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ARTICLE

Towards the Establishment of a Green Infrastructure in the Region of Montreal (Quebec, Canada)

JÉRÔME DUPRAS, CHARLES DROUIN, PIERRE ANDRÉ & ANDREW GONZALEZ

Abstract

Through the analysis of semi-structured interviews held with key actors involved in the planning of the Greater Montreal region, we seek to understand the conditions that could lead to the establishment of a green infrastructure for the city. This article first describes the region's environmental and political context and then analyzes the opportunities, constraints, advantages and disadvantages in the implementation of this type of project. We conclude that experts favor an approach leading to ecological connectivity, but they underline several obstacles that could hinder its implementation.

Keywords: land-use and urban planning; green infrastructure; green belt; Montreal

1. Introduction

To allow for a healthier interaction between city dwellers, nature and agriculture, several major cities in the world have adopted policies to manage the growth of urban areas and protect natural and agricultural environments, like London, Sao Paolo, Seoul or Toronto (Ahern, 1995; Taylor *et al.*, 1995; Bengston *et al.*, 2004; Richardson & Bae, 2004). These policies have seen the implementation of green infrastructures, of which greenbelts, greenways and ecological networks are among the best known (Bryant, 2006; Ignatieva *et al.*, 2011).

The term green infrastructure is frequently used in the context of land use planning and biological conservation (Fábos & Ryan, 2004). Its broad definition sometimes includes engineered structures (in contrast to gray infrastructure) or micro scale natural or semi-natural arrangements of vegetation, such as woodland or a wetland. In this study, we define a green infrastructure as a type of land-use

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consisting of a network of natural areas and open spaces that optimizes biodiversity protection and generates other environmental and social benefits.

These green infrastructures are known to act on ecological connectivity of urban and peri-urban landscapes (Opdam *et al.*, 2006). Ecological connectivity refers to the capacity of a landscape to allow movement of living organisms and matter and influences both biodiversity and ecosystem function (Gonzalez *et al.*, 2009). Even if there are important gaps in our comprehension of the links between landscape connectivity, ecosystem functions and ecosystem services (Mitchell *et al.*, 2013), there is evidence green infrastructure enhances ecosystem services, namely the benefits provided to human by ecosystems and biodiversity (Millennium Ecosystem Assessment, 2005).

However, implementing green infrastructures in a manner that favours ecological connectivity in urban areas is complex and calls for the integration of social, political, economic and environmental issues in a land use planning and management perspective (Ignatieva *et al.*, 2008, 2011).

In order to understand the complexities of implementing a green infrastructure, we analyse herein the situation in the Greater Montreal Area (GMA). The coexistence of urban development, agricultural activities and natural systems in the Montreal region has been a growing challenge over the past decades. Urban sprawl and agricultural development in this region have created a range of environmental impacts that fall within the typical consequences attributed to these phenomena (Pan *et al.*, 1999; Johnson, 2001; Bélanger & Grenier, 2002; Brisson & Bouchard, 2003; Jobin *et al.*, 2010). Although protected since 1978, agricultural land continues to be subjected to real estate speculation and is in constant decline (Marois *et al.*, 1991; Sénécal *et al.*, 2001; Bélanger & Grenier, 2002; Dupras & Alam, 2015).

This study aims, through the discourse of experts, to identify and understand the characteristics of the political, social, environmental and economic context that dictate the direction of the land-use development and planning of the region.

2. Study's Context

2.1 Green Infrastructures in Canada and Elsewhere

Since the early 20th century, several types of land-use policies have been implemented worldwide to protect the natural and semi-natural ecosystems. One of the best known is the Garden City concept of Ebenezer Howard, whose concentric approach to open spaces inspired models of green belts which have spread notably in Europe, North America, Japan and Australia (Searns, 1995; Fábos & Ahern, 1996). The planned development of the city of London was the starting point of the modern concept of greenbelt in the 1930s and since, many cities have joined the movement, including Seoul, Sao Paolo, San Francisco and Frankfurt (Fábos & Ryan, 2004).

In Canada, the concept of greenbelt has been anchored in the planning of urban and peri-urban areas since the 1960s, the most obvious example being the city of Ottawa (Taylor *et al.*, 1995). Ottawa's Greenbelt is one of the most iconic internationally (Taylor *et al.*, 1995), while the Greenbelt of Toronto,

legally established in 2005, is a newer model of development of green peri-urban areas.

Originally designed to contain urban sprawl, the contemporary approach to green infrastructures promotes an urban development based on connectivity between green spaces, natural and semi-natural systems (Searns, 1995; Ignatieva *et al.*, 2011), resulting in planning policies often designated as "greenways", "green networks" or, more generally, "green infrastructures" (Searns, 1995; Ignatieva *et al.*, 2011). Generally, the principle of a "modern" green infrastructure aims at protecting the natural environment of intact islets, connecting them through ecological corridors that also serve as buffer zones. The development of such a network seeks to increase the mobility of plant and animal species, and increase the resilience of biodiversity as well as the production of ecosystem services benefiting human communities (Sandstrom *et al.*, 2006; Tzoulas *et al.*, 2007; Ernstson *et al.*, 2008). Developed in the 1970s, particularly in the United States, Great Britain, Portugal, Italy and Japan (Searns, 1995; Zube, 1995), these kinds of green infrastructure have experienced a major international development since the 1990's (Ignatieva *et al.*, 2011). This phenomenon is observed in Canada where four major cities (Calgary, Ottawa, Saskatoon and Toronto) have amended their development planning to move from typical green belt planning to green infrastructures that promote ecological connectivity (Taylor *et al.*, 1995).

The rise in popularity of green infrastructure is related to the benefits it provides that goes beyond the protection of natural capital (e.g. forests, wetlands, riparian zones) (Amati & Taylor, 2010). The functional structure of these infrastructures allows for a spatial ecological dynamics. Indeed, the connectivity of green areas increases the production of ecosystem goods and services (Loreau *et al.*, 2003), such as pollination, control of water loss and habitats for biodiversity, which produces a positive effect on the aesthetic, recreational, social and economic aspects of urban and peri-urban landscapes (Foley *et al.*, 2005; Mitchell *et al.*, 2013).

Consequently, green infrastructures facilitate the removal of the barriers between city and nature, and promote access to natural environments for residents. This surrounding nature is sought by citizens who appreciate these impacts on their quality of life. Many studies have shown that proximity to nature has positive effects on public health (as reviewed by Tzoulas *et al.*, 2007) and the psychosocial development of children (Louv, 2008). With this perspective, nature passes from a destination to a component of the urban environment.

2.2 Target Area

The area that we define as the GMA has been proposed by scientists and NGOs as the best ecological area in which to develop a Green infrastructure project for the region (Fondation David Suzuki, 2012; Dupras *et al.*, 2015). The limits of this area are based on the natural region of the Upper St. Lawrence Plain of Quebec's ecological reference framework (Ministère Développement durable, Environnement et Lutte contre les Changements climatiques – MDDELCC, 2014). The Quebec's ecological reference framework is a common, hierarchical natural systems framework that in turn is embedded in similar Canadian and North American initiatives (Ducruc *et al.*, 1995). Thus, this area does not correspond to

an administrative entity but relies on a common geographical approach where the territory is delineated according to an ecological logic included in a larger North American framework. This framework was implement in the 1990s to allow coherence in land use planning and resources management mechanisms. The GMA is a 1.7 million hectares territory that includes the City of Montreal, Montreal Metropolitan Community (MMC) and its 82 municipalities, and adjacent territories, whose boundaries are based on persistent elements of the regional landscape (i.e., geology, surficial deposits, topography, climate, network drainage, vegetation, and wildlife) (Figure 1). The GMA covers less than 1% of Quebec's territory, but is home to more than half of its population (over 4 million in 2015). Figure 2 illustrates and Table 1 details the land use cover of these areas.

In both the MMC and the GMA, the very important agriculture sector covers about one third of their territory. Diversified economically, the city of Montreal is an important scientific, cultural and intellectual center, known for its dynamic manufacturing, services, telecommunications, aerospace, computer and pharmaceuticals. Agriculture and biotechnology are the main economic sectors of

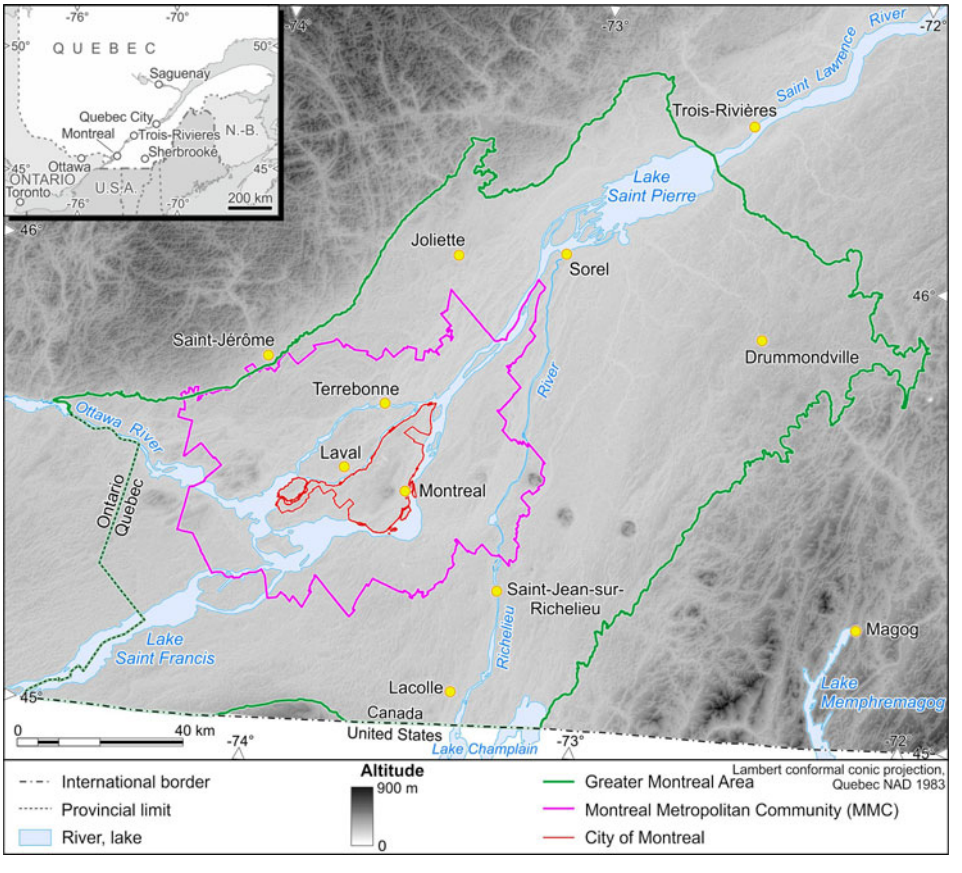

FIGURE 1. Location and boundaries of the City of Montreal, the Montreal Metropolitan Community, and the Greater Montreal area.

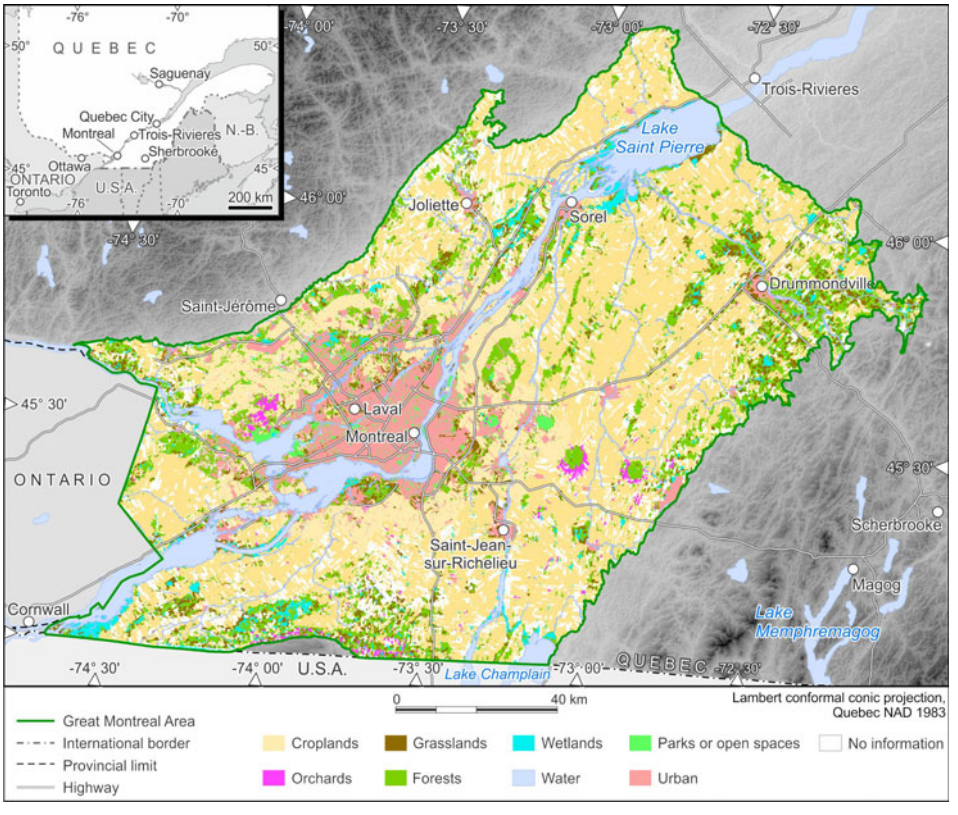

FIGURE 2. Characterization of the Land Use Cover of Greater Montreal in 2011.
Source: Base de données de cultures généralisées (BDCG)—Financière agricole; Base de données topographiques du Québec (BDTQ) – MRNF; Inventaire des terres du Canada—Productivité forestière des terres; Produits du système d'information écoforestière (SIEF); Système d'information hydrogéologique (SIH); Cartographie des milieux humides de la Communauté métropolitaine de Montréal Canards Illimités Canada.

the South Shore of the St. Lawrence River, while recreation, tourism and forestry are among the major activities of the North Shore (Communauté Métropolitaine de Montréal, 2010).

The greatest biodiversity of the Province of Quebec is found in its Southern part, where is located the GMA (Tardif *et al.*, 2005). This area is also where biodiversity is the most threatened by anthropogenic pressures on natural environments (Pan *et al.*, 1999; Brisson & Bouchard, 2003). The number of plant and animal species at risk is the highest in the province, and the area also holds the lowest percentage of protected areas (Brassard *et al.*, 2010). Urbanization, urban sprawl, intensive exploitation of natural resources, agriculture practices, industrialization, and the introduction of invasive alien species are contributing to the loss of biodiversity, the fragmentation of essential habitats and the degradation of natural environments (Bélanger & Grenier, 2002; Brisson & Bouchard, 2003; Fondation David Suzuki, 2012). Once fragmented, the isolated areas of habitats may no longer allow

TABLE 1. Land use cover of the City of Montreal, the Montreal Metropolitan Community and the Greater Montreal area

	Greater Montreal area		Montreal Metropolitan Community		City of Montreal	
	ha	%	ha	%	ha	%
No info	87, 129.7	5.0	1, 517.2	0.3	0.0	0
Urban	224, 379.1	13.0	160, 232.2	36.3	33, 871.1	87.1
Water	133, 618.7	7.7	52, 821.5	12.0	176.3	0.5
Forests	357, 083.2	20.7	56, 012.1	12.7	824.6	2.1
Park or green space	12, 800.5	0.7	9, 807.2	2.2	2, 993.3	7.7
Croplands	700, 310.2	40.6	147, 541.2	33.4	455.9	1,2
Grasslands	56, 449.2	3.3	11, 164.5	2.5	516.1	1.3
Wetlands	25, 462.7	1.5	2, 036.5	0.5	38.5	0.1
Unknown	129, 638.9	7.5	0.0	0	0.0	0
Total	1, 726, 872.2	100	441, 132.5	100	38, 875.8	100

Source: Base de données de cultures généralisées (BDCG)—Financière agricole; Base de données topographiques du Québec (BDTQ)—MRNF; Inventaire des terres du Canada—Productivité forestière des terres; Produits du système d'information écoforestière (SIEF); Système d'information hydrogéologique (SIH); Cartographie des milieux humides de la Communauté métropolitaine de Montréal Canards Illimités Canada.

populations of the same species to migrate in order to ensure their genetic exchange essential in maintaining their adaptive process (Gonzalez *et al.*, 2009).

The urban sprawl of the Montreal area between 1966 and 2011 (Figure 3) shows the doubling of the urban area, mainly at the expense of agricultural land and forests. Future pressures, such as climate change, combined to the cumulative impacts of the actual practices and invasive species in time and space, are other arguments for the conservation and ecological management in the region (Gonzalez *et al.*, 2013).

2.3 *Montreal Political Context*

Many institutional actors of the GMA recognize the urgency to protect and enhance the natural and agricultural areas of the metropolitan area (Communauté Métropolitaine de Montréal, 2011). The Montreal Metropolitan Community (MMC[1]) (the urban core of GMA) published a management and development plan for the metropolitan area over the 2011–2031 period with the objective of protecting 17% of the territory by then (currently, slightly more than 4% of the territory is protected) for the maintenance of biodiversity (Communauté Métropolitaine de Montréal, 2011). To this end, the MMC identifies the metropolitan woodlands, forest corridors and wetlands as potential conservation areas. The Quebec government demonstrated its commitment by allocating 50 million dollars to support the protection of urban natural areas in 2012.

Urban planning changes occur simultaneously at the provincial, regional and municipal levels. The revision of the laws on planning and development in 2014–2016 will result in an overhaul of the development schemes of regional county municipalities (MRC), which catalyze the urban planning of municipalities.

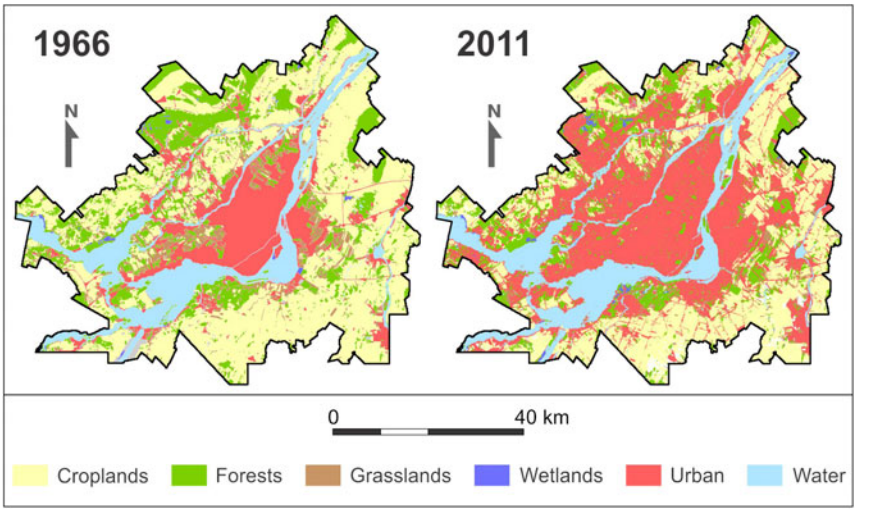

FIGURE 3. Change of land use in the Montreal Metropolitan Community between 1966 and 2011. *Source*: 1966: Canada Land Use Monitoring Program, http://geogratis.cgdi.gc.ca; 2011: Base de données de cultures généralisées (BDCG)—Financière agricole; Base de données topographiques du Québec (BDTQ)—MRNF; Inventaire des terres du Canada—Productivité forestière des terres; Produits du système d'information écoforestière (SIEF); Système d'information hydrogéologique (SIH); Cartographie des milieux humides de la Communauté métropolitaine de Montréal Canards Illimités Canada. (Partially adapted from Dupras and Alam, 2015.)

Additionally, numerous actions for the protection of natural heritage have already been undertaken to consolidate and ensure the sustainability, productivity and integrity of its agricultural and natural environments (Communauté Métropolitaine de Montréal, 2011). These actions are not only deployed in the areas of conservation and agriculture; citizens, municipalities, the provincial government, as well as tourism and forestry sectors readily acknowledge the need to integrate biodiversity into the strategies targeting the development and exploitation of natural resources (Fondation David Suzuki, 2012).

Currently, two projects are suggested to provide the GMA with a development plan based on the concept of green infrastructure: (1) a politically-based project focusing on access to the natural environment proposing the protection of 17% of the territory to maximize its public accessibility (Communauté Métropolitaine de Montréal, 2011), and an ecologically-based project, aiming to maximize the ecological connectivity through the establishment of urban, forest and agricultural green corridors. While the first project is proposed by the administration (MMC), the second emerges from NGO's actions. It is led by the Green Belt Movement (namely *Mouvement Ceinture Verte*), a coalition of environmental organizations dedicated to the promotion and creation of green infrastructure in the Montreal region within the ecological region of the GMA.

Given these important local developments and the open window on the future design of land use management, in this research we look at the context and conditions for the implementation of the best development strategies in urban planning and suburban-urban areas. What should be the characteristics of a

green infrastructure to ensure the ecological integrity of the region? What are the constraints and opportunities associated with the implementation of this infrastructure? What tools are available for its implementation? What form of governance should it be provided? These are the questions this study aims to answer by probing the views and recommendations of key stakeholders in the development of Montreal.

3. Methodology

For this investigation, we used semi-structured interviews, which gives freedom of discourse to respondents in a relatively strict framework. It provides us with qualitative data from a relatively small number of respondents (Patton, 2002). We used selected questions to probe the diversity of opinions, perceptions and interests of respondents (Patton, 2002) and that allowed us to know their individual prospects as well as their personal experiences.

In preparation for the interviews and based on a literature review related to investigation techniques, regional land use changes and green infrastructure, we developed an interview guide around 7 open questions

1. What key characteristics should define a green infrastructure at the ecological, geographical, legal and administrative levels?
2. What should be the priority actions to initiate its implementation?
3. What are the main social, economic and environmental benefits it could bring?
4. What are the main social, economic and environmental disadvantages it could generate?
5. At present, what are the most important opportunities that could help its implementation?
6. What are the biggest obstacles that could hinder or prevent its implementation?
7. What are the administrative, political and legal tools, current or planned, which are most useful for its management?

The sample was composed of respondents from the main governmental and non-governmental institutions involved in planning or whose activities have important impacts on land use modifications. From the 50 invitations sent to these key actors of GMA, 32 people agreed to participate. Table 2 collates their affiliation and range of action. The interviewees are mainly from three groups: 10 persons working in public agencies or departments of the Government of

TABLE 2. The institutionnel associations of experts interviewed in this study

Type of organization	Province of Quebec	GMA	MMC	Total
Public institutions	10	–	–	10
Parapublic institutions	7	3	2	12
Non profit organizations	5	5		10
Total	22	8	2	32

Quebec related to spatial planning (e.g. natural resources and environments ministries), 12 working in parapublic organizations affecting land use management (e.g. Regional Commissions on Natural Resources and Territory, Regional environmental Boards) and 10 from non-profit and non-governmental organizations working in forestry, environment, tourism and agricultural sectors. At the end, even if respondents are from different areas of expertise and range of action, we can conclude that our sample represent people well versed in environmental planning and concerned by the impacts of urban sprawling.

The in-person interviews were scheduled to last about 60 minutes, and recorded. After the discussion, respondents were asked to write their main answers on a paper questionnaire. The interviews were conducted from November 2011 to May 2012, in the offices of the interviewees.

Motivated by the production of descriptive and relatively objective data, we conducted a formal quantitative content analysis of the collected discourses. According to Bardin (2013), it is a relatively reliable way to proceed because it is a systematic, controlled and reproducible investigation and analysis. The information was classified in a grid based analysis of themes and topics covered by the respondents. We filled the grid by adopting classification, comparison and counting rules. We analysed the information both by the occurrence of keywords (themes) and its frequency. Using this content analysis strategy, we aimed to address the most common themes, assuming that the frequency reflects the importance of a theme by respondents.

The analysis was done in two steps. First, we transcribed the main components of the interviews and then recorded the main issues raised by respondents in a first intuitive reading (floating reading). Additional floating readings clarified the categorization for each question. The categorization was determined from a dozen of interviews where the material was divided into themes (coding). After the first classification, an inductive approach was applied passing from a specific statement to a more general representation of an idea (Patton, 2002). Other reinterpretations have enabled us to build an analytical framework with statements collected at progressive rate. This allowed us to determine the categorization criteria for the seven questions. The selection criteria respected classic qualities' indicators categories: completeness, exclusivity, objectivity and relevance (Patton, 2002).

Any content analysis of discourses obliterates some parts of the message, reducing their quality and richness. However, we feel that this technique has allowed us to understand the views and opinions of experts from different disciplines and backgrounds.

4. Results

The elements of experts' answers that raised consensus in the seven questions are presented in Table 3.

4.1 Green Infrastructure's Characteristics

From a biological and ecological perspective, three elements arise in the experts' responses: the conservation of natural habitats was indicated by 44% of experts,

TABLE 3. Elements of consensus in the experts answers

Question theme	Elements of consensus
Green infrastructure's characteristics	– Landscape connectivity
Priority actions	– Communication and public awareness – Legal recognition
Main advantages	– Maintaining quality of life
Main disadvantages	– None
Implementation opportunities	– Actual political context – Programs of acquisition of natural area – Public interest in environmental issues
Implementation obstacles	– Lack of political will – Poor overall vision – Disinformation
Tools	– Development plan of MMC

Note: A consensus represent and element that have been cited by more than 50% of the experts.

the ecological connectivity by 41%, and, 16% indicated compensation mechanisms as a solution to maintain the regional biodiversity potential.

Surprisingly, when asked about the geographical characteristics that should be present in the green infrastructure, the experts did not focus on the geographic boundaries (should it be the city of Montreal, the MMC or GMA?). The responses are mostly directed towards the network structure. Connectivity was raised by 56% of respondents, while 22% stressed both the importance of access to natural environments distributed over the entire territory, and the need to maintain an regional vision in territorial planning.

From a legal point of view, the experts identified two main points (31% of experts in each case): the respect of private property (in response to certain expropriation processes experienced in the region in the 1970s) and the harmonization of legislation at different levels of intervention, from local to provincial. Only 19% of the interviewees stressed the need for a stronger legal framework for the conservation of natural environments, whereas 6% noted that the conservation of natural habitats required a framework for multiple legal actions deployed in a transversal strategy.

The points mentioned on the Governance by the largest number of experts are the need to better equip policymakers with decision making tools to protect and enhance the natural environment (38%), to have a flexible and dynamic regional administrative structure (34%), the involvement and development of agricultural land (31%), citizen involvement in the design and governance of the project (31%) and a decentralized policy management respectful of different levels of government (provincial, regional and municipal) (28%). Only 13% of the respondents suggested that the green infrastructure should be managed by a public or quasi-public agency working regionally.

4.2 Priority Actions

Among the eight priority actions four were mentioned by more than 40% of experts. These were the communication and public awareness of the importance

of green infrastructure (56%), an urgent need for legal recognition (53%), the importance of considering the economic contribution of non-market services produced by ecosystems in taxation and decision services (47%), the protection of vulnerable natural environments (41%) and fostering the participation of local stakeholders and citizens (38%). Finally, the development of research on green infrastructure and the involvement of elected representatives were listed as a priority by 34% and 25% of experts respectively.

4.3 Main Advantages and Disadvantages

Figure 4 summarizes the social, economic and environmental advantages and disadvantages of a green infrastructure. The main benefits appeared to be environmental, whereas, the disadvantages were primarily economic, no environmental disadvantage was mentioned by respondents.

The main social benefit that would result from the introduction of a green infrastructure, as mentioned by 59% of respondents, is maintaining the quality of life. Accessibility to natural environments is also noted (16%), followed by the social vitality (9%) and the protection of multifunctional landscapes (3%). The main social disadvantage mentioned is the risk that this type of project be frowned upon by the community, which would for example put a brake on the development of their community or raise the specter of expropriation (38%). The possible generation of conflicts between stakeholders with different interests is mentioned by 22% of respondents, while 19% highlight both the risks of creating a third ring of urban sprawl and gentrification.

In general, few topics and responses were generated to illustrate the economic benefits that could result from a green infrastructure in comparison to the disadvantages. 28% of experts noted the possibility of an increase in tourist and recreational potential of the area while 25% talk about the need for a common development and management policy for the territory that could lead to economic gains. One person noted that green infrastructure contributes to the increase of market and non-market ecosystem services that have an economic value.

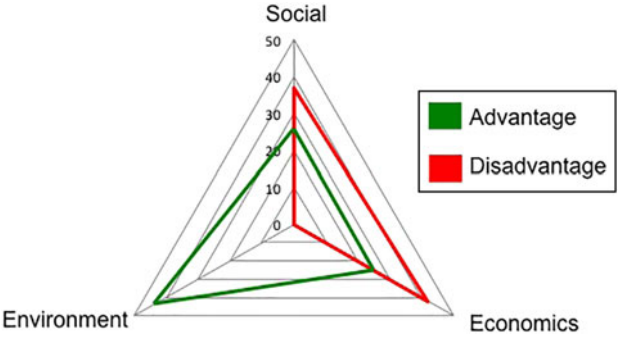

FIGURE 4. Summary of expert opinion on social, economics and environmental advantages and disadvantages of a green infrastructure in the region of Montreal. The units represent the aggregation of expert answers to Question 4.3.

According to the experts, the main disadvantages are economic: 34% of the interviewees pointed to the reduction in tax return for municipalities and the increase pressure on the private sector, mainly developers. This theme was followed by the rising costs of land management (19%), the loss of agricultural income (19%), and a potential administrative burden that would add institutional complexities involved in such a project (16%).

According to the respondents, the most important gains that emerge from a green infrastructure would be environmental. Production of ecosystem services, access to natural environments and better management of natural resources are the most cited points with respectively 38%, 38% and 34% support. Protection of regional biodiversity was mentioned by 19% of respondents and the control of water runoffs by 9%. No environmental disadvantages have been raised.

4.4 Opportunities and Obstacles

The respondents have identified more obstacles to green infrastructure development than opportunities.

For 78% of experts, the greatest opportunity that arises in the present context is the period of rethinking the planning by regional public institutions. The acquisition of natural area programs jointly implemented by the provincial government and conservation NGOs is seen as an opportunity to facilitate the implementation of green infrastructure by 66% of interviewees, and the public interest in environmental issues and nature conservation by 63%. To a lesser extent, two other themes related to Opportunities have been raised: Adaptation of the agricultural sector to environmental concerns through the adoption of good management practices (31%), particularly through planting riparian strips and windbreaks, and the possible implementation of profitable activities, including tourism and recreation (19%).

Out of all the responses compiled in this survey, the highest consensus (84%) concerned the constraints to the implementation of green infrastructure: the lack of political will among politicians and elected representatives, at all levels combined. The poor overall vision (59%), disinformation (50%) and the lack of resources allocated to this initiative by the agencies (44% each) are three other important obstacles. Gray infrastructures are cited as a constraint by 38% of respondents because of their important physical impact on the territory and their weight in the vision of urban development. Finally, the respondents pointed out competition and demand for land use (28%), the difficulty of the application of laws and regulations (25%) and the difficulty of reaching citizens (22%).

4.5 Tools

The main tool to promote the implementation of green infrastructure is, according to 66% of respondents, the development plan of MMC, where the stated guidelines of development planning encourage the development of a regional green infrastructure. This plan is followed in importance by the acquisition and stewardship of natural environments by NGOs (44%) and the program and tax incentives for ecological gifts (38%). To a lesser extent, provincial laws such as

the Act on Environmental Quality (19%) and the riparian zones (9%,) were also mentioned.

5. Discussion

From a cross-sectional analysis of the results, we can drawn four main points in relation to green infrastructure and the situation in the region of Montreal: (1) experts agree on the importance and emergency of the implementation of ecological regional planning and the need for new planning tools; (2) a consensus emerges on the spatial arrangement of the plan: a green infrastructure based on ecological urbanism, ecological connectivity and ecosystem multi-functionality; (3) green infrastructure and the protection of nature, in general, face constraints primarily because economic losses are generated; (4) the main obstacles to the implementation of a green infrastructure is the lack of political will. In the following subsections, we discuss these four points and highlight what lessons other metropolitan regions and green infrastructure planning in general can learn from Montreal's experience.

5.1 New Planning Vision and Required Tools

There is a need for action in the discourse of experts to address issues related to the legal recognition of a green infrastructure, the communication of its costs and benefits to the general public, and the protection of the remaining natural environments. There is an urgency because of the significant environmental degradation of the region begun in the middle of the last century (Brisson & Bouchard, 2003). The cumulative effects of historic pressures on the landscape such as urban sprawl, land-use conversion and the high dependence on the automobile combined with other current and future impact such as climate change and invasive species (for instance, the emerald ash borer), urges experts to find new solutions that can combine urban development, whilst respecting the ecological integrity and maximization of resilience (Pan *et al.*, 1999; Jobin *et al.*, 2010).

From the same perspective, the experts stressed the need to quickly review the toolbox available to managers and policy makers. Indeed, very few tools are specifically dedicated to the promotion of ecological urbanism and green infrastructure. The only one available, the regional development plan of the MMC, proposes the implementation of a green infrastructure network, but suffers from its lack in providing legal tools, policies or programs to facilitate its implementation. Moreover, the plan does not encourage constraining measures for territorial planning and the protection of natural environment, but rather proposes incentives based on the willingness of stakeholders and performance indicators.

Existing legal tools for the development of green infrastructures are difficult to apply because of the opposition of certain economic sectors, insufficient political will and insufficient resources. One of the most obvious examples of this challenge is the Quebec Act of Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains. In rural areas, landowners have to leave between 3 and 10 m of natural riparian strip to preserve the water quality and to limit erosion. However,

this element of the policy is rarely applied due to the three factors previously mentioned (Sager, 2004). Thus, a new vision of management and land use planning and the development of new legal tools for its implementation must be concomitant to social acceptability and resources that will ensure sustainability. These conditions for success based on an alignment between ecological urbanism and social acceptability have been raised by many authors, such as Yli-Pelkonen and Niemela (2004) and Kinzig *et al.* (2005) among others. The situation in Montreal is similar to several other cities in the world where planning tools and policies are reconsidered, especially in ecological and economics perspectives (see Section 5.3).

5.2 A Consensus Towards Ecological Urbanism, Connectivity and Multifunctionality

The vision of the spatial arrangement of the green infrastructure is representative of the overall trend that is apparent since the beginning of the 21st century, namely, a multidisciplinary approach to the planning and design of ecological networks that respects, preserves and enhances natural processes (Amati & Taylor, 2010; Ignatieva *et al.*, 2011). This is possible through the establishment of different types of green corridors and networks, optimization of patch sizes and spacing (Meurk & Hall, 2006) and sustainable management of many types of ecosystem services (Ignatieva *et al.*, 2008). In the last years, many cities, like Beijing (Yang & Jinxingb, 2007), Hong-Kong (Tang *et al.*, 2007) or London (Amati, 2008) had difficulty in efficiently containing and managing urban sprawling with traditional and rigid green space protection such as the green belts. One of the planner's reactions was to propose evolving from green belts to green infrastructures (Amati & Taylor, 2010; Thomas & Littlewood, 2010) in order to enhance ecological connectivity and allow flexibility in the design and management (i.e. from hard to soft governance). This was accomplished in several cities (e.g. Taylor *et al.*, 1995; Evans & Freestone, 2010), and in sub-national (e.g. Northern England, see Thomas & Littlewood, 2010) and national (e.g. France, see Debray, 2011) urban planning acts.

The multifunctionality of a green network was also mentioned as an important advantage, experts saw opportunities to implement a connected network through the participation of diverse sectors like forestry and agriculture. From this perspective, a green network is a form of reconciliation of landscape ecology (e.g. habitat patch, hubs, corridors) and urban development. Bonds held in the framework are designed in a logical development of the countryside and built at various scales, from urban and suburban, at the level of cities, and larger territories (Fábos & Ryan, 2004; Clergeau *et al.*, 2006). The urban green network aims to provide both biodiversity conservation and social utility, a frame to meet the demand of urban nature and the need for densification of the city. The multifunctionality principle stems from a recurring theme in the study of ecosystem services. Increasingly recognized in recent years (Millennium Ecosystem Assessment, 2005), multifunctionality is, for the experts consulted in this study, a means to address environmental, social and economic benefits simultaneously. This is a strong argument in favour of green infrastructure

development and, as a consequence, the design of new indicators and decision support tools.

5.3 The Protection of Nature is (Still) an Economic Constraint

Trade-offs between the environment and the economy are a prerequisite. We observed a clear opposition between environment and economic advantages and disadvantages in the scenarios with or without a green infrastructure. Environmental protection is still seen as a constraint to economic development. Urban development, typically linked to the phenomenon of urban sprawl, where municipal revenues rely heavily on property taxes and generates a strong spatial demand, is still strongly present in the minds of politicians and policymakers.

To rethink the economics of ecological urbanism, the experts highlight the economic opportunities associated with the green infrastructure. Various approaches exist to measure the green infrastructures contribution to economic growth and investment, land and property values, labour productivity, tourism and agriculture (Vandermeulen *et al.*, 2011). More broadly, this measure of economic advantages joins the concept of ecosystem services, both market or non-market benefits provided to communities by nature. In this context, the experts underlined the need to take into account in planning decisions the benefits provided by the cultural services such as recreation and tourism activities and aesthetic landscapes, regulating services (e.g. control of water runoff and flooding) and support services such as habitat for biodiversity. In recent studies, Dupras *et al.* (2015) show that 11 non-market ecosystem services provided by the ecosystems of the GMA have an annual value of $ 2.2 billion, while Dupras and Alam (2015) showed significant losses in value of ecosystem services ($ 235 million per year) related to urban sprawl.

World-wide, ecosystem services valuation is a growing field of research that has the potential to make some very positive changes in urban land-use planning (The Economics of Ecosystems and Biodiversity—TEEB, 2010). The central role that ecosystem services play in local economies is often taken for granted, and their economic valuation can reveal certain opportunities and trade-offs among various policy options, planning proposals or infrastructure choices (The Economics of Ecosystems and Biodiversity—TEEB, 2010). As in Dupras *et al.* (2015), several studies have examined the economic valuation of ecosystem services in urban areas. We can cite as examples the work of Wilson (2008) in Toronto (Canada), Schäffler and Swilling (2013) in Johannesburg (South Africa), Kreuter *et al.* (2001) in San Antonio (Texas, USA) and Tianhong *et al.* (2010) in Shenzen (China).

However, the operationalization of ecosystem-service knowledge is in its initial stage and planners are facing difficulties in integrating these new ideas in their existing planning and decision-making tools and processes (Albert *et al.*, 2014). This is particularly true for elements that cannot be quantified, like most of the cultural services, and elements presenting a virtually infinite value, based on their cultural or ecological uniqueness. Moreover, being based on a lot of subjective and hypothetical assumptions, ecosystem services valuation is far from being an exact science (Spangenberg & Settele, 2010). This approach will provide

context and method-dependant prices instead of a general measurement of the value of biodiversity, ecosystems and services. Consequently, in order to efficiently integrate public policies, something more hard-nosed is also needed.

In summary, the experts investigated in this study believe that the recognition of these non-market ecosystem services values in the decision-making tools should be a priority for action. We also believe that this new information can have an eye-opener effect and may speed up the spread of these ideas into political and decision making domains. However, they should be combined with more tangible economic indicators in order to efficiently integrate the actual planners' decision-making tools. For example, Schäffler and Swilling (2013) suggest to couple ecosystem services values with the investments that are already made by citizens towards nature and economic supply chains that are related to the green infrastructure. In the same way, in order to acknowledge the public good character of ecosystem services, and capture the social and economic value of ecosystems services, consensual, multi-criteria and multi-stakeholder valuation processes were also developed (Kumar & Kumar, 2008). With an institutional perspective, we may conclude that transitions are necessary and at all policy levels. If the maintenance of ecosystem services can be achieved without direct economic valuation, sustainability policies that take into account the contribution of ecosystem and their services to communities' welfare are essential.

5.4 *Lack of Vision and Political Will*

Although the benefits of green infrastructure are well documented at global (Tzoulas *et al.*, 2007; Ignatieva *et al.*, 2011) and local (i.e. Montreal) scales (Fondation David Suzuki, 2012; Dupras *et al.*, 2015), the rather negative view concerning the implementation of a green infrastructure by political authorities echoes the conclusions of Jim (2004) regarding the difficult transition of this knowledge from research to politics. The obstacles to the implementation of the green infrastructure, such as a lack of political will, poor overall vision and disinformation, are among the most important consensus of our study.

The favourable context in the Montreal region and yet such strong political, legal and economic obstacles to green infrastructure development raises an interesting paradox. This may be linked to the political dynamics in Quebec and Montreal at the time the interviews were held. Since the autumn 2011, police investigations and a public commission held on the construction industry[2] have made public numerous cases of corruption among politicians, entrepreneurs and organized crime causing a significant negative impact on the land and environment, including the intensification of speculation and re-zoning observed over the last few decades (Marois *et al.*, 1991; Sénécal *et al.*, 2001). This has certainly contributed to increasing the cynicism of respondents towards the political will, as well as the difficulty of enforcing environmental laws and regulation; a phenomenon that has been previously described (e.g. Bohman, 1996; Chaloupka, 1999). The complexity of the governance of the territory of Montreal, a highly decentralized multi-scale structure (Communauté Métropolitaine de Montréal, 2010) also contributes to the difficulty of implementing a shared regional vision.

This negative vision towards public institutions is case-sensitive, but a parallel can be drawn with other international experiences which demonstrated that environmental programs, policies and acts on green infrastructures are embedded in specific institutional and political contexts, which often represent the main criteria for their success or failure (Ali, 2008; Amati & Taylor, 2010; Thomas & Littlewood, 2010). In that sense, an interesting comparison can be made with the City of Toronto. After several decades of a strong, continuous and conflict-generating tradition of rethinking urban growth, an upscaling of traditional urban-regional regulation was made by the provincial government of Ontario through the implementation of a green belt legislation. In first instance, with this act the province took back and fully occupied the space of regional planning (Macdonald & Keil, 2012). The upscaling through the green belt legislation outflanked the traditional lines of conflict between cities and regions and regrouped decision-makers, contesting voices, elite organizations, citizens' groups, transportation planners, and environmentalists around an emerging regional project. In her analysis of the green belt implementation, Ali (2008) concluded that the two key elements of success that ensured and enforced the implementation of the green belt plan were a strong political will and an enabling legislation. These two elements are missing in Montreal and this might explain the difficulty to implement a green infrastructure as experienced in the region for several decades now. Toronto constitutes an excellent example of the effects and power of political will on scaling and new regionalism in planning theory and practice.

6. Conclusion

Many initiatives and programs reflect a growing interest in the development of green infrastructure in the region of Montreal. The natural, political and structural complexity of the area and the many issues related to its implementation make it a challenging endeavour. Among the main challenges, the structure of municipal tax return is important. Its dependence on urban expansion, coupled with strong growth in land values of agricultural and natural land in the region, is a disincentive to the protection and enhancement of natural environments. The predominance of private land tenure in the region, the administrative complexity of the territory and the large number of actors and types of interventions involved complicate the implementation of a proposed green infrastructure overseeing the entire GMA. This study helps to identify, classify, and differentiate experts' views and opinions on the development of a green infrastructure in the Montreal region.

From this GMA study, four main conclusions could be drawn and be relevant for green infrastructure planning in general:

(1) To develop a sense of belonging – It is crucial to inform and commit citizens and elected officials. These actions could be centered on actions to mobilize and inform citizens and decision-makers by proposing a shared definition and structure of a green infrastructure, and consultation forum to assess stakeholder's visions and opinions.
(2) To define clearly and accurately prioritize conservation targets – This step in the deployment of a conservation strategy requires an acute knowledge of the

territory, including its biodiversity (e.g. species richness, ecosystem functioning, landscape connectivity) and its socio-ecological dynamics. In order to make informed decisions, conservation targets and habitat reconnection should be based on scenarios involving the application of a full range of tools designed for the conservation and enhancement of natural and agricultural space.

(3) To identify and recognize good practices that promote the realization of a green infrastructure – The emphasis should be placed on the actors and initiatives already in place. It includes projects and practices of stakeholders for the agricultural, forestry and urban planning sectors as well as political leaders, NGOs, citizens and businesses that are part of the protection and enhancement of the territory. Defining best practices in each category of actors would support and promote their adoption.

(4) To put in place an efficient and flexible structure for mobilizing stakeholders – This requires the development of an integrated multi-actor regional strategy that focuses on the definition of a co-designed action plan. This structure could identify sources of funding for the implementation of the green infrastructure, harmonize funding programs, and establish a coordination structure, with a light and flexible financing. These actions would be implemented and regularly monitored for the improvement of the action plan, towards an adaptive implementation and management of the green infrastructure.

Faced with this complex reality, and a diverse array of objectives across many actors, it will be essential for local planners to identify key focal points upon which to build a clear and precise road map for the implementation of a green infrastructure in the region.

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Notes

1. MMC is an organization that offers regional management services to the population and land use planning of the urban area of Montreal.
2. Commission d'enquête sur l'octroi et la gestion des contrats publics dans l'industrie de la construction, on line (August 25, 2014): https://www.ceic.gouv.qc.ca

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