Using Boolean truth tables to evaluate property acquisition for private forest investment: A case study in Montreal's rural-urban fringe

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ABSTRACT

Using Boolean truth tables to evaluate property acquisition for private forest investment: A case study in Montreal's rural-urban fringe

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This thesis offers a decision-making framework to select the best land near a city for private investment in multiple-use urban forestry. More specifically, this thesis postulates that privately financed forest restoration for multiple-use urban forestry can add green infrastructure to ecologically impoverished landscapes in a city's rural-urban fringe.

A strategic framework simplifies complex decision-making in land selection problems, and here a multi-criteria Boolean algebraic truth table is used to create the framework. A truth table cell is set to either true (YES) or false (NO) by checking the land plot conditions against each land selection criteria. The selection criteria included biophysical factors, zoning types, and threat of takings. The approach is illustrated with a bottomland area along the St. Jacques River, in the City of La Prairie, in Montreal's rural-urban fringe.

A major conclusion is that a Boolean decision-making framework may be useful to evaluate property acquisition before making private forest investments. Of the property selection criteria examined, stability of property rights may be the most important to consider first. While private investment in forest restoration for future uses could add new forests in urban areas, several important regulatory takings cases in the past 20 years in the Montreal region may discourage investors from making long-term investments. To encourage reforestation of underused degraded land, policy makers should consider regulatory reform, permitting multiple-use urban forestry near the city, and that this be combined with land tenure reform, thus encouraging private investment in green infrastructure.

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CHAPTER 1: INTRODUCTION

1.1 Research Objective

This thesis postulates that privately financed forest restoration for multiple-use urban forestry can add green infrastructure to ecologically impoverished landscapes in a city's rural-urban fringe. More specifically, this thesis offers a decision-making framework to select the best land near a city for private investment in multiple-use urban forestry.

This thesis was motivated by Walmsley (2006) who suggested that visionary initiatives are still needed to add green infrastructure to a city's rural-urban fringe. Green infrastructure is defined in this thesis as forest restoration for future multiple-use objectives. These multiple-use objectives may include, for example: (1) biodiversity conservation and scientific research; (2) commercial forestry and recreation; and (3) residential development.

This thesis is organized into 4 chapters. Chapter 1 introduces the thesis research objectives and problem context. Chapter 2 critically reviews key concepts from several academic fields of study that apply to this thesis. Chapter 3 presents a case study that introduces a Boolean truth table decision-making framework to select land for forest restoration on private property in the rural-urban fringe. Chapter 4 summarizes the key findings and the conclusion.

1.2 Problem Context

Choosing suitable land parcels for private forest investment in the rural-urban fringe is a complex, multidisciplinary problem requiring an understanding of key land use concepts. These concepts will be used in this section to develop a suitable set of criteria to make land selection decisions. These key land use concepts include, the forest transition and the urbanization process, anticommons property, land use regulation and land use change. To begin to understand the problem context, I will then review some of the contemporary solutions to land use problems, notably, forest conservation on private property. Finally, the benefits of privately-owned, multiple-use urban forests are presented followed by a synopsis of the framework advanced in this thesis.

I use anticommons property theory to explore how future urban forest uses may be constrained by increasing land use regulation. An anticommons property regime sometimes emerges when multiple stakeholders hold veto power over land uses. That is, the anticommons property regime may discourage forest restoration on private property for future mixed uses.

1.2.1 Forest Transitions and Anticommons Property

Two decades of international research makes more clear how different property ownership types, land tenure stability and growing national wealth have impacted the world's forest regions (Deacon 1994, DeSoto 2000, Evans and Kelley 2007, Kauppi et al. 2006, Mather et al. 1998, Mather and Needle 1998, Parisi et al. 2005, Rudel et al. 2005). Forest transition research, for instance, is leading to a greater understanding of the key social and economic drivers of land use change. In particular, forest transition research has explored differences in land cover changes in countries with mostly public property, mostly private property or a more balanced mix of public and private property (Siry et al. 2005).

New forests develop naturally all the time within urbanized areas, so the real issue becomes whether these new forests can be managed from the start to achieve certain goals. Industrialized northeastern cities like New York, Boston and Montreal have been expanding for centuries from their original town centres into forest areas as well as into agricultural areas that were formerly forested. As this urbanization process continues, expanding suburban communities in the rural-urban fringe are losing most of their forest cover, while the urban core is gaining the most new forest (MacDonald and Rudel 2005).

Globally, forest cover in almost all developed countries has been expanding for at least a century. As the intensification of agriculture permits abandonment of the more marginal arable land, forests naturally regenerate on uncultivated land (Kauppi et al. 2006, Mather et al. 1998, Mather and Needle 1998, Rudel et al. 2005). However, Domon et al. (2007) have suggested that the forest cover additions are frequently degraded or ecologically impoverished and should be viewed as forests in need of reconstruction rather than forests that need to be protected. Indeed, ecologically impoverished and degraded urban land and rural land has been recognized as one of the fastest growing land classes (Hall 2000, Ode and Fry 2006).

Connecticut can serve as an example of the forest transition in the northern hardwood forest of North America (Kauppi et al. 2006). Forest cover there expanded from 29% in 1860 to 60% in 2002; much of this occurred in formerly agricultural areas that were abandoned. Schmitt et al., (2006) described Connecticut as a 'suburban forest' and 'one-great ecosystem' something 'semi-domesticated'. In southern Quebec, to take another example, in mixed-farming communities in Brome County in the Eastern Townships (Booth 1966, 1971, Pochopien 1952, Quebec 2000), forest cover expanded from 39% in the 1930's to almost 80% by 1999, especially on the Green Mountain ridge along the Sutton Mountain range bordering Vermont.

The primary drivers of positive forest transitions in the developing world are: (1) growing national wealth; (2) migration to urban areas; and (3) agricultural intensification. Although recent studies have shown that urbanization is occurring on the most productive and fertile land with the highest potential for indigenous forest growth (Imhoff et al. 2004, Xu et al. 2007), appropriate market-based strategies to reconstruct forests on private property in urbanizing areas have not been fully realized (Sayer et al. 2004). Nonetheless, there is growing interest in many countries in developing new forests in urban areas based on principles of landscape ecology and urban forestry (Anthon et al. 2005, Colding 2007, Miyawaki 1998, Ruiz-Jaen and Aide 2006).

On private property left idle, after industrial or (more rarely), residential abandonment, forest almost invariably regenerates. For example, in one of the most densely populated areas in the United States, net gains in forest cover have occurred between 1986 and 1995 within the urban cores of Jersey City and Newark (both in New Jersey), where 84 and 26 ha, respectively, of forests have regenerated (MacDonald and Rudel 2005). More generally, the modest additions of urban forest within the city core are offset by larger losses of forest toward the city's edge (i.e., rural-urban fringe). It is expected that this pattern will continue in many older North American cities, as industrial land use is abandoned on private property near the urban core and land is left idle or converted for mixed private and public uses.

Beyond more mainstream notions of private property and public property is the concept of anticommons property (Heller 1998) which has challenged commonly held beliefs regarding the regulation of private property in both developed and developing countries. Generally, anticommons property arises in cases when there are an indeterminate number of external stakeholders with, essentially, veto power over private property land uses. The proponents of the anticommons property concept suggest that it can lead to complete non-usage of land for any beneficial purpose, including forest restoration, due to the discretionary power of third parties to deny pursuant private property uses to the land title holder.

1.2.2 Land Use Regulation

Regulations frequently attempt to resolve the conflict between the benefits of new urban development for private uses on the one hand and the public's desire for more forested land reserves and public parks on the other hand (Tzoulas et al. 2007, Walmsley 2006). Both central place theory and highest and best use theory suggest conversion to the highest economic value (MacDonald and Rudel 2005). However, changing societal values are changing how the public views forests. For example, forests are now valued more for their ecological, aesthetic and recreation potential rather than for their forestry potential (Berry 1976, Daniel 2001, Fry and Sarlov-Herlin 1997).

The current "green renaissance" in North America that increasingly values urban forest for aesthetics and recreation originated in European town forestry traditions (Daniel 2001, Konijnendijk et al. 2006, Nielsen and Jensen 2007, Parsons and Daniel 2002, Sullivan and Lovell 2006). In Europe, near major cities, working forests for timber production and recreational forests for fish and game and for nature appreciation have been a part of the urban fabric for generations – they are part of an evolving cultural landscape (Johann 2007, Jongman et al. 2004, Naveh 1998). In North America, where urban sprawl is often the focus of public attention and new land use regulation (Bengston et al. 2004, Cheshire and Sheppard 2004, Symons 1988, Zhang 2000), a new sense of environmental aesthetics is broadening the concept of highest and best land use (Jim 2004, MacDonald and Rudel 2005, Schmitt and Suffling 2006). Consequently, environmental groups are combating land use change by lobbying government officials to stop any development of vacant land near the city's edge (Mertig et al. 2001, Rome 1998).

1.2.3 Land Use Change

A mosaic of private forests (much of that representing abandoned farms) and agricultural land encircle cities throughout North America, Europe and Pacific Asia. Located on the leading edge of land transformation activity, the rural-urban fringe is the area where the city overtakes the surrounding country (Starchenko 2005). Inevitably, land is converted to urban uses to support the growth and expansion of transportation corridors, industrial parks, utilities and public infrastructure, public parks and recreation areas, residential developments, commercial strip malls, 'lifestyle centers' (Adams 2005) and various types of commercial enterprises (Duryea and Vince 2005, Johnston 2006). As a result, land use change is often the focus of heated debate on whether public or private interests should lead land use decision-making in a market-oriented economy.

Researchers have explored the problems associated with land use change and urban expansion for generations (Bruegmann et al. 2001, Carrion-Flores and Irwin 2004, Radeloff et al. 2005). Resolving these problems through land use regulation or conversion of undeveloped land to permanent green reserves is often complicated by the relatively high property values prevailing near cities. Converting land to permanent green reserves distorts land markets around cities by increasing the price for other developable land, especially land parcels close to the green reserves. Indeed, housing and land values have consistently experienced the greatest price inflation in areas where urban growth containment strategies have been imposed (Dawkins and Nelson 2002, Millward 2006). In addition, property prices near permanent green spaces and conservation areas have been found, in at least one study, to be worth three times the value of an equivalent amount of developable land elsewhere (Geoghegan 2002). Green reserves also attract new development because of the demand to live near recreational open spaces with natural forest amenities. Consequently, young families often choose to live further away from the city, in rural areas, where housing is more affordable and where there is more green space (Carrion-Flores and Irwin 2004, Marcouiller 2005, Newburn and Berck 2006). Thus, paradoxically, urban sprawl can occur faster in areas with urban growth containment strategies.

1.2.4 Possible Solutions to Land Use Change Problems

It has been said that government regulation and private property rights are two possible solutions to the majority of land use change problems (Wey et al. 2005). Migue et al. (1993) suggested that in the absence of complete private property rights, governments must increase subsidies and land use restrictions for public interests. However, this often increases political rivalry by rent-seekers competing for scarce public funds. Migue (1993) found that increased land use subsidies exacerbates land resource inefficiencies thereby increasing land use change problems. A greater reliance on market institutions and private incentives to encourage technological innovation and economic development may solve many land use change problems by improving land use efficiency and natural resource management (Cerin 2006, Porter 1991). Private investment in the development of green infrastructure in the rural-urban fringe, well in advance of urban development, can overcome some of the limitations of restrictive land use regulation (Mark 1999).

Contemporary land use regulations often require developers to set-aside green spaces and to protect existing forested areas. Consequently, developers are motivated to invest in forest restoration (Mark 1999, Moons et al. 2007). Private investment in forest restoration, reforestation and afforestation is becoming feasible as a result of recent advances, technological innovation and socio-economic developments (Jin and Sader 2006). Recent large-scale forest landscape restoration projects in the United States and in Western Europe have greatly augmented the existing practice of forest restoration (Stanturf 2004).

One of the goals of private investment in forest restoration may be to fund new 'green infrastructure' (Walmsley 2006). Green infrastructure is the development of planned forest landscapes in anticipation of future land uses. The future land use potential, in say 40 years, of a reconstructed native forest adds more multiple land use options than if the land was left in a degraded or ecologically impoverished state. Increasing the diversity of native forest trees by reforestation of the more productive sites can achieve a planned ecological restoration goal in less time than if the land was left idle (i.e. left to become a species-poor assemblage dominated by invasive species). This is often the case in the urban-forest-agricultural land matrix near cities where native forest trees are usually absent or rare and thus cannot act as potential sources of seeds for the more "natural" regeneration (D'Orangeville et al. 2008). The impoverished forests of Mount Royal near downtown Montreal are a case in point; the woody plant diversity is quite low compared to similar sites (i.e. the other Monteregian Hills) and it is rapidly being invaded by invasives such *Acer pseudo-platanus* (Norway maple). Furthermore, D'Orangeville et al. (2008) found that in early successional forests on former farmlands in southern Quebec, natural regeneration of native hardwoods was insufficient to produce high value forests, As Stanturf et al. (2001) concluded, the first step in forest restoration is reforestation with valuable native trees. Indeed, restoring forests with native trees can increase the multiple use options of degraded land in urban areas.

1.2.5 Multiple Use Urban Forests

Locating suitable properties in the rural-urban fringe for forest restoration development may provide many long term public and private benefits. For example, recreational green spaces will be created and maintained within the fringe. These new forest landscapes may be effective at precluding land use change to other more intensive uses and may ameliorate some of the negative aspects of urbanization. Restored forests along waterways, for example, provide important wildlife habitat, maintain and increase biodiversity, maintain water quality, and provide recreational and aesthetic natural areas for people to enjoy. The inclusion of living, working and recreation spaces within new forested landscapes in the rural-urban fringe, however, is perhaps the most beneficial aspect of forest restoration (Miller 2006, Miller and Hobbs 2002). Therefore, land use regulation that permits multiple uses, including both forest restoration and residential uses, may be important to consider before selecting land for private forest investments.

1.3 Synopsis

This thesis introduces a Boolean truth table decision-making framework to select the best land near a city for private investment in forest restoration for future multiple-use urban forestry. Contemporary approaches to forest restoration that largely rely on non-governmental organizations, subsidies, public agencies or land use regulations rarely succeed because of restoration techniques leading to low survival rates, inadequate funding, poor planning and project management, and poor quality tree planting stock (Mercer 2005, Stanturf et al. 2001). This thesis postulates that private investment in forest reconstruction for multiple-use urban forestry may be a pragmatic alternative for adding new native forests to ecologically impoverished landscapes on private property around a city.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter is a critical review of the relevant literature, with a focus on current practices, limitations, challenges and opportunities. Because of the complexity of forested ecosystems and as well as of the regulatory system, this literature review necessarily ranges widely over many interrelated fields of study, such as land transformation, urban forestry, forest ecology, forest management, and forest restoration and management. I begin with land transformation with an emphasis on phenomena at the edges of expanding cities.

2.1.1 Land Transformation in the Rural-Urban Fringe

Through a complex system of land regulations urban planners try to influence land transformation in the rural-urban fringe. This may include applying and modifying zoning for purposes such as public parks, conservation, agricultural, commercial, industrial and residential land use. Land use regulations in the rural-urban fringe impact local communities, businesses, farms, and forests, and can have a long term, incremental effect on important aesthetic features of the evolving cultural landscape (Conzen et al. 2001, Daniel 2001, Ewald 2001, Moreira et al. 2006, Naveh 1998, 2005, Parsons and Daniel 2002, Tyrvainen et al. 2003). Consequently, land transformation usually takes place in the rural urban fringe where vacant land is available and in areas where zoning modifications have been made.

2.1.2 Rural-Urban Fringe

The rural-urban fringe may be thought of as the area where the city expands into the countryside and displaces farms, fields and forests (Duryea and Vince 2005). A city's expansion into the rural-urban fringe is, especially when rapid and minimally planned, referred to as 'urban sprawl.' The implication is that the urban area is larger than it otherwise would be if there were higher density development (Peiser 1989). Urban sprawl is often considered a leading cause of deforestation although much of this displacement is of second growth, species poor forests on previously abandoned agricultural land (D'Orangeville et al. 2008). Economic growth and decline may also explain land use changes at the rural-urban fringe.

From a temporal-spatial perspective, the rural-urban fringe undergoes complex land use changes every few decades as a consequence of economic growth or decline. Viewed as a complex, adaptive system, the relentless reshaping of a city's edge is an essential attribute. Also, a city may be viewed as a man-made complex adaptive system that extends its reach and influence into the countryside, far beyond its borders, as it grows and adapts to emerging social, economic and environmental events.

Some of the earliest definitions of the term rural-urban fringe (Starchenko 2005); include, " ... the built up area outside the limits of the city," (1937: T. L. Smith, credited with having coined the term), " ... the areas of transition between well recognized urban land uses and the area devoted to agriculture," (1942: Wehrwein, considered to be the first formative author of the field) and "... fringes of pre-industrial and early industrial cities are easy to narrow and delimit as they constitute " ... 'tidemarks' around the edges of cities". Just as the city itself may be viewed as a complex, adaptive system, subject to continuous change, then the "rural-urban fringe" of a city can be expected to change too as the post-industrial city of the 20th century gives way to the post-information age city of the 21st century. Ultimately, however, the complex interplay among landowners, locals and government officials in response to historical events largely determine the form and function of forested open spaces in and around the city. This complex multi-stakeholder land transformation process is explored next.

2.2 Land Transformation

2.2.1 Stakeholders

Bryant (1995) developed a conceptual framework he termed the 'segment model' to examine the role played by local stakeholders as they attempt to influence land use changes in the rural-urban fringe. In particular, Bryant (1995) examined how land use regulation can be "distorted" by local interests calling for bans on any new residential construction on undeveloped private property. In particular, land use regulation becomes an arena of competition for the net benefits arising from undeveloped private property and from the financial benefits transferred to those owning residential or developable property next to newly protected green spaces. This reminds us that that there are both winners and losers in most land use decisions.

Bryant (1995) argues that there were essentially three scales of human influence in the rural-urban fringe: (1) a macro scale, including international and national produce markets, capital markets and international corporations; (2) a meso scale, including regional produce markets, capital markets and labour markets; and (3) a micro scale, including local labour markets, social networks, produce markets and political systems. Not surprisingly, Bryant (1995) found that local stakeholders who successfully organize can more effectively influence land use change to benefit their financial interests than can the majority of the population who remain more passive.

2.2.2 South Shore Montreal

An interesting example of interventionist "distortion" is the case of the Montreal suburb of St-Bruno, a 30 minute drive to the south of the city, where individual stakeholders and community groups sharing similar interests took an active role in transforming the rural-urban fringe (Bryant 1995). They approached the Quebec government when a residential development was about to be built on the slopes of a small mountain in the community. As a result, the government expropriated the mountain property and, instead of new homes being built, a public park was created. In turn, the local residents saw an increase in their property values as a direct result of the green spaces that were protected near their homes (Bryant 1995). While local community groups are increasingly more active in influencing land use change to protect local interests, city planners are, perhaps because of such citizen initiatives, also beginning to promote new urban designs to solve some of the negative aspects of urban growth and perhaps to pre-empt the activism of other groups.

2.3 Urban Forestry

2.3.1 General

Another approach to mitigating negative perceptions regarding urban expansion is the use of greenbelts around cities and 'new urbanism designs' (Brown et al. 2004). The strategic intent of green belts is to contain urban sprawl by protecting large areas of undeveloped land around cities. The greenbelt land removes developable land from the residential property market through policy intervention. This urban "containment" strategy has been described by at least one author as another form of growth regulation (Dawkins and Nelson 2002).

2.3.2 Urban Containment Strategy

Millward (2006) used a spatially explicit model to analyze the issues, plans and outcomes of different containment strategies of six cities in Japan, Britain and Canada. The containment strategies were characterized by differences in building density within the metropolitan area and outside the greenbelts in the rural areas. The urban containment strategies were characterized along a scale from the most restrictive regulation to the least restrictive regulation. Millward (2006) concluded that land market distortions created by the containment regulations redirected economic development to other areas outside of the restricted growth areas. The stronger the containment regulation, the greater the distortion to land markets, the higher the land prices and development densities, and consequently, the higher the prices for single family homes near the city (Millward 2006).

There are also international and intercultural differences to land use issues largely controlled by a nation's transition through different stages of economic development. Huston (2005) suggests that land use changes are driven by a nation's transition from an agricultural, industrial and finally to an information-driven economy. For example, a key difference among Japan, Britain and Canada are land development rights. In Britain and Japan, the state controls development rights, whereas in Canada development rights are controlled through municipal land use regulation (Millward 2006).

Another important cross-cultural difference between containment strategies is the time horizon. Both Japan and Britain have been characterized as employing 'town cramming' regimes which 'entrench high land values and high building densities' (Millward 2006). Millward (2006) suggested that Canadian planners employ unbounded, strategic, long-term time-frames as opposed to the tight bounded, shorter-term, tactical time frames seen elsewhere. Millward (2006) concluded that the ultimate goal of urban containment regulation were culturally-driven. In Britain, the policy is to preserve the aesthetic features of the cultural landscape while in Japan the policy is to preserve scarce agricultural land.

Containment strategies and other approaches to urban sprawl are often reflected in local land use zoning. However, each municipality (or county) and township has evolved a set of unique land use zoning regulations. Land use zoning regulations are a product of a region's development in relation to politics, culture, economy and natural resource endowments (Cheshire and Sheppard 2004, Sevenant and Antrop 2007, Vaillancourt and Monty 1985). Consequently, land use in most countries has become one of the 'most regulated of all possible human activities' (Ellickson 1973, HLR 1978).

The first land zoning regulations and nuisance bylaws emerged in the 19^{th} century at a time when free-roaming livestock, raw sewage and foul drinking water were common occurrences in settled areas, and led to periodic bouts of illness occasionally resulting in epidemics (Pincetl 2006, Tang et al. 2007). In response, farming and livestock rearing activities were prohibited in cities to prevent illness and to reduce the nuisances associated with live animals that were raised for local human consumption. In many cities today, farmland at the periphery of the city is often protected from land use change through agricultural land use regulation. In Quebec, for example, agricultural land has been protected from land use changes since 1978 (Vaillancourt and Monty 1985). The goal of agricultural land use regulation is to prevent changes to other land uses including commercial land uses or a return to commercial forestry use.

2.3.3 Urban Forestry and Green Infrastructure

Konijnendijk et al. (2006) conducted a comparative analysis of North American and

European urban forestry concepts and definitions. The authors found that urban forestry had a longer tradition in North America than in Europe, albeit one based merely on the tradition of managing shade trees. In Europe, urban forestry was largely built around the concept of 'town forestry' (Konijnendijk et al. 2006) with productive forests maintained at the edge of municipalities. This broader concept is very useful perhaps for understanding the North American conceptual difficulty in integrating forestry and forests in the urban fringe (Konijnendijk et al. 2006).

Green spaces were included as key design elements by early 19th century U.S. parkway designers. Walmsley (1995) reviewed the work of designers such as Cleveland, Eliot, Kessler, and the Olmsteds. These early designers planned parkway networks to connect cities to the country through an elaborate system of rivers and lakes, forests, parks and greenways. Walmsley (1995) recommended combining the various design approaches into an integrated approach that he called 'green infrastructure'.

Recently, Walmsley (2006) compared the concepts of 'green infrastructure planning,' 'smart conservation' and 'new urbanism.' Walmsley (2006) suggested that some aspects of the 19th century parkway design movement should be applied to the 'edge cities' on the rural-urban fringe in the form of green infrastructure.

Green infrastructure has been described by Walmsley (2006) as a system of parks, forests, rivers and lakes that is necessary for an urbanized society. In contrast to green spaces, that merely offer a "pleasant" contrast to pavement (e.g. lawns and parks for recreation), green infrastructure is viewed as essential for the quality of life in highly urbanized communities. Green infrastructure is emerging as an essential element of urban landscape design. Greenway vision plans have been developed for many urban centres around the world, although most of these remained in the early conceptual stage (Fabos 2004, Fabos and Ryan 2004, 2006). Green infrastructure requires the integration of planning, design and strategic decision-making because significant private investments must be made far in advance of development for mixed land uses. This concept is not new and is reflected in the landscape design movements of the past.

2.3.4 Forest Amenity Values

Many of the early American landscape design movements incorporating forests demonstrated how green infrastructure pays for itself over the long-term through premium prices paid for nearby properties. These more highly valued properties in turn provide increased tax revenue for public services.

The example of Riverside in Chicago presents an exceptional case study of a 19th century suburban development incorporating green infrastructure. Designed in 1868 by Fredrick Law Olmsted, the founder of American landscape architecture, Riverside has been recognized as one of the first planned suburban communities in the United States (Crow et al. 2006). Incorporating an urban forest as a keystone design feature, Olmsted's vision of 'refined sylvan beauty' was one of the first demonstrations of the long-term value of integrating green infrastructure in a suburban development (Crow et al. 2006).

Today, Olmsted's idealized vision of suburban residential development is reflected in the amenity values of Riverside homes compared to adjacent homes. In a recent study that contrasted Olmsted's Riverside development with the adjacent community of Berwyn, 75% of the responding property owners from Riverside planned to remain there 'as long as possible' compared to only 45% of respondents from Berwyn (Crow et al. 2006). In addition, the median Riverside home value in 2000 was almost twice the median Berwyn home value.

Mount Royal Park, near downtown Montreal, is another of Olmsted's visionary landscape projects that links the provision of green infrastructure to the contemporary concept of sustainable development. In a preliminary design proposal for Mount Royal Park, Olmsted hinted at his 'unpractical' (unconventional) landscape design philosophy with its emphasis on a long-term vision that incorporated 'some regard for your heirs' (Scheper 1989).

There are numerous other examples of the integration of forests and fields at the expanding city edge (Conzen et al. 2001, Moreira et al. 2006, Naveh 1998). Bruns et al. (1997) described how urbanized land and countryside had become 'interwoven' over the centuries into a single cultural landscape at the edges of German cities such as Potsdam, Ulm and Heilbronn. Other researchers have also provided examples of sustaining cultural landscapes within urbanized areas in Japan (Cheng and McBride 2006, Miyawaki 1998), Italy (Hall 2000, Marignani et al. 2007), Spain (Montiel Molina 2007), France (Poudevigne et al. 1997) and Australia (Abensperg-Traun et al. 2004, Alexandra and Riddington 2007, Banks and Brack 2003).

Given the choice, most people prefer to live in areas with forests because of the enhancement of the environmental aesthetics and the opportunities for outdoor recreation (Burley et al. 2001, Tyrvainen et al. 2006). The real capital value of forest amenities is reflected in the premium prices paid for nearby property (Kong et al. 2007, Tyrvainen et al. 2007, Tyrvainen and Miettinen 2000). Starting in the urban core and moving out into rural areas, the pattern remains the same; people are willing to pay a premium to live near forests (Lichtenberg et al. 2007). Manhattan apartments with scenic vistas of New York's Central Park, for example, are among the most highly priced living spaces in the world at $1,139 per square foot (Croghan 2007). In a study that examined property prices and urban forest proximity in Finland, properties were priced 5.9 percent lower for each kilometer further away from the nearest forest. Similarly, properties with a scenic view onto a forest were priced 4.9 percent higher than similar properties without a view (Tyrvainen and Miettinen 2000). This suggests that any new development in the rural-urban fringe seeking to maximize price should include scenic vistas, aesthetics and recreational forest amenities as keystone landscape design elements (Tyrvainen et al. 2006).

2.3.5 New Urban Forests

Tyrvainen et al. (2007) discussed how best to design new urban forest landscapes, drawing examples from major cities in northern Europe. Two methods for urban forest design and planning were suggested: (1) computer-based visualization methods; and (2) demonstration forests and landscape laboratories.

The development of new urban forests are long term strategies that require significant investments (Tyrvainen et al. 2007). Since long term plans and strategies are often difficult to grasp, Tyrvainen et al. (2007) suggested combining computer visualization and landscape laboratories to better inform people. At least two benefits of locating forest landscape laboratories within the rural-urban fringe were recognized: (1) demonstrating new silviculture treatments of young urban forests, and (2) as an educational resource (Tyrvainen et al. 2007).

Having examined some of the literature regarding new urban forests, the next section briefly introduces the challenges of applying Sustainable Forest Management (SFM), as defined by the Montreal Process, on private land in the rural-urban fringe. At least a few authors have discussed how land tenure issues may complicate the application of SFM on private land.

2.3.6 The Montreal Process and Private Land

Although the theoretical basis for Sustainable Forest Management (SFM) was established in the early 19th century with Normality Theory and Discounted Cash Flow Theory (von Gadow 2002), increasing consumer demand for non-timber forest products and services and other environmental amenities is challenging land managers with the problem of implementing SFM in practice. In short, the original theory developed by Faustmann was for a sustainable harvest of only one or a few selected tree species in perpetuity.

While there is some disagreement over what a multi-use SFM might require (Crook and Clapp 2002, Wang and Wilson 2007), most interpretations share the basic concept that SFM attempts to balance the current social, economic and environmental values with the longer-term goal of ensuring forest resources (i.e wood volume per area) will be available for future generations (Hickey 2007).

The Montreal Process established a working group that prescribed criteria and indicators for evaluating SFM (Reynolds et al. 2003). However, this approach created a great deal of confusion because, the critics argue, many of the criteria and indicators are immeasurable, costly or malleable (Gough et al. 2007, Hickey 2007).

Problems with SFM and the Montreal Process are especially acute on private land (Reynolds 2003). In particular, Reynolds (2003) suggested that 'framework criterion,' may be difficult to implement because of the complex linkage between land tenure arrangements (i.e., land use rights) and forest management practice. Tenure rights determine the owner's ability to plan, control and manage the forest for both timber and non-timber products and services. DeSoto (2000) has argued that stable land tenure, if adequately represented in property documents in a public land registry system, and enforced by law (Deacon 1994), is the key to economic development. DeSoto (2000), and many others (Barrows and Roth 1990, Feder and Feeny 1991, Parsons 1956, Russett 1964, Zhang and Pearse 1997), have recognized that stable property rights allow an owner to borrow money to acquire new tools and to buy other goods which are necessary to improve land productivity – including for sustainable forest management.

Implementation of SFM on private land and bequests are often intimately connected (Deacon 1994), (Cubbage et al. 2007, Hultkrantz 1992). An altruistic bequest motive has been found to be an important factor in promoting the long-term silviculture investments that are necessary for sustainable forest management (Hultkrantz 1992). Altruism of course also implies that the cost of implementing SFM will be borne by the present generation (Duku-Kaakyire and Nanang 2004).

Failing and Gregory (2003) provided a critical assessment of the issue of biodiversity indicators for developing forest management strategies. They suggested reducing the number of indicators in order to make better forest management decisions. The two main problems with using indicators to guide forest management decision-making is a lack of priority setting and the equally problematic lack of a clear way to determine how different management decisions will affect biodiversity objectives (Failing and Gregory 2003). They recommend that the selection of a forest management strategy must realistically consider the expected performance-based outcomes, and must also consider the trade-offs among the different objectives. Contemporary best management practice calls for setting priorities first and then identifying the resources, tools and performance measures needed to achieve these priorities rather than, as with the Montreal process, imagining that the same performance measures are called for globally. Given that the pragmatic goal of forest restoration projects is to achieve some desired end-state or future forest condition, how is this best achieved?

2.3.7 Forest Restoration

People have been restoring degraded forests to more desired states for at least the last few decades (Hall 2000). Scientific approaches to ecological restoration, however, have been criticized for ignoring the cultural landscape context (Antrop 2005, Moreira et al. 2006, Naveh 1998). Whereas the goal of ecological restoration may be to restore key ecological species in particular habitat types (Aronson et al. 2006, Parviainen and Frank 2003), forest restoration often attempts to integrate important aesthetic features of cultural landscapes with a desired species suite based on knowledge of regional forest history (Abensperg-Traun et al. 2004, Agnoletti 2000, Moreira et al. 2006, Yahner et al. 1995).

Given our incomplete knowledge of forest dynamics, Stanturf (2004) argues for a pragmatic approach to forest restoration. This may be a goal to restore as much of the known original forest structure and function as possible rather than some unknown but imagined pristine state. In addition, forest restoration should integrate important aesthetic features and artefacts of the local cultural landscape (Antrop 2005). Understanding a region's cultural landscape has been recognized as an important aspect in landscape ecology and forest restoration (Doman and Bouchard 1997, Gerald Domon 2007, Hall et al. 2002).

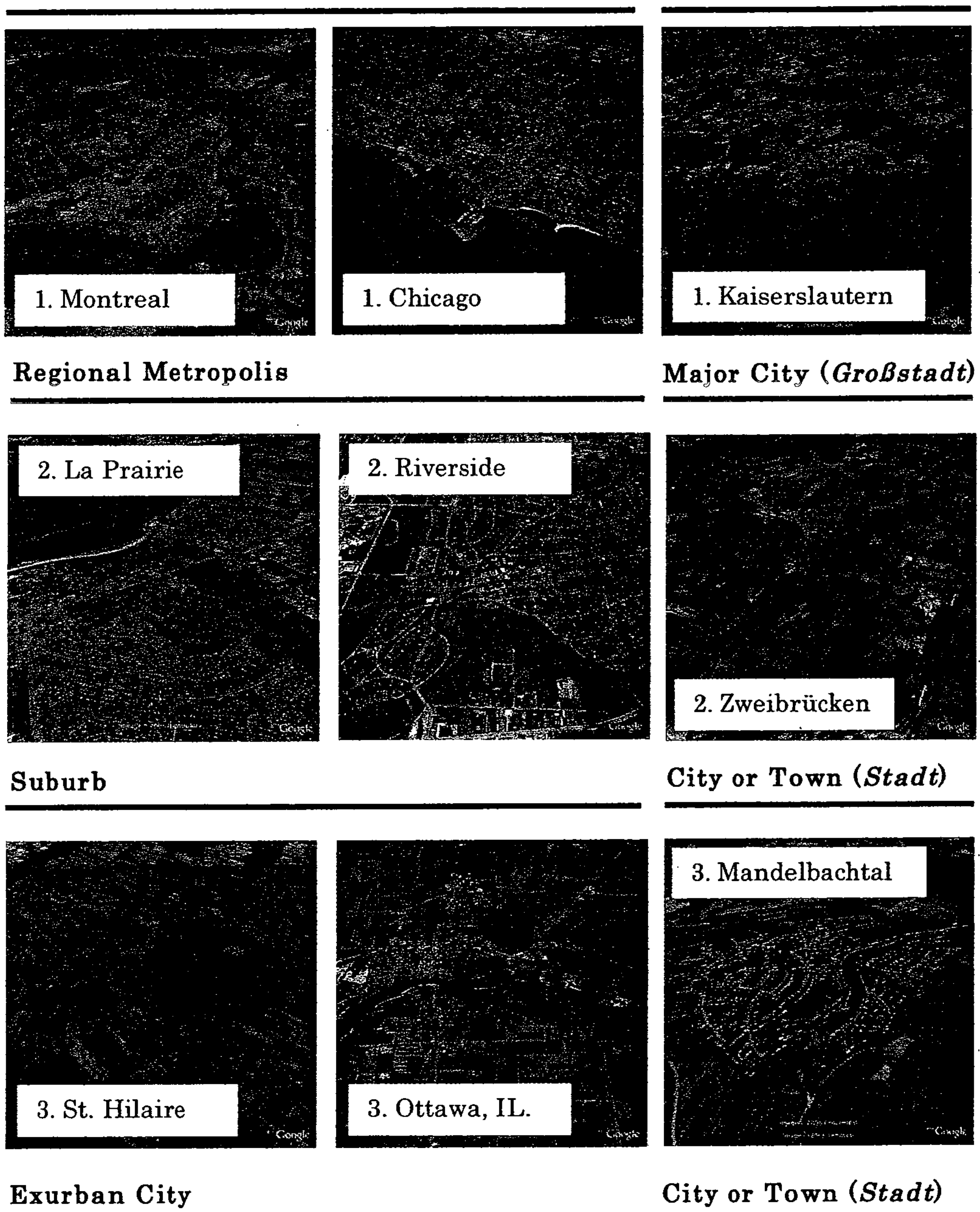
Differences in cultural landscapes are obvious in Figure 2-1 which shows the contrast between North American and German landscape forms. Post-industrial landscapes in North American are presented at 3 scales: (1) regional metropolis, (2) suburb and (3) exurban city. In the right hand column, landscapes in Germany are shown categorised as (1) Major City, (2) City or (3) Town. In many pre-industrial cities of the old world there is no distinction between City and Town (Holzner 1970). Urban areas, forests and agricultural areas are interwoven in the urban fabric in German landscapes because of master land use planning that promotes mixed land uses at the city edge (Bruns and Schmidt 1997). Whereas in North America, exclusionary land use zoning for urban, agriculture and forest land results in a distinct sprawling pattern of the urban landscapes.

2.3.8 Forest Restoration in Southern Quebec

Forest restoration in southern Quebec is complicated by agricultural land use policy (McCallum 1994, Poulin 1967, Savard and Bohman 2003). For example, agricultural land use legislation in Quebec regulates afforestation on farmland in designated agricultural production areas (Menard and Marceau 2007). Government investment for land irrigation in agricultural areas in the St. Lawrence lowland flood plains has created policy barriers to forestland improvement projects. For example, land use change from agricultural land to forestland requires both local landowner and government approval to justify previous irrigation subsidies on private property used for a commercial agriculture enterprise. Therefore, in Quebec, land use regulations must be considered first before selecting land for investments in long-term forest restoration.

Figure 2-1: Contrasts in Old and New World Cultural Landscapes

Source: GoogleEarth (images accessed February 16, 2008) Images not all to same scale.



2.3.9 Forest Restoration in the Rural-Urban Fringe

Current examples dealing specifically with private investment in forest restoration in the rural-urban fringe could not be found in the literature. There is, however, some literature on nature conservation in the rural-urban fringe, more on land use change in the fringe, and a great deal on protection of rural land uses in the fringe. Hobbs (2002) found that fewer than 6 percent of the papers in recent volumes of the journal Conservation Biology dealt explicitly with conservation work in urban, suburban and exurban areas, and pointed out that he could not find any research that explicitly dealt with the effect of human settlement in urban and exurban development in forested landscapes. Four years later, in 2006, with the publication of, "Forests at the Wildland-Urban Interface: Conservation and Management," a first attempt was made to explore the issues of human settlement on the forests at the rural-urban fringe (Duryea and Vince 2005).

It should be noted that urban ecologists are perhaps in conflict with conservation biologists who may view conservation near urban centres as redirecting priorities and funding away from the protection of biodiversity at a larger scale (Battisti and Gippoliti 2004). There may be grounds for this fear: Battisti et al. (2004) found at least one case where conservation plans in urban areas in Italy resulted in a redirection of limited conservation funds.

2.3.10 Forest Restoration Challenges

Lessons learned from current and ongoing restoration projects are important to consider when attempting forestland restoration in the rural-urban fringe. Stanturf et al. (2001) outlined 9 myths derived from the failure of the 1992 Wetlands Reserve Program in Mississippi (Table 2-1). For example, a widely held belief is that preservation is the only valid goal of ecological restoration.

Table 2-1: Myths in Bottomland Hardwood Forest Restoration

[Source: (Stanturf et al. 2001)]

Number	Myth
1	Afforestation is ***Not*** the Same as Restoration
2	Restoration is Easy – Anyone Can Do It
3	Desired Future Conditions Can be Specified
4	The Same Strategy is Appropriate to All Ownerships
5	Plantations Have No Wildlife Value
6	Understocked Stands are Sufficient
7	Preservation is the Only Valid Goal
8	Ecological and Economic Goals are Incompatible
9	Restoration Can Proceed Without Management

Stanturf et al. (2001) argued that forest restoration should be viewed as part of the continuum of sustainable forest management options rather than a discrete end state goal. Forests restored to a state of 'self-renewal' can be managed for sustained yield timber and for other forest values that provide economic incentives to the landowner. In the case of private landowners in the bottomland hardwood forests of the lower Mississippi Alluvial Valley, for example, Stanturf et al. (2001) suggested that land protection should not be the sole objective of forest restoration. Rather, private landowners who plant trees for high-value commercial hardwood lumber also make meaningful investments in forest restoration.

A related restoration myth, according to Stanturf et al (2001) is that ecological and economic goals are incompatible. For example, both timber production and conservation may be viewed as compatible goals since any economic return can offset restoration costs. The approach proposed by Stanturf et al. (2001) suggest that restoration goals will be more achievable if the economic objectives of landowners are included in the program goals. Stanturf et al. (2001) concluded that afforestation 'is a necessary and costly first step but not an easy task.'

2.3.11 Indigenous Planting Stock

The importance of selecting the appropriate genetic material has been highlighted since this influences restoration processes from forest establishment to tree harvesting (Kjaer et al. 2005, McKinney 2006, Steven G. Newmaster et al. 2006). Davis (2005) surveyed forest tree nurseries in the eastern United States and found that hardwood tree improvement is rarely practiced. For instance, only 6.8% of hardwood seedlings were found to be genetically improved stock. It was also found that for the most valuable hardwoods for veneer and lumber (e.g. in the northeast, sugar maple, black walnut, and black cherry), less than 20 percent of the planting stock was derived from improved seedlings. Survey respondents agreed that genetically improved planting stock was important for timber production and for ecological restoration and that integration of research into operational nursery production was recommended to improve the future potential of hardwood forest resources. It was also recommended that hardwood tree improvement programs should focus on restoring rare keystone species (Davis 2005). While the demand for rare keystone species and other valuable hardwoods may be currently limited to niche market segments like government forestry agencies, arboretums, botanical gardens and large property owners in the North American northeast, the diminishing quantity of valuable hardwood trees (D'Orangeville et al. 2008) used in the fine hardwood lumber industry can be expected to create new demand in the future (Davis 2005, IRS 1998). Investment for hardwood tree improvement programs are at present undertaken by entrepreneurial forest tree nurseries that cater to niche market segments, and use seeds obtained from healthy parents that have been marked as having good form, resistance to local pests, etc (Greenberg 2000, Healy et al. 1999, McKenney et al. 1999, McLachlan and Bazely 2003, Pakkad et al. 2003).

2.3.12 Paying for Forest Restoration

How to pay for the high cost of forest restoration has recently emerged as an issue. The literature is rather thin on ways to pay for forest restoration. Different countries have approached the issue of paying for restoration operations in different ways (O'Hara 2004).

Mandatory and voluntary actions are the most common approaches with key differences noted regarding the problem of who should pay (O'Hara 2004): the public or private land owners? O'Hara (2004) noted that creative policy and program approaches are still needed.

While some aspects of the ecological, social and economic values of forest restoration may be well understood, forest restoration is often framed as an ethical issue – creating conflict, confusion and myths over what are deemed to be socially acceptable goals (Gobster 2001, Kennedy et al. 2001). Nevertheless, it is generally recognized that different social and environmental histories, and different land tenure systems in different jurisdictional regions, require different management approaches to forest restoration (Abensperg-Traun et al. 2004, Holl and Smith 2007, Mark 1999, Moreira et al. 2006, Naveh 1998, Schmitt and Suffling 2006, Wong et al. 2007). Having examined how to pay for forest restoration in a broad sense, we now turn to the strengths and weaknesses of forest investments held by institutional investors as non-traditional real estate assets.

2.3.13 Strengths and Weaknesses

While the average retail investor may be unconvinced of the merits of holding real estate assets such as restored forestland and raw land for 40 years before a potential pay-off, the institutional investment manager holds long-term, non-traditional real estate assets, such as restored forestland, because of its known risk diversification benefits in a portfolio (Graeme and Hsu Wen 2006, Thomas 1997). Institutional investment managers manage pensions, trusts and endowments (e.g., Ontario Teacher's Pension Fund, the Canadian Pension Plan, etc.). Institutional investors are mandated by their governing boards to manage substantial portfolios of diversified assets (i.e., cash, stocks, bonds, real estate) and are often required to hold diversified real estate assets such as forestland, undeveloped (raw) land, and commercial properties. The Hancock Timber Resource Group is recognized as the first investment management firm to develop and manage non-traditional forest investment portfolios on behalf of institutional investors (Yale 2002). However, the types of non-traditional forest investments have now broadened to include land parcels for carbon-credit projects, green housing development projects, and land use mitigation banking.

There are many recognized strengths of forest investment assets that are well known to the institutional investor (Rogers 2001): (1) returns are highly correlated with inflation; (2) returns are negatively correlated to stock market returns providing a risk diversification benefit; and (3) investment in forests can improve the risk-return relationship of a portfolio when combined with other assets. Institutional investors may invest in forested land to reduce portfolio risk through asset diversification and because of the relatively high, risk-adjusted returns (Rogers 2001). The average annual investment returns for forest investments were 11.06 percent with a 6.64 standard deviation compared to the S&P 500 return of 15.15 percent with a standard deviation of 14.73 percent for the period 1981 to 1996 (Rogers 2001). The National Council of Real Estate Investment Fiduciaries (NCREIF) Timberland Property Index is the best available source of historical forest investment returns in the United States (HTRG 2003). The purchase of special risk insurance can also reduce investment losses associated with the unique attributes of a forest property. For example, Holecy et al. (2006) suggested a general model to calculate the cost of insurance premiums to protect against potential financial loss from forest destruction from a single event or from cumulative damaging agents. Therefore, appropriate risk assessment and risk management strategies must be adopted when making long-term land acquisition decisions for forest investments.

In the example of a forest investment found in Chapter 3, degraded land is acquired, the forest is restored over a period of up to 40 years, and then eventually sold for a low-impact green housing development and possibly for mitigation banking credits for conserved wetlands on the protected portions of a land parcel (Hallwood 2007). Given this long-term investment strategy that necessarily involves significant investment in land, labour and capital, risk assessment is an important step. While Borchers (2005) found that many managers have traditionally neglected risk assessment in forest management decision-making, it is important to consider contemporary approaches and methods to risk management for targeting land for forest restoration development.

The lack of liquidity (liquidity risk) is recognized as the single greatest weakness of forestland assets. (Liquidity is the timeframe required to convert an asset to cash; cash and bonds, of course, being the most liquid and real estate being the least liquid because of the time to process a sale transaction). Traditional approaches to reduce liquidity risk are to manage many forestland properties (land parcels) with different maturities (time to sale). Risk is further contained by keeping the proportion of non-traditional real estate assets below 5 percent of an institutional investment portfolio. From an operational perspective, losses may be minimized and the potential returns increased by timing land sales and acquisitions according to market conditions. We now turn to the broader, systemic risks to forest investments.

The systemic risks to be considered may include regulatory takings such as expropriation, insecure property rights or changes to land use regulation that could deny future development rights (Deacon 1994). Specific risks to forested land parcels are hurricanes, floods, wildfires, pests, pathogens and other natural disturbance events or cumulative damaging agents. Systemic risks may be managed by restricting investments to the northeastern jurisdictions of the United States and to the south eastern provinces of Canada where there are high-value hardwood forests and where there is a 150-year tradition of private property ownership. Also, socio-economic developments in the Northeast (i.e., environmentalism, green space conservation) would appear to support green housing development and mitigation banking (Robertson 2004). In summary, the risks associated with forest investments can be managed by asset diversification, by prudent selection of high quality properties and by purchasing insurance.

2.4 Management

2.4.1 General

The non-industrial private forestland (NIPF) owner acquires forestland for many different reasons and in many different ways. Furthermore, decision-making varies depending on ownership characteristics, market factors and forest conditions. Beach et al. (2005) reviewed the econometric literature on the NIPF owner and found that the four primary drivers related to forest management decision-making were: market factors, land use regulations, owner characteristics and forest conditions. Generally, since private land accounts for the majority of forestland around many cities, ownership characteristics are an important consideration for setting forest restoration goals and policies in the rural-urban fringe.

Prior to the 1980s, research on the NIPF landowner focused on harvesting, reforestation or stand improvement decision-making (Beach et al. 2005, Gregory et al. 2003). In the past decade, research has shifted toward NIPF landowner attitudes and decision-making regarding non-timber forest products and services. It is important to understand the different ownership segments and owner motivations since these characteristics largely determine forest management decision-making strategy (Arano and Munn 2006).

2.4.2 Private Forest Management

Private landowners control less than 13 percent of the world's forests; the vast majority are held by governments and other public bodies (Siry et al. 2005). Table 2-2 provides a regional account of the world's forest ownership. Intensively-managed plantation forests represent only 5% of the world's forests with the remaining 95% of forests left to grow naturally or managed entirely for wood products.

Table 2-2: World's Forest Ownership

[Source: Abridged from (Siry et al. 2005) with source data from FAO statistics]

Forest ownership by region	Area (000 Ha)	Government ownership (%)	Ownership data coverage (%)
Africa	649866	99	47
Asia	547793	94	80
Europe	1039251	90	100
South America	885618	86	91
Central America	78740	85	70
Oceania	197623	84	99
North America	470564	64	100
World	3869455	87	84

At these continental scales, governments control the great majority of the world's forests. However, at finer scales, private forest lands are not so easily dismissed. To give a sense of the variation, private forestland owners hold almost 70 percent of the treed lands in the United States, 46 percent in Germany, and 7 percent in Canada (Beach et al. 2005, Bieling 2004, Canada 2006).

Interesting details regarding ownership emerge as we examine finer scales. Maine, to take an example, has the most privately owned forests in the United States at about 95% (Jin and Sader 2006). Maine is also the most heavily forested state with 90 percent of the land cover forested and 97 percent of the forest classified as productive timberland. In a review of the owner types and harvesting patterns in northern Maine, Jin et al. (2006) noted some important changes to traditional forest ownership. New owners emerged in the 1990s such as Real Estate Investment Trusts (REITs) and Timberland Investment Management Organization (TIMOs) (Jin and Sader 2006). Institutional investors such as pension plans, endowments, and foundations have also become active in timberland investment (Heo et al. 2006) and typically hire TIMOs to manage their holdings (Jin and Sader 2006). Jin and Sader (2006) found that the NIPF owner represented the most stable ownership and consistently harvested the same proportion of forest types (i.e., hardwood, softwood, hardwood-softwood) compared to other owners. Stable ownership was defined as no ownership change between 1994 and 2000. While the industrial owners harvested the most timber in Maine in the 1980s, it was the TIMOs that harvested the most subsequently.

To take another example, private ownership in the southern United States comprises almost 88% of forestland (Siry et al. 2005). Here, Munn (2006) found that TIMOs and industrial landowners invested three times as much as NIPF landowners did on silviculture activities. It is expected that the timber supply will continue to grow as plantation forestry becomes increasingly concentrated on the more productive lands in the U.S. South.

It has been estimated that 5% of the world's forests are intensively managed in plantations that supply 25 percent of the world demand for industrial roundwood (Siry et al.

2005). Industrial roundwood is locally specified minimum log sizes, small end diameter and length, delivered to a saw mill or pulp mill (species' minimum log sizes vary locally by mill). Given current trends, it is estimated that within two decades half of the world demand for roundwood will be supplied by intensively managed plantations. Munn (2006) suggests that policies should focus on encouraging intensive management on NIPF forestlands to increase the supply of timber products and for other non-timber products. NIPF forest management varies from intensive management to complete absence of management for either protection or for production (Siry et al. 2005).

2.4.3 Decision Management

This section reviews contemporary decision management approaches to select the best locations for different forestland uses. Zhang (2005) suggested four generic forestland uses based on global trends: (1) ecological forest reserve, (2) hardwood plantation, (3) softwood plantation, and (4), native (heterogeneous) forest for multiple-uses. In this thesis the hypothetical goal is to reconstruct a native forest near the city for future multiple uses. Therefore, a set of selection criteria is needed to target the best land parcels to achieve this goal. A review of the literature can provide insight into the appropriate set of criteria and a method to target the best sites for forest reconstruction.

There are many approaches to selecting the best locations for different forest uses. Horst et al. (2005) suggested a target species method to identify locations for new farm woodlands to support biodiversity. Van Elegem et al. (2002) suggested a multicriteria analysis method to select the best locations for new urban forests near a city. Sabbadin et al. (2007) developed a land selection model to identify forested areas that are at risk of deforestation due to encroaching development. Walker et al. (2004) suggested that former farmland is the best land to target first for ecological restoration because it will typically be the most productive.

Lichtenberg et al. (2007) developed a conceptual model that showed how forest conservation and minimum-size lot zoning regulations could crowd out the provision of open spaces in suburban developments. Therefore, land use regulations and lot zoning must be considered when selecting land near a city for forest restoration. However, incorporating regulations and land-use zoning information in decision-making is complex. Boolean logic approaches have been widely used in land selection problems to reduce complex information into a simple decision-making framework.

2.4.4 Boolean Logic and the Anticommons

While still considered novel, a few authors have now used Boolean logic to address land selection issues. For example, Pequet (1994) provided a conceptual framework for applying the Boolean logic approach to land classification and selection problems. A Boolean approach was also used by Kalogirou (2002) to select the best land parcels for different types of agriculture. Furthermore, Kalogirou (2002) argued that this method is less complicated than fuzzy logic approaches. This applies especially when valid and reliable land classification data already exists; something generally true in most developed regions in the world.

Invented by George Boole in the mid 19th century, first order logic or Boolean algebra became widely applied in many branches of mathematics, science and philosophy (Peckhaus 1999). Tennant (1985) showed that first order logic was adequate for the natural sciences by demonstrating the use of non-existence conditions ('there-is-not'). Tennant (1985) also argued that the capacity to rule out possibilities means that conclusions are 'falsifiable'—Karl Popper's litmus test for telling science from 'psuedoscience'. In contrast, land classification systems define areas for proposed uses by using <u>both</u> existence conditions (there-is) and non-existence conditions (there-is-not).

Boolean logic is useful for a wide variety of complex problems. It may be especially useful in interdisciplinary work group settings where debate, voting and consensus are a part of the group decision-making process. In particular, Boolean logic is useful to solve multi-disciplinary problems such as land selection problems for forest restoration development. Table 2-3 illustrates the simple logic of the Boolean operands AND and OR, where A and B are any two conditions and C is the result.

Table 2-3: Boolean Logic Truth Table

AND			OR		
A	B	C	A	B	C
0	0	0	0	0	0
0	1	0	0	1	1
1	0	0	1	0	1
1	1	1	1	1	1

Simple Boolean logic is applied as follows. The AND operand (symbolically represented by "∩") requires that *all* conditions are set to 1 or "true" to return a condition of 1. The OR operand ("∪") requires that at least one condition is set to 1 or "true" to return a condition of 1. Therefore, $A \cap B = 1$ only if A AND B are both equal to 1. Also, $A \cup B = 1$ only if one or the other, or both A and B, are set to 1. The Boolean operand AND will be used in Chapter 3 to set the selection conditions for targeting land for forest restoration development. Therefore, all conditions must be true or "1" for the land parcel to be selected for forest restoration development.

Another benefit of a Boolean logic approach is that it reduces the complexity of land selection problems possessing, as they invariably do, both social and ecological constraints. For example, land use zoning regulations, tenure stability, regulatory takings and overuse of an anticommons (Heller 1998) can be integrated in decision-making using a Boolean logic approach.

As Heller (1998) suggested, an anticommons property regime may lead to land remaining perpetually idle despite potentially beneficial usages. This is worth pursuing here as it is a key result in what will follow. Suppose, for example, that a land use proposal is submitted to the local regulatory authority for a permit to develop vacant land. Let's assume that the landowner or developer conducted due diligence to ensure that the proposed land use complied with all levels of land use regulation. Then, let's assume that the development proposal required five types of approval to ensure regulatory compliance. For instance: (A) an environmental approval; (B) zoning compliance approval; (C) economic development approval; (D) architectural design approval; and (E) heritage and cultural approval. If, after all the approvals had been given by the regulatory authorities, a third party actor [$F_{(i-n)}$] emerged to oppose the development for any of an indeterminate number of reasons, and this objection is accepted at the discretionary power of the regulatory authority as legitimate, thus rejecting the project; then a de facto anticommons property regime comes to exist according to this hypothetical case history. Qadeer (1985) has said that a regulatory land use failing arises in Canadian jurisdictions because of 'public officials [in Canada] with excessive discretionary powers'. Qadeer (1985) recommended land reform in Canada to clarify: de facto property rights, and the legal roles and responsibilities of all actors in land use decision-making.

An anticommons property regime may be represented in a Boolean equation by $A \cap B \cap C \cap D \cap E \cap F_{(i-n)}$ (where A, B, C, D, E = 1), and (where [$F_{(i-n)}$] = O) and where n is indeterminate. Therefore, [$F_{(i-n)}$] = 0 because of the high probability that a third party will emerge to reject a project that conforms to pursuant land use regulations. Reviewing cases where a third party has rejected similar land use proposals in the jurisdiction under analysis may reveal a high probability of project rejection. Consider that in such a jurisdiction, *any* single third party [$F_{(i-n)}$] can be reasonably assumed to have de facto regulatory power to reject a permitted land use after just a single case. As Heller (1998) has observed, an anticommons property regime emerges in a jurisdiction 'accidentally' over time as more cases of land use projects are rejected. Once the precedent of a de facto third party regulatory power [$F_{(i-n)}$] becomes established in a jurisdiction, it becomes difficult if not almost impossible to reverse (Heller 1998). Concretely, this situation will arise because of the costly discouragement of landowners fruitlessly applying for permits in jurisdictions with regulators that have high discretionary power and an indeterminate number of opaque avenues for rejecting pursuant land uses. This potential veto power of a small minority is especially likely in relation to small forested privately-held parcels in the urban-rural fringe where many cottagers, possessing both the education, contacts, and ideological motivation, can effectively stall forest restoration projects that involve any element of wood utilization.

In summary, to identify the best land parcels near a city for forest restoration investment, it will be necessary to assess biophysical conditions, former land uses, zoning regulations and systemic risks to land tenure stability. It should be noted that land tenure stability may be quantitatively or, more typically qualitatively, judged by an assessment of the cases of private property development moratoria, expropriation and regulatory takings (Schwartz and Bueckert 2006, Turnbull 2004) that occur in a region under consideration for forest investment at the temporal scale of a decade.

2.4.5 Ecosystem Management

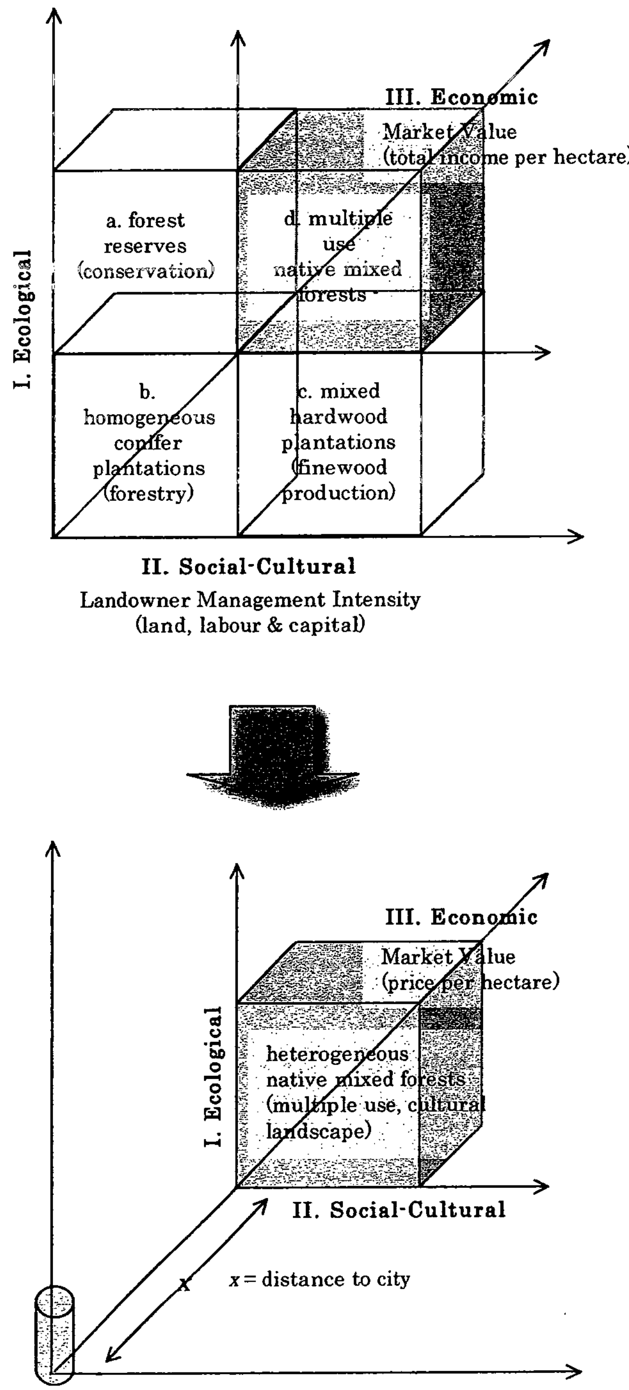
The ecosystem management approach suggests that different factors, such as forest type, location and local land use traditions require different levels of human intervention to achieve optimum social, economic and ecological objectives (Andersson et al. 2006, Gkaraveli et al. 2004, Howe 1997, Jim 2004). Therefore, the intensity of forest management has been differentiated to produce different combinations of timber and non-timber products depending on these factors (Bellmann 2000, Zhang 2005). Management intensity is the total amount of resources (land, labour and capital) invested over time.

Figure 2-2 illustrates four contemporary approaches to forest management with different levels of forest management intensity: (1) forest reserve, (2) conifer plantation, (3) mixed hardwood plantation, and (4) multiple use, native forest. This conceptual framework was constructed by combining (1) Porter's (1980) strategic analysis approach, (2) a synthesis of the global forest management trends suggested by Siry (2005), and (3) the different levels of management intensity for each forest use suggested by Zhang (2005) and Wang (2007). Applying this simplified context, forest uses can be broadly classified according to two dominant strategic orientations: a single use specialization strategy (for protection *or* for timber production) or a multiple use diversification strategy (forest reserve *and* timber production *and* residential use).

Referring to Figure 2-2, each forest management strategy incorporates three dimensions: (1) x-axis (inputs): management intensity, (2) y-axis: ecological outputs, and (3) z-axis: economic outputs. The economic dimension (z-axis) shows the link between proximity to the city and the price of forestland (Mohring 2001). Therefore, to benefit the local urban population, the highest and best use for more expensive land near the city may be for multiple, mixed forest uses rather than single, specialized uses (Van Elegem et al. 2002).

Figure 2-2: Forest Management Strategic Framework

The conceptual framework shown below illustrates four generic forest management strategies that may be employed according to the ecological, economic and social objectives: (a) forest reserve; (b) conifer plantation; (c) mixed hardwood plantation; and (d) multiple use native mixed forest (heterogeneous). According to central place theory, the increasing cost of land closer to the city (x = distance to city) influences the choice of forest management strategy.



We now outline the argument that will underpin Chapter 3. The strategic framework shown in Figure 2-2 suggests that, by organizing a land parcel into different forest management zones, multiple use objectives may be achieved on expensive land near the city. This includes both economic and non-economic objectives. For example, economic uses may include a working forest and a residential development. Non-economic uses may include land set aside for ecological and recreational uses. Under a multiple use management approach, one wonders: might a residential development pay for reconstructed forests on a single land parcel? Recall the earlier review on prices and forest amenities where homes located close to forests are known to command premium prices. Therefore, in addition to paying for the forest reconstruction, new homes could provide tax revenues to municipalities to pay for municipal services (Anderson and West 2006, Tyrvainen and Miettinen 2000). A concern in this argument, in a North American context, is whether homeowners would tolerate a working forest nearby (i.e., logging).

Generally, management zones may be applied to a forest restoration development according to ecosystem management principles (Andersson et al. 2006, Carey 2003, Kelty 2006, Siry et al. 2005). In a hypothetical forest restoration development, mixtures of native tree species could be planted in different management zones to achieve different objectives; e.g. for wildlife habitat, urban forestry research, premium wood production, recreation and residential land uses. Indeed, in what follows, I propose that there will be three zones of roughly equal size, managed for: (1) conservation and scientific research (32%); (2) commercial forestry and recreation (38%); and (3) urban forestry and residential development (30%).

The pragmatic essence of this proposal is that designating multiple use management zones creates the potential to eventually generate an economic return to offset the very high cost of reconstructing forests on ecologically degraded land in the urban-rural fringe that is, due to speculation, quite expensive. Furthermore, this multiple-use forest restoration development approach permanently maintains a high quality native forest on about 2/3rds of the restored land area for wildlife habitat and recreational uses (Kangas et al. 2005, Kant 2003). In addition, an urban forest would be managed on the other 30% of the land area for wildlife, shade trees and for aesthetic functions (Parsons 1995, Parsons and Daniel 2002, Tyrvainen et al. 2003).

CHAPTER 3:
Using Boolean truth tables to evaluate property acquisition for private forest investment: A case study in Montreal's rural-urban fringe

3.1 Introduction

As an urbanizing nation becomes wealthier, scarce land near a city is inevitably developed into new public and private spaces (Kauppi et al. 2006, Phillips 2005, Phillips et al. 2007, Smith and Phillips 2001). In northeastern North America, for example, undeveloped land in a city's rural-urban fringe is highly valued for suburban development (Friedberger 2000). To ameliorate some of the negative aspects of this development, rural land is increasingly being set aside for aesthetic reasons, preserved as forest reserves, public parks or cultural landscapes (Fabos 2004, Krause 2001, Yahner et al. 1995).

Conflicts over the nature and size and location of these set aside areas can arise however. In Quebec, for example, the provincial government created a public park by expropriating private property in Montreal's rural-urban fringe. This public park was created after local interests opposed a new suburban development there (Bryant 1995). This example not only shows the obvious potential for conflict over undeveloped land near a city but also hints at the possibility of reconstructing native forests on highly valued land parcels near the city. But not all forests or vacant land are equally valuable *as forests*. One asks: what is the typical state of forestland found in a city's rural-urban fringe?

Undeveloped forestland around a city rarely resembles the original, pre-settlement forest (D'Orangeville et al. 2008, Schmitt and Suffling 2006). Domon et al. (1997) suggested that these remnant woodlands, almost always the result of invasions by woody plants after farm abandonment, should be viewed as forests in need of reconstruction rather than forests in need of protection. Indeed, D'Orangeville et al. (2008) found that most of the forests regenerating on abandoned farms lacked high value native forest trees, presumably because of a lack of adequate numbers of seed sources. (i.e. the woodlots available for recolonization on abandoned land were poor in valuable native trees precisely because they were valuable and had therefore been the focus of intermittent harvesting over two centuries.) Not only the commonplace second-growth forests on former farmlands, but also abandoned rail yards and post-industrial lands will eventually need to be restored for various future ecological, social and economic purposes (Hall 2000). That is, they are neither valuable (for any but perhaps aesthetic reasons) nor particularly native. Granted the very long-term nature of forest investments, the choice of where to focus property procurement and restoration for future multiple-use urban forestry requires a strategic decision-making framework to reduce complexity (Marshall 2004, Mendoza and Martins 2006).

3.2 Land Use Management

3.2.1 Single-Use and Multiple-Use Forest Management

Single-use and multiple-use forest management are two generic forest resource strategies (Siry et al. 2005). A *single-use* management strategy includes managing a forest resource as a protected forest reserve or for timber production. A multiple-use or mixed-use management strategy typically means managing a forest resource not merely as a protected forest reserve permitting recreational usage but also perhaps for timber production and for residential use. A mixed-use strategy is pursued in this article. More specifically, it is envisioned here that premium-priced homes will be developed on 30% of a land parcel to offset the high cost of forest reconstruction on the other 70%. To guide forest reconstruction, Larsen et al. (2007) suggested first defining a forest development type (FDT) as the forest composition objective. Miyawaki (1998, 1993) suggests defining an FDT by selecting important native trees from regional reference forests; it is understood that from this list a smaller, more suitable, subset can be chosen based on local site factors. In addition, early settlement locations, biophysical factors, and zoning regulations are used to select the survey area. Before final selection of land parcels for forest reconstruction, a risk analysis is conducted to increase the likelihood of long-term success (Duku-Kaakyire and Nanang 2004, Kangas and Kangas 2004).

This risk analysis is a fundamental step. It considers the likelihood, given a preponderance of case precedence, of local interests emerging to oppose future economic uses of reconstructed forests on private property. Bryant (1995) found that local land use interests largely drive public opposition to economic uses of vacant land. For example, public opposition to commercial forestry and to residential development in jurisdictions with overlapping regulatory powers may lead to regulatory intervention (Bryant 1995, Clark 2003, Conseil des Oeuvres 1966, Knetsch and Borcherding 1979, Nosal 2001). These interventions, including land expropriation, development moratoria (Turnbull 2004) and prohibitive land use regulations, can deny a private landowner the right to obtain full market value from the ecological improvements made to their land (Nosal 2001). In the extreme, Heller (1998) and Parisi et al. (2006) described how excessive land use regulation in regions with overlapping jurisdictional powers may lead to an anticommons property problem. This problem may render land unsuitable for private investment in forest restoration since land use rights are uncertain, variable and discretionary in these jurisdictions.

A private investment approach to adding new forests to urban areas overcomes many of the political, legislative, financial and operational limitations of contemporary approaches to open-space planning (Acevedo et al. 2007, Daly 1993, Mark 1999, Monticino et al. 2007, Scheeder et al. 2002) because the latter revolve around environmental mitigation banking, special land use subsidies, non-profit land conservation, restrictive land use regulation and land expropriation (Abensperg-Traun et al. 2004, Feldman 1987, Holl and Howarth 2000, Pincetl 2006). Mahoney (2002) found that the growing use of conservation easements designed to restrict future land use options actually furthered the interests of the present generation at the expense of the next generation. There are for example entrenched institutional obstacles that prevent farmers from investing in biodiversity conservation in agro-forested landscapes (Pascual et al. 2007). Menard et al. (2007) showed how government subsidies and agricultural land use policy favouring intensive pork production in southern Quebec has almost completely deforested the region. Extrapolating from recent trends, they predicted that the remaining forests in this region would diminish from about the 15% cover estimated in 2002 to less than 3% by 2027. (We point out that almost all these forests are poor-quality second growth stands.)

Within North America, the strategic approach advanced in this article is perhaps most suitable for the east where private forest land is far more common than elsewhere (Beach et al. 2005, Bieling 2004, Compton 1945, Ellefson et al. 2007, Gibson et al. 2002). More globally, nominally private land is an insufficient requirement; this approach may not succeed in regions lacking a secure and stable tenure system (Angelsen et al. 2001, Hyde et al. 1996, Tirtiroglu et al. 2004). As mentioned above, in developed countries with an emerging anticommons property regime, a forest restoration development may be at risk of land expropriation or regulatory uncertainty (Conseil des Oeuvres 1966, Miceli and Sirmans 2007). To elaborate on the regulatory risks to forest restoration on private property, the concept of anticommons property requires review.

3.2.2 The anticommons

In his seminal article, Heller (1998) advanced the concept of anticommons property. The "tragedy of the anticommons" is that it may lead to idle land, thus destroying its potential for forest restoration and other uses that almost all members of society would recognize as beneficial. Buchanan et al. (2000) provided an economic explanation of how contemporary, overlapping regulatory bureaucracies may inadvertently create an anticommons problem resulting in major underutilization. An anticommons property regime emerges when a property owner must seek the permission for a permitted, proposed land use from an essentially *indeterminate* number of rent-seekers.

Krueger (1974), Grossman et al. (1995) and Migue et al. (1993) described some of the detrimental effects of rent-seekers on the environment. Rent seekers may include, but are not limited to, governmental organizations, non-governmental organizations, community groups, firms and individuals (Buchanan and Yoon 2000, Heller 1998, Parisi et al. 2005, Parisi et al. 2006, Sim et al. 2002, Vanneste et al. 2006). Even a single rent seeking actor may exclude the owner from using the land in certain regulatory regimes. Thus, the threat of regulatory takings (Heller and Krier 1999, Pendall et al. 2002, Turnbull 2004) must be investigated as part of a due diligence process when making long-term investments in forest restoration in the rural-urban fringe.

3.2.3 The Threat of Regulatory Takings

Assessing the risk of regulatory takings is a crucial step in selecting the best land parcels for forest reconstruction for multiple-use urban forestry. This risk assessment is based on an analysis of the history of takings within the case study area jurisdiction. While a review of the literature found no authors who have specifically studied the effect of regulatory takings on forest restoration or forest reconstruction on private property for multiple-use urban forestry, nonetheless there are many examples of the effect that the threat of takings has on private investment in land improvement (Riddiough (1997), Turnbull (2004), and Pendall et al 2002). Where there is a preponderance of evidence signalling to a potential buyer that there is a long-standing pattern of regulatory takings in a locality, parcel purchase for subsequent conservation will typically cease (Alterman 2006, Riddiough 1997, Schwartz and Bueckert 2006, Turnbull 2004).

There is of course a history of regulatory takings everywhere in the developed world. In the province of Quebec, for example, at the turn of the 20th century, Ross (1915) found that land expropriation was so widespread in Montreal that notaries used a standard clause in a promise of sale document. This clause defined the rights of each party in a land transaction in the event that the property was expropriated during the term of the promise of sale (period between offer and acceptance). But despite this history, the real issue for a contemporary would-be buyer would be the likely threat over the next few decades, and thus the subjective sense of the level of recent regulatory "activism" of the local government. A brief review of some of the most significant recent takings cases in southern Quebec will serve to illustrate the potential risk to land tenure certainty in the case study area in the greater Montreal region.

Private property has been expropriated in Quebec for the stated public goal of protecting natural heritage, for urban renewal projects and for rural land preservation (Bryant 1995, Conseil des Oeuvres 1966, Qadeer 1985, Ross 1915, Vaillancourt and Monty 1985). The most recent well-publicised case in southern Quebec was a development moratorium that targeted a commercially zoned land parcel valued at nearly $300 million dollars on a small island near Montreal after a non-profit group opposed the project (Wilton 2007). This moratorium stopped all development on the property for a 4-year period. In another recent takings case in Quebec, property that was zoned for residential development near Montreal was expropriated and made into a park after local interest groups protested (Bryant 1995).

Finally, in 1978, Quebec enacted one of the strongest agricultural land protection policies in North America which, some argued, amounted to the "... taking of property rights without reasonable compensation" (Vaillancourt and Monty 1985). This created a set of green land zoning regulations in designated agricultural regions in Quebec. Reviewing the impact of Quebec's green land zoning regulations on rural land use near Sherbrooke, McCallum (1994) found that small green-zoned land lots were appraised higher than large lots suggesting eventual conversion to rural residential land uses. Conversion of green zoned rural property to residential uses occurs through an application process and approval by the Commission de protection du territoire du Quebec (CPTAQ) (McCallum 1994). McCallum (1994) found that the most frequently authorized change to the zoning was to build a residence (i.e., succeeding 58% of the time) followed by subdivision and sale of land. Most land zone changes were clustered near the edges of white-zoned land (i.e., commercial and residential land use property) (McCallum 1994). Considering this history of takings, contemporary land tenure stability in southern Quebec can be reasonably judged to be uncertain by someone looking to acquire property for a long-term, multiple-use, forest restoration development project.

3.3 Forest Reconstruction on Multi-use Parcels

Forest reconstruction is undertaken for a wide variety of objectives ranging from stream and riverbank protection, scientific research, habitat creation, wood production and to create new urban forests for multiple-use. In particular, we follow here Skarback's (2007) suggestion that private investment in forest reconstruction to create new urban forests could be used to offset the environmental impacts of urban development projects.

Forest restoration for multiple-use urban forestry as advanced in this article is accomplished in two steps. The first is to reconstitute the forest with commercially valuable native tree species as well as less-valued native shrub species on ecologically impoverished land parcels (Stanturf et al. 2001). Properly matching the species to the site type is crucial. For example, eastern tree species such as sugar maple (*Acer saccharum*) and red oak (*Quercus rubra*), as well as ostrich ferns (*Matteuccia struthiopteris*) and wild garlic (*Allium ursinum*), may be planted on the best sites selected for their appropriate biophysical conditions and other characteristics. Land parcels with high soil fertility should be selected first because they will lead to the most rapid growth. The approach advocated here will of course tend to exclude native species that characterize sites of low fertility.

The second step is long-term management for future multiple-use urban forestry objectives (Andersson et al. 2006, Carey 2003, Kelty 2006, Siry et al. 2005). To plan for future multiple uses, and to reduce the risk of capital losses, three urban forestry management zones are envisioned on a selected land parcel, with roughly a third of the parcel allocated to each zone: (1) conservation and scientific research; (2) commercial forestry and recreation; and (3) residential development. The first management zone incorporates a forest conservation area and forest restoration laboratory to be used for public education (an amenity in its own right) and for long-term scientific studies in urban forest management (Tyrvainen et al. 2006, Tyrvainen et al. 2003). Flood tolerant native tree species will be planted along rivers and wetlands, with more mesic species on modestly drier sites. Furthermore, commercially-valuable, rare, and endangered native trees would be planted for a seed orchard (Jacobs 2007, Lexer et al. 2004, Nehra et al. 2005, Tzfira et al. 1998). The second management zone incorporates a commercial working forest that is also (at certain times) a recreation area. This zone includes high value tree species grown for veneer lumber such as sugar maple, northern red oak and black cherry (*Prunus serotina*). Finally, the third management zone is reforested with eastern white pine (*Pinus strobus*). Premium-priced green homes will be eventually constructed on the site when the white pine trees attain commercial sizes in about 40 years (UFS 2004). Given the rate of sprawl, it is expected that in 40 years these pine sites, given not merely their location but the adjacent forest amenities, will be worth a great deal; the price of the high value pines is an additional financial benefit. This unique residential development may appeal to environmentally-oriented homeowners willing to pay a premium to live close to and within a managed urban forest. Equally important, over the long term the sale of the pine and the pine land will pay for the restoration project and still leave about 2/3rds of the area forested.

Forest reconstruction for multiple-use urban forestry differs from contemporary suburban green development. With the latter, initially one subdivides the land into densely spaced building lots to maximize the economic return on investment. Green space planning offsets are then negotiated between the developer and the municipal planning authorities after the initial development has been approved. The developer may plant shade trees or protect any existing green spaces to trade-off the perceived negative impact of the suburban development (Lichtenberg et al. 2007). Roads, infrastructure and buildings are then constructed as the building lots are sold off to homeowners or to other developers. But there is no reason to suppose that either the planted trees or the preserved (degraded) second growth forest fragments will contribute meaningfully to the maintenance of metapopulations of native animal and plant species in the landscape.

3.4 A Private Investment Approach

3.4.1 Strategic Objective

The strategic objective advanced in this article is to reconstruct new forests near a city for multiple-use urban forestry. This requires long-term forest management inputs to achieve different multiple-use objectives in the future. Indeed, different forestland use objectives require different levels of management inputs (Siry et al. 2005). Management inputs are usefully conceived of as a mix of land, labour and capital to achieve the desired forestland use objectives or outputs. Outputs may include recreational land uses, wood products, biodiversity values, clean water and a variety of other products and services (Arano and Munn 2006).

Due to the high cost of forest restoration, and the high cost of mixed-use land parcels located near urban areas, it may be more cost effective to restore forestland near the city than to protect forest remnants from development. This follows the urban planning rationale that calls for letting development pay for green spaces (Hidding and Teunissen 2002). In other words, forest restoration on part of a land parcel can be paid for by the higher prices and higher tax revenues generated for multiple-use forests on other parts of the land parcel.

3.4.2 Boolean Truth Tables in Land Selection Problems

Boolean algebraic truth tables are used in this article for two purposes: (1) to define a forest development type (FDT) as the forest restoration goal; and (2) to select the best land parcels for forest restoration. The advantage of using Boolean logic is that once the set of conditions have been proven suitable for a land selection problem, the algorithm can be programmed for GIS and satellite imagery analysis of large datasets. Kalogirou (2002) used Boolean logic to select the best land parcels for different types of agriculture. In most developed regions in the world where valid and reliable land classification data exist, a Boolean approach is more cost effective than other approaches. Boolean logic has also been used to prioritize restoration sites on the Mississippi River alluvial plain (Llewellyn et al. 1996), to estimate historical changes in North American cropland through time (1850-1992) (Ramankutty and Foley 1999), to predict forest songbird habitat in southern Ohio, and to target floodplain forests for conservation in the urban landscape of the 'Chicago wilderness' (Wang and Moskovits 2001).

3.5 Case Study Area

The case study area encompassed 17 land parcels on the eastern bank of the St.

Jacques River in the former county of La Prairie, on Montreal's south shore (N45°23.80668, W073°31.74546). This area is within the southern Quebec region of the Montérégie comprising agricultural land (54%), forestland (30%), urban land and other land use types (15%) and water and wetlands (1%) (AFM 2007).

This study area is unique because: (a) it is considered a 'perfect example of an urban fringe' located directly across the St. Lawrence River from Montreal (Murshid 2002); (b) it has historical importance with respect to the region's economic and cultural development; (c) it is within the important sugar maple – hickory forest region[1] of southern Quebec which lies at the northern fringe of the eastern deciduous forest in North America; and (d) 98% of the land is privately owned (province-wide less than 8 percent is privately-held).

La Prairie contains some of the best quality agricultural land in the region (Murshid 2002, Vaillancourt and Monty 1985). It was once the breadbasket of Montreal because of its proximity and its extensive agriculture. For a number of years in the 18th and 19th centuries, La Prairie was also an important trade route that connected Montreal to New York City by a mixed rail and waterway network centered on Lake Champlain and the Hudson Valley (Bladen 1932, Dorwin 1881, McLean 1898).

Southern Quebec's forest composition, Montreal's development history and La Prairie's urbanization process are well known. The forest composition of southern Quebec was described by Marie-Victorin (1935, 1938), Bouchard (1970) and Op de Beeck (1972). Gilliland (2001) described the influence that early urban transport networks had on the expansion of the City of Montreal. Murshid (2002), comparing the state of urbanization in La Prairie in 2002 to earlier appraisals going back as far as 1964, concluded that the land zoning regulations introduced in Quebec in 1978 had not achieved the goal of protecting agricultural land. Over the past 30 years, for example, La Prairie has developed into a suburban city much like the rest of the rural-urban fringe areas around Montreal.

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[1] The sugar maple – bitternut hickory forest domain may be the most ecologically important in Quebec since it contains the greatest diversity of rare forest trees, many at the most northern extent of their range: bitternut hickory, shagbark hickory, black maple, swamp white oak and rock elm (Quebec 2003)

3.6 Land Selection Framework

3.6.1 Land Selection Decision-Making

The generic approach used to select the best land parcels for forest reconstruction for multiple-use urban forestry is comprised of five steps: (1) defining a forest development type; (2) narrowing the search area; (3) evaluating feasibility; (4) identifying mixed-zoning land parcels; and (5) assessing the risk of regulatory takings. Van Elegem et al. (2002) employed a multi-variable reduction process to narrow land choices to a suitable area without considering risk or a forest restoration goal, and the decision-making approach advanced here has two advantages over their method. Firstly, a forest development type (FDT) is defined as the forest restoration goal (Konijnendijk 2000, Tyrvainen et al. 2006). This FDT is then used to narrow the search area to land with the highest potential to attain the forest restoration goal. Secondly, a risk analysis is performed to evaluate regional land tenure stability. A reasonable expectation of land tenure stability is required to justify long-term investments in land, labour and capital for forest reconstruction. Land tenure stability has been shown to both: (a) improve sustainable forest management practices to achieve long-term forest restoration goals; and (b) increase the ecological, economic and social values of private forestland (Sayer et al. 2004, Zhang and Pearse 1997).

3.6.2 Land Parcel Selection Analysis

The Boolean truth table shown in Table 3-1 summarizes the land parcel selection analysis for the 17 land parcels bordering the St. Jacques River in La Prairie. This truth table uses the Boolean logic operand "intersection of" or "AND"; that is, all conditions must be true (cell = 1) otherwise that land parcel is rejected as a candidate (cell = 0). The Boolean expression for Forest Restoration Development (FRD), is defined as TRUE (FRD) = (C1,C2,C3,C4,C5,C6) = 1. Regional, local and land parcel criteria was incorporated in the land parcel selection analysis. Regional scale land selection criteria included: forest type (C1); and land class (C2). Local and land parcel scale criteria included: forest tree species diversity potential (C3); mixed land use zoning (C4); low risk of takings (C5); and vacant land

(C6). In short form; criteria C1 and C2 are regional criteria. Criteria C3, C4, C5 and C6 are local criteria. Since the Boolean analysis is conducted hierarchically, from a regional scale to a local or land parcel scale, that is, from left to right, the first occurrence of FALSE or "0" negates any need to continue with a finer scale analysis.

Table 3-1: Land Parcel Selection Analysis

C1: High Value Forest Tree Species Potential (bioclimatic region = bitternut hickory / sugar maple); C2: Land Class = 1 or highest soil fertility; C3: Riparian Forest Biodiversity Potential (parcel extends to river bank); C4: Mixed Use Zoning; C5: Low Risk of Takings; C6: Vacant Land. Land parcel coding; H: Residential; C: Commercial; I: Industrial; P: Public; A: Agricultural. Boolean logic selection based on: TRUE = (C1,C2,C3,C4,C5,C6) = 1. Further analysis is not required (NR) after finding a first FALSE condition or "0". The 17 parcels examined in this study are from the east side of the St Jacques River.

No.	Land Parcel	Regional		Local				TRUE	Zoning
		C1	C2	C3	C4	C5	C6		
1.	P-03	1	1	1	0	NR	NR	0	Public
2.	P-02	1	1	1	0	NR	NR	0	Public
3.	H-01	1	1	1	1	0	NR	0	Residential
4.	C-10	1	1	1	0	NR	NR	0	Commercial
5.	P-154	1	1	1	0	NR	NR	0	Public
6.	C-173	1	1	0	NR	NR	NR	0	Commercial
7.	C-172	1	1	0	NR	NR	NR	0	Commercial
8.	P-154	1	1	1	0	NR	NR	0	Public
9.	P-153	1	1	1	0	NR	NR	0	Public
10.	P-137	1	1	1	0	NR	NR	0	Public
11.	P-135	1	1	1	0	NR	NR	0	Public
12.	I-133	1	1	1	0	NR	NR	0	Industrial
13.	H-134	1	1	0	NR	NR	NR	0	Residential
14.	P-132	1	1	1	0	NR	NR	0	Public
15.	C-131	1	1	1	0	NR	NR	0	Commercial
16.	A-200	1	1	1	0	NR	NR	0	Agricultural
17.	C-176	1	1	0	NR	NR	NR	0	Commercial

3.6.3 Defining a Forest Development Type

The first step in this land selection case study was to define a forest development type (FDT) by selecting appropriate tree species for the bioclimatic region of study. The end-state goal of this FDT is a high diversity of native rare, endangered and important tree species (Bouchard

1970, Op de Beeck 1972) derived from four reference forests in the region (Table 3-2, Table 3-3). Reference forests provide an inventory of native trees and shrubs in a region as targets of restoration (Ruiz-Jaen and Aide 2006). Unlike before, truth for the FDT (Table 3-2) will now be defined as TRUE = C1 AND SUM (C2, C3, C4, C5) ≥ 2.

Table 3-2: Forest Development Type

C1: Rare; C2: Endangered; C3: High commercial value for fine hardwood; C4: Special uses; C5: long-lived tree (greater than 150 years) (Note: all the species identified are rare on the south shore of Montreal due to the lack of forest cover near the city; however, Black Maple, Rock Elm, Butternut and Swamp White Oak are defined as regionally rare by the Minister of Natural Resources for all of Quebec since these species are found at their northern limit of their native range and have been commercially exploited for special uses during the period of intensive commercial forestry in southern Quebec (1850 – 1930). Boolean logic tree selection for the FDT: TRUE = C1 AND SUM (C2, C3, C4, C5) ≥ 2

No.	Species	C1	C2	C3	C4	C5	TRUE
1.	Red oak *(Quercus rubra)*	1	0	1	1	1	1
2.	Black maple *(Acer nigrum* Michx. F.)	1	1	1	1	1	1
3.	Black cherry *(Prunus serotina)*	1	0	1	1	1	1
4.	Eastern hemlock *(Tsuga Canadensis)*	1	0	0	1	1	1
5.	Sugar maple *(Acer saccharum* Marsh.)	1	0	1	1	1	1
6.	Yellow birch *(Betula alleghaniensis)*	1	0	1	1	1	1
7.	American beech *(Fagus grandifolia)*	1	0	0	1	1	1
8.	Butternut *(Juglans cinerea)*	1	1	0	1	0	1
9.	Swamp white oak *(Quercus bicolour)*	1	0	1	1	1	1
10.	White pine *(Pinus strobus* L.)	1	0	0	1	1	1
11.	Rock elm *(Ulmus thomasii)*	1	1	1	1	1	1

Table 3-3: Reference Forests in Southern Quebec

A review of important tree species from reference forests in a region is required to inform the development of a regionally adapted forest development type as a goal of forest restoration (Miyawaki 1998, Miyawaki and Golley 1993, Stanturf 2004). Reference Forest Data Sources: [Abridged from Quebec Minister of Environment, Department of Natural Heritage and Ecological Reserves (2002) leaflets; (Muller et al. 2003); Vegetation Zones and Bioclimatic Domains in Quebec, Minister of Natural Resources, Forest Inventory Management (2003)]

Name	State	Important tree species
Southern Quebec region	98% private land	Sugar maple, black maple, bitternut hickory, shagbark hickory, swamp oak, rock elm
Mont St-Hilaire (present day)	Nature reserve	Red oak, Black maple
Mont St-Hilaire (paleoclimate reconstruction)	Nature reserve	Eastern hemlock, Sugar maple, American beech, Butternut, Elm, Oak, Birch
Marcel-Raymond	Ecological reserve	Swamp white oak
Ruiter-Valley	Ecological reserve	American beech, Sugar maple, Yellow birch, Black cherry
Muir-Forest	Ecological reserve	American beech, Sugar maple, Yellow birch

3.6.4 Narrowing the Search Area

The south shore of Montreal is located on a floodplain and is within the hickory-maple bioclimatic region thus providing suitable growing conditions for the forest development type (FDT). Since a riparian forest is desired as an element of the FDT, the search area was narrowed to the St. Jacques River on the south shore of Montreal. Furthermore, population centres are known to have land with the highest soil fertility (Barrios et al. 2006, Kalogirou 2002, Sanders et al. 1979). For these reasons, the east bank of the St. Jacques River in the City of La Prairie was selected. The location of La Prairie was then compared to existing vegetation zone maps and to soil fertility maps to confirm site suitability for the FDT. These maps confirmed that La Prairie is within the region of Quebec with the highest soil fertility.

3.6.5 Evaluating Feasibility

To determine the feasibility of land parcels for forest restoration, information on the land zoning and lot sizes was obtained from the La Prairie urban planning office. Satellite photos were then examined to identify undeveloped land. This was followed by a field survey to confirm that the land was undeveloped and to evaluate the state of existing vegetation. The undeveloped land was then matched to the cadastral lot maps that were obtained from the municipal land planning office. Cadastral lot maps identify the location of major property divisions and the applicable municipal land use zoning (residential, commercial, agriculture). For example, in La Prairie, cadastral lot numbers are prefixed with H for residential zoning, P for public use, C for commercial uses, I for industrial use and A for agricultural uses.

3.6.6 Identifying Mixed-Use Zoning Land Parcels

To identify mixed-use zoning land parcels, detailed property descriptions for the only undeveloped land parcels (two land parcels comprising plot H-01) in Table 3-1 that met criteria C1 to C4 were obtained from the urban planning office (zoned for residential development). Property description documents detail additional plot-specific municipal land use regulations that may limit mixed-uses such as urban forestry, commercial building construction, and set the limits on number and types of buildings permitted. The municipal property description for both parcels (part of H-01) identified a 'general land use restriction' as: '9100: undeveloped, vacant land (excluding commercial forestry use)' [translated from the original French]. A conversation with the La Prairie urban planning counsellor confirmed that the land use regulation that excluded commercial forestry use may no longer apply and that a landowner may need to apply for an exemption to permit urban forestry for mixed uses. In many cases, a land purchaser can obtain approval for a new land use from the municipality prior to making an offer to acquire the property from the current owner. This suggests it is prudent for a land purchaser to confirm whether existing or planned land use zoning regulations will permit forest restoration for future mixed uses.

This long-term perspective is of course crucial. Forest restoration development first calls for afforestation or reforestation of a land parcel. This creates a future option to harvest these trees. White pine, for example, would be processed in about 40 years, or when the trees attain minimal commercial size, for high quality timber frame homes on forested lots. Residential building lots would occupy the same area where the white pine trees were harvested.

In the event that a regulatory exemption could not be obtained from the municipal zoning authority for plot H-01 to permit forest reconstruction for future mixed uses, then a de facto threat of regulatory takings exists. That is, there is no stability of land tenure to prevent expropriation or further development restrictions after 40 years of investment has been made in forest restoration on this land parcel. Given the current regulation that excludes urban forestry for the two land parcels (part of plot H-01), a de facto threat of regulatory takings is reasonably assumed. Therefore, this uncertain land tenure condition on the only undeveloped property in the study area precludes any low-risk, long-term investments in forest restoration development.

In summary, of the 17 available parcels along the east bank of the St. Jacques River, Table 3-1 shows that 4 were rejected because they did not actually extend to the riverbank, another 12 were rejected because of zoning restrictions, and the final parcel was unsuitable because of the risk of taking. From this feasibility analysis, it may be concluded that local land use zoning and the stability of private property land use regulations, become the deciding factor when considering significant, long-term investments in forest restoration development on private property in the urban-rural fringe.

3.7 Discussion and Conclusion

This thesis introduced a decision-making framework to select the best land near a city for private investment in multiple-use urban forestry. A truth table methodology was advanced to select land parcels in the case study area. The benefits of this land selection method are that it reduces decision-making to Boolean logic (i.e., criteria met; YES or NO). Of course, for single purpose land uses, such as for conservation, the selection criteria would be different than for the multiple purpose land uses suggested here. Furthermore, this selection method can be adapted to group decision-making. That is, different sets of selection criteria can be adapted to the group's land use objectives. For example, in the case of land conservation, the presence (or absence) of endangered species habitat would be included in the selection criteria. In this thesis, zoning restrictions and land use regulations were important to consider since they could be significant barriers to forest reconstruction on private property for future multiple-use urban forestry. As we saw, the only available lot (part of H-01) in the Boolean truth table had a general land use restriction that precluded commercial forestry use.

Reynolds et al. (2003) identified land tenure stability and land use regulations as key legislative indicators of sustainable forest management as defined by the Montreal Process. This suggests that land tenure stability is a fundamental requirement for long-term investment in forest restoration development on private property.

In southern Quebec, private property in the rural urban fringe is zoned at the provincial level for either agricultural and forestry (green-zone) or urban land uses (white-zone) (Vaillancourt and Monty 1985). The municipalities then apply additional, exclusionary zoning that further restricts land uses from the most intensive uses such as heavy industry to less intensive uses such as residential. Finally, provincial public policy favouring agricultural land use exclusively in some regions, as well as local municipal zoning, can exclude sustainable forestry (forest restoration or forest reconstruction) from both white-zoned land and green-zoned land. This establishes a rigid regulatory barrier that may discourage private investment in ecological land improvement projects. In addition, the historical record of government takings and land expropriation in Quebec for the purpose of creating public parks, for nature protection, for urban renewal[2], for agricultural land protection projects and most recently, for man-made landscapes, may be lead to the emergence of an anticommons land system. If so, ecologically impoverished vacant land may remain in a perpetually idle state. This then results in landowners in jurisdictions with a high threat of regulatory takings (Greene and Harlin 1995, Riddiough 1997, Tonn 2002, Turnbull 2002, 2004) holding land in reserve, while paying rent through taxes, in the hope that future regulatory changes may allow pursuant land usage.

Another, less apparent, consequence of an emerging anticommons land regime is that

[2] Acquisition of degraded land or decrepit properties through eminent domain (expropriation proceedings), restoration of the land or clearing of structures, and subsequent development by a public agency or by a private developer "to whom the property is sold." [Source: (HLR 1978)]

it may crowd out any innovative land improvement investments that may not be viewed as politically expedient by public officials – either overtly or through an opaque regulatory land use control process. This suggests that private investment dollars for innovative ecological improvement projects, such as forest restoration, forest reconstruction (Miyawaki and Golley 1993), or other open-space green design projects, may gravitate to jurisdictions with stable private property legislation, enforced by the rule of law, and which permits diversity of land uses through progressive, mixed-use zoning (Andersson et al. 2006, Bengston et al. 2004, Bray et al. 2004, Brown et al. 2007, Dabla-Norris and Freeman 2004, Gallent and Kim 2001).

In a global market environment, in which cities compete for highly mobile labour and capital, policy makers and regulators must consider the broad, long-term consequences of excessive discretionary land use regulations affecting different forms of urban development (Barron 2003, Richardson 1960). Any land use reform should establish a clear goal to protect the public from excessive use of arbitrary and discretionary police powers by public officials in land use decisions (Buchanan and Yoon 2000, Heller 1998, Parisi et al. 2005, Sim et al. 2002, Vanneste et al. 2006). Further research is required to define a robust legal test that may be used to evaluate and guard against the risk of an anticommons property regime accidentally emerging in a developed country.

Several difficulties were encountered in trying to obtain source data and supporting research material for this article. For example, the municipal planning office in both La Prairie and the adjacent municipality of Brossard had not released any information on an on-going environmental assessment of the St. Jacques River at the time when the research was conducted for this article. It is expected that this environmental assessment may result in new land use regulations in the case study area that could further diminish the feasibility for long-term forest restoration development on local properties.

In conclusion, the overlapping regulatory jurisdictions of provincial level agricultural land preservation zoning and municipal level exclusionary zoning, combined with regulatory takings jurisprudence, presents a significant barrier to low-risk private investments in forest restoration and forest reconstruction for multiple-use urban forestry in the case study area of La Prairie. This land tenure uncertainty is not unique to Quebec. Despite recent developments in jurisprudence, Canadian law lacks adequate protection for landowners from arbitrary and discriminatory regulatory takings in all the provinces (Schwartz and Bueckert 2006).

CHAPTER 4: CONCLUSION

This thesis advanced a decision-making framework to select the best land near a city for private investment in multiple-use urban forestry. The long-term goal was that the purchase and restoration of these forested areas would not merely pay for themselves, but would offer amenities to the urban dwellers as urban sprawl engulfed the area in the coming decades. A case study illustrated a simple land selection method using Boolean truth tables to conduct a multi-criteria analysis of the land survey area in La Prairie. It was postulated that the best locations for forest restoration development were private properties bordering rivers located close to the city.

The best locations at the bioclimatic regional scale are areas that have high soil fertility and high potential for forest tree species diversity. In southern Quebec, the highest forest tree diversity potential is found in the Sugar Maple-Hickory forest region in and around Montreal. The strategic dimensions for targeting land parcels were further assessed at the local scale for feasibility by: (a) mixed land-use zoning; and (b) vacant land status. Finally, land tenure stability was identified as the deciding strategic factor when considering the systemic risk of failure to long-term forest restoration development in a region.

Generally, high potential land parcels for forest reconstruction as suggested in this thesis would meet the following conditions: (1) a large gap between current land use and highest and best use; (2) high gross primary production potential; (3) free of commercial forest development restrictions; (4) permissive mixed-use zoning regulations that allow land transformation for multiple uses (residential, commercial, agro-forestry); (5) close to high value amenities (central places); and (6) low threat of regulatory takings.

A soft systems approach (Mendoza and Martins 2006) was adopted for the decision-making framework. Generally, soft system approaches focus on first identifying the most relevant strategic factors to guide land selection decision-making rather than applying complex mathematical models (hard systems approaches). In the case study, a simple Boolean truth table decision-making framework was adopted for targeting high potential sites for long-term forest restoration investment. In particular, this thesis suggests that mixed-use land regulation and land tenure stability are two important factors to consider.

With regards to mixed land uses, the land selection framework advanced in this thesis follows the Sustainable Forest Management (SFM) principle of 'both-and' suggested by Kant (2003) which enables ecological, social and economic forestland uses rather than 'either-or' uses. For example, three land use zones were suggested for a single plot of restored forestland: (1) conservation and scientific research; (2) commercial forestry and recreation; and (3) residential development. Of course, the precise allocation of mixed land use zoning for each plot of land would depend on local land use regulations and local environmental, social and economic conditions.

While there are never any clear choices in decision-making under uncertainty and stochasticity, land use choices are inevitably made through the complex interplay among regulatory authorities, individual landowners and non-governmental organizations. Given this decision-making uncertainty, several general observations can be made regarding the cost and benefits of land transformation in a region as a consequence of having many small land owners or only a few large land owners (i.e., industrial or public land). For example, having many small land owners, rather than only a few large land owners, can provide an inherent risk management mechanism to ensure the lowest total costs and highest long-term benefits through land use diversification in a region. For instance, a single, or only a few large landowners, with a dominant, singular land use (i.e., forestry, agriculture, industrial uses) may increase the risk of unpredictable environmental, social-cultural and economic consequences over a large region, whereas, many small landowners, with different land uses (i.e., residential, small-scale forestry, conservation, commercial uses), may be seen as less risky (DeSoto 2000, Mark 1999, Mlambo 2005, Ostrom and Nagendra 2006, Parsons 1956, Russett 1964). This suggests that the collective effect of independent decision-making, by many individual landowners with different land uses, diversifies risk by limiting the absolute spatial and temporal scale of any single potential negative land use in a region. Thus, decentralized, pluralistic approaches can reduce the probability of creating broad-scale problems for future generations (Arano and Munn 2006, Beach et al. 2005, Jin and Sader 2006, Matta et al. 2007).

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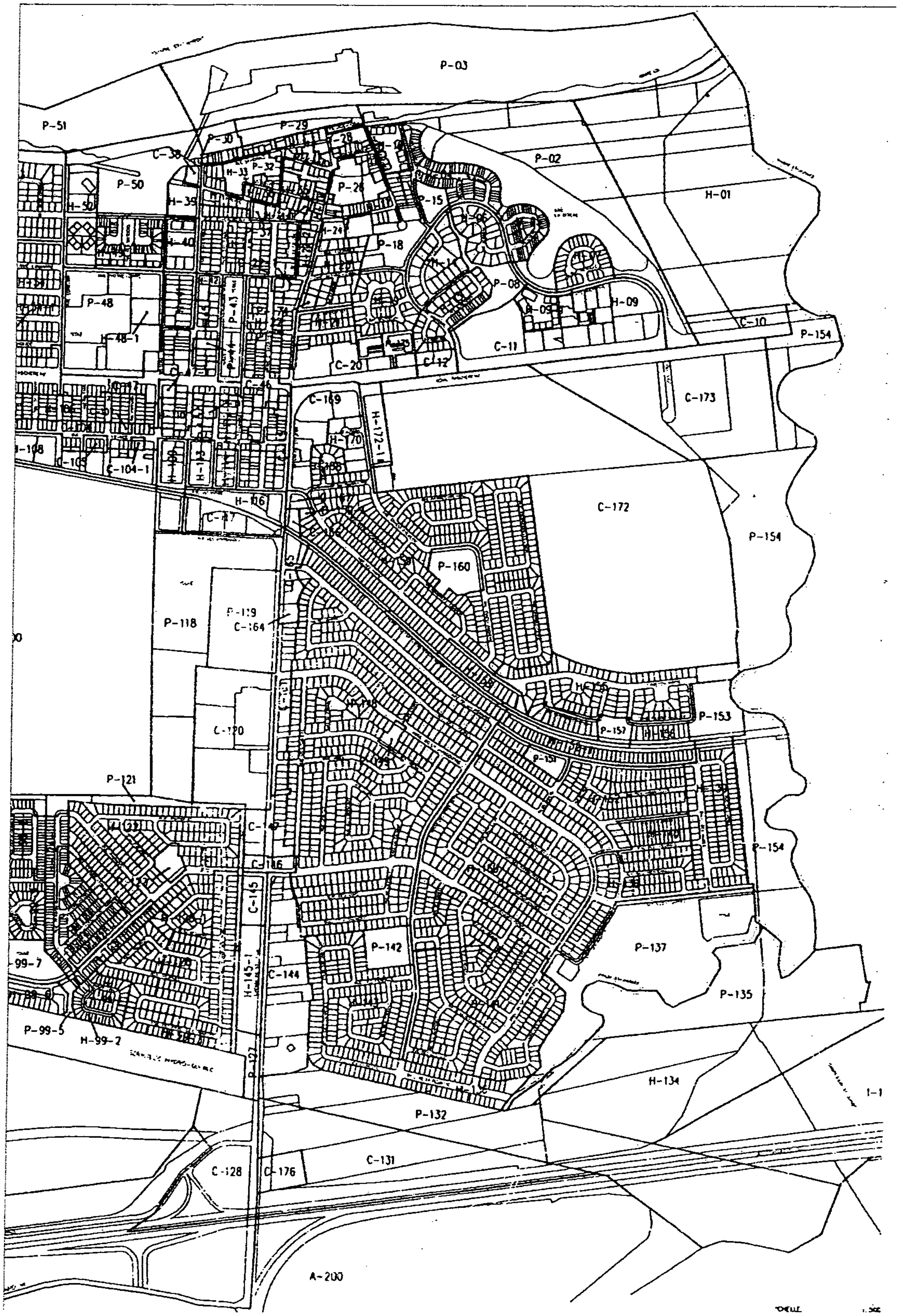
Appendix A:
Case Study Area - La Prairie Cadastral Plan



P-03
P-51
P-29
P-30
C-38
P-50
P-32
H-33
H-39
P-28
P-02
H-01
P-15
P-18
H-40
P-48
H-48-1
P-08
H-09
C-10
P-154
C-11
C-20
C-12
C-46
C-169
H-170
C-173
H-172-1
H-108
C-105
C-104-1
H-116
C-47
C-172
P-160
P-118
C-164
C-170
P-121
P-153
P-157
P-151
C-186
C-145
P-142
P-137
P-135
C-144
H-145-1
P-99-5
H-99-2
H-134
P-132
C-131
C-128
C-176
A-200