Planning for Urban Biodiversity

An examination of the relationship between Integrated Community Sustainability Planning principles and novel ecosystem formation.

by

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1.0 INTRODUCTION

Municipal planning exerts significant pressure on the formation and diversity of urban ecosystems through the various tools it employs. Specifically, many municipalities undertake initiatives to implement land management plans that seek to balance infrastructure development and preservation of natural land with conservation of ecosystem services (Underwood et al., 2011; Kaplan et al., 2004). The Integrated Community Sustainable Planning (ICSP) approach represents the current trend in planning for sustainability in mid-sized Ontario municipalities. This approach attempts to formalize various sustainability principles (see: Gibson, 2006; Hodge, 2004; Dalal-Clayton & Sadler, 2005) within upper-level municipal policy and planning documents while supporting vertically and horizontally integrated approaches to municipal planning (AMO, 2008). Vertically aligned approaches focus on the differing spatial scales of planning (local, regional, provincial) while horizontally aligned approaches are interested in the coordination of planning efforts across different sectors or departments (Planning, Public Works, Community Services, etc.).

Municipalities from around Ontario and the rest of Canada have engaged with sustainable planning principles in various ways for some time. The Integrated Community Sustainable Planning framework represents a purposeful approach to sustainability planning and has received significant support from various governmental agencies and programs (FCM, 2008). Most notable, it has received monetary backing through the Federal Gas Tax program which provides municipalities with federal funds to support infrastructure projects which promote a number of sustainable objectives (AMO, 2011). This represents a significant opportunity for Ontario municipalities to develop plans specific to their location that will utilize sustainability principles to ensure smart development and a planning process that is integrative. Because the ICSP method is meant to be utilized in various locales, the development process is quite flexible in order to allow plans to reflect the inherent uniqueness of individual communities. Ling et al. (2009) stream-lined the process by creating a template that could be generally utilized to develop an ICSP. In doing so the authors touch upon the underlying sustainability principles and how they relate to the planning process, but do not investigate how these principles have been enacted by municipalities with existing ICSPs. This research analyzes how these principles have been formalized by various municipalities and examines the effectiveness of the ICSP process, along with illuminating policies that may be relevant to most urban areas.
Of these sustainability principles, the idea of precaution is one that may already permeate planning doctrine and may affect the formation and biodiversity of urban systems through the employment of zoning by-laws, site-plan control and other planning tools. These tools allow municipal policy to exert control over environmental factors at the landscape level. This specific level of control has created fragmented urban landscapes which recent research suggests spur the formation of urban novel ecosystems (Ernstson et al, 2010).

Urban novel ecosystems are a fairly new avenue of research that attempts to address how urbanization may be affecting biodiversity at a landscape scale. Novel ecosystems in general are produced by anthropogenic patterns of development and, in some areas, have transformed more than three-quarters of pristine ecosystems (Mooney et al, 2009). These systems are linked to the planning profession as they are affected by plans for subdivisions and development as well as policies enacted that promote intensification and green infrastructure. Although there has been adequate study into the formation of novel ecosystems, what is poorly understood is how some of these systems are sustained in a dynamic cityscape. Furthermore, while these types of systems are generally thought of as undesirable, there may be positive aspects that are not promoted in the current legislative climate.

This research will address how three specific principles of sustainability (ecological integrity, resource management, and precaution/adaptation – see section for detailed explanations of each principle) are incorporated within Integrated Community Sustainability Planning (ICSP) and how each can be used to preserve urban biodiversity and promote the creation and protection of novel ecosystems.

2.0 LITERATURE REVIEW

2.1 Planning for Biodiversity.

The concept of biodiversity has enjoyed prolonged exposure in the environmental debate forum for quite some time now and has evolved significantly along the way. From identifying elevated species extinction rates we have progressed to understanding the interconnected relationships between biotic organisms and their environment; and how these collective interactions drive ecosystem function (ICLEI, 2010). Alongside the progression of research, biodiversity has also been addressed in an international policy context. The Convention on Biological Diversity (CBD) component of the 1992 Rio Conference put forth three main goals: (1) biodiversity conservation, (2) sustainable use of that diversity and (3) fair
access to results and benefits of genetic resources (UNEP, 1992 p. 3). The CBD acted as a template from which national strategies for biodiversity conservation could be adapted, and much academic research followed suit focusing on broad strategies. As such, much of biodiversity research has focused on regional conservation methods, while the urban context has been largely overlooked (Elander et al, 2005). As human populations increasingly congregate in urban areas, understanding how human pressures affect and control biodiversity levels will become increasingly important.

With increasing urbanization human populations have come to dominate Earth’s ecosystems (Grimm et al, 2000; Alberti, 2008 p. 1; Barrico et al, 2012). It is due to this dominance that humans must be integrated into ecological models for complete understanding of ecosystems (Grimm et al, 2000). This idea extends towards planning for urban ecosystems as well. If human populations truly dominate the ecosystems they interact with, then the tools that are used to control the health of ecosystems, such as zoning, official plans (OPs), site plan control among others, are of importance especially at an urban scale. However, although policy-makers have recognized the role ecosystems play in maintaining health and well-being, most policies are directed at removing or mitigating negative influences; while policies that are considered proactive are largely overlooked (Brown & Grant, 2005). Generally this is the result of environmental factors having to compete with other socio-economic issues within political discourse. While this may be the typical explanation, current research promotes the idea that biodiversity is shaped through the social and cultural context in which it operates (Brown & Grant, 2005; Nilon, 2011). This suggests that all components, socio-economic, cultural and ecosystem health can be addressed through the planning process in order to achieve the overarching goal of biodiversity conservation.

One such way to incorporate all the elements needed to achieve biodiversity conservation is by looking at governance from a resilience theory approach. Resilience theory suggests that systems consist of quantifiable parts and through limited interactions produce structures that persist over spatial and temporal scales (Folke, 2006; Ernstson et al, 2010). Thus, instead of assuming urban ecosystems are moving towards or away from an equilibrium state, this idea suggests multiple system “regimes” that are the result of localized interaction and human influence. Because these regimes create a fragmented landscape, the specific services supported by one or more of these systems could be significantly impacted if a regime is not conserved (Ernstson et al, 2010). From a planning prospective, governance of these systems should involve focused, collective action among all stakeholders to either sustain a regime, or force a transition to a more desirable and more resilient regime (Ernstson, et al 2010). To illustrate the advantages of this type of planning strategy the example of post-hurricane Katrina New Orleans is given. Much of the secondary damage caused by the hurricane can be related to failure of
environmental services, specifically hydrological services. Although this is considered to be an engineering failure (levee breach), the underlying problem is the alteration of natural systems brought on by increased urbanization. Due to this underpinning, the rebuilding effort involves a planning process that identifies ideal system regimes that mitigate increased flooding and proposes strategies to support their progression (Ernstson, et al 2010). Specifically this has led to policies involving comprehensive plans written explicitly with regional hydrology in mind alongside the remodelling of landscapes to support approximations of natural systems. On a smaller scale, there have been community-based programs focused on introducing more natural components such as terraces and drainage enhancement into areas threatened by serious flooding (Ernstson, et al 2010). While the New Orleans initiative was not originally focused on the idea of ecological resilience, it is an example of how understanding regimes and getting the public involved can help address problems with environmental services and simultaneously enhance system diversity.

2.2 Principles of Sustainability Assessment & Planning

Despite much deliberation over the past 20 years regarding the meaning of the term ‘sustainability’, there is some consensus developing concerning the basic insights of this term (Gibson, 2006). Based on these common understandings, Gibson reasons that, as a fundamentally integrative model, sustainability “must aim to foster and preserve socio-ecological systems ... that are dynamic and adaptable, satisfying, resilient, and therefore durable” (Gibson, 2006 pg. 173). In this way, Gibson (2006) has developed a set of sustainability principles for application in decision-making, especially in sustainability assessment, meant to extend the benefits of environmental assessment (EA), strategic assessment and land use planning. This study draws from three of Gibson’s core criteria for sustainability assessment as outlined in Table 1.

Table 1 – Summary of Gibson’s (2006) Principles Utilized Within Study

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precaution &amp; Adaptation</td>
<td>• Planning methods must respect uncertainties and avoid poorly understood risks regardless of their apparent level of impact. Utilized strategies that are dynamic and adaptable to change</td>
</tr>
<tr>
<td>Resource Maintenance &amp; Efficiency</td>
<td>• Maintaining a base of resources extensive enough to ensure sufficient livelihoods for all individuals is increasingly becoming a significant factor within sustainability policy</td>
</tr>
<tr>
<td>Socio-ecological Systems Integrity</td>
<td>• The idea of protecting the integrity of socio-ecological systems recognizes that natural systems play a foundational role within the life-support functions of a city</td>
</tr>
</tbody>
</table>

Adapted from Gibson (2006)
2.3 What Are Novel Ecosystems?

Novel ecosystems are human built, modified or engineered systems that tend to lack natural analogues. These novel systems contain new combinations of species that are the result of anthropogenic action, environmental change and the deliberate or inadvertent introduction of exotic species (Lindenmayer et al, 2008; Hobbs et al, 2006; Seastedt et al, 2008). In general, when an ecosystem endures a pressure it can either stay at or near its historic state, adapt into a hybrid system, or be altered so dramatically that little historic context remains and is now consider novel (Hobbs et al, 2009). Because the functionality of these systems may not be immediately apparent it is easy to overlook the impact they may be having on the biodiversity of an area.

2.4 How are Novel systems formed?

Studying how novel systems are formed is a complicated task as their inherent uniqueness makes comparative studies difficult to uncover. Regardless, there are several theories which attempt to explain novel system formation and evolution. Hobbs et al (2006) suggest that overall, novel systems result from two key characteristics: (1) novelty defined as the combination of species which has the potential to alter ecosystem functionality and; (2) human agency which relates to human induced pressures which affect a system but may not be continually sustained. These two characteristics are fairly straightforward but are not directly linked to urban novel ecosystems just novel systems in general. In fact, this research seems closely linked to agricultural processes and significant changes in land use. Specifically, Hobbs et al. directly mention the abandonment of human controlled management systems (agricultural, agroforestry, pastures) as a significant driver of novel system development (Hobbs et al, 2006). While this may be a factual statement, this type of novel system creation is unlikely within existing urban areas and therefore may be inappropriate for a study on urban novel ecosystems.

However, Hobbs et al (2006) also provide a broad overview of novel system creation that would seem to be a decent theoretical starting point for understanding the origin of novel systems (Table 2) While the human impact and biotic/abiotic disruption elements relate directly to the two key characteristics of novel systems suggested by the Hobbs et al., the fragmentation element speaks more towards an urban context as urban ecosystems are routinely small and disjointed. As stated, these three elements deliver an adequate overview, but still do not directly address the issue within an urban context.
Table 2 – Pressures supporting novel system creation.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Impact</td>
<td>• Species selection directly through policy or indirectly through cultural/traditional pressures.</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>• Direct contact with urban, cultivated and/or degraded landscape barriers which has a profound effect on species heterogeneity.</td>
</tr>
<tr>
<td>Biotic/Abiotic Disruption</td>
<td>• Affected by changes in direct environmental composition (soil degradation, water disruption, agricultural harvesting) and indirect biotic changes (food availability, erosion, food chain disruption).</td>
</tr>
</tbody>
</table>

Adapted from: Hobbs et al, 2006.

2.5 Urban Novel Ecosystems.

Conducting research on novel ecosystems from an urban context will be paramount in adequately describing the functionality of these systems when faced with anthropogenic pressures. Unfortunately, much of the existing research into urban ecological systems is based on broad ecological theories like deterministic succession and equilibrium dynamics (Pickett et al, 2001; Seastedt et al, 2008). Kowarik (2011) approaches novel urban ecosystems using the “four natures” methodology described in Table 3. In essence, the four natures approach to novel ecosystems recognizes the fragmented nature of urban ecosystems and categorizes them using four broad categories that reflect differing levels of human interaction (Kowarik, 2011). Further, this methodology is based largely on a historical pretext which relates to the importance of habitat continuity.

Table 3 – Four natures approach to Urban Novel System Categorization

<table>
<thead>
<tr>
<th>Ecosystem Identifier</th>
<th>Composition/Evolution</th>
<th>Level of Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pristine (wetlands)</td>
<td>• Components of natural ecosystem remain</td>
<td>Low</td>
</tr>
<tr>
<td>Agricultural (edge ecosystems)</td>
<td>• Human managed systems, few natural remnants</td>
<td>Medium</td>
</tr>
<tr>
<td>Horticultural ((sub)urban parks)</td>
<td>• Newly established after destruction of original system</td>
<td>Medium/High</td>
</tr>
<tr>
<td>Urban-industrial (brownfields)</td>
<td>• Emerge after habitat destruction and human occupation</td>
<td>High</td>
</tr>
</tbody>
</table>

Adapted from Kowarik, 2011.

Generally this approach is coupled with the use of desirable/indicator species to identify the level of transformation a system is at; alongside what species will generally populate these systems (Kowarik, 2011). However, initial research has uncovered that, with increasing trends in agriculture and silviculture, many systems classified as horticultural (gardens, parks) actually have the ability to harbour various species displaced by anthropogenic pressures (Kowarik, 2011; Dvorak & Volder, 2010, Goddard et al, 2010). This finding further supports the need for proper study and conservation of urban novel
systems, as they have the ability to take on varying compositions, and as such can be suitable for a variety of plant and animal species.

3.0 METHODS

3.1 Scope

This research was undertaken within the bounds of four mid-sized Ontario municipalities: City of Kingston, Town of Markham, City of Burlington, and City of London, and will contribute to a larger SSHRC project “Examining Integrated Community Sustainability Planning from an organizational learning perspective: A comparative case study of four mid-sized municipalities in Ontario” led by Dr. Patricia Collins (Principal) and Dr. Graham Whitelaw. Specifically, this study assesses how three specific principles of sustainability (ecological integrity, resource management, and precaution/adaptation) are formalized within the Integrated Sustainable Community Planning process. Further, the principle of precaution was explicitly examined to ascertain how its utilization within the planning structure may be impacting urban biodiversity and how this may be tied to the formation of novel systems.

3.2 Methodology

This research employed a mixed-method approach to uncover the utilization of sustainability principles in ICS planning and link them to issues of urban biodiversity and novel system formation. Specifically, a triangulation method involving the examination of peer-reviewed literature from related fields, analysis of municipal-level planning documents utilizing organizational software; alongside determining habitat diversity levels through passive observation was undertaken. Finally, visual representation (photos) of analysis units was included to better contextualize the passive observation method. These photos will provide a view of locations sampled as well as the type of elements incorporated into the sampling method. Utilizing a triangulation of methods is ideal as no single method can adequately resolve problems arising from rival casual factors (Denzin, 2006 p. 306; Patton, 2001 p. 249). Further, applying a single method makes a study more vulnerable to errors related to that specific method. By employing multiple methods it was assumed that they have non-overlapping areas of weakness coupled with supporting strengths (Patton, 2001 p. 248).

In order to uncover trends relating to the effect municipal planning has on urban biodiversity, an evaluation of municipal planning documents from four mid-sized Ontario cities was undertaken using a content analysis approach operationalized by organizational software (NVivo). For research pertaining to
the larger SSHRC proposal discussed above, information regarding three of the ICSP principles (system integrity, resource maintenance & efficiency, adaptation and precaution) was utilized to provide insight into how ideas of sustainability (Gibson, 2006) and, by extension, biodiversity are being incorporated into municipal strategies. Furthermore, this analysis is expected to reveal how the principle of precaution permeates planning strategies and how this might be the catalyst for novel system development.

Creating a conceptual framework for the path of the policy document analysis went through various iterations. *Figures 5.1 and 5.2* represent frameworks developed to analyze how precaution in the planning process affects biodiversity and, in turn, the formation of novel systems. However, both of these frameworks misplace ICS planning by somehow defining it as an extension of biodiversity when in reality, ideas relating to biodiversity are addressed *within* ICS planning. Moreover, these frameworks especially put emphasis on the precautionary principle as a separate entity when, it too, is a concept of ICS planning.

*Figure 1* – Initial nested framework

*Figure 2* – Initial hierarchical framework

To address this disparity a third conceptual framework (*figure 1*) was developed which attempted to make the flow of research less hierarchical and more integrative. This framework highlights biodiversity as a set of ecological and socio-economic goals, which then are formalized through ICS planning. Moreover, it treats novel systems as a product of biodiversity, but also links them to ICS planning as the mechanism by which they can be controlled and planned for. While this framework has advantages, it would be more suited to analyzing novel systems from a broader, biological scope. In essence novel systems become the broad topic of interest while research strays
away from the planning mechanisms which may influence their creation. *Figure 2* represents a return to a hierarchical approach and properly places ICS planning at the apex of the framework.

*Figure 3 – Cyclical framework*  
*Figure 4 – Hierarchical framework*

These concept maps (*figures 3 & 4*) incorporate *socio-economic goals* as a major component of ICS planning when in reality they are the underpinning of sustainability planning and as such represent an incredibly broad avenue of research beyond the scope of this study. Furthermore, both *figure 3* and *4* still separate the precautionary principle to envelope all other elements of research, which again puts large emphasis on the idea of precaution as a discrete variable instead of a principle of ICS planning.

*Figure 5 – Finalized Conceptual Framework.*
Figure 5 represents the final iteration of the conceptual framework utilizing the strengths of the four previous works. This framework places ICSP as the initial unit of interest and indicates the direction research flowed. From within ICSP related policy documents, an understanding of how ICSP addresses ecological integrity, ecological planning and biodiversity was uncovered. Because novel systems are a fairly new avenue of research, it was not expected that municipal documents would directly address strategies related to this area of study. However, by linking ideas of novel systems to other aspects of ICSP, most notably biodiversity, indirect planning strategies understood to be related to novel ecosystems were uncovered. Finally, the precaution/adaptation ICSP principle was separated into two components solely to conceptualize the importance of the precautionary principle and how it is being utilized in all ideas pertaining to ICSPs.

3.3 Document Analysis

This research compares the four municipalities across four types of municipal documents (Table 4): Official Plans (OPs), Strategic Plans, Infrastructure Master Plans, and Integrated Community Sustainability Plans (ICSPs). These plans offer different focus areas and come from different branches of planning, but as formal policy documents, they reflect the way a municipality officially expresses its vision and priorities.

Official Plans (OPs) are adopted by City Councils, and are subject to 5-year reviews and are required by the Ontario Planning Act. The four OPs used in this study have been updated since 2005. At the time of writing, the Town of Markham was undergoing an OP review and so the 2005 updated version was used. Strategic Plans are corporate municipal documents that outline a municipality’s vision and action over a period of time. It should be noted that the Markham Strategic Plan was the basis for the development of the Markham Integrated Community Sustainability Plan., and as such is representative of a preliminary ICSP. On the infrastructure side, Water and Sewage Master Plans make recommendations for water and wastewater servicing priorities. These plans have been adopted in the past 5 years with the exception of the Vision London Infrastructure Plan, which has not been updated since 1996. Two regional documents, the Halton Infrastructure Master Plan and the York Region Water and Wastewater Master Plan, were chosen for inclusion in the study to better understand the vertical integration of innovative sustainability principles. Of the four municipalities, only two have ICSPs in place. The Sustainable Kingston Plan was adopted in 2010 and the Markham Greenprint was adopted in 2011. Because two of the municipalities are without dedicated ICSPs (Burlington & London), the analysis of ICSPs using Gibson’s principles (2006) is provided separate from the section detailing strategies.
incorporated into the conventional municipal planning documents of all four municipalities. This way, an effective comparison can be better achieved as a combined analysis may skew the results due to Kingston and Markham having an extra document which is mandated solely to achieve sustainability.

Table 4. – Municipal Policy Documents Analysed

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Document Name</th>
<th>Pages</th>
<th>Last Date Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingston</td>
<td>Kingston Official Plan</td>
<td>262</td>
<td>August 2011</td>
</tr>
<tr>
<td></td>
<td>Sustainable Kingston (Integrated Community</td>
<td>68</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>Sustainability Plan)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kingston Strategic Plan 2011-2014</td>
<td>23</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Sewer Infrastructure Master Plan for the City of</td>
<td>123</td>
<td>September 2010</td>
</tr>
<tr>
<td></td>
<td>Kingston</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Master Plan for the Water Supply for the City of</td>
<td>161</td>
<td>June 2007</td>
</tr>
<tr>
<td></td>
<td>Kingston</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markham</td>
<td>Markham Official Plan</td>
<td>225</td>
<td>July 2005</td>
</tr>
<tr>
<td></td>
<td>Markham Greenprint (Integrated Community</td>
<td>190</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Sustainability Plan)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>York Region Water and Wastewater</td>
<td>142</td>
<td>November 2009</td>
</tr>
<tr>
<td></td>
<td>Infrastructure Master Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>City of London Strategic Plan 2011-2014</td>
<td>24</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Vision London Infrastructure Master Plan</td>
<td>68</td>
<td>June 1996</td>
</tr>
<tr>
<td>Burlington</td>
<td>Burlington Official Plan</td>
<td>257</td>
<td>December 2011</td>
</tr>
<tr>
<td></td>
<td>Burlington Strategic Plan 2011-2014</td>
<td>18</td>
<td>November 2011</td>
</tr>
<tr>
<td></td>
<td>Halton Region Infrastructure Master Plan</td>
<td>37</td>
<td>September 2011</td>
</tr>
</tbody>
</table>

3.4 Passive Observation of Habitat Units

Observation of habitat units was undertaken in a fashion similar to Hermy & Cornelis’ (2000) work on monitoring biodiversity indicators in urban and suburban parks. Although urban parks are not being specifically targeted within the scope of this research, the methods employed are appropriate for analyzing habitat diversity trends within relatively compact areas. The method adopted explicitly analyzed habitat diversity as municipal and planning policy are thought to directly impact the compositional nature of a habitat, which in turn affects species diversity. In essence, this method is specifically interested in the planned elements of urban greenspaces and how habitat diversity is being altered in various locations (Hermy & Cornelis, 2000). It should also be noted that the method was originally deployed to look at significantly larger urban park areas and how fragmentation resulted in varying habitat units within one study area. For the purposes of this research, smaller greenspaces are
utilized to represent small habitat units in their own right and further characterized as a system when combined. Thus, the analysis is slightly adjusted to provide insight into the assumed fragmented nature of urban ecosystems through an examination of the individual diversity scores.

Passive observation of habitat units was guided by a categorical list of elements containing features thought to affect the biodiversity of open spaces. Because specific elements impact habitat composition in different ways, the categories are distinguished by the way in which they are measured (Hermy & Cornelis, 2000). *Table 5* indicates the three element classifications and the method of delineation.

<table>
<thead>
<tr>
<th>Element Category</th>
<th>Unit of Measurement</th>
<th>Conditions <em>(Hermy &amp; Cornelis, 2004)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>Area (m²)</td>
<td>- Planar units have and area &gt; 100 m² and a length/width ratio of &lt; 10</td>
</tr>
<tr>
<td>Linear</td>
<td>Length (m)</td>
<td>- Linear elements must have length/width ratio &gt; 10</td>
</tr>
<tr>
<td>Punctual</td>
<td>Count</td>
<td>- Punctual elements have a maximum area of 100 m²</td>
</tr>
</tbody>
</table>

*Example of Planar Element (Kingston)*

*Example of Linear Elements (Markham)*
The evaluation criterion for the passive observation of habitat elements is detailed in appendix A. The original criterion of Hermy & Cornelis’ work has been slightly altered for use in Ontario mid-size municipalities. The most significant alteration is the addition of more human-introduced elements such as car parks, road infrastructure and human-use infrastructure elements. This modification is important as originally the authors omitted such elements citing that they did not contribute to the biodiversity of urban areas; adding that the method would not vary fundamentally if they were to be added (Hermy & Cornelis, 2000). However, recent research would seem to indicate that human infrastructure elements can alter the diversity of an urban system, and specifically can contribute to the heterogeneity, or “patchiness” of urban areas (Geng & Côté, 2004; Wiersma et al, 2004). This is accomplished though the alternation of the physical landscape to a point where its composition is more conducive to a certain set(s) of biota. During observations a number of elements were added once it became evident their presence would be continually encountered and that they exerted an impact on the make-up of the systems analyzed. Appendix X displays the passive observation elements that were utilized over all study sites.

Once all observed elements were delineated a proportion (%) of the total area, length or number of habitat units within an area was calculated through the use of the Shannon-Wiener diversity index (figure 6).

\[ H = - \sum_{i=1}^{s} \frac{n_i}{N} \ln \frac{n_i}{N} \]
Where: \( i \) is the \( i \)th unit, \( s \) is the number of habitat units, \( n_i \) is the area, length, or number of the \( i \)th habitat, and \( N \) the total area, length, or number in the study area.

Through this calculation each habitat type was given a diversity index score that is influenced by number of units present within the area (Hermy & Cornelis, 2000 & 2004). Due to this study deploying this method at a scale that differed from the original research, this diversity index may be misleading when compared to the maximum diversity (Table 6) ratio achievable. Picture evidence will be provided to better orient the reader towards differences in unit diversity within the study areas. Further, this Shannon-Wiener calculation will only uncover proportions within one study area, and offer little insight into how one area may compare to the next. For comparative purposes, a ratio calculation is required which measures the elements present in an area against the maximum number of elements possible. This ratio requires that elements be described simply as present, or not present within an area. Figure 7 illustrates the ratio calculation.

Figure 7.

\[
H/H_{max} \times 100 \quad where \quad H_{max} = -\ln \frac{1}{s_{max}}
\]

Where: \( s_{max} \) is the total amount of distinguished elements within a category.

Table 6 – Maximum Potential diversity within three elements

<table>
<thead>
<tr>
<th></th>
<th>Max Number</th>
<th>( H ) max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>20</td>
<td>2.996</td>
</tr>
<tr>
<td>Linear</td>
<td>14</td>
<td>2.639</td>
</tr>
<tr>
<td>Punctual</td>
<td>5</td>
<td>1.609</td>
</tr>
</tbody>
</table>

The values obtained from this ratio calculation represent a saturation index as it represents diversity as a percentage of a maximum level. \( H_{max} \) will remain the same for all observed areas, but will be significantly altered by the addition or subtraction of observation elements. As such, solidification of the observation criteria prior to data collection becomes more important. As a final step to judge an area’s broad diversity, a total saturation index \( (S_t) \) for all units together was calculated as a weight average of all three saturation values (Figure 8). Weights are derived using total number of recorded units in a study area.
Where \( S_{pt} \) is the saturation index of planar elements, \( n_{pt} \) is the number of planar elements, \( S_{li} \) is the saturation index of linear elements, \( n_{li} \) is the number of linear elements, \( S_{pu} \) is the saturation index of punctual elements, \( n_{pu} \) is the number of punctual elements and \( n_t \) is the total number of elements.

### 3.5 Case Site Selection

The case study cities were chosen due to their comparable populations, patterns of development and economic profiles (Table 7). Burlington and Markham are rapidly growing cities that are part of a larger urban centre, while Kingston and London are more isolated and experiencing relatively lower rates of growth (Statistics Canada, 2011)

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>SELECTED MUNICIPALITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population (2011)</td>
<td>London</td>
</tr>
<tr>
<td></td>
<td>366,151</td>
</tr>
<tr>
<td>Population Change % (2006 to 2011)</td>
<td>3.9</td>
</tr>
<tr>
<td>Land Area (km(^2))</td>
<td>420.57</td>
</tr>
<tr>
<td>Population Density per km(^2)</td>
<td>870.6</td>
</tr>
<tr>
<td>Immigrant as % of population</td>
<td>21.2%</td>
</tr>
</tbody>
</table>

2011 Census (Statistics Canada)

Individual sites within the municipalities were chosen based on the use of online mapping tools. All four municipalities host online interactive mapping tools based on traditional GIS software. These tools were used to identify greenspaces of suitable size for inclusion in the passive observation methodology. Although many of the sites chosen ended up being parks, this was not the purpose of the selection process. In fact, within the interactive mapping software of the respective municipalities, many of the selected areas were not labeled as parks.
3.6 Limitations

The habitat diversity sampling method was used to determine the level of urban habitat heterogeneity witnessed within a municipality. While the results of this method do not directly examine urban biodiversity, they indicate levels of “patchiness” within urban systems which is a pattern linked to the development of novel ecosystems (Ernston et al, 2010). Sampling results were compiled and then combined with information collected from the content analysis to uncover municipal planning policy, pertaining to the principles outlined in figure 5 that govern the areas studied. Through this, policies and tools utilized by the planning profession were linked to the formation of fragmented urban systems as
well as protective planning strategies (precaution) which play an important role in the creation of novel ecosystems.

Significant alteration has been made to the original method employed by Hermy & Cornelis, the most noteworthy being the change in spatial scale when defining a habitat unit. Within this study’s approach habitat units are seen as entire spaces cut off from the rest of the system by physical boundaries that are a product of urban development. Specifically, these spaces relate to greenspaces or small parks within municipal boundaries and not a single, large park with habitat units contained within. For this reason conclusions based on the first set of calculations (unit diversity) may be misleading as they were designed to uncover patterns of fragmentation within one, albeit larger, space.

As the passive observation method was deployed in four mid-sized municipalities in Ontario, Canada, the effect seasonality may have on this type of technique must be considered. Data was originally collected during the month of February which was thought to have impacted the presence of specific elements which are only readily identifiable during warmer seasons. For this reason sites were revisited in the spring to ensure the original data was not compromised. Upon reassessment, the original data only contained errors relating to two (2) of the selected elements and was updated to properly represent those elements subject to the effect of seasonality.
4.0 RESULTS

4.1 Passive Observation (Quantitative Analysis)

The habitat unit survey yielded diversity index ratio values for each individual site within the municipalities. These calculated values are provided, in full, attached as Appendix B. The results indicate noticeable variation in habitat composition with regards to the units incorporated into the observation criteria. Specifically, Kingston shows the greatest amount of variation especially with regards to the incorporation of punctual elements between all sites visited. Both London and Burlington show discernible variation between sites with regards to linear elements. In general, linear element variation seemed to be influenced by the type of land-use that was surrounding it, as linear elements tend to be deployed as natural privacy barriers. This can be better understood through viewing of photographic evidence (appendices C,D,E,F). The photos reveal that in residential areas, linear elements such as tree rows and fences are utilized to delineate the barriers between private and public property. On sites that were located near urban cores or in the cases where the site was confined by roadways, linear elements were much less predominant. Further, many of the photographs show large spaces within the sites being used for recreation and sporting activities. While these large areas contribute to the saturation of planar elements within the site, their expansive, non-fragmented compositional nature will only result in the generation of one count of a single planar element. Due to many of the sites containing these recreational elements, and the fact that the size of these elements are standardized (soccer fields, play structures) the diversity index values pertaining to planar elements remains fairly constant over all sites visited. In fact, the few sites that do deviate (Rollingwood, Bur Oak, Strathcona, Champlain) are those which contain few or no recreational elements.

Table 8 provides a glimpse at the combined diversity index values of all sites within a specific municipality. When compared to maximum achievable diversity values (Table 6) the results indicate that the sites surveyed seemed to maintain higher diversity values regarding the punctual elements. These results should be interpreted as a ratio representing the number of elements found to be present within all sites analyzed within a specific city. As the scale of the study differed from the Hermy & Cornelis 2000 study, there may be bias towards the sets of elements which incorporate the least amount of criteria. This is the result of the combination of study sites and the fact that a smaller set of criteria accommodates less variation.
Table 8 – Diversity index

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Markham</th>
<th>Burlington</th>
<th>Kingston</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>1.53</td>
<td>1.53</td>
<td>1.50</td>
<td>1.55</td>
</tr>
<tr>
<td>Linear</td>
<td>1.45</td>
<td>1.56</td>
<td>1.49</td>
<td>1.59</td>
</tr>
<tr>
<td>Punctual</td>
<td>1.44</td>
<td>1.49</td>
<td>1.55</td>
<td>1.39</td>
</tr>
</tbody>
</table>

Table 9 provides an overview of the saturation of habitat elements with all sites of a specific city. When combined with the results from Table 8, it becomes clear that the punctual elements are displayed much more prominently within all four municipalities. Although it was stated earlier that reduced sets of elements may skew results with regards to variation, the saturation index provides an overview not just of whether an element is present, but is also sensitive the number of a specific element present. As punctual elements can be viewed as singular elements not interconnected with other elements, they are less likely to foster biodiversity. Conversely, as planar and linear elements provide a more substantial space for species to reside, as well as providing connected spaces, a higher saturation index value can be thought to be fostering biodiversity levels. With this in mind, the results portray Kingston as the leader of all four cities with lower punctual saturation rates, alongside higher rates of planar and linear elements. Results from London suggest a movement towards more integrated open spaces by having a lower punctual saturation index and a moderate incorporation of planar elements. However, when compared to the other municipalities, the sites in London include fewer linear elements. While maintaining moderate levels of planar and linear element saturation, Markham and Burlington still witness very high saturation values with regards to punctual elements.

Table 9 – Saturation Index (compared to maximum achievable)

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Markham</th>
<th>Burlington</th>
<th>Kingston</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>51.07%</td>
<td>51.20%</td>
<td>49.94%</td>
<td>51.75%</td>
</tr>
<tr>
<td>Linear</td>
<td>54.89%</td>
<td>59.08%</td>
<td>56.59%</td>
<td>60.36%</td>
</tr>
<tr>
<td>Punctual</td>
<td>89.71%</td>
<td>92.55%</td>
<td>96.12%</td>
<td>86.20%</td>
</tr>
</tbody>
</table>

Finally, a total saturation index of all four municipalities is provided as a quick comparative tool (Table 10). While it may be tempting to draw conclusion from this set of results, it should be understood that because the original method called for the use of weighted averages, the size of sites analysed will skew the results especially if there is a proportionally higher saturation of punctual elements (Markham, Burlington).
4.1.1. Photographic Evidence

Photos of all sites are provided as appendices B through E. It should be noted that while the sites within the municipality of London were revisited in the spring, there are no photographs available from those visits. Instead, photos taken during the winter site visits are provided in appendix E. These photographs are still able to portray many of the elements present within these areas.

4.2 Qualitative Analysis

4.2.2 Use of Gibson’s (2006) Sustainability Principles in Non-ICSP Policy Documents

Precaution & Adaptation

The use of this principle within policy documents of the four respective municipalities is largely directed towards the concept of operational flexibility. This concept was primarily utilized to describe a strategy directed towards ensuring the continual provision of infrastructure services; specifically the effective delivery of water services. Operational flexibility is an idea largely rooted in the manufacturing industry, but has seen increased used within the energy sector (Marreco & Carpio, 2005). In general though, the term is used to describe the day-to-day function of a process or system and how it responds to previously untested pressures. Thus, a system that is able to operate satisfactorily under conditions that are unlike the nominal design conditions is said to have a high degree of flexibility (Hopkins et al, 2001; Grossman & Morari, 1983). Language directly referencing operational flexibility is incorporated into infrastructure plans of all four municipalities. The Kingston Water Supply Master Plan encourages flexible strategies to service delivery and further cites flexibility as the rationale for proposed recommendations for improvement.

“The interconnection of the Kingston West and Kingston Central (including Kingston East) water supply and distribution systems could reduce the required additional water supply and would provide increased operational flexibility.” (Kingston Water Supply MP – Reference 1 – Page 72)

“Alternative 3 – Should be easier to operate and maintain (one water treatment plant) and large new expansion – Additional system flexibility would reduce critical operations interventions.” (Kingston Water Supply MP – Reference 4 – Page 102)
Both the Halton Region Infrastructure Plan and the Vision London Infrastructure Plan reference operational flexibility as a key consideration of development and evaluation of infrastructure servicing strategies\(^1\)\(^2\). In this light, the role of infrastructure plans are primarily focused on providing a sort of redundancy to ensure that servicing remains adequate while facing unpredictable future needs and trends. However, the York Region Water and Wastewater Plan extends this approach by linking the concepts of flexibility and adaptive management within a strategy that is responsive to socio-economic trends while still addressing issues of sustainability.

“Flexible (adaptive) approaches will be needed based upon a holistic view of water resources. Critical elements of the Region’s approach will be managing groundwater resources, wastewater effluents and supporting municipal and Conservation Authority programs for stormwater.” (York Region W & WW Plan – Reference 4 – Page 62)

“Monitoring, Performance Measurement and Adaptive Management – York Region will monitor and report on the implementation and operation of water and wastewater sustainability strategies through a range of objective performance measures. York Region will learn from sustainability successes and challenges. It will adapt management methods and practice continual improvement toward sustainability leadership.” (York Region W & WW Plan – Reference 5 – Page 68)

The combination of these two ideas within the York Region Water and Wastewater Plan shows that increasingly adaptive management is being utilized within the water management sector as a way to face increasing uncertainties posed by climate change and changing socio-economic boundary conditions (Pahl-Wostl, 2007). Further, research linking adaptive management to an ecosystem planning approach suggests successful implementation requires three types of information: site-specific baseline information on ecosystems, knowledge of how services located within specific ecosystems will respond to biophysical changes (resiliency), and integrated regional models documenting economic and technological change providing policy-makers information on the consequences of different management options (Ayensu et al, 1999). The York Region Water and Waste Water Plan attempt to address any gaps in these areas of information by incorporating strategies and recommendations\(^3\) that promote intensive monitoring of ecological and socio-economic trends, as well as inter-governmental cooperation and information sharing.

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1 Sustainable Halton Water and Wastewater Master Plan – Executive Summary, pg. 7
2 Vision London Infrastructure Plan, pg. 7
3 York Region Water and Wastewater Plan, pg. 67
“Successful implementation of York Region’s water and wastewater sustainability strategy relies on an adaptive management approach, which allows for adjustments to be made in the timing and scope of strategy components to better accommodate changes in:

- Socio-economic factors, that is, the estimates of population and economic growth, including the rates of growth and the locations within the Region where growth is occurring;
- Regulatory requirements, which are external pressures and to which the Region’s policies and programs must be able to respond; and,
- Environmental conditions, notably the potential impacts of climate change, which can affect the quantity and quality of drinking water sources as well as the receiving environments for wastewater effluents and biosolids”. (York Region Water and Wastewater Plan – Page 6)

The policy documents of all four municipalities also refer to monitoring strategies to combat uncertainty in much the same manner as the ICSPs of Kingston and Markham. Where the approaches differ is that much of the Non-ICSP policy is interested in the monitoring of development trends that can be linked to growth. This focus on the monitoring of a precise subset of planning related trends has been described as the result of pressures created by the economic restraint places on municipalities who are witnessing a down-shifting of responsibilities from upper-tier governmental bodies as well as reductions in revenue generations (Seasons, 2003; Graham et al, 1998). Within Burlington’s Official Plan monitoring policy is implemented to uncover trends related to quality of life indicators, sustainable development, efficiency within municipal departments, housing markets, population trends, service efficiency and delivery; alongside transportation infrastructure. Reference to the uncertainty principle can be found through Sec. II and IV of Burlington’s Official Plan.

“In conjunction with the Region of Halton, the City shall regularly monitor the attainment of population and employment targets contained in the Regional and City Official Plans by considering measures such as the current overall municipal employment-to-population ratio, amount of infill development, and prevailing residential and employment densities of developing areas as compared with those stated in the respective Secondary Plans.” (Burlington OV-IV Land-Use Policies Rural Planning Area – Reference 7 – Part VI, Page 20)

“City Council shall annually monitor the local housing market and review the effectiveness of the City’s housing policies in addressing local housing needs.” (Burlington OV-IV Land-Use Policies Rural Planning Area – Reference 6 – Part VI, Page 20)

The City of Kingston’s Official Plan also refers to uncertainty through the use of monitoring policy. Some of the policy provides the municipality significant powers to require that the developer include the future costs of long-term monitoring if such a requirement is deemed necessary by an environmental assessment.
Any approved development or site alteration shall be constructed in accordance with the recommendations of the approved EIA. An implementing agreement between the proponent and the municipality will normally be required (e.g. a subdivision, site plan, or development agreement). The municipality may require that funds be held in reserve for the purpose of long-term monitoring, which may occur following the completion of the development or site alteration." (Kingston OP Appendix A – Reference 2 – Page 3)

The inclusion of this policy is unique in that the municipality is mandating the developer take responsibility for the uncertainty that results from the alteration of land and natural systems. However, there is increased scepticism that potential developers will just download the increased cost of such initiatives onto the consumer (Bowman & Thompson, 2009). Further, the argument is being made that there is a lack of willingness to pay on the consumer side, regardless of community and municipal groups stating their support for such monitoring and ecologically-minded initiatives (Bowman & Thompson, 2009). The Kingston Official Plan also incorporates much of the traditional monitoring policy regarding socio-economic indicators that are found in many municipal policy documents. Specifically, Section 9: Administration and Implementation of Kingston’s OP defines the type of monitoring that the municipality will be responsible for. These responsibilities are extended to include the monitoring of: impacts of growth, alteration or contamination of natural land, destruction of trees, approval procedures for condominium applications, and implementation and financial components of Community Improvement Plan. In much the same fashion and Kinston’s Official Plan; London’s Official Plan too adopts significant language related to the monitoring of development goals and the implementation of monitoring policy, but the language also contains direct reference to uncertainty. As part of the general practices of London land-use strategy Ch.1:

“Provide for an allocation of land use that reduces uncertainty regarding future development, promotes compatibility among uses and recognizes environmental constraints to development.” (London OP Chapter 1 — 1.2.ix)

In essence, the London Official Plan uses uncertainty as a rationale for the allocation of land-use through zoning. Furthermore, Ch.1 also refers to how planning documents cannot be static and trends must be monitored in order to adequately react to pressures:

“...the Plan should not be regarded as a static or inflexible document that is resistant to the pressures of unforeseen economic, social or development changes during the planning period. It is intended, therefore, that the validity of the Plan should be maintained through an ongoing process of monitoring, review and modification as required.” (London OP Chapter 1 – Reference 2 – 1.4)
Finally, monitoring policy and responsibility is discussed in depth throughout Chapters 2 and 12 of London’s Official plan. In these chapters the monitoring of indicators such as housing demand, land requirements, servicing demand, and economic and population growth trends are discussed with a special emphasis on tracking the municipality’s progress in relation to provincial and national averages.

Overall, ideas relating to adaptive management of resources and monitoring policy seem to be commonplace within the non-ICSP documents of the four municipalities. Although none refer directly to novel ecosystems, these types of policies suggest that these municipalities could entertain such a notion. The practice of adaptive management could lend itself well to novel ecosystem classification and identification as it brings with it the ability to include new ideas and definitions in an on-going fashion. As with adaptive management, the monitoring of ecological assets that the majority of these municipalities promote could aide in the documentation of urban novel ecosystems if the information is gathered and grouped in a manner conducive to the identification of novel ecosystem elements.

Resource Maintenance and Efficiency

Much of the language with regards to resource maintenance and efficiency focuses on conservation efforts within the context of curbing consumption of services. These efforts are further enforced by the recent incorporation of strategies that promote a transition towards renewable sources of energy. The combination of these strategies has seen increased used in other parts of the world (US, EU) and attempts to utilize economic measures to de-incentivize consumption within the existing market, while simultaneously incentivizing investment and implementation of renewable energy (Maques & Fuinhas, 2011). Although these strategies are regularly intertwined, some municipalities have yet to incorporate strategies regarding renewable energy. However, all four municipalities make reference to conservation strategies when dealing with resource maintenance issues. Within Burlington’s Official Plan conservation is generally used when describing the use of services and the consumption of resources. In fact, consumption of resources is a significant factor with the official plan and can have an effect on the development of land. Sec. IV Land-Use Rural Planning States:

“Only Commercial uses with a low level of water consumption and sewage generation as approved by the Region of Halton shall be permitted.” (Burlington OP-IV – Part IV, Page 24)

“Only institutional uses with a low level of water consumption and sewage generation as approved by the Region of Halton shall be permitted.” (Burlington OP-IV – Part IV, Page 25)
Furthermore, with the functional planning section of the Burling OP, potential development applications must be reviewed in order to ascertain if the building layout accommodates waste reduction activities and access to the city’s transportation system. These policies indicate the high level of importance Burlington puts on ensuring the efficient provision of servicing, especially water and wastewater, while promoting industry that uses these services sustainably. Similar to Burlington, Ch. 3-6 of Kingston’s Official Plan make direct references to transitioning to renewable sources of energy as well as enacting conservation programs for energy usage. Unlike Burlington however, Kingston’s Official Plan suggest the implementation of soft-strategies such as educational programs and integrated waste management programs to address the consumption issue.

“To develop an integrated waste management system that is appropriate to the City’s environmental, social and economic conditions and that maximizes waste diversion from landfills, controls or reduces overall system costs, creates new economic opportunities, and preserves the natural environment through reduced consumption of natural resources.” (Kingston OP Section 4 – Page 186)

“The City intends to encourage the reduction, reuse and recycling of waste through programs aimed at educating consumers. The City will promote such programs to reduce the amount of residential waste that goes to landfills and to meet market demands for recyclables”. (Kingston OP Section 4 – Page 187)

The Official Plan of London thoroughly investigates the concept of conservation. Specifically there is significant mention of conservation of water usage in order to combat frequent shortages during certain times of the year. The plan directs these conservation efforts to areas that traditionally use sizable amounts of water and are not considered to be high priority when considering the public good (landscaping, recreation). Conservation of water resources is also referenced within the context of encouraging the minimization of energy and water usage within new urban developments

“New developments shall be encouraged to minimize energy and water use and where feasible, to provide for the conservation of building materials through re-use, recycling and renovation. (London Official Plan – Ch. 11: Urban Design Guidelines – Page 3)

However, it is not made clear within the plan how the municipality plans to enforce these conservation initiatives. Further, the use of language such as “encourage” suggests a less than proactive strategy when promoting conservation measures within the development industry.

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4 Burlington Official Plan Part II: Functional Policies, pg. 8
5 London Official Plan, Ch. 11 – Urban Design Guidelines. pg. 2
Infrastructure plans take a particularly forward thinking approach to conservation initiatives and in some cases link these strategies to existing issues of climate change and sustainability. The York Region Water and Wastewater plan specifically refers to conservation in the context of decreasing water demand and making infrastructure more efficient. However, the plan makes the argument for conservation methods citing the importance of protecting natural heritage for future generations and improving the overall quality of life for residents within the municipality. This plan has also been updated to include references to other planning documents and the strategies championed by them.

“York Region’s Official Plan describes the Region’s intent “to conserve and improve the natural environment for this and future generations so that it will sustain life, maintain health and provide an improved quality of life”.” (York Region W & WW Plan – Page 61)

“Resource conservation, in terms of energy efficiency, and acknowledgement and accommodation of the uncertainties that may result from changes in climate are main components of both the York Region Sustainability Strategy and the Region’s Water and Wastewater Sustainability Strategy.” (York Region W & WW Plan – Page 65)

The focus on conservation of resources and services portrayed within the municipal policy documents suggest significant concerns relating to shortages, or threats of shortages regarding water and energy. Water shortages specifically have been responsible for inducing innovative demand management and supply efficiency enhancement measures (Wilchfort & Lund, 1997). To be effective, successful management and efficiency programs will incorporate policies that promote education and consumption reduction, as well as reducing municipal utilization of resources in areas of high use (landscaping) (Wilchfort & Lund, 1997). Although these strategies were developed for use within water related services, the approach is readily applicable to other services such as energy and waste. In this light, London and Kingston are making significant progress towards effective conservation.

Socio-Ecological Systems Integrity

Most of the language uncovered relating to this principle focuses on utilization of environmental impact assessments (EIA) and the conditions under which the process is enacted. Initially urban planning theory and EIA developed on separate but parallel paths (Lawrence, 2000). Over the past decade much work has been completed that attempts to align EIA and planning theory in order to arrive at a more integrative tool that encourages great attention to properly defining problems and supports the generation of alternative solutions (Lawrence, 2000). Beyond integration into municipal planning policy, research has also been interested into how effective EIAs are when utilized to ascertain the viability of
proposed land transitions. Kingston’s Official Plan makes extensive reference to the environmental impact assessment principles and process. The OP also refers the Provincial Policy Statement as well as other government documents in order to establish guidelines for when assessments should be enacted as well as the areas in which they are meant to protect.

“The demonstration of no negative impacts is normally the subject of an environmental impact assessment (EIA), which is prepared by a qualified person at the expense of the proponent. The PPS and supporting documents indicate the types of natural heritage features and areas, and the width of adjacent lands around them, where an EIA is normally required.” (Kingston OP Appendix A – Page 1)

Within the context of environmental assessments, Kingston’s Official Plan makes it clear that the Cataraqui Regional Conservation Authority (CRCA) is to play a significant role in the implementation and review of such processes. Moreover, policies contained with the official plan indicate that the CRCA is to be involved in all stages of environmental assessment, extending the Authority’s responsibilities to a “pre-consultation” stage. Even though the CRCA’s involvement is extensive, the Official Plan still indicates that EIAs approved by the Conservation Authority must still attain council approval.

“The completed EIA is reviewed by municipal and CRCA staff, and sometimes by MNR or others, and is then either endorsed or refuted by a planning approval authority (e.g. a municipal council).” (Kingston OP – Appendix A – Reference 4 – Page 1)

“The completion and acceptance of an EIA by the CRCA shall not guarantee that a development or site alteration proposal will automatically be approved by the municipality.” (Kingston OP – Appendix A – Page 3)

In much the same manner as Kingston, Markham’s Official Plan requires Environmental Impact studies in a number of specific situations and Section 2 of the plan largely describes the various obligations of the city and provincial/federal governments.

“An Environmental Impact Study shall be required for: proposals which would encroach on the valleylands, locally significant area complexes and woodlots and other vegetative communities as identified on Schedule ‘I’ – ENVIRONMENTAL PROTECTION AREAS;” (Markham Section 2 pp. 2-21)

“In cases where a Subwatershed Study, Federal or Provincial environmental assessment, detailed Environmental Master Drainage Plan or equivalent or other broader scale environmental study has been completed in advance of a development proposal affecting Environmental Protection Area lands, the Town may reduce or modify the environmental study requirements provided the study satisfactorily addresses the environmental matters of municipal concern.” (Markham Section 2 – pp. 2-22)
As some of the reviewed municipal policy would suggest, the EIA process is generally deployed when dealing with a proposed development that would fundamentally alter the existing landscape. However, what are not discussed are the types of sources of data that the municipality is relying on for its baseline data alongside a lack of discourse on the required qualifications of those who are deploying the study. For this reason it is imperative that such an impact assessment process draw on reliable sources of data that reflect current conditions and scope or are derived from reliable land use scenarios (Rothman et al, 2007; Wiek et al, 2006). Further, the municipal EIA process must incorporate criteria that details the level of expertise needed for the various classes of EAs.

Both Burlington’s and London’s Official Plans incorporate EIA policy similar to that of the two other municipalities, however both further link EIAs to planning for buffer areas and environmentally sensitive areas (ESA). The City of Burlington’s Official Plan specifically indicates that their Assessment guidelines will adhere to those adopted by Conservation Halton while the Rural Planning section of the plan directly links the EIA process to ESAs.

“A buffer area adjacent to the Grindstone Creek Valley ESA and Sassafras Woods ESA shall be established through Environmental Impact Assessments. For those lands adjacent to an ESA for which an Environmental Impact Assessment has not been completed, a minimum buffer area of 15 m shall apply.” (Burlington OP-IV – Part V, Page 16)

“(d) For areas regulated by Conservation Halton, such as floodplains, wetlands, watercourses, the shoreline of Lake Ontario/Burlington Bay, or regulated valleylands, the Environmental Evaluation report may also be required to fulfill the requirements of the Conservation Authority’s Environmental Impact Assessment.” (Burlington OP-II – Part II, Page 6)

Similarly, London links EIAs to ESAs, but the language differs slightly through significant reference to the protection of the natural heritage system and restraining development that would impact the integrity of a sensitive system from taking place. Although integrity is not directly mentioned, the policy suggests that the maintaining the integrity of natural heritage is an important goal.

“As a condition of approving infrastructure projects within the Natural Heritage System, the City shall require specific mitigation and compensatory mitigation measures that are identified in the accepted environmental impact study to address impacts to natural features and functions caused by the construction or infrastructure maintenance.” (London OP Chapter 15 – 15.3.3.iii)

“It is the preference of the Municipal Council that the preferred location of infrastructure not be within the Natural Heritage System. New or expanded infrastructure shall only be permitted within the Natural Heritage System where it is clearly demonstrated through an environmental assessment process
under the Environmental Assessment Act that it is the preferred location for the infrastructure, and that the alternatives are all evaluated in accordance with the policies of the Official Plan, including the completion of an environmental impact study accepted by the City." (London OP Chapter 15 – 15.3.3.)

Unique to London however, is policy with the OP that makes reference to the labeling of unclassified greenspaces as “vegetation patches”6. This classification is used, in part, to identify potential naturalization areas with specific interest in creating corridors between and within riparian and wildlife habitats. These areas are further defined as either “environmental review” or “unevaluated vegetation patches”. These labels are used purely as interim measures until further information can be gathered on their environmental importance and how they should be further defined for inclusion in London’s natural heritage system.

Finally, as with other principles covered, the London Infrastructure Plan from 1996 contains much of the language found in the OP, making specific reference to the protection of natural heritage systems7. This protection of natural heritage systems, alongside the space for a novel classifications of urban ecosystems to be incorporated into Ch. 15 of London’s OP, suggests that London may be the best municipality equipped to begin incorporating novel ecosystem concepts into their legislative framework, regardless of whether or not an ICSP is in place.

4.2.3 Use of Gibson’s (2006) Sustainability Principles in ICSPs

Precaution and Adaptation

ICSPs have been designed to be adaptive to changing conditions while supporting diversity and flexibility where possible to mitigate risk. The Markham Greenprint specifically mentions adaptive management as the overall strategy to attract partnerships and champions from businesses and community groups. In this light, the concept of adaptive management is utilized as a way of linking community learning and involvement with policy creation and implementation (Bormann et al, 2007).

“In all of this, the Sustainability Office is busy encouraging staff and community champions, establishing partnerships, launching pilot projects, all while active learning and adaptive management are taking place.” (Markham ICSP – page. 126)

6 London Official Plan, Ch. 15 – Environmental Policies. pp. 9-25
7 Vision London Infrastructure Plan – pg. 18
Markham’s *Greenprint* utilizes adaptive management to better accommodate a diversity of views and approaches to sustainability. Since a community planning initiative of this nature must be inherently inclusive of all relevant stakeholders and individuals, there is a significant risk of encountering hostilities between the varying contributors. By maintaining an adaptive approach to partnership building from the beginning, the Markham’s ICSP ensures there is a place for all interested participants and that their ideas will be considered equally. While *Greenprint* incorporates aspects of adaptive management into their partnership approach, the *Sustainable Kingston Plan* was directly developed using an adaptive management framework. This process acknowledges that there is uncertainty within any system and attempts to minimize this uncertainty through close monitoring and adjustment of the system under management (Satterstrom et al, 2007 pg. 92).

“The Sustainable Kingston Plan was developed using the Adaptive Management Framework (AMF). This approach offered a systematic process of alignment and feedback between the various levels of the framework was used to inform the development of Sustainable Kingston.” (Sustainable Kingston – page. 7)

In this approach, the *Sustainable Kingston Plan* is the culmination of an adaptive management process as its design incorporates goal setting, system modeling, as well as the monitoring of real or perceived feedbacks (Satterstrom et al, 2007 pg. 90). In this way all issues regarding sustainability brought before Sustainable Kingston are subject to a process that is integrative and considers multiple factors when formulating a solution.

Both ICSPs mention monitoring strategies as a way to combat uncertainties related to climatic change and environmental impacts related to urban development. Kingston’s ICSP specifically fills the gaps left by the municipality’s OP in terms of monitoring policy by focusing on the monitoring of socio-economic and community goals in a broader attempt to ensure up-to-date information for members as well as develop strategies to further improve the plan. Both ICSPs utilize a set of indicators and recommendations developed through community and stakeholder input that attempt to monitor a wide variety of issues pertaining to sustainability. This approach requires that adequate baseline data is collected for all indicators for comparison purposes as well as ongoing review of monitoring practices and responsibilities.

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8 *Greenprint*, Markham ICSP, pg. 137
9 *Sustainable Kingston*, pg 49.
“Indicators are a measure of where we are now, which are useful for measuring how things change over time. These indicators are a baseline or starting point since this is the first time that such information has been collected. The Sustainability Office will monitor these indicators over time to track progress toward community sustainability goals and will report the results.” (Markham ICSP – page. 20)

“Monitor Progress – Our indicators will track positive and negative changes in community sustainability. Technically sound and measurable results will be communicated with partners, individuals, and organizations. They will be used to ensure transparency and accountability while enabling us to continuously improve our plan.” (Sustainable Kingston – page. 15)

Both ICSPs support a community-based monitoring approach to achieve specific sustainability goals relating mostly to socio-economic issues. Research suggests the benefit of this type of approach is that it engages ordinary citizens to work together on shared objectives which further fosters the creation of “social capital” (Bliss et al, 2001). Furthermore, effective regulation related to community-based monitoring can help policy-makers recognize the need to involve stakeholders and citizens in planning and management as a strategy for achieving sustainability goals (Cuthill, 2000; Malmborg, 2003; Whitelaw et al, 2003).

Resource Maintenance and Efficiency

This principle shares a close relationship with the concept of inter/intra-generational equity as maintaining a base of resources requires compromises between present and future needs. Strategies are generally tailored towards reducing the ecological damage of resource extraction processes, avoiding excess waste, and curbing overall energy and material consumption (Gibson 2006). Language incorporated into both ICSPs describes these strategies through the concepts of conservation and increased efficiency. Greenprint specifically mentions conservation within the context of promoting decreased use of natural resources as well as the reduction of GHG emissions. The ICSP also contains recommendations for where consumption reduction initiatives should be directed as well as establishing specific reduction targets.

“When a positive action is taken in one area of the system, such as protecting biodiversity through habitat conservation, the action ripples through the rest of the system to help conserve cultural landscapes, protect water resources, sequester carbon, clean the air and provide recreational amenities.” (Markham ICSP – page. 16)

10 Greenprint, Markham ICSP, pg. 121
Beyond recommendations and specific targets to achieve, Greenprint uses language that is closely related to concepts found in ecosystem planning and other environment related fields (e.g., conservation of biodiversity through habitat preservation). Markham’s ICSP further supports a strategy directed towards responsible materials management that promotes movement towards a closed-loop system of resource use and resource consumption within Markham\(^\text{11}\). These strategies aim to alleviate the stress that resource consumption and waste production exacts on sources of natural capital such as water sources, air quality, and ecosystem integrity (Kenworthy, 2006). The maintenance of these systems is considered paramount as they provide valuable services to the community, reduce costs associated with service delivery, as well as contribute to increased public health.

Conservation practices need not be restricted to the preservation of natural resources. As uncovered in both ICSPs, there was interest in proper management and protection of heritage resources. The Sustainable Kingston Plan especially focuses on this area of resource protection through the incorporation of a fourth pillar of sustainability that is concerned with the protection and promotion of culture within the Kingston area. As the ICSP process is one that encourages the adaptation of planning practices to fit the unique needs of individual municipalities, Kingston’s focus on culture as a separate pillar can be linked to the extensive catalogue of historical assets contained within the city.

“By including, protecting, respecting, and sharing our community’s unique cultural heritage, rich and diverse narratives, and local history, Kingstonians will have a better understanding of ourselves, others, and our world.” (Sustainable Kingston – page. 19)

The Sustainable Kingston Plan also makes reference to heritage preservation within the context of non-tangible heritage assets such as indigenous sources of knowledge, shared experience, oral history, traditional practices and skills, alongside a local sense of place\(^\text{12}\). This idea of incorporating non-tangible assets within heritage conservation represents a departure from the notion of a “historic city” as one’s whose economy is dependent on physical heritage assets and actively promotes the exploitation of these resources for economic gain (Stubbs, 2004; Strange, 1996). Modern notions of heritage conservation recognize the need for the integration of three interrelated objectives for urban conservation: physical, spatial and social (Nassar, 2003). The physical and spatial aspects have traditionally been well incorporated through preservation and rehabilitation programs, as well as holistic planning practices that attempt to link heritage through spatial ideas of use and accessibility.

\(^\text{11}\) Greenprint, Markham ICSP, pg. 91
\(^\text{12}\) Sustainable Kingston, pg. 19
However, the social component is often overlooked due to the difficulty in defining the intrinsic values associated with heritage preservation (Nassar, 2003). New thinking adopted by the Sustainable Kingston Plan suggests cultural heritage should be viewed as a source of capital that is concerned with the specific ways tangible assets, mythologies, memories and traditional knowledge become intertwined with present-day resources (Stubbs, 2004; Graham, 2002). In this light, the Sustainable Kingston Plan is making strides to better define its vast catalogue of heritage resources within a broader, social context that recognizes the value of these resources to community identity rather than solely on the economic value provided by the commodification of cultural assets and resources. Markham’s ICSP also makes reference to the conservation of cultural heritage but directs the majority of strategies to capitalizing on the economic opportunities these resources represent. However, within the definition of culture, the Greenprint document makes reference to the value of intangible cultural resources to the identity and well-being of the Markham Community.

“Community identity includes the physical features of the community, from natural and built heritage (old buildings, main streets, cultural landscapes) to the designs of new public realm developments (parks, streets, bridges, public buildings). Identity also includes less tangible aspects of a community like reputation (accomplishments, track record) and sense of community (connections, neighbourliness, sense of belonging). Culture includes the artistic, musical, literary, culinary, political and social elements that are representative of a community”. (Markham ICSP – page. 33)

Socio-Ecological Systems Integrity

Approaches related to the protection of systems integrity focus on specific places and natural functions that contribute to overall systems’ health and thus require increased planning attention. Markham’s ICSP refers to places within the context of protecting and restoring the natural environment by documenting trends in biodiversity and planning with ecosystem services in mind. Greenprint uses ecosystem theory to describe the potential advantages of a healthy urban ecosystem in dealing with such problems as water purification, wastewater management, and nutrient cycling for agriculture alongside carbon sequestration strategies for reducing GHGs. The plan further identifies the importance of promoting networked natural ecosystems to encourage biodiversity through reduced fragmentation.

“Implement an interconnected Natural Heritage Network, working towards connectivity between existing green spaces and ensure they are of sufficient quality and size to support wildlife.” (Markham ICSP – Reference 29 – Page 158)

13 Greenprint, Markham ICSP, page. 37.
“Ecosystem services provided by natural and vegetated areas reduce infrastructure costs and support local ecotourism.” (Markham ICSP – Reference 5 – Page 90)

The importance of protecting ecosystem function and the services it provides falls into 3 distinct domains: ecological, socio-cultural and economic (de Groot et al, 2010; MA, 2003). The ecological domain must be concerned with the health state of the specific system and monitor indicators that relate to systems diversity and integrity (de Groot, 2010). Markham’s Greenprint incorporates ecosystem integrity as one of twelve priorities and uses indicators related to network interconnectedness, naturalness, effective impervious area, and urban canopy coverage14. The socio-cultural domain of ecosystem function relates to the importance that the community derives from these systems either through a sense of cultural identity or through provision of adequate services (de Groot et al, 2010). Greenprint operationalizes this concept by applying the ecosystem integrity priority within the context of individual health and community well-being stating that “access to nature promotes a sense of well-being and provides the foundation for healthy food production”15. Finally, the economic domain requires that both use and non-use values of ecosystem function be considered equally. Use values should encompass direct use resource benefits such as food and timber as well as direct, non-consumptive values such as those related to recreation and aesthetics; while non-use values should relate to the services provided by ecosystems such as air and water purification, food production, and erosion control (de Groot et al, 2010). Within this economic domain, Markham’s ICSP refers the priority of ecological integrity to a reduction of costs associated with infrastructure provision, as well as mentioning the support of local ecotourism as a direct economic advantage. Through this, Greenprint makes significant strides to incorporate all three domains of ecosystem function and attempts to preserve these systems as a key approach to achieving sustainability.

The Sustainable Kingston Plan, in contrast, puts far less emphasis on the protection of ecosystem function and natural heritage. The only specific mention of similar ideas comes through the incorporation of ecosystem resiliency as a by-product of natural area planning and protection:

“Kingston is actively conserving, protecting, restoring, enhancing, and expanding natural areas and green space for public enjoyment, community health, and ecosystem resiliency.” (Sustainable Kingston – page. 33)

14 Greenprint, Markham ICSP, pages 105-108
15 Greenprint, Markham ICSP, pg. 46.
Although the pursuit of ecosystem resiliency reflects an orientation towards the protection of ecosystem function, the concept is not operationalized within the Sustainable Kingston Plan. The idea of ecosystem resiliency is only mentioned as the result of a process involving the monitoring of two indicators related to tree canopy cover and the total amount of parkland and protected areas represented as a percentage of total municipal land area\textsuperscript{16}.

The protection and enhancement of natural heritage is another significant concern mentioned within Markham’s Greenprint plan. Specifically, developing and maintaining an interconnected natural heritage network is considered a meaningful approach towards enhancing and supporting wildlife habitat in addition to increasing levels of biodiversity\textsuperscript{17}. The Greenprint plan further provides a graphic representation of the natural heritage areas within Markham which provides a reviewer with a visual depiction of where natural heritage connections are required as well as vulnerable areas of high interconnectedness\textsuperscript{18}.

\textsuperscript{16} Sustainable Kingston, pg. 33
\textsuperscript{17} Greenprint, Markham ICSP pg. 110.
\textsuperscript{18} Greenprint, Markham. pg. 107
Table 11 – Summary of Gibson’s Sustainability Principles Incorporated in Municipal Policy Documents

<table>
<thead>
<tr>
<th>PRINCIPLE</th>
<th>DOCUMENT SET</th>
<th>LANGUAGE USED</th>
<th>STRATEGIES EMPLOYED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precaution &amp; Adaptation</td>
<td>ICSP</td>
<td>Self-sufficiency &amp; resiliency, Indicator monitoring, Flexible governance</td>
<td>Monitoring progress using indicators, Implement community-based monitoring programs, Creation of vulnerability index</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>Adaptive management, Monitoring responsibilities, Conservation (Natural &amp; Cultural), Operational Flexibility</td>
<td>Risk assessments required for development application process, Effective monitoring of energy consumption</td>
</tr>
<tr>
<td></td>
<td>Non-ICSP</td>
<td>Environmental assets, Food security, Adequate services, Public safety</td>
<td>Monitoring of residential services use, Referencing of upper-tier regulatory documents, Preservation of existing agricultural lands through land-use planning</td>
</tr>
<tr>
<td>Resource Maintenance &amp; Efficiency</td>
<td>ICSP</td>
<td>Ecosystem function, Biodiversity protection</td>
<td>Habitat preservation initiatives, Committee oversight structure, Community stewardship of natural areas and monitoring of ecological indicators</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>Conservation (Natural &amp; Cultural), Renewable energy technology</td>
<td>Preservation of natural, cultural, and built resources utilizing regional and provincial protection programs, Support of programs that promote a reposition towards renewable sources of energy, Restoration of natural features</td>
</tr>
<tr>
<td></td>
<td>Non-ICSP</td>
<td>Ecosystem approach, Optimization of infrastructure, Flexibility for future land-uses, Efficient and optimal business practices</td>
<td>Application of the ecosystem approach to conservation and sub-watershed issues, Land-use planning integrated with service consumption, Carbon neutral building initiative, Monitoring of demographic trends</td>
</tr>
<tr>
<td>Socio-Ecological Systems Integrity</td>
<td>ICSP</td>
<td>Ecosystem management, Networked ecosystems, Rehabilitation</td>
<td>Maintenance/promotion of ecosystem connectivity, Protection/restoration of natural or green areas for increased public enjoyment &amp; ecosystem resiliency</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>Climate change mitigation, Community health, Ecosystem resiliency</td>
<td>Referencing upper tier assessment regulation, Preservation initiatives for natural heritage, Links to industry (Eco-tourism)</td>
</tr>
<tr>
<td></td>
<td>Non-ICSP</td>
<td>Sensitive buffer areas, Biodiversity retention</td>
<td>Assessment review by conservation authority, Up-scaling or down-scaling EAs, Delineation/preservation of ESAs, EIAs linked specifically to ESA development process</td>
</tr>
</tbody>
</table>
5.0 DISCUSSION

5.1 Use of Ecological Concepts in ICSPs

5.1.1. Ecological Integrity

Within municipal policy, much of the language pertaining to ecological integrity is characterized as ecosystem integrity. Although these two concepts are markedly similar, a slight difference exists in the way they are utilized. While the ecological integrity of a system may refer to the safety and protection of its natural features, ecosystem integrity is often judged within the context of maintaining services that support human populations (Kowarik, 2010; Alberti, 2010). Markham’s *Greenprint* utilizes the concept of ecosystem integrity in two distinct ways. The first way utilizes ecosystem integrity as an indicator through which other priorities are evaluated. In this way all policy decisions made within the context of other areas of focus are forced to consider potential impacts to ecosystem integrity that may result. While this reflects a highly integrated systems approach to sustainability planning, from an ecological perspective in means that ecological priorities will witness impacts from all other priorities in turn. Many of these priorities are human-oriented by nature (shelter, food security, etc) and have the capacity to alter ecological integrity in a manner that will ultimately benefit human settlement patterns. This would represent significant human impact on natural urban systems, and may result in abiotic/biotic disruption of habitats; two criteria incorporated in Hobbs *et al* (2006) novel ecosystem research (Table 2).

The second way ecosystem integrity is utilized within the *Greenprint* is as a priority itself. As discussed by Kowarik (2010) and Alebrti (2010) ecosystems within urban areas are often evaluated on their ability to provide services and the language contained within Markham’s *Greenprint* exemplifies this notion. Within a local context the plan recognizes that decades of urban development has compromised the ecosystems of the Markham area and that the services provided by these systems have been degraded\(^\text{19}\). In order to ascertain the level at which urban ecosystems have been compromised the plan puts forth four indicators that have been developed specially for assessing the ecosystems within Markham. These indicators include: Naturalness, Ecosystem Networks, Effective Impervious Areas, and Urban Canopy. The plan further offers a general assessment of these four indicators to provide a baseline that reflects the current state of Markham’s ecosystems. Much of this assessment emphasizes components that are considered to be a beneficial to human systems such as:

\(^{19}\) *Greenprint*, Markham ICSP, pg. 104-105
water recharge, wastewater runoff, air quality improvements, and erosion control. A primary strategy championed by the plan to improve overall integrity involves reaching a goal of 30% tree and vegetation canopy cover throughout the municipality\textsuperscript{20}. This strategy incorporates tree-planting, habitat enhancement, and climate mitigation programs all within the context of supporting ecological services. Further, to improve community access to food and promote involvement, the Greenprint suggests food growing techniques be incorporated into municipal landscaping guidelines.

While these strategies are being utilized to protect and enhance ecological integrity they can also be seen to be spurring the formation of novel systems. Utilizing the criteria developed by Hobbs et al (2006) provided in table 2, the strategies promoting ecological integrity can also represent impacts that regulate the composition of individual systems. As the baseline evaluation revealed specific areas where these strategies were to be directed\textsuperscript{21} some areas will be subjected to enhancement and protection while others are not. While this targets resources to the areas of most need, it will also significantly generate an overall system that becomes more fragmented, a primary impact that has been shown to create novel systems. Further, the tree-planting initiatives and urban food growing techniques demonstrate a direct disruption to the compositional nature of biotic and abiotic elements especially if these are to be adopted by the municipality’s landscaping guidelines. Finally, as many of these specific strategies are the result of human invention in overall species selection, the human disruption impact component of Hobbs et al (2006) criteria of novel system formation is also satisfied.

The Sustainable Kingston plan makes no direct reference to ecological integrity. However, there are provisions within the agriculture theme that incorporates a regional farm and food system with urban components. This system, if implemented, would promote an integrated ecological food system based on sustainable farming practices\textsuperscript{22}. This would represent an impact on abiotic/biotic features as well as species selection and introduction based on human needs; two criteria thought to promote novel system formation (Hobbs et al, 2006). Further, within the environmental theme of the Sustainable Kingston plan indicators based on the amount of tree canopy cover and greenspace coverage are used to assess Kingston’s progress towards sustainability. In order to solve any shortcomings uncovered though the assessment, strategies promoting increased tree planting in city parks, remediation of degraded natural areas, and an overall increase in greenspaces that includes natural corridor

\textsuperscript{20} Greenprint, Markham ICSP, pg. 110.
\textsuperscript{21} Greenprint, Markham ICSP, pg. 107
\textsuperscript{22} Sustainable Kingston, Kingston ICSP, pg. 28
construction are encouraged\textsuperscript{23}. These strategies once again suggest an impact on system composition; however the type of approach for these strategies is not explicitly detailed within the plan itself. Depending on how these ideas are approached (standardized/dynamic) will determine whether there will be an overall change in the composition of existing ecosystems. Further, while a greenspace network that attempts to incorporate a natural corridor system may reduce fragmentation in the overall system, the composition of existing systems will be altered. Whether this will result in a more homogeneous system of natural areas is unclear as the effective connection of systems will undoubtedly modify food chains, which is considered an impact that can lead to novel ecosystem formation.

5.1.2. Ecological Planning

Ideas pertaining to ecological planning are incorporated in various ways with Markham’s Greenprint. As previously discussed, one of the more prominent ways ecological planning is considered is through including an overall assessment model that incorporates a systems approach to planning policy. The system approach is a common practice in ecological planning as it attempts to find identify principles and strategies that have the ability to affect change at various scales as well as within related areas of interest (Tippet et al, 2007). If adhered to, the ecosystem integrity component of the model can enact change within all other components of the plan ranging from material management to social equity. Conversely, all of the priorities and strategies developed solely for the ecosystem integrity component of the plan must be sensitive to the obligations of all other sections. This method is thought to be a positive step towards a truly integrated approach to planning for sustainability. Beyond this however, lies the ability for all components of the model to exert influence on ecosystem integrity, and by extension the formation of novel ecosystems. For example, within the context of promoting ecosystem integrity the “shelter” component of the Greenprint model requires that outdoor greenspace be located adjacent to existing structures in an attempt to enhance the quality of life\textsuperscript{24}. This type of consideration, while perhaps succeeding in enhancing quality of life, may still result in varying degrees of fragmentation that comes as the result of human-made barriers impeding interaction between systems. The complex nature of all the interactions that must be considered may ultimately result in strategies being targeted to areas of least resistance within the integrated model. This would result in increased fragmentation and could result in the emergence of novel ecosystems.

\textsuperscript{23} Sustainable Kingston, Kingston ICSP, pg. 33.
\textsuperscript{24} Greenprint, Markham ICSP, pg. 112.
The Sustainable Kingston ICSP utilizes resiliency and self-sufficiency as a guiding principle in order to minimize risk and ensure security for a sustainable future. Self-sufficiency and resiliency are used in the context of community development in order to promote community ownership and stewardship with regards to local concerns such as economic development and social equity. Research contends that in order to generate social capital it is critical to create relationships that link together groups of tightly bonded individuals regardless of whether institutional policy recognizes the relationship or not (Dale et al, 2006). This approach attempts to gain advantage from a web of diverse community interconnections which is said to foster community resilience as specific ties allow for internal groups to function together as well as more effectively access outside resources (Dale & Newman, 2006; Newman & Dale, 2005). In this light, Sustainable Kingston can be said to be promoting sustainable sufficiency through endorsing community involvement programs and offering partnerships to a variety of stakeholders. Sustainable sufficiency has been suggested to be the next logical iteration to sustainable development as the latter has been criticised for over-emphasising the economic component within the three-pillar approach to sustainability (Lamberton, 2005; Rogers, 2000). This idea incorporates ecological, social and economic objectives into an interconnected and mutually supportive framework whereby economic priorities are not put ahead of, or in conflict with, the social objectives that safeguard the welfare of citizens or the ecological objectives focused on preserving the natural environment (Lamberton, 2005). Due to this focus on promoting socio-ecological strategies by fostering community involvement the Sustainable Kingston plan can be said to be encouraging biodiversity in urban areas. Kowarik (2011) suggests that providing citizens proper and meaningful interaction with natural areas can enhance the impact of city-wide conservation strategies. As the Sustainable Kingston plan strives to incorporate community involvement in multiple aspects (urban agriculture, monitoring of indicators, remediation efforts), there is the possibility that significant alteration will be made to natural systems within urban areas. Depending on how rigorous the standards are for implementing this type of work, there could be significant alterations to natural systems that could result in a more fragmented ecological landscape while simultaneously promoting increased human impact on natural systems; two criteria mentioned in Hobbs et al (2006) analysis of novel system formation (Table 2).

Both ICSPs include reference to mapping of ecological features in order to create an inventory of natural assets alongside varying levels of vulnerability they may be witnessing. The plans further define highly vulnerable natural areas as Environmentally Sensitive Areas (ESAs) (often referred to as ANSIs) and once again direct protection and conservation efforts to these regions/sites. This can be considered
as targeted human impact of natural systems with the intent of forcing the system into a desirable state. Since this process is largely enacted on a site-by-site basis, it can be understood to stimulate a fragmented system through human alteration of natural system components and therefore encourage the formation of novel systems.

5.1.3. Biodiversity

Conserving and enhancing biodiversity has become important within an urban context largely due to the unique implications for public health and well-being (McKinney, 2002; Goddard et al, 2010). The ability for communities to experience natural landscapes in an urban setting has been shown to be a positive influence to public health while promoting a wider interest in conservation issues (Goddard et al, 2010; Kowarik, 2010). The Markham Greenprint realizes the advantages of biodiversity conservation and mentions protection of biodiversity and natural capital within their commitment to the “Natural Step” set of principles. These principles are utilized as a way to achieve the Greenprint’s overall vision to create liveable and healthy neighbourhoods. This focus on biodiversity further permeates the Greenprint plan and is mentioned as one of three broad goals to achieve in order to maintain ecological integrity. Most notable within the ecological integrity priority, biodiversity is used with Markham’s Natural Heritage Network programme to identify core urban areas where the biodiversity is seen to be impacted by human pressures. Further, sustaining biodiversity within urban areas is linked to the creation and enhancement of natural hubs and corridors. However, there is no indication of how biodiversity is being measured within the programme or how core areas were selected specially for biodiversity conservation. Further, as core areas are traditionally denser, creating hubs and corridors in an attempt to foster biodiversity may not be easily achievable. Regardless, the apparent focus on biodiversity within the urban core will further support fragmentation of ecosystems based on Kowarik’s (2010) Four Nature’s Approach to novel ecosystem categorization (Table 3). However, with spatially targeted biodiversity strategies seeing increased use, Kowarik’s approach may have to make room for an added category describing remediated urban systems. Due to the spatial limitations imposed by urban densities, it is unlikely that degraded urban ecosystems could achieve the same level of biodiversity as their larger suburban counterparts.

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25 Greenprint, Markham ICSP, pg. ix
26 Greenprint, Markham ICSP, pg. 107
The *Sustainable Kingston* plan puts much less emphasis on the concept of biodiversity. The plan itself recognizes numerous environmental challenges across multiple scales and includes the diminishment of biodiversity levels among them\(^{27}\). This list of challenges was created during the preliminary stages of the plan’s development utilizing substantial community input. The inclusion of biodiversity levels suggests that municipalities and communities now understand the pressure urbanization patterns exert on biodiversity and are attempting raise awareness of the potential impacts (Kowarik, 2010; McKinney, 2002). Finally, the *Sustainable Kingston* plan incorporates one goal related to biodiversity. This goal directs biodiversity protection measures to areas of existing natural habitat and specifically measures riparian zones as areas of interest\(^{28}\). It is unclear whether strategies will be focused on conservation or if enhancement of biodiversity in these areas will be considered. If conservation is the main motivation novel systems may arise through continued use of techniques that promote a system’s historic state regardless of an area’s ability to sustain such a state. Likewise, enhancement strategies targeted towards riparian zones could disrupt food chains, alter species composition, and promote fragmentation; all impacts thought to encourage novel ecosystem formation.

### 5.2 Permeation of Precautionary Principle in Municipal Policy

In general, much of the overall language used throughout multiple documents mentions the use of risk management strategies as a way to operationalize the principle of precaution. Regions that endure risks associated with natural hazards word much of their risk management strategies to deal with issues regarding public safety. The Markham ICSP (Greenprint) references the mitigation of risks related to natural hazards specifically and provides general strategies that will help achieve that goal. Markham’s Official Plan however, already makes mention of mitigating risk associated with natural hazards though the use of site and risk assessments. The key difference in the language usage is that the ICSP of Markham links risk management strategies entirely to climate change, including strategies focusing on the mitigation of natural hazard impacts. The ICSP goes as far as to create a qualitative vulnerability index that can that measures the risk posed by climatic change to specific systems (eg: Ecosystems, Water Resources Management, Transportation etc.). This index points to specific areas where mitigation and adaptation strategies should be focused in order to protect the most at risk systems. The index categorizes areas as having high, medium, low, or minimal risks pertaining to areas not covered under current policy or whose data on standards and services is out-dated. The most at risk

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\(^{27}\) *Sustainable Kingston*, Kingston ICSP, pg.29  
\(^{28}\) *Sustainable Kingston*, Kingston ICSP, pg.33
areas identified will be addressed through the provision of increased research and monitoring in those areas. While this vulnerability index is linked to natural hazards rather than ecosystem integrity, it is important to understand that many strategies that attempt to overcome risk posed by hazards incorporate natural measures to absorb perceived impacts. Is this way ecosystem resilience is being promoted which requires the alteration of natural areas to an equilibrium state (Ernstson et al, 2010) that aides in mitigating risk related to natural hazards. This can be understood as human disruption of biotic/abiotic function within targeted areas to promote human systems. Due to this, the alteration of landscapes based on a precautionary analysis of natural hazard risk could result in novel system formation. The focus on planning for natural hazards emanates through the OPs and infrastructure plans of all four cities specifically London, and Markham.

Beyond risk management related to natural hazards, much of the municipal policy incorporate environmental impacts assessments or some sort of site assessment that are enacted when a proposed development will likely have a large impact the surrounding environment. These environmental assessments generally are concerned with significant impacts rather than a categorization of all impacts (Snell & Cowell, 2006). For this reason many impacts related to novel system formation may be overlooked. For example, the fragmentation that may be witnessed due to increased support infrastructure and physical boundaries. However, these assessments are designed to identify potential disruptions to habitat and natural processes, and suggest mitigation measures that can be enacted to reduce the impact. In this light, the municipal environmental assessment represents a way to compile to kind of local information needed to label novel systems. If municipal assessments were to incorporate some sort of inventorying method such as the one displayed in Appendix A information on the existing composition of urban novel systems could be efficiently gathered and could further be used as a baseline for measuring the change in system composition after the impacts are witnessed.
6.0 CONCLUSIONS

The quantitative analysis of the passive observation criteria revealed discernable patterns of varying system composition with the municipalities analysed. Although a study of species diversity would be required to definitively prove the existence of novel systems within an urban context, the passive observation approach provides a simpler and faster way to determine if the compositions of natural areas vary. If the elements incorporated into the passive observation approach are predictors of system diversity, then an analysis of biodiversity involving biotic sampling may ultimately prove unnecessary. This is advantageous as any program seeking to inventory all natural areas would need to utilize community monitoring initiatives. These community monitoring initiatives operate more effectively if complexities within data collection methods are minimized and the level of expertise required is easily achievable. The modified version of Hermy & Cornelis’ passive observation method deployed within this study could represent such an approach.

Through the analysis of policies relating to ecological principles several strategies emerged as being possible triggers for novel system formation. While none of the policy uncovered directly mentions novel systems or speculated on their existence within urban areas, there were certain policies which could be considered to promote the conditions from which novel systems emerge. Table 12 provides a concise summary of these policies. This overview suggests that the fragmentation impact is the most prominent influence when linking policy with novel systems. This makes sense intuitively as fragmentation is by-product of urban development, especially with regards to ecological function. Further, many of the policies seem to stem from a focus on utilizing ecological systems for the benefit of human populations. While this does represent a fairly pro-active integrative approach to sustainability, municipalities should be cautioned from making the human element the primary focus of these initiatives. Finding a balance between provision of human services and the protection and enhancement of ecological integrity will be paramount in ensuring ICSPs and other municipal planning documents are successful in promoting sustainable communities.
Table 12 – Summary of Policies Linked to Novel Ecosystem Formation

<table>
<thead>
<tr>
<th>Type of Policy</th>
<th>Description</th>
<th>Type of Impact(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Services</td>
<td>Ecological features are conserved or enhanced according to their ability to provide services for human settlement</td>
<td>• Fragmentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Human Impact</td>
</tr>
<tr>
<td>Systems Thinking</td>
<td>Through a complex, integrated framework, objectives not aligned with ecological goals are allowed to exert influence on natural systems and biodiversity.</td>
<td>• Fragmentation</td>
</tr>
<tr>
<td>Risk Management</td>
<td>Promotes interference based on a predetermined notion of an ideal set of system conditions developed to protect public safety</td>
<td>• Biotic/Abiotic Disruption</td>
</tr>
<tr>
<td>Spatially Targeted</td>
<td>Use of vulnerability indices and ESAs proactively disrupt operating natural systems due to perceived degradation resulting from urbanization or inefficiencies relating to potential uses (urban food systems)</td>
<td>• Fragmentation</td>
</tr>
<tr>
<td>programme</td>
<td></td>
<td>• Biotic/Abiotic Disruption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Human Impact</td>
</tr>
<tr>
<td>Natural Hazards</td>
<td>Directs planning attention to specific areas and modifies these areas to reflect a system more resistance to extreme events</td>
<td>• Fragmentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Biotic/Abiotic Disruption</td>
</tr>
<tr>
<td>Biodiversity Retention</td>
<td>Retention measures can include provision for enhancement strategies to be deployed without a full inventory of a system or knowledge of its function within an urban area</td>
<td>• Biotic/Abiotic Disruption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Human Impact</td>
</tr>
<tr>
<td>Impact Assessment</td>
<td>Not seen to directly affect the emergence of novel systems, but could provide a mechanism by which inventorying can be undertaken on a site level. Has the potential to provide relevant data for comparative purposes</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The ICSPs of Markham and Kingston both cite the incorporation of innovative concepts and long-term planning practices as key factors to achieving sustainability. Both plans position themselves to be welcoming of non-traditional approaches to realising sustainability as well as employing flexible partnership frameworks that are accepting of a diversity of groups and institutions that may not have played a large role in sustainability planning in the past. Moreover, both cite a long-term planning approach as a fundamental requirement to achieving sustainability, recognizing that the process must be on-going and adaptive to change. Where a point of contention may arise, is that these two strategies, innovation and long-term objective planning, may not be mutually supportive and could result in an insipid approach to both. Although innovation is an idea that should be fostered by the ICSp approach, there is an existing concern that an overly accepting strategy could fall victim to “trendiness”. As the finance of these ICS plans rely heavily on public funding, projects and initiatives considered for
incorporation into the sustainability plans must prove their contribution to achieving sustainability and that the underlying concepts will be viable over the long-term. Furthermore, in Markham especially, recommendations to decision-making bodies should have the support of experts as well as community stakeholders.

The general acceptance of innovative concepts provided by the ICSP framework makes the process an ideal vehicle from which to promote the idea of novel ecosystems. Further, because the construction of these plans involves significant input from the public, there is a better chance of fostering awareness and concern over ecological principles. Thus ICSPs are able to take on a certain amount of responsibilities relating to environmental protection and conservation, while engaging the public and implementing policy that is sensitive to public concern.

6.1 Recommendations

Recommendation 1: The concept of novel ecosystems should be recognized within urban sustainability planning and linked to initiatives relating to biodiversity and ecosystem integrity.

As the emerging trend in sustainability planning in Canada, the ICSP process can provide a platform for new, innovative ideas to gain exposure within a meaningful forum. The idea of novel ecosystem represents a new way of understanding how human populations impact, and utilize the natural spaces in which they live. If urbanization is promoting novel system formation as this research proposes, then planners must address the effect new biotic assemblages will have on key interactions and processes in urban ecosystems. Further, new management strategies will have to be considered in order to maximize beneficial changes and reduce aspects thought to be degrading (Hobbs et al, 2006). Due to the capacity ICSPs have shown in incorporating well-rounded strategies for the protection of ecosystem integrity and biodiversity retention, the inclusion of the concept of novel urban ecosystems would represent the next logical iteration to ecological protection.

Recommendation 2: Biodiversity conservation and enhancement programmes must be considerate of the existing state of targeted systems.

Many of the strategies concerning biodiversity focus on targeting conservation and enhancement to specific areas thought to be experiencing impacts generally relating to urban intensification (urban cores). While this may be a logical conclusion to make, decisions impacting the compositional nature of individual systems should not be made based on a broad categorization related to location. Instead, information pertaining to an area’s abiotic and/or biotic composition should be gathered on a site-by-
site basis, and decisions pertaining to enhancement or conservation should be made accordingly. Once the state of an individual site is ascertained it can be categorized based on its level of diversity and appropriate actions can be taken. For direction, municipalities may consider Hobbs et al. (2006, p. 601) framework which provides a categorization structure and appropriate actions based on a system’s categorization.

**Recommendation 3:** Municipal Impact Assessments should consider including passive observation criteria for use in comparative analyses of urban ecosystem composition.

A passive observation framework, much like the one deployed within this research, could be integrated into municipal environmental assessments as a method of inventorying urban ecosystems. Currently the municipal impact assessment process has been shown to be largely interested in significant impacts rather than all discernable impacts (Snell & Cowell, 2006). They encourage a process that is better-rounded. A passive observation framework could be combined with traditional assessment techniques to provide an entire picture of the impacts posed not just too ecological integrity, but to species and habitat diversity as well. Further, the community monitoring efforts championed by the two existing ICSPs may be useful in conducting passive observations given that the framework is kept fairly simplistic. The utilization of community resources in this matter would help educate through involvement, as well as compiling important data pertaining to novel ecosystems and biodiversity at minimal cost to the municipality. Community involvement and education is especially important for smaller municipalities with smaller budgets and no dedicated staff.

**Recommendation 4:** Risk management strategies should incorporate provisions which measure risk in a broader context other than natural hazards and development impact.

Recent research suggests shortcomings in traditional quantitative risk assessment strategies cite the effective assessment of risk as complex, contingent on time and dependent on socio-economic trends (van Asselt & van Bree, 2011). In this light many public agencies have begun to approach risk management not only though an analysis of the probability of occurrence versus the level of impact, but also by considering issues pertaining to: uncertainty within the methodologies, the perceived effect on society, as well as how the risk is observed by the public. A study conducted by the Netherlands Environmental Assessment Agency identified 5 main considerations that must be deliberated when creating policy to deal with uncertain risks:

1. A hands-off governmental approach vs. political pragmatism
2. Scientific rationality vs. risk perception
As risk management has been shown to impact ecological integrity through landscape alteration policy and natural hazards planning, there must be a full understanding of the influences that precautionary policy can have. The 5 considerations outlined in the Netherlands can aide in ensuring proper measures are being implemented, on the correct scale, and targeting the most pertinent issues.

**Recommendation 5:** Municipalities should design passive observation criteria unique to their location in order to ascertain the level of habitat diversity inherent in urban ecosystems.

As ecosystem composition has been shown to be dependent on geographic and socio-political conditions, a standardized passive observation methodology would be ill equipped to effectively judge ecosystem composition at a local scale. For this reason, any municipality that considers such a strategy should develop criteria that are known to be prevalent based on policy and ecology. Further, any quantitative analysis based off the observation methodology should be considerate of the scale at which the study is being undertaken. Failure to do so may lead to biased conclusions of the relative diversity of individual sites.

Results from the passive observation method should be used to answer the following questions developed by Hobbs *et al.* (2009) which can aide in directing conservation and enhancement programs to areas most suitable for those methods.

- Is the system maturing, or capable of maturing, along a stable trajectory?
- Is the system resistant and resilient?
- Is the system thermodynamically efficient?
- Is the system providing ecosystem goods and services?
- Is it providing opportunities for individual or community engagement?

**6.2 Opportunities for Further Research**

As the concept of novel urban ecosystems is still in its infancy there may be resistance to its incorporation within municipal policy. However, recent trends in sustainability planning have revealed an emerging interest in urban biodiversity and its effects on the operation of ecological services. Using this newfound interest, further research should be focused on methods that attempt to accurately quantify levels of species biodiversity at the site level. Currently the solution to ascertaining species biodiversity has been through random sampling techniques. However, these techniques require specific
expertise to design and deploy and are more accurate at extrapolation trends over larger areas. For this reason further research should not only focus on incorporating a species diversity component, but should strive to create a method that is suitable for the scale at which urban novel systems are analyzed.

This research has largely focused on identifying specific policies that are thought to affect ecological integrity and ecosystem diversity. What was not discussed was the magnitude of impact these policies have and which ones require modification. Further research could be conducted in order to create a biodiversity toolkit for planners that details common policy employed to regulate natural areas and the type of impact a decision could have on ecosystem composition within a municipality. Further, research regarding the proper entity to make use of this toolkit would be advantageous as its creation would undoubtedly require the use of complex ecological concepts that must be fully understood by those using it.
7.0 WORKS CITED


Ayensu, E; Claasen, D; Collins, M; Dearing, A; Fresco, L; Gadgil, M; Gitay, H; Glaser, G; Juma, C; Krebs, J; Lenton, R; Luchenco, J; McNeely, JA; Mooney, HA; Anderson, P; Ramos, M; Raven, P; Reid, W; Samper, C; Sarukhan, J; Schei, P; Tundisi, JG; Watson, RT; Guanhua, X; and Zakri, AH. 1999. International Ecosystem Assessment. Science. 286(5440), pp. 685-686.


Ernstson, H; Van Deer Leeuw, S; Redman, C; Meffert, D; David, G; Alfsen, C; and Elmqvist, T. 2010. Urban Transitions: On Urban resilience and human-dominated ecosystems. AMBIO: A Journal of the Human Environment. 39(8), pp. 531-545.


Hobbs, R; Arico, S; Aronson, J; Baron, J; Bridgewater, P; Cramer, V; Epstein, P; Ewel, J; Kilink, C; Lugo, A; Norton, D; Ojima, D; Richardson, D; Sanderson, E; Valladares, F; Vila, M; Zamora, R; and Zobel, M. 2006. Novel Ecosystems: Theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography. 15(1), pp. 1-7.


Hodge, A. 2004. Mining's seven questions to sustainability: from mitigating impacts to encouraging contribution. EPISODES. 27(3), pp. 177-184


ICLEI – Local Governments for Sustainability. 2010. Cities and Biodiversity Case Study Series: Canadian Best Practices in Local Biodiversity Management. ICLEI. Toronto, ON.


Marreco, JDM; and Carpio, LGT. 2001. “Flexibility Valuation in the Brazilian power system: A real options approach”. Energy Policy. 34(18), pp. 3749-3756


Mooney, H; Larigauderie, A; Cesario, M; Elmquist, T; Hoegh-Guldberg, O; Lavorel, S; Mace; GM; Palmer, M; Scholes, R; and Yahara, T. 2009. Biodiversity, climate change, and ecosystem services. Current Opinion in Environmental Sustainability. 1(1), pp. 46-54.


Rothman, D.S; Kok, K; and Patel, M. 2007. Participatory scenario construction in land use scenario analysis: an insight into the experiences created by stakeholder involvement in the Mediterranean. Land Use Policy. 24(3), pp. 546-561


Wiek, A; Binder, C.R; and Sholtz, R.W. 2006. Functions of scenarios in transition processes. Futures. 38(7), pp. 740-766


### APPENDIX A: Passive Observation Criteria

<table>
<thead>
<tr>
<th>Planar Elements (Area)</th>
<th>Deciduous</th>
<th>Coppice (regularly cut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Stand (natural vegetation composition)</td>
<td>Single tree stand (Ligneous growth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High forest tree</td>
<td></td>
</tr>
<tr>
<td>Coniferous</td>
<td>Forest stand</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>Mixed stand of coniferous and deciduous trees</td>
<td></td>
</tr>
<tr>
<td>Plantation (planted trees)</td>
<td>Forest grassland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grassland with forest trees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tree gallery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linear plantation without undergrowth</td>
<td></td>
</tr>
<tr>
<td>Shrub Plantation</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit composed of various planned shrubs</td>
<td></td>
</tr>
<tr>
<td>Grassland (grass species composition)</td>
<td>Lawn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequently mown grass area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recreational field (sports)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequently mown grass area used as sporting ground</td>
<td></td>
</tr>
<tr>
<td>Tall Herb Vegetation</td>
<td>Mixed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit composed of tall herbaceous species (reed inclusive)</td>
<td></td>
</tr>
<tr>
<td>Garden (enclosed unit containing vegetable, fruit or ornamental flora)</td>
<td>Kitchen garden</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composed of fruits and/or vegetables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Herb garden</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composed of medicinal herbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ornamental garden</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composed of ornamental plants (roses, tulips, etc.)</td>
<td></td>
</tr>
<tr>
<td>Ornamental Plantation</td>
<td>Non-enclosed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composed of ornamental plants with no constructed boundaries</td>
<td></td>
</tr>
<tr>
<td>Water Feature</td>
<td>Pond</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water feature free from buildings and building features</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>Man-made Structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composed of buildings, inclusive of limited space between buildings</td>
<td></td>
</tr>
<tr>
<td>Car Park</td>
<td>Asphalt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parking lot with hardened cover</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parking lot with half-hardened cover</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Play structures, sporting areas (baseball)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Play structures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pavement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Play structures, sporting areas (tennis, basketball)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linear Elements (Linear)</th>
<th>Single Row</th>
<th>Row of trees standing alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree-Row Alley</td>
<td>Double tree row</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double row of trees with space in between allowing movement.</td>
<td></td>
</tr>
<tr>
<td>Hedgerow (Linear vegetation)</td>
<td>Sheared</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hedgerow subjected to regular maintenance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-sheared</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-maintained hedgerow</td>
<td></td>
</tr>
<tr>
<td>Embankment</td>
<td>Human built hedgerow on embankment (used as natural boundary)</td>
<td></td>
</tr>
<tr>
<td><strong>Road Verge</strong></td>
<td><strong>Porous Strip</strong></td>
<td>Non-hardened buffer on the side of road</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td><strong>Bank</strong> (Strip on either side of water feature)</td>
<td>Bank of Water feature (pond, fountain)</td>
<td>Natural (not consolidated by humans)</td>
</tr>
<tr>
<td></td>
<td>Bank of watercourse (ditch, brook, river)</td>
<td>Semi-Natural (consolidated by humans but vegetation still possible)</td>
</tr>
<tr>
<td><strong>Watercourse</strong> (Linear element discharging water)</td>
<td>Ditch</td>
<td>Watercourse with max width of 1m which <em>may</em> contain water</td>
</tr>
<tr>
<td></td>
<td>Brook</td>
<td>Watercourse with max width of 3m which <em>must</em> contain water</td>
</tr>
<tr>
<td></td>
<td>River</td>
<td>Watercourse with a width of &gt;3m.</td>
</tr>
<tr>
<td><strong>Road Infrastructure</strong> (for pedestrian and service use)</td>
<td>Road</td>
<td>Road infrastructure with a width &gt;2m</td>
</tr>
<tr>
<td></td>
<td>Path</td>
<td>Road infrastructure with a width &lt;2m</td>
</tr>
<tr>
<td><strong>Wall</strong></td>
<td>Linear Masonry</td>
<td>Use as enclosure or vertical vegetative growth area</td>
</tr>
<tr>
<td><strong>Punctual Elements (Count)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tree/shrub</strong></td>
<td>Single element</td>
<td>Tree or shrub not surrounded by others</td>
</tr>
<tr>
<td><strong>Rock</strong></td>
<td>Single Element</td>
<td>Rock not surrounded by others</td>
</tr>
<tr>
<td><strong>Human Constructed</strong></td>
<td>Bench</td>
<td>Singular bench</td>
</tr>
<tr>
<td></td>
<td>Light Post</td>
<td>Lighting fixture (along paths)</td>
</tr>
<tr>
<td></td>
<td>Recreation</td>
<td>Individual play structure, varying (Basketball hoops, slides, etc)</td>
</tr>
</tbody>
</table>
**APPENDIX B: Individual Site Diversity Index Ratios**

**London Study Sites**

<table>
<thead>
<tr>
<th></th>
<th>Carriage</th>
<th>Rollingwood</th>
<th>Belvedere</th>
<th>Picadilly</th>
<th>Genevive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planar</strong></td>
<td>0.331</td>
<td>0.204</td>
<td>0.315</td>
<td>0.365</td>
<td>0.315</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>0.319</td>
<td>0.365</td>
<td>0.266</td>
<td>0.362</td>
<td>0.136</td>
</tr>
<tr>
<td><strong>Punctual</strong></td>
<td>0.363</td>
<td>0.248</td>
<td>0.241</td>
<td>0.337</td>
<td>0.254</td>
</tr>
</tbody>
</table>

**Markham Study Sites**

<table>
<thead>
<tr>
<th></th>
<th>Lincoln</th>
<th>Bur Oak</th>
<th>Reesor</th>
<th>Walker</th>
<th>Lincoln/Green</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planar</strong></td>
<td>0.303</td>
<td>0.235</td>
<td>0.303</td>
<td>0.367</td>
<td>0.326</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>0.317</td>
<td>0.225</td>
<td>0.353</td>
<td>0.317</td>
<td>0.347</td>
</tr>
<tr>
<td><strong>Punctual</strong></td>
<td>0.348</td>
<td>0.367</td>
<td>0.331</td>
<td>0.252</td>
<td>0.192</td>
</tr>
</tbody>
</table>

**Burlington Sites**

<table>
<thead>
<tr>
<th></th>
<th>Berton</th>
<th>Pinemeadow</th>
<th>Strathcona</th>
<th>Lions</th>
<th>Thorpe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planar</strong></td>
<td>0.364</td>
<td>0.333</td>
<td>0.147</td>
<td>0.319</td>
<td>0.333</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>0.361</td>
<td>0.361</td>
<td>0.181</td>
<td>0.322</td>
<td>0.269</td>
</tr>
<tr>
<td><strong>Punctual</strong></td>
<td>0.287</td>
<td>0.259</td>
<td>0.342</td>
<td>0.365</td>
<td>0.295</td>
</tr>
</tbody>
</table>

**Kingston Sites**

<table>
<thead>
<tr>
<th></th>
<th>Champlain</th>
<th>Garrigan</th>
<th>Auden</th>
<th>William</th>
<th>Rotary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planar</strong></td>
<td>0.221</td>
<td>0.313</td>
<td>0.362</td>
<td>0.327</td>
<td>0.327</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>0.302</td>
<td>0.333</td>
<td>0.333</td>
<td>0.281</td>
<td>0.344</td>
</tr>
<tr>
<td><strong>Punctual</strong></td>
<td>0.299</td>
<td>0.239</td>
<td>0.353</td>
<td>0.308</td>
<td>0.189</td>
</tr>
</tbody>
</table>
APPENDIX C – Burlington Site Photographs

Site 1 – Berton Park
Site 3 – Pinemeadow Park
Site 4 – Strathcona Park
Site 5 – Thorpe Park
APPENDIX D – Markham Site Photographs

Site 1 – Alma-Walker Park
Site 2 – Lincoln Park
Site 3 – Reesor Park
Site 4 – Robinson Park
Site 5 – Williamstown Green
**APPENDIX E – Kingston Photographs**

**Site 1 – Auden**
Site 2 – Calderwood Park
Site 3 – Champlain Park
Site 4 – W.C. Wanica Park
Site 5 – William Hackett
APPENDIX F – London Photographs

Site 1 – Belvadere Park
Site 2 – Carriage Hill Park
Site 3 – Picadilly Park
Site 4 – Rollingwood Park

Site 5 – Genevive Park