URBAN CO_EVOLUTION:

THE ARCHITECTURAL LINKAGES BETWEEN PEOPLE AND ECOLOGY

A Thesis in
Architecture

By
Emily Rose Denhoed

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The dissertation of Emily Rose Denhoed was reviewed and approved* by the following:

Lisa Iulo  
Assistant Professor of Architecture  
Thesis Advisor  

B Ikubolajeh Logan  
Professor of African Studies and Geography  

Ute Poerschke  
Associate Professor of Architecture  

James Wines  
Professor of Architecture  

Loukas Kalisperis  
Professor of Architecture, Chair of Graduate Program  

*signatures are on file in the Graduate School
Abstract

Certain urban forms contribute more than others to sustainability. Although there is a general lack of agreement about the most desirable urban form, context provides a fundamental basis in establishing standards for sustainable cities. Design as a response to environmental context also reinforces the profound relationship between people and place. This extraordinary relationship is initially defined by a region’s ecology, yet constantly evolves according to cultural flows, technological innovation, and subtle environmental variations. It is clear that the constant intermingling between human society and environmental context is not a static process.

This thesis inquires to how urban development parallels the evolution of human ecology and nonhuman ecology in the region of Montreal. By determining the common linkages between urban development, human ecology and non-human ecology, one can begin to extrapolate the responsive qualities of the existing urban forms of Montreal. Moreover, what does the architectural record reveal about the human-environment dynamic and how can this insight be used to develop mutually advantageous design strategies for infill development in Montreal? The investigation begins by outlining the theoretical background surrounding the concept of co-evolution, a process of adaptation between humans’ material practices, ideas and values and the non-human environment. Subsequently, a comprehensive site analysis of Montreal is performed, which will firstly reveal the ecological determinants of this region. The implications of eco-determinants are dependent upon a site’s ecology on varying scales, i.e. they are context specific. This site assessment derives the data necessary to generate a record of urban evolution along three parallel axes: human ecology, non-human ecology and built environment which are defined in the introduction to this thesis.

The data from the case study is analyzed to evaluate how infill development in a Montreal district (Le Plateau Mont-Royal) reacts to its environment according to predetermined sustainable design parameters. The results from data collection are interpreted in order to isolate the passive design practices and strategies that are appropriate for this particular city and climatic region. Infill development has the most potential as a point of intervention in the context of this study because infill is defined as a measured and deliberate process of urban evolution. Infill development is realized through varied designers, innovative methodologies and diverse design principles. In effect, the revolution of these methodologies and design principles represents an initial step toward reciprocal co-evolution between people and place.
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Most importantly, I would like to thank my very clever thesis advisor Liso D. Iulo, an assistant professor in the Department of Architecture. Her critical eye and innovative ideas have greatly enhanced the quality and character of my thesis. After working with her my first semester on a design inquiry course, I was utterly convinced of her profound insight in the field of sustainability of architecture and urban design.
1.1 Introduction

This thesis intends to define and explore the linkages between the urban form and its context. The ensuing discussions of this work emerged as a result of the imprecise and indefinite standards on the subject of what constitutes a sustainable urban form. This initial query quickly became layered with multiple other uncertainties and reservations about the progression of urban development and the correlation between a city and its surrounding ecology. Thus, the city establishes the context of this particular research. The image most often evoked of “the city” is a cityscape, essentially buildings viewed from afar along a skyline. This thesis argues that a city is not really the architecture; a city is primarily composed of people and an environment or ecology. Architecture is a secondary result, a manifestation between these two entities: ecology and people.

If people and ecology are the primary actors in a city, various questions arise regarding urban development. For example, does urban development parallel the evolution of these two primary constituents? How is the growth of the systems connected? For precision purposes throughout this research, the term environment or “nature” is re-termed non-human ecology and “people” as human ecology. The following sections will frame the research questions and articulate the research methodologies used to resolve each question.
1.2 Research Questions

In order to begin to respond to the very broad questions presented in Section 1.1, several factors have to be refined. Firstly, more specific research questions will be defined and justified. Also in this section, the scope of the study must be narrowed; this can be achieved by selecting a sample region. The reasons for this selection will also be presented within this section. Lastly, this section will introduce some of the main concepts interwoven throughout the remainder of the thesis.

As mentioned in Section 1.1, this exploration is fundamentally based on the intermingling systems between non-human ecology and human ecology. The opening question of this research is the following: how does urban development parallel the evolution of human ecology and non-human ecology in the region of Montreal? Human ecology is defined by the cultural systems socially constructed as a direct response to environmental context. In effect, the system of human ecology represents the way humans understand and interact with their surrounding ecology, whereas non-human ecology includes the physical systems functioning outside of the human species.

The interaction between human civilization and non-human ecology results in a tangible, built environment. Before proposing modifications to the City of Montreal, the existing dynamic between its people and context must be analyzed. This research seeks to answer a second question, what does the architectural record reveal about the human-environment dynamic and how can this insight be used to develop mutually advantageous design strategies for infill development in Montreal? By determining the common linkages between urban development, human ecology and non-human ecology, one can begin to extrapolate the responsive qualities of initial urban forms of Montreal. The diagram presented on the following page schematically introduces the research questions according to a “train-of-thought” process. Refer to Section 1.3 if any terms in the diagram are unfamiliar.
Montreal, a large city in Quebec, Canada, was selected as the case in which to explore this subject matter. The city of Montreal is selected for the core of this research because it is a quickly developing and urbanizing metropolis of Canada. There is an extensive amount of infill development in the city due to population growth and neighborhood revitalization projects. Infill provides a means for adjustment to develop or augment the sustainability of the city. The rapid materialization of commercial and industrial regions, such as Le Plateau Mont-Royal (also referred to as Le Plateau), coupled with a growing population, identifies Montreal as a relevant candidate to initiate a gradual process of structural and landscape modifications.

The design of this research responds directly to the research objectives. To reiterate, the objectives of this research are to reveal what constitutes a sustainable urban form and propose and cultivate future strategies to enhance the sustainability of cities. By uncovering a combination of theoretical and practical data regarding urban evolution, this research will reveal how the inherent systems in cities interact with one another. Secondly, the analysis of urban development will also indicate useful design guidelines to guide urban evolution towards urban sustainability.

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1.3 Term Definitions

Co-evolution
Co-evolution is a concept that begins to articulate the interconnected and interdependent linkages and processes between humans’ material and non-material practices and the non-human (living and physical) environment. The term “co-evolution” is typically associated with the discourse surrounding Biology or Ecological Economics. Ecological Economics is a transdisciplinary field which seeks to define the dynamic interrelationships between human economies and natural ecosystems. Mutualistic co-evolution is a co-evolution that enhances the survival of each contributor. The concept of mutualistic co-evolution has been previously applied to land management techniques in which humans have had a direct and positive impact on the ecology. Agricultural burning is a prevalently cited example; the loss of human presence in regions of forest-savannah mosaic resulted in the hindrance of forest island growth, thus forest islands are partly a product of human-vegetation interaction.²

Ecological determinant
Site-specific conditions can be broken down into categories which fall under what this study will refer to as eco-determinants. An eco-determinant is an ecological, biological or geographical condition/context which may prompt certain aspects of building form, spatial design or material use. Specific eco-determinants applied in this study: climate, vegetation cover, access to water, geological materials.

Passive Design
Passive design is a method of design which aims to reduce a building’s energy consumption through specific measures which do not require outside energy, major technological commitment or additional maintenance. Passive design is a direct response to a site’s ecological and geographical context.

**Infill Development**  
As defined in this inquiry, infill development is the development of abandoned or underutilized urban sites to further ecological advancement in the form of a built structure, greenspace or combination of both. These spaces are potential opportunities to showcase advanced ecological performance standards, thus advanced reciprocity. Through infill development, the city can reflect its physical conditions through specific design methods and features.

**Humid Continental Climatic Region**  
The Humid Continental Climate Region is designated by the Köppen System of Classification as the zone characterized by a cold climate and the lack of a dry season (See Appendix for Climatic Maps). The climate regions are constantly shifting due to global warming, and currently Montreal is in proximity to the boundary between warm summers (climate region Dfb) and hot summers (climate region Dfa).

*AXES of CO-EVOLUTION*  
The following terms will be used as the primary classifications for the data analysis. While these axes are individualized for the purposes of this research, they constitute evolution as a whole.

**Human Ecology**  
Human ecology is the cultural systems socially constructed as a direct response to environmental context. In effect, the system of human ecology represents how humans understand ecology and explains why they interact with it the way they do.

**Non-human Ecology**  
The physical systems functioning outside of the human species.

**Built Environment**  
A direct result of the interaction between human ecology and non-human ecology; it is how human ecology is physically manifested. The Built Environment may also be defined as Architecture.
1.4 Research Design

The following section will break down each research question and propose a methodology to fully respond to the question.

Research Questions Review

- Does urban development parallel the evolution of human ecology and non-human ecology in the region of Montreal?
- What does the architectural record reveal about the human-environment dynamic and how can this insight be used to develop mutually advantageous design strategies for infill development?

The focus of this research is to explore the human-environment dynamic with specific regard to ecological systems (human and non-human). If this interrelationship is well defined, it will be easier to derive mechanisms to refine and modify it to be increasingly responsive and mutually beneficial.

1.4.1 Data Collection

The first research question will be addressed through data collection as well as data analysis. The concept of “parallel evolutions” mentioned in the first question is clearly defined by the concept of co-evolution. The parameters necessary for a co-evolutionary analysis are defined by a theoretical basis (Chapter Three), but the applicable information is discovered through the case study of Montreal (Chapter Four). The theoretical understanding of co-evolution compiled with the existing data found in Montreal, such as its eco-determinants, provide the necessary elements for the data analysis (Chapter Five). A diagram in the form of interrelated timelines serves as the tool for data analysis and verifies that urban development parallels the evolution of human and non-human ecology. The phases of data collection are further outline below.

Examining Co-evolution: (Section 2.1 and Chapter Three)

Co-evolution is a complex and interdisciplinary subject. This phase of research will evaluate the various applications of the concept and define it within the particular context of urban architecture.
Profiling the Region of study: (*Chapter Four*)

This is an inquiry into environmental factors that affect Montreal today (wind, climate, solar exposure, etc). Environment, in this case, is strictly the biological/physical conditions and ecological surroundings. To repeat, this phase of study will be an in-depth site analysis focusing on *urban*-specific ecological determinants of a city in the Humid Continental Climate Region. These determinants coupled with design parameters will be used as criteria to help recognize co-evolutionary elements in the city. Archival data will be acquired regarding ecology, climate and geology.

Case Study of Co-evolution in Le Plateau-Mont-Royal: (*Chapter Four*)

Specific analysis of this region intends to uncover if and how architecture and urban form represent the evolutionary dynamic between people and place. This phase will explore the architectural record of the human-environment dynamic with respect to eco-determinants (non-human ecology). This case study will reveal the co-evolutionary aspects of a portion of the Le Plateau Mont-Royal district to date. In effect, it will outline the predominant development and lifestyle methodologies as well as ecological standards, including any sustainable design techniques. The evolution of Le Plateau Mont-Royal will be documented according to set criteria. The data gathered will specifically refer to the predetermined eco-determinants as well as the design parameters defined by Jabareen (also see Literature Review, Section 2.5). Jabareen’s Design parameters have been interpreted in order to establish parameters directly relevant to the Montreal Case Study (Table 1).

This research requires a continuing thread, a sort of structural system, to tie the many phases of research together. Jabareen’s design parameters have been integrated into the research inquiry as this structural framework (See Section 2.5 to review parameters). Jabareen proposes these parameters as key considerations for sustainability in cities, thus they are being applied as research support while also being tested. They will reoccur in the ensuing chapters as an organization tool as well as be evaluated in accordance to the research findings.

Relevant ecological events and stages of Le Plateau’s development will also be included in the data collection. The information gathered from Le Plateau case study will naturally include reoccurring building development techniques as well as urban
planning strategies. The beneficial ecological and human-specific co-evolutionary standards for the district will become apparent as the data is documented and analyzed.

1.4.2 Data Analysis

The Data Analysis partly answers the initial research question but also responds to the principle research question of what does the architectural record reveal about the human-environment dynamic and how can this insight be used to develop mutually advantageous design strategies for infill development? The data is analyzed by assembling the collected information regarding Montreal into a Co-evolutionary Diagram (Chapter Five). This diagram illustrates that the systems of human and non-human ecology have corresponding evolutions and that the built environment is a direct manifestation of this interaction. Although this wholly resolves the first research question, it only responds to the first part of the second question. The remaining fragments of the second question are answered through the data interpretation of defining an urban design strategy (Chapter Six). The Guiding Principles found in Chapter Six demonstrate how the insight gained from the analysis in Chapter Five can be used to enhance the sustainability of a city.

Integrating co-evolutionary theory and Montreal: (Chapter Five)

The data analysis will assimilate the two previous topics of co-evolution and Montreal urban development. A co-evolutionary timeline diagram will outline events and phases of urban development in Montreal and specifically in the Le Plateau Mont-Royal District. The timeline will also be used to assess of the effectiveness of existing methodologies demonstrated by the case study. By referencing evolutionary concepts, design practices will be evaluated to determine which facilitate mutualistic co-evolution and which do not. The timeline diagram generated by the case study will reveal several persisting design models. The models presented in the diagram may or may not have been purposefully, collectively sustainable. This research exclusively and objectively looks at existing responses, disregarding intent. Conversely, some design elements may have been intended to address the physical environment, but are unsuccessful.
1.4.3 Data Interpretation

Synthesizing results into a Collection of Guiding Principles

This phase of the thesis will be the “generative” phase where an urban design approach will be formatted for mutualistic co-evolutionary development in Montreal. Using the results from the co-evolutionary timeline analysis, Chapter Six will compile all the guiding principles which directly respond to an urban infill site’s specific conditions as well as its inhabitants. Effectively, these measures will directly contribute to reciprocal co-evolution in Montreal by proposing an alternative approach to urban planning.

The Research Design is summarized in the Table below.

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<td>o Synthesizing results into Guiding Principles for Site-by-Site Development</td>
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<td>o Pinpoint the interactions between evolutions according to established design parameters</td>
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Table 1. Overview of Research Inquiry

1.4.4 Research Methodologies

Data will be collected during the first three phases of the research design. The collection methodology is outlined below:

Archival Research:

The appropriate methodology for researching co-evolutionary theory and for profiling Montreal is *archival research and literature analysis* (including obtaining environmental data). A geography course, Human Environment (GEOG 507), provided the background necessary to comprehend the concept of co-evolution.
Initially, articles and books written on the region’s geography and ecology will suggest the environmental factors which affect the formal arrangement of cities in the Humid Continental Climate Region. These indicators will be further reduced or broken down to the scopes of the Köppen Climatic Region Dfb, Montreal, Le Plateau Mont-Royal, and perhaps elements within the district to define the eco-determinants for the case study region. A number of resources in the literature review refer to “ecological indicators.” These resources can triangulate what is deduced from archival research. In any case, there will be clear indications that the building design reflects the environmental context. These indicators will be recorded as eco-determinants.

**Case Study:**

A case study method will be used to determine the past and current stage of the co-evolutionary process in Le Plateau. This phase will cover how urban infill has been and is being considered in Montreal, Quebec, Canada and outline the predominant development methodologies, including any sustainable design techniques. Through *field study and archival research*, several aspects of Le Plateau will be evaluated until a generalization can be made concerning the current co-evolutionary practices of Montreal and how these practices have evolved. Examining the historical record of urban development and comparing it to current practices will reveal the extent of mutualistic co-evolution over a given period of time and suggest trends in passive design consideration (whether purposeful or not).

The specifics of the Montreal case study include selecting the exact land area and the time frame for which to assess the infill records. The midtown district of Le Plateau Mont-Royal (Shown in Figure 2b) is a relevant selection because it has a heterogeneous distribution of building styles,” therefore the building techniques will be less likely a result of a single culture or tradition. The data from this phase will be analyzed through archival research and according to qualitative criteria mentioned in the previous section.

---

**Case Study Selection Criteria:**

The advantages of selecting Montreal as a large scale case study are that there is a clear lack of documentation on this subject in this city. Montreal is also recognized as having a significant amount of recent and relevant urban development. Information will be obtained through observation, documentation review and photography. Some conclusions may require secondary observation for some of the practices observed in order to interpret each correctly. This can be accessed through local literature found at the CCA Library or the McGill Redpath Library.

**1.4.5 Trustworthiness**

Trustworthiness in the investigation will be ensured by documenting each phase of the timeline analysis and development of design principles and will include errors, flawed data and unpredictable results. For example, an accepted passive design or “eco-friendly” technique will not be assumed to necessarily facilitate a mutualistic co-evolutionary outcome. Explanations for these phenomena will be provided if at all possible.

**1.5 Significance**

Winston Churchill’s insight that, “We shape our buildings, and afterwards our buildings shape us” can also be rephrased to read “We shape our environment, and afterwards our environment shapes us” or, even “Our environment shapes us, and afterwards we shape our environment.” The versatility of this concept illustrates the depth of the people-place dynamic. Humans are intrinsically linked to their ecological surrounding and both depend on it and desire to escape from it. Given this paradoxical condition, humans (being creatures who comprehend the notion of future) must first learn to develop cities which at the very least, co-exist with natural ecosystems. Subsequently, instead of maintaining a mere static co-existence, mutualistic co-evolution can transpire. By modifying the design process to embrace, even require, passive design techniques, cities and eco-systems can co-evolve through a process which is advantageous to both parties.

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This exploration of urban co-evolution is intended to initiate a movement toward a more biocentric perspective, which includes the human species as a component of global ecology. In order to co-exist efficiently with our surroundings, human and non-human networks must co-evolve. A co-evolutionary condition does not suggest an [imaginary] absolute harmonious co-existence, i.e. the highly criticized 18th century perception of the ecological “Noble Savage.”5 The fact remains that without the air conditioning, heat and ventilation innovations of the last few centuries, the formal arrangement of human settlements were context-specific, determined by ecological factors, and represented a more intimate interrelationship between people and place. It is possible for humankind to, once again, design according to these ecological constraints with the knowledge that for now, it may be by choice; but in the near future, it will be out of necessity.

Past and present expressions of the co-evolutionary process between people and place will be examined in order to derive effective co-evolutionary practices for Montreal. Furthermore, the derived passive design planning techniques will represent distinctive responses depending on the regional eco-determinants. The challenge of defining the urban co-evolutionary relationship and the creation of generalized passive design principles for infill development remain the foci of this investigation.

1.6 Limitations

Narrow Region of Case Study

This research explores the co-evolutionary process to determine the future of urban infill development, so one must begin with a focused study to determine a methodology, and only then can these conclusions be applied to other cities. By limiting the case study to one city, the results will be somewhat biased to the particular urban culture of Montreal. It is not practical to explore every infill site in every North American city or look at all types of the infill in a single case study.

Le Plateau (Figure 3⁶) is an appropriate beginning because the neighborhood has a mixture of residential, commercial and office typologies and is mature enough to be representative of the co-evolutionary process. Le Plateau district is 7.74 km² (2.99 mi²).⁷

![Figure 3. Map of Island of Montreal; Plateau is highlighted in green](image)

**Differing Scales of Evolution**

Urban evolution will be examined according to three corresponding axes: human ecology, non-human ecology and built-environment. These three systems, namely non-human ecology, develop and adapt on extremely different scales. The system of human ecology represents the way humans understand and interact with their surrounding ecology, whereas non-human ecology includes the physical systems functioning outside of the human species. This limitation will addressed by redefining traditional concepts of evolution. Instead of focusing on independent *physical* manifestations of adaptation, the data will be primarily explored and interpreted according to the qualitative evolution of the *interaction* between the three axes. In other words, how does the *relationship* among the various systems evolve?

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Exclusion of Various Ecological Determinants

Several ecological determinants have been discounted in this study. Although eco-determinants include numerous ecological factors such as hydrology (rainwater run-off) and biodiversity; this research is limited to climate, access to large bodies of water, wind direction, local resources and vegetation cover. It can be argued that hydrology (and perhaps even biodiversity) can play a significant part in sustainable architectural design; however, these determinants have been excluded for a number of reasons. Proper application of these factors requires additional expertise and, perhaps more importantly, these aspects should be initially applied on a much larger scale than the scale of the intended research. Also the animals relating to biodiversity have a complex evolutionary history in the region before the introduction of humans which excludes the axis of human ecology. As a secondary future investigation, these additional eco-determinants may be included in order to develop a master plan for a city such as Montreal which includes storm water systems and fauna regeneration.

The preceding Chapter outlines the research design and specific methodologies to address the thesis questions. The next Chapter introduces the chief literary resources surrounding the issues confronted by these research questions. The information gathered from the Literature Review may be incorporated as collected data but will also expose the missing links regarding the complex relationships between people, ecology and cities.
2.1 Co-evolution

A reoccurring concept throughout this research is that of parallel evolutions. Initially this presence of two systems with corresponding development was inherent in the research question, but lacked concrete terminology. Through coursework and archival research, the concept was elucidated through the theory of co-evolution. The following section summarizes the literature surrounding this concept and serves to establish the term’s background, applications and contemporary discourse. The first article presented defines co-evolution as a model linking humans and eco-systems, but also recognizes human’s unique potential to comprehend this relationship.

The human species has the exceptional ability to incorporate reasoning skills and environmental awareness in making decisions. In “Sustainable Co-evolution,” J. Cairns attempts to define and outline the relationship between humans and earth’s systems of ecology. He defines co-evolution as the simultaneous development of individual populations of different species that interact so closely each is a “strong selective force” on the other, such as bees and flowers. This relationship can also be reassigned to the forces of people and ecology, as shown in this thesis. Cairns

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asserts that a truly sustainable relationship requires humans and ecological systems to coexist in a mutualistic co-evolution, one that enhances the survival of each population. In the context of this research, the extent of mutualistic co-evolution is analogous to the extent of urban sustainability. Sustainability in this case refers to a broader scope than simply building performance. Sustainability is a key objective of environmental management, energy conservation and ecological preservation. Currently, there are a number of issues concerning sustainability: the disruption and deletion of certain evolutionary processes and the ecological and genetic isolation of certain populations (i.e. loss of biodiversity). One such evolutionary process that may be jeopardized is the evolution of ecology in urban areas. He maintains that humans are primarily dependent on their surrounding ecosystems, although many humans perceive their sole dependence being on technology. Due to the recent “green movement”, this attitude is quickly losing ground while the ecological situation is simultaneously worsening. Cairns highlights that a foremost key to sustainability is the realization that humans are only a small part of the overall web of life which makes up the planet.

Following his discussion regarding parallel developments, Cairns introduces the concept of the human footprint. Humans are using resources at a higher rate than the planet can renew them. Generally, when faced with a decision between advancing economic growth and preserving earth’s ecosystems, humans choose the former. Instead, innovation should maximize the benefits of technology while minimizing the environmental impact of the ecologically detrimental processes and products. Is there enough time to complete this shift and repair the damage? The theme of time also becomes a fundamental basis for the thesis research. The research process following this article attempts to address how long the damaging exploitation has been present and how long it may take to reverse or revolutionize it. A series of generalized human choices point out the fundamental issues of current lifestyles and support the promotion of a harmonious relationship between humans and ecosystems.
Two examples of these generalizations\(^9\) are listed below:

1. **Economic growth cannot continue indefinitely at the expense of natural capital and ecosystem services.**  
   *Humankind is now choosing economic growth.*

2. **Humankind, especially in the United States, has chosen material consumption over ecological and sustainability ethics.**

Overall, it is understood that mutualistic co-evolution relies upon formulating new ecological and sustainable ethics, but Cairns only suggests what these ethics may entail. The connections presented are not tested within the scope of the paper and this open-ended opportunity resulted in the Co-evolutionary Timeline Diagram and further exploration in Chapter Three.

Co-evolution is a relevant topic regarding the valuation of “nature.” Environmental valuation is “a complex system of social tools and processes used to articulate values that reflect the economic worth of un-tradable environmental phenomena.”\(^10\)

In other words it explains the systems of values assigned by a social group to reflect the worth of a non-commercialized environmental occurrence/condition. Environmental valuation is a major element of the Human Ecology argument. If human ecology is defined by human understanding of environment, environmental valuation is a direct consequence of human ecology. According to K. Farrell’s 2007 article “Living with living systems: The co-evolution of values and valuation” the human parties who assign this value also assume a value within the ecological systems in question. Farrell’s argument attempts to synthesize environmental valuation and the co-evolutionary condition which exists between the two systems. In other words, the discourse concerning sustainability must include the interactions between human and non-human systems as well as those between ecology and valuation. This interaction is addressed in this research through the evolutionary tables (Table 4 and 5). The directions of human ecology shown in the tables

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represent the need to reconnect the divergent evolutions between human ecology (environmental valuation) and non-human ecology.

As portrayed by evolutionary theory, there is, to some extent, implicit co-evolution between species and their environments. K. Farrell’s 2007 article further explains that the current state of co-existence between human and environment is learned by subsequent human generations and, therefore, repeated. Co-evolution is realized through a phenomenon the article refers to as “niche construction.” Niche construction involves altering one’s environment in order to ensure or at least improve survival rates. The topic of urban co-evolution involves modifying infill sites, i.e. niche construction. Overall, Farrell’s investigation of co-evolution concludes that a self-referential valuation system will inherently fail because it will eventually isolate itself from the objects to which it assigns values. Societies must focus on designing new “priceless” valuation methods to apply to future living systems which avoid the basis of preference.

There have been several other adaptations of evolutionary theory applied to economics, politics, and business philosophy. Co-evolution, and thus evolution, has been established as useful concepts in Ecological Economics. According to G. Kallis in his 2007 paper on socio-environmental co-evolution, many applications have used the terminology while simply creating a co-dynamic instead of co-evolutionary analysis, i.e. the analysis does not include a comprehensive exploration into diversity, punctuation or mutation. These will be central parameters for the case study data collection. Evolutionary and co-evolutionary theories can also be applied to various other social sciences. Co-evolution expands upon the notions of evolutionary theory to include co-dynamic interactions as well as highlighting variation and selection. Kallis presents a number of ideas for an effective analysis using a co-evolutionary approach including utilizing the “variation-selection-retention” model and several applicable methodologies. This variation-selection-retention model will be applied in this research within the timeline analysis (Chapter Five).

According to Kallis, co-evolutionary analysis is more valuable when coupled with established definitions and classifications from other sciences (biology, anthropology, architecture, etc.). The diagram below depicts how co-evolution could be translated into the field of Architecture, where the built environment is a measurement tool.

Figure 4. Diagram translating Co-evolution from Ecological Economics to Architecture

Any analysis, including an architectural analysis should specifically use theories unique to the phenomenon studied. As a final note, Kallis states that evolutionary theory as a means to describe anything outside biology is a new concept – yet it is showing great promise. This challenge of applying evolutionary theory to diverse fields is met through the investigation of urban co-evolution in Montreal.

2.2 Human Ecology

The subject matter of Human Ecology incorporates both sociological and ecological methodologies in order to examine the constant intermingling between human society and its environmental context. In *Human Ecology: Following Nature’s Lead*, Frederick Steiner presents a comprehensive, theoretical review of the discourse surrounding the transdisciplinary field of Human Ecology. Steiner structures the initial discussion according to spatial scale by exploring habitat, community, landscape, region and planet. Subsequently, he delves into the ever-
present matter of the “green chaos” facing human civilization and proposes the adoption of more organic, retrospective means of existence in order to salvage the remainder of the earth’s resources.

The field of Human Ecology is emerging in much of contemporary discourse because of the current trends in “green” living and environmental management. The foremost intention of Human Ecology: Following Nature’s Lead is to expose several modes of interaction between people and their surroundings. Steiner states that, “First, I seek to explore how nature and culture interact in human settlements. Second, I am interested in how an understanding of such interactions informs how we shape our homes, neighborhoods, landscapes city-regions, and nations.”\textsuperscript{14} This topic is particularly relevant to the investigation at hand. This thesis will attempt to further define such interactions and elaborate upon this specific dynamic in cities. An underlying premise in the work suggests that just as each person on earth is unique, “Every spot on Earth has its own tale to tell.”\textsuperscript{15} This statement leads the reader to the recognition that there is an intrinsic linkage between people and place. This concept is introduced in the preface of the book and lingers as a recurring theme both in the book and in this thesis.

As the dissociative nature between the human organism and environment dissolves, Steiner reinforces both the distinctions and parallels between the two. For example, he asserts that, “Landscapes don’t change overnight, at the rate of economics and politics. A landscape changes sustainably at the rate of local and regional culture.”\textsuperscript{16} This statement highlights a difference (the ephemeral, high speed nature of capitalism) and a similarity (the gradual, enduring nature of culture) between society and landscape. Steiner’s purpose is not necessarily to promote enlightened environmental practices nor some sort of eco-fanaticism. The initial sections of the work simply summarize the theoretical background and nuances inherent in the multitude of networks composed of people and places.

\textsuperscript{15} Ibid. p. xvi.  
\textsuperscript{16} Ibid. p. xvii.
Many reoccurring ideas in *Human Ecology: Following Nature’s Lead* are developed from notions associated with the New Ecology movement and bioregionalism. Steiner repeatedly refers to New Ecology to provide reasonable explanations and define problematic terminology linked with Human Ecology. New Ecology theory perceives living systems as having complex and shifting existences instead of being static and stable entities. Another key concept realized through New Ecology is that boundaries between living systems often are blurred; “Open systems possess fluid, overlapping boundaries across several spatial scales from the local to the global.” Thus, boundaries between human communities are also perceived as hazy. The concept of blurred boundaries between each group as well as between each echelon will reappear in the ensuing discussion.

The framework of Steiner’s book adopts a typical structural system emerging from the basic assumptions of New Ecology, “that human interactions can be studied using hierarchy as an organizing device – interactions that occur at one level, the habitat, for instance, are nested in other ‘higher’ groupings, such as community.” Furthermore, this tiered organizational strategy is effective because the reader can develop a cumulative awareness of their individual position on several different levels within several different contexts. This tactic also lends itself to Steiner’s writings regarding adaptation and change. “The understanding of how living systems are organized from the local to the regional provides a means for assessing their capabilities to adjust to change.” In other words, understanding the natural hierarchies of the earth aids human efforts in evaluating natural systems’ ability and capacity to adapt to shifting surroundings.

Although the book’s chapters have a well defined beginning and end, it is essential to note that Steiner openly recognizes such clear distinctions do not exist within the hierarchies of ecosystems. He specifically addresses this shortcoming of geographical classification when he speaks of regional languages, “Regions exhibit diversity within larger nations through dialects. Regions have clear cores but blurry

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18 Ibid. p. 16.
19 Ibid. p. 12.
edges. Language diversity may be more apparent at the edge that at the core.\textsuperscript{20} The opening chapters skillfully assemble the hierarchy which frames the human-environment dynamic. The final chapters switch course slightly in order to underscore the troublesome circumstances of this dynamic which are reflected by the dire status of the planet. After presenting some distressing statistics, Steiner concludes that the future of humanity, not to mention the planet, appears exceedingly grave unless humans revolutionize their way of life and actively participate in developing innovative “adapting mechanisms that achieve ‘adequate diversity’.\textsuperscript{21} After all, “healthy systems sustain themselves, and sustainability depends on how we choose to live.”\textsuperscript{22} On the whole, the book presents a powerful message and provides abundant background information to support it.

The need for constructive human adaptation comprises much of the concluding chapter. One cannot argue that humans will forever question, “How can the landscapes of the planet adjust to changes, while retaining their fundamental characteristics?”\textsuperscript{23} Perhaps, even more so, they will ask, “How can humans adapt to better ensure the environment retains its fundamental characteristics?” Frederick Steiner poses this challenge to readers.

Frederick Steiner offers a perceptive interpretation of the human-environment dynamic when he testifies, “We continue to refine and redefine our relationships with our surroundings, which, in turn, continue to exert influences on how we live.”\textsuperscript{24} He does not provide direct solutions to the environmental crisis, but, instead, illustrates what has worked so far and suggests directions in which to move. This thesis research will begin to resolve the tensions between human infrastructure and non-human eco-systems. In effect, there is no choice but to co-exist, so humankind should refrain from overcoming nature and instead might as well co-evolve in a way that is favorable for both parties.

\textsuperscript{20} Ibid. p. 109.
\textsuperscript{22} Ibid. p. 170.
\textsuperscript{23} Ibid. p. 145.
\textsuperscript{24} Ibid. p. 173.
2.3 Ecological Determinants

The breakdown of the large scale overview found in many articles is somewhat addressed by the actual ecological conditions of urban forms. “City form and natural process – indicators for the ecological performance of urban areas and their application to Merseyside, UK” by V. Whitford et al. describes various “ecological indicators” which reflect the effects of urbanization on three environmental conditions. Following an ecological performance analysis, the article applies each model to a number of case studies in the UK. It is the aforementioned natural conditions which can be translated into basic “eco-determinants” and relate to the particular research question of sustainable infill development. Whitford et al. propose these eco-conditions to be climate, water (or hydrology), and vegetation (or biodiversity).²⁵

While the aim of “City form...” is to suggest the negative outcomes of urbanization, it simultaneously suggests solutions. For example, urbanization generally affects hydrology by replacing vegetation networks such as forests or grasslands with impermeable structures, e.g. concrete and asphalt (buildings and roads).²⁶ The proposed rainfall run-off model is analyzed using specific site parameters, such as permeable surfaces within catchment.²⁷ Thus, “the ecological performance of cities depends crucially on the amount of vegetation cover,”²⁸ and this implies that vegetation could be a resolution to flooding problems.

A concept closely related to vegetation as a response to flooding is vegetation as a response to climate regulation. Whitford also indicates that establishing a presence of trees and other indigenous plants on a site also reduces heating loads in the winter (wind buffer) and reduces the cooling loads in the summer by “direct shading and evapotranspiration.”²⁹ There are additional design responses to this particular

²⁶ Ibid. p. 93.
²⁷ Ibid. p. 95.
²⁸ Ibid. p. 101.
²⁹ Ibid. p. 96.
eco-trigger. The article states that tall buildings facilitate urban warming; however, low-rise developments are not as affected by “summer heat islands.” Designating infill construction to be zoned as low-rise could eventually help regulate urban temperatures.

2.4 Infill Development

Contemporary North American civilizations are unquestionably thriving hubs of innovation, but certain aspects of these flourishing cities are being overlooked. There are specific areas of potential advancement which have been neglected until recently, namely sustainable development in an urban infill context. In the last decade, few sources have simultaneously responded to both the developing infill and developing infill with respect to the site’s ecological context. Much of the discourse around this topic is outlined on a city-wide scale (however, an article specific to Montreal has yet to surface). For instance, there are many sources, which reinforce the benefits of infill development in general; however, there is gap when it comes to specific design considerations on the scale of a single infill site.

A broad approach to the realm of sustainable urban planning is introduced by Ajay M. Garde’s article in the Journal of Planning Education and Research. The paper, titled “New Urbanism as Sustainable Growth?: A Supply Side Story and Its Implications for Public Policy,” is particularly relevant to the topic at hand because it surveys a variety of the perspectives of professionals within this particular discipline, in effect, a major portion of readers to whom this research question is directed. The article does not define New Urbanism, but analyzes instead designers’, developers’ and planners’ responses to its principles. One example of an applicable concept of The Charter for New Urbanism is that of Smart Growth, “the preservation of open space, farmland, natural beauty and critical environmental areas.”

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Smart Growth inquires to the public’s views regarding the principles of New Urbanism and what a new development should address. For instance, one chart demonstrates responses to such questions as “Should new developments include parks and community gardens?” and “Should new development minimize environmental deterioration?” This could suggest which objectives are poorly received (and by whom) and imply what principles may be misunderstood or diluted in sustainable urban concepts. This article can indicate areas of focus or concentration within the scope of this thesis study which are generally misinterpreted or misconstrued in the development field. It contains a great deal of insight into today’s climate of sustainable urban infill.

Many articles advocate the effectiveness of infill development. “The Opportunity in Urban Infill as a Means of Balancing Developmental Needs and Environmental Quality Preservation” written by Peter B. Meyer endorses the development of urban infill as a means to cultivate sociological and economic investment within the context of communities or neighborhoods. His use of the term environmental quality refers to the “sensational” atmosphere rather than physical environment or ecological surroundings; however the article is quite supportive of this research in that it testifies to the negative effects of sprawl, thus the advantages of infill. Meyer’s article asserts that appropriate development of “centrally located sites whose prior uses have been rendered obsolete over time,” i.e. infill sites, is a prominent topic of discussion in land use planning and urban development fields. The main points of discourse in the article are Private and Public Causes of Urban Abandonment, Environmental and Economic Consequences of Decentralization, The “Urban Infill” Approach, Spatial Scale and the Experience of Decentralization and Infill Impacts and Toward an Economically and Environmentally Efficient and Equitable Infill Policy. The article is relevant to the research questions at hand because it highlights the impacts of infill, not only why infill is beneficial to a city, but what might be driving urban abandonment. From this information I will be able to address each topic within a given infill context and rectify any predominant issues.

Meyer alleges that “the infill logic ignores (or may underestimate) the possible value of increasing urban parks and open spaces as stimuli to more intensive utilization of the land carrying buildings and other uses.” In other words, the term infill assumed built construction and disregards the option of greenspace as infill. This reveals a possible controversial concept or gap in the definition. Infill could instead be defined as the development of abandoned or underutilized urban sites to accelerate social, economical or ecological advancement. This could be in the form of a built structure, greenspace or combination of both. Surprisingly, Meyer hints at this earlier in the article when he states that infill sites, “may be more akin to elements of the ‘natural environment’ – areas and features of the local landscape that are not currently the direct objects of human action but could play such a role.”

Eventually, Meyer elaborates on the implementation of a successful infill policy; “the determination of an efficient infill policy requires balancing developmental needs and environmental preservation objectives.” This can be interpreted to be balancing infill development in order to reflect developmental needs, address atmospheric conditions and maximize ecological benefits. The author highlights a gap in the field of infill development when he stresses the difficulty of attempting to “optimize” infill land use and questions whether or not it will inevitably ignore “distributional impacts.” This missing link concerning optimization correlates with sustainability and promotes reconciliation between with urban infill impacts and the physical environmental.

A response to part of this query is found in Building the Ecological City. Rodney White touches on the concept of optimizing the ecological side of infill land use. In Part II, he introduces the concept of urban eco-systems and establishes a foundation about why and how this context is unique. White goes on to discuss what went wrong with early urban attitudes and how to restore cities to a healthier status. The statement “Unused urban lands are symptomatic of our failure to make the most of

34 Ibid. p. 1.
36 Ibid. p. 7.
our opportunities while living within the environmental limits.\footnote{White, Rodney R. \textit{Building the Ecological City}. Boca Raton, Florida: CRC Press, Woodland Publishing, 2002. p. 140.} undoubtedly asserts that vacant urban lots should quickly be reconsidered and timely developed into a well thought-out program to reap the benefits of location and infrastructure which accompany infill sites. As mentioned before, there are countless articles which outline the many benefits of infill and how the overall infill network and provide various benefits to the city. However, there continues to be a break in the realm of specific small scale infill site development models. An additional relevant portion of White’s book is contained in his concluding arguments. Once again, the remarks reflect a city scale solution; however he is able to assess human ability to achieve the “ecological city” which provides some insight into the potential of peoples’ intentions.

The city of Montreal is specifically addressed in the book, “Montreal in Evolution” by Jean-Claude Marsan. Marsan assesses the development of Montreal from its very beginnings to the late twentieth century. This comprehensive analysis summarizes the initial geographical conditions of the region and then outlines chronologically the absorption of surrounding towns over several centuries. In some parts of the book Marsan evaluates building design, floor plans and materials according to cultural eras and demographics. Overall, the book is quite helpful in portraying the general context of Montreal; however, does not go into great detail about specific districts, such as Le Plateau-Mont-Royal. The expansion of Montreal is a key factor in the development of these outlying regions, thus “Montreal in Evolution” provides an invaluable resource to aid this exploration.

2.5 Factors of Sustainable Urban Design

Environmental conditions are tightly linked to sustainability, and Yosef Rafeq Jabareen’s article makes directs suggestions for design with this condition in mind. Jabareen implies in his article, “Sustainable Urban Forms: Their Typologies, Models and Concepts” that certain urban forms contribute more than others to sustainability. There is a controversial topic within this statement because Jabareen asserts that
there is also a “lack of agreement about the most desirable urban form in the context of sustainability.”

In this article, Yosef Jabareen cites four types of sustainable urban forms. He assesses an alternative concept to New Urbanism, characterized by the term Eco-City. The Eco-City in particular emphasizes a passive solar approach to designing within the city. This model is not discussed at length but is portrayed as a clearly relevant source for any infill scale applications in an urban community. “Sustainable Urban Forms” evaluates the extent of the benefits of infill, and advocates mixed use or heterogeneous zoning to reduce travel distances between activities, but this remains to be a scale which is slightly too broad for the scope of this question. This article contains much insight into sustainable urban forms on a large scale, but meager information within the analysis of urban form models pertaining to the scale of a single site.

The article does, however, present a framework in which to evaluate urban sustainability by identifying seven concepts associated with sustainable urban forms: compactness, sustainable transport, density, mixed land uses, diversity, passive solar design and greening. While some of these concepts are more relevant to a larger scale than simply an infill site, the author introduces the fundamentals of passive design.

The concept of passive design, according to Jabareen, is “to reduce demand for energy and to provide the best use of passive energy in sustainable ways though specific design measures.” Solar conditions can be addressed passively through a variety of design considerations, e.g. design, siting, orientation, layout and landscaping. An instance of passive design is that because of larger [wall surface] areas, more solar radiation can be collected on a built urban site than on a flat open terrain, especially in winter. This information is useful to this study because of the concentrations on urban infill development. Jabareen expands on this concept of

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40 Ibid. p. 38.
41 Ibid. p. 42.
urban passive design by stating that “in the city, a surface’s exposure to the sun at any given time is largely determined by the build form, as well as the street widths and orientation.” Where this text directly contributes to the study at hand is the information compiled about passive design. Jabareen specifically cites some design parameters which have been established as factors in a sustainable urban environment:

- **Built form** – density and type, to influence airflow, view of the sun and sky and exposed surface areas
- **Street canyon** – width-to-height ratio and orientation, to influence warming and cooling processes, thermal and visual comfort conditions, and pollution dispersal
- **Building design** – to influence building heat gains and losses, albedo and thermal capacity of external surfaces, and use of transitional spaces
- **Urban materials and surface finishes** – to influence absorption, heat storage, and emissivity
- **Vegetation and bodies of water** – to influence evaporative cooling processes and building surfaces and/or in open spaces
- **Traffic** – reduction diversion and rerouting to reduce air and noise pollution and heat discharge.

These design parameters play a pivotal role in this thesis research. As mentioned in Chapter One, the sustainable development factors listed above serve as a framework for data collection as well as a structure the organization for Chapters Five and Six of this dissertation. Chapter Five incorporates the design parameters as organizational categories in which to exhibit the data from Chapter Four to the reader. Co-evolution is illustrated through the timeline by tracing corresponding events related to Jabareen’s design parameters. The Guiding Principles for Urban Development in Chapter Six are also presented according to each design parameter. Jabareen’s sustainable design parameters represent a launch point for sustainable urban design in the case of this research.

This thesis also goes beyond these parameters in various ways. Firstly, some of the design parameters are redefined as well as refined in some cases (See Table 2).

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43 Ibid. p. 42.
For example, street canyon is a specific condition which is better incorporated into the more general heading, Orientation. Building Design is a term Jabareen has assigned, but is not specific enough. Vague terminology like “Building Design,” could include or not include the category of Urban Materials. Instead Building Design is translated to Building Type and Urban Materials is translated to Building Materials as a separate category.

This thesis investigation applies the parameters to varying scales – that of a city, a district and an infill sight. The parameters are clearly meant to be relevant to a city scale, but are not as compatible when looking at individual sites or blocks. Some parameters are used on a large scale in this research, such as traffic or vegetation, but others, after being refined are applied to infill development. Initially the parameters are used to analyze historical data regarding the city of Montreal in Chapter Five. Chapter Six broadens the scope of the parameters by focusing on site-by-site urban development. The “big picture” city is only affected as small scale interventions are assembled.

Much of the literature found in the process of reviewing sources on infill design strategies concentrates on circumstances concerning larger scale models; there is also little widely published documentation of Montreal-specific infill development. The final article presented provides a specific framework to structure the remainder of the thesis, but overall most of the literature which has been uncovered concerning this topic tends to only address one portion of the research question (e.g. passive design, advantages of infill or ecological cities). Overall, these pieces of information

<table>
<thead>
<tr>
<th>Initial Design Parameter</th>
<th>Description</th>
<th>Interpreted Design Parameter</th>
</tr>
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<tbody>
<tr>
<td>Built Form</td>
<td>density and type, influence airflow, view of the sun and exposed surfaces</td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>width-to-height ratio and orientation</td>
<td>Urban Grid</td>
</tr>
<tr>
<td>Street Canyon</td>
<td>to influence building heat gains and losses</td>
<td>Orientation</td>
</tr>
<tr>
<td>Building Design</td>
<td>to influence absorption, heat storage, and emissivity</td>
<td>Building Type</td>
</tr>
<tr>
<td>Urban Materials and</td>
<td>to influence evaporative cooling processes and building surfaces</td>
<td>Materials</td>
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<tr>
<td>Surface Finishes</td>
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<td>Vegetation</td>
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<tr>
<td>Vegetation and Bodies of</td>
<td>reduction diversion and rerouting to reduce air and noise pollution and heat discharge</td>
<td>Access to Water</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>Traffic</td>
</tr>
</tbody>
</table>

Table 2. Interpretation of Jabareen’s Design Parameters.
can only serve to supplement, and not answer, the inquiry of passive design strategies for infill development in Montreal.

The information that has been presented in this Chapter highlights the gaps in knowledge concerning specific aspects of co-evolution, human ecology, passive design and urban development. More importantly, this section emphasizes which horizontal linkages remain blurred. All of these concepts are clearly correlated, yet the direct relationships have not been properly recorded. This thesis seeks to describe the linkages between many of these basic concepts. This literature review outlines the existing information which is necessary to define the main concepts addressed in this research, but not resolve the thesis questions. In order to answer the indicated research questions properly and establish absolute linkages, the information gathered through this literature review must be synthesized and, in some cases, expanded. The next section of this thesis will analyze the co-evolutionary background presented in this chapter in order to make the transition from Biology and Ecological Economics to Architecture.
3.1 Introduction to Co-evolutionary Theory

The ways in which human systems interact with the non-human realm are complex and diverse. Philosophers and scientists alike have attempted to define, quantify, and valuate these interrelationships; however, the recent emergence of acute environment issues has accelerated the pace of this exploration of the duality between people and ecology. The relatively new (inter)discipline of Ecological Economics has materialized as a response to the escalating tension between environmental problems and economic objectives. By adopting a pluralistic perspective, Ecological Economics intends to reexamine the conventional approaches to both environmental policy-making and resource economics.

The core of research in Ecological Economics is comprised of economic theory as well as ecological concepts. A prevalent theme in the field’s discourse is one of evolution; the notion that time gradually transforms biological systems, economic models, and even cultural norms. As context changes, humans must develop new modes of adaptation. Occasionally these mechanisms of adaptation are physical changes, but often they are cultural, technological, or lifestyle changes. The course of these changes is a process of evolution, but rarely is it evaluated in the context of external, yet interconnected systems. The simultaneous evolution of two correlated systems is termed, *co-evolution*. Co-evolution, as previously mentioned, is a concept which originated within the field of biology; however, it is quickly becoming a term relevant to several other disciplines. Richard Norgaard, a professor of Energy and Resources Group and of Agriculture and Resource Economics at The University
of California Berkeley, is credited as the first to apply the concept of co-evolution in the discipline of Ecological Economics.\footnote{Kallis, G. "Socio-environmental co-evolution: some ideas for an analytical approach." \textit{International Journal of Sustainable Development and World Ecology} 14 (1), February 2007. p. 4-13. p. 4.} The concept of co-evolution is commonly used in this respect to define the human-environment dynamic and illustrate the linkages between the two systems.

Primarily, this investigation explores how co-evolution has been applied in Ecological Economics and expands upon these ideas in order to redefine them in the context of architecture. In particular, co-evolution can be further characterized if a reciprocal symbiosis exists between the two systems being assessed. The concept of \textit{mutualistic co-evolution} is a parallel evolution that enhances the survival of each contributor. Overall, this paper inquires to the possibility and probability that humans can revolutionize their anthropocentric mentality in order to facilitate mutualistic co-evolution with proximate ecosystems. Subsequently, the discussion will address how this can be done and make the argument that architecture clearly represents a potentially useful and necessary component in the process of mutualistic co-evolution.

### 3.2 Co-evolution and Ecological Economics

The discipline of Ecological Economics explores longstanding themes through a contemporary lens. In 1989, Robert Costanza wrote the first article of the first edition of the discipline’s journal titled \textit{Ecological Economics}. His contribution, “What is Ecological Economics?” is an article that introduces the new (inter)discipline and presents an overview of what it will entail.\footnote{Costanza, R. “What is Ecological Economics?” \textit{Ecological Economics} 1 (1), 1989. p. 1-7.} \textit{Ecological Economics} is the synthesis of economic issues and environmental concerns. The discipline addresses both human economies and natural ecosystems. It is unique in that it integrates two disciplines which previously were accepted as unrelated. Most importantly, Constanza underscores the gap between the disciplines of ecology and economics.\footnote{Ibid. p. 1.} Because of this gap, it seems that theorists and academics with inherently conflicting
backgrounds would have a difficult time reconciling such contradictory positions concerning development and conservation.

According to Richard Norgaard, the differing backgrounds of contributors only enrich the discourse. It is true that at times, economists fail to consider the ecological implications of their exploits and \textit{visa versa}, but this field’s pluralistic and cooperative perspective ultimately serves both fields. Each side presents different patterns of thinking, perceptions of energy flows and interactions, so it contributes to an environment of conflict resolution and shared learning.\textsuperscript{47} Ecological Economics employs a collective judgment process; the presence of specialized knowledge is necessary to communicate new and innovative insight.

By and large, Ecological Economics represents a convincing case for “methodological thoroughism.”\textsuperscript{48} The existence of multiple systems is inherently characteristic of all science, so in a way it is only reasonable to take a pluralistic outlook when exploring all global sciences, including economics and ecology. Richard Norgaard also emphasizes that irreconcilable differences are another innate element of science. In order to participate in Ecological Economics discourse, one must be comfortable with contradictions, and uncomfortable with established truths.\textsuperscript{49} Economics approaches issues of the “state of the world” and resource limitations from a pluralistic point of view in order to accommodate various perspectives and fully address critical matters of sustainability.

The emergence of Ecological Economics coincided with the rapid expansion of globalization. Generally, matters which incorporate elements of natural science are at odds with the process of globalization and, thus the ecological repercussions of globalization are being compounded daily. Norgaard asserts that the field of Ecological Economics is effectively in contention with globalization.\textsuperscript{50} The process of generating global markets has several advantages for world economies, but severe consequences for ecological systems. Ecosystems are structured in loosely coupled networks, but in essence are localized entities. While globalization is an ideal

\textsuperscript{48} Richard Norgaard. Telephone Interview. 15 April. 2008.
\textsuperscript{49} Ibid.
\textsuperscript{50} Ibid.
condition for economic advancement, it is completely incompatible and inconsistent with the fundamental spatial limitations of ecosystems.

Urbanization is another process experiencing rapid acceleration and is also directly conflicting with critical matters of eco-system management. At the moment, half of the world’s people live in urban areas, and the population of cities worldwide will double by the year 2030. By the year 2050, two-thirds of the planet will live in cities.51 Ecological Economics commonly focuses on rural areas because there are high instances of poverty and direct correlations between economy and ecosystems, specifically natural resources. In order to comprehensively examine global stability and sustainability, there must be a shift. Ecological Economics must focus on the urban-rural harmonic instead of each geographic element as a separate entity. Urban regions depend on external resources for the most part, and farmers cannot live without cities.52 Urban regions will play a huge role in the struggle for global sustainability and are slowly refocusing the concentrations of Ecological Economics.

As outlined above, Ecological Economics is asking the relevant and essential questions of today. The implicit conflicts of the economic-ecological struggle must be brought to the forefront of environmental discourse. These questions must be confronted and analyzed by several participants with varying backgrounds if there is any hope of resolution. The pluralistic underpinnings of Ecological Economics reinforce the need for a new philosophy toward the exploration of the human-environment interaction. Moreover, the complex dynamics of this relationship, ultimately that of sustainability, require a more nuanced language with a wider range of terms53 both new and borrowed. Ecological Economics begins to develop this language by redefining these complex dynamics, i.e. the subtleties of the duality. Overall, its fundamental terminologies are beginning to better reflect the dual qualities of the discipline.

Co-evolution is a prime instance of a borrowed expression incorporated into this new language. Although, co-evolution was originally associated with discourse regarding Biology, Ecological Economists are able to apply the term in a way which evokes a fresh, new meaning. Co-evolution is a concept particularly useful in the transdisciplinary context of Ecological Economics (EE), which seeks to define the dynamic interrelationships between human economies and natural ecosystems. The concept begins to articulate the interconnected and interdependent linkages and processes between humans’ material practices and the non-human environment (living and physical).

There have been several adaptations of evolutionary theory applied to economic, political, and business-related topics. Co-evolution and thus evolution have been established as useful concepts in EE. Although the concept of evolution is a useful explanatory tool, many applications have used the terminology to simply delineate a co-dynamic analysis instead of co-evolution, i.e. the analysis does not include a comprehensive exploration into diversity, punctuation or mutation. Evolutionary and co-evolutionary theories can also be applied to various other social sciences or perhaps arts and architecture. Co-evolution expands upon the notions of evolutionary theory to include co-dynamic interactions as well as highlighting variation and selection. Giorgios Kallis presents a number of ideas for an effective analysis using a co-evolutionary approach including utilizing the “variation-selection-retention” model and several other applicable methodologies.

Co-evolutionary analysis is generally more valuable when coupled with established definitions and classifications from other sciences (biology, anthropology, etc.). Any analysis should specifically use theories unique to the phenomenon studied. For example, an evolutionary approach to exploring architecture must include evolutionary theories, such as the “variation-selection” method. Kallis states that evolutionary theory as a means to describe anything outside biology is a new concept, yet it is showing great promise.

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55 Ibid. p. 9.
56 Ibid. p. 13.
Co-evolutionary research attempts to define the multifaceted connections between changing systems, and given the complexity of the human-environment dynamic, there are several perspectives. According to traditional theory, environment, economy and society are interrelated in a way similar to three intersecting things (See Figure 1\textsuperscript{57}). Giddings \textit{et al.} propose a new model to describe this relationship.\textsuperscript{58} Although contemporary focus is currently concentrated within the economic aspects, all three of these sectors have a very direct and equal bearing on co-evolutionary sustainable development. Instead the three sectors should be arranged in concentric circles to illustrate their inherent dependence on each other (See Figure 2\textsuperscript{59}). In effect, this “nested” model shows the economy nested into society which in turn nested within the environment.

The two models begin to express the overlap and intricate linkages between economy, society and environment. Although the boundaries of this secondary model appear rigid and precise, these sectors intersect, blur and have great impacts on one another. One cannot assume or insist that economy and society are independent of the environment. In order to break down the boundaries humans have placed on these sectors of sustainable development, a “win-win” scenario must


\textsuperscript{58} Ibid. p. 187-196.

\textsuperscript{59} Ibid. p. 192.
be established.\textsuperscript{60} In effect, the global focus should shift from economic growth to satisfying the needs of humans. After all, humans must function under a stable system of beliefs in order to satisfy both their primary and secondary needs.

### 3.3 Co-evolution and Belief Systems

An important attribute of co-evolution in the context of EE is that the concept incorporates changing ideas and values, instead of simply biological manifestations. In other words, co-evolution also refers to sociological dynamics. Culture translates directly into human knowledge systems,\textsuperscript{61} so a change in culture will have a direct effect on the development of economic institutions.

Furthermore, the study of co-evolution assesses a dynamic between something physical, the non-human environment; and something intangible, whether cerebral or spiritual (culture or economy). The interactions between such distinct realms are difficult to qualify, like finding connections between “apples and oranges”; however, they are linked on a fundamental basis. In every society, there are physical components that constitute the intangible belief systems. Richard Norgaard further explains this phenomenon through a discussion of various belief systems. For example, parts of the Bible are based on the physical and social environment of the past, an environment that is irrelevant today. Although the physical surroundings of the Bible do not apply to the world today, the fundamental expression of beliefs persists, especially in economic systems.

Norgaard states that “God is the invisible hand to the market” and the market is the “rationalization to how we structure ourselves.” In other words, the things that drive the marketplace are the same things that drive our morals and relationship with other people. Conversely, the things that drive human nature to believe in God, are the same things that convince people to believe in the economic systems. Many of today’s belief systems are partially structured by what economists say.\textsuperscript{62} It is the process of co-evolution which has gradually altered the composition, but not the


\textsuperscript{61} Richard Norgaard. Telephone Interview. 15 April. 2008.

\textsuperscript{62} Ibid.
foundation, of human belief systems. Overall, human values, beliefs and economic systems are tightly interrelated. Because of this intersection condition, humans tend to develop institutions which inappropriately incorporate this overlap, such as placing monetary value on “nature.”

As established, co-evolution is a relevant topic regarding the valuation of “nature.” Co-evolution between values and valuation rests entirely within the human social system. Environmental valuation is “a complex system of social tools and processes used to articulate values that reflect the economic worth of un-tradable environmental phenomena.” In other words it explains the systems of values assigned by a social group to reflect the worth of a non-commercialized environmental occurrence or condition. According to the article “Living with living systems: The co-evolution of values and valuation” the humans who assign this value also assume a value within the ecological systems in question. The discourse concerning sustainability must include the interactions between human and non-human systems. Farrell’s argument attempts to synthesize environmental valuation and the co-evolutionary condition which exists between the two systems.

The first step in assigning value to an object is to thoroughly describe it. The resulting value will be a combination of the object’s features and the method employed to determine a value. In the study of co-evolution, the objects of value are complex living systems. The focus of Farrell’s investigation remains to evaluate the relationship between the articulated values of the living system and the method of environmental valuation. The co-evolution between these two subjects is dependent upon the human system of connection and interaction. As portrayed by evolutionary theory, there is understood co-evolution between species and their environments. The current state of co-existence between human and environment is learned by subsequent human generations and therefore repeated. Ultimately, within this system, there is a vicious cycle of self-referential adaptations.

64 Ibid. p. 14.
Co-evolution is realized through a phenomenon the article refers to as “niche construction.” Niche construction involves altering one's environment in order to ensure or at least improve survival rates. The co-evolution of values and valuation also engages the concept of niche construction. Niche construction applies in this case because the values will alter the valuation methods, thus affecting their endurance in the social system. Additionally, the two systems must co-evolve because the previously assigned value will affect the future method of valuation and *vise versa*. Overall, it can be concluded that a self-referential valuation system, such as that of all human society, will inherently fail because it will eventually isolate itself from the objects to which it assigns values. Farrell claims that there is a possibility of generating virtuous cycles because of human free will. Ultimately, societies must focus on designing new “priceless” valuation methods to apply to future living systems which avoid the basis of preference.

### 3.3 Co-evolution & Sustainable Development

The Walrasian economic models of the past no longer apply to the broader definitions of sustainability today. The solution to environmental problems is not to intensify current human practices, and it is unlikely that technology alone will repair the planet's condition. As outlined in previous sections, several researchers are looking into the co-evolution between individuals and social behaviors (“General Darwinism”) as well as the co-evolution between human's and earth's ecosystems.

Human behavior is generally self-referential so, according to Gowdy, there is the possibility of developing a new economic model that employs individual incentives to actions, which also benefits the population as a whole. This notion begins to develop the individual-society aspect of co-evolution. The intrinsic awareness of individuals can have a greater effect of society, especially if individual philosophies

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69 Also referred to as “call market.” A similar model is used by the NYSE.
are transformed collectively. The ability of humans to make decisions based on “conscience” or awareness, which affect society as a whole clearly reflects this aspect of co-evolution.

The difference between humans the thousands of other species is their ability to include reasoning and environmental awareness to make decisions. Humans are dependent on both technology and the surrounding eco-systems. In “Sustainable Co-evolution,” J. Cairns attempts to define and outline the relationship between humans and earth’s systems of ecology. As previously mentioned, co-evolution is the simultaneous development of individual populations that interact so closely each is a “strong selective force” on the other, such as bees and flowers.

A truly sustainable relationship requires humans and ecological systems to coexist in a mutualistic co-evolution, one that enhances the survival of each population. Currently, there are a number of issues concerning sustainability: the disruption and deletion of certain evolutionary processes, ecological and genetic isolation of certain populations (loss of biodiversity). A foremost key to sustainability is the realization that humans are only a small part of the overall “web of life” which makes up the planet.

Following this discussion, Cairns introduces the concept of the human footprint. Humans are using resources at a higher rate than the planet can renew them. Generally, when faced with a decision between advancing economic growth and preserving earth’s ecosystems, humans choose the former. Instead, innovation should maximize the benefits of technology while minimizing the environmental impact of the processes and products. Do we have enough time to complete this shift and repair the damage? A series of co-evolutionary principles support the promotion of a harmonious relationship between humans and ecosystems. Overall, this mutualistic co-evolution relies upon formulating new ecological and sustainable ethics.

72 Ibid. p. 103.
If the process of co-evolution is reciprocally beneficial, it can be further modified to convey this condition. Mutualistic co-evolution is typically applied to land management techniques where humans have had a direct and positive impact. As an example, researchers Fairfield and Leach claim that specific food cultivation in the Republic of Guinea accelerated the initial stages of forest progression leading to a gradual expansion of forest islands. Additionally, the loss of human presence in regions of forest-savannah mosaic lead to the hindrance of forest island growth, thus forest islands are party a product of human-vegetation interaction. Agricultural burning, or the “slash-and-burn” technique, is another prevalently cited example.

Mutualistic co-evolution is a concept which lends itself particularly well to the field of sustainable development. A truly sustainable relationship requires humans and ecological systems to develop through a process of mutualistic co-evolution. One can speculate that this sort of link between human society and the planet’s ecosystems may manifest itself in our expressions of architecture. As illustrated through this research, the tumultuous relationship between society and environment is largely manifested through architecture. In the context of contemporary architectural practices, the relationship is decidedly one-sided; ecological systems, including but not limited to natural resources, better ensure the survival of humanity, but humanity continues to evolve to the detriment of natural ecosystems.

Instead of designing human infrastructure specifically for human needs, building could be constructed with other species’ (plants or animals) best interests in mind. This is counterintuitive, perhaps “unnatural” given that all animals are meant to adapt in order to ensure the survivability of their own kind. This is an extremely short-sighted mentality for a species which comprehends the notion of future generations. If people begin to think about “survival” and persistence of life on a less superficial degree, they may be lead to think about the major connections between humans and ecosystems. The majority of connections between eco-systems are unknown by humans, so it is impossible to know the extent of the long term damage of practices.

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such as clear-cutting, air-conditioning, damming, etc. Humans are only beginning to realize the degree of damage human infrastructure has on the environment.

On a deeper level, the preservation of biodiversity may be the remaining means of ensuring the survival of the human species. Instead of surviving on a superficial level or living “in the moment” such a drastic change in philosophy may help to sustain all biological life in the future, including *H. sapiens*. Designer and planners much initiate the process of mutualistic co-evolution.

The non-human environment is essential to human survival. All species rely on other living species; a purely anthropocentric perspective of the world is a fallacy. Through a process of mutualistic co-evolution, micro-organisms transformed to live on the human body and all human artifacts. More obvious living things, the emergence of domesticated animals, generated new species to fill environmental niches formed by human needs. Richard Norgaard also points out that rats, mice and cockroaches rely on human built structures; for instance, New York City is home to vast populations of “vermin.” On a planetary scale, there is a necessary and mutual dependence between all living things.

The harder humans try to rid their surroundings of unwanted invasive species, these species either evolve, adapt or others move in to fill the empty niches. Instead of practicing extermination, perhaps humans practice co-evolution. People should evolve and adapt to better co-exist with their surroundings. If humans continue to be distracted by the cure-all appeal of information technology, there is likely to be a catastrophic die-off of *H. sapiens*. This may happen anyway, of course, and the planet would easily persist in the absence of humans. Instead of continuing to research how to halt natural processes, exterminate unwanted pests and innovate upon building technologies to exclude all evidence of life, people must strive restore it.

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3.4 Co-evolution and Architecture

Ecological Economists would likely encourage a co-evolutionary approach to design. The co-evolutionary dynamic is arguably already clearly manifested through architectural practices. Designing human structures to accommodate other species of plant or animal is the beginning of a change in philosophy. This is not a new approach by any means. It is a concept that has been widely applied at human’s convenience. To put this notion into perspective, people commonly will place bat houses near their eaves in order to regulate mosquito populations. Instead of spraying the entire yard with pesticide, this option is directed toward a specific interspecies relationship, so it pinpoints a single living system.

On a similar note, a recent visit to an environmental center\(^75\) revealed that barn owl populations are endangered because of diminished habitats. Farms are disappearing all over Pennsylvania due to urbanization and rural development. Barns are being taken down or falling down all over the state and not being rebuilt. The intriguing aspect of this case is that the initial habitat for the owl was a human construct, hence the common name *barn owl*. Therefore, it is possible to facilitate mutualistic co-evolution through architectural design; in this circumstance, it was the particular style of construction of the barn. The disappearance of barn owls demonstrates that disregard for ecological systems will have serious ecological implications regarding biodiversity. To reiterate, humans have little understanding of the extent of ecosystem connections and the long term effects of biodiversity loss.

Architecture traditionally conformed to a region’s ecological determinants – climate, proximity to water, etc. Technological innovation has almost rendered this practice obsolete and is leading to increased tension between humans and their environment. The resulting tension has huge economic implications. Society pays huge sums to keep the “outside” world at bay. Human overconfidence in these technological advances is already resulting in severe and fatal consequences. The residents of New Orleans are the unfortunate victims of this mentality. Hurricane Katrina caused such serious damage because human technology failed. Already, the previous

\(^{75}\) Shaver’s Creek Environmental Center, Stone Valley Recreation Center, PA.
The discipline of Ecological Economics aims to define the interrelationship between human and non-human systems, and speculate on why this state of discord has reached a point where change in design practices is needed. The argument of this chapter is not attempting to romanticize living with nature. Instead, the discourse represents the need to relieve the tension between human and non-human systems. A change in architectural philosophy can shift processes of co-evolution and restore a symbiotic relationship between people and planet.

The discipline of Ecological Economics is being upgraded to “superior” solutions which will ultimately be just as susceptible. The struggle to keep non-human forces at bay is losing one on several levels. From time to time, these forces overcome human constructs anyway and moreover, the very absence of these undesired forces will likely result in the ultimate disappearance of humankind.

The ideas discussed in this chapter can now be interpreted and applied in a case study. The emergence of co-evolutionary theory in this research has suggested a structural framework in which to collect and analyze data. The background concept is the idea that rather than adapting to the environment, one’s true adaptation is to the concept of co-evolution. This discourse represents the need to relieve the tension between human and non-human systems. Jacob Bronowski’s series, “The Ascent of Man,” suggests that one of man’s defining characteristics is the process of growth and adaptation. Two systems which directly influence one another’s fitness or potential to survive must eventually reach a state of mutualistic co-evolution to sustain life. Mutualistic co-evolution guides systems into a sort of symbiotic relationship necessary for long-term survival. The predominant voice behind the concept of co-evolution is Richard B. Norgard who served as a dominant resource within this thought process. Eventually, the state of disunion between human and non-human systems can potentially be restructured through a change in design practices.

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information regarding Montreal will be outlined in the next chapter, and will subsequently be used in conjunction with the presented co-evolutionary theory to generate a co-evolutionary diagram.
4.1 Introduction

In order to revolutionize human perceptions of place, one must start at the beginning. The dynamic between people and place evolved (and still evolves) as cultural values change. Initially this dynamic was also partially determined by ecological surroundings. One can hypothesize that cultural values and architecture itself were in fact, manifestations of human adaptation. Although this statement may require additional investigation, it can be concluded that all early human settlements conformed to context by developing solutions which reflected their physical environment.

In order to establish a new understanding of cities, people must shed all preconceptions about how a city should function, look and initially emerge from space. If a city’s context is unique, why does contemporary city development formally reflect a universal style? Cities today are constructed of concrete, orthogonal buildings of varying heights, arbitrary placement of greenspace and a generally unsystematic reference to preexisting urban planning philosophy. The images of cities today, for the most part, disregard, and thus reject, the potential benefits of their distinct ecological circumstances.

By summarizing the historical development of Montreal as a city, this chapter will firstly lay the groundwork for a chronological analysis. This information is crucial to formulating a new sustainable framework for the city. Secondly, Montreal’s past and present ecological determinants will be derived. Eco-determinants are ideally
applied in the outset of the development of a city; however, given the fact that cities are already deeply rooted within a specific cultural context, one must think retrospectively, immediately as well as toward the future. In other words, cities should reflect the original systems and ecological networks on a site, but these circumstances are rarely feasible. Instead, a city may also be retrofitted to respond better to existing conditions.

This Chapter is the first step in the process of developing guiding principles for sustainability in Montreal. The data presented in this Chapter was collected in order to populate the diagram introduced in Chapter Five. This process of urban development has neither a purely ecological nor anthropological perspective. Instead, it seeks to establish a planning model that replaces the strained relationship between people and ecology with mutual co-evolution. By relieving some of the tension between human infrastructure and non-human systems, both humans and ecological networks will benefit. This process is advantageous to humankind because it will result in less overall maintenance of manufactured mechanisms which struggle against eco-systems; similarly, ecological networks will be replenished and biodiversity will thrive in this urban environment. The following sections build the groundwork for the co-evolutionary analysis in Chapter Five.

4.2 The City of Montreal: A History

The complete history of Montreal, as any other city, is lengthy and complex. Along with a simplified survey of Montreal’s urban development history, this section will highlight relevant phases, events and qualities for analysis in the subsequent sections. For the purposes of this paper, the selected historical references are specific to the region’s ecology and to the general urban development of Montreal. The City of Montreal is located in the southwestern sector of the province of Quebec (45° 45’ N and 74° 15’ W) and is situated at the confluence of three geographically significant waterways, the St. Lawrence, Richelieu River and Ottawa River. It was the land’s proximity to these particular rivers which initially defined it as a prime

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opportunity for settlement. It was in the year 1535 that Jacques Cartier sailed up the St. Lawrence River and reached a small Iroquoian village called Hochelaga. Hochelaga was located at the foot of a mountain which Cartier later named Mont-Royal. Due to the various waterways of the region, Cartier established Montreal as a desirable location for trading, and thus for settlement; “Between these ranges lies the finest land it is possible to see, being arable, level and flat. And in the midst of this flat region we saw one river.” Years later, at the outset of the 17th century, Samuel Champlain arrived at the island of Mont-Royal and also recognizing the ideal qualities of the region, established a commercial hub.

In addition to the highly advantageous riverfront location, alluvial deposits remaining from the Paleozoic Era enriched the soil of Montreal and its surrounding areas. Consequently, the region was not only positioned within three interconnected waterways for ease of trade, but the area was extremely valuable agriculturally. A major factor in Montreal’s rapid growth was its flourishing agricultural industry.

Montreal’s foremost asset, the St. Lawrence River, also afforded the city a natural harbor due to the location of river rapids. The shipping industry swelled in the mid 1700s which encouraged increased migration to the city. As shipping and agricultural industries expanded, Montreal attracted migrants and swelled to include surrounding land. Montreal is, somewhat surprisingly, an island and therefore has opportunities for multiple sectors of shipping industry. Through the use of many rivers, Montreal links the Old World to the New World and is the hub of several cross-continental shipping routes. These key waterways connect the Atlantic Ocean to the Great Lakes. One drawback of Montreal’s ecology in relation to the shipping industry is the periodic freezing of the rivers during the winter months. The harsh, freezing climate was a major downside of Montreal as an industrial hub until adequate land transportation was developed.

79 Ibid. p. 8.
80 Ibid. p. 8.
81 Ibid. p. 6.
82 Ibid. p. 8.
The land’s orientation in relation to the Saint Lawrence River determined the primary structures of urban planning of both Montreal and the surrounding villages. Several villages materialized along the Saint Lawrence River which complimented the many industries developing in Montreal. Montreal, as well as these various other waterfront settlements, were French Colonies until 1760 when they were relinquished to Great Britain. Due to the rapid expansion of Montreal, many of these small villages are now included within the urban boundaries of Montreal. In effect, the Saint Lawrence River not only dictated the location of Montreal, but also the initial street orientation within and surrounding Montreal. If one examines early maps of the Mont-Royal settlement, it becomes clear that land division, and consequently the streets, are approximately perpendicular to the shoreline of the river (See Figure 6).

Figure 7.
Map of Montreal in 1758; Note the orientation of the streets and buildings. See appendix for larger image.

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84 Map provided by the McCord Museum in Montreal.
Land was divided into plots running approximately North-South in order to fairly distribute waterfront property. These divisions initially defined the boundaries of the farmlands to the North of the waterfront; however, each farm was eventually absorbed by the city and further divided as the city expanded. Of course, the value of this property also escalated as Montreal grew. As more people moved to Montreal for work, the city expanded, and housing stretched northward and westward. These neighborhoods, or côtes, further divided land within and surrounding Montreal. Côtes, following the original tracts of land, generated a permanent urban grid (See Figure 7).

Figure 8.
Map of Montreal in 1846 with overlay highlighting the distribution of côtes.
See Appendix for larger image.
The early 19th century was a period of rapid industrialization in Montreal. This industrialization led to increased urbanization and immigration, mainly from Europe and elsewhere in Canada. In fact, from 1891-1921, the population of Montreal tripled. As farmlands were absorbed into the city, Montreal became increasingly dense, productive and chaotic. During this time, industry also began moving away from the river’s edge towards the urban centre. The result of an expanding industrial core, increased commercialization and rising populations was a settlement rich in technological invention and cultural diffusion, yet little architectural variation. Jean Claude Marsan declares that “The structures as well as the orientation of the urban landscapes of the metropolis grew with scarcely any alterations for the initial pattern of rural settlement.” The period of development between 1880 and 1930 is often considered to be the Golden [industrial] Age of Montreal.

Post industrial age, Montreal continued to expand which put even more pressure on urban housing requirements. Due to the ongoing growth during the twentieth century, a new residential pattern arose. Apartment buildings and high rises replaced many of the low-rise accommodations. Furthermore, people began moving out of the city into suburbs. Regardless of the trends toward suburbanization, many residents remained in the urban core. From the years 1951 to 1971, the percentage of urban households owning cars doubled. This was the beginning of a truly modernized Montreal.

It could be argued that Montreal has developed in a similar way to many North American cities. The non-distinct industrialization of Montreal lends itself well to this study because the conclusions from this research may be more applicable to other cities. It is important to note that although the generalized development of the city may correspond to several others, the regional attributes are unique. The specific interactions between human society and the surrounding environment are specific to

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86 Ibid. p. 11.
this climatic region and the extent of ecological understanding of the inhabitants and immigrants may even be specific to this particular city. In order to trace such interactions, the recorded history which has been provided will be analyzed according to Montreal’s specific ecological qualities. These ecological determinants will be discussed in the following section.

4.3 Eco-determinants of Montreal

This exploratory process has neither a purely ecological nor anthropological perspective. This study does not assume to revive or recover the ecological systems which existed in the region before the presence of people. Those systems are effectively obsolete, yet they can be reviewed to inform planners to how the city can become more sustainable. Some of the ecological determinants observed today will also have changed from the time when Montreal was initially established. A profile of the region will consist of the city’s current conditions and assumed historical conditions. This data will be manipulated to accommodate regional ecological solutions which may eventually replace ineffective human-made mechanisms. Montreal's eco-determinants can be broken down into the categories of climate, wind, hydrology and access to water, vegetation cover, and finally biodiversity as well as geological diversity.

Montreal is located within the Humid Continental Climate Region. The Humid Continental Climate Region is designated by the Köppen System of Classification as the zone characterized by a cold climate and the lack of a dry season.\(^89\) The climatic regions are constantly shifting due to global warming, and currently Montreal is in proximity to the boundary between warm summers (climate region Dfb) and hot summers (climate region Dfa – See Appendix). Based on this climate classification, Montreal will need extensive insulation in winter and moderate ventilation in summer. Although there is commonly an average of 140 frost free days, Montreal residents experience snow cover for between 12 and 15 weeks.\(^90\) The layers of snow

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occurring in the winter actually prevent soil from being damaged by the frigid air temperatures. Paralleling the Laurentien Valley, wind blows primarily from the southwest, but also gusts from the west and northeast bringing moisture from the Gulf, Atlantic and Great Lakes. The average wind speed in Montreal is five miles per hour. The wind speed and direction may be used in design as a ventilation strategy; however will not be analyzed in the co-evolutionary diagram.

Montreal is a dense urban environment with a major greenspace in the center, known as Mount Royal, and an additional 2,100 greenspaces scattered throughout the remainder of the city. In this discussion of eco-determinants, greenspaces are defined as areas of vegetation cover, such as parks, gardens and unplanned natural areas. The original vegetation cover of the city is unknown; however, it can be assumed that it would have been similar to surrounding undeveloped areas in southern Quebec. Today, vegetation covers 6,500 hectares of Montreal which is roughly 13%. Depending on the district and zoning, there are various percentages of greenspace on individual sites. Within the scope of the studied district, there is very little private or semi private greenspace and more importantly, these green spaces are not connected to one another. Besides Mt. Royal Park, a recreational area designed by Frederick Olmstead, most the significant greenspace in Montreal is found along the river.

The extent of biodiversity in Montreal is a result of several geographical factors. The city has 315 km (196 miles) of shoreline and also includes several small islands in the St. Lawrence in addition to the main land mass. As the shorelines became industrialized and the islands developed land uses, Montreal’s biodiversity diminished. However, according to the Convention on Biological Diversity, Mt. Royal Park is the apex of a recent project to promote biodiversity conservation. The park serves as the core of this particular study because its expansive land area (200 hectares) allows for buffer zones and facilitates effective use of ecological corridors toward to the river.

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92 Ibid.
The geological formation of the region’s soils also yielded several useful building materials for early settlers. Wood, stone and clay are foremost examples of local materials which were utilized as the primary building materials of the emerging city. Montreal was an area rich in timber resources; in fact, many of Montreal initial structures were framed and veneered with wood. Also incorporated in the discussion of building materials are the regions rich deposits of rich geological materials. Much of the rocky outcrops found within the island’s limits quickly became quarries. Montreal’s geological formations included limestone, which is a grey stone of average hardness mainly used as building blocks, and the clay embedded in the detritic mantle which was called Leda clay and used to form bricks.93

The outlined eco-determinants, climate, wind, hydrology and access to water, vegetation cover, and finally biodiversity, function as the foundation for sustainable development in Montreal. Eco-determinants are the initial layer of this exploration. The secondary layer of sustainable planning is a basic breakdown of the existing infrastructure of the city. The next section presents the conventional urban structures of development in Montreal and will be applied in the co-evolutionary diagram in order to derive their relationship to the established eco-determinants.

4.4 Conventional Urban Forms of Montreal

Montreal is primarily characterized by low to mid-rise buildings, single or double lane roads, and a mix of residential and commercial zoning. Much of Montreal has been developed as a dense, urban environment which results in a number of unique conditions. A typical building site in this city depicts shoulder-to-shoulder construction, which means there is no buffer space between sites (firewalls are shared). This city is also especially relevant to this topic of study because there is a substantial amount of recent and relevant infill development in this area. Infill development is the key to realizing a sustainable vision in existing cities because it provides a vital opportunity to either rezone the site for an alternate function (such as

an ecological corridor) or instead, (wholly or partially) rebuild a structure with passive design intentions in mind.

Infill is particularly useful to showcasing passive design strategies because it is characteristically in dense regions of development. Thus, innovative passive design concepts can reach many more people than a suburban, or rural detached context. Passive design is a significant avenue to alter the impression of cities because it is a method which integrates energy saving components into the formal design. Because it is a method introduced at the outset of a project, it becomes an integral part of the solution, instead of simply extra credit. To reiterate a point made before, passive design is not limited to the context of a single site.

Sustainable urban orientation is another matter of interest; as mentioned in the historical section, the orientation of streets and buildings in Montreal is dependent upon the orientation of the riverfront. Because the riverfront is used as a point of reference for the whole city, transformations will have to be made gradually on a very minor scale. Alternatively, since the grids of most cities are already established, passive design for infill may have to disregard optimal orientation and adapt its techniques to the standard position of city blocks. Montreal’s streets are at a slight angle to the standard east-west directionality. Additionally, the roads are constructed of impermeable surfaces and are based on a grid system. These are not the best circumstances for sustainable urban design.

Now that the ecological determinants and conventional urban forms have been clarified, a specific area of Montreal will be further analyzed. This study will focus primarily on the central-east region of the city, the district of Le Plateau-Mont-Royal. By adopting a bottom-up approach to this research inquiry, a realistic process can be developed and adapted as needed. In other words, instead of approach urban transformations from the city scale, this proposal suggests designers begin from many projects developed over time. This progression lends itself to co-evolutionary theory by incorporating the aspect of long term evolution. Site specific data will be presented in the following section and then this data will be input into a timeline in order to analyze it within the context of co-evolution according to human and non-human ecology.
4.5 Le Plateau Mont-Royal: A District of Montreal

It was not until the year 1745 that the development of the city of Montreal overflowed the fortified walls and extended northwards. By 1850, the necessary infrastructure had been installed in these previously remote areas and established the northern villages as integrated, yet still rather rural, municipalities adjacent to Montreal. In 1909, the Town of Montreal annexed the villages of De Lorimier and the Mile End (Saint Louis), both which contained extensive industry. The amalgamation of these villages eventually became Le Plateau-Mont-Royal, also called Le Plateau by many local Anglophones. Since the outset of the 20th century, the region now known as the Le Plateau was established as a commercial and cosmopolitan core of Montreal. Throughout Montreal’s Golden Age, the population density of the area continued to swell at a swift rate and continued to increase well into the 21st century.

Figure 9. Shows the Old Port and the expansion of the city into Le Plateau.

Most housing was constructed in Le Plateau between 1860 and 1920, but some were constructed as early as 1745 when Montreal first extended beyond its fortified border. The initial dwelling type used in Le Plateau district (before it was established as Le Plateau) was a one family, stone or wood house which was typically built in strewn-out rows with two or more storeys. It is important to note that this initial building type was distributed breadth wise along the streetscape\(^{95}\) (See Figure 9).

The second residential model characteristic of this region, which is still common today, is slightly different. The rowhouse is oriented in order to distribute most of its square footage depth-wise toward the interior of the site. The size of building lots are also standardized, typically 7.6 meters (25 feet) wide and 24.4 to 30.5 meters (80 to 100 feet) deep.\(^{96}\) This secondary model of housing was very popular at the turn of the century which was also a period of rapid urbanization in Montreal. This second building type, the rowhouse, was more suited to the economic, social and cultural conditions of Montreal's predominant inhabitant, the industrial worker or merchant.\(^{97}\) The reasons for this evolution between the first two building types will be derived in the subsequent section.

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\(^{96}\) Ibid. p. 271.

\(^{97}\) Ibid. p. 266.
The rowhouse is a typology which was designed for profit. To some extent, this condition reflects the economic side of the co-evolution of Montreal’s urban vernacular. According to Jean Claude Marsan, these housing units were built at a time where there was a need to increase the density of residential urban development. To substantiate this statement, the population of Montreal tripled from 219,616 to 618,506 during the period between 1891 and 1921 due to the major influx of impoverished immigrants.\textsuperscript{98} Due to the environmental problems coupled with current trends toward urbanization, this need has remained today. Thus, the rowhouse also provides a desirable housing typology for select contemporary cities.

The low – mid height characteristic of the rowhouse is advantageous for cities searching for a solution to the “right to light” debate. The rowhouse model can accommodate the greatest number of people with the shortest lines of access to commerce and, in some cases, employment. By increasing the density of Le Plateau area, Montreal established a district which had a low cost of transportation and the city provided necessary infrastructure to sustain a large, local population – sidewalks, sewers, gas and electricity, and eventually public transportation.

The need for rapid densification also determined the floorplan of the main rooms of the rowhouse. The desire for concentration had a direct effect on the orientation of the rooms. Although the shoulder-to-shoulder condition limited the amount of daylight which penetrated the dwelling, an outdoor staircase and front balcony enhanced the rowhouse as a prospect for many families. It is thought by some that the front balcony and setback from the sidewalk were necessary because of cultural familiarity.\textsuperscript{99} These aspects of the rowhouse also elevated its appearance to that of a higher social status regarding architecture. These status symbols prevented the rowhouse from being viewed as a dark and cramped, lower-class, immigrant dwelling; although, for the most part, that is what it was at the time.

Hans Blumenfeld asserts that a country’s most prevalent building type is also likely to be the most inexpensive building to construct because it is not only most profitable but also establishes the preliminary building standard for the building industry as well.

\textsuperscript{99} Ibid. p. 272.
as emerging construction codes. The rowhouse is commonly constructed with a structural wooden frame then covered with stone, which was quickly replaced by more inexpensive brick. Bricks cost less to transport, handle, set and cut. Brick applied to a wooden frame eliminates the potential for fire and storm damage, yet also requires little maintenance while provided cost-effective warmth. A survey taken in 1984 states that 62% of the building exteriors in Le Plateau were constructed of brick (33% were grey stone). The “blind common wall” or “party wall” also reduced the cost of the rowhouse model. Having a masonry wall separate each unit cuts down on the cost of windows, insulation and allowed for builders to more readily repeat the same floor plan on either side.

As mentioned before the rowhouses of Montreal follow a particular orientation, with the bulk of the volume perpendicular to the street. The entry elevation of all rowhouses is directly parallel to the street which generates a rigid street pattern (Figure 10). The street pattern in Le Plateau follows the structure of the Côte, which was the colonial unit of territorial boundaries in the early settlements of the city. The streets typically run slightly skewed from east to west with fewer main arteries

running north to south. If a wall happens to borders a sidestreet, it typically is expressed as an endwall with no opening unless the required setback conditions are met. Typically, the orientation of the rowhouse is not flipped for additional units. Thus only one side of the house gets sunlight for the most part of the year. Depending on the height of surrounding buildings and the existence of alleyways, there are also circumstances were the sunlight does not penetrate the rowhouse at all (Figure 11). Daylighting and ventilation are key issues in rowhousing typology. The rowhouses of Montreal typically have large sets of window along the street, but this does little to illuminate the central rooms of the house.

The typical and current site conditions in the district of Le Plateau-Mont-Royal are outlined below:

![Diagram](image)

**Figure 12. Example of infill site within typical urban context**

An outdoor stair is also a common occurrence in many Montreal residential structures, specifically the rowhouse (See Figure 12). Although a stair blocks out additional sunlight from the front and back of the house, it mitigates the need for interior semi-private spaces. Residents are able to access their unit directly from the outside. Jean Claude Marsan points out the many dwellings also face the prevailing winds in the winter, so snow accumulates on the entry porches and balconies during
the colder season.\textsuperscript{101} Although this may create more maintenance for the tenant, it is possible that the snow drifts provide additional insulation in areas which are not entryways. Additionally, over half of the apartments have a courtyard\textsuperscript{102} which provided some semi-private exterior space for recreation, pets or children. The existence of such courtyards may explain the high percentage of greenspace in such a densely populated urban area. Overall, the rowhouse is considered the foremost vernacular dwelling of Le Plateau and arguably of Montreal.

Merely 15\% of the residential buildings in Le Plateau were built post 1960.\textsuperscript{103} As more and more residents recognized the advantages of the low-rise historical typology, buildings were renovated instead of being replaced with mid- or high-rise apartment buildings (Figure 13). Many new construction projects also adopted an updated interpretation of the Montreal rowhouse rather than appeal to city commissions for high-rise construction permits (Figure 14).


\textsuperscript{103} Ibid. p. 23.
The buildings situated on commercial streets also accommodate several residences which are located above the commercial space on the ground floor. These main arteries are mixed use areas. The diagram map below distinguishes the land use designation in the borough of Le Plateau. Although most of the region is identified as being a residential zone, the main routes of mixed-use typologies provide necessary commerce and industry to sustain a population that is still increasing (Figure 15). Le Plateau today is comprised mostly of brick rowhouses consisting of two or three storeys designated for residential use.

As shown in the above figure, one of Le Plateau’s main commercial arteries is St. Laurent Boulevard. This street is also considered the linguistic border between the Anglophone districts to the west and the Francophone districts to the east. Le Plateau is unique in that it is one of the few districts that successfully integrates both French and English culture while offering a distinctively urban experience. Since the end of the Second World War, Le Plateau-Mont-Royal has also become a refuge for
many ethnic communities upon their arrival on the continent. Throughout the influx of several ethnic groups, such as Greeks, Portuguese and Vietnamese, the crumbling houses dating back to the turn of the last century have been repaired and repainted. Since 1980, the recent urbanization trends in Montreal have been centered towards Le Plateau district. Many professionals, artists and students have discovered this area as a desirable and emerging mainstay of Montreal. This cultural summary concludes the data collection sections of the thesis.

This historical overview introduces several relevant aspects of Montreal’s urban development. As presented in this Chapter, the collected, historical data is comprised of many individual events and several evolutionary phases of urban development in Montreal. The main phases of urban growth in Montreal’s history are the settlement period (approx. 1535-1825), the industrialization period (approx. 1825-1921) and the post industrial period (1921-present). Each major growth period can also be broken down into secondary phases, such as the urbanization phase from 1825-1851 or the suburbanization phase in the 1950s and 60s. Key years also are representative of significant events in the city’s history. The Great Fire of 1852 signifies the transition from residential building types and the inauguration of Mount Royal Park (1876) indicates a shift in the importance placed on public green spaces (also a shift in Human Ecology?). The varied and abundant amount of data clearly requires a formal method of organization in order to fully explore its uses. The ensuing chapters analyze the presented data through a Co-evolutionary Timeline Diagram (Chapter Five) and interpret the data analysis into guiding principles for site-by-site urban development (Chapter Six).
5.1 The Timeline Diagram

As mentioned in Chapter Three, the concept of co-evolution was initially limited to the field of biology while sociological and anthropological discourse was mainly founded upon socio-cultural evolution. Currently, there are several “accounts that regard socio-cultural change as a result of co-evolution between a biological system with genetic mechanism and a cultural system with nongenetic mechanism.”\textsuperscript{104} Thus, it is both observed and understood that biological and cultural systems are tightly entwined in a parallel evolutionary relationship “in which there is reciprocal selection between these seemingly incompatible systems.”\textsuperscript{105} Although this theory has not yet been tested in the realm of urban culture and ecology, the relationship clearly depicts conditions which are applicable to this model.

The following chapter will present a co-evolutionary diagram in the form of an interrelated series of timelines or axes. These axes, titled Human Ecology, Non-human Ecology and the Built Environment, originate at the foundation of the Montreal settlement and chronologically record the data presented in Chapter Four. The timelines will be exhibited adjacent to each other for comparative purposes in order to test if the evolutions are parallel and thus, indicate urban co-evolution. The diagram displays the dynamic nature of the link between people and ecology and illustrates how this relationship corresponds to the resulting architecture in Montreal.

\textsuperscript{105} Ibid. p. 37
5.2 Axes of Urban Co-evolution

Urban evolution can be evaluated with regard to the following parameters: human ecology, non-human ecology and the built environment. The axes were selected according to a number of assumptions. Firstly, all functioning ecological systems can be broken down into systems of human ecology and non-human ecology. These two categories of systems are not assumed to be of equal quantity or importance, but instead represent the two aspects of co-evolution discussed in the introduction of this chapter. One aspect is the biological system with genetic mechanism (non-human ecology) and the other aspect a cultural system with nongenetic mechanism (human ecology). The third axis is categorized as “built environment.” The third axis represents the architectural linkages resulting in or from factors and phases of human or non-human ecology. There should be an electronic file attached to this document with the co-evolutionary diagram at a larger scale.

As a suggestion, the timeline diagram should be “read” or examined in the following order: 1) Review each event or phase horizontally along each axis. Begin with human ecology (yellow), move down to non-human ecology (blue), and finally review the phases of the built environment axis (green). Sections 5.2.1, 5.2.2 and 5.2.3 reintroduce the axes and elaborate on their definitions. 2) Secondly, focus on the design parameters (red). Each parameter is meant to be studied individually by selecting a parameter from the bottom of the page and moving vertically along the red dotted lines. The red dotted lines represent the connections between the other three axes. Review each parameter before continuing. 3) Lastly, move into the text of this Chapter to peruse the parameter-specific analysis with regards to the co-evolutionary axes. Section 5.3 examines each parameter and then evaluates the data by drawing connections and linkages between each axis.

5.2.1 Human Ecology

Human ecology is defined, not as “everything human,” but as the cultural systems socially constructed as a direct response to environmental context. In effect, the term “human ecology” represents how humans understand ecology and explains why they interact with it the way they do. The Human Ecology axis, which is presented in
the timeline diagram, includes major events in Montreal’s history pertaining to initial settlement, immigration, land distribution, family structure and large scale real estate trends (other than those trends specifically resulting in built structures). The selection of the events which constitute the human ecology axis was informed by the book *Human Ecology: Following Natures Lead* which was outlined in Chapter Two (Section 2.2). The trends, events and phases of Human Ecology presented also suggest the modes of interaction between humans and a region’s ecological determinants.

### 5.2.2 Non-Human Ecology

Non-human ecology is comprised of the physical systems functioning outside of the human species. This concept can be further explained by reintroducing ecological determinants. Although each eco-determinant is portrayed as an isolated characteristic, eco-determinants are entrenched in the ecological systems of the regions. In other words, this study isolates them for the purposes of explanation and analysis, but eco-determinants are actually interwoven amongst themselves and contribute to overall non-human ecology. The concept of ecological determinants was used to determine what data was appropriate for input into the timeline.

As the title suggests, “non-human ecology” excludes the cultural factors affecting ecology. In other words, this axis excludes the fundamental factors which distinguish human society from that of the animal kingdom (although these factors are determined and defined by humans themselves). It could be argued that if one assumes a biocentric mentality toward human existence, systems of human interaction could be portrayed as a species of animal within the greater systems of biology. If this is the case, humans participate to some extent in both human and “non-human” systems, although through very different channels. Unfortunately, this biocentric frame of mind is rare among human beings, being that our definitions of environment are ultimately self-referential. Frequently, humans differentiate themselves from other systems owing to their assumed superlative nature and supposed influence over external systems. This reality provides the justification for maintaining the differentiation between human ecology and non-human ecology in this research. In this case, human ecology and non-human ecology are
distinguished for the sake of argument, only to be shown to be utterly dependent on one another. It is the purpose of this thesis to show that although people commonly differentiate themselves from their surrounding non-human environment, people are clearly inextricably entangled within it.

The axis of non-human ecology is slightly less active then the others because non-human ecology changes and evolves on a much different scale than human society. Not only is it made up of many more systems, but these systems require genetic modifications in order to be conclusively evolved. A genetic mechanism requires a longer time frame to distinguish comprehensible modifications than a nongenetic mechanism. It is also important to note that it is much for difficult for humans as the observer (which in this case are excluded from the system) to recognize these genetic changes outside their own systems of recognition. Humans are more intimately aware of those changes and trends in their identifiable culture, than those minute mutations taking place in a supposedly extraneous system. The few non-human ecology events and phases on the timeline relate to greenspace distribution or very early geological happenings. For example, the non-human axis on the timeline suggests very early geological modifications to the Montreal's landscape, modifications which took place before the timeline's origin. Also included in proximity to the axis of non-human ecology are phases of development related to ecological determinants such as topography, natural disasters, changes in vegetation cover (although these may have been initiated by human-ecology), and measures for increased biodiversity.

5.2.3 Built Environment

Lastly, the “built environment” axis introduces the architectural aspect to the timeline diagram an of this thesis study. This axis illustrates the physical manifestations of the interaction between human ecology and non-human ecology. For instance, the built environment axis contains information regarding the location of new settlements along the St. Lawrence River as well as the physical division of Cotes, descriptions of building typologies and examples of construction techniques. The “built environment” axis also situates the establishment of Le Plateau within Montreal.
5.3 Tracing Sustainable Design Parameters

The following section will trace the design parameters that have been interpreted from Jabareen’s proposed guidelines (to review see Section 2.5). The purpose of this section is to guide the viewer through the co-evolutionary timeline diagram along significant pathways while simultaneously explaining the linkages between each. The order in which each design parameter is introduced may have several implications which will be presented in the conclusion.

5.3.1 Access to Water

An established ecological determinant of Montreal is its proximity to several significant waterways. Geographical context is a condition that is considered as a factor of non-human ecology. Human settlement is commonly a direct result of a region’s access to water regardless of the specific climatic region. In other words, human ecology identifies water as a necessary resource for settlement. Water provides transportation opportunities, irrigation for food production, a source of drinking water, and as the hydroelectric technology develops, also a source of energy. Jacques Cartier recognized the land upon which Montreal was built as a prime location to connect a new world to the old world and establish and trade route throughout the initial settlements of North America. In general, the best agricultural land is also the most desirable upon which to establish an urban settlement. Flat, well-drained topography in proximity to a water source is advantageous for farming and well as city dwelling. On a very basic level, the built environment originated due to the region’s access to water. Thus, there is a clear relationship between the three axes. The land is very close to several waterways (non-human ecology), which were not only recognized as connective passages but also recognized as advantageous for urban settlement (human ecology), upon which the city of Montreal was built (built environment).

5.3.2 Materials

Building materials are a direct result of the interaction between non-human ecology and human ecology. The geological substances generated by a region’s ecology provide shelter on a most basic level. The geological matter found in the area
generally determines the vernacular structures of a region. Montreal is no different. The region within and surrounding Montreal is/was rich with timber, clay and stone resources; thus, most of the early structures were constructed from these materials. The recognition of familiar building materials by European settlers may have had an impact on what materials were applied and also how the buildings were constructed.

It is important to note that Montreal had similar ecological systems as the European origins of the first explorers. If one refers to the Köppen System of Climate Classification, western European countries are characterized by temperate climates with cool summers. Its possible the climates and local materials were similar enough to facilitate construction as a result of both experience and ecology rather than strictly ecology. Although there may have been influence on building materials by French tradition, these traditions were based on the same theory presented here – that of ecological determinants. There is unmistakable overlap between the three axes of co-evolution regarding local materials. The materials available were determined by non-human ecology, human ecology recognized these materials as desirable (either by experience or trial-and-error) and thus, the built environment reflects a linear process of interaction.

5.3.3 Orientation

The orientation of land distributions in Montreal was initially determined by the angle of the Saint Lawrence River. All of the original villages were built in a linear fashion along the river and expanded away from as well as parallel to the shoreline. New landowners were allocated long land parcels perpendicular to the river, yet with each additional landowner, Montreal’s boundaries extended parallel to the river. Each narrow plot of land extended away from the shoreline in order to afford equal access to the river. These plots of land were termed “strip farms” according to their formal arrangement.

The orientation of Montreal is conclusively determined by the geological formation of the region, or the non-human ecology. Human settlers acknowledged the significance of the river by dividing access to it accordingly and responded to the typology by allowing slight variations in the overall layout of strip farms (not all are precisely perpendicular to the river). This condition also proves the intersection
between human and non-human ecology in Montreal. The resulting strip farms represent a physical result of the interaction between typology, geology and human comprehension.

5.3.4 Urban Grid

The narrow strip farms were eventually absorbed into a city center and further divided into smaller blocks. These additional divisions provide an interesting departure from ecological determinants, and instead present the result of cultural determinants. At the time, the urban grid of European cities were moving away from the medieval model of winding convoluted streetscapes, and instead adopting Master Plans conceived by urban planners. Several European countries experienced a vast urban remodeling beginning in the early 19th century. Since the strip farms provided approximately parallel streets going roughly North-South, the east-west streets were installed directly perpendicular to them in order to provide efficient movement in the expanding city.

Unfortunately, the orientation of secondary streets and small districts or Côtes, was neither a result of sun diagrams nor ecological determinants. If the development of secondary streets had taken the region’s ecology into account, the streets may have been oriented in a way that took full advantage of potential solar gains. This consideration may have altered the urban form and configured the city for a more ecological future. In the case of the urban grid there was not a co-evolution between people and ecology, but instead the built environment co-evolved with cultural inclinations and assumptions. Perhaps the city was expanding at too rapidly a rate and efficiency regarding movement took priority over efficiency regarding energy. If the growth process had been more gradual, there may have been more attention paid to passive design versus traffic patterns.

5.3.5 Building Type

As outlined in the previous chapter, there have been several building “species” in Montreal. The initial residential building type was a result of the available building materials (see 5.3.2) and cultural inclinations. Building Type One is a single detached family dwelling reflective of the residual farmhouse structures in the region.
These rural vernacular buildings had an appropriately pitched roof for snow loads; however, rooms were consistently distributed breadth wise which meant urban dwellings were distributed along the street. As indicated, Building Type One has factors that coincide with human ecology as well as non-human ecology, but also exhibits some variations influenced by rural typologies and European filtrate.

The second building typology that was introduced to Montreal is the rowhouse. Clusters of rowhouse developments are located throughout the city, but are especially concentrated in Le Plateau District. After the Great Fire of 1852, city officials had to rapidly construct housing for the masses of displaced citizens. As mentioned in Chapter Four, the rowhouse quickly became the vernacular residential architecture of the city due to its cost efficiency and dense urban structure. In fact, the rowhouse was the most common housing type at the turn of the century. Due to the rapid industrialization of Le Plateau-Mont-Royal coupled with the tragedy of the Great Fire, a dense residential structure was necessary to provide housing for a growing workforce.

Although there are several variations of the Montreal rowhouse, the rowhouse is predominantly distinguished by exterior building materials, width, depth, and floor plan. Because of the rowhouse’s flexible nature, the typology could accommodate inhabitants of low, middle or high income brackets. Furthermore, although the term rowhouse suggests a residential building, several of the commercial spaces in Le Plateau are also modeled after the “rowhouse” typology. Section 4.5 provides a generalized description of a common variant of the rowhouse which will be considered as representative of all rowhouses in the region. Rowhouses are characterized by deep narrow footprints and exhibit a shoulder-to-shoulder condition. Today, most infill sites in Le Plateau are indicative of the rowhouse typology. The numerous, deep, narrow sites illustrate the widespread popularity of this building model.

The third typology of building of Montreal and Le Plateau region is the high-rise building. The longstanding, universal height limitation in Montreal could be a result of a cultural value being assigned to an ecological entity. Although it is the city commission, not ecological sensitivity, which prohibits buildings from surpassing the
height of Mount Royal, building height in this case is still indirectly affected by ecological determinants. The geographically predetermined the height of the mountain and thus the image of the mountain dominates the skyline of the city and highlights the importance of non-human ecology in an urban context. Most of the city’s skyscrapers are located in the central business district; very few have been constructed in Le Plateau. It was not until the middle of the twentieth century that mid and high-rise buildings were introduced to Le Plateau.

According to Jean-Claude Marsan, the typical family structure was gradually changing during this period of Montreal’s history.\(^{106}\) The high-rise building is a clear departure from the traditional model of Victorian dwelling and may be attributed to a transforming the typical family unit. As more and more people remained single and independent for longer, there was a higher demand for smaller, more individualized apartments. On the other hand, these demands were also met to some degree by landlords modifying the Victorian row house to accommodate additional tenants by subdividing each unit.

The initial two building typologies had adapted to the non-human ecology of the region through the specific use of local building materials. Type Two emerged due to an ecological catastrophe, but was also able to accommodate the growing population. The resulting building forms have been directly influenced by human ecology, whether it be human ecology from a European country and adapted to the conditions of Montreal, or directly reflective of the ecology of Montreal. The third typology does not respond to ecology in the same way as the first two. For example, through technological advancement, high-rise construction in Le Plateau is characterized by imported materials and different methods of construction. Because there is so little high-rise construction in Le Plateau, it is fair to say that it was not a typology which thrived in the region. Recalled from Chapter Four, only 15% of the residential buildings in Le Plateau have more than 11 dwelling units (71% of residential buildings accommodate three units or fewer).\(^{107}\) The high-rise typology


neither reacts to ecological determinants nor meets the need of the district’s residents (a fact proven by its dwindling numbers in Le Plateau).

5.3.6 Vegetation

The state of and changes in the vegetation cover of Montreal are also introduced in the timeline. As the built infrastructure (or “built environment”) of Montreal expanded into outlying farmlands, city planners permitted the installation of necessary infrastructure. Greenspace became a central part of this infrastructure, recognized as having several advantages clearly stated by Frederick Olmstead. Parks have the potential to improve one’s health, combat urban vice and social degerations and advance the cause of civilization, i.e. democracy. In 1881, Mount Royal Park, designed by Frederick Olmstead, is inaugurated as a protected park region in the center of the city. The purposeful, inclusion of urban parks represents the human ecology aspect of vegetation. In 1881 as the “central park” of Montreal neared completion, 23.5% of the province of Quebec was urbanized. By 1921, 51.8% of the province lived within the city limits.

Unfortunately, as the population of Montreal increased, the number of parks deceased. The means in which the urban grid was developing did not allow for adherence to the natural topography of the region. Because Montreal became industrialized and expanded so quickly, there were many lost opportunities when it came to greenspace, the urban “grid generated monotony and suppressed areas which may have been more advantageous as greenspace.” During this explosive time in Montreal’s development, there was a marked loss of public space, most notably greenspace which influenced the ecology and biodiversity of the region.

In summary, the preservation and design of greenspace was of higher priority in Montreal during gradual periods of expansion and development. This mentality reflects aspects of both human ecology and non-human ecology. As the population

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110 Ibid. p. 174.
111 Ibid. p. 288.
of the city increased, the demand for public space was not as high as the demand for housing and jobs. Therefore, the built environment of this time exhibits more large scale structures and fewer parks. Today, Montreal is a dense urban environment with a major greenspace in the center, known as Mt. Royal, and an additional 2,100 greenspaces scattered throughout the remainder of the city. Even though many public squares and gardens were demolished during the early 1900s, Montreal is still a city with a considerable amount of greenspace. Currently, vegetation covers 6,500 hectares of Montreal which is roughly 13%.\textsuperscript{112}

5.3.7 Density

On a similar note, the influx of immigrants during the first half of the 20\textsuperscript{th} century drastically altered the urban form of Montreal. As parks and public squares were converted into dwellings or industry, the populations of Montreal became more and more concentrated. The human ecology axis demonstrates that more and more people were moving into the city and settling in an already dense urban environment. The trend toward expansion and industry had serious effects on the non-human ecology of the region. Farms were absorbed into the city and, as stated, gardens were converted into additional housing, the resulting built structure.

5.3.8 Traffic

Several new planning strategies attempted to organize the population as well as alleviate the mounting traffic problems. In May of 1941, the Montreal City Planning Commission was formed in order to develop a master plan that would improve the city while simultaneously controlling settlement patterns and other related activities.\textsuperscript{113} According to Jean Marson, the 1944 master plan blue print lacks regional perspective. He adds that the solutions put forth to regulate land use and traffic patterns similarly offer little relief to the rapidly changing city. It wasn’t until the


“Horizon 2000” plan proposed in 1967 that an approach was sufficiently flexible and convincing.\textsuperscript{114}

**Transportation Alternatives**

In addition to the transportation alternatives already in place, Montreal has recently enacted a bicycling program being tested in Le Plateau region. The Beckvert program was initially introduced to the city at the metro stop within Le Plateau region. Since 49\% of Plateau residents do not own a vehicle and prefer to travel by bicycle or on foot,\textsuperscript{115} this location maximizes exposure to the public as well as appeals to a significant population of local residents.

This brief summary of traffic alleviation strategies represents the human-ecology aspect of traffic. A high concentration of vehicles is recognized as compromising the quality of human life in part by compromising the quality of non-human ecology in the region. The installation of public transport systems, such as the subway (metro) affects the non-human ecology and human ecology of the region. The excavation of earth for the system is detrimental to the natural subterranean systems of local ecology. Human society justifies such damage by assuming that it is outweighed by the advantages of mass transportation (less pollution, more efficient use of natural resources, etc).

**5.4 Conclusions from the Diagram**

Several factors exhibited in the timeline contribute to co-evolution between people and ecology. The points of interaction were determined by examining design parameters relevant to cities in the context of Montreal. There are clear intersections between the timeline axes when it comes to Access to Water, Building Materials, Orientation, Building Type, Vegetation, Density and Traffic. The extent of overlap and dependence between the timelines varies depending on predetermined cultural influences, worldwide trends in building as well as time itself.


It seems that during periods of rapid growth and intensification, Montreal experienced different kinds of interaction than during the settlement period. If one looks at the overall timeline, there are fewer events toward the beginning and more linkages between the events. This implies that the early phases of building or human ecology were more deeply rooted in non-human ecology. In other words, human ecology and the built environment were essentially dependant on non-human ecology. This conclusion supports the concept of ecological determinants. As Montreal industrialized, non-human ecology was less of a catalyst and instead experienced change as a consequence of human-ecology.

To elaborate, as Montreal became a solidly established settlement and was able to turn its attention toward industrial expansion, i.e. money replaced survival. The built environment was no longer determined by the non-human ecology of the region, but instead was determined by population surges. This tendency toward mass development may have been due to a very high demand for housing, as an example, and therefore less consideration was given to greenspace. All of the design parameters eventually experienced this reverse trend, although the building materials did not change until Building Type Three in the 1960s. Nevertheless, both manners of parallel evolution can be categorized as a co-evolution between a biological system and cultural system with specific emphasis on ecological understanding.

The sole design parameter which did not entirely experience significant interaction between axes was the Urban Grid. In this case, the built environment was somewhat informed by the orientation of Cotes to the river, but was also significantly informed as a result of foreign, cultural influences. This could have been due to several factors. By the time secondary streets are positioned in a city, the city has almost certainly moved away from the “settlement phase” mentioned in the previous paragraph. Therefore, the urban grid is rarely influenced at all by non-human ecology. Secondly, being that Montreal was a relatively new city compared to its European counterparts, there was a new system or urban organization. The development of young industrialized cities resulted in very different urban forms than the urban organization left over from feudal societies where the layout of streets was
more ad hoc. In Montreal, streets were planned in order to facilitate efficient movement through the city.

Another interesting phenomenon demonstrated by the co-evolutionary diagram is the order in which the design parameters appeared. The order suggests what eco-determinants and development phases were important. The order also indicates when these specific factors became important. For example, events relating to the Access to Water parameter were exhibited at the outset of the timeline. This may suggest that water is the most essential resource when establishing settlement. Secondly, after the location of Montreal was chosen, attention seemed to turn toward building Materials. Subsequently the Orientation, Urban Grids and Building Type models are developed.

As mentioned before, between Orientation and Urban Grid, there appears to be an transfer of power between human-ecology and non-human ecology. In Montreal, this signified the transference from an important trading settlement to an expanding industrialized society. Building Type appears after the Urban Grid because it requires a given amount of time to establish a clear, persisting vernacular. It was not until the late 1700s that this type of urban dwelling, the rowhouse, was prevalent enough to label it as a typical building model.

The Great Fire appears in the timeline during a period of rapid industrialization and population growth. This event triggered the second building type which quickly became the emblematic building type of Montreal. Building Type Two filled a significant niche in the urban development in Montreal and thus endured for centuries. This series of events is representative of fundamental evolutionary theory. During the period just before the fire there may have been several genres of each Building Type One and Two. This is termed “variation” within a group. A natural disaster obliterated the more common Building Type One which was more susceptible to fire because it was characterized by wood construction. This could be explained according to evolutionary theory as “natural selection.” Natural selection describes a selection process which wiped out a weaker variant or in this case building model. It is important to note that there was still a housing niche in that a vast amount of people were now demanding replacement housing. The second
building type was able to fill this niche and was functional both physically and culturally. The fact that Building Type Two has lasted for over a century embodies the evolutionary concept of “retention.”

The next urban design parameter which appears in the timeline is Vegetation. Vegetation is introduced at this point because the rapidly expanding city was invading the green spaces of Montreal. The demand for housing was obviously much higher than the demand for outdoor public space. Fortunately, the city had foresight enough and responded to the absorption of many gardens and farms by establishing Mount Royal Park. As the amount of Vegetation in Montreal diminished, the Density of the city intensified. Although there were small fluctuations in density earlier in the timeline, this industrial era of Montreal marked a major change in urban density. Of course, as Density increased, Traffic congested the urban core of Montreal. It was not until after Montreal’s age of industrialization that city commissions were able to turn their attention to urban congestion. Traffic was addressed through several long-term transportation plans and, although not a completely resolved, major improvements were made.

Another significant mutation related to population growth prompted the final Building Type of Montreal. As stated in previous sections, there was a noted change in family structure in the early to mid-1900s. There was a new demand and thus a new niche to fill. Family units were reduced to single people or couples who needed much less space than a traditional Victorian family unit. Mid-rise and High-rise buildings attempted to fill this niche but this building type also competed with the adaptation of Building Type two. The rowhouse adapted by dividing into smaller living units. These smaller apartments appealed to the same user as the high-rise building type but retained the familiar charm of the Montreal vernacular. Building Type Three, containing many vertically space apartments, has not be obliterated, yet struggles to compete with the rowhouse.

The co-evolutionary timeline is used in this research inquiry as a tool to explore the question, “how does urban development parallel the evolution of human ecology and non-human ecology in the region of Montreal?” Firstly, the co-evolutionary timeline analysis of Montreal demonstrates that, in this particular city, the built environment is
a physical manifestation of the interaction between ecology and people’s interpretations of ecology. The urban forms of Montreal can be traced to people’s overall understanding and material application of their surrounding ecological resources. In some cases, the physical structures are a direct result of human manipulation of non-human ecology. In other cases, the development of the urban form has disregarded non-human ecology, yet has a clear impact upon it. Secondly, the tracing of the sustainable design parameters has suggested a sequential process and structural organization to that of urban development. The physical manifestations of the interaction between people and place coupled with the derived urban process will inform a set of urban strategies for infill development in Montreal.

The process of urban evolution results in various forms which may or may not contribute to a sustainable urban form. The term “sustainability” in this paper is identified with Yosef Jabareen’s assertion that a sustainable city reduces its energy dependency and “enable[s] built environments to function in a more constructive way than at present.” The order in which the various design considerations emerge in the timeline has several implications to the extent of sustainability in the City of Montreal. For example, the parameters which first appear earlier in the timeline, such as local building materials or access to water, are dependent on the non-human ecology of the region. This outward dependence promotes more sustainable building forms because there are less resulting intrinsic energies embedded in the material or resource, assuming the material is transported from local deposits. Intrinsic energy is loosely defined in this study as the embodied energy of a material or process. In other words, it is the amount of energy required in order to manufacture and distribute a service or product. The design parameters which emerge partway through the evolutionary Timeline of Montreal, such as Building Type 2, illustrate a more convoluted dependence on the region’s ecology. The rowhouse is a result of factors related to ecological economics; the rowhouse typology persisted as an economical alternative because of its use of local materials, its dense, modular structure and its efficient means of construction.

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The table below is organized according to the given parameters and presents a general and simplified overview of the results from the co-evolutionary study. This table suggests what was influencing each axis of development at the time and during what era this shaping was taking place.

### Conclusions from Montreal

Interpreted from co-evolutionary analysis

<table>
<thead>
<tr>
<th>Settlement Period</th>
<th>+</th>
<th>Industrialization Period</th>
<th>+</th>
<th>Post Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-human ecology</td>
<td>• Non-human ecology</td>
<td>• Non-human ecology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vital resources</td>
<td>sellable resources</td>
<td>useful resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Human Ecology</td>
<td>• Human Ecology</td>
<td>• Human Ecology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>survival</td>
<td>economics</td>
<td>futures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>food production</td>
<td></td>
<td>comfort/health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Built environment</td>
<td>• Built environment</td>
<td>• Built environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ecological determinants</td>
<td>mass production</td>
<td>technology/innovation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Conclusions from Montreal: Evolutionary Table depicting influence of 3 axes

The table proposes that non-human ecology initially provided vital resources required for survival. During the industrialization period, these ecological resources transitioned into commodities which indicate an economical advantage rather than a need. At present, resources comprised of non-human ecology are somewhat useful but non-essential according to the timeline analysis. The previous focus on local resources has diminished with technological advances and there is a reduced awareness of ecological determinants with the introduction of artificial lighting and ventilation strategies.

A similar pattern is exhibited through the evolution of human ecology. During the city’s settlement, Montrealers’ relationship with their environment was primarily that of dependence. Inhabitants closely followed and interpreted ecological trends in order to support agricultural systems, in effect to subsist. As agricultural means
proved to support existing populations and produce a surplus yield, Montreal grew. People began to understand how to commodify local resources in order to earn profit. The fur trade and food production led Montreal into a major industrialization period, based around shipping and manufacturing. The industrialization model evolved into the present mentality. It can be argued that during a post-industrial period, people relate to their environment with regards to comfort, “It is too hot/cold today” or “Let’s get some fresh air and walk in the park.” Whether for health or recreation, there is a deep disconnect between urban inhabitants and what is left of a city’s non-human ecology. People are beginning to recognize that there are emerging issues with regards to “the environment” but there is still a feeling of disjointedness between people and their surrounding ecology.

Lastly, the evolution of architecture or the built environment is interpreted in the table. This evolution is highly evocative of the previous two discussions. The early built environments of Montreal reflect the region’s ecological determinants. In short, there is a very close relationship between people, their shelter and their surrounding environment. The built structures display an element of insight on the part of people. In order to survive in the conditions of Montreal, certain materials were used; buildings were constructed using specific methods and in some cases built with particular attention to wind direction or solar orientation (although this was not designated as “passive design” at the time). As the population of Montreal expanded, more housing was built according to a different set of criteria. Economy and efficiency became priorities to accommodate the massive influx of immigrants. Today, these criteria remain embedded in the field of building, but also considered are the additional criteria of controls or technology. Present day buildings in Montreal have the means to control aspects of the interior environment by blockading the outside which causes a further rift between people and surrounding non-human ecosystems.

As shown in the timeline and in Table 3, architecture provides a sort of litmus test for how people are recognizing and responding to their environment. The evolution of the built environment thus far suggests a key to mutualistic co-evolution. The question remains to what will the next era of Table 3 depict? Designers should reincorporate deeply rooted ecological determinants into architectural solutions in
order to inform a 4\textsuperscript{th} and 5\textsuperscript{th} column in Table 3 (this expanded table will be revealed in Chapter Seven: Conclusions). For now, one can only speculate to the relationship between the three axes in a future period of development; however, passive design for architecture, and specifically urban infill, will facilitate a fourth era of human ecology in Montreal, one of mutualistic co-evolution.

Tracing each sustainable design parameter throughout the timeline is a technique that was used in order to confirm specific aspects of co-evolution in Montreal. In other words, the design considerations provide convenient occurrences of overlap which can be explored to further mutualistic co-evolution. Although the sustainable design parameters are meant to lead to a more sustainable city, it is important to recognize the extent of, or lack thereof, sustainable practices in place today. The remaining sections of this thesis will interpret the results from the Co-evolutionary Diagram analysis in order to determine what urban design parameters can be further promoted by advancing people understands of ecology (human ecology) and suggest how these adaptations can lead to a more mutualistic co-evolution between people and place.
6.1 Guiding Principles for the Site-by-Site Design Approach

The remainder of this section will propose a set of guidelines which responds to the previous analyses. The following guidelines are presented as one possible answer to the question “how can insight from eco-determinants and the co-evolutionary timeline be used to develop strategies for infill development in Montreal?” In this context, the term infill specifically includes the vacant lots resulting from the deconstruction of the unsustainable Building Type 3 (high-rise), but also the spaces resulting from the devastation of rowhouses due to fires, flooding, or structural issues. There are also various brown fields in Le Plateau of which it is unclear how the infill site transpired.

It is important to note that the following strategy represents a single interpretation of the information presented in the previous chapters. This information can and should be interpreted in various ways depending on the designer’s intentions and the individual city. To reiterate, the guidelines below are outlined to demonstrate how the timeline analysis may be interpreted. They are not the only guidelines which would enhance the sustainability of Montreal, but are a single set of potential strategies derived from this particular exploration. Before the guidelines are presented, an ensuing section will discuss the intended usages emerging from the guiding principles. The guide is meant to initiate a process of urban transformation.
6.2 A Process for Infill Development

The guidelines are focused on infill development because a bottom-up approach is a strategy which most feasibly promotes and maintains a steady rate of urban transformation. Although the rate of transformation will be gradual, even slow, the deliberate nature of widely distributed, small-scale changes allows for a flexible evolution of the city. The term “bottom-up” is meant to convey a development approach that is piece-meal or begins at a small scale and through the development of many small components, transforms the city on a large scale. The reverse approach would be top-down master planning urban development which eliminates the aspect of evolution and experimentation.

It is important and necessary to incorporate an evolutionary aspect to the application of the proposed guidelines. Not only is evolution a central idea to this research inquiry, but Chapter Five asserts that a gradual co-evolution is the conventional process of urban growth in cities. It would be counterintuitive to discuss the co-evolution of a city at length, and then simply propose an all encompassing, top-down master plan to facilitate authentic sustainability. Instead, recommended guidelines and timeline analyses can be presented and circulated among many designers who will then reinterpret and apply the design strategies to widespread infill sites throughout Le Plateau and potentially the city. A specific, pre-determined procedure for the intended bottom-up approach is not justified in this case because the development of infill should remain flexible and evolve as the region’s human ecology evolves.

An interesting consequence of many small-scale interventions is that each designer may have a different perception or understanding of the guidelines. This is very relevant and significant aspect of this proposal. Differing and evolving perceptions of design parameters reintroduce a previous concept of this investigation that of the human reaction to ecology factors into the discussion of human ecology. In other words, these strategies are a record of human ecology and different interpretations of them can potentially further advance the state of human ecology. As particular applications of the proposed guidelines emerge as major contributors to overall
urban sustainment, new or innovated building types will emerge. Although the rowhouse is considered the vernacular urban model of Montreal, it is far from being unconditionally ecologically non-invasive or beneficial.

Time is a reoccurring theme within this research and must be addressed in relation to the application of the guidelines. Given that the people and ecology of Montreal have been co-evolving for several centuries, it is only reasonable to assume a comprehensive, urban transformation will take several more centuries if not longer. As more and more infill is designed in order to assist ecological development, the shaping of human ecology will also be revolutionized. In summary, the guidelines will generate increasingly mutualistic co-evolution through further processes of architectural and social evolution. In many ways, the bottom-up approach suggested through this Chapter is an alternative Master Plan or Urban Planning device. Infill development itself is a device of urban planning and is a legitimate means to reform the urban form.

6.3 Guidelines for Infill Development in Montreal

This section demonstrates how eco-determinants and the co-evolutionary analysis can be applied in developing sustainable, urban infill. The guidelines presented will firstly propose design strategies for infill development and eventually create a more sustainable urban form for Montreal. The guidelines will also adopt a similar structure to the design considerations presented in the timeline analysis. In other words, guidelines will be categorized according to and presented in the order which the design parameters appear in the timeline. Although this may appear to suggest the complete re-building of a city, the guidelines intend to promote a re-structuring or re-ordering of building design in the city. As infill sites become available for re-development, the guidelines aid designers in re-considering the relationship between people and ecology.
Developing an Organization for the Guidelines

As the analysis began with the sustainable design parameters, they will be reintroduced as a tool to determine appropriate guidelines for the city. The now familiar design parameters have been used to generate the table below (Table 4); this table divides them into the three major periods of urban growth in Montreal. Each parameter is assigned a category based on the conclusions from the co-evolutionary analysis.

### Design Parameters for Urban Sustainability

<table>
<thead>
<tr>
<th>Settlement Period</th>
<th>Industrialization Period</th>
<th>Post Industrial / Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to Water</td>
<td>Urban Grid</td>
<td>Density</td>
</tr>
<tr>
<td>Building Materials</td>
<td>Building Type One</td>
<td>Traffic</td>
</tr>
<tr>
<td>Orientation</td>
<td>Building Type Two</td>
<td>Building Type Three</td>
</tr>
<tr>
<td></td>
<td>Vegetation</td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. The chronological emergence of Design Parameters for Urban Sustainability

The table presented above demonstrates that currently, the need to design based on access to water, building materials and orientation has diminished greatly due to innovation. The latter two will be a major focus of the forthcoming guidelines. The analysis has illustrated that the main urban parameters which are affecting design today are density, traffic and building type, especially the high-rise. It is necessary to reiterate at this point that these design parameters do not imply sustainability; they simply must be considered to further urban sustainment. Although density, traffic and building type are having a great effect on current trends, the trend is not necessarily directed towards a more harmonic relationship between people and ecology. These guidelines will be used to lead designers to adapt their practices and
to reincorporate some of the parameters which have been discarded during the settlement and industrialization period. The guidelines will be proposed as a list of considerations directly responding to the contents of the above table. The guidelines will be limited to the scale of a block and a single infill lot in order to emphasize the “bottom-up” approach.

Guidelines for Infill Development

Firstly, several factors that reflect the appropriate scale of an infill will be evaluated in the context of the region under scrutiny. The following factors have been derived from Jabareen’s list (Section 2.5) and include those which will initially impact the city on a small scale: built form, street canyon, vegetation and bodies of water, and traffic. Eventually, adaptations and ecological innovations regarding these factors will have an extensive, sweeping impact in Montreal. The design factors will be addressed in the order which they appeared in the timeline. At the scale of infill development, it may seem that several of the factors are not applicable, such as access to water, urban grid, density and traffic. In fact, the urban grid and density are effectively consequences of the interaction between many small scale units, such as infill sites. Although these factors are not directly affected by small scale modifications, the summation of many altered infill sites will affect more substantial aspects of urban sustainability such as the urban grid, density and traffic patterns. These factors will be briefly mentioned in the infill discussion and reintroduced in a concluding section regarding the resulting urban guidelines.

Eventually the assemblage of many small scale changes will impact the city on a large scale. The large-scale implications will be interwoven into this thesis as a final query. The overall outcome is that this strategy will be unknown until cities begin to adopt a long-term, co-evolutionary mentality toward creating sustainable cities. The complete proposal represents a new philosophy, one which begins to restore the fundamental interaction and interrelationship between humans and ecological systems.
Access to Water

The first design parameter that materializes in the timeline is “access to water.” It has been established that the site of Montreal was chosen due to its easy access to water. Being that Montreal is static and located on an island; design guidelines regarding access to water on a large scale are somewhat irrelevant. The fact is that Montreal will remain along the shores of the St. Lawrence River. This proximity to water affords the city many contemporary advantages, such as an alternative energy source. The river also offers an alternative mode of transportation as well as a means for regulating urban temperatures. The river facilitates an evaporative cooling process; however water as a regulator could possibly be applied in areas which do not border the river, such as Le Plateau. The introduction of water pools or urban circulation within the city could be beneficial on the scale of infill. There are existing man-made canals which were constructed during the industrialization period, but may prove to be beneficial with regards to temperature regulation and recreation.

Recommended Guideline:

• Small scale, water installations in infill sites could serve to reduce heat island effects in the summer and provide additional buffer zones for vegetation which was reduced during industrialization (see page 23, Jabareen).

Building Materials

As mentioned in Chapter Four, the Island of Montreal is rich in materials necessary for building structure. The large deposits of clay, stone and timber continue to be applied to buildings within Montreal but there is a growing trend of product usage imported from other areas. According to the Groupe d’intervention urbaine de Montréal, approximately five percent of the buildings in Le Plateau were constructed between 1970 and 1982.\footnote{Groupe d’intervention urbaine de Montréal. Patrimoine résidentiel du Grand Plateau Mont-Royal. Montreal: Le Group, 1984. p. 23.} The group goes on to state that approximately five percent of the buildings in Le Plateau are constructed of materials other than stone or brick such as aluminum or concrete.\footnote{Ibid. p. 35.} This correlation suggests that most of the newer buildings in Montreal are not

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\footnote{Ibid. p. 35.}
constructed of materials found locally which illustrates the divergent evolution in the present day. In order to promote mutualistic co-evolution in Montreal, designers should begin to specify materials found on the island once again. If it is no longer feasible to obtain material directly on the island, materials should be shipped in from surrounding regions of Québec to reduce intrinsic energies.

As mentioned, this argument is being made with concentration on the scale of infill development. In order for there to be a vacant or infill lot in a largely established city such as Montreal, a building first must come down. The recovered materials from deconstructed or demolished buildings should be re-used in infill construction. These materials can be recovered in order to prevent resource depletion on the island of Montreal.

Recommended Guidelines:

- Use materials native to the island or the province
  - Wood, stone, clay
- Re-Use materials from surrounding deconstructed infill sites
- Limit the importation of “exotic” materials to reduce compounding intrinsic energy.

**Orientation**

The major axes of the city were predetermined by the land divisions into Côtes. This division is defined by practicality, economy and equality. In order to change the orientation of the city, one can alter the orientation of the streets, or the orientation of the buildings. Both of these options seem impractical; instead, the eco-determinants may suggest modifications to building facades to facilitate energy reductions. According to Montreal’s eco-determinants the built form should react to conditions in both warm and cold seasons. It was mentioned that Montreal is cold in the winter and the wind blows toward the southwest. Thus, the built form acts as a buffer to the wind in the winter; however, buildings will block air flow in the summer as well.

Depending on location, buildings could be oriented south for maximum passive solar gains and also this will partially buffer winds while allowing urban ventilation in the summer. To reiterate the data collected on the eco-determinants of sun and wind, the following diagrams are presented below.

Figure 16 shows the average wind speeds and directions in Montreal between 2001 and 2004.120

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Figure 16 shows there are essentially two basic directions for the prevailing winds in Montreal. The winds predominantly blow from the south-west or west (40% of the time), but occasionally blow out of the north-north-east (17% of the time). Generally, the city and Le Plateau region experience winds between .62 mph and 6.21 mph (46% of the time). The wind directions and orientation of the city have implications regarding passive ventilation guidelines. In order to evaluate this aspect of sustainable urban form, a single block of the city will be used to illustrate wind patterns. A smaller scale is useful to determine relevant guidelines for infill development. Figure 18 shows series of buildings in Le Plateau and the street’s relationship to the prevailing winds. As shown, the prevailing wind direction is almost directly perpendicular to the primary city blocks.

![Block Diagram showing prevailing wind directions.](image)

As mentioned in Chapters Four and Five, the orientation of the city was primarily determined by the riverfront. This diagram reveals that the orientation of the city may serve additional purposes. If the frigid winters of Montreal included daily 6 mph winds, the long block also serves to protect the main streets of the city. Even if on the odd day, the wind blew from the north-east bringing cooler arctic air, the dense
urban structure is orientated to impede major wind gusts from reaching a main commercial thoroughfare such as Avenue du Parc. This structure is shown to be effective in the cold season, but somewhat less functional in the warmer seasons. Ideally, cross ventilation would be used to ventilate the individual buildings along the blocks, many of which are not air conditioned. Because of the narrow alleyways between building clusters, which run parallel to the primary streets, cool air intake for buildings on the north eastern side is limited. Although 17% of the time, the wind blows from the northeast there are multiple obstructions in the form of additional blocks, this is also an issue for the opposing buildings on the south west side. Moreover, the orientation of the city interferes with ideal daylighting conditions. The solar diagram below represents the annual daylight hours in Montreal.

Figure 19. Right: Plateau Highlighted in yellow. Above: Sun Diagram for Plateau Area.
The lighting conditions of Le Plateau in the winter are characterized by very short days of low sun angles (Montreal’s angle of declination is 45° 30’). The circumstances for the building clusters on the north-east side of the alleyway also face daylighting challenges. In an area of Le Plateau with slightly more generous alleyway space (than Figure 18), daylight reaches only a minimal number of the southwest facades before and after twelve noon. Depending on the heights of the surrounding buildings, long shadows hinder the few hours of accessible daylight.

The solution for the ventilation-daylight issue comes in the form of appropriate glazing (for direct solar gain in winter and daylighting to minimize need for electrical lighting fixtures) and adequate solar shading (in summer). Most of the buildings in the urban sectors of Montreal reflect the rowhouse convention in which the structure’s greater dimension runs perpendicular to the road. Depending on what sort of road borders the greater dimension of a corner lot, some corner rowhouses are prevented from having glazing due to the building code requirement of a “step back”. This is problematic for the above light and wind intentions.

Figure 20. Daylight modelling of a portion of Christophe Street in Le Plateau.
This condition is shown above (Figure 21). The two rowhouses bordering the alleyway, or secondary street, are prevented from having glazing unless they adhere to the mandatory step back. Having a step back and glazing means losing interior square footage. Regardless of the intent of the required “step back,” this limitation translates to sacrificing natural light for square footage. Possible solutions to this issue either alter the layout of the corner rowhouse (Figure 22) or propose to disregard the step back (which is seen in several areas of Le Plateau, see Figure 23). The first figure illustrates an alternative orientation for the corner rowhouse. The overall height and aesthetic is similar to the traditional rowhouse, but the building turns the corner and therefore can glaze both sides without compromising the typology.
Subtle changes such as these can slowly increase the solar gains for residents in the winter and also increase cross ventilation efficiency in the warmer weather.

Recommended Guidelines:

- All glazing should have operable closures, such as blinds and be “openable” for ventilation purposes. Fenestration should be aligned to promote cress-ventilation where possible.
- Buildings should be no taller than 4 stories to minimize obstruction of light (see Figure 20 and timeline analysis)
- Rowhouses or buildings on corner lots should turn the corner to take advantage of glazing opportunities for additional daylighting and natural ventilation

**Urban Grid**

As discussed in the orientation section above, the urban grid of Montreal is solidly established so current design for infill has generally disregarded optimal orientation and conformed to the standard position of city blocks. As seen in the image below (Figure 24), Montreal’s streets are at an angle to the ideal east-west directionality, an orientation which would permit a higher percentage of south facing surface area.
The solution to the established orientation is challenging and may involve adapting conventional urban forms in order to promote sustainability.

Although it may have been more ecologically advantageous for the urban grid to follow the natural topography of the region, Montreal was organized around rigid, perpendicular city blocks. For the purposes of this infill-scale proposal, the urban grid will remain intact. Instead of proposing concentric circles following the topography of the region, the guidelines will adhere to Jabareen’s discussions on compactness and diversity. At the scale of an infill site or a city block, compactness refers to “urban contiguity (and connectivity), which suggests that future urban development should take place adjacent to existing urban structures.” Jabareen maintains that for any new development to be sustainable, it should be incorporated into the existing urban form. This affects the overall urban grid in that the grid remains a dense and cohesive form although the program or typology varies

over time. A possible exception to this notion is the installation of public parks. Although parks could be viewed as breaks in the urban fabric, they should be perceived as integrated components contributing to the overall ecology of a city (see Vegetation). Another way to keep the city compact and contiguous is to question the extent of secondary and tertiary streets. Street space breaks up a dense urban form and should be reconsidered in regards to a sustainable city (See Traffic). Ecologically, the removal of secondary or tertiary streets would have several advantages. The removal of unessential streets would free up vast amount of impermeable surfaces which can be replaced by functional structures or vegetation. The removal of extraneous streetscape could facilitate denser development and the materialization of street canyons which are shown to be beneficial in the warmer months (depending on the orientation of the canyon, see Orientation).

Recommended Guidelines:

- New development should be adjacent to existing structures (i.e. infill)
- Public parks should be included as vital components to the urban grid
- Reduce the amount of secondary or tertiary streets in favor of spaces or right-of-way that are beneficial to the public and maintain public rights-of-way
- Create Street Canyons
  - Street canyons are another option to shade streets in summer and buffer winds in winter. [This condition is rare in contemporary cities because streets are wider to accommodate double lanes of cars].
- Buildings should be low to mid rise to avoid wind tunnels and also counteract the summer heat islands mentioned in a previous section.
- The urban form should be dense yet variable.

Jabareen also asserts that the urban grid should contribute to the area’s diversity; urban planning should “blend different combinations of housing types in the form of neighborhoods, rather than superblocks, suburbs, or projects.”\(^{122}\) At the scale of infill, this implies that there may be breaks in the rigid urban grid to create distinctive, functional urban spaces. City blocks should be compact, clusters of various

typologies which will promote more autonomous neighborhoods. To break down the scale of the city block or urban grid, the next section will discuss Building Type.

**Building Type**

Much of Le Plateau is representative of the previous suggestions regarding compactness and diversity. There are four neighborhoods within Le Plateau region: Milton Parc, St Louis, Mercier and Mile End (Figure 25). Within each of these compact neighborhoods there is a mix of residential typologies, commercial sectors and recreational facilities (See Figure 15, p. 65). The guidelines for this section will apply to all four neighborhoods and reflect the ecological determinants analyzed in the timeline.

![Sectors d'analyse](image)

Figure 25. Neighborhoods of Le Plateau

Jabareen asserts that diversity and increased density facilitate human contact in neighborhoods which “reinforce human presence by taming the ubiquitous
automobile.” This statement also reflects the need to reduce traffic problems demonstrated in the timeline. The rowhouse has proven to be a successful residential model for Le Plateau, as shown in the timeline. This paradigm can and should be innovated and adjusted to present-day requirements in the district. The figure below shows an early, traditional rowhouse on the left and an innovated rowhouse built soon after in the middle. The rowhouse on the very right depicts a contemporary interpretation of the Montreal rowhouse, an infill project.

![Figure 26. Innovations on the Montreal Rowhouse](image)

Recommended Guidelines:

- Each neighborhood should be a mixture of
  - income ranges
  - household structures
  - apartment sizes.
- Continue to innovate on and reinvent the popular “rowhouse” model of Montreal. The evolutionary timeline affirms the longevity of this housing model.
- Reduce the number of high-rise typologies in Montreal.

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The proposed guidelines are representative of how insight from the timeline can be used to develop insight into infill design. Diversity is also representative of evolutionary theory. As illustrated in the timeline, a diverse approach to development allows for natural selection for superior building models such as Building Type Two, the rowhouse. Diversity also reveals varieties that are not well adapted to the environment (ecological and demographical). Infill development is mainly characterized by building construction, but there is another option to improve a city. The following section discusses guidelines for vegetation as a response to vacant urban lots.

**Vegetation**

As infill sites become available for development, designers must consider the suggestions of the previous sections. Compactness, density and diversity are all very significant components of a sustainable city. Ecologically, there must also be a strong presence of green space or greening. As Montreal expanded beginning in the last half of the 19th century, farmlands were absorbed and parks were developed into much-needed housing. The ecological determinants of a region are highly dependent on past and present levels of biodiversity. Greening can mitigate the effects of pollution and help to regulate urban climates.

In Montreal, there is a tangible presence of vegetation and green spaces. Mount Royal holds a central place in its geography and there are many parks interspersed within the city. The primary roads of the city surround the mixed-use neighborhoods in Le Plateau, but the movement within each neighborhood is often by foot and public transportation. Green corridors could serve to connect the principal greenspaces and to create recreational space as well as regions for biodiversity regeneration. Public transportations routes and bike paths can run freely along ecological corridors in order to further reduce traffic congestion. Although the number of parks has increased since industrialization, green spaces should be further reintroduced back into the urban fabric which will contribute to its diversity.

Recommended Guidelines:

- Cultivate green corridors through infill development to connect principle green spaces
Changing the anthropocentric systems within the city to accommodate ecological networks will relieve the strain between the two sides. Flooding problems will be mitigated, congestion will be diminished, and it is likely that new methods of building will emerge which correspond to the introduction of this ecological and recreational component. The immediate presence of visual eco-determinants will generate a new philosophy and aid in modifying the cultural norms.

The Diagram below is a conceptualization of a possible green corridor in the South-East region of Le Plateau. Infill sites and alleyways are reprogrammed as green space to connection several parks and reintroduce permeable surfaces which would provide advantages for stormwater management.

Figure 27. Conceptual Diagram of Proposed Green Corridors
Connects the Parc des Veterans, Parc des Faubourgs, Parc des Pompiers, and Parc des Royaux in the South East corner of Le Plateau

**Density**

The region under investigation is characterized by low to mid-rise buildings, double lane roads, and a mix of residential and commercial zoning. A typical building site in this region depicts shoulder-to-shoulder construction, which means there is no buffer space between sites (firewalls are shared). Montreal is a highly dense city, with surprisingly little high-rise development. It can be argued that the numerical density
of Montreal is acceptable for a sustainable urban environment; however the distribution could be adjusted. Infill provides a vital opportunity either rezone the site for an alternate function (such as an ecological corridor) or instead, (wholly or partially) rebuild a structure with passive design intentions in mind.

Recommended Guidelines:

- Redistribute density
- Decrease density by using infill sites to produce ecological corridors
- Increase density by replace some secondary and tertiary streets with diverse developments

The guidelines presented above may appear contradictory at first glance but they are suggesting a redistribution of space. The density will not change overall, but may show small adjustments from block to block.

**Traffic**

The replacement of streets with greenspace or structure has serious implications for traffic congestion. Clearly, city commissions would think twice about removing street space, but Montreal has demonstrated a successful process for doing so. In the “McGill Ghetto”, a neighborhood along the western limits of Le Plateau, parking lanes were recently transformed into a bike lane. At the Mount Royal Metro station, there is a kiosk offering free bicycle rentals. These two precedents prove that the removal
of some streets space is a feasible option for improving the sustainability of the city. The images below depict the Bécyk Vert Program at Mount Royal Metro Stop.

![Figure 29. Bécyk Vert Program at Mount Royal Metro Stop](image)

As represented in the timeline, Le Plateau has served as the experimental setup for both of these modifications. Guidelines for this section simply would be to continue removing street space while providing viable alternatives.

Conclusions

As mentioned in the outset of this chapter, the timeline can be interpreted in several ways. The results from the timeline and eco-determinant analysis were interpreted here as an example in order to inform and generate a possible set of guidelines for infill development in Montreal. There are many other sustainable strategies which may apply to the city of Montreal or the District of Le Plateau Mont-Royal. The proposed set represents a single interpretation of a region’s history and ecological determinants to promote sustainable infill development. Infill is particularly useful to showcasing passive design strategies because it is characteristically in dense regions of development. Thus, innovative passive design concepts can reach many more people than a suburban, or rural detached context. More importantly these guidelines illustrate the deeply rooted connectivity between all sustainable design parameters. In other words, the overlapping nature of the guidelines for urban infill development indicates that the problem of urban sustainability must emerge from a comprehensive and multidimensional perspective.
Most importantly, the guidelines outlined in this Thesis are linked to a rigorous process for understanding context (past and present), to allow for an appropriate response to eco-determinants that can evolve as human and non-human factors change. The guiding principles and urban interventions outlined in Chapter Six are phases of a process. As these changes begin to take shape in the city of Montreal, there will be subtle adjustments made to the overall urban form. For example, the redistribution of density would not expand or contract the outer boundaries of Montreal, but may serve to regulate the concentrations of space and mass. Instead of large pockets of green space punctuated by dense clusters of building blocks, the green corridors create a uniform connection between major parks. If the amount of secondary streets is reduced, this may increase the land availability for additional greenspace or built space.

The design parameters and corresponding recommended guidelines are tightly interconnected and must be considered as a complete package. Although the timeline diagram distills each parameter to an individual time period, in reality the major phases of transformation continue to impact Montreal and inform other sustainable design factors. Assuming the suggested strategies are practiced, the future of Montreal could easily be the future of other cities around the world. The data collection and analysis was specific to a particular region of Canada and Montreal, but many of these design methodologies are applicable to several North American cities or cities across the Humid Continental Climate Region.

For now, this research must stress that all the recommended strategies have been customized for Montreal based on the evolution of this city’s human ecology and built form. The insight offered by the proposed process of urban planning based on co-evolution has a universal relevance and is not specific to Montreal. All infill development should be perceived as a “bottom-up” approach and is clearly stated in this research as a strategy for effective urban planning.
7.1 Anticipated Effects of Co-evolution

The data collected from the case study in Montreal has been analyzed with respect to a number of criteria: human ecology, non-human ecology, built environment and lastly that of time. The table that was present at the end of Chapter Five can now integrate the results from Chapter Six. The guiding principles offered in Chapter Six propose a method of urban transformation that is dependant on both time and the practice of ecological consideration. The site-by-site or bottom-up approach to urban planning has several implications for Montreal that may be applied to cities in general as well.

The following table is a combination of the “existing” evolution of co-evolutionary axes (found in Table 3 at the end of Chapter Five) and “future” evolution of co-evolutionary axes. This table (Table 5) is not specific to Montreal, but ventures to illuminate the state of the co-evolutionary axes across the planet. This table speculates to the future of the human-environment relationship in general. More importantly, it is optimistic about the prospect of survival and mutualistic co-evolution. If cities adopt a similar approach to urban infill development as presented in Chapter Six, the table offers a very viable outlook for future cities.
## Present and Future Directions of Co-evolutionary Axes

<table>
<thead>
<tr>
<th>Present</th>
<th>Post Industrial</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SETTLEMENT</strong></td>
<td><strong>INDUSTRIALIZATION</strong></td>
<td><strong>ECOLOGY</strong></td>
</tr>
<tr>
<td>Non-Human ecology</td>
<td>Non-Human ecology</td>
<td>Non-Human ecology</td>
</tr>
<tr>
<td>Vital resources</td>
<td>Vital resources</td>
<td>Vital resources</td>
</tr>
<tr>
<td>Human Ecology</td>
<td>Human Ecology</td>
<td>Human Ecology</td>
</tr>
<tr>
<td>Health</td>
<td>Survival</td>
<td>Mutualistic co-evolution</td>
</tr>
<tr>
<td>Built environment</td>
<td>Built environment</td>
<td>Built environment</td>
</tr>
<tr>
<td>Modern</td>
<td>Ecological determinants</td>
<td>Non-invasive</td>
</tr>
<tr>
<td><strong>PRESENT</strong></td>
<td><strong>POST INDUSTRIAL</strong></td>
<td><strong>FUTURE</strong></td>
</tr>
<tr>
<td>Non-Human ecology</td>
<td>Human Ecology</td>
<td>Human Ecology</td>
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<td>Vital resources</td>
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<tr>
<td>Human Ecology</td>
<td>Economics</td>
<td>Common health</td>
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<tr>
<td>Built environment</td>
<td>Technology</td>
<td>Innovation</td>
</tr>
<tr>
<td>Reduced invasiveness</td>
<td>Mass production</td>
<td></td>
</tr>
</tbody>
</table>

Table 5
The “Present” column depicts the direction in which humankind is currently moving. There is increasingly more information permeating popular culture and the media about the depletion of renewable resources. Many societies are beginning to perceive non-human ecology as vital to the sustenance of the planet beyond the fate of humankind. Ecosystems are adaptable but are linked in ways people will never be able to understand. Today, many people are adopting a lifestyle that attempts a neutral coexistence with the surrounding ecology. An absolutely non-invasive lifestyle is still not feasible due to lingering architectural practices and social values, but progress is being made. Many countries are advancing their approaches toward the built environment with respect to invasiveness. Much of the “green” movement is representative of this trend.

The “Future” column in the table has an undefined timeline but a clear objective. In this column, non-human ecology and human ecology are no longer distinctive elements in co-evolution. The two axes will be merged in order to fully demonstrate a mutualistic co-evolution. The Built Environment will be non-invasive in the sense it will balance and adapt to the needs and changes of the surrounding ecology. The future column is meant to generate contemplation regarding a mutualistic co-evolution. It does not suggest a definite result, but a probable result based on expanding human ecology and the guiding principles for urban development.

### 7.2 Passive Urban Design Strategies for Montreal

The purpose of this study was to answer the question of how urban development parallels the evolution between human ecology and non-human ecology in Montreal. The timeline and various discussions in this thesis summarize the evidence of this parallel relationship. It also professes what architecture can potentially reveal about the human-environment dynamic. It reveals that many people are becoming less aware of their surrounding non-human ecosystems and in some cases have replaced them with man-made devices. The trends in the architecture of Montreal also exhibit some models which provide insight into the current state of co-evolution.
between people and place. By analyzing the city according to set design parameters (Section 2.5), several guidelines emerged which respond to final research question, how can this insight be used to transition to an existence of mutualistic co-evolution?

As the discussion in Chapter Five has illustrated, all of these design parameters are tightly interrelated. The built form overlaps orientation, vegetation and even traffic. This condition is similar to the dynamic between eco-systems. Many eco-systems are loosely correlated and experience overlap, which is why urban planners and architectural designers should carefully consider ecological determinants. Also, the ecological determinants and urban development of a region can be interpreted in several ways. The results from the timeline analysis were interpreted in order to inform and generate the set of guidelines for infill development in Montreal. These guidelines presented in Chapter Six are a beginning of a process. These proposals suggest how to apply the concept of ecological determinants with the assumption that many more will emerge as people renew their perceptions of non-human ecology. Eco-determinants and co-evolutionary exploration will generate a new philosophy and modify the cultural norms of human ecology. This process of retrospective analysis coupled with recording current ecological determinants is in itself a fundamental passive design strategy for urban planning.

7.3 Application of this Method to Other Cities

This method of developing passive design guidelines yielded a set of results for Montreal. The theory of ecological determinants and co-evolution can and should be applied to other cities following the process that was applied in this case study. The practice of analyzing the growth of a city and its major architectural building types offers insight into future building techniques and ecological efforts. The anticipated results presented in Table 5 apply to Montreal, but potentially to any other city that adopts this method of urban development. Many cities worldwide are presently leading cities like Montreal in the advancement of passive design techniques and sustainable urban development. If other cities adopted this process and subsequently shared their results, this could have a huge impact on the momentum of change in cities, such as Montreal. Sharing data and conclusions could rapidly increase the pace of evolution in Table 5.
7.4 Ecological Economics, Co-evolution and the Future

The proposed approach to urban philosophy is not new, yet it must be effectively revived. Globally, humankind is moving to a more anthropocentric existence which will inevitably lead to self-organized extinction. Ecological determinants intend to initiate a movement toward a more biocentric perspective which includes the human species as a component of global ecology. In order to co-exist with our surroundings, human and non-human networks must co-evolve.

The site specific meta-analysis which has been presented intends to uncover how architecture and urban form represent the evolutionary dynamic between people and place. Further inquiries must be conducted to determine how humans, specifically human culture, can adapt to facilitate mutually advantageous co-evolution. Cultural changes are a major force behind the shifting of urban forms and may play a big part in the struggle to sustain favorable conditions on the planet. Also, more in depth analyses of Architecture, Ecology and Economics will play a key role in defining human culture, as illustrated in Chapter Three.

To reiterate an argument introduced through co-evolutionary theory, this research does not attempt to romanticize “living with nature” as some sort of a purely harmonious existence. This discourse represents the need to relieve the tension between human and non-human systems. Jacob Bronowski’s series “The Ascent of Man” suggests that “one of man’s defining characteristics is that rather than adapting to the environment, he changes it.” Perhaps instead of changing the environment, we may attempt to partially reinvent ourselves and how we go about manipulating our surrounding ecology. Human adaptation may be moving away from an emphasis on survival, but there are substantiated arguments which propose we must maintain

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our understanding of context. A change in architectural philosophy can shift the process of co-evolution and restore a symbiotic relationship between people and planet.

By relieving some of the tension between human infrastructure and non-human systems, both the building occupant and ecological networks will benefit. This process is advantageous to humans because it will result in less overall maintenance of manufactured mechanisms which struggle against eco-systems; similarly, ecological networks will be replenished and biodiversity will thrive in this urban environment. Overall, there is significant contemporary theory regarding sustainable urban forms, however the changes in philosophy needed to initiate action have been sluggish. Urban planners and developers do not look at the “true cost” of their design decisions. If there continues to be significant tension between human infrastructure and the non-human infrastructure, both sides face a grim and challenging future. On the other hand, if mutualistic co-evolution is adopted as a way-of-life, this cultural change will be a major force behind shifting urban forms and play a positive role in the struggle to sustain favorable conditions in the planet.
References


29. Shaver’s Creek Environmental Center, Stone Valley Recreation Center, PA.


APPENDIX

Koppen System of Classification

Humid Continental Climatic Region highlighted in Blue
<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Description</th>
<th>Criteria</th>
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</thead>
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<tr>
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<td></td>
<td>F</td>
<td>- Frost</td>
<td>( T_{\text{hot}} \leq 0 )</td>
</tr>
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Koppen System of Classification: Humid Continental Climatic Region: Climate Descriptions
Map of Montreal from 1865
Map of Montreal from 1846
Wind rose
Eastern Montreal
2001-2004

Wind Rose for Montreal