Re-thinking Urban Vacancies: Strategic Re-use Of Vacant Land
To Establish More Sustainable Land Patterns

by

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A thesis
presented to
The University of Guelph

In partial fulfilment of requirements
for the degree of
Master of Landscape Architecture

Guelph, Ontario, Canada

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Eighty percent of the Canadian population lives in urban centres, where typical land use patterns negatively impact urban ecosystems and decrease quality of life. Current municipal Community Improvement Plans target urban vacancies for intensification efforts, which can increase fragmentation and degradation of the urban ecosystem. This project examines the urban environment: its vacancies, ecological patterns and human impacts. A strategy was derived from ecological principles aiming to design more sustainable urban landscape patterns. Applied to the Two Rivers neighbourhood in Guelph, Ontario, the strategy identified 19.5 hectares of land capable of contributing to more sustainable ecological patterns of which 12.41 hectares were brownfields. Results revealed 4.3% more high-quality land cover, in 53% more patches, 45 m closer together, but with increasing edge contrast. An area-wide strategic integration of vacant lands may provide previously unconsidered opportunities to improve urban ecological patterns and create a more sustainable urban environment.
Acknowledgements

I would like to thank my advisor, Prof. Rob Corry. Your guidance, patience and the generosity with which you share your time were deeply appreciated. To my committee member, Prof. Karen Landman, and Prof. Sean Kelly, chair of my defence, thank you both for your time and positive feedback.

To the staff in the Data Resource Centre, and Adam Bonnycastle and Marie Puddister in Geography Department at the University of Guelph, thank you for your enthusiasm and willingness to share your technical expertise.

To my mother, my family and friends – I am deeply grateful for the love, support and words of encouragement that saw me through this degree and all its challenges.
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Chapter 1. Introduction

Urbanized areas cover roughly 3% of the earth’s land surface, yet half the world’s population (50.5%) lives within an urban centre; it is a growing trend that impacts biodiversity, ecosystem functioning and services with effects extending beyond urban boundaries (United Nations, 2011; Wu, Jenerette, Buyantuyev, & Redman, 2011).

Humans are attracted to nature, prefer to live near it and can benefit from its nearby presence, yet methods of urban development degrade and diminish urban natural areas. The degradation of the natural processes in cities has social, economic and ecological implications. Research in urban ecology and health studies has revealed that patterns of urban development used for decades are unsustainable within the watersheds cities depend on (ASCE, 1998, as cited in; Environment Canada, 2008). These patterns are also recognized as contributing to an increase in obesity, respiratory ailments, vehicular mortality, increased stress and loss of social capital, as defined by the “social, political and economic networks and interactions inspiring trust and reciprocity among citizens” (Ontario College of Family Physicians, 2005, Vol. 1 p.5, Vol. 4 p.7). Walkable, pedestrian-friendly neighbourhoods improve social capital and the Ontario College of Family Physicians (2005) promotes easily accessible green spaces for recreation and sense of community, recognizing the positive social and health benefits for neighbourhood citizens.

Forman (1995) built an ecological framework of patterns for a ‘whole landscape’, and outlined that nurturing a sustainable environment requires a plan to support ecological integrity followed by human needs. The current state of urban ecological patterns and processes is a reflection of applied planning that did not follow these principles, or priorities.

“We seek a design language whose inspiration derives from making the most of available opportunities; one that re-establishes the concept of multi-functional, productive and working landscapes that integrate ecology, people and economy” (Hough, 2004, p. 31).
This work investigates the question: Can seizing opportunities to re-integrate vacant lands into more sustainable, ecological land patterns at the neighbourhood scale effect positive changes with respect to these ecological patterns? The objectives are to:

- Gain a more in-depth understanding of urbanization, urban ecology, landscape ecology planning, and planning policies;
- Create a set of ecological principles for landscape assessment in the form of a strategic decision-making tool;
- Apply the strategy to an urban neighbourhood re-integrating vacant lands into improved ecological patterns, to improve their ecological processes; and
- Evaluate the outcome to determine if the strategy was successful, i.e., increased patch size, re-establishment of a corridor, or more heterogeneity in the matrix.

This area-wide approach is experimental. Pilot studies done in the United States for neighbourhood revitalization in the midst of high rates of vacancies focus primarily on economic redevelopment and less so on reconstituting sustainable urban ecology (Environmental Protection Agency, 2012). In Ontario, the Places to Grow Act is attempting to curb the negative patterns of urbanisation, such as sprawl, with intensification (Ministry of Infrastructure, 2012b); however, this increases built form in urban centres and fills open space with more built form. With land costs representing a significant proportion of all development costs, reducing lot size and intensifying urban development is seen as a means to entice developers and provide more affordable housing. The Canadian Mortgage and Housing Corporation (CMHC) indicates the savings resulting from increased density through lot size and design can range from 5% to 25% (CMHC, 2012). These factors influencing intensification may lead to further fragmentation of the landscape, replacing vegetated land cover with more impervious land cover types.

Ecological design processes consider landscape position, multi-dimensional landscape attributes such as presence of water, proximity to existing patches or corridors and context of the surrounding built environment. Choice selection and re-purposing some of
these gaps and abandoned places to vegetated spaces that support ecological patterns is a test of revitalizing concepts for urban neighbourhoods.

The literature review will provide a foundation for landscape ecology planning, important ecological patterns and processes, and the impacts of urbanisation on them. This foundation will inform the re-integration strategy by which vacant lands are chosen to help reconstitute ecological patterns and support neighbourhood vitality. The new spatial patterns produced by the strategy will be evaluated for improvement to the ecological patterns. A discussion of the strategy, its impact and future considerations will conclude the work.
Chapter 2. Literature Review

This chapter will provide a brief review of the process of urbanisation, the advent of urban vacancies and decay, and their effects on people and urban ecology including its patterns and processes.

2.1. Urbanisation

Urbanisation is a complex process by which a country's organized communities become larger, more specialized and more interdependent (Artibise & Stelter, 2011). In the Canadian context:

- Eighty percent of the Canadian population lives in an urban centre (defined by a minimum population concentration of 1,000 people and a population density of at least 400 per square kilometre) (HRSDC Canada, 2011)
- Urban growth was 5.4% between the years 2001-2006 (an average 1.1% per annum) while the rural population increased at 2.7% (Statistics Canada, 2008)
- Urban growth is predicted to continue at this rate until 2025 arriving at a projected 32,065,000 people living in Canadian urban centres, approximately 83% of the national population (United Nations, 2011).

The recent census and projections imply future urban growth will be disproportionate to rural population growth. The population shift from rural to urban centres fuels urban development and results in increased stress on local and regional resources and urban infrastructure.

Cities accommodate population growth by two urbanisation processes: urban boundary growth (sprawl) and urban intensification.

2.1.1. Urban sprawl

Urban sprawl is defined as growth that is: low density, uncoordinated, and with spatially segregated land uses (e.g., homogenous single family residential development; shopping centres, retail and services; freestanding industrial areas) (Gayda et al., 2005). Current
policies to ensure the curb of urban sprawl are settlement area boundaries such as those outlined in the Greater Golden Horseshoe Plan which allows expansion only under certain criteria, following a municipal review (Ministry of Infrastructure, 2012b).

Pauleit and Breuste (2011) noted changes in the land use as a result of sprawl in European Union cities (i.e., Brussels, Bristol, Helsinki, Milan, Rennes and Stuttgart), which seem to be reflected in the Canadian context. Their observations include that:

- Commercial and industrial areas have extended at a faster rate than residential areas, which results in large lot brownfields on the fringe of the city.
- Green urban areas have grown on the fringe but declined in the urban core areas. Parks are planned for suburban developments, but due to the value of land in the urban core, vacant lots are re-used for housing development.

Both urban and suburban sprawl must be managed effectively for a city to be considered sustainable. Suburban growth, synonymous in many cases with greenfield use, is favourable due to the failure of the market to fully account for the costs associated with suburban development. While there may be land vacant within the urban core, subsidies to spur economic growth ease the initial cost of suburban development. Low density, spatially segregated development is not sustainable due to negative effects such as:

- Consumption of land, loss of high quality agricultural land and open space
- Destruction of biotopes and fragmentation of ecosystems
- Higher costs of new neighbourhood infrastructures
- Land use patterns which are unfavourable to the development of collective and other sustainable transport modes; hence, increased use of the private car
- Increased trip lengths
- Increase in fuel consumption
- Increase in air pollution
- Contribution to the decay of downtown areas, known as the ‘hollowing out’ effect (Gayda et al., 2005)
The metropolitan area of Toronto is an example where individuals left the urban core, and industries migrated out of the city to peripheral greenfield areas since the mid-1970s leaving the urban centre with innumerable under-utilized or vacant industrial sites (Gertler, 1995). Land further from the urban core is less costly and appealing to large factory-type businesses that necessitate a large horizontal footprint. When greenfields on the periphery are developed, the result is an outmigration of jobs, people and loss of open land at the periphery. Employment is growing faster in locations farther away from the core metropolitan cities as a result of the shift of manufacturing as well as retail trade activities from the core to the suburbs (Heisz & LaRochelle-Côté, 2005). In the years between 1996-2001, the percentage of jobs in Montreal within a 5 km radius of the core decreased from 13.8% to 10.2%, resulting in 8,600 jobs leaving the core; in Toronto, an additional 208,300 workers commuted to locations more than 20km away from the city centre (Heisz & LaRochelle-Côté, 2005). The continued shift to the suburbs caused an increase in suburban traffic, but public transit ridership remained steady over the same time period. The Ontario College of Family Physicians recently linked the patterns associated with urban sprawl (i.e., increased car usage, decreased exercise) to respiratory conditions such as asthma, cardiovascular disease, lung cancer, negative effects on pregnancy and birth defects (Ontario College of Family Physicians, 2005). The outmigration to suburban areas also resulted in increased vacancies in the core, creating a sense of decay in the inner city.

2.1.2. Intensification

**Intensification** is the process of re-using vacant urban or under-used land, reducing lot size and/or redeveloping to increase density in a city centre. The goals are to:

- Decrease agricultural land encroachment,
- Reduce the cost of public infrastructure
- Reduce urban sprawl and
- Revitalize existing urban areas (Bunce, 2004)

Shrinking cities or cities experiencing a ‘hollowing out’ of the urban centre while the footprint of the city remains the same are the focus of intensification efforts. These cities
or sections of them have experienced a long-term trend of population loss as well as the decline or loss of a significant industry (LaCroix, 2010). According to Canadian census data gathered in 2001 and 2006, 48% of Canadian urban centres are shrinking (Statistics Canada, 2008). However, it is the small urban centres that are shrinking the most, i.e., 52% of urban centres under 20,000 are shrinking compared to 15% of urban centres over 20,000 in population (see Table 2-1). In Guelph, a city experiencing an average yearly population growth of 1.2%, the rate of designated urban vacancy is expected to be low (Statistics Canada, 2012). Although work was done by the City to identify brownfields (City of Guelph, 2008), the extent of vacant or abandoned private land is difficult to ascertain.

Table 2-1: Number of Canadian urban centres experiencing negative growth, 2001-2006

<table>
<thead>
<tr>
<th>Urban Centre Population Ranges</th>
<th>Number of Cities with Negative Growth (2001-2006)</th>
<th>Percentage of Urban Centres with Negative Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 – 5,000</td>
<td>323</td>
<td>56</td>
</tr>
<tr>
<td>&gt; 5,000-10,000</td>
<td>319</td>
<td>33</td>
</tr>
<tr>
<td>&gt; 10,000-20,000</td>
<td>183</td>
<td>24</td>
</tr>
<tr>
<td>&gt; 20,000</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Intensification is a means of growth management to achieve mixed-use, compact, and walkable urban centres, attributes defining concepts of Smart Growth and New Urbanism (Kushner, 2003). Extensive changes to provincial planning and infrastructure policies have been taking place in Ontario since 2003. For example, the City of Ottawa, and the Regions of Waterloo and York were in the process of incorporating Smart Growth strategies into their planning policies with the explicit goal of changing past development patterns by intensifying cities and improving connectivity for transit, improving street layouts to reduce pedestrian travel distances, protecting greenspace and conserving natural heritage. However, all three regions reported difficulty with drafting policies and implementing them within a legacy of sprawl and continued pressure for development, as well as establishing a means to monitor changes (Brunt & Winfield, 2005).
On June 13, 2005, the Places to Grow Act, embodying Smart Growth principles, was enacted in Ontario to effectively manage growth. The Act mandates the Ministry of Infrastructure to prepare regional growth plans to establish density targets and planning priorities for compact, sustainable urban communities province-wide. The first Growth Plan, released in November 2005, was created for the Greater Golden Horseshoe (GGH) area, which includes the city of Guelph (Figure 2-1) (Ministry of Infrastructure, 2012b). The plan establishes specific density targets and planning priorities for managing growth in the region including through intensification of GGH cities. Efforts are being made toward more sustainable growth patterns but planning policy change is slow.

As of February 2012, all 19 upper- and single-tier municipalities in the GGH area have adopted amendments to conform to the Growth Plan; however, only six municipalities, Guelph included, had their plans completely in effect. The remainder are still going through the approval process (Ministry of Infrastructure, 2012a).
Figure 2-1: Growth Plan for the Greater Golden Horseshoe Area, 2006
2.2. Urban Vacancy

Vacancies in cities are evidence of the dynamic nature of the urban fabric. Vacant land is defined as, “publicly-owned and privately-owned unused or abandoned land or land that once had structures on it, but also the land that supports structures that have been abandoned, derelict, boarded up, partially destroyed, or razed “ (Pagano & Bowman, 2000, p.2). The concept of ‘vacant’ lands indicates land in disuse, but lends no indication of its former use, which may impact its eventual re-use (e.g., contamination). The term brownfield denotes vacant land of a particular former land use and is defined as: “Abandoned, vacant, derelict or underutilized commercial or industrial property where past actions have resulted in actual or perceived contamination” (NRTEE, 2003, p.1).

![Figure 2-2: Abandoned structure at 70 Wyndham Road, Guelph, ON (Photo: M.Gatner)](image)

Rarely is vacant land considered a positive characteristic within an urban neighbourhood. “Short-term vacancy speaks of transition, often normal in the course of business events. But long-term vacancy speaks overtly of failure: the inability to revitalize” (Jakle, 1992, as cited in Corbin, 2003, p.15). The perceived inability to revitalize can eventually impact the surrounding area and lend the neighbourhood a derelict, un-cared-for appearance, which can trigger a downward spiral of neighbourhood vitality. Surrounding residents and businesses move to other neighbourhoods that are considered safer, cleaner
and more economically sound, causing out-migration and further reduction in municipal property tax revenues (The Bloom Centre for Sustainability, 2011). Brownfield sites as a subset of vacant sites can affect both neighbourhood vitality and opportunities for re-integration to meet urban intensification targets; however, in the haste to fill the gaps, urban revitalization can “obscure or destroy local history, miss an opportunity to reconsider openness, or deny inevitable change” (Corbin, 2003, p.14). Urban ecological re-vitalization requires a rethinking of the potential within the urban environment, and a will to forego short-term economic gain, obtained in the rush of replacing built form with built form, for long-term gains of improving the health of a local ecosystem.

Integrating both definitions of vacant land and brownfields, urban vacancy can be considered to be publicly or privately owned lands; abandoned; structure-free, or with derelict or partially destroyed structures; and with potential, perceived or real contamination. The fundamental characteristic is land that is unused or has fallen into disuse.
2.3. Impacts of Urbanisation

Urbanization is a “complex process in which a country's organized communities become larger, more specialized and more interdependent” (Artibise & Stelter, 2011). The process by which urban centres develop has great impacts on the immediate and surrounding environment. The change in land pattern and function of the urban land causes many changes in urban ecosystem as a result of urbanisation. Although urbanized areas cover only about 3% of the earth’s land surface, they impact biodiversity, ecosystem functioning and services effects which extend beyond urban boundaries (Wu, Jenerette, Buyantuyev, & Redman, 2011).

The field of urban ecology has evolved from its roots in landscape ecology and planning, which are part of an interdisciplinary field with biological, physical and social science components (Ahern, 1997). It is a way of directing or managing change in the landscape to bring human action in tune with natural processes (Thompson & Steiner, 1997) and, as such, it naturally encompasses the concept of sustainability that the Brundtland Commission report defined as, “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations: Report of the World Commission on Environment and Development, 1987, p.1). The rise in interest and research in urban ecology is a response to the steady increase in urbanization. It is an increase of interest and understanding of the connections between people’s health and well-being and their interaction with the natural world and the realization that the ecology in urban areas is different than other systems (Gaston, 2010). The following subsections describe some of the impacts of urbanization on habitat, water and human well-being.

2.3.1. Habitat

Habitat is defined as the “place or environment where a plant or animal naturally or normally lives and grows” (Merriam-Webster Dictionary, 2012). Urbanisation affects nearly all ecological patterns and processes by fragmenting ecosystems (Forman, 1995). It is considered one of the greatest threats to biodiversity and occurs via loss of original
habitat (attrition), reduction in patch size (shrinkage) and increasing isolation of patches (Botequilha Leitão & Ahern, 2002).

Urban vegetation exists in patches of habitat (including vacant lots) and, due to fragmentation, these patches are isolated within an urban matrix (Dunn & Heneghan, 2011). This vegetation likely grows under biological, chemical and physical stress. In some cases, it is only spontaneous growth in extreme habitats (i.e., vacant lots with mostly impervious surfaces) but still diverse and layered. Its presence, however, provides the urban environment with noise abatement, canopy cover, sequestration of atmospheric pollutants, and habitat for biodiversity (Dunn & Heneghan, 2011).

High-density residential and commercial built environments that dominate the urban landscape cause some of the following habitat impacts:

- Fragmentation of urban habitat patches
- Occurrence of many transient habitats
- Habitats with extreme environmental conditions (i.e., devoid of vegetation)
- Invasion by non-native species of flora and fauna
- Climate conditions that buffers the environment from extremes
- Direct or indirect disturbances resulting from human activity Arrested and managed succession (mowing), and
- Varied or particularly rich food supply

(Forman & Godron, 1986; Hough, 2004; Young, Jarvis, Hooper, & Trueman, 2008; Pauleit & Breuste, 2011)
2.3.2. Water

Freshwater systems are vulnerable to the effects of urbanisation, as people tend to settle near running water. Riverfronts connect urban dwellers to the natural processes that are generally hidden in the built environment, to the history of their cities, and to each other (May, 2006). Rivers systems within proximity of urban centres are usually highly regulated, compounded by fragmentation and land cover change to impervious surfaces; urban freshwater systems are much abused. As an urban ecosystem service, water provides support in the way of water cycling, regulation of quality, provisioning of fresh water, and cultural services (Gaston, 2010).
Impervious surfaces are major contributors to the environmental impacts of urbanization (Arnold Jr. & Gibbons, 1996). Soil absorbs water, acting as conduit for groundwater recharge thus filtering stormwater runoff, but when it is sealed this ecosystem service is no longer available (Marshall & Shortle, 2005). Contaminants are washed off impervious surfaces of the urban landscape by stormwater runoff, and are carried either directly or indirectly into waterways or groundwater; this is called non-point source pollution (Arnold Jr. & Gibbons, 1996). Impervious surfaces are major contributors to a collection of symptoms grouped under the term “urban stream syndrome”, causing effects on streams that include:

- Flashier hydrograph – more frequent and larger flow events with increased magnitude of high flow and decreased time to peak flow, causing more flooding and erosion (Walsh et al., 2005).
- Elevated concentration of contaminants and nutrients (Walsh et al., 2005)
- Deforestation along riparian corridors leads to an increase in stream temperature thus changing the biota of the stream, and resulting in a overall loss of aquatic/riparian fauna and habitat (Schueler, 1995).

In the effort to restore function, the focus is on restoring pattern. Hydrologic restoration efforts focus on hydrologic connectivity, which is defined as “water-mediated transfer of matter, energy and/or organisms within or between elements of the hydrologic cycle” (Pringle, 2003, p.2685).

Hydrologic connectivity is considered essential to the ecological integrity of the landscape, and reduction or enhancement of this property by humans can have major negative environmental effects (Pringle, 2003). Anthropogenic effects on urban hydrology are causing the destruction of watershed integrity, which exacerbates growing water quality and quantity issues. Twenty-six percent of Canadian municipalities experienced water shortages between 1994-1999; chief among the reasons included seasonal shortages due to drought, infrastructure problems, and increased consumption (Environment Canada, 2001). From 2007-2009, 206 Canadian municipalities
(representing 33% of the total responding population of 20.4 million, approximately affecting 7 million individuals) indicated they experienced a water quality problem (Environment Canada, 2011).

The Canadian situation is summed up in the following: “It is now recognized that current practices of urban development are not environmentally sustainable with respect to receiving water quality and ecosystem integrity, when assessed on watershed and long-term bases” (Environment Canada, 2008)

2.3.3. Human Well-being

‘Biophilia’, meaning the “love of life or living systems” (Fromm, 1964, as cited in; Simaika & Samways, 2010) refers to the psychological tendency in humans to be attracted to nature. Contact with nature has a positive effect on an individual’s psychological and physical health; it is reported to reduce stress, improve attention, aid mental restoration, and result in increased longevity (Grinde & Patil, 2009).

A theory proposed by Kahn (2002) suggests the long-term effect of degradation of nature in cities results in the slow erosion of a sense of urban nature and what is considered “normal”. Environmental generational amnesia phenomenon is defined as follows:

“People take the natural environment they encounter during childhood as the norm against which they measure environmental degradation later in their lives. With each ensuing generation, the amount of environmental degradation increases, but each generation in its youth takes that degraded condition as the non-degraded condition – as the normal experience” (Kahn, 2002, p.106).

The loss of natural areas in urban centres result in the progressive loss of our connection with nature, one that is being proven vital to our well-being. There is a social response to the fragmentation of our habitat. Naturalness, or vegetative presence, is a principal component of neighbourhood attachment and is a factor affecting use of space and informal social contact among neighbours (Hur, Nasar, & Chun, 2010). Small patches of semi-natural areas in the urban landscape are known to increase landscape preference and
residential value (Halton Region, 2011; Heerwagen & Orians, 1993), and contribute to the well-being of local residents (Di Giulio, Holderegger, & Tobias, 2009).

The resurgence of the traditional neighbourhood unit in New Urbanist principles, is a response to the negative effects of urbanisation, sprawl in particular. These principles form a planning concept outlining a pedestrian-centred, mixed-use neighbourhood with size limits permitting the majority of its residents live within a five-minute walk (400 m.) to the town centre, and its basic services (Congress for the New Urbanism, 2001; Sustainable Community Research Group, 2012). The New Urbanist movement supports the restoration of urban neighbourhoods to provide a higher quality of life, while respecting the natural environment (Congress for the New Urbanism, 2001). The Places to Grow Act echoes some of these compact, walkable principles as a means to curb the negative effects sprawl on the environment and its citizens.

2.4. **Opportunities within Urban Vacancies**

In Ontario, vacant properties are assessed at significantly lower tax rates than occupied ones (Ministry of Municipal Affairs and Housing, 2004). Thus brownfield properties reduce the local tax assessment base and represent lost revenue potential for municipalities. Many cities within Canada have developed brownfield plans to focus development efforts on these vacancies, providing economic incentives and grants for developers in an attempt to reduce barriers to redevelopment (City of Guelph, 2008; City of Ottawa, 2007; City of Toronto, 2008). The redevelopment of urban vacancies is seen as seizing economic opportunities and secondarily as tied to sustainability of a city, by offsetting urban sprawl.

An example of a larger Canadian city, Guelph has addressed brownfields in the urban policy framework of the “City of Guelph Brownfield Redevelopment Community Improvement Plan”, which has as objectives to stimulate private sector investment for brownfield site development by reducing financial and procedural burdens from environmental assessments, potentially costly remediation and taxation concerns, and
facilitate the redevelopment/re-use of municipally-owned brownfield sites (City of Guelph, 2008).

In Canada, many numbers regarding brownfield extent and urban vacancies are estimates. The number of brownfields is estimated at 30,000; in the United States, estimates are in excess of 450,000 brownfield sites; in Europe some of the highest estimated numbers are in Germany with 362,000 sites and in France with 200,000 sites (De Sousa, 2003; EPA, 2011; Oliver, Ferber, Grimski, Millar, & Nathanail, 2005). There is no national database in Canada listing brownfields and information on vacant land is difficult to obtain. In Ontario, change of land use will trigger a legal requirement under Ontario Regulation 153/04 to register a Record of Site condition in the Environmental Site Registry; however, this is only if the land use changes from a ‘less sensitive’ to a ‘more sensitive’ usage, i.e., from industrial to residential usage (Ministry of Environment, 2011). Therefore during the development of the Guelph’s Brownfield Strategy, the city had to take an accounting of all their brownfields. Of the 175 brownfield sites within city boundaries, the City felt that the cost of clean up for 60 to 80% of these is likely prohibitive unless incentives are in place (City of Guelph, 2008). In a further 10-20% the cost of traditional remediation would likely prohibit private sector investment regardless of incentives (City of Guelph, 2008), likely resulting in long-term, idle land in the urban core.

Other Canadian cities such as Ottawa and Toronto have similar concerns for the re-use of brownfields. De Sousa (2003) investigated an alternative direction of vacant land redevelopment and revealed the benefits and barriers to the greening of brownfields. He suggests redevelopment of brownfields into parks or open space could:

- Improve the social well-being of city residents in a variety of ways (e.g., in crime reduction, business enhancement and improved well being, i.e., stress reduction)
- Improve environmental quality (e.g., air, water, microclimates), restore natural habitats, enhance recreational opportunities, and enhance urban appearance
- Reduce costs related to urban sprawl and infrastructure provision; attract investment, raise property values and invigorate local economies; boost tourism;
preserve farmland; prevent flood damage; and safeguard environmental quality generally.

Given such consideration, vacant lands in urban centres could provide opportunities for both economic and ecological gain. In the United States a survey of 244 cities revealed only 4% to 5% of all brownfield projects resulted in green space and recreation redevelopment, in England 37% of brownfields were converted between 1988-1992, and in Scotland 21% between 1993 and 2002 (De Sousa, 2004).

In the United States, as a result of the brownfield crisis, the Environmental Protection Agency (EPA) is supporting alternative approaches to brownfield redevelopment. The “Brownfields Area-Wide Planning Pilot Program” is a partnership started in 2010 with the EPA and Sustainable Communities (Department of Housing and Development) and the Office of Transportation offering grants of $175,000 to 23 communities affected by brownfields. The programme “recognizes that revitalization of the area surrounding the brownfield site(s) is just as critical to the successful reuse of the property as assessment, cleanup, and redevelopment of an individual site” (Environmental Protection Agency, 2012). Many of the areas in question comprise one or more neighbourhoods but the common denominator is usually a post-industrial neighbourhood with low-valued housing and high incidence of brownfields. The main purpose of the fund is economic renewal via removal of hazardous brownfields and creation of affordable housing; however, in some cases, the context of the area has seen recipients use the funding to reconstitute ecological patterns. One such example is the Blue Greenway in San Francisco, a 13-mile corridor along the city’s Southeastern waterfront and the historical industrial heart of the city. The funding supported the generation of an area-wide revitalization plan and community involvement in the process. The plan included creek restoration, creation of open green space, a trail system and increased public access to water.

The importance of mitigating and potentially reversing some of the effects of urbanisation in support of ecosystem functions, coupled with the amenity value of green space and its effect on human well-being, support this novel approach to vacant land re-use. Re-integration of these abandoned lands can be as a result of ad-hoc steps (i.e. individual site
redevelopment) or as a planned approach to reviewing all vacant lands within a given area in a holistic manner.

2.5. Patterns Suitable For Strategic Re-Integration Vacant Land

2.5.1. Sustainability and Resilience

A key component of sustainability is adaptability, “the pliable capacity permitting a system to become modified in response to a disturbance” (Forman, 1995, p.502) or to changing internal and external processes (Pickett, Cadenasso, & Grove, 2004). This ability to adapt is also known as resilience and within an urban system it depends on the city’s ability to maintain ecological and human functions simultaneously (Alberti et al., 2003); to “adapt to the economic, social, and physical stresses it will face as it confronts the challenges of increasing energy scarcity, climate change, and population change” (Applegath, 2012). Building resiliency and sustainability are intertwined goals with similar planning guidelines (e.g., neighbourhoods conserving and enhancing natural areas, conserving areas of environmental significance and place making within cities by creating vibrant pedestrian-friendly neighbourhoods where amenities are accessible within walking distance (Applegath, 2012). It would seem the fundamental key to a resilient, sustainable city is a well-functioning ecosystem that has a capacity to absorb stresses. To maintain ecological function, a system must possess ecological integrity, which means to have near-natural conditions of productivity (e.g., plant productivity), biodiversity (e.g., number of native species), soil quality (amount of erosion) and hydrologic regimes (Forman, 1995). However, Perlman & Milder (2005) take a more moderate approach of ‘ecological health’ given the context of urban centres, suggesting that where development occurs the guiding principle is avoidance of permanent negative impacts on a site or degrading the healthy periphery. Unfortunately, cities are converting natural ecosystems and remove large portions of the productivity of its ecosystems, which threatens ecosystem functions and ecological services well beyond the city boundaries. Instead cities should work toward the goal of providing the benefits of dense living centres without compromising ecology services or ecosystem health (Su, Fath, & Yang, 2010).
2.5.2. Landscape Pattern and Process

The main goal of studying landscape pattern is to understand its relationship with ecological properties and processes (Wu & Hobbs, 2002). The works mentioned in this section guide land use planning founded on ecological knowledge to sustain ecological function in the environment.

Land use patterns and land cover (LULC) influence most ecological processes in cities (Botequilha Leitão & Ahern, 2002), and environmental elements such as hydrology (Pauleit & Duhme, 2000). LULC derived from remotely sensed data (Figure 2-4), is widely used in landscape pattern analysis. To understand this link, the pattern must first be accurately quantified at the scale appropriate for a specific research question (Gustafson, 1998).

![Figure 2-4: Example of land use from remotely sensed data](image)

Examples of urban development patterns based on land use: commercial, mixed use, multi-family residential (MFR), single-family residential (SFR) and open green space. Data source: IKONOS 2000 from (Alberti et al., 2003)

A seminal work to sustainable planning is Forman’s (1995) *aggregate with outliers* principle (Figure 2-5), which states that “one should aggregate land uses, yet maintain corridors and small patches of nature throughout developed areas, as well as outliers of human activity spatially arranged along major boundaries” (Forman, 1995, p.437). The principle uses building blocks of four indispensable patterns of land use (Figure 2-6).
Figure 2-5: Forman's (1995) aggregate with outliers principle modified to urban environment.

Arrangement of land uses based on the aggregate with outliers principle, where A=natural vegetation, B=built area, C=Outliers of natural vegetation within built area. (Illustration: M. Gatner)

Figure 2-6: Forman's four indispensable patterns for land planning modified to urban environment

1-Large patch natural vegetation, 2-Wide vegetated corridor along major water course, 3 – Connectivity for movement of species among large patches, 4 – Heterogeneous bits of nature (Illustration: M. Gatner)
Four indispensable patterns considered priority components to any sustainable land plan:

1. **A few large patches of natural vegetation**
   These large patches can provide:
   a. Water quality protection, due to large area of pervious land cover. Water will infiltrate, be filtered and help recharge the water table.
   b. Core habitat to sustain populations of patch interior species, enriching biodiversity (Forman, 1995).

2. **Wide vegetation corridors along major water courses**
   Corridor anatomy involves active channels that contain the water, floodplain, hillslopes and terrestrial areas (Figure 2-7). These serve as habitat, conduits through the matrix, filters for materials and between areas, a source, and a sink for materials from the matrix (Forman, 1995).

![Figure 2-7: River corridor anatomy (Illustration: M. Gatner)](image)

3. **Connectivity for movement of key species among the large patches**
   Connectivity can be established via wide corridors or small stepping-stones. This pattern enables protection of biodiversity and enhances water resource management and recreation (Forman, 1995).

4. **Heterogeneous bits of nature throughout human-developed areas**
   The small patches provide unique habitat value and aid in movement of species by acting as stepping-stones through the matrix (Forman, 1995).
Dramstad et al. (1996) formulated 55 design principles using the patch, corridor, edge, and matrix elements. Movement through the matrix is a major objective of many of the design principles and below are examples from this work related to subtler patterns in support of movement through an area:

1. Forman’s (1995) pattern of ‘heterogeneous bits of nature’ was illustrated as ‘soft’ or ‘tiny-patch’ boundaries to reduce abrupt edges between two areas and can be the set-up for a stepping-stone pattern (Figure 2-8:1-A). This pattern may appear as in Figure 2-8:1-B in an urban environment.

2. Orientation of patch to area to support ease of movement: if a patch is oriented with its long axis parallel to a natural area (Figure 2-8: 2-B), it presents a wider surface area to the dispersing species and makes movement more likely as opposed to a rectangular patch shape with its long axis perpendicular to a natural area (Figure 2-8: 2-A) (Dramstad, Olson, & Forman, 1996).

Working from Forman’s indispensable patterns, Hersperger articulated concepts of *neighbourhood mosaics* as “a local assemblage of landscape elements linked together by strong interactions” (Hersperger, 2006, p.230). The “neighbourhood as the lifeblood to any the city” (Rybczynski, 1995 p.227 as cited in; Hersperger, 2006) and as such perhaps the scale to be the most appropriate level for planners to interact with citizens.
(Hersperger, 2006). The patterns and interactions applicable to this work include: patch adjacency, patch and matrix pattern and patch neighbourhood Figure 2-9.

Figure 2-9: Neighbourhood spatial adjacencies and interactions adapted from Hersperger (2006) (Illustrated: M. Gatner)

Note: A – Patch adjacency (red arrows= adjacent elements); B= Patch-and-matrix pattern, C=Patch Neighbourhood (black arrows=strong interactions between patches, grey arrows=weak interactions focal patch and matrix)

1. **Patch adjacency**

Patch adjacency refers to the patch and its immediate adjoining elements, i.e., patch and its surrounding matrix (see Figure 2-9-A). With the use of landscape indices, this adjacency can be quantified with characteristics such as perimeter and
area to describe shape and compactness and the percent of shared border with each element. Shape of the patch will affect movement (Forman, 1995); if the shape permits movement and the neighbouring elements are desirable, i.e., green space, the adjacency effect is positive. Conversely, negative adjacency effects result from permeability and negative neighbouring elements, i.e., locally unwanted land use (LULU) such as industry producing odour and noise (Hersperger, 2006), or derelict lots. Adjacencies in this context can also be expressed as ‘contrast’ between neighbouring patches. High contrast would be a patch of open green space beside an industrial lot; this configuration would cause a negative adjacency effect and likely an abrupt edge, almost barrier, to movement between the patches.

2. **Patch-and-matrix pattern**

This is a pattern created by a focal patch of a certain type, i.e., large patch of open green space within a matrix and the strong patch-to-patch interactions with nearby patches of the same type and the weak interactions with the surrounding matrix (see Figure 2-9 – B), i.e., a network of parks within an urban neighbourhood (Hersperger, 2006). The pattern of green patches could provide a network of habitat resources depending on range of species or dispersal method (Freemark, Dunning, Hejl, & Probst, 1995 as cited in; Hersperger, 2006). As a corridor-and-matrix pattern is a special case of the pattern, it can present interesting opportunities for research on how humans and other species move within the matrix, i.e., paths and railways between communities/patches of interest. This is a derivative theory from Forman’s (1995) third indispensable pattern of connectivity of patches for movement between large patches; however, in this case the pattern is applied on a smaller scale and not explicitly to movement between large patches but interactions among similar patch types throughout the matrix are stronger than with the ‘hostile’ matrix (Hersperger, 2006).
3. Patch neighbourhood

The patch neighbourhood is the focal patch and all surrounding neighbouring elements with strong interactions regardless of patch type (Hersperger, 2006). This pattern helps define neighbourhood quality for multi-habitat species with special attention to connectivity between elements.

Good spatial configurations can reduce spatial conflicts and enhance the quality of socio-economic and ecological systems; therefore, “landscape ecological planning needs approaches for addressing adjacencies and interactions in spatial arrangements” (Hersperger, 2006, p.228).

These patterns and principles will be the foundation upon which a strategy is formulated for re-use of vacant lands. It is an experimental approach to reconstituting ecological patterns within an established urban neighbourhood.
Chapter 3. Methodology

This project developed a GIS-based, spatial analysis decision-making strategy for urban land use. The land use and land cover (LULC) changes as a result of designed manipulation will be described and assessed. The relationship between altering land use and landscape pattern will be assessed to describe how neighbourhood scale LULC alterations might contribute to improvement in landscape function.

The process involved the overlay of GIS maps, providing spatial and physical characterization of the neighbourhood. A step-wise approach (Appendices A-1, A-2 and A-3) was taken to first applying the strategy Patterns 1.1-3.2 to the GIS overlays, considered the ‘first pass’ of the strategy. The ‘second pass’ (Pattern 4.1) further refined the results by introducing the criteria of low contrast of combined LULC of the chosen vacant lot and its surroundings. The ‘third pass’ selected among Pattern 4.1 vacancies, lots that are brownfields or could contribute toward community vitality by means of providing a closer open space amenity. These lots represented the final selection of urban vacancies. These steps are described in detail in Section 3.3. A final map representing the outcome of the strategy was analysed against the existing neighbourhood LULC with the landscape analysis software, Fragstats 3.3 (McGarigal, Cushman, Neel, & Ene, 2002) to quantify how suggested spatial configurations from the strategy affect landscape patterns. The sections that follow in this chapter reference the step listed in Figure 3.1.
Figure 3-1: Overview of methodology for strategically selecting vacant lands to enhance ecological function
The area of study is the Two Rivers neighbourhood, a mature inner city neighbourhood within the City of Guelph, Ontario (Figure 3-2). It is bounded by the Speed River to the West cutting it off from the downtown core and to the South by the Eramosa River. Its northern boundary is Elizabeth Street and to the West where York Road (Hwy 7) intersects Watson Parkway.

Figure 3-2: Site Location of Two Rivers Neighbourhood, Guelph, Ontario
Modified from Southern Ontario Regional-Municipality Boundaries (Source: Brock University Map Library, 2012)

3.1. Step 1 - GIS Data Sets
The spatial analysis begins with an overlay of the following data sets:

- Land Use (DMTI Spatial Inc., 2011) data describes patterns of construction and activity for which the land is used. Land use descriptions were used as opposed to broad categories provided to obtain a finer grain of understanding of the land use. Descriptions included Municipal Park, Manufacturing, Parking, etc.
• Southern Ontario Land Cover Information System (SOLRIS) (Ontario Ministry of Natural Resources, 2008) is a landscape level inventory of natural, rural and urban lands
• Neighbourhood Boundaries of Canada (DMTI Spatial Inc, 2009b): municipally-sourced data regarding neighbourhood boundaries.
• Floodplain (Grand River Conservation Authority, 2011) data describe the regulatory 100-year floodplain. It was developed to contain floodplain information determined through engineered floodplain mapping studies, observed occurrences of flooding, or estimated based on mapping, aerial photography, and field observations.
• Surface Hydrology (DMTI Spatial Inc, 2009a): provides spatial characteristics regarding rivers, and lakes.
• CanMap Rail (DMTI Spatial Inc., 2009) data provide details regarding railways, transit, sidetrack and abandoned railways across Canada.
• Guelph’s Natural Heritage (City of Guelph: Planning, Engineering and Environmental Services, 2010; Shute, 2010) is the integration of the Natural Heritage Ecoland classifications, part of Guelph’s Natural Heritage Strategy, and data regarding buried and surface creeks overlaid on the land use and land cover maps (LULC). This helped characterise the natural ecological patterns in the neighbourhood.
• Guelph Street Networks (City of Guelph, 2007) provided context for neighbourhood maps.

The base maps were overlaid and clipped to the neighbourhood boundaries. The resulting overlay maps are found in Appendix B-1, B-2, and B-3, and provide a characterization of the neighbourhood with existing land use, land cover, transportation corridors and existing natural patterns. Although land use maps were recently updated, they did not include residential vacancies, or privately held abandoned buildings or lots, only those that are municipally owned. As mentioned in Section 2, the definition of vacancy for the purposes of this project includes both privately and publicly held land. Due to this shortcoming, an additional method of obtaining the data was pursued.
3.2. Step 2 – Vacant Lot Groundtruthing

The Two Rivers neighbourhood was visited twice to verify land use classifications. Both visits occurred during regular business hours, one morning trip and one afternoon trip. Vacant buildings and lots were noted on a GIS derived land use map (DMTI Spatial Inc., 2011) then later entered into GIS by reclassifying polygons in the land use map (Step 2, Figure 3-1).

Criteria for considering a lot vacant were empty properties with:

1. No indication of active use, i.e., empty parking lot, with the appearance of spontaneous vegetation:
   a. Appearance of spontaneous vegetation and signage indicating property is privately owned but managed by third party
   b. Appearance of spontaneous vegetation and signage indicating property is for sale

2. Lot possesses a commercial building showing signs of abandonment:
   a. Building shows signs of lengthy dereliction:
      i. Lack of maintenance of building appearance, i.e., boarded up or cracked windows; tattered or broken window coverings, broken lights, etc.
      ii. Contents show signs of abuse, i.e., broken or overturned furniture visible from curb
   b. Notice posted on door of current legal action causing close of business
   c. No one on premises during regular business hours (listed on door) and building showing signs of any of criteria listed in 2)
   d. Building is empty with ‘For Lease’ sign posted
   e. Business no longer possesses a listed telephone number
   f. Business possesses a listed phone number or email, but attempts to contact business goes unanswered or voicemail does not correspond to business and premises is showing one or more 2) criteria
3.3. **Step 3: Identifying vacant lots that fulfil Strategy 1.1-3.2 criteria**

A decision-making strategy derived primarily from Forman’s (1995) indispensable patterns for sustainable land use (Figure 2-6) acted as selection guide for the vacant lands (Appendices A-1, A-2, A-3). This strategy enabled prioritization of land parcels chosen to contribute toward improving the ecological function of the neighbourhood. The goal of the strategy is to identify and prioritize opportunities that could increase connectivity and patch size, or that could break up the homogeneity of the urban matrix. At the conclusion of the process, the selected vacant lands would be reclassified into a more natural land cover representing a strategic selection of vacant properties developed and managed to enhance ecological function.

**3.3.1. Connectivity**

Identifying key vacant lands to create or increase connectivity is the first pattern in the strategy as connectivity throughout the matrix either by river or stream systems, or terrestrial corridors is one of the indispensable land patterns (Forman, 1995). Hydrologic connectivity is the first pattern of connectivity in the strategy; it is essential to the ecological integrity of the landscape (Pringle, 2003), followed closely by connectivity of terrestrial non-stream corridors. The strategy is a series of formed questions to prioritize land parcel properties for conversion from vacant to re-vegetated land cover.

1.1 Is the vacant land adjacent to a wide/large riparian corridor?

Vacant lots able to contribute to the riparian corridor were identified in an effort to enhance habitat and potentially access to the river system (Figure 3-3).

(Note: black = built impervious, white = vacant, light grey = transportation, dark green = riparian corridor)
1.2 Is the vacant land adjacent to a narrow riparian corridor?
Streams or creeks identified by using Guelph’s Natural Heritage Features (Shute, 2010) were included in the strategy for their potential contribution toward connectivity (Figure 3-4).

1.3 Is the vacant land within a floodplain?
Due to the availability of data, the 100-year regulatory floodplain line was used for this pattern identification. Any lots contained within the floodplain or lots with approximately more than 25% of their area within the floodplain were included in this category (Figure 3-5).

1.4 Is the vacant land adjacent to a floodplain?
At this level, vacant lots with less than 25% of floodplain present on the site or a lot adjacent to the floodplain were chosen (Figure 3-6).

1.5 Is the vacant land adjacent to a terrestrial corridor?
Within an urban neighbourhood, terrestrial corridors will likely be compromised corridors, such as railways offering only a mown verge for connectivity, or short grassy lanes. For the scope of this project, railways and any natural path system were acceptable (Figure 3-7).
1.6 Could the vacant land eliminate a gap in the corridor?
Vacant lands only one parcel away from a terrestrial or riparian corridor were acceptable for this category (Figure 3-8).

1.7 Could the vacant land become a ‘stepping-stone’ in a fragmented corridor?
Vacant land(s) between either a patch or corridor provide disrupted continuity, but potentially enough for movement depending on species (Figure 3-9).

3.3.2. Large Patches

2.1 Is the vacant land adjacent to vacant or green spaces?
Two vacant lots in adjacency are considered opportunities to create small patches in the matrix (Figure 3-10).

2.2 Is the vacant land compact in shape with a substantial core?
These are large vacant lots dominating most of a neighbourhood block, more likely square than elongated in configuration, providing potential core habitat (Figure 3-11).
2.3 Is the vacant land parallel to a corridor or large patch?
A good orientation permits more movement between patches. Vacant lots parallel to another or to a green space provides higher probability of movement between patches (Figure 3-12).

3.3.3. Heterogeneous Matrix

3.1 Is the vacant land a small patch that could act as a stepping-stone in a void?
Opportunities to break up the homogeneity of the developed areas provide different and supplemental ecological benefits than large patches (Figure 3-13).

3.2 Is the vacant land capable of generating a ‘tiny patch’ boundary?
These vacant lots provide the opportunity to buffer the urban matrix, breaking up the hard edge of the land use and extending ecological benefits into the neighbourhood. Small patches immediately surrounding large patches of naturalized areas were chosen for this pattern (Figure 3-14).
3.4. Step 4: Land Use/Land Cover (LULC) Mapping to Evaluate Contrast

3.4.1. Step 4.1 Aggregating Land Use Classifications

Land use descriptions from City of Guelph (DMTI Spatial Inc., 2011) were used to classify the urban matrix by zoning designations (see Table 3-1). These 22 designations were reclassified into eight more general types such as residential, commercial, industrial and others to consolidate land uses that were similar in character (see Table 3-1).

Table 3-1: Original Land Use Descriptions from DMTI Spatial Inc.

<table>
<thead>
<tr>
<th>Original Description</th>
<th>Reclassified to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartments (3-5 units)</td>
<td>Residential (Low/Med)</td>
</tr>
<tr>
<td>Apartments (6 or more)</td>
<td>Residential (High)</td>
</tr>
<tr>
<td>Automotive service/retail</td>
<td>Commercial</td>
</tr>
<tr>
<td>Church/ religious facility</td>
<td>Institutional</td>
</tr>
<tr>
<td>Educational facility</td>
<td>Institutional</td>
</tr>
<tr>
<td>Industrial Mall</td>
<td>Commercial</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Commercial</td>
</tr>
<tr>
<td>Mixed commercial uses</td>
<td>Commercial</td>
</tr>
<tr>
<td>Mixed residential commercial</td>
<td>Commercial</td>
</tr>
<tr>
<td>Municipal park</td>
<td>Municipal Park</td>
</tr>
<tr>
<td>Office</td>
<td>Commercial</td>
</tr>
<tr>
<td>Parking facility</td>
<td>Utility/transportation</td>
</tr>
<tr>
<td>Recreation facility</td>
<td>Institutional</td>
</tr>
<tr>
<td>Restaurant</td>
<td>Commercial</td>
</tr>
<tr>
<td>Retail</td>
<td>Commercial</td>
</tr>
<tr>
<td>Semi-detached/ duplex dwelling</td>
<td>Residential (Low/Med)</td>
</tr>
<tr>
<td>Service Commercial</td>
<td>Commercial</td>
</tr>
<tr>
<td>Single detached dwelling</td>
<td>Residential (Low/Med)</td>
</tr>
<tr>
<td>Townhouse</td>
<td>Residential (Low/Med)</td>
</tr>
<tr>
<td>Utility / transportation</td>
<td>Utility/transportation</td>
</tr>
<tr>
<td>Vacant land</td>
<td>Vacant</td>
</tr>
<tr>
<td>Warehousing</td>
<td>Industrial</td>
</tr>
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</table>
3.4.2. Step 4.2: Aggregating Land Cover Classifications

Land cover from Southern Ontario Land Cover Information System (SOLRIS) (Ontario Ministry of Natural Resources, 2008) and Guelph’s Natural Heritage Ecoland Classifications (City of Guelph: Planning, Engineering and Environmental Services, 2010) were used to provide land cover type interpretations. The Natural Heritage System (NHS) of Guelph replaces current Core and Non-Core Greenlands within the City’s Official Plan that is consistent with the 2005 Provincial Policy Statement (PPS) and conforms with the Growth Plan for the Greater Golden Horseshoe (City of Guelph: Planning, Engineering and Environmental Services, 2010). This was done to capture diverse vegetative land covers within the neighbourhood and provide finer-grained details of land cover. For instance, SOLRIS designated some areas as ‘Built-up pervious’, whereas the NHS recognized part of the area as ‘Cultural Savannah’; therefore the area would be considered ‘Open Green’ with a subsection of ‘Cultural Savannah’. The resulting combination described land parcels by a range of diverse vegetation types, from natural to cultural.

The land cover maps simplify the fine-grained texture of urban landscape. Due to resolution of the SOLRIS map (Figure 3-15), the fine-scale semi-natural areas are absent, (i.e., semi-natural areas such as residential gardens are classified ‘Built up Impervious’). As such, these data capture more detail than SOLRIS land cover alone, but overlook some fine-scale data at the parcel-level.

**Figure 3-15: Comparison of map resolutions A) land cover and B) Natural Heritage Map and C) satellite imagery**

Note: Sources A-(Ontario Ministry of Natural Resources, 2008); B-(City of Guelph: Planning, Engineering and Environmental Services, 2010); C-(Google Earth, 2006)
Table 3-2: Consolidation of Southern Ontario Land Cover Information System categories and Guelph Ecoland (Natural Heritage) Categories

(City of Guelph: Planning, Engineering and Environmental Services, 2010; Ontario Ministry of Natural Resources, 2008)

<table>
<thead>
<tr>
<th><strong>Original Land Cover Classifications (SOLRIS)</strong></th>
<th><strong>Guelph Ecoland Additions</strong></th>
<th><strong>Land Use Classifications (DMTI Spatial, Inc.)</strong></th>
<th><strong>Consolidated LULC Classifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Meadow</td>
<td></td>
<td>Meadow</td>
<td></td>
</tr>
<tr>
<td>Cultural Savannah</td>
<td></td>
<td>Savannah</td>
<td></td>
</tr>
<tr>
<td>27 – Forest</td>
<td>Cultural Meadow</td>
<td>Forest</td>
<td></td>
</tr>
<tr>
<td>30 – Deciduous Forest</td>
<td>Cultural Woodland</td>
<td>Forest</td>
<td></td>
</tr>
<tr>
<td>42 – Transportation</td>
<td>Utility / Transportation</td>
<td>Transportation</td>
<td></td>
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<tr>
<td>44 – Built-up Pervious</td>
<td>Park</td>
<td>Open Green</td>
<td></td>
</tr>
<tr>
<td>45 – Built-up Area Impervious</td>
<td>Industrial</td>
<td>Industrial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>Commercial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Institutional</td>
<td>Institutional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential (High)</td>
<td>Residential (High)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential (Low/Med)</td>
<td>Residential (Low/Med)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vacant</td>
<td>Vacant</td>
<td></td>
</tr>
<tr>
<td>50 – Swamp</td>
<td></td>
<td>Swamp</td>
<td></td>
</tr>
<tr>
<td>66 – Open Water</td>
<td></td>
<td>Open Water</td>
<td></td>
</tr>
</tbody>
</table>

3.5. **Step 5: Aggregating and Prioritizing LULC Classifications**

The LULC classifications were ranked in order of ecological value. This ranking was used to simplify additional analyses of landscape patterns to only those land covers with the highest ecological value (Table 3-3). The contrast values are used to compare cover type adjacencies: the higher the difference in values of adjacent land cover types, the higher the ecological contrast between two adjacent patches.
<table>
<thead>
<tr>
<th>LULC Classification</th>
<th>Contrast value</th>
<th>Ecological Value Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Water</td>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>Swamp</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Savannah</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Meadow</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Open Green</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Residential (Low/Med)</td>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>Residential (High Density)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Institutional</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Vacant</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Parking</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Utility/ Transportation</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>Industrial</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

3.6. Step 6: LULC Contrast Evaluation (Strategy 4.1)

Using Table 3-3, the strategy resumed at Step 4.1 evaluating lots identified by strategy Patterns 1.1-3.2 against their neighbours with respect to ecological value ranking, i.e., the highest contrast is Open Water (or others with contrast value of 1) to Industrial site (ranked as 6); the lowest contrasting neighbours are in the same LULC category, i.e., Vacant land next to Vacant land (ranked as 1). For contrast rankings to be considered close enough to create a low contrast edge promoting ease of movement, a limit was set of contrast rankings of 3 or lower on the surrounding 50% of the perimeter of vacant lands.
Table 3-4: Contrast rankings of LULC categories

<table>
<thead>
<tr>
<th>LULC Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Water</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Swamp</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Forest</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Savannah</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Meadow</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Open Green</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Residential (Low/Med)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Residential (High D)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Institutional</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Vacant</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Parking</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Utility/Transportation</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Commercial</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Industrial</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: 1 & 2 = lowest contrast (dark and medium green), 3 and 4=medium contrast (light blue and teal), 5 and 6=highest contrast (light and medium grey) between LULC categories
3.7. Step 7: Identifying Brownfields and Community Opportunities (Strategy 5.1)

3.7.1. Brownfields
As mentioned earlier in Guelph’s Brownfield Redevelopment Plan, it is estimated that 60-80% of brownfields likely have clean-up costs that are prohibitive to private sector redevelopment and in a further 10-20% the clean-up costs would be so high using traditional remediation methods that redevelopment by the private sector would likely not occur (City of Guelph, 2008). These lots possess potential ecological value by spatial configuration but bear prohibitive costs of redevelopment, thus targeting these sites at this stage of the strategy is an alternative to years of dereliction. The scope of this project does not encompass providing a prescriptive design or remediation process for these lots, only to improve the condition on the lot (recognizing that some of the properties might be compromised by contamination).

The map of 4.1 low contrast vacant lots was overlaid with the City of Guelph’s map of known brownfields in the Two Rivers neighbourhood. In the case of a positive overlap, the vacant brownfield contributed to Pattern 5.1.

3.7.2. Enhancing Community Vitality
This stage identified opportunities to improve the vitality of the neighbourhood. New Urbanist principles proscribe an average radius of development to be within a 5-minute walk (approximately 400 metres). This element of the strategy works to ensure amenities that can improve neighbourhood vitality would be contained within the neighbourhood and accessible within a 5-minute walk. Once again, the 4.1 strategic lots are examined against the following criteria, which go beyond ecological value:

a. Food accessibility: Locations selling fresh produce within or in proximity to the Two Rivers Neighbourhood are identified on a land use map with all 4.1 lots present. A 400 m. radius around grocery locations was created and areas of the neighbourhood outside this reach were considered food deserts and any vacant lands within or near food desert were chosen for urban agricultural opportunities.
b. Walkability to natural areas: Above the improvement of ecological patterns within the neighbourhood, the strategy provided for the accessibility to naturalized areas. A 5-minute pedestrian walking radius (400 m) around existing parks was applied and low contrast vacant lots chosen to fill any voids.

c. Place identity: The unique natural or historic aspects of a neighbourhood’s character should be nurtured. Vacant lots that could present design opportunities to enhance the neighbourhood’s character were chosen, (i.e., neighbourhood entry points or character buildings within brownfields remains).

This concludes the prioritization of vacant lands for the strategy. To prepare data maps for analysis, a set of pre-and post-strategy maps were created by re-classifying LULC into a three-tier ecological value ranking of high, medium or low. The pre-strategy map (see Table 3-3) represented existing ecological value of the neighbourhood. Adding the selected vacant lots and re-classifying them as “high” ecological value created the post-strategy map.

### 3.8. Step 8: Analysis of Pre- and Post-strategy LULC Maps

Landscape spatial analysis on the pre- and post-strategy neighbourhood was performed using the spatial analysis software FragStats (McGarigal, Cushman, Neel, & Ene, 2002). The landscape pattern indices are “measures for quantifying the composition and configuration of ecosystems across a study area” (Corry & Nassauer, 2005, p. 266); they are readily available tools that can be applied at different scales of study. The following landscape metrics were obtained:

#### 3.8.1. Landscape Composition Metrics

**3.8.1.1. Area**

This metric calculates the total area of land cover for each type. It will provide the amount of change in the “high” ecological value land cover when comparing the pre- and post-strategy landscapes.
3.8.1.2. **Patch Number (PN)**

Patch number measures the total number of patches of a land cover type. This metric will reflect changes as a result of Patterns 1.1-3.2. An increase in the number of “high” quality patches of land cover type would indicate a more heterogeneous landscape.

3.8.1.3. **Percentage land (PLAND)**

Percentage of land calculates how much of the landscape is comprised of a particular patch type. It is expected that the amount of “high” quality patches with respect to the other land cover types in the matrix should increase as a result of applying the strategy.

3.8.2. **Landscape Configuration Metrics**

3.8.2.1. **Mean Patch Shape Index (Shape MN)**

The mean patch shape index metric considers all patches of a particular type simultaneously and indicates the tendency of change in patch shape across the landscape (McGarigal, Cushman, Neel, & Ene, 2002). Values range from 1 to infinity, where low values indicate compact shape (e.g., perfectly square patch has a value of 1) and higher values indicate more irregular shapes (e.g., very long skinny patches may have values of 3 or more) (Giddings et al., 2009). This value will reflect any changes as a result of accruing “high” ecological land types, (i.e., patches adjacent to one another will create a single large patch thus changing its shape values). Consequently not only the patterns 2.1-2.3 intended to increase patch size, but changes from all patterns will be reflected in this metric.

3.8.2.2. **Mean Euclidean Mean Nearest Neighbour Distance (ENN_MN)**

The ENN_MN measures the change in the distance between patches of the same type. The unit of measure is in metres. The strategy aims to increase the heterogeneity in the urban matrix with dispersed patches of natural areas. The ENN_MN “high” ecological ranking is expected to decrease to indicate more closely spaced patches and an increase in stepping-stone connectivity among best-quality patches.
3.8.2.3. Total Edge Contrast Index (TECI)

The edge contrast index provides a percent magnitude of edge contrast between adjacent patch types; weights must range between 0% (no contrast) and 100% (maximum contrast), (McGarigal, Cushman, Neel, & Ene, 2002). A low edge contrast index is advantageous for movement through the matrix; however, this is dependent on species type (McGarigal, Cushman, Neel, & Ene, 2002). It is expected that the edge contrast index may decrease as a result of the application of the strategy. As mentioned in Section 2 from Hersperger’s (2006) theories of patch adjacency, patches with similar or desirable neighbouring elements (low-ranked contrast) will exhibit positive adjacency effects supporting movement between these neighbouring patches.

The methods applied yielded new neighbourhood maps for evaluating outcomes. This section described the strategic approach to mapping and re-classifying land cover types, and the methods for spatial analysis. The following section will detail the results of these methods.
Chapter 4. Results

4.1. Neighbourhood Land Use and Land Cover (LULC) Characterisation

The spatial analysis within the neighbourhood began with a characterisation of current land use. The Two Rivers neighbourhood encompasses 232 ha, southeast of downtown Guelph. Its land use classification revealed almost as much manufacturing use (24.5%) as presence of single-detached dwellings (24.4%) (Table 4-1). Eight percent of land in the neighbourhood is vacant and the large green corridor along the Eramosa River provides considerable green space accounting for the 23.5 ha (11.4%) of municipal park space (Appendices B-1 and B-3).

The total area of assigned land use sums to 205.4 ha (Table 4-1). This sum does not include road surfaces or water. The area of the neighbourhood bounded by an outline polygon is 232.1 ha. This includes all defined land uses as well as road surfaces and water, accounting for a higher area. Both data sets originated from DTMI Spatial Inc.; however, land use data defined parcels with assigned land use classifications and the total neighbourhood area set a boundary encompassing total surface area. As well, there were duplicate entries found in the land use database and artefacts from clipping land use to the neighbourhood boundary. Two duplicate entries in the tables were found and removed; however, a rigorous review of the database for duplicates was not performed. When land use was clipped to the neighbourhood boundary line, there were issues with the records representing polygons along the interface of the neighbourhood boundary, mostly along the Eramosa River. One example of such an issue was found with two remnant patches appearing to be < 0.5 ha when viewing the land use map were in the location of the Eramosa River. They are the remaining patches after the clipping procedure of a larger “recreational” land use totalling 83.1 ha. Their corresponding database record still had an associated area of 83.1 ha. It was assumed these patches represented the River, to which the City of Guelph had associated a “recreational” land use. As water is accounted for in the land cover and hydrology maps, and this record did not have an accurate area value, it was removed from the land use table. The area total based on land use is less reliable than the area of the neighbourhood bounded by an outline polygon.
Table 4-1: Existing Land Use Classifications and Areas

<table>
<thead>
<tr>
<th>Land Use Classification</th>
<th>Hectares</th>
<th>Percent of Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartments (3-5 units)</td>
<td>2.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Apartments (6 or more units)</td>
<td>2.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Automotive service / retail</td>
<td>5.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Church / religious facility</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Educational facility</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Industrial mall</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>50.4</td>
<td>24.5</td>
</tr>
<tr>
<td>Mixed commercial uses</td>
<td>6.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Mixed residential / commercial</td>
<td>3.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Municipal park</td>
<td>23.5</td>
<td>11.4</td>
</tr>
<tr>
<td>Office</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Parking facility</td>
<td>11.8</td>
<td>5.7</td>
</tr>
<tr>
<td>Recreational</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Restaurant</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Retail</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Semi-detached / duplex dwelling</td>
<td>8.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Service Commercial</td>
<td>2.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Single detached dwelling</td>
<td>50.1</td>
<td>24.4</td>
</tr>
<tr>
<td>Townhouse</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Utility / transportation</td>
<td>8.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Vacant land</td>
<td>17.3</td>
<td>8.4</td>
</tr>
<tr>
<td>Warehousing</td>
<td>5.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Total area assigned land use</td>
<td>205.4</td>
<td>100</td>
</tr>
<tr>
<td>Total area of neighbourhood</td>
<td>232.1</td>
<td></td>
</tr>
</tbody>
</table>

The land cover map (Appendix B-1) indicates the dominance of impervious surface cover, such as roads and parking lots, but also the presence of the large riparian corridor along the Eramosa River. The resolution of the land cover map (Ontario Ministry of Natural Resources, 2008) at 15 m. is not fine-grained enough to distinguish backyard vegetation, residential driveways, buildings, or fine neighbourhood detail like sidewalks.

The Natural Heritage System (NHS) within the built boundaries of the City of Guelph is a plan identifying unique ecosystems for protection, (i.e., savannah, meadow and forest. Within the area of study the NHS provides ecological land classifications that replace Core and Non-Core Greenlands (Appendix B-2), is consistent with the 2005 Provincial
Policy Statement (PPS), and conforms to the Growth Plan for the Greater Golden Horseshoe. The ecological land classifications within the NHS provided additional detail in land cover by defining culturally significant natural areas now protected by the NHS.

4.1.1. Vacant Lots

Vacant lands in the neighbourhood were classified from City of Guelph data (‘Vacant Land’ category) and from groundtruthing in the neighbourhood. The total area of vacant land is 35.8 ha, about half of which (48%) came from city data and the remainder (52%) from groundtruthing (see Figure 4-1). The groundtruthed vacant lots possessed a variety of land use classifications, primarily manufacturing, parking and warehousing facilities (Appendix B-5), all of which were reclassified as vacant according to the methods described in section 3.2.

![Figure 4-1: Land Use Classifications of Vacant Land](image-url)
4.2. Strategy Patterns 1.1-3.2

The first pass of the strategy selected all 35.8 ha of vacant lands to improve ecological patterns (Table 4-4). This included Patterns 1.1-3.2, resulting in 53 selected sites that fit the primary criteria (Appendices B-7, B-8).

4.2.1. Connectivity (Patterns 1.1-1.7)

With two rivers, their floodplains and a railway corridor the opportunity to contribute toward the connectivity pattern was abundant. Results are arranged by pattern type.

<table>
<thead>
<tr>
<th>Pattern Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large riparian corridor</td>
<td>Pattern 1.1, large riparian corridors included two sites totalling 3.2 ha (9% of vacant lands) (Appendix B-7).</td>
</tr>
<tr>
<td>Narrow riparian corridor</td>
<td>The presence of creeks in the neighbourhood increased the opportunities to enhance narrow riparian corridors, Pattern 1.2, which included six sites totalling 11.9 ha (33% of all vacant lands).</td>
</tr>
<tr>
<td>Floodplain</td>
<td>The floodplains as extensions of the riparian system included 23 sites within Pattern 1.3, totalling 7.1 ha (20% of vacant lands) and six sites adjacent to the floodplain, Pattern 1.4, totalling 0.3 ha (1% of vacant lands). The majority of these sites within the floodplain (5.1 ha) are manufacturing sites showing signs of abandonment.</td>
</tr>
<tr>
<td>Terrestrial corridors</td>
<td>The most significant contribution of vacant lands was to terrestrial corridors, Pattern 1.5, which included eight sites totalling 12.2 ha (34% of vacant lands). Pattern 1.6, vacant lands to eliminate a gap in a corridor found three small sites, totalling 0.5 ha (1% of vacant lands). Lastly Pattern 1.7, vacant lands become a ‘stepping-stone’ in a fragmented corridor, identified two sites totalling 0.6 ha (2% of vacant lands).</td>
</tr>
</tbody>
</table>

4.2.2. Patch Size (Patterns 2.1-2.3)

The area of study was a mixed-use neighbourhood adjacent to a downtown core and, as such, had a well-established matrix of urban development. Opportunities to create large patches within the matrix were not plentiful as many large sites were selected by the first set of patterns, 1.1-1.7. The only pattern contribution from this level was in Pattern 2.1, vacant land adjacent to a vacancy or green space totalling 0.1 ha, (<1% of vacant lands)
Patterns 2.2, vacant land compact in shape with a substantial core, and Pattern 2.3, vacant land parallel to a corridor or large patch, were not found among the vacancies in the neighbourhood.

4.2.3. Heterogeneous Matrix (Patterns 3.1-3.2)
Searching for small parcels to break up the homogeneous matrix of urban development resulted in only one site under Pattern 3.2, a vacant land capable of generating a ‘tiny patch’ boundary which totalled less than 0.1 ha (<1% of the vacant lands) (Appendix B-8).

4.2.4. Contrast
For the purpose of spatial analysis, land use and land cover maps were merged and their aggregated classifications (see Table 3-2, Table 3-3, Appendix B-4) formed the basis of contrast evaluation for Pattern 4.1 of the strategy (Appendix B-9). Selecting vacant lands with an ecological pattern (Patterns 1.1-3.2) that exhibited low contrast on 50% of its perimeter (Pattern 4.1) added 18.4 ha of low contrast, “high” ecological valued, vacant land (Appendix B-9).

4.2.5. Brownfields
Pattern 5.1 was the overlapping of low contrast lots with the City of Guelph Brownfield Redevelopment Plan map, this resulted in the identification of eight brownfield sites totalling 12.2 ha (City of Guelph, 2008) (Appendix B-10).

4.2.1. Neighbourhood Vitality
A. Walkability
Maps evaluating pre- and post-strategy walkability to accessible green spaces within the neighbourhood are displayed in Figures 6.14 and 6.16. A radius of 400 metres around each green space indicates the majority of existing, accessible green spaces are within a 5-minute walk within the neighbourhood, with the exception of the top north-west corner.
of neighbourhood which corresponds to the block bounded by Arthur Street South, Elizabeth Street and Cross Street and the Speed River (Figure 4-2). The corner lot previously identified as a brownfield was also designated as having potential for neighbourhood vitality. Due to the location at a main entry point of the neighbourhood, it could be an opportunity to enhance neighbourhood character. This phase of the strategy does not prescribe any design, but suggests possible opportunities and are not limited to those mentioned in this project (Appendix B-11).

![Figure 4-2: Gap in accessible existing green space within a 5-minute walk](image)

**B. Food Resources**

Researching fresh food availability based on a 5-minute walk (400 m. radius) revealed no fresh produce stores within the neighbourhood, but two on the periphery. The groundtruthing for vacant lots confirmed this and found one small community garden in the neighbourhood (Appendix B-12).

The resulting vacant lots chosen to enhance neighbourhood vitality are suggestions based on estimated community needs and opportunities to build or preserve character (Table 4-3) (Appendix B-13).
Table 4-3: Low-contrast vacant lands selected for Pattern 6.1

<table>
<thead>
<tr>
<th>Number</th>
<th>Area (ha)</th>
<th>Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>Gateway to neighbourhood from downtown, could contribute to neighbourhood identity</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>Existing community garden</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>Large site at core of neighbourhood with a character building, previously the Northern Rubber Company, and small forested section of the property currently not accessible to the public. Potential for neighbourhood community initiatives are based on central location, character building and current vegetative cover.</td>
</tr>
<tr>
<td>4</td>
<td>3.5</td>
<td>Meadow, currently designated as manufacturing land use</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>Potential site for urban agriculture.</td>
</tr>
</tbody>
</table>

The sum total of strategic vacant lands chosen using the strategy can be seen in Appendix B-14.
### Table 4-4: Total Area Identified by Strategic Patterns

<table>
<thead>
<tr>
<th>Strategic Priority</th>
<th>(ha)</th>
<th>Number of lots</th>
<th>Percent of Total Vacancies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>3.2</td>
<td>2</td>
<td>9%</td>
</tr>
<tr>
<td>1.2</td>
<td>11.9</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>1.3</td>
<td>7.0</td>
<td>23</td>
<td>20%</td>
</tr>
<tr>
<td>1.4</td>
<td>0.3</td>
<td>6</td>
<td>1%</td>
</tr>
<tr>
<td>1.5</td>
<td>12.2</td>
<td>8</td>
<td>34%</td>
</tr>
<tr>
<td>1.6</td>
<td>0.5</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>1.7</td>
<td>0.6</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>35.7</td>
<td>50</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

| Patch size                         |      |                |                           |
| 2.1                                | < 0.1| 2              | 0%                        |
| 2.2                                | 0    | 0              | 0%                        |
| 2.3                                | 0    | 0              | 0%                        |
| **Subtotal**                       | <0.1 | 2              | 0%                        |

| Heterogeneous matrix               |      |                |                           |
| 3.1                                | 0    | 0              | 0%                        |
| 3.2                                | <0.1 | 1              | 0%                        |
| **Subtotal**                       | <0.1 | 1              | 0%                        |

| **Total 1.1-3.2**                  | 35.8 | 0.00%          |

| Contrast                           |      |                |                           |
| Brownfields                        |      |                |                           |
| Neighbourhood vitality             |      |                |                           |
| 4.1                                | 18.4 | 12             | 51%                       |
| 5.1                                | 12.2 | 8              | 35%                       |
| 6.1                                | 4    | 3              | 11%                       |

| Overlap of Brownfields and Neighbourhood vitality sites | 5.1 + 6.1 | 3 | 2 | 8% |

| Sum of Strategic Vacancies (5.1 & 6.1) | 16.4 | 11* | 46% |

| Total Vacant Land in Neighbourhood | 35.8 |

* Note: Based on location, two brownfield sites from pattern 5.1 were suitable contributions toward neighbourhood vitality, Pattern 6.1. These numbers were not included in the calculation of the number of lots for Neighbourhood vitality, Pattern 6.1.
4.3. Landscape Metrics

Upon completion of the strategy, the landscape analysis program FragStats 3.3 (McGarigal et al. 2002) was used to calculate six different landscape pattern metrics on grid data at cell dimensions of 10 m. for existing land use and modelled land use change.

Land classifications in the grids were based on an ecological land value of high, medium, and low (Table 3-3). This ecological ranking of lands, pre- and post strategy are represented in Appendices B-15 and B-16 respectively.

<table>
<thead>
<tr>
<th>Ranking of Ecological Value</th>
<th>Area</th>
<th>Number of Patches (NP)</th>
<th>Percentage of Land (PLAND)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Change</td>
</tr>
<tr>
<td>High</td>
<td>32.77</td>
<td>42.05</td>
<td>9.28</td>
</tr>
<tr>
<td>Medium</td>
<td>141.38</td>
<td>131.64</td>
<td>-9.74</td>
</tr>
<tr>
<td>Low</td>
<td>44.65</td>
<td>44.88</td>
<td>0.23</td>
</tr>
</tbody>
</table>

4.3.1. Landscape Composition Metric Results

The land cover type class “high” includes the best ecological cover types and strategically chosen vacant lands. From the analysis, the number of patches (NP) in the “high” classification increased by 8, (53%) resulting in 9.3 ha more high-quality cover type in the neighbourhood. This increased the proportion of high-quality cover in the landscape by 4.2% (from 15.0% to 19.2%; PLAND values).

When comparing LULC data on parcels, 11 lots totalling 10.9 ha were added to the “high” classification (see Table 4-4). There is a difference of three patches totalling an area of 1.6 ha between the spatial pattern analysis results through FragStats and land use parcels from ArcGIS vector map. This discrepancy represents 0.1% of the total area of the neighbourhood or 3.2% of the “high” land cover type. The patch area discrepancy could be attributed to working with data sets at differing resolutions. During the work with ArcGIS, some of the merged land cover polygons (e.g., roads, existing green space) were edited to fit within the parcel data of the land use map. Despite this effort the conversion
generated spots of undifferentiated land cover types, which although not counted in FragStats may have altered the total area value.

The discrepancy in patch number may likely be the result of a parcel versus patch count difference: Fragstats considers patches as contiguous grid cell values, which are not affected by lot or parcel interpretations. Table 4-5 represents patch data and Table 4-4 an accounting of the number of lots.

4.3.2. Landscape Configuration Metric Results

Table 4-6: Mean Patch Shape Index and Euclidean Nearest-Neighbour Distance Metrics

<table>
<thead>
<tr>
<th>Ranking of Ecological Value</th>
<th>Mean Patch Shape Index (SHAPE MN)</th>
<th>Mean Euclidean Nearest-Neighbour Distance (ENN_MN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>High</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Medium</td>
<td>4.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Low</td>
<td>1.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

The spatial analysis did not reveal any patch shape change for the lands of ecologically “high” value, but the strategy did result in a shift in mean shape size index (SHAPE_MN), from 1.4 to 3.8, of the “low” valued lands across the neighbourhood. This would indicate the patch shape of lands of “low” ecological value is becoming more irregular, less compact, but with no effect on the “high” valued land and small effect on the “medium” classified lands (0.4 decrease of SHAPE_MN).

The Mean Euclidean nearest-neighbour distance (ENN_MN) between the “high” ecological land cover types decreased by 44.9 metres, from 104.6 to 59.7 m as a mean distance value, indicating these patches are closer to one another. With the increased number of “high” valued patches and a decrease in ENN_MN, it may indicate a more interspersed presence of these patches throughout the neighbourhood. The ENN of the “low” and “medium” land cover types changed <1 metre as a result of the strategy.
Total edge contrast index (TECI) is the percent magnitude of edge contrast between adjacent land cover class types. A high percentage indicates the class, as a whole, has a high contrast with its neighbours, whereas a low number indicates low contrast (land cover types that are alike are more commonly adjacent). The total edge contrast index values increased for all classifications; however, the largest increases were for class 1 (Open water, Swamp, Forest, Savannah, Meadow) and class 4 (Vacant, Parking, Utility/Transportation), indicating that lands of highest ecological value showed the greatest increase in edge contrast subsequent to applying the strategy (Table 4-7). That is, the TECI values show that the open water, swamp, forest, savannah, and meadow lands have a higher contrast with surroundings after vacant lands were strategically incorporated than in the existing situation.

Table 4-7: Summary of Total Edge Contrast Index Values of Pre- and Post-strategy Application

<table>
<thead>
<tr>
<th>Land Uses</th>
<th>Class Number</th>
<th>Total edge contrast index (TECI) (percent)</th>
<th>Change</th>
<th>Change by ecological land cover rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-strategy</td>
<td>Post-strategy</td>
<td></td>
</tr>
<tr>
<td>Open water, Swamp, Forest, Savannah, Meadow</td>
<td>1</td>
<td>22.93</td>
<td>27.00</td>
<td>+ 4.07</td>
</tr>
<tr>
<td>Open green</td>
<td>2</td>
<td>17.45</td>
<td>17.54</td>
<td>+ 0.09</td>
</tr>
<tr>
<td>Residential (Low/Med), Residential (High Density), Institutional</td>
<td>3</td>
<td>19.28</td>
<td>19.39</td>
<td>+ 0.11</td>
</tr>
<tr>
<td>Vacant, Parking, Utility/Transportation</td>
<td>4</td>
<td>17.76</td>
<td>19.42</td>
<td>+ 1.66</td>
</tr>
<tr>
<td>Commercial</td>
<td>5</td>
<td>21.78</td>
<td>22.25</td>
<td>+ 0.47</td>
</tr>
<tr>
<td>Industrial</td>
<td>6</td>
<td>34.02</td>
<td>34.21</td>
<td>+ 0.19</td>
</tr>
</tbody>
</table>

4.3.3. Summary landscape metric analysis
The following table summarizes the trends of change in landscape metrics indices as a result of applying the strategy:
1) “High” valued patches increased in area, number of patches, and percentage of land, and have a resulting higher edge contrast; the mean shape index showed negligible change and the distance between patches decreased.

2) “Medium” ranked patches decreased in area, percentage of land, but increased patch number and edge contrast.

3) “Low” valued patches became less compact.

Table 4-8: Summary Trends of Landscape Metric Indices

<table>
<thead>
<tr>
<th>Ecological Ranking</th>
<th>Composition</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>NP</td>
</tr>
<tr>
<td>High</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Medium</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Low</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

Note: + means increase, - equals a decrease, and / indicates change of value of <1.
Chapter 5. Discussion

This chapter considers the development and application of the strategy to selecting vacant lots for building a more ecologically-functional city, and explores the results of the landscape pattern assessment relative to the strategy. It discusses the implications of applying a strategic approach based on “indispensable patterns” from landscape ecology literature. Based on the three key pattern attributes of connectedness, large patches of diverse cover, and a heterogeneous matrix, the discussion describes how the pattern attributes were applied and an interpretation of their measured outcomes. The chapter concludes with limitations of this study offers and suggestions for future research.

5.1. Area-wide Approach

This project was a test of altering spatial land use and land cover patterns within a highly fragmented environment. It took an opportunistic approach with respect to choosing vacant lands as the key ingredient of the approach, but a planned approach with respect to the prioritized ecological patterns. The neighbourhood extent, as used in this work, is a highly fragmented, social construct but provided strong bounding criteria for “area-wide”. The approach enabled the use of multiple criteria to select from many lots exhibiting ecological patterns and to identify some opportunities to enhance neighbourhood vitality. The process considered adjacencies and interactions of the sites selected for enabling a network of more ecologically valued land use, the result of which can not be duplicated when considering an ad-hoc, site approach. This approach could be combined with planning for areas of intensification; choosing lands more suitable for higher-density development and reserving or reconstituting others that would help sustain the growth by creating a more resilient, ecologically-healthy neighbourhood. The approach could also be an alternate method for municipalities to address brownfields re-use. Cities investing in brownfield lots that would otherwise remain idle, to receive higher ecological valued land and the ecosystem services it brings.
5.2. Founding Principles

The strategy developed for this project draws from ecological principles of land use and spatial analysis methods synthesized from works of Forman (1995), Dramstad et al. (1996), Hersperger (2006), and Ahern (1997). Their works support this strategic form of urban ecological analysis and planning.

The strategy’s patterns were chosen from among Forman’s (1995) four indispensable patterns to create a sustainable land plan. Three major themes were connectivity, large vegetated patches and a heterogeneous matrix (small patches). The connectivity pattern prioritized water corridors, then vegetative corridors. This was done in deference to the importance of water as a resource and the cascade of negative effects a degraded water source can create. “Large vegetated patches” was the second priority of the strategy based on the positive impact it could provide for habitat; however, this choice presented application challenges within the context of an urban neighbourhood, which will be discussed further in section 5.3. The third theme, the ”heterogeneous matrix” created small bits of habitat where possible, the advantage of which, in an urban neighbourhood, is to break up the matrix of development and provide natural areas in closer proximity to residences. The patterns were ordered by relative impact the intact ecological pattern could have on the environment, from a larger impact to less so.

5.3. Application and Effects

The strategy defined patterns to build from the vacant lot ‘building blocks’. The outcome of spatial analysis provides feedback whether the method by which the lots were chosen resulted in an improvement in the ecological pattern of interest. In the application of the strategy in the Two Rivers neighbourhood, connectivity patterns were abundant in the matrix. These patterns claimed most of the vacant lots, 50 of the total 53 (Table 4-4). The predominance of this pattern may be site-specific (i.e., post-industrial neighbourhood). It did present challenges for identifying the remaining patterns in the matrix.
5.3.1. Connectivity

The majority of vacant lands absorbed by the strategy were as a result of the connectivity patterns (1.1-1.7). After these were applied to the neighbourhood, patterns to re-establish large patches (patterns 2.1-2.3) acquired only two small lots, totalling <0.1 ha and patterns to improve a heterogeneous matrix (Patterns 3.1 and 3.2) contributed one very small lot. Thus any changes to patch size and heterogeneity are primarily the result of enhancing connectivity. Elements of corridors, either natural (i.e., rivers) or engineered (i.e., railways) were strong in the existing spatial pattern of the neighbourhood.

Within the patterns of connectivity, the major strategic additions were a result of adjacency to terrestrial corridors (1.5-1.7), 34% of vacant lots; then narrow riparian corridor adjacency, Pattern 1.2 selected 33% of vacancies; and being within or adjacent to a floodplain (Patterns 1.3 and 1.4), 21% of vacant lots.

The patterns to improve narrow riparian corridors identified mostly large manufacturing lots with the presence of a creek, either surface or buried water. The floodplain, in ecological terms, represents a low-lying habitat zone potentially exposed to the periodic presence of water. Re-integrating these patterns could be valuable opportunities to contribute to healthier urban hydrology. Municipal zoning places less desirable land uses (i.e., industry and manufacturing) in the less desirable lands (i.e. low-lying areas or with presence of surface hydrology making development difficult). Building connectivity using patches within the floodplain transforms the ecologically “low” ranked land cover use (i.e., industry and manufacturing) to higher ecologically-valued land use. This effort would see true potential if eventually riparian corridors were returned to a more natural state; applying Patterns 1.1 -1.4 would support this effort. It would help create softer edges to the riparian system, protecting habitat, and supporting movement and flow of materials (Forman, 1995).

Within the selected area of study, the terrestrial corridor was interpreted as the system of railway lines through the neighbourhood. Along certain sections of route, the mown verge of the rail corridor is used as a pedestrian path and its presence is a reminder of the
industrial heritage that includes textile mills and a rubber factory (Crowley, 2010). It is likely that the addition of patches adjacent to the “terrestrial” corridor, contributed more to heterogeneous matrix than to a pattern of connectivity. It may have the added benefit of buffering more of the railway activity from residential land use; however, the transformed land may experience a certain negative adjacency due this activity.

Improvement in connectivity can be inferred by the decrease in the Mean Euclidean nearest-neighbour distance (ENN_MN) an index suitable for a highly fragmented matrix, one that measures connectivity allowing for gaps. The decreased ENN_MN indicates patches are closer, potentially improving movement between them via a network of stepping-stones or “circuitry” within the neighbourhood (Dramstad, Olson, & Forman, 1996).

The majority of vacant lots being absorbed by patterns of connectivity may reflect the predominance of this pattern in urban post-industrial neighbourhoods, indicating the degree development has both created and intruded upon the corridors within the neighbourhood. Whether engineered or natural, the corridors within an urban matrix should be nurtured as a means to support movement through a highly fragmented environment.

5.3.2. Patch size

Patch size and shape are important in landscape pattern assessment (Dramstad, Olson, & Forman, 1996; Forman, 1995). The strategy specifically attempted to increase patch size of diverse land covers with strategic Patterns 2.1-2.3 (Appendices A-1 and B-8). The site is highly fragmented by roads and other urban infrastructure, as well as urban land uses and cover types of poor habitat quality. Patch size is limited by the grain size of the urban matrix to norms for city blocks and urban lots, with larger vacant lots commonly zoned for industry, institutional, or commercial purposes. The shape of urban vacancies is regular and geometric – mainly rectangular, elongated, or triangular. The formal language of the urban matrix limits the range of expected outcomes in changing patch sizes or shapes.
After the connectivity patterns were applied, there were few remaining vacant lots that could create a large patch or increase an existing patch size substantially. Patterns 2.1-2.3 for identifying opportunities to build large patches identified only two small lots (Appendix B-8). These two lots were less than 0.1 ha in area and do not appear to contribute sufficiently to building larger patches in a dense urban matrix.

Three of the metrics used in the analysis describe the outcome of the strategy with respect to patterns for large patches: area, mean shape index (SHAPE_MN) and percentage of land (PLAND). Area of “high” valued land increased by 9.3 hectares and the percentage of land increased by 4.3%; however, there was no change in SHAPE_MN, indicating the addition of these patches was not sufficient to achieve a more compact shape of these lands.

The shape index increased for “low” ecologically ranked patches, from 1.4 to 3.8 (Table 4-6), indicating that compact shape of the “low” ranked lands was distorted, from an insertion of green space, which may have resulted in the increase in total edge contrast index (TECI) for the “high” valued lands. The principle of shape compaction to improve core habitat (Dramstad, Olson, & Forman, 1996) inserted in the strategy in Patterns 2.1-2.3, was not met. Although the brownfields contributed large areas within the context of an urban neighbourhood, their addition did not result in a patch shape change (Table 4-4). These patterns may not be achievable within a rectilinear infrastructure of an urban matrix, and with the use of only existing vacant lots.

### 5.3.3. Heterogeneous Matrix

The third pattern in the strategy looked for opportunities to ‘soften the matrix’ with small patches of green. As mentioned previously, only one small lot was found to contribute to this pattern (Appendix B-8). Any changes in this pattern would be as a result of previously established patterns, largely the strategic patterns for connectivity. For “high” value lands, ENN_MN decreased by 45 m. (Table 4-6) and TECI increased by 4.2% (Table 4-7), which is interpreted as green patches closer and transforming areas that previously had at least 50% of “medium” valued lands on the perimeter (Pattern 4.1, low
contrast, Table 3-3). The result is an encroachment of green spaces in areas with classified land uses predominantly residential (low to high density) or institutional supporting an increase in natural areas. The increase could support greater biodiversity, resilience and unique amenities contributing to a more desirable neighbourhood (Ling & Dale, 2011).

From the abundance of low contrast lots (Appendix B-9), only those identified as brownfields or thought to have potential to increase community vitality based on the lots location and needs loosely indentified by Pattern 6.1 were chosen. These final criteria (Patterns 5.1 and 6.1) were derived in a manner to reduce the overall number of strategic lots and present a more feasible planning outcome. The patterns and their order in the strategy could be altered based on different ecological or community needs. For instance, if small patches to create a more heterogeneous matrix were a priority and brownfields were not considered, likely the result would be a dramatic increase in the number of “high” valued patches in the matrix, a lowering of the ENN_MN and potentially further increasing TECI. Within the context of the urban neighbourhood it would be seen as a dispersal of “high” ecological valued lands. The insertion of “high” value patches into a mostly residential matrix may create positive adjacency effects (e.g., noise buffering, cooling effects of urban forested areas, providing recreational opportunities, more experiences with nature promoting well-being and increasing location preference and residential value) (Di Giulio, Hoheregger, & Tobias, 2009; Halton Region, 2011; Hersperger, 2006; Kahn, 2002).

5.4. Limitations
The approach to this work was unusual in its scale (i.e., neighbourhood) and use of vacant lands, both publicly and privately owned. The following express some of the limitations to the approach.
5.4.1. Landscape metrics
In this project several indices were used on ecologically ranked neighbourhood patches, pre- and post-strategy, to assess if any ecological changes might result from the change in landscape indices. However, these indices are not explicitly linked to ecological processes (Corry & Nassauer, 2005) and change in particular indices, i.e., decrease in patch distance as measured by Euclidean nearest-neighbour distance, does not mean definitively that patches will act as stepping-stones and result in a movement of species in the environment.

5.4.2. Scale
Using a neighbourhood scale for urban spatial analysis meant using data that were not resolved for finer-scale environments such as urban neighbourhood (i.e., Southern Ontario Land Resource Information System) (Ontario Ministry of Natural Resources, 2008). There are no data readily available on land cover at a sub- or small parcel level other than what can be derived from using satellite imagery. SOLRIS as currently available gives the impression of a largely binary land cover for urban environment, either built-up impervious or built-up pervious in cities. This is as a result of data resolution and its classification, i.e., green spaces and other pervious features are included within built-up impervious if the portion of pervious surfaces (e.g., grass, vegetation and bare ground) is less than 80% per 0.5 ha (Ontario Ministry of Natural Resources, 2008). This classification procedure leads to the exclusion of many small patches of green at the neighbourhood scale and inaccurate accounting of this land cover in the urban landscape. If future application of the strategy has as a measured objective to increase the pervious surface area in a neighbourhood, (i.e., for improved stormwater management) then small parcel data would be required information.

In quantifying vacant lands within the neighbourhood, only municipally-owned vacant lands were available on land use maps (DMTI Spatial Inc., 2011). The strategy involved groundtruthing for all vacant lots, regardless of ownership. It was an attempt to provide a more accurate accounting of neighbourhood vacancy; the presence of these lots contributes to an appearance of dereliction regardless of ownership. However, data on
privately owned vacant lots are difficult to obtain. As groundtruthing found vacancies it also found recent development. Groundtruthing is time consuming and the criteria listed in Section 3.2 are subject to interpretation and may result in error.

Brownfield contamination information is also data not readily available, but it could contribute to the strategy. Knowledge of contaminant type and the extent of contamination must be obtained before considering proposed uses such as urban agriculture.

The re-classification of the land use and land cover (LULC), and the task of aggregating these was a matter of interpretation and theory. Methods described in Section 3.4 merged many LULC classifications from four data sources together and reduced them to six LULC classifications (Table 3-3). Ecological ranking of these classifications was based on how close the land represented in the classification was to a natural state. This data manipulation is based on a synthesis of theory outlined in Section 2, but the application is still subjective.

5.4.3. Community Vitality Criteria

New urbanist principles were applied within the strategy. They provide guidelines for urban development in which services, (i.e., health services, food, commerce, and open green space) are readily accessible within a neighbourhood. Walkability and location of food resources are easily measured and readily available data; however, a more exhaustive list based on community input would be valuable additions to the strategy. In similar work done by Schadler et al. (2011), the team derived sustainability goals for the redevelopment of brownfields; borrowing from their work, additional goals for vitality could provide a more comprehensive list of opportunities for this aspect of the work. Ultimately, the area-wide approach would entail community engagement with planners to establish a list of community needs to inform the community vitality patterns, Pattern 6.1, see Section 5.8.
5.5. Future Work

5.5.1. Landscape Metrics
The increase of TECI for “high” valued lands suggested further work necessary to assess the impact on the overall success of re-integrating vacant lands into more ecological patterns. It was an unexpected outcome and should not be considered as the sole indicator for strategy success. It may be a by-product of the land transformation. How this index works in concert with others within a land transformation such as this one requires further investigation.

Another metric in which the interpretation might mislead is the SHAPE_MN index. It is not tuned to the fine scale of an urban neighbourhood. It is relatively insensitive to differences in patch morphology (McGarigal, Cushman, Neel, & Ene, 2002). More finer-scaled SHAPE indices may provide greater insight into patch shape changes as a result of the strategy application.

5.5.2. Ecosystem Service Models
The incentive to remediate vacant lots to address a dysfunctional ecosystem network will require the municipal will and community participation to do so along with financial initiatives. Municipal policy incentives exist and the economic potential of redevelopment for some lots is evident; however, the economic benefits derived from their conversion to more ecologically functional land cover are much less evident. The land in the urban core of many major cities is highly valued and the municipality would derive no income from additional green spaces, but likely incur maintenance costs. Ecosystem services are defined as “the provision of direct and indirect benefits to people from ecosystems” (Chan, Satterfield, & Goldstein, 2012, p. 8), direct benefits such as reducing energy demands of air cooling and infrastructure cost in terms of stormwater management, but also indirect cultural returns that cannot be quantified monetarily (Bolund & Hunhammar, 1999). Ecosystem service models are in the early stages of development with research yet to agree upon constituent elements and metrics of a ‘healthy’ ecosystem (Su, Fath, & Yang, 2010). However, when attempting to convince
municipalities of the benefit of increasing green space, ecosystem service calculations may be a compelling part of the evaluation process in the future.

5.5.3. Neighbourhood vitality
As mentioned earlier, walkability and location of food resources are easily measured and readily available data. However, a more exhaustive list based on user input would be valuable additions to the strategy. Work done by Schadler et al. (2011) derived sustainability goals for the redevelopment of brownfields; borrowing from their work, additional goals for vitality could include:

1) Reduction of individual car use, i.e., do the sites have good access to public transportation? At the neighbourhood scale for this methodology, the criteria could be defined as: does the location of the site promote pedestrian movement through the neighbourhood?

2) Primary school walking distance: selecting sites closer to schools to provide additional recreational amenities for children. This criteria could be expanded to include any institution likely present in a neighbourhood (i.e., hospital or church).

5.6. Conclusion
As cities strive to balance growth and the maintenance of infrastructure, looking to different models of urban development may be required to ensure desirable, more sustainable cities. Land-management strategies that reduce the anthropogenic effects of urbanisation, should “combine ecological values including biodiversity and more sustainable land use along with social values of restoration” (Di Giulio, Holderegger, & Tobias, 2009, p.2960).

Including ecological patterns considered “indispensable” (Forman, 1995) with the use of vacant lands is a planning concept for a more sustainable way forward for urban neighbourhoods. The strategy as proposed in this work attempts to apply these ecological
patterns, in a prioritized order, using readily available material, (i.e., vacant lots) to improve a compromised urban ecosystem. Results indicate that connectivity patterns played a strategic role in the outcome and it is easier to make an urban matrix heterogeneous at any point, but opportunities for creating large patches are few.

The strategy could be used to test choices of sites, as well as establish priorities among them to aid phasing of land transformations. Alternatively, the strategy could be applied beyond the scope of vacant lots, to identify degraded ecological patterns and key patches, to be prioritized as useful for future ecological improvement. Testing the constituent patterns and priorities is needed to clarify their relationship to the results.
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Appendix – A: Strategy
A- 1: Strategy for connectivity

1. Connectivity

This first step in the strategy is derived from concepts of corridor adjacency (Hersperger, 2006) and the second indispensable land pattern: Wide vegetation corridors along major water courses (Forman, 1995).

1.1 Is the vacant land adjacent to a wide/large riparian corridor?

1.2 Is the vacant land adjacent to a narrower riparian corridor?

1.3 Is the vacant land within a floodplain?

1.4 Is the vacant land adjacent to a floodplain?

1.5 Is the vacant land adjacent to a ‘narrow’ riparian corridor?

1.6 Could the vacant land eliminate a gap in the corridor?

1.7 Could the vacant land become a ‘stepping stone’ in a fragmented corridor?

2. Large Patches

4.1 Is the contrast between the restored ecological pattern and surrounding matrix low?

5.1 Is vacant lot a brownfield?

6.1 Could the vacancy contribute a social function within the neighbour?

Vacancy given high priority for improving sustainability

Vacancy is lower priority for improving sustainability

Vacancy is lower priority for improving sustainability

No

Yes

Yes

No

Yes

No

No

No
2. Large Patches

Patch adjacency (Herpsperger, 2006) and Forman’s (1995) first indispensable pattern: maintaining a few large patches of natural vegetation.

- **2.1** Is the vacant land adjacent to vacant or green space?
  - **Yes**
  - **No**

- **2.2** Is the vacant land compact in shape with substantial core?
  - **Yes**
  - **No**

- **2.3** Is the vacant land parallel to a corridor or large patch?
  - **Yes**
  - **No**

**4.1** Is the contrast between the restored ecological pattern and surrounding matrix low?
- **Yes**
- **No**

**5.1** Is the vacant lot a brownfield?
- **Yes**
- **No**

**6.1** Could the vacancy contribute to neighbourhood vitality?
- **Yes**
- **No**

**Vacancy given high priority for improving sustainability**

**Vacancy is lower priority for improving sustainability**

**3. Small Opportunities**
3. Heterogeneous matrix
Softening the matrix (Dramstad et al., 1996) and Forman's (1995) third and fourth indispensable patterns: Connectivity with stepping stones between large patches; heterogeneous bits of nature throughout human-developed areas.

3.1 Is the vacant land a small patch that could act as a stepping-stone in a void?

3.2 Is the vacant land capable of generating a 'tiny patch' boundary?

No

Vacant land is not desirable for the strategy

Yes

4.1 Is the contrast between the restored ecological pattern and surrounding matrix low?

Yes

5.1 Is vacant lot a brownfield?

No

Vacancy is lower priority for improving sustainability

Yes

6.1 Could the vacancy contribute to neighbourhood vitality?

No

Vacancy is lower priority for improving sustainability

Yes

Vacancy given high priority for improving sustainability
Appendix – B: Maps
Ecoland Classifications of the Natural Heritage Strategy
Two Rivers Neighbourhood, Guelph, ON

LEGEND
Vegetation Communities
- Agricultural
- Cultural Meadow
- Cultural Savannah
- Cultural Thicket
- Cultural Plantation
- Cultural Woodlands
- Deciduous Forest
- Mixed Forest
- Coniferous Forest
- Hedgerow
- Meadow Marsh
- Shallow Marsh
- Open Aquatic
- Deciduous Swamp
- Mixed Swamp
- Thicket Swamp
- Coniferous Swamp

B - 2: Guelph Natural Heritage Strategy, Ecological Land Classifications

(City of Guelph: Planning, Engineering and Environmental Services, 2010)
Land Use and Land Cover Aggregated Classifications
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary

Land Use and Land Cover
- Industrial
- Commercial
- Utility/Transportation
- Parking
- Vacant
- Institutional
- Residential (High Density)
- Residential (Low/Med)
- Open Green
- Meadow
- Savannah
- Forest
- Swamp
- Open Water

Scale 1:12,800

Coordinate System: NAD 1983 UTM Zone 17N

Sources:
City of Guelph, 2010; DMTI Spatial Inc., 2011;
DMTI Spatial Inc., 2009b;
Ontario Ministry of Natural Resources, 2008

Date: 5/25/2012

B - 4: Land use and land cover aggregated classifications
B - 7: Strategic vacant lots to improve connectivity, Patterns 1.1-1.7
A vacant lot for a "tiny patch" boundary

Two adjacent vacant lots

B - 8: Strategic vacant lots to improve heterogeneity of matrix, Patterns 2.1-3.2
Low Contrast Vacant Lots
Pattern 4.1
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- 4.1 Low Contrast Vacancies

Ecological Land Value
- 1 High
- 2
- 3
- 4
- 5
- 6 Low

Coordinate System: NAD 1983 UTM Zone 17N
Sources:
City of Guelph, 2010; City of Guelph, 2007;
DMTI Spatial Inc., 2011; DMTI Spatial Inc., 2006b
Ontario Ministry of Natural Resources, 2006

Date: 5/25/2012

B - 9: Low contrast vacancies, Pattern 4.1.
Low Contrast Vacant Lots and Brownfields, Patterns 4.1 & 5.1
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- 4.1 Low Contrast Vacancies
- 5.1 Brownfields
Ecological Land Value
- 1 High
- 2
- 3
- 4
- 5
- 6 Low

Scale 1:12,800

Coordinate System: NAD 1983 UTM Zone 17N

Sources:
City of Guelph, 2010; City of Guelph, 2006;
City of Guelph, 2007; DMTI Spatial Inc., 2011;
DMTI Spatial Inc., 2009b;
Ontario Ministry of Natural Resources, 2008

Date: 5/25/2012

B - 10: Low contrast vacancies and City of Guelph brownfields, Patterns 4.1 and 5.1
Walkability to Existing Green Space
5-minute walk (400 m.)
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- Existing Accessible Green
- 400 m radius, 5-minute walk

Coordinate System: NAD 1983 UTM Zone 17N
Sources:
City of Guelph, 2010; City of Guelph, 2007;
DMTI Spatial Inc., 2011; DMTI Spatial Inc., 2009b;
Ontario Ministry of Natural Resources, 2008;
Date: 5/25/2012

B - 11: Walkability to existing green spaces, 5 minute walk (400m)
Accessibility to Fresh Food
5-minute walk (400 m.)
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- Fresh Produce Location
- 400m Radius

Land Use
- Commercial
- Industrial
- Institutional
- Parking
- Utility/Transportation
- Vacant
- Residential (High density)
- Residential (Low/Med)
- Park

Scale: 1:12,800
Coordinate System: NAD 1983 UTM Zone 17N
Sources:
City of Guelph, 2007; DMTI Spatial Inc., 2011; DMTI Spatial Inc., 2009b
Date: 5/25/2012

B - 12: Accessibility to fresh food
Neighbourhood Vitality
Pattern 6.1
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- 4.1 Low Contrast Vacancies
- 6.1 Neighbourhood Vitality
- 400 m radius around 6.1 lots

Ecological Land Value

1 High
2
3
4
5
6 Low

Scale 1:12,000

Coordinate System: NAD 1983 UTM Zone 17N

Sources:
City of Guelph, 2010; City of Guelph, 2007;
DMTI Spatial Inc., 2011; DMTI Spatial Inc., 2009b;
Ontario Ministry of Natural Resources, 2008

Date: 5/25/2012

B - 13: Neighbourhood vitality potential, Pattern 6.1
Final Strategic Vacant Lots
Patterns 5.1 & 6.1
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
- 5.1 Low Contrast Brownfields
- 6.1 Neighbourhood Vitality

Ecological Land Value
- 1 High
- 2
- 3
- 4
- 5
- 6 Low

Coordinate System: NAD 1983 UTM Zone 17N
Sources:
- City of Guelph, 2010; City of Guelph, 2007;
- DMTI Spatial Inc., 2011; DMTI Spatial Inc., 2009;
- Ontario Ministry of Natural Resources, 2008;

Date: 5/25/2012

B-14: Final strategic vacant lots, Patterns 5.1 and 6.1
Ecological Value Ranking
Pre-strategy
Two Rivers Neighbourhood, Guelph, ON

LEGEND
- Two Rivers Boundary
Ecological Ranking
- High
- Medium
- Low

Scale 1:12,000
Coordinate System: NAD 1983 UTM Zone 17N
Sources:
City of Guelph, 2010; DMTI Spatial Inc., 2011;
DMTI Spatial Inc., 2009b;
Ontario Ministry of Natural Resources, 2008
Date: 5/25/2012

B - 15: Ecological value ranking, pre-strategy