Land use and value creation in Quebec: Mines, hydroelectricity, agriculture and forests

A sectoral approach to assessing impacts

by

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Two recent presentations (***Quebec mines: Land use and value creation*** in 2013, and ***Uranium exploration and development issues*** in 2014) highlighted the value created by four sectors of the Quebec economy in relation to the geographical area these sectors use in the province (**Figures 1 to 4**):

	2010 GDP	Land footprint		Value creation/km^2
Mines:	$7.0 B	90 km^2	(0.005%)	$77.47M/km^2
Hydroelectricity:	$9.8 B	51,474 km^2	(3.1%)	$190,000/km^2
Agriculture:	$3.05 B	19,333 km^2	(1.2%)	$160,000/km^2
Forests:	$7.0 B	3,432 km^2	(0.2%)	$2.03M/km^2

This approach led to three main concerns:

- The first concern is the calculation method used to determine the value created by the four economic sectors.
- The second concern questions the validity of comparing mining activity to the other economic sectors because mining activity generates a negative impact on the environment, which would also need to be quantified.
- The third concern questions the validity of comparing the value generated by non-renewable resources (mines), which are destined by definition to become depleted, to renewable resources.

This document addresses these concerns.

Establishing a methodology to estimate the value created per unit area

Basic assumptions:

- Each economic sector examined has a known contribution to Quebec's GDP. The Ministry of Finance's 2012 budget (page 14) is the reference used.
- The four sectors generate value through their use of specific portions of Quebec's land. These parts of the province represent the primary production areas that enable the creation of the sectoral value chains.
- Therefore, it is possible to assess the value created annually by each of these sectors according to their use of the land. This value is calculated by unit area (km^2) in order to compare the value created by the different sectors.

For mines (90 km^2), the total geographical area is established by compiling the areas of all the mining leases of active mines at the time of the study (27 active sites in 2011, **Figure 5**). GESTIM is the source of this information. Certain areas were validated by photo interpretation of satellite images (ESRI, Google Earth). It should be noted that the surface areas of mining leases always exceed the actual surface areas of the active mines.

Although this leads to an overestimation of the actual surface areas of the mines, the mining lease areas for 19 mines (total of 86.25 km^2) were added together without adjustment. For 8 other sites representing quarry mining of industrial minerals (7 sites) or iron (1 site), the areas were adjusted according to the actual land footprint (total of 4.11 km^2).

In 100 years of mining activity, approximately 325 sites have produced a total of 430 km^2, representing 0.03% of Quebec's territory. This includes 280 km^2 of mining infrastructure and 150 km^2 of tailings management facilities (Cyr, 2011).

For hydroelectricity (51,474 km^2), the surface area was determined from Hydro Québec's public data; it includes the surface areas of water reservoirs, related infrastructure and power lines.

For agriculture (19,333 km^2), the surface area was determined by the surface areas used by crops and livestock.

For forests (3,432 km^2), the surface area is the area harvested annually (the areas that effectively contribute to the GDP), representing approximately 1% of commercially exploitable forests.

Although the land use areas established for these four sectors are based on factual information, they remain rough order-of-magnitude estimates. Furthermore, the analysis does not aim to establish a merit ranking for these sectors that constitute vital, complementary and practically indivisible pillars of the Quebec economy. Furthermore, each sector has its own social and environmental challenges.

Assessing the impacts related to land use

By its very nature, mining has an impact on the land used, particularly on the environment. Current legislative and regulatory provisions provide a framework for mining activities by imposing, on the one hand, standards to minimize the negative impacts during the production phase (neutralization of solid waste and effluents, air quality control, dust and noise reduction, etc.), and on the other hand, rehabilitation measures at the end of the production cycle.

It is sometimes mentioned that the exclusive quality of mining activity is also incompatible with other activities. Though mining takes place on a very small portion of the province (0.005%), it should be noted that many sectors of the economy are also incompatible with other activities. For example, activities linked to forests, agriculture and mines are practically non-existent in the areas used by the hydroelectric sector.

Furthermore, it would be totally unrealistic to believe that among the economic sectors studied, only mines would have negative impacts. For the other sectors, negative environmental impacts are also subject to mitigation measures. The main potential impacts are as follows:

Hydroelectricity (involving the flooding of vast areas) (**Figure 6**)

- Long-term suppression of the forest's carbon storage capacity due to the release of carbon dioxide and methane (GHG) in the flooded areas; the change brought about by these significant expanses of water contributes to climate change
- Release of mercury and other heavy metals leading to bioaccumulation in the food chain; this bioaccumulation has a potential impact on human health
- Reduction of biodiversity due to the disappearance of ecosystems
- Fragmentation of habitats related to the creation of access roads and hydroelectric lines (approximately 34,000 km of lines)
- Long-term or permanent damage to other ways of deriving value from the land (forestry, mining, etc.)
- Damage to archeological heritage
- Changes to First Nations' way of life due to the reduction in their traditional hunting and cultural grounds

Agriculture (**Figures 7 and 8**)

- Pollution of ecosystems and groundwater by fertilizers (phosphate, nitrate) and pesticides
- Fragmentation and depletion of ecosystems related to initial deforestation, the development of monocultures over large areas, the impact of access roads
- Pollution from animal waste (damage to waterways and groundwater, odours, greenhouse gas emissions)
- Soil compaction from heavy equipment use
- Erosion of land and of river banks
- Increased water turbidity in waterways due to the influx of suspended particulate matter; artificialization of the water system

Forests (**Figures 9 and 10**)

- Reduction in carbon storage capacity (impact on climate change due to increase in greenhouse gases)
- Damage to biodiversity caused by the fragmentation of habitats by highways and access roads (at least 15,400 km of forest roads)
- Soil compaction and erosion from heavy equipment use
- Deterioration and artificialization of water systems
- Increased water turbidity and consequent impacts on flora and fauna
- Changes to First Nations' way of life due to the reduction in their traditional hunting and cultural grounds

Building the infrastructure for each sector goes beyond the areas considered by the study. As mentioned, these infrastructures may impact ecosystems. It should also be noted that they are not always for exclusive use, and this may include use by the general public and local communities.

The cost-benefit analysis for society of these economic sectors goes way beyond the scope of this study. Environmental costs are partially tied to the surface areas used and to the duration of land use. A schematic representation is as follows:

- Mines: 10 to 30 years per mine, eventually more, on a limited amount of land (average of 3.5 km^2 per mine)
- Hydroelectricity: at least 50 years with regional impact
- Agriculture: at least 100 years with regional impact
- Forests: 20 to 30 years, depending on speed of recovery, with regional impact

Comparing the value of renewable and non-renewable resources

The value generated by **non-renewable resources** (mines) can be strictly compared to the value generated by **renewable resources** as long as the stock of extracted metal (that cannot regenerate itself) is **replaceable** over the long term by new discoveries:

- Deposits have been continuously depleted since the origins of mining. Other deposits take their place when the value of these deposits (which depends in part on metal prices) allows a profit to be made.

- From a geological point of view, only a small portion of the lithosphere has been explored until now. The ability to identify new economic resources does not diminish with the depletion of a specific deposit. Local depletion does not mean global depletion.

- The fixed-stock theory (advanced by the proponents of metal depletion) is a theoretical vision, not applicable in the real world. In fact, this theory has no impact on the price of mineral commodities, otherwise metals prices would only increase over time due to a

worldwide depletion of deposits. In reality, the level of known resources adjusts itself according to market demand; the only sure way of running out of metals is to stop exploration.

- Depleted deposits are thus **replaced**, overall, by new deposits: there is a kind of **sustainability in the overall availability of metals**, due namely to better research and production methods.

Comparing the mining sector to a so-called “renewable” resource like the forest puts into perspective the concept of ***non-renewable***, which typically conjures up the idea of **short term**, in contrast with ***renewable***, which is typically associated with the notion of **long-term**.

Forestry operations carried out over a surface area of about 3,400 km^2 per year render the affected land non-productive for many decades before it regenerates. Every year, 3,400 km^2 of new land must be put into production. In the 20 years before production can finally take place again on the initial land, the cumulative area will attain 68,000 km^2.

In 2011, on the basis of equivalent value added ($7B/year), Quebec's 27 active mines produced from 90 km^2 what the forest produced from 3,400 km^2. However, mines don't move the location of their production every year, in contrast to the forest industry.

Therefore the approach developed here proposes a factual analysis of the value generated by the land. Mines, by exploiting a volume from surface to depth, maximize land use in relation to other economic sectors that must, by their very nature, only develop the surface. Therefore, by using the value of mining production as a reference ($7B in 2010), the other sectors would have had to deploy over much larger surface areas in order to produce an equivalent value: 409 times greater for hydroelectricity, 486 times greater for agriculture and 38 times greater for forests. A mine is, in fact, a high-value volume (an '**orebody**'), the extraction of which deepens the value of the land, both literally and figuratively.

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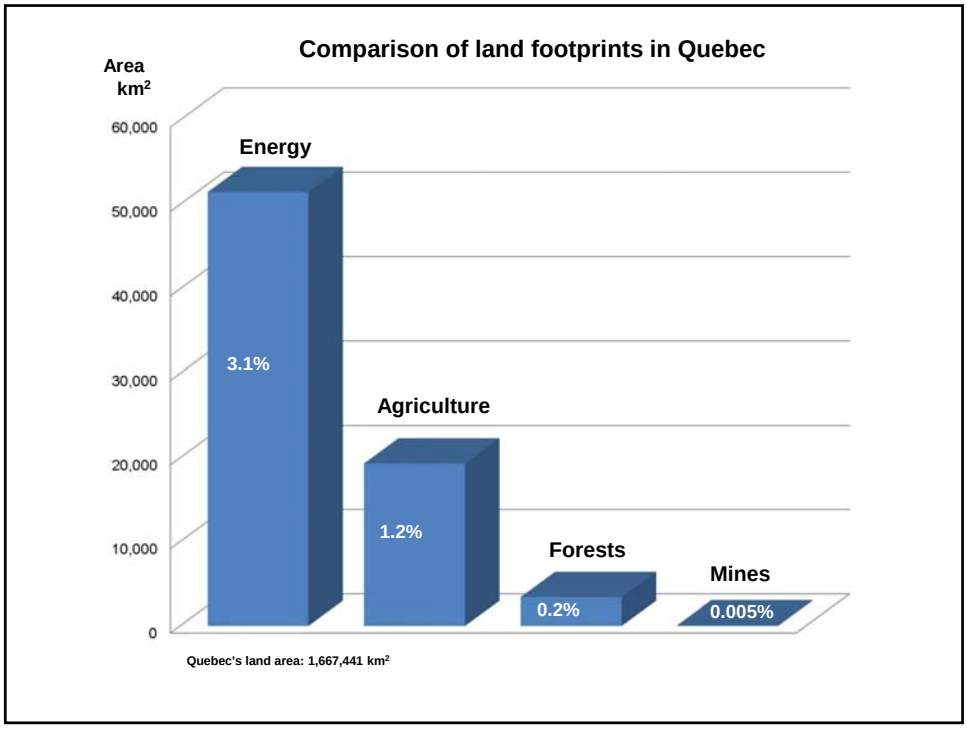

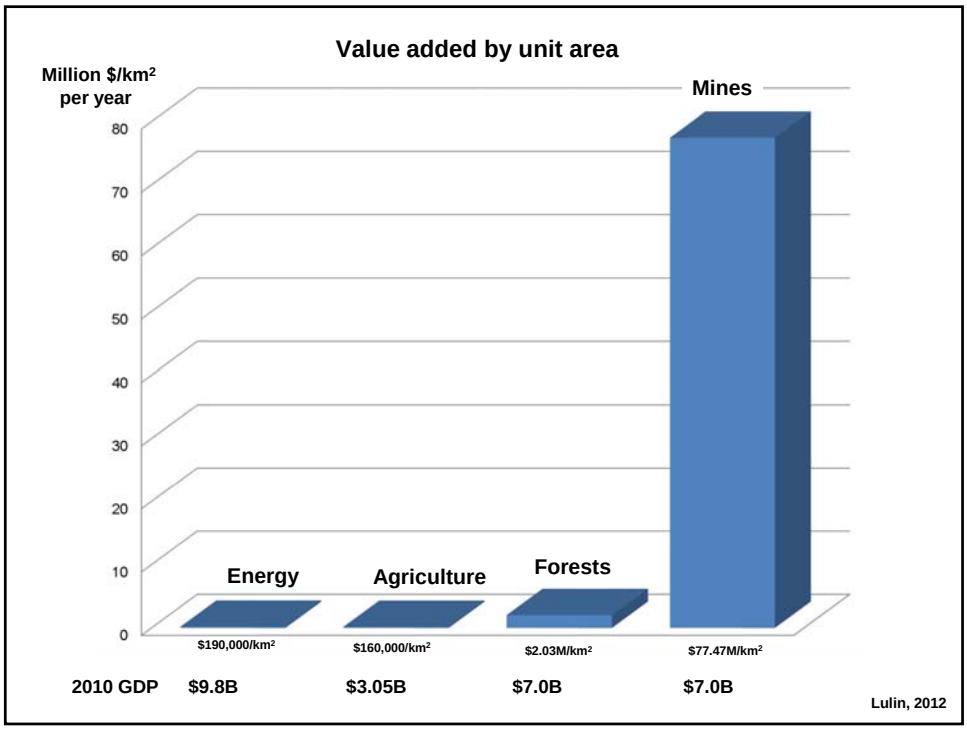

Figures 1 and 2

Sectoral comparison

	Land footprint (km²)	Comparison with mines: Area	Comparison with mines: Value created/km²
Mines	90		
Forests	3,432[a]	38 times more	38 times less
Agriculture	19,333[b]	215 times more	485 times less
Energy	51,474[c]	572 times more	410 times less

(a) Area harvested annually
(b) Area under cultivation, 2006
(c) Hydroelectricity

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Mines in Quebec

- Very small land use: 0.005%
- Huge value added per unit area: $77.5 million per km²
  - $7.0B GDP
  - 23.2% of exports

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Figures 3 and 4

Utilisation du territoire par les mines actives au Québec

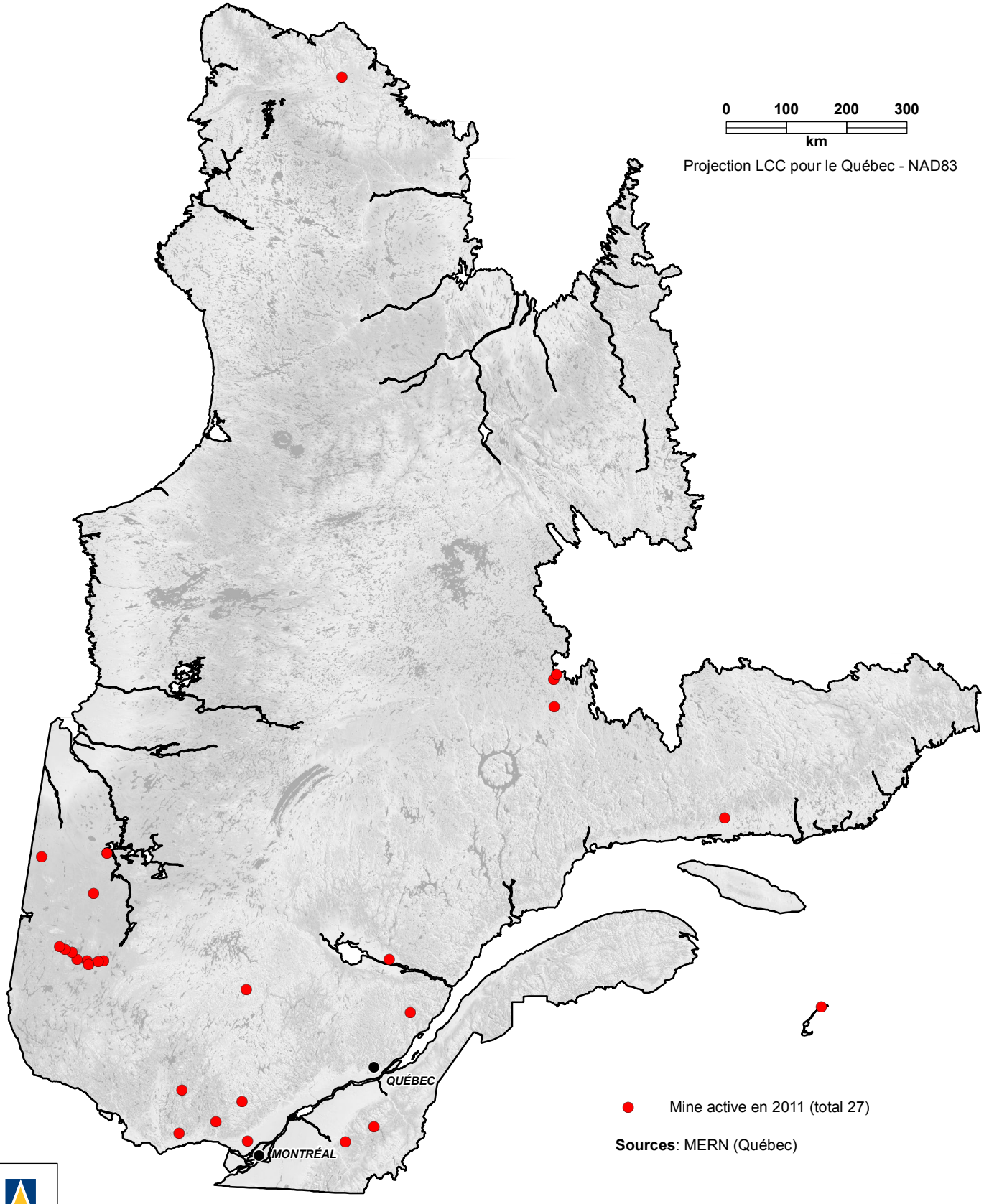

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Figure 5: Land used by active mines in Quebec

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Utilisation du territoire par les aménagements hydroélectriques au Québec

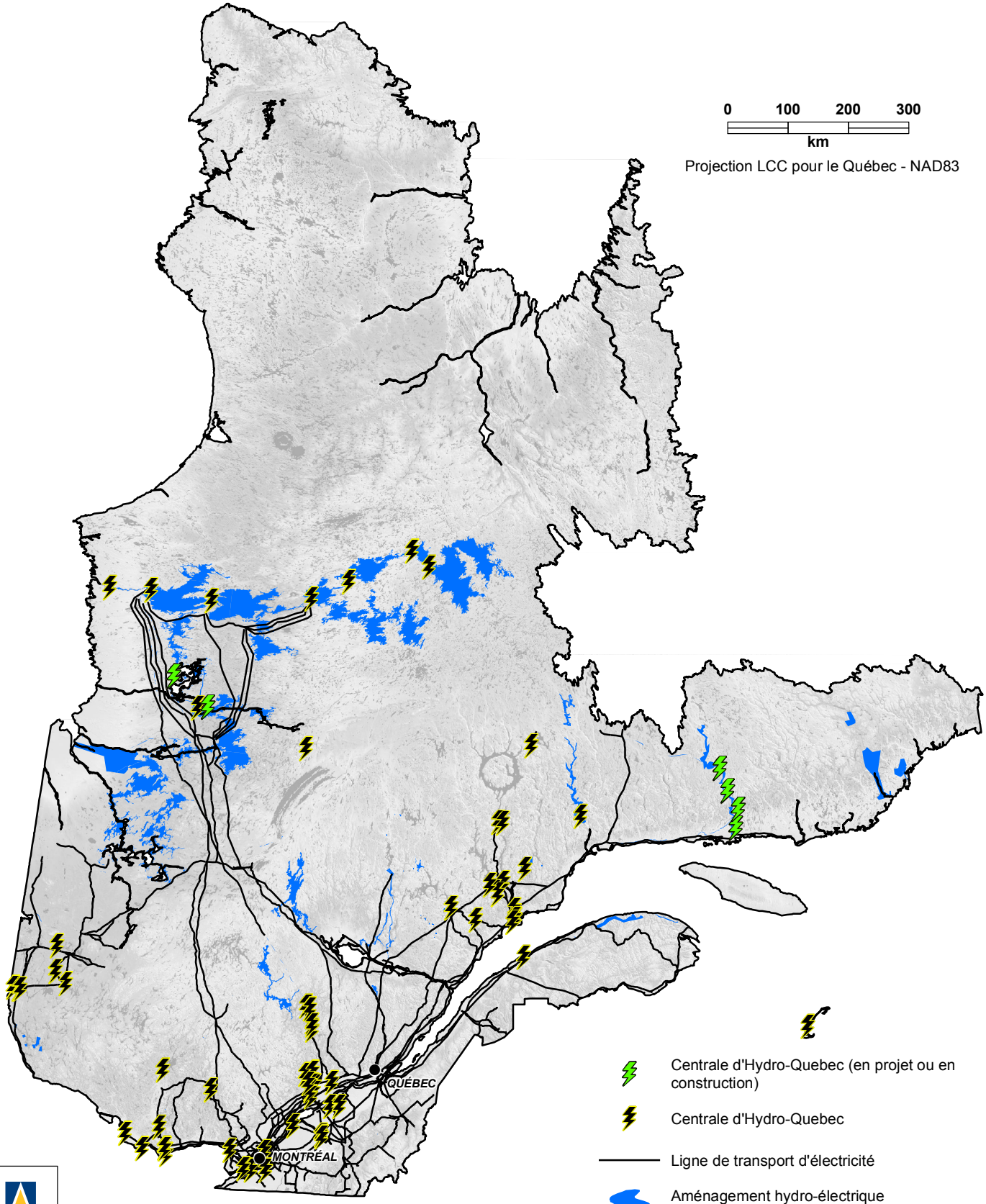

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Figure 6: Land used by the hydroelectric sector

Sources: MERN (Québec), MTQ, Hydro-Québec.

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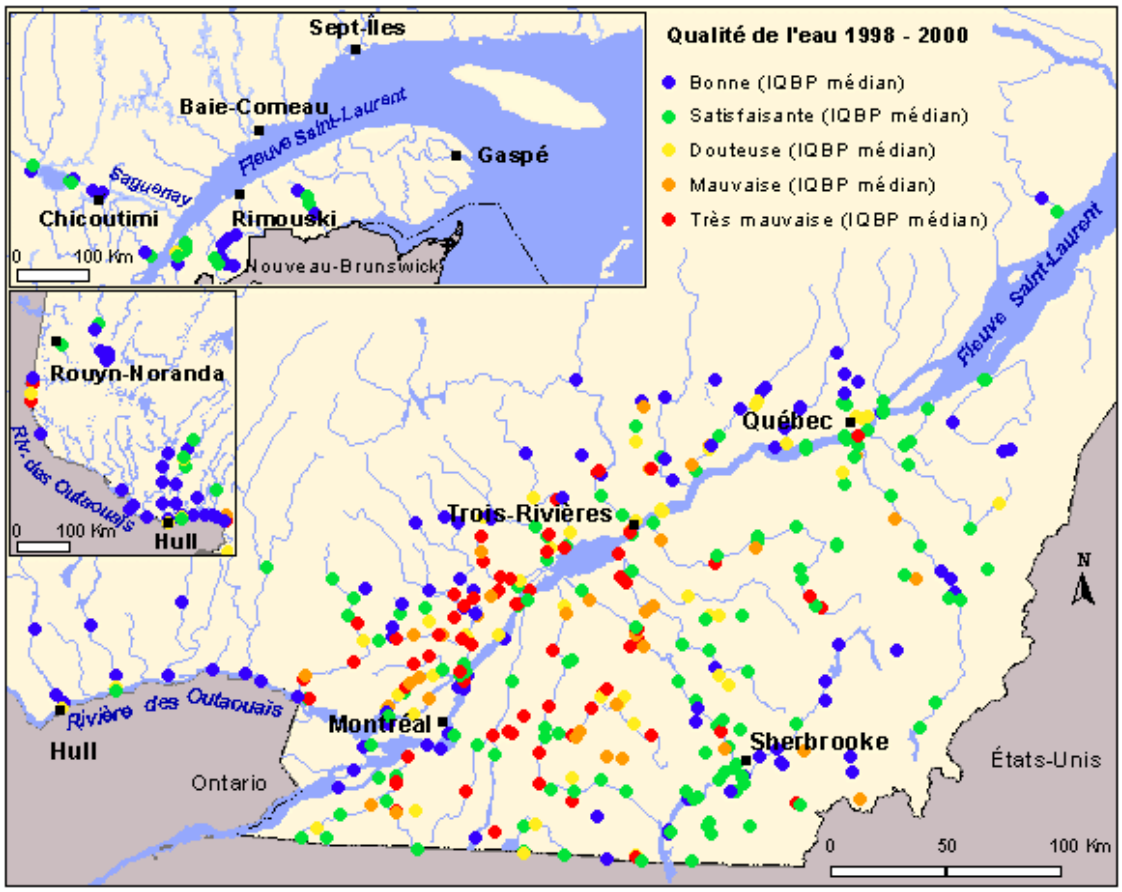

Figure 7: Microbial and physico-chemical water quality index ("IQBP"), 1998-2000 (Rapport Ministère de l'Environnement, 2003).

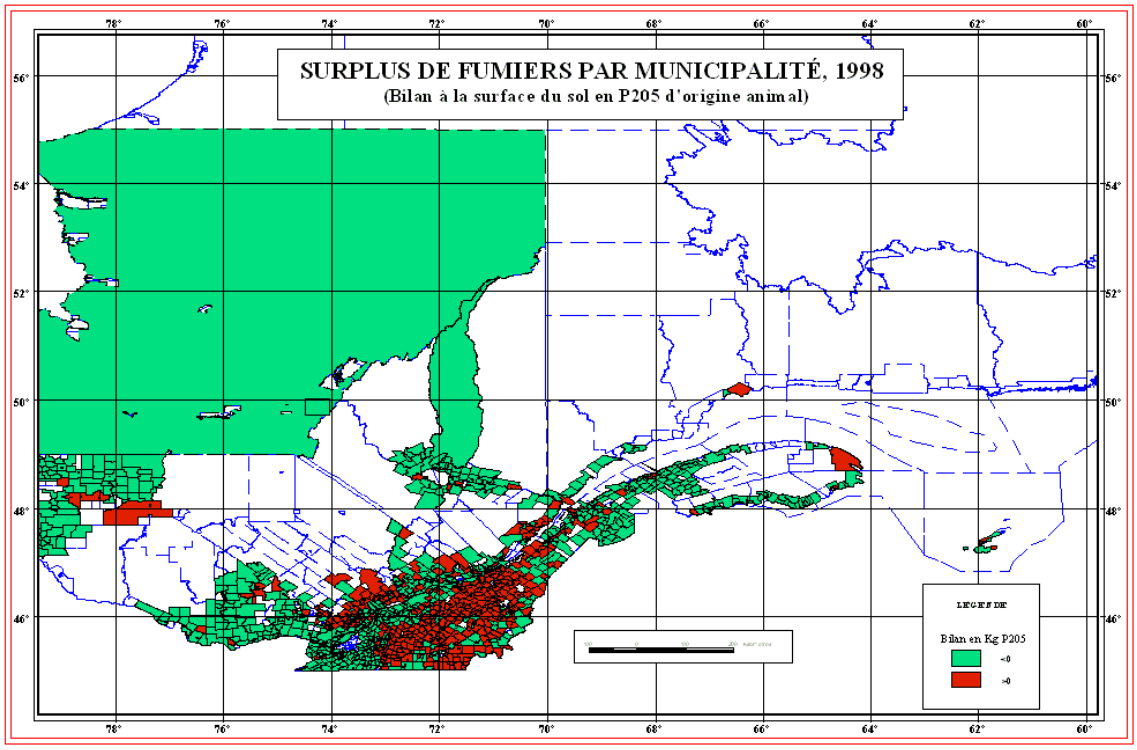

Figure 8: Surplus of manure by municipality (Émond, 1999)

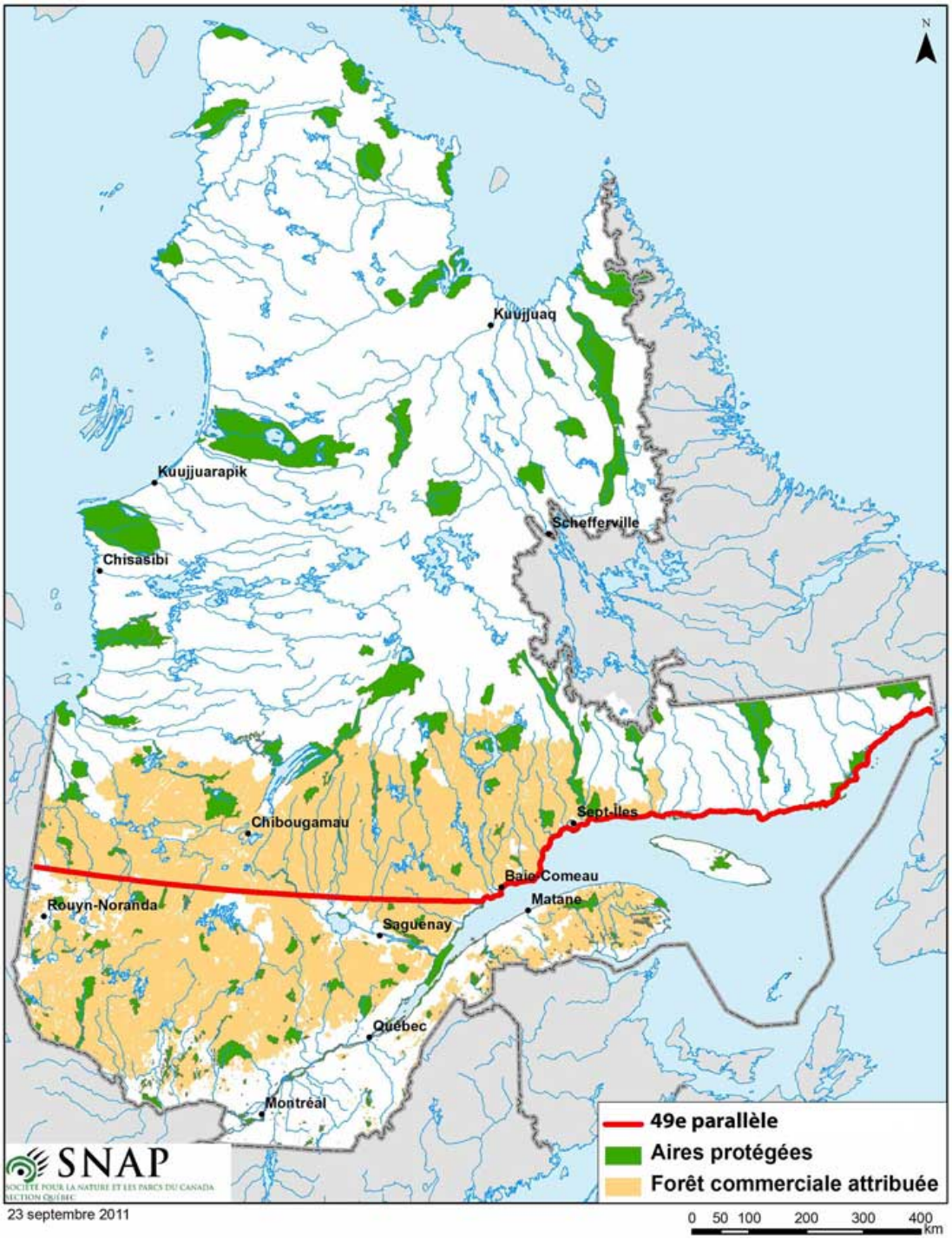

Figure 9: Commercial forest cover in Quebec

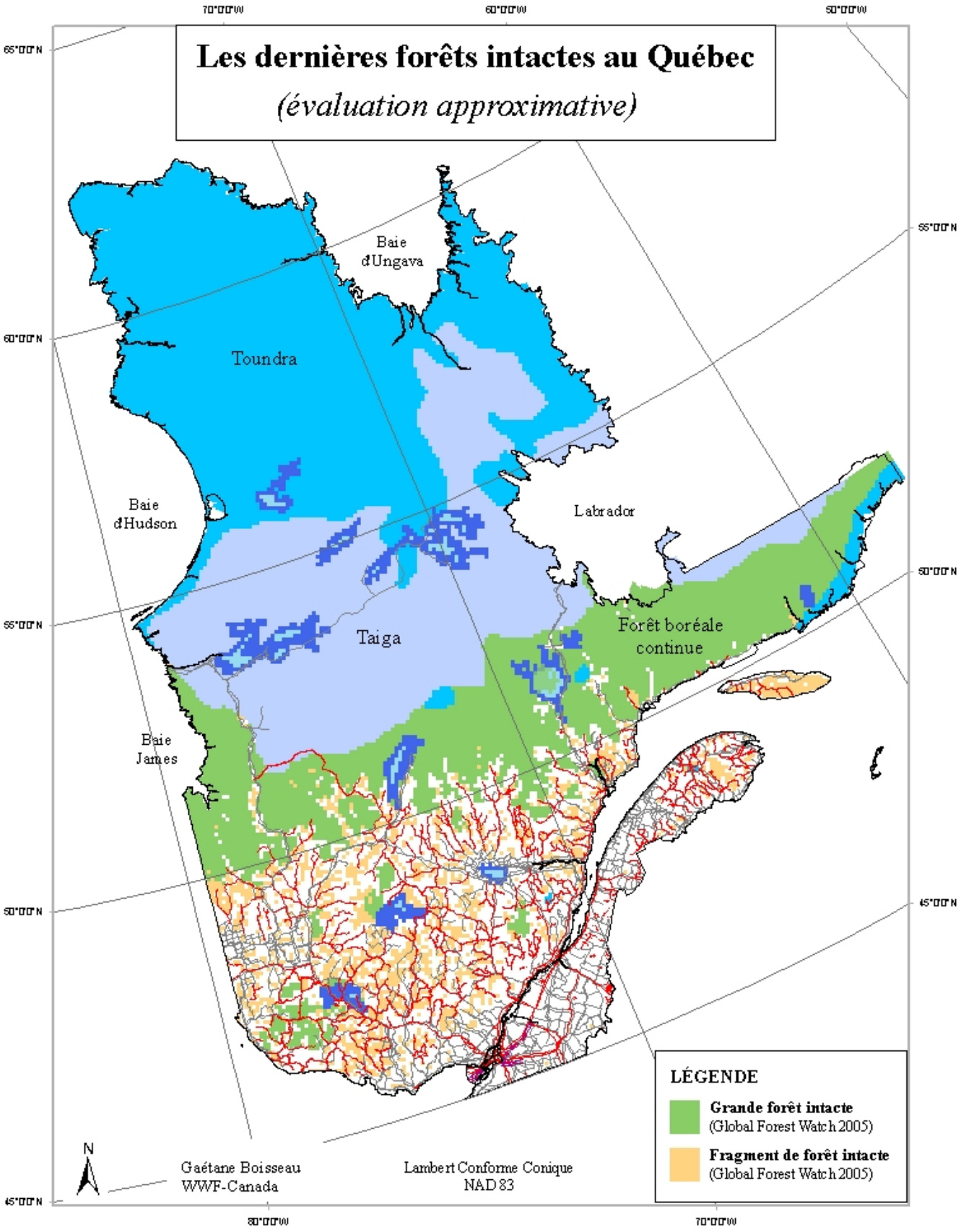

Figure 10: Remaining intact forests in Quebec, in green (Bourgeois et al., 2005)