On Plans to build new housing on the West island in Pierrefonds and the REM Skytrain brief to ocpm 2017-04-26

On the current plans to develop buildings on the land which was zoned Urban from Agricultural in September 1991, and the dreadful mass transportation rail system that has precipitated these plans. 2017-04-25

Twenty five years ago in 1991, I had the opportunity to write a brief and speak against the de-zoning as agricultural land, an area of which Pierrefonds now wants to build up with houses. The plans made in support of this idea is for more of the same as has been built on most of the other land that was rezoned in 1991. The unpopular decision made then, to approve this urbanization of the land for the kind of development that has happened was wrong then; and the development of this land now, with more buildings and services: sewers, water roads and electrical services, schools, local commerce and the like, makes little sense today. More than ever Montreal suffers from far too much urban sprawl of the worst sort, damaging to the production of Greenhouse gasses, un-economical mass transit solutions, and the forced use of automobiles, to allow people of all ages to get around. The promise of the promoters of the REM to build thousands of apartments in blocks which has seduced the political powers behind the Pierrefonds and the Ste-Anne de Bellevue municipalities to believe that their cities will be able to benefit from new growth along the new Skytrain rail lines will simply aggravate the problems that increased urban sprawl have created for today and will go on worsening in the foreseeable future, if the land in question is developed with any sort of buildings.

The land should revert to some agricultural production as model farms and as natural spaces. A large park would be a very good idea that would eventually be another Mount-Royal Park. If necessary, the speculator owners so long waiting for their payday, should be bought off at fair prices. The avoidable ecological damage that urban development would do would be worth any reasonable sum. Such investment in which speculators have engaged, shouldn't have a guarantee of limitless profits that await patience for decades, waiting for builders to come along.

Montreal's urbanized area is already greatly extended. It is a relatively low density highly extended urbanized city. See the ecological research that has been done at Concordia University by Nazarnia, Schwick, and Jaeger, *Accelerated Urban Sprawl, Montreal, Quebec City and Zurich: Investigating the Differences, using time series 1951-2011*, Our whole region is a prime candidate to be designated as an area where very sparing new extension of the built-up area should be allowed under almost any circumstances for some time. The Excuse that the REM will open the area for new development should be rejected along with the new plan submitted by Pierrefonds. The money for the REM can be much better used for new infrastructure in the centre and east of the city

I most especially urge you to reject the idea that the Caisse de Dépôt will be able to build enough apartment buildings for the tens of thousands of families that would justify both the extension of the urban fabric and the profitability of their so called mass transit system which in this area, will damage the economic viability of the existing Hudson Rail line and the densification of their population which will be slowed down by whatever is forced along the unnecessary new line of the REM along autoroute 40. Further, even the success of new buildings here would only mean that other areas that are as under-developed as Pierrefonds is now, will await their own densification that much longer making their economic problems that much less soluble. It is only the possible advent of a mass transit system that will finally appear to justify the urban development of this, the finest farmland in the province, and its most valuable still viable natural spaces in the region, has finally moved the local municipality to

approve the massive public spending that they will have to undertake to allow the speculators who have waited two and a half decades, to finally unload their properties to merchant builders who will all build what will sell as quickly as possible for the maximum price. Some of the land will be developed as high rise buildings for those people who make all of this possible, the future tenants that are not here now, but whom the Caisse de Dépôt contend will justify their unecomical scheme to destroy several good public transit systems while they substitute others that are in every way inferior. Their transportation work as a whole has inferior qualities to what exists, by virtually every measure: environmental, in terms of every sin known to urban planning, enormous unnecessary costs that will raise fares, subsidies and municipal taxes. Provincial taxes as well will be raised to defray these unnecessary costs. La Caisse is in full control. They plan to be now and forever our masters of the public sphere with a bizarre - what they call : a public – public - limited corporate container whose private aspects will own forever a key public utility that has been democratically controlled for a hundred and forty years. Our existing systems have been nursed by experts in transportation and traffic science and engineers. All this history and its assets will be delivered to what is basically a greedy hedge fund. It is the tenth largest pool of private capital in the world; and it behaves as befits the role. It is by turns obsequious, arrogant, selfish - yet always comfortable in its abusive takeover of our patrimony.

Pushing this tawdry complex transit scheme on a public that actually sees it as: ”Hé, trains électriques!” and they see the Caisse as “…notre petit bas de laine… ; so what if it makes a lot of money. Isn’t that good for everyone.” Yes, it would be good for everyone if it wasn’t almost a criminal waste of our capital, a damage to our environment, an abuse of public subsidies and the paying clients of a mass transit system meriting conservation, and an abuse of all of us, when we have to pay for it all, through multiple taxes and high fares.

We urge you to read the pamphlets of the Trainsparance group, the documents submitted to the BAPE, their refusals to approve the REM line on which local politicians count to make the further sprawl possible. I urge you to reject the possibility that with a little tweaking, this total public transit disaster might be made somehow OK, or at least partly acceptable. The unethical push *survey (Suzuzki Foundation and Equiterre by Leger)* which is quoted by the press on every occasion simply asked whether citizens approved of electric trains. They assumed that respondents knew the facts and the figures behind the unbelievably complex eight Billion dollar project with one glib question.

Our transportation systems need new equipment, a lot of it, but not here in Peirrefonds west. Economical plans, long discussed by the expert authorities which designed and ran our public transport infrastructure, had and have profitable plans for trams and tram trains which have been long needed where population densities are high, where money won’t be wasted, where existing good infrastructure will be conserved.

We urge you to learn about the Grand Virage, one good plan among others, that make sense, that conserve our ownership of our transportation heritage. We urge you to start the process of refusing more urban sprawl. If not here – Where ? Don’t let yourselves down. Don’t let the region down. Past mistakes elsewhere, just like this example, have cost us all dearly.

Michael Fish

Mr. Fish was an architect from 1958 to 1994. He is now retired

Annexe - extrait d'un article de 24 pages
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Accelerated urban sprawl in Montreal, Quebec City, and Zurich: Investigating the differences using time series 1951–2011

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ABSTRACT

Increasing awareness of the negative effects of urban sprawl has made sprawl a topic of great debate. However, higher efforts are needed to protect forests, agricultural lands, and other open spaces from urban sprawl. This study compares patterns of accelerated increase in sprawl in the Montreal and Quebec Census Metropolitan Areas in Canada with the Zurich metropolitan area in Switzerland between 1951 and 2011. We applied the recent metrics of urban permeation (*UP*) and weighted urban proliferation (*WUP*) to measure urban sprawl. Urban sprawl has accelerated continuously in Montreal and Quebec since 1951. Here, the fastest increases in sprawl have been observed in the last 25 years, whereas in Zurich the strongest acceleration was in the 1960s. Urban sprawl has increased exponentially in Montreal since 1951. On the Island of Montreal, the degree of urban sprawl (*WUP*) increased 26-fold from 0.49 UPU/m^2 in 1971 to 12.74 UPU/m^2 in 2011, while in Quebec City it increased 9-fold from 2.41 UPU/m^2 to 21.02 UPU/m^2 from 1971 to 2011. In contrast, the level of sprawl (*WUP*) in the Inner Zurich metropolitan area increased almost 3-fold from 3.12 UPU/m^2 in 1960 to 8.91 UPU/m^2 in 2010, i.e., it was higher before 1980, but then was surpassed by Montreal and Quebec City. The strongest increases in land uptake per person were observed in Quebec City and on the Island of Montreal, while it increased only slightly in Zurich. Two major reasons for this striking difference in sprawl dynamics are Switzerland's stronger planning legislation since 1979 and a much higher level of public transportation availability in Zurich. The comparative analysis of urban sprawl presented in this study can greatly help land-use planners critically assess projected plans and control urban sprawl and its negative consequences. The *WUP* method can also be used to establish targets and limits to urban sprawl and to evaluate the effectiveness of measures to control sprawl.

1. Introduction

More than half of the world's human population has been living in urban areas since about 2008 as a consequence of population growth and a movement of people from rural to urban areas (UNFPA, 2007). For example, while only 50% of Americans lived in cities in 1950, 80% lived in metropolitan areas by the 1990s (Putnam, 2000). In many cases, this has resulted in urban sprawl, in particular in North America where low-density suburban development and automobile dependency have been prevalent, but also in many other places all over the world for similar reasons (Irwin and Bockstael, 2002; Batisani and Yarnal, 2011; Hennig et al., 2015).

1.1. Causes and consequences of urban sprawl

Many factors contribute to the particular pattern of urban development known as urban sprawl, e.g., consumer preferences for inexpensive lots, single-family detached housing, and for living in green low-density neighbourhoods, and the wish for second homes. Telecommunication improvements and low gasoline prices have made human choices of dwelling locations more independent of their distances from central facilities (Ewing, 1997). Unorganized patterns of growth have resulted from planning activities without

Abbreviations: CMA, Census Metropolitan Area; CMM, Communauté Métropolitaine de Montréal; *DIS*, dispersion; FSO, Federal Statistical Office of Switzerland; *LUP*, land uptake per person; MA, metropolitan area; NTDB, National Topographic Database; PMAD, Plan Métropolitain d'Aménagement et de Développement; RCM, regional county municipalities; TLM, topographic landscape model; TOD, transit-oriented development; *UD*, utilization density; *UP*, urban permeation; URSMEC, URban Sprawl MEtrics Calculation (tool); *WUP*, weighted urban proliferation.

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a clear vision for the future (Wright and Boorse, 2013). Public policies, such as taxation systems, subsidies, and road construction, may contribute to, or moderate, the drivers of urban sprawl.

However, sprawl is an unsustainable form of development due to its many harmful environmental, economic and social effects. Soil sealing, increasing scarcity of land for renewable energy and food production, increase in greenhouse gas emissions and water pollution, loss of habitats and valuable ecosystem services, lower infrastructure and public transportation efficiency, long commuting times, and reduced civic involvement in the society are widespread consequences of urban sprawl (Haber, 2007; Frumkin, 2002; Forys and Allen, 2005; Siedentop and Fina, 2010; Ewing, 1997; Putnam, 2000).

In Canada, urbanization is the second most important human activity causing habitat loss, which in turn is the most prevalent threat to endangered species in this country (Venter et al., 2006). The effects of urban sprawl are cumulative, i.e., they result from the combination of all development projects, and most are irreversible in human time spans. Therefore, effective efforts are needed to better apprehend, measure, and control sprawl.

1.2. Definition of urban sprawl

The wide variety of definitions of "urban sprawl" have rendered the term fuzzy (Audirac et al., 1990). Three main reasons for this confusion are that (1) sprawl has been defined differently by different disciplines (Bhatta et al., 2010); (2) it is difficult to distinguish "sprawl" from similar terms such as "suburbanization" or "suburban development" (Maier et al., 2006); and (3) causes and consequences of sprawl are often confused with the phenomenon of sprawl itself (Jaeger et al., 2010a). Hence, a reliable definition of urban sprawl is needed, and this study uses the following: "The more area built over in a given landscape (amount of built-up area) and the more dispersed this built-up area in the landscape (spatial configuration), and the higher the uptake of built-up area per inhabitant or job (lower utilization intensity in the built-up area), the higher the degree of urban sprawl" (Jaeger and Schwick, 2014). This definition is based on a comparison of definitions in the literature (Jaeger et al., 2010a) and served to develop a recent metric of sprawl according to 13 suitability criteria (Section 2.2).

1.3. Comparing urban sprawl in Canada to Switzerland

There is increasing consensus among scholars, decision makers, and the general public that most Canadian cities are severely affected by urban sprawl. However, most studies in Canada focus on the consequences and other aspects of sprawl rather than the degree of sprawl itself. Examples are the investigation of direct and indirect impacts of urban development on land conversion by Pond and Yeates (1993) and the comparison of residential density between four major metropolitan areas of Canada by Filion et al. (2010). The latter study identified Montreal as a more administratively fragmented and decentralizing metropolitan area compared to Toronto, Vancouver and Ottawa. A study about the relation between municipal fragmentation and suburban sprawl in North American cities identified Montreal and Quebec City as the most municipally fragmented metropolitan areas in Canada (Razin and Rosentraub, 2000). When comparing 96 cities in North America, Montreal and Quebec City were found to be more similar to US metropolitan areas than most other Canadian metropolitan areas (since five of the ten least fragmented metropolitan areas were Canadian: Toronto, Calgary, Hamilton, Winnipeg, Vancouver and Ottawa; Razin and Rosentraub, 2000). Municipal fragmentation was measured based on the number of local governments in relation to the number of residents, the existence of multi-purpose metropolitan governments, and the proportion of population in the cities of more than 100,000 residents in the metropolitan area. A low level of municipal fragmentation did not directly correlate with compact urban development. However, a low level of municipal fragmentation could be a precondition for less dispersed urban development because the existence of numerous local governments may encourage sprawl through less coordinated planning (Razin and Rosentraub, 2000).

Few studies have measured urban sprawl in Canada. Sun et al. (2007) used Shannon's Entropy to measure the level of urban sprawl in Calgary for six points in time: Shannon's Entropy increased continuously from 0.850 in 1985 to 0.905 in 2001 indicating an increase in urban sprawl.

The Montreal and Quebec Census Metropolitan Areas (CMAs) lack a quantitative assessment of urban sprawl. About half of the population of the Province of Quebec lives in the Montreal CMA, and one-tenth lives in the Quebec CMA. Located on the north bank of the Saint Lawrence River, Quebec City is among the oldest settlements in North America and is the political capital of the Province. The Montreal and Quebec CMAs comprise lands that are among the most fertile in Canada. However, many fertile areas have been converted to urban land use during the past few decades. In Montreal, population growth in combination with a continuous reduction in population densities in the central zones of the city since 1950 can partly explain the current level of urban sprawl. In the 1960s, the population spread towards the Eastern and the Western parts of the Montreal Island and to Laval (north of Montreal Island), which resulted in a high increase in urban sprawl. Since 1996, migration to suburbs located further from the Island of Montreal has also risen strongly (Linteau, 2013). In Quebec City, population growth along with the extensive growth in the amount of built-up areas are among the main drivers of urban sprawl. Between the years 1971 and 2006, the population of the Quebec CMA increased by 62%, where during the same period of time, the built-up areas increased by 261% (CMQ, 2006).

The Communauté Métropolitaine de Montréal (CMM) council published a metropolitan land use and development plan in 2011, entitled "Plan Métropolitain d'Aménagement et de Développement" (PMAD), that presents the projected urban development and the associated land-use challenges in greater Montreal. The CMM estimated that the population of greater Montreal will increase by 530,000 additional people (or 320,000 households) by 2031. It also predicted that 150,000 new jobs will be created by 2031. The CMM proposed that transit-oriented development (TOD) neighbourhoods should be the main focus for future urban development to increase mass-transit use and reduce the proportion of private transport. The PMAD also suggested that the densification of the urban areas between the vacant lands outside of TOD zones should be considered in projected developments (CMM, 2011).

We wanted to compare Montreal and Quebec with a contrasting region that (1) has a significantly higher modal share for public transport, (2) has a longer history of development with a significant level of sprawl in the 1960s, and (3) has a stronger regional planning legislation than Canada, while (4) it is part of the Western culture and has a comparable lifestyle. Therefore, we selected a region from Europe: Zurich metropolitan area (MA). The cantonal government of Zurich created a Specialist Department for Spatial Planning (Fachstelle für Raumplanung) in 1942, which is the Office for Spatial Development (Amt für Raumentwicklung) today. Sensitive areas were protected from construction activities by regulations in the canton of Zurich for the first time in 1942. The canton has implemented Regional Comprehensive Plans (regionale Gesamtpläne) on a regular basis since 1948. The revision of the Construction Act in 1959 distinguished designated building zones from non-building zones. The designated building zones of the years between 1964 and 1973 were rather large, based on the predicted increase in population and employment, and they were significantly reduced in

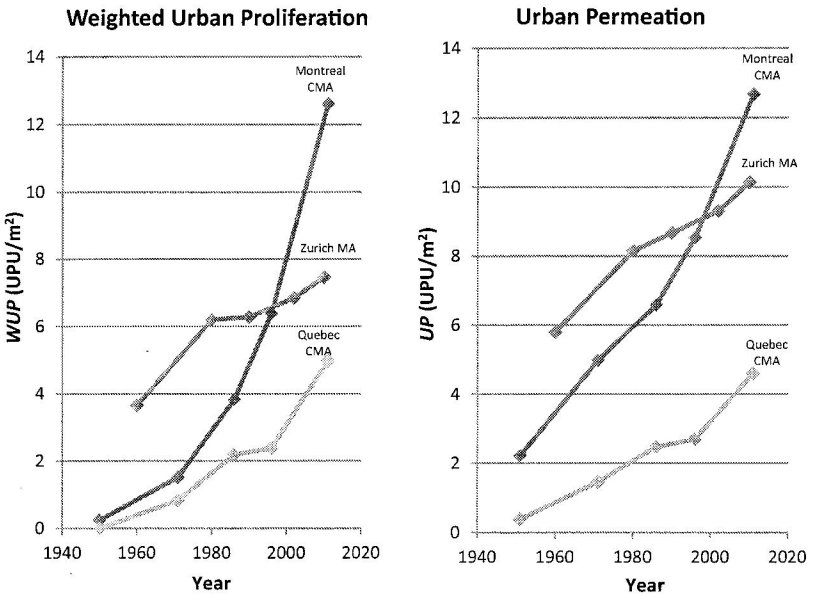

Fig. 6. Increase in the values of weighted urban proliferation (*WUP*) and urban permeation (*UP*) in Montreal CMA (always for the 2011 delineation), Quebec CMA (2011 delineation) and Zurich MA since 1951 (using average *WUP* for Montreal and Quebec CMAs). Calculation of average *WUP* used for the years 1951–1996 and the use of correction factors for the calculation of *UD* for these years for the Montreal and Quebec CMAs are presented in Appendix B.

districts with the lowest levels of sprawl (<0.7 UPU/m^2). These districts are all located in the centre of the Island and constitute the city core of Montreal, which is the most densely populated space in Montreal.

The *WUP* values in districts off the Island of Montreal (i.e., Laval, Deux-Montagnes, Les Moulins, L'assomption, etc.) were always higher than 8 UPU/m^2, with the exception of Mirabel and Rouville (3.05 and 3.84 UPU/m^2, respectively), while *WUP* is 27.07 UPU/m^2 in Laval.

In Quebec City, the district of L'Ancienne Lorette exhibits the highest and La Cité-Limoilou the lowest level of sprawl. The latter can be explained by the high value of *UD* (11,398 inhabitants and jobs per km^2) in this district which constitutes the downtown of Quebec City (Fig. 10a).

In the Zurich MA, a similar pattern is observed. The highest values of sprawl were found in the municipalities that constitute the suburbs (e.g., Zollikon, Kilchberg, Rüschlikon, and Erlenbach with *WUP* > 20 UPU/m^2). Municipalities located north of the city of Zurich are also highly sprawled (>15 UPU/m^2). They are covered by large built-up areas that are mostly a mixture of residential and industrial areas with relatively low values of *UD*. Low to relatively low values of sprawl are found in the outskirts of the Zurich MA. The city of Zurich (1.32 UPU/m^2 in 2010) and the city of Zug (1.71 UPU/m^2) are also among the areas that have lowest values of sprawl. Although these cities have large built-up areas, their *UD* is high to very high. All the other municipalities with *WUP* values of below 2 UPU/m^2 in 2010 are rural and located in hilly terrains.

3.2. Historic development

Urban sprawl in all three study areas has been continuously increasing. Until 1971, the degrees of urban sprawl in the Montreal and Quebec CMAs were close to each other, and much lower than in the Zurich MA. However, since 1971, urban sprawl in Montreal CMA has increased more sharply compared to Quebec CMA (Fig. 6).

Until 1997, the Zurich MA had the highest value of *WUP* among the three metropolitan areas, and only then was surpassed by the Montreal CMA. The Zurich MA clearly has a longer history of urban sprawl, and exhibited a much higher level of 3.65 UPU/m^2 in 1960 than the Montreal and Quebec CMAs, where it was still less than 1 UPU/m^2 at this time. Some may have expected that Zurich was less sprawled in 1960 than Montreal and Quebec. However, an important finding of our study is that sprawl in Montreal and Quebec is a more recent phenomenon than in Zurich, and the strongest increases in sprawl have happened since the early 1980s. Both Quebec and Montreal have exhibited their sharpest increases in sprawl during the past 25 years, whereas the sharpest increases of sprawl in the Zurich MA happened between the years 1960 and 1980, while urban sprawl in the Zurich MA increased less strongly during the past 25 years than in earlier times.

Since the comparison of values of urban sprawl in study areas of different sizes needs to be done with caution, to correctly consider the influence of the sizes of the reporting units, we also compared the three inner areas as their extents are very similar and their comparison is more straightforward (Fig. 7).

Utilization density has decreased significantly on the Montreal Island and in Quebec City. *UD* in Montreal Island decreased by about 50% (from 17,151 to 8237 inhabitants and jobs per km^2) and is now close to *UD* of Inner Zurich MA (7476 inhabitants and jobs per km^2). *UD* in Quebec City also decreased by about 50%, but starting in 1970 already from a level of 8079 inhabitants and jobs per km^2 which Montreal has arrived at today, down to 3798 inhabitants and jobs per km^2. In contrast, *UD* in the Inner Zurich MA has been almost stable, and even increased slightly in the periods of 1980–1990 and 2002–2010. It almost equals the current *UD* in Montreal and the *UD* of Quebec City in 1971.

Urban dispersion has been increasing in all three study areas, most pronouncedly in Quebec City, and the least in Zurich. Montreal Island has always exhibited the highest values of dispersion. The strongest increases in Montreal occurred between 1951 and 1971. In Quebec, the increase was more or less equally strong at all times. In the Inner Zurich MA, the sharpest increases took place in 1960–1980. Approximately in 1987, *DIS* values in Quebec and Zurich were similar, but *DIS* continued to increase faster in Quebec City.

Urban permeation also has increased; for example, *UP* in Montreal increased by a factor of three from 10.78 UPU/m^2 in 1951 to

We used the number of full-time equivalents for the calculation of *UD*, but these numbers may not always be available. The raw number of jobs can then be used instead as a good approximation: the value of *UD* will then usually be a few percent higher (3–8%), and rarely more than 10%. The differences in the resulting (lower) *WUP* values depend on the value of *UD* in the weighting function $w_2(UD)$, i.e., the differences can be small or rather large. For example, the decreases in *WUP* are 23.5% in Montreal Island (from 12.74 to 9.74 UPU/m^2), 3.3% in Quebec City (from 21.02 to 20.33 UPU/m^2), and 19.4% in Inner Zurich MA (from 8.91 to 7.18 UPU/m^2). One option to avoid this difficulty is to use a general conversion factor between jobs and full-time equivalents, which can be applied when no other value is available for the region studied. In Switzerland this factor is: 1 job = 0.85 fulltime equivalents. Alternatively, one can use the raw number of jobs (+inhabitants) for time series, but then the results cannot be directly compared to regions where full-time equivalents (+inhabitants) were used.

Future refinements of the *UD* metric are possible by also including the number of people using specific buildings (e.g., number of students in a school or visitors of theatres) in addition to the number of jobs, but such data may not be easily available.

5. Conclusion

In Montreal and Quebec, urban sprawl has gotten out of control and has turned into a serious and fast growing problem since the late 1980s. In the last 25 years, urban sprawl in Montreal and Quebec has become worse than ever before and has done so faster than ever before. Quebec City is a prime example of urban sprawl today, in particular regarding its rapid increase since 1970. The steepest increases were observed in L'Acienne Lorette, Les Rivières, and Sainte-Foy-Sillery-Cap-Rouge in Quebec, and in Hampstead, Beaconsfield, Baie D'urfe Dollard-Des-Ormeaux, and Kirkland in Montreal. Montreal and Quebec City are still investing large amounts of money in more roads and almost nothing in the expansion of public transport, even though this path is considered as being unsustainable. For example, in 2012 Quebec used $705 million from the Building Canada fund for the completion of the second phase of highway 30 that connects Vaudreuil-Dorion to Chateauguay. Another example is the ongoing reconstruction of the Turcot Intersection in Montreal for 3 billion dollars (Thompson et al., 2013). Therefore, we expect that this trend will continue in the future. The steps planned currently for Montreal and Quebec such as the intensification of urban areas or the development of TOD zones in Montreal (CMM, 2011) are so little compared to Switzerland (that itself suffers from sprawl) that much stronger efforts are needed to discontinue these unsustainable growth patterns. Switzerland should continue on its way to limit urban sprawl or at least stabilize the level of sprawl over all its cantons, including Zurich. However, in Montreal and Quebec rigorous measures and long term plans such as massive expansion of public transport are required.

Our study provides an indication of the potential of how much sprawl could be reduced and what factors could be changed in Montreal and Quebec. There is ample room in Montreal and Quebec for improvements in public transport, in the regional planning legislation, in the settlement pattern (creation of sub-centres with higher densities), and in *UD*. For example, Laval should be densified and covered by the metro system.

The *WUP* method can be applied for measuring the levels of sprawl and dispersion of the urbanized areas and their temporal changes at any scale and for the classification of regions regarding urban sprawl and the identification of areas that are most in danger from sprawl, and areas with higher potential for future urban developments and for reduction of urban sprawl in particular. The *WUP* can be used to investigate relationships between sprawl and its impacts (e.g., relation with car ownership), as an indicator to monitor urban development, to evaluate the effectiveness of new regulations for urban development (e.g., development of TOD zones in Montreal CMA) and the effectiveness of the protection of high-value lands. For example, goal 6 of the federal sustainable development strategy aims to "Maintain productive and resilient ecosystems with the capacity to recover and adapt; and protect areas in ways that leave them unimpaired for present and future generations" (Sustainable Development Office & Environment Canada, 2010, p. 27). Various measures to limit urban sprawl have been proposed in the literature (summarized by Schwick et al., 2012), e.g., controlling the dispersion of built-up areas and stronger protection of agricultural lands. Better education of the public about the negative consequences of urban sprawl may encourage consumers to decrease land uptake per inhabitant and help decrease the level of urban sprawl.

In the Zurich MA, every vote about suggested expansions or improvements of public transport has been accepted by the population, while many proposed road construction projects were rejected. This indicates that more sustainable patterns of development require strong support in the society and long-term planning with a 20–30 year planning horizon. Elements of direct democracy seem to be very helpful in the case of Switzerland in this regard.

Increasing the modal share of public transport in Montreal from 22.2 to 40% would be easier to achieve than increasing it from 63 to 78% as is currently being done in Zurich. These numbers indicate the order of magnitude of the effort that is needed for the increase of metro connections between the sub-centres in Montreal. Since the inauguration of the Montreal metro in 1966 its expansion has been far less significant than the expansions of the tramways and S-Bahns (rapid (sub-)urban railways) in Zurich. Without a strong increase in *UD* and a massive expansion of public transport, urban sprawl in Montreal and Quebec will continue to increase at a fast rate and will result in even more serious traffic problems than today and growing negative effects that are typical of unsustainable development.

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Appendix A. Data used for the delineation of built-up areas

Tables A1 and A2 present the layers (including point and polygons) that represent urban areas. Table A1 presents the features of CanVec dataset, used for the delineation of built-up areas for the year 1996 and previous time steps (1951, 1971 and 1986), and Table A2 presents the features of the CanMap dataset used for the delineation of built-up areas of the year 2011. CanVec was produced from three main sources: the National Topographic Database (NTDB), Landsat 7 imagery coverage, and Geobase data. CanVec contains 11 themes, one of which is the layer of buildings and urban structures that includes all types of buildings and urban structures defined as "permanent walled and roofed constructions". This layer consists of 41 types of buildings as areas or points. Some other relevant features such as airports, domestic and industrial waste, and gas and oil facilities are not included in this layer, but were added to the analysis because we also considered them as urban areas.