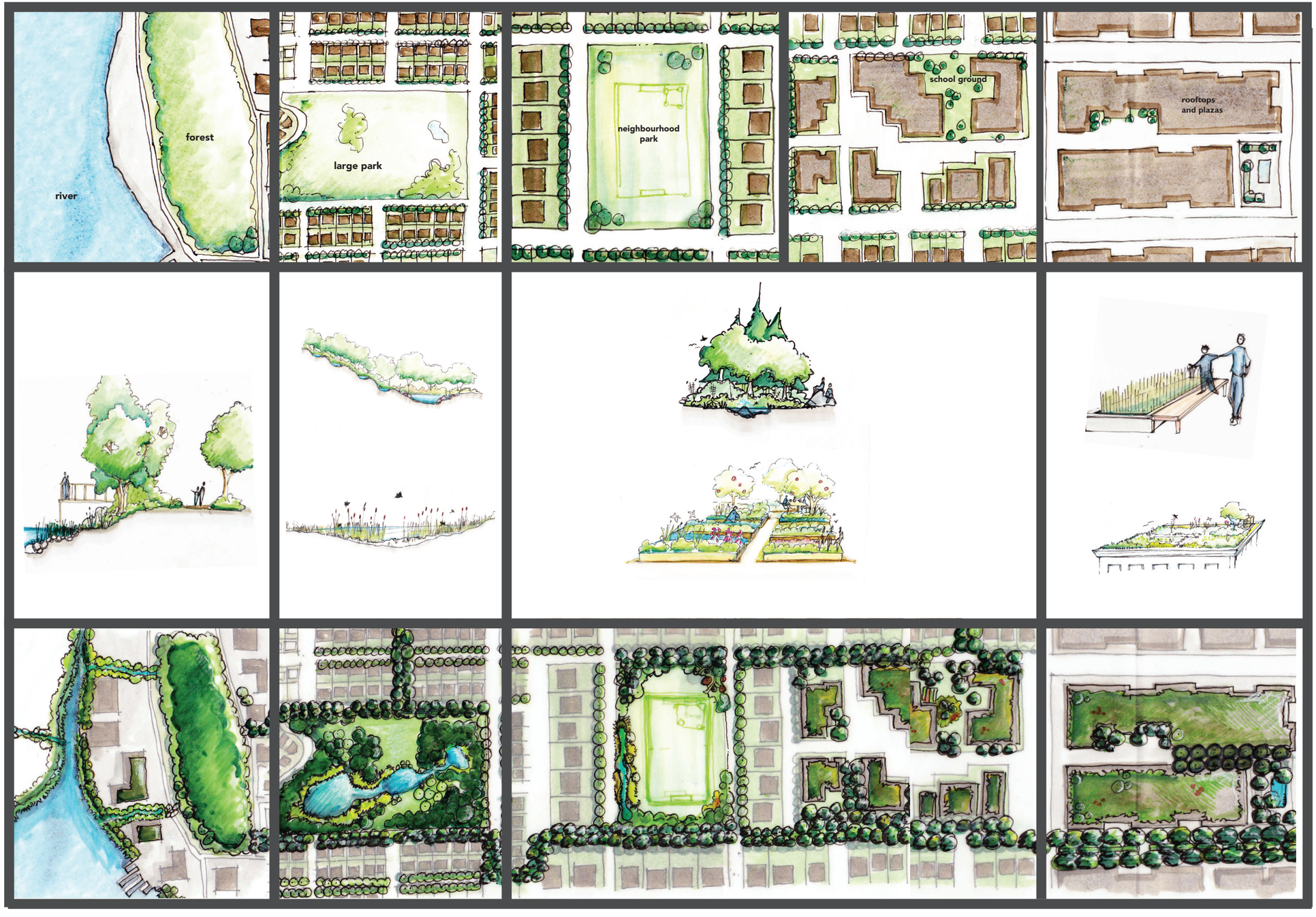
Most biodiversity

Least biodiversity

URBAN LANDSCAPES

BIODIVERSITY BUILDING BLOCKS

ECOLOGICAL NETWORK



A Note About Functional Landscapes

Ornamental landscapes beautify the urban fabric by providing green, open space and places to play. Typically these landscapes are purely for aesthetics or recreation, have little habitat value and are not managed sustainably.

A shift toward organic, productive landscapes even in the most built up environments can provide habitat while reducing environmental impact.

Street trees, already important for carbon sequestering and decreasing heat island effect can be selected with seeds, berries or fruit to feed birds (For example Hawethorne trees on Comox street in Vancouver, BC, provide important food sources for songbirds including cedar waxwings and flickers). Water features can be designed as art forms that also filter stormwater and provide habitat value with aquatic plants.

Even in the most built up environment, functional landscapes can provide ecosystem services. Greenroofs, living walls and greenstreets have been shown to "reduce stormwater runoff up to 13% (4% by green roofs, 3% by green streets and 6% by green façades), reduce building energy demand by 9%, and reduce CO2 emissions by 12%" (Roehr & Laurenz, 2008).

Potential guidelines for functional landscapes:

- Provide habitat value for birds and/or beneficial insects (bees, ladybugs for example)
- A high portion of suitable native plants (see appendix II)
- Use plants suitable for the site, for example drought tolerant plants in dry sites, moisture loving plants in wet sites.
- Prioritize soil health to support soil organisms.
- Plants provide shelter and/or berries, seeds, fruit for foraging
- Water features have elements of habitat value by providing wildlife with drinking water and water for bathing.
- No invasive plants
- Functional landscapes have no negative impact on local ecosystems

Planter box Bentall Centre, Vancouver

This garden is a mix of native and non-native plants. Native nodding onion in the centre, showcases edible natives. Drought tolerant grasses mixed with Verbena bonariensis, a perennial that attracts beneficial insects and butterflies.

It was meant to be a showcase for a sustainable garden for one summer, then be replaced with annuals. It has been there for over three years (personal experience).

Raingarden in a neighbourhood park, Vancouver

This raingarden, meanders down the slope of the park and draining to a wetland that collects the water at the base of the hill. There are dragonfiles, water insects and lush vegetation that breaks up the typical lawnscape of a traditional neighbourhood park

8.0 PRECEDENT STUDIES

Research for this project revealed there are almost no case studies of cities that have integrated habitat in design with measured outcomes. Berlin,Germany; Seattle, USA and Malmo, Sweden all have applied planning tools that integrate biodiversity into the planning processes (Biotope Area Factor, Green Factor and Greenspace Factor respectively), however there were no records measuring resulting biodiversity.

Actual instances of urban biodiversity seem to result from landscapes designed for other purposes. Central Park, for example, was designed to provide fresh air and respite from the miasma of the city. However, it's size and multiple habitat types supports a number of species including native turtles, amphibians and bird species.

Very recently, cities and designers have started incorporating ecological features into urban and landscape designs, however many of them have not yet been implemented or have not been implemented long enough to provide measurable results. Fresh Kills on Staten Island for example, is a plan designed with natural features for both people and wildlife. At the time of writing this project, the plan is only just starting to be implemented.

Although these planning tools and plans are worth further research, the following precedents have been selected because they are either established landscapes with instances of biodiversity or landscapes implemented that have prioritized biodiversity in the design process.

Precedent Study > The Red Ribbon Qinghuangdao, China

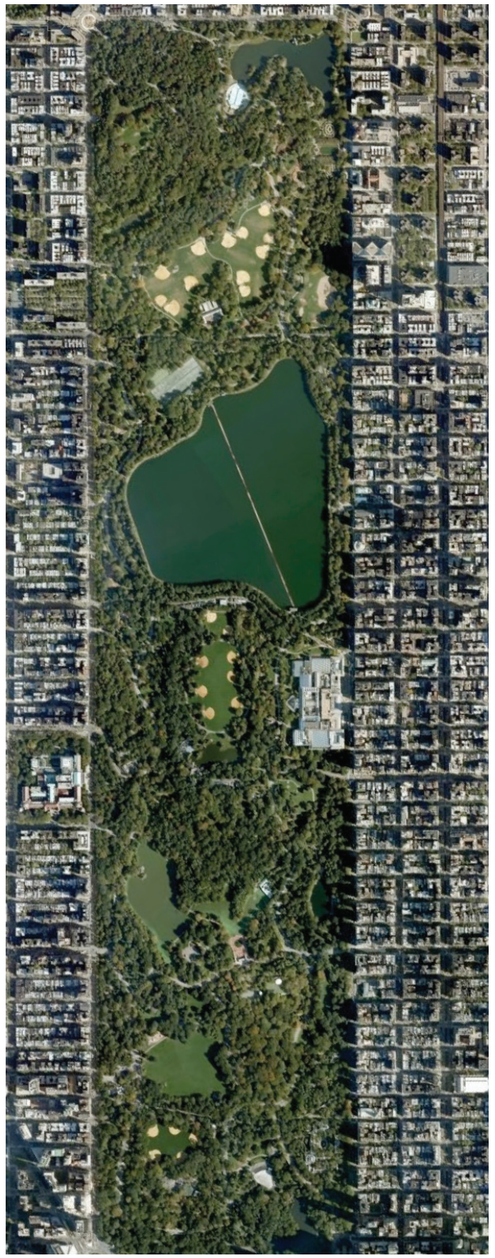
The Red Ribbon is a 1,640-foot long Boardwalk that was designed to meander along the Tanghe's riverbank providing an urban oasis for city dwellers.

The Red Ribbon was designed by Turenscape company that focusses on natural, sustainable design. The premise behind the Red Ribbon was to remediate a formal garbage dump into a natural habitat. The boardwalk and ribbon allow visitors access to the site while limiting disturbance to the natural areas as they undergo recovery.

Pavilions along the boardwalk are named after local fauna to raise awareness about the natural heritage of the area.

http://www.turenscape.com

Precedent Study > Central Park, New York City



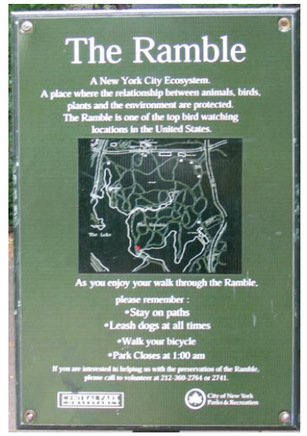
Central Park is a 843 acre park designed in the late eighteen hundreds by Frederick Lawn Olmsted and Calvert Vaux.

The designers sought to create a pastoral landscape in the English romantic tradition, with large open meadows contrasting with the more wooded "Ramble and the formal Promenade. This diversity of landscapes that includes ponds, forests and meadows, has resulted in a relatively high number of wildlife, especially considering the parks location in the centre of New York City.

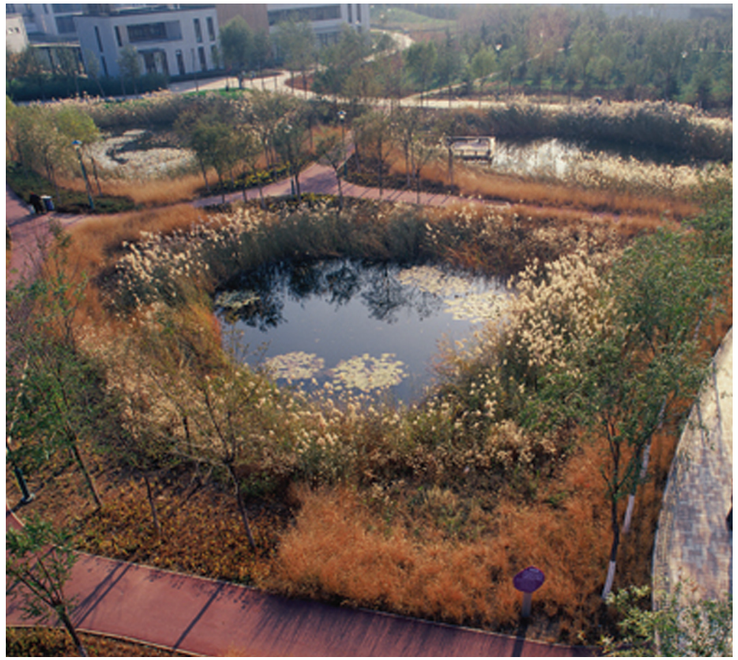
Although designed more for people, it supports a great deal of native flora and fauna. There are over 270 bird species in the Ramble alone. In 1997, Turtle Pond was renovated primarily to provide habitat to the growing populations of fish, frogs and native snapping turtles. There are bird watchers and naturalists who are constantly monitoring the wildlife in the park.

The Central Park Conservancy, a private fundraising body, is partially in charge of the restoration and management of the park. Most funds are raised through private donors

www.centralparknyc.org



Precedent Study > Tianjin Qiaoyuan Wetland Park, Tianjin City, China



The Tianjin Qiaoyuan Wetland Park is an example of a successful urban wetland that collects and filters water and also provides opportunities for visitors to connect with nature.

This 22ha park was once a severely degraded and polluted dump site in a highly urbanized setting. In 2006 a plan was put into effect to restore the degraded site. The goal for the design was to:

"*Create a park that can provide a diversity of nature's services for the city and the surrounding urban residents, including: containing and purifying urban storm water; improving the saline-alkali soil through natural processes; recovering the regional landscape with low maintenance native vegetation; providing opportunities for environmental education about native landscapes and natural systems, storm water management, soil improvement, and landscape sustainability; creating a cherished aesthetic experience.*" (Turenscape, 2010).

The result was a wetland park complete with paths and viewing platforms. The vegetation was carefully seeded and selected to adapt to the site over time through natural processes.

According the the site, the park attracts thousands of visitors everyday and in the first two months of the opening in 2008, approximately 200,000 visitors came. Stormwater is successfully filtered through the park and according to the designers, the site needs very little maintenance (Turenscape, 2010).

http://www.turenscape.com/english/projects/

Precedent Study > Mole Hill, Vancouver, BC

The West End located in downtown Vancouver, BC is one of the most dense neighbourhoods in Canada with a reported 141.9 dwellings per hectare in 2006 (Statistics Canada, Census).

West Enders find relief from the density in the open ocean, the sea wall and Stanley Park. There are also numerous street trees and gardens found throughout the neighbourhood.

Mole Hill, a social housing complex is particularly rich with urban habitat. Lining the back lane are community gardens and edible landscapes this lane is connected to Nelson Park through a native plant walkway mid block. Along the street are Hawthorns with berries that provide a substantial source of food for birds. Nelson Park is a multi-functional neighbourhood amenity complete with community gardens, a pond and a dog park.

Collectively these landscapes form a ribbon of habitat that is frequently used for food, water and shelter by birds and insects.

The pedestrian walkway, layered with trees, shrubs and perennials, provide habitat for songbirds not usually spotted in an urban setting and surprisingly few invaders such as pigeons or starlings.

Many people go out of their way to visit or pass through the walkway. Rarely is a bench empty and children are constantly found playing by the stream (personal experience).

WILDLIFE OBSERVED IN PEDESTRIAN WALKWAY

- Red wing blackbirds
- Cedar waxwings
- Flickers
- Western Taneger
- Chickadee
- Hummingbirds
- American robin
- Monarch butterfly
- Dragonflies
- Invasive bull frog

Precedent Study > Highline, New York City

The Highline in New York City integrates naturalized landscapes throughout the linear park from drought tolerant landscapes to ecological refuges not publicly accessible.

The Highline is an elevated, linear park adapted from an old rail line used to lift freight trains off the streets below. When the elevated rail line was slated for demolition, the organization, Friends of the Highline was founded by two neighbourhood residents in an effort to preserve the site.

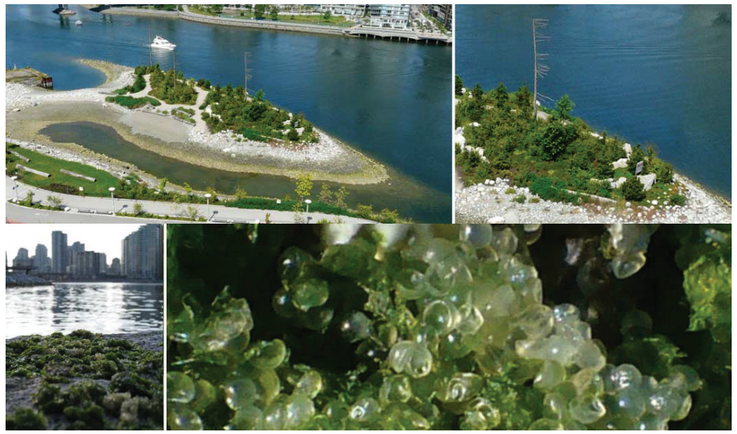
The park was opened in 2009. Once all of the sections are finished the park will run a mile-and-a-half-long, through the West Side neighborhoods of the Meat packing District, West Chelsea and Clinton/Hell's Kitchen. This will ideally provide a linear habitat corridor for birds and insects in the city.

The Park is now owned by New York City Parks and Recreation. The maintenance and funding is managed by Friends of the Highline.

Key features of the site include naturalized landscaping, movable furniture and paths.

http://www.thehighline.org/

Precedent Study > South East False Creek & Habitat Island, Vancouver BC



Habitat Island and Herring Return. Source: PWL partnership.

South East False Creek, is an award winning Vancouver development completed in 2010. It was designed with a number of features that contribute to ecological health:

Approximately 50% of the buildings are covered with greenroofs and rainwater is locally treated through a wetland before it enters False Creek. Raingardens are also incorporated into many of the landscapes (COV, 2010)

Habitat Island, was built in an effort to compensate for the portion of shoreline that was taken up by development. The island was built with over 200 native trees and shrubs to support aquatic species and shorebirds. Shortly after completion, herring spawned on the shallow benches resulting in a herring run that has not been seen for decades. The island is accessible to the public and managed by the Vancouver Park Board (Bayley, 2010; COV, 2010). A biologist was involved in the design of the wetland and habitat island.

Many of the landscapes are planted with native plants and/or drought tolerant non-native plants, many of which attract beneficial insects.

Habitat Island path from mainland. Source: Author

Native plantings. Source: Author

Constructed wetland. Source: Author

Drought tolerant plantings. Source: Author

Pacific Flyway (Texas Parks & WIldlife)

Temperate Rainforest Source: Creative Commons

This project uses the Cambie Corridor, a major street corridor in Vancouver, BC, as a test site to explore habitat integration. The Cambie Corridor runs along Cambie Street from 16th avenue to the Fraser river.

It is an area of interest because: it is currently up for redevelopment, it is rich in a range of greenspaces and greenways and it involves the Fraser River, a significant ecosystem to British Columbia.

This design approach is a conceptual exploration, design and implementation of each site will require more rigorous ecological assessment, design guidelines and maintenance strategies.

REGIONAL CONTEXT

Vancouver and it's surrounding region, has globally significant ecosystems. It is part of the Pacific Temperate Rainforest, the largest temperate rainforest in the world, home of the Fraser River, the largest salmon producing river in the world and located in the Pacific flyway where millions of birds migrate to the Fraser River estuary, the largest estuary along the Pacific coast (Butler and Campbell 1987; BCS, 2008). Vancouver is also surrounded by the rich aquatic habitat of the Pacific Ocean, the marine life of which is the some of the most diverse in the world (Cannings, 2006). With ecosystems so rich, it is no wonder that humans have graced this area for thousands of years.

Sprawl, resource exploitation and human activity, degrades these significant ecosystems and limits opportunity to protect large intact areas from further impact (LUCK, 2007). Metro Vancouver's ecosystems are experiencing this very impact.

In 2008, The Biodiversity Conservation Strategy Partnership (BCSP) a partnership of government and organizations devoted to biodiversity conservation in the Metro Vancouver region, released the report "*Strategic Directions for Biodiversity Conservation*"in an effort to "better integrate biodiversity into land use policies, plans and programs"...It "supports regional collaboration and effective conservation efforts on the ground"(BCS, 2008).

This report revealed that most of the wetlands in the Lower Fraser Valley were impacted by urbanization or agriculture" (BCS, 2008). An estimated 1,500 hectares of tree cover were lost between 1986 and 2002 and there are approximately 100 species designated as Red or Blue species at risk including: "8 mammals, 24 birds, 3 amphibians, 1 reptile/turtle, 12 fish, 6 dragonfly/ damselfly species, and 43 plant species" (BCS, 2008)

Metro Vancouver Recreation and Conservation Areas in proposed Regional Growth Strategy Source: http://www.metrovancouver.org

REGIONAL STRATEGIES TO ADDRESS ECOSYSTEM DECLINE

Regional Growth Strategy

The Regional Growth Strategy (RGS), developed by Metro Vancouver and membership municipalities, is a document that sets out regional strategies to achieve livability as the region grows. Each municipality is bound by legislation to follow these strategies.

One of the major components of the RGS is to protect the Green Zone:"*The Green Zone protects Greater Vancouver's natural assets, including major parks, watersheds, ecologically important areas and resource lands such as farmland. It also establishes a long-term growth boundary.*" (GVRD, 2010). The Green

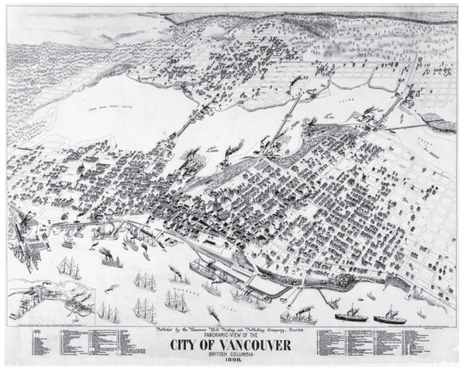
There is a new Regional Growth Strategy currently being developed. In this document the greenzone is has been re-named Conservation and Recreation areas, and consists of major parks, wetland and natural assets, not including agricultural lands (GVRD, 2010).

	LEGISLATION	DESCRIPTION (how it relates to biodiversity conservation)
FEDERAL	Canadian Environmental Protection Act	Is an amalgam of several acts concerning environmental standards, protection, and penalties for violation. It deals primarily with regulation of pollution.
	Canadian Environmental Assessment Act	Ensures that a rigorous environmental assessment and public consultations are performed on projects carried out by the federal government or Crown corporations.
	Canada Marine Conservation Areas Act	Enables the establishment of marine conservation parks and a network of marine protected areas.
	Canada National Parks Act	Maintains and restores the ecological integrity of Canada's national parks.
	Canada Wildlife Act	Authorizes the acquisition of land by the federal government for creating National Wildlife Areas and protecting marine areas.
	Fisheries Act	Subsection 35(1) is a general prohibition of harmful alteration, disruption or destruction of fish habitat.
	Income Tax Act	Includes provisions for ecological gifts
	Migratory Birds Convention Act	Prevents the commercialization of migratory birds by hunting and trafficking, and allows the federal government to establish Migratory Bird Refuges.
	Oceans Act	Allows Canada to enforce its rights and responsibilities over exploration and exploitation of living and nonliving resources in the Exclusive Economic Zone (EEZ), which extends for 200 nautical miles off Canadian coasts.
	Species at Risk Act (SARA)	SARA provides for scientific assessment of the status of species through an organization (COSEWIC) and applies to all federal lands in Canada.
PROVINCIAL	Agricultural Land Commission Act	Sets out processes for land use approvals including the inclusion or removal of land from the Agricultural Land Reserve, non-farm uses and subdivisions.
	Agricultural Land Reserve Use, Subdivision and Procedure Regulation	Details procedures for applications and defines permitted land uses and land subdivisions within the Agricultural Land Reserve.
	Drainage, Ditching and Diking Act	This Act establishes a comprehensive scheme for the regulation and authorization of ditches, watercourses, dikes and drainages throughout B.C.
	Drinking Water Protections Act	Covers all water systems other than single family dwellings and outlines water requirements for water supplies.
	Ecological Reserves Act	Provides for the establishment and administration of ecological reserves in the Province. New ecological reserves are created by regulation (order-in-council).
	Environmental Assessment Act	Proposed projects designated as reviewable projects as a result of prescribed type, size, scope or location are subject to an environmental assessment.
	Fish Protection Act	Prohibits dams, designates sensitive streams, limits Water Act approvals and licenses on sensitive streams, and allows the development of recovery plans and actions to protect fish habitat.
	Land Act	Governs the disposition, management and administration of Crown land and for base mapping and land information systems in B.C.
	Park Act	Prohibits any person from transporting garbage, refuse, domestic or industrial waste through, in, or over a park except with a permit for park use.
	Riparian Areas Regulation	Enacts sections 12, 13 and 37 of the Fish Protection Act. Establishes directives to protect riparian areas from development so that the areas can provide natural features, functions and conditions that support fish life processes.
	Waste Management Act	Prohibits the discharge of all wastes to the environment and pollution, unless the discharge is exempt or is made in accordance with a system of permits or approvals.
	Water Act	Legislation for managing the diversion and use of provincial water resources including: flow regulation; authorization of water use development; water supply, pollution control; and power development.
	Wildlife Act	Enables the listing of plant, animal and invertebrate species at risk and protection of the residence of a listed species through the designation of Wildlife Management Areas.
REGIONAL	Regional Growth Strategy	A shared commitment among member municipalities and the region that provides a long range vision and framework for land use policies.
LOCAL	Official Community Plans (OCP)	A statement of objectives and policies to guide decisions on planning and land use management, respecting the purposes of local government.

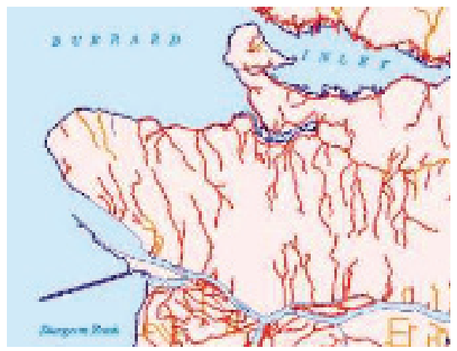
Federal, provincial, regional and local legislation conserving and protecting biodiversity

- Source: BCS, 2008

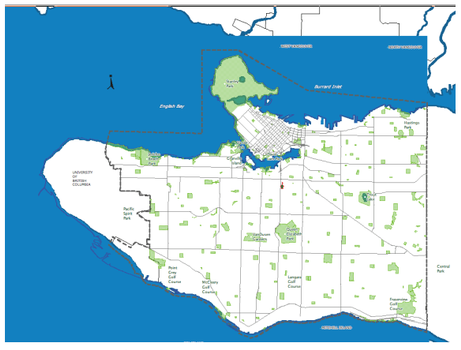
Vancouver Context:



Vancouver 1898



Lost Streams of Vancouver in Red. Source: DFO, 2010


Vancouver Today. Source: VanMap, 2010

Before European contact, Vancouver, located in the Coastal Western Hemlock Biogeoclimatic zone, was predominantly forests and creeks bordered by the Fraser River and the Burrard Inlet (Cannings, 1996). Old growth forest, rich riparian and marine ecosystems likely provided habitat for bears, cougars, deer, moose, birds of prey, sturgeon, whales and dolphins. There were an estimated 100,000 salmon spawning in over 50 creeks that dominated the Vancouver landscape (MECS, 2009).

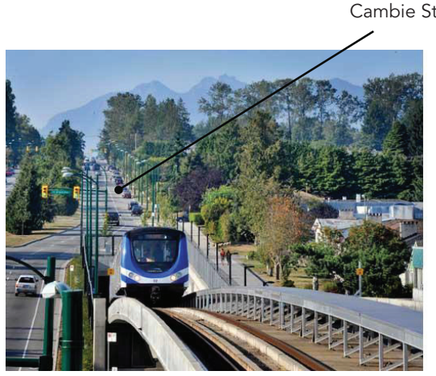
Now, as one of the largest and most dense cities in Canada, Vancouver is predominantly built up. Only two remaining salmon spawning creeks remain Still Creek and Musqueam Creek, both undergoing enhancement (MECS, 2009; COV, 2009). The only other predominant remnant ecosystems include Stanley Park, Renfrew Ravine, the Fraser River and the Burrad Inlet.

Vancouver now has over 200 parks, most of them human-made. Some of these parks provide a surprising range of biodiversity. Stanley Park ecological Society is currently monitoring 17 eagles nests throughout the city. A heron rookery has been established over a number of years where hundreds of herons come to breed in the spring (SPES, 2010). VanDusen Gardens ponds, streams and vegetation provides habitat for osprey, breeding owls, falcons, songbirds, coyotes and amphibians. The recently built habitat island in South East False Creek resulted in a surprising herring return in 2009 (COV, 2010).

Vancouver Parks Board is responsible for the design and maintenance of these parks. The Parks Board works with a number of local non-profit organizations that are involved in protecting and restoring nature in the city. Stewardship groups remove invasive species, restore parks and provide public education. Streamkeepers monitor, restore local streams while educating the public, government bodies and development about local stream protection. Groups such as Evergreen and Environmental Youth Alliance work with school groups and organizations naturalizing school grounds and public parks.


STANLEY PARK
• 30 mammal species,
• 236 bird species,
• 10 amphibians and reptile species,
• 72 freshwater and marine fish,
• Over 192 genera of invertebrates
- SPES, 2010
Stanley Park
VANDUSEN BOTANICAL GARDEN:
"Osprey, mergansers, coopers hawks. red tail hawks, bard owls, sawett owls, kingfishers, heron, ruby crowned kinglets, coyotes, turtles (invasive pet store variety), humming bird nests, wood ducks, salamanders, crows and ravens, eagles, pine siskins, herons, flickers, nuthatches, chickadees, stellar jays, wrens, bushtits, cedar wax wings, yellow warbler, towee, junkie, red winged blackbirds, moles"
- Gardener, VanDusen Botanical Gardener, 2010
VanDusen Botanical Garden

10.0 STUDY SITE > Cambie Corridor



The "Cambie Corridor" runs along Cambie Street from 16th Avenue to the Fraser River and encompasses roughly 2 blocks on either side. However for the purpose of this project, some features will extend to Main St to the East and Oak St to the West.

In 2009, the Canada Line, a new rapid transit system, opened along Cambie Street, creating a redevelopment opportunity for the City of Vancouver. The following excerpt comes from the Cambie Corridor Planning Program web site:

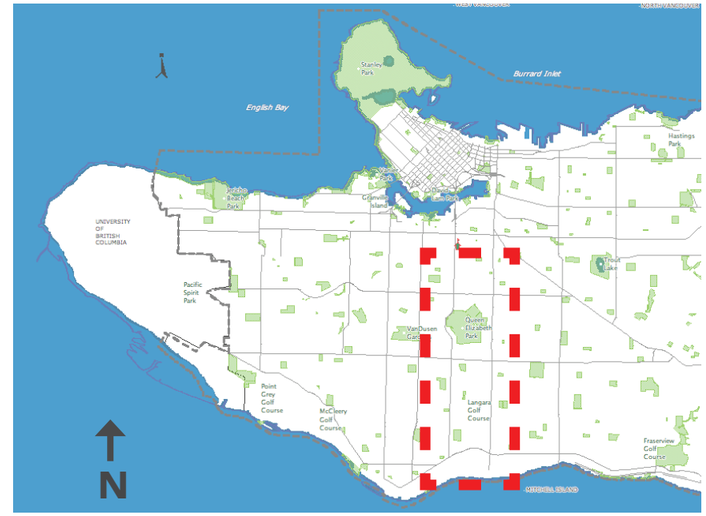
"*To take advantage of this transit investment, the City has embarked on a major planning initiative to develop a land use policy plan for the Cambie Corridor between 16th Avenue and the Fraser River. The plan will focus on opportunities to integrate development with transit along and around the Canada Line to support the City's goals of environmental sustainability, livability and affordability*" (CCPP, 2010).

There are a number of reasons why the Cambie Corridor provides an opportunity to explore habitat integration.

- There is a well defined patch, corridor and matrix infrastructure found in the existing greenspace. Although none of the "patches" are natural remnants, the large patches, or large parks, already have some biodiversity.

- The Greenest City Initiative strategy addresses increased access to nature, enhance the urban forest and the restoration of ecosystem services.

- Finally, the City of Vancouver has a number of strategies to improve watershed health through stormwater management and storm sewer updates. Habitat integration with an emphasis on protecting the Fraser River through stormwater management could potentially reduce current stormwater impacts on aquatic ecosystems in the Fraser River.




Langara Golf Course


Neighbourhood Park


Trail around Langara Golf Course


Fraser River


Queen Elizabeth Park


Heritage Boulevard

Cambie Corridor > Planning Process

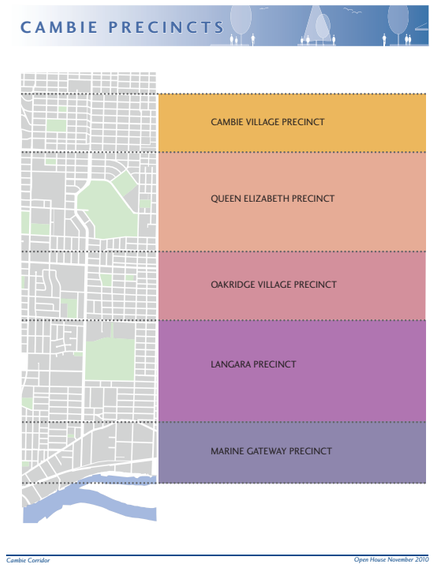
CAMBIE PRECINCTS

At the time of writing this project, the future plan for the Cambie Corridor was to focus density and commercial use around the transit stations. New commercial areas will build off existing commercial areas which include:

- The Cambie Village around 19th and Cambie St.:
- Around Oakridge Mall at 41st and Cambie
- At Cambie St and South West Marine Drive

Precincts have been developed around these commercial areas, existing and future transit stations and distinct features along the corridor. These are currently being referred to as:

Cambie Village Precinct
Queen Elizabeth Precinct
Oakridge Village Precinct
Langara Precinct
Marine Gateway Precinct



Cambie Precinct concepts for the 2010 public open house (CCPP, 2010).

GUIDING PRINCIPLES FOR THE CAMBIE CORRIDOR:

Principle 1
Provide land use that optimizes the investment in transit land uses along the Cambie Corridor will optimize a shift in travel choice to walking, biking and taking transit.

Principle 2
Provide a complete community
Living close to where you work, shop, play and learn – that is the essence of a complete community.

Principle 3
Create a walkable and cycleable corridor of neighbourhoods seemlessly linked to public transit. Bikeways and greenways currently exist along the Corridor and can help increase accessibility to transit.

Principle 4
Focus intensity and community activity at stations and other areas with strategic opportunities for sustainability, renewable energy and public amenity.

Principle 5
Provide a range of housing choices and affordability.

Principle 6
Balance city-wide and regional goals with the existing community and its context. The Emerging Plan for the Cambie Corridor will help address broader goals of sustainability while encouraging varied urban design responses based on the context of the surrounding community.

Environmental goals:

• Emphasizing walking, cycling and transit as preferred transportation options

• Focussing activity and intensity close to transit, allowing people to drive less and reduce greenhouse gas emissions

• Requiring passive design approaches for new/existing development, district energy/heating and urban agriculture

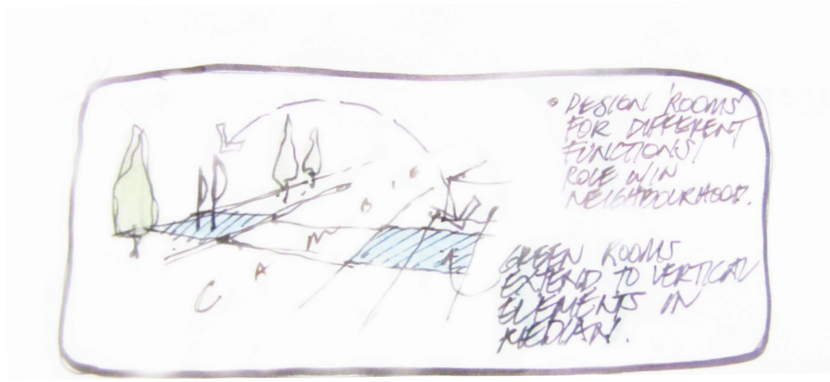
Principle 7

Ensure job space and diversity

As outlined in the Graphic / written description of the Council approved Planning Principles (CCPP, 2010)

THE PUBLIC REALM PLAN

The public realm plan, addresses greenspace (parks), civic space (plazas), greenway, streets and the boulevard. The city is also aiming to incorporate a habitat layer into the public realm plan that will identify goals and strategies to protect, restore and enhance habitat in both the blue zone (Fraser River) and the Green Zone (Cambie to 16th) over time. The work of this project will explore these goals and strategies and what they might look like on the ground.



Sketch for the Public Realm Plan. Matthew Roddis, 2010

Cambie Corridor > Site Analysis: Greenspace

LARGE PARKS

Queen Elizabeth Park
Located at Cambie Street at West 33rd Avenue, this park is 52.78 hectares and is located at the highest point in Vancouver. Highly manicured gardens are situated at the centre, while the outer landscapes are dominated with grass, large trees and ponds. There are 3000 trees in total in the park. There are a reported 6 million visitors a year to the park (COV, 2010). This park is part of the green zone in Metro Vancouver's Regional Growth Strategy.

Langara Golf Course
Also in the Green Zone, Langara Golf Course, owned by the City, is a 48 hectare, 18 hole golf course. In 2004 it received designation as a Certified Audobon Cooperative Sanctuary:

"*The Audubon Cooperative Sanctuary Program for Golf Courses (ACSP-Golf) is an award winning education and certification program that helps golf courses protect our environment and preserve the natural heritage of the game of golf. The program helps golf officials enhance the valuable natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf operations*" (Audobon International, 2010).

A forested trail system runs the entire perimeter of the park for public use. This trail is planted with mostly native trees and shrubs.

Neighbhourhood Parks and Institutional Greenspace:
There are approximately 12 neighbourhood parks in the corridor, 15 public schools, 2 hospitals and one campus – Langara College (COV, 2010). These smaller greenspaces collectively creating significant opportunities for habitat "stepping stones" or "patches" between larger parks.

CORRIDORS

The Heritage Boulevard
Running the length of Cambie Street, The Heritage Boulevard reflects the original design of the city and in many parts features large majestic trees. It was designated a municipal heritage site in 1993 (COV, 2010). The digging up of a part of the boulevard during the building of the Canada line was widely protested by the public.

Greenways
Four greenways weave through the Cambie Corridor: Ontario St, 37th Ave (Ridgeway Greenway), 59th ave (North Arm Greenway) and Fraser River Greenway. The goals for Greenways set out by the City of Vancouver are:

- Make walking more interesting
- Make cycling safer and more convenient
- Reduce the impact of the car
- Make the Greenway 'greener'
- Use public art to make the Greenway more interesting

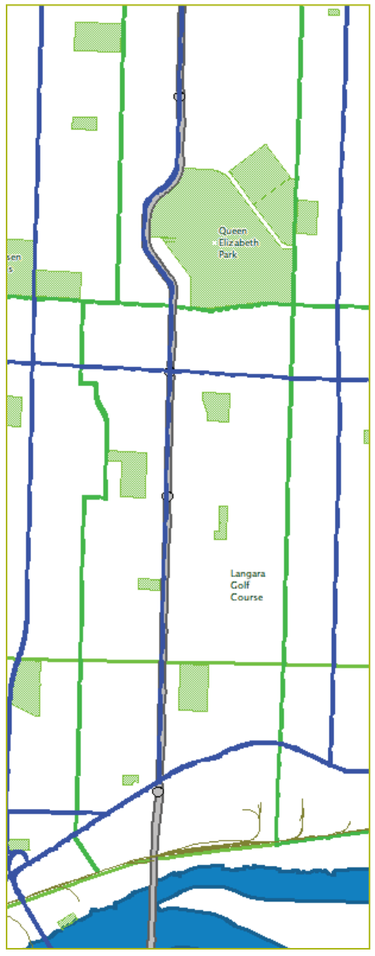
Pedestrian Walkthroughs
A future concept for implementation throughout the corridor are pedestrian oriented walkways from commercial and residential areas to greenspaces.

REMNANT ECOSYSTEMS

The Fraser River

The one remnant ecosystem in the Cambie Corridor, This River is a major feature of the site. It is globally significant for salmon runs but also an important feature that connects Vancouver to the Fraser Valley and as a "working river" contributes to goods movement through the region. The shoreline of the Fraser along the Cambie Corridor is within an industrial zone.
There are no natural streams left in the Cambie Corridor

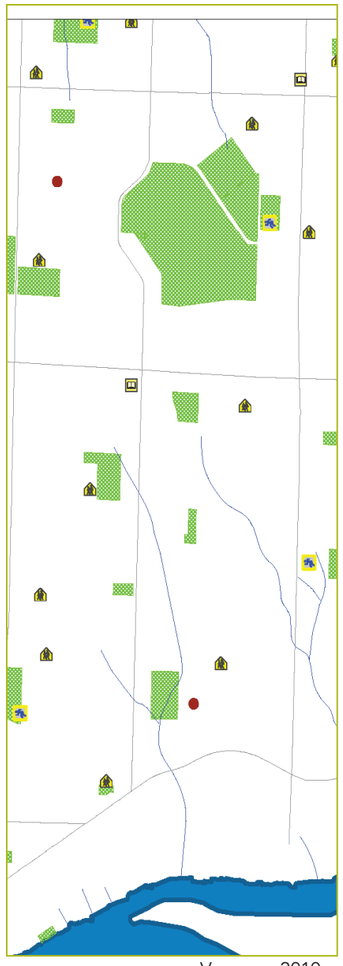
Cambie Corridor > Site Analysis: Circulation, Public Amenities, Land Use



Vanmap, 2010

Circulation

When considering wildlife corridors, Streets with the least vehicle traffic would likely be the safest for wildlife species. These include bikeways, greenways and traffic calmed pedestrian streets where vehicles are not as prevalent.



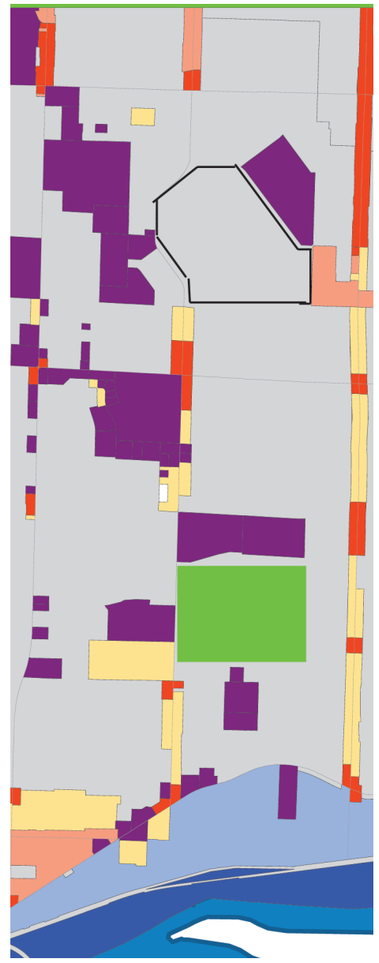
Vanmap, 2010

Public Amenities

Amenities within the Cambie Corridor include a number of schools, both secondary and elementary, a college campus, Langara College; BC Womens and Children's hospital and Pearson Clinic.

The location of many of these amenities are within walking distance of greenspaces, providing opportunities to connect people to nature.

It is also worth exploring habitat integration within these greenspaces with relevant landscapes such as natural play spaces or healing gardens



Vanmap, 2010

Land Use

The Cambie Corridor is largely low density residential. There are three key commercial areas: Cambie Village, Oakridge Mall and surrounding area and the Cambie Street, SW Marine intersection.

Industrial Land use is located at the foot of Cambie Street between SW Marine and Fraser River. Current policy is to keep this industrial.

There may still be opportunities to restore the riparian edge of the Fraser River, despite industrial activity (COV, 2010).

Cambie Corridor > Site Analysis: Water

The Cambie Corridor slopes toward the Fraser River.

Both the topography and storm sewer infrastructure influence water inputs into the river.

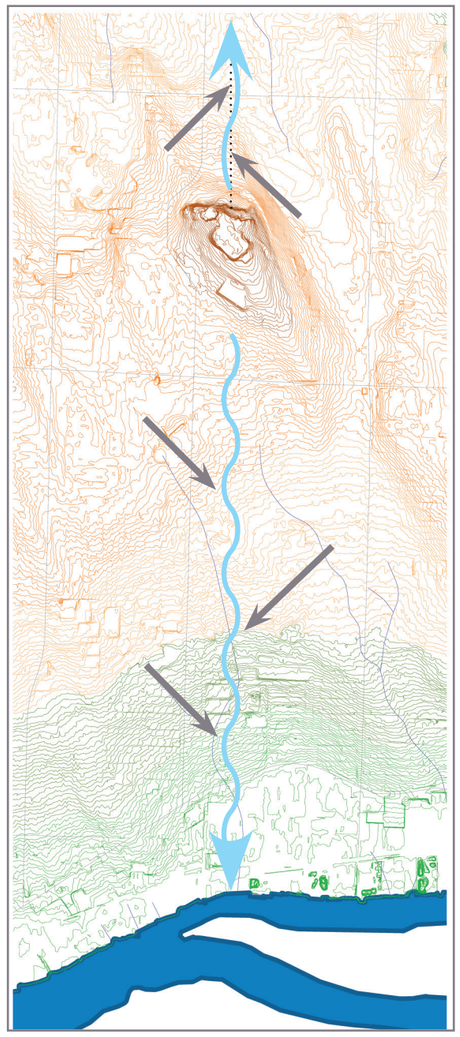
Vancouver's wastewater primarily goes to a treatment plant. There are a number of combined sewer outflow pipes that combine sewer and stormwater, during heavy rainfall, there is risk of raw sewage entering Fraser River or Burrard Inlet through these pipes. Wastewater can be high in contaminates harming aquatic wildlife. Vancouver's current strategy is to separate all of the CSO's by 2050 (COV, 2009)

Stormwater, drains and piping designed to collect rainwater from the cities impermeable surfaces, does not lead to a treatment plant, instead they eventually discharge in local waterbodies. The runoff water can carry a high pollutant load collected from streets, driveways and parking lots where oil leaks, sediments, metals, chemical pesticides and fertilizers, hydrocarbons and litter accumulate. Once in waterbodies, these pollutants can harm aquatic wildlife and disturb the natural water balance (Marsh, 2010; EPA, 2010).

With the dominance of impermeable paved surfaces combined with the stormwater system, rainfall, especially after large events discharge into water bodies very quickly, in more technical terms, there is a shorter lag time from peak of storm to peak of stream discharge (Marsh, 2010). This dumps pollutants in water bodies, and can cause severe erosion of the stream bank, rapidly fluctuating water levels, especially in rivers and streams, impacting fish habitat and water quality.

Although Metro Vancouver and the City of Vancouver are taking measures to capture storm water, it is also important to design infrastructure to both remove pollutants and mimic the natural drainage times of rainwater from peak to discharge.

Stormwater management applications such as rain gardens, bioretention, rain barrels, vegetated swales, tree box filters, curbless roads with swales, pervious pavement, greenroofs raingardens, bioswales and retention ponds have proven to be effective, and often result in creative landscape designs solutions.

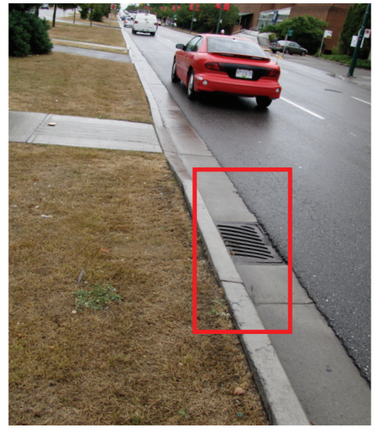


The highest point in the Cambie Corridor is just South of Queen Elizabeth Park. From there water flows North and South through stormwater infrastructure where it eventually ends up in the Burrard Inlet and the Fraser River.

Marselek at al offer additional recommendations for both the neighbourhood and watershed scale:

- Minimize road width, romove curbs and gutters and direct run-off into bioswales
- Parking lots should be constructed with pervious pavements or integrated with detention systems, swales and constructed wetlands
- Create riparian buffer zones with constructed wetlands to retain and filter pollutants
- Limit direct out fall discharging into streams
- Build natural river channels within the riparian zone
- Designate sections within buffer zone for temporal storage of water, enough for large storm incidents

(Marselek & Shrier, 2008)



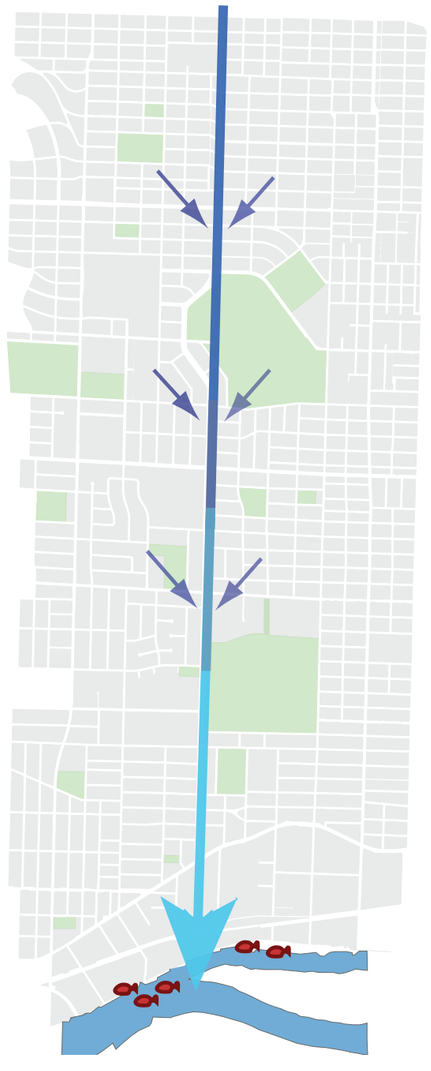
Stormdrain beside the Heritage Boulevard, Cambie Street.

Source: author

GOAL 1. PROTECT AND RESTORE FRASER RIVER AND BURRARD INLET (BLUE ZONE) AQUATIC HABITAT THROUGH POLICY, DESIGN AND LAND MANAGEMENT.

Strategies:

- Limit point and non-point source pollutants from landscape fertilizers and pesticides, and surface flow toxins from the city into the Fraser River and Burrard inlet and through CSO (combines sewer outflow) restructuring. Remediate contaminants from industrial activity.
- Implement stormwater management in all new developmentb and in any new infrastructure upgrades
- Restore riparian fish habitat
- Consider creating channels into industrial area to foster fish spawning.
- Connect other habitat to the Fraser River through habitat corridors
- Adopt a "Net Gain" fish habitat policy.



GOAL 2. ENHANCE AND PROTECT EXISTING BIODIVERSITY, CREATE NEW HABITAT

Strategies:

- Map existing biodiversity of the Cambie corridor to inform future planning and land management strategies
- Limit chemical (fertilizers and pesticides) pollutants in all parks.
- Convert the Langara Golf Course to and organic course. Consider dedicating a large portion of the Langara Golf Course to amphibian habitat through a series of bioswales, ponds and wetlands. Limit disturbance with boardwalks involving public art, seating areas and educational pavilions.
- Create a vegetative buffer around Queen Elizabeth Park. Enhance habitat around existing ponds for amphibians. Increase tree cover. Considering incorporating an interpretive native forest that will mimic the natural history and geology of the area.
- Create an environmental management plan for existing biodiversity in VanDusen Botanical Garden.

GOAL 3. CONNECT HABITATS THROUGH HABITAT CORRIDORS

Strategies:

- Create continual canopy coverage the entire length of the greenway using native trees, fruit and seed baring trees in mixed stands. Choose trees that have both aesthetic and habitat value.
- Designate greenways and/or pedestrian walks as habitat corridors, particularly those connecting water bodies and large parks.
- Incorporate understory shrub and herb layer plantings through the greenstreet program, traffic circles, bump-outs and planters. Keep site lines open to for public safety (layer tree sizes and underplantings, stager shrubs).
- Implement bioswales and other stormwater management servic-es vices throughout the entire greenway to provide a continuous water source. Provide water features of some form intermittent-ly along corridor, designed for birds.

GOAL 4. WEAVE BIODIVERSITY INTO THE URBAN FABRIC

Strategies:

- Designate areas with high habitat value and opportunities for increased nature/culture connections– along corridors, near large parks, along waterways.

- Incorporate green infrastructure with some function for habitat or food production- greenroofs, greenwalls, balconies, street plantings, rain gardens, food gardens. Choose plants with nectar, pollen, seeds, fruit or nuts where possible.

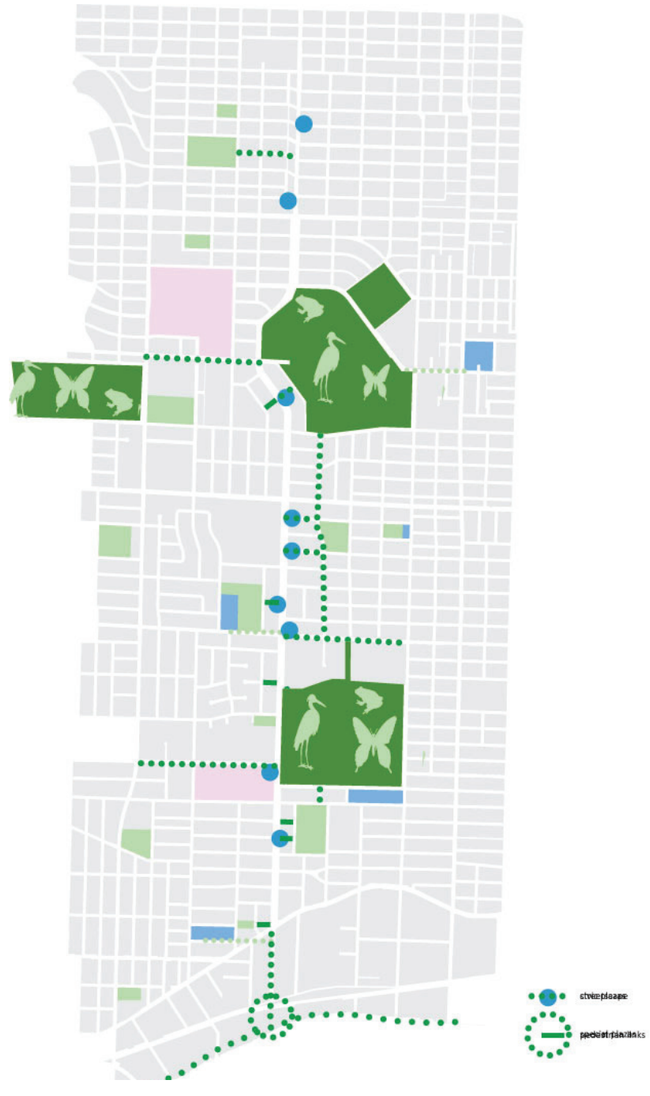
- Promote naturescaping of residential yards through education campaigns and partnering with local nurseries and the landscape industry

- Limit light pollution where possible as it can alter breeding patterns

GOAL 5. PROVIDE NUMEROUS OPPORTUNITIES FOR ALL URBANITES TO CONNECT WITH NATURE.

Strategies:

- Designate areas in a "habitat zone" for quiet contemplation, play, eating, gardening and stewardship
- In areas of sensitive habitat, create viewing platforms and board-walks to limit disturbance.
- Where possible, create safe places with no light pollution for star gazing
- Create programming for education and interpretation
- On hospital grounds plant landscapes with healing properties
- On school grounds create natural play spaces, food gardens and habitat gardens for education and interaction. Create pedestrian walkways for safe access to large parks for curriculum opportunities and after school play.
- Provide seating, picnic benches, natural playgrounds in areas where habitat can be disturbed



GOAL 6. MAINTAIN LONG-TERM ECOLOGICAL HEALTH OF BOTH BLUE AND GREEN ZONES THROUGH SUSTAINABLE MANAGEMENT AND MONITORING

Strategies

Enforce chemical pesticide and fertilizer ban on all landscapes including golf courses

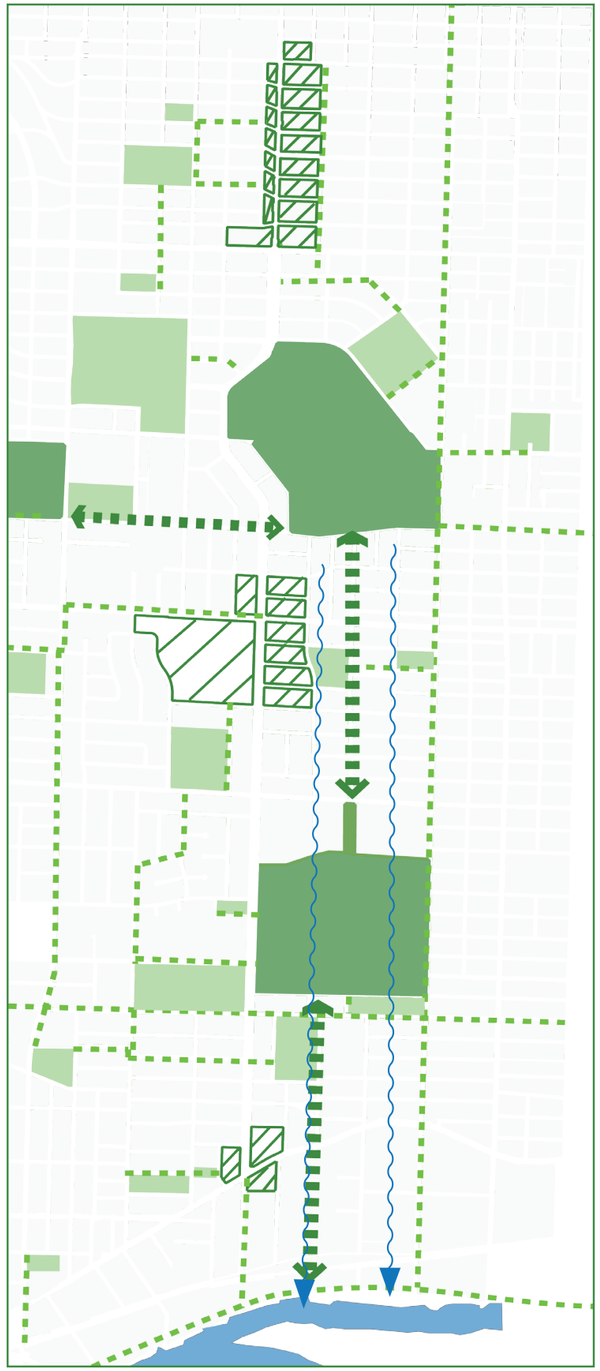
Decrease presence of lawn. Only use lawn for sports fields, picnic areas, and outdoor entertainment. Where lawn is implemented use lawn species cultivated for minimal watering and mowing. Use only organic fertilizers and mechanical or biological pesticide controls.

Develop a land steward certification for professionals to learn to environmentally manage habitat

Develop policies banning invasive plant cultivation, planting and sales and/or work with invasive plant councils to develop an aggressive public awareness campaign about invasive plants

Monitor species health through inventory and mapping projects

Cambie Corridor > Habitat Spectrum



LEVEL I
THE FRASER RIVER

Protect and Restore

Stormwater management, riparian restoration, creek day lighting and creation of spawning channels

LEVEL II
LARGE PARKS (QUEEN ELIZABETH PARK AND LANGARA GOLF COURSE)

Enhance and Protect

High quality habitats, urban forest, constructed wetlands, urban meadows, ponds and streams

LEVEL III
NEIGHBOURHOOD PARKS AND INSTITUTIONAL GREENSPACE

Integrate habitat

Bioswales, raingardens, natural playgrounds, wild corners, food gardens.

LEVEL IV
COMMERCIAL OPEN SPACE

Integrate habitat

Greenroofs, formal raingardens, urban ponds, natural walkways, urban oasis, functional landscapes

CORRIDORS
RESIDENTIAL STREETS, GREENWAYS, PEDESTRIAN WALKWAYS, STREETSCAPES, BOULEVARDS, RIGHT OF WAYS.

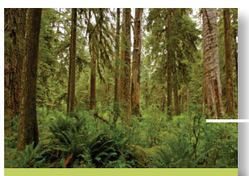
HABITAT CORRIDOR - Connecting remnant ecosystems and habitat in large parks

ECOLOGICAL NETWORK - Increase habitat connections througout the city, connect people to nature along greenways, pedestrian walkways and quiet residential streets.

STORMWATER MANAGEMENT - Integrate bioswales, constructed wetlands and stormwater management applications in streets, parks, boulevards to filter and manage stormwater before it reaches the Fraser River

11.0 HABITAT INTEGRATION IN THE CAMBIE CORRIDOR

Natural playgrounds in parks



Urban Forest

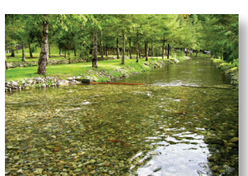
Bioswales in parking lots

Bioswales in sportsfields

Daylit streams

Wetlands in new developments

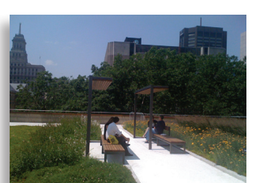
Raingardens in boulevards



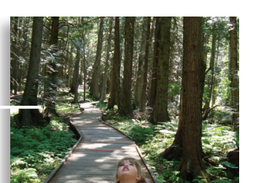
Spawning channels

Wetland Park

Habitat Corridors connecting
large parks and the Fraser River



Greenroofs in Commerical areas



Enhanced forest trail

Enhanced Ponds and streams

Riparian buffer

Potential opportunities for habitat integration in the cambie corridor

12.0 RECOMMENDATIONS

POLICIES

- Identify and establish biodiversity within the City of Vancouver
- Protect and restore all remnant aquatic and terrestrial ecosystems
- Protect and enhance existing biodiversity
- Integrate nature where possible through high quality ecological landscapes
- Map out a secure functioning biodiversity to inform future land use planning, design and management.
- Develop environmental plans for complete habitats and areas of biodiversity
- All landscapes should have no impact on the greater environment whether it is water use, chemical pesticide and fertilizer pollution, or mowing pollution.
- All landscapes should benefit the community and the environment with habitat value, aesthetic value and provide ecosystem services where possible (filter pollutants, purify water).
- Allocate resources to biodiversity conservation and enhancement
- Expand the definition of greenspace and nature.

ACTIONS

- Map existing biodiversity at site, city and regional scale through community asset mapping and scientific mapping approaches
- Hire ecologists and biologists as permanent staff
- Involve landscape architects and ecologists from the start of the project through to completion of a project
- Engage community through education, stewardship and public consultation
- Work with local naturalists and stewardship groups to help inform design and policy, considering having a design charrette with local ecologists.
- Quantify the value of local ecological services for the city.
- Quantify the percentage of lawn in the city and measure environmental impacts including carbon emissions mowing pollutants, fertilizer use, water use and labour. Identify areas where lawn is required for open space and recreation and where it can be replaced with alternative landscape treatments.

13.0 CONCLUSION

Intact ecosystems will always be the most important to protect and restore but as development expands, there is value in exploring how, cities can prioritize local ecosystems and increase urban biodiversity through the planning and design process.

This project explored how this could be done. Rigorous analysis of research and ecological principles lead to the development of the "Habitat Integration model. This model recommends a wholistic, multi-scaled approach that first protects and restores existing intact ecosystems, while also enhancing and protecting existing urban biodiversity and integrating high quality ecological landscapes or "biodiversity building blocks" into the urban core. Finally, in an effort to create a city wide ecological network, connecting these habitats through habitat corridors along greenways, pedestrian connections and quiet streets.

This approach was applied to the Cambie Corridor, an area up for redevelopment in Vancouver, BC. Green buildings and sustainable development drive the planning process but with the current City of Vancouver strategy to become the greenest city in the world, this large scale redevelopment could benefit from taking a closer look at biodiversity and local ecosystems in the planning program.

Despite being highly built up, with few remnant ecosystems, the Cambie Corridor, complete with two large parks, approximately 12 neighbourhood parks, four greenways and encompassing the Fraser River, is rich with opportunities for habitat integration. This design exploration resulted in a series of goals and strategies and a map illustrating where and how habitat integration could take place along the corridor.

The habitat integration approach could be incorporated into the sustainable development movement, where currently, it appears to be missing from the agenda. Considering ecological health when designing and planning cities is imperative to increase biodiversity, protect intact ecosystems from further degradation and connect people to nature to benefit human health and well-being.

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