Appendix – Changing terrestrial habitat connectivity within the St. Lawrence Lowlands under scenarios of climate and land cover change

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Table of contents

List of tables

List of Figures

Section 1. Additional data tables and figures

Table A1. List of GIS data used in our analyses. The database is indicated in parentheses if it is different than the title. Abbreviations are as follows: MELCC - Ministère de l'Environnement et de la Lutte contre les changements climatiques; MERN - Ministère de l'Énergie et des Ressources naturelles; AAC - Agriculture et Agroalimentaire Canada; MFFP - Ministère des Forêts, de la Faune et des Parcs; RMN - Réseau de milieux naturels protégés.

Type	Title (Database)	Format	Content Date	Publication Date	Published by	Source	Access Date
Administrative units	Municipalité régionale de comté (Découpages administratifs)	Shapefile 1:20 000	2018	2018	MERN	*/decoupages-administratifs	2021-04-03
Ecological units	Province naturelle, Ensemble physiographique, District écologique (Cadre écologique de référence du Québec)	Shapefile	2018	2018	MELCC	*/cadre-ecologique-de-reference	2021-04-03
Land use/land cover	Land Use 1990, 2000 & 2010	30 m^2	1990-2010	2015	AAC	https://open.canada.ca/data/en/dataset/18e3ef1a-497c-40c6-8326-aac1a34a0dec	2021-04-03
Forest dynamics	LANDIS-II forest landscape simulation model of commercial forest in Quebec	250 m^2	2020 – 2150	2021	Boulanger & Puigdevall (2021)**	Direct request to authors	
Roads	AQreseau (Base de données topographiques du Québec)	Shapefile 1:20 000	2018	2018	MERN	*/adresses-quebec	2021-04-03
Habitat suitability	Âge des forêts (SIEF 4e inventaire)	Shapefile	2001-2018	2018	MFFP	*/carte-ecoforestiere-avec-perturbations	2021-04-03
	Densité des forêts (SIEF 4e inventaire)	Shapefile	2001-2018	2018	MFFP	*/carte-ecoforestiere-avec-perturbations	2021-04-03
Protected areas	Répertoire des milieux naturels protégés en terres privées	Shapefile	Actuel	2021	RMN	Direct request to Réseau de milieux naturels protégés	
	Registre des aires protégées au Québec	Shapefile	Actuel	2021	MELCC	*/aires-protegees-au-quebec	2021-04-03

* Data availability : Partenariat Données Québec - https://www.donneesquebec.ca/recherche/fr/dataset
** Boulanger, Y. and Puigdevall, J.P., 2021. Boreal forests will be more severely affected by projected anthropogenic climate forcing than mixedwood and northern hardwood forests in eastern Canada. Landscape Ecology, pp.1-16.

Table A2. Relationship between land use and land cover class definitions between AAFC (2015), Phase II (Rayfield et al. 2019), and the current analysis.

Current analysis LULC Class	Phase II LULC Class	Definition	AAFC (2015) LULC Class	Definition
Agriculture	Agriculture, Agriculture Linear Elements, Fallow, Fallow Linear Elements	Annual, perennial, specialized and unidentified crops,	Cropland, Grassland Managed	Annual and perennial
Forest	Coniferous, Deciduous, Mixed	Forests of all composition types	Forest, Trees	Treed areas >1 ha, Treed areas <1 ha
Roads	Roads Major Roads Minor	Minor and major roads	Roads	Primary, secondary and tertiary
Open Water	Open Water	Lentic or lotic, deep or shallow water	Water	Natural and human-made
Urban	Urban, Built, Disturbed Areas 1, Disturbed Areas 2	Developed areas, airports, gravel or sand quarries, exposed soil, nursery, plantation,	Settlement, Other land	Built-up and urban
Wetland Open	Wetlands Open	Bog, marsh, wet meadow	Wetland, Wetland Herb, Wetland Shrub	Undifferentiated wetland, wetland with shrub cover
Wetland Treed	Wetlands Treed	Swamp	Treed Wetland, Forest Wetland	Wetland with tree or forest over

Table A3. Habitat suitability values for focal species. Cells within the table are coloured according to a habitat suitability threshold of 60. State Classes with values equal to or greater than 60 are considered suitable habitat (green). Any other value is considered non-habitat (white).

Species	State Class	Value
Northern short-tailed shrew	Agriculture:All	44
Northern short-tailed shrew	Water:All	10
Northern short-tailed shrew	Forest:Coniferous Young	16
Northern short-tailed shrew	Forest:Coniferous Medium	32
Northern short-tailed shrew	Forest:Coniferous Old	40
Northern short-tailed shrew	Forest:Deciduous Young	40
Northern short-tailed shrew	Forest:Deciduous Medium	80
Northern short-tailed shrew	Forest:Deciduous Old	100
Northern short-tailed shrew	Forest:Mixed Young	36
Northern short-tailed shrew	Forest:Mixed Medium	72
Northern short-tailed shrew	Forest:Mixed Old	90
Northern short-tailed shrew	Wetland:Forested	50
Northern short-tailed shrew	Wetland:Open	50
Northern short-tailed shrew	Roads:All	0
Northern short-tailed shrew	Urban area:All	15
Wood frog	Agriculture:All	40
Wood frog	Water:All	40
Wood frog	Forest:Coniferous Young	100
Wood frog	Forest:Coniferous Medium	100
Wood frog	Forest:Coniferous Old	100
Wood frog	Forest:Deciduous Young	100
Wood frog	Forest:Deciduous Medium	100
Wood frog	Forest:Deciduous Old	100
Wood frog	Forest:Mixed Young	100
Wood frog	Forest:Mixed Medium	100
Wood frog	Forest:Mixed Old	100
Wood frog	Wetland:Forested	100
Wood frog	Wetland:Open	90
Wood frog	Roads:All	0
Wood frog	Urban area:All	15
American marten	Agriculture:All	44
American marten	Water:All	5
American marten	Forest:Coniferous Young	50
American marten	Forest:Coniferous Medium	100
American marten	Forest:Coniferous Old	100
American marten	Forest:Deciduous Young	18

American marten	Forest:Deciduous Medium	35
American marten	Forest:Deciduous Old	35
American marten	Forest:Mixed Young	50
American marten	Forest:Mixed Medium	100
American marten	Forest:Mixed Old	100
American marten	Wetland:Forested	44
American marten	Wetland:Open	44
American marten	Roads:All	0
American marten	Urban area:All	10
Black bear	Agriculture:All	50
Black bear	Water:All	50
Black bear	Forest:Coniferous Young	60
Black bear	Forest:Coniferous Medium	60
Black bear	Forest:Coniferous Old	60
Black bear	Forest:Deciduous Young	100
Black bear	Forest:Deciduous Medium	100
Black bear	Forest:Deciduous Old	100
Black bear	Forest:Mixed Young	80
Black bear	Forest:Mixed Medium	80
Black bear	Forest:Mixed Old	80
Black bear	Wetland:Forested	70
Black bear	Wetland:Open	70
Black bear	Roads:All	0
Black bear	Urban area:All	0
Red-backed salamander	Agriculture:All	44
Red-backed salamander	Water:All	10
Red-backed salamander	Forest:Coniferous Young	40
Red-backed salamander	Forest:Coniferous Medium	40
Red-backed salamander	Forest:Coniferous Old	40
Red-backed salamander	Forest:Deciduous Young	100
Red-backed salamander	Forest:Deciduous Medium	100
Red-backed salamander	Forest:Deciduous Old	100
Red-backed salamander	Forest:Mixed Young	90
Red-backed salamander	Forest:Mixed Medium	90
Red-backed salamander	Forest:Mixed Old	90
Red-backed salamander	Wetland:Forested	44
Red-backed salamander	Wetland:Open	44
Red-backed salamander	Roads:All	0
Red-backed salamander	Urban area:All	15

Table A4. Resistance classes and LULC types for focal species. Scores are assigned according to a scale of values which double with each increment of habitat quality (i.e. 1, 2, 4, 8, 16, 32). The greyscale indicates weak (white) to strong (dark grey) resistance levels.

Species	State Class	Value
Northern short-tailed shrew	Agriculture:All	8
Northern short-tailed shrew	Water:All	16
Northern short-tailed shrew	Forest:Coniferous Young	2
Northern short-tailed shrew	Forest:Coniferous Medium	2
Northern short-tailed shrew	Forest:Coniferous Old	2
Northern short-tailed shrew	Forest:Deciduous Young	2
Northern short-tailed shrew	Forest:Deciduous Medium	2
Northern short-tailed shrew	Forest:Deciduous Old	2
Northern short-tailed shrew	Forest:Mixed Young	2
Northern short-tailed shrew	Forest:Mixed Medium	2
Northern short-tailed shrew	Forest:Mixed Old	2
Northern short-tailed shrew	Wetland:Forested	8
Northern short-tailed shrew	Wetland:Open	8
Northern short-tailed shrew	Roads:All	32
Northern short-tailed shrew	Urban area:All	32
Wood frog	Agriculture:All	8
Wood frog	Water:All	8
Wood frog	Forest:Coniferous Young	2
Wood frog	Forest:Coniferous Medium	2
Wood frog	Forest:Coniferous Old	2
Wood frog	Forest:Deciduous Young	2
Wood frog	Forest:Deciduous Medium	2
Wood frog	Forest:Deciduous Old	2
Wood frog	Forest:Mixed Young	2
Wood frog	Forest:Mixed Medium	2
Wood frog	Forest:Mixed Old	2
Wood frog	Wetland:Forested	2
Wood frog	Wetland:Open	2
Wood frog	Roads:All	32
Wood frog	Urban area:All	32
American marten	Agriculture:All	16
American marten	Water:All	16
American marten	Forest:Coniferous Young	2
American marten	Forest:Coniferous Medium	2
American marten	Forest:Coniferous Old	2
American marten	Forest:Deciduous Young	4
American marten	Forest:Deciduous Medium	4

| American marten	Forest:Deciduous Old	4
American marten	Forest:Mixed Young	4
American marten	Forest:Mixed Medium	4
American marten	Forest:Mixed Old	4
American marten	Wetland:Forested	8
American marten	Wetland:Open	8
American marten	Roads:All	32
American marten	Urban area:All	32
Black bear	Agriculture:All	16
Black bear	Water:All	16
Black bear	Forest:Coniferous Young	4
Black bear	Forest:Coniferous Medium	4
Black bear	Forest:Coniferous Old	4
Black bear	Forest:Deciduous Young	4
Black bear	Forest:Deciduous Medium	4
Black bear	Forest:Deciduous Old	4
Black bear	Forest:Mixed Young	4
Black bear	Forest:Mixed Medium	4
Black bear	Forest:Mixed Old	4
Black bear	Wetland:Forested	2
Black bear	Wetland:Open	2
Black bear	Roads:All	32
Black bear	Urban area:All	32
Red-backed salamander	Agriculture:All	8
Red-backed salamander	Water:All	32
Red-backed salamander	Forest:Coniferous Young	2
Red-backed salamander	Forest:Coniferous Medium	2
Red-backed salamander	Forest:Coniferous Old	2
Red-backed salamander	Forest:Deciduous Young	2
Red-backed salamander	Forest:Deciduous Medium	2
Red-backed salamander	Forest:Deciduous Old	2
Red-backed salamander	Forest:Mixed Young	2
Red-backed salamander	Forest:Mixed Medium	2
Red-backed salamander	Forest:Mixed Old	2
Red-backed salamander	Wetland:Forested	8
Red-backed salamander	Wetland:Open	8
Red-backed salamander	Roads:All	32
Red-backed salamander	Urban area:All	32
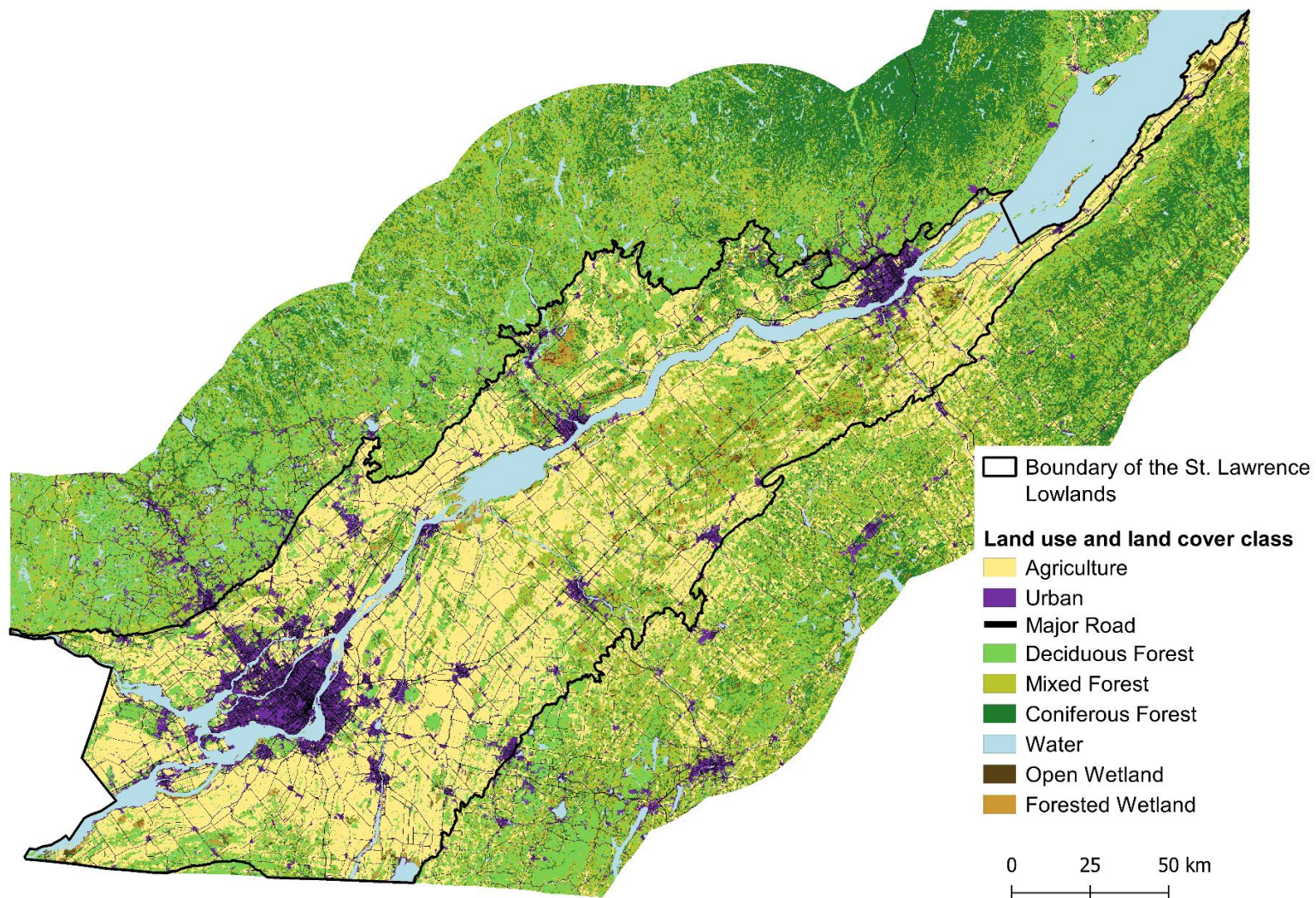
Figure A1. Land use and land cover class of each cell in 2010 at the start of the simulation (for all realizations) in the St. Lawrence Lowlands and surrounding analysis buffer.
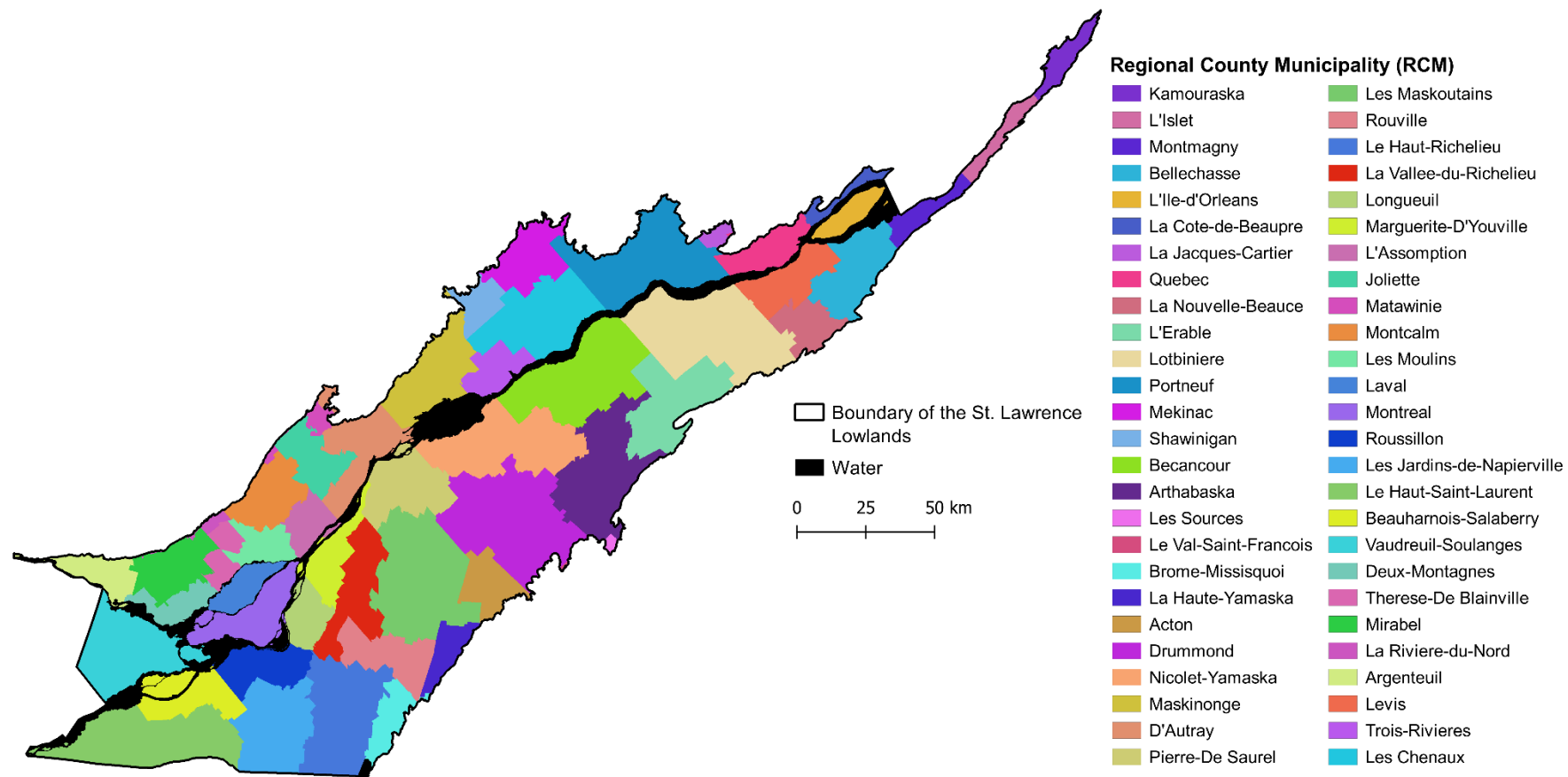
Regional County Municipality (RCM)

Kamouraska	Les Maskoutains
L'Islet	Rouville
Montmagny	Le Haut-Richelieu
Bellechasse	La Vallee-du-Richelieu
L'Ile-d'Orleans	Longueuil
La Cote-de-Beaupre	Marguerite-D'Youville
La Jacques-Cartier	L'Assomption
Quebec	Joliette
La Nouvelle-Beauce	Matawinie
L'Erable	Montcalm
Lotbiniere	Les Moulins
Portneuf	Laval
Mekinac	Montreal
Shawinigan	Roussillon
Becancour	Les Jardins-de-Napierville
Arthabaska	Le Haut-Saint-Laurent
Les Sources	Beauharnois-Salaberry
Le Val-Saint-Francois	Vaudreuil-Soulanges
Brome-Missisquoi	Deux-Montagnes
La Haute-Yamaska	Therese-De Blainville
Acton	Mirabel
Drummond	La Riviere-du-Nord
Nicolet-Yamaska	Argenteuil
Maskinonge	Levis
D'Autray	Trois-Rivieres
Pierre-De Saurel	Les Chenaux

Boundary of the St. Lawrence Lowlands

Water

0   25   50 km

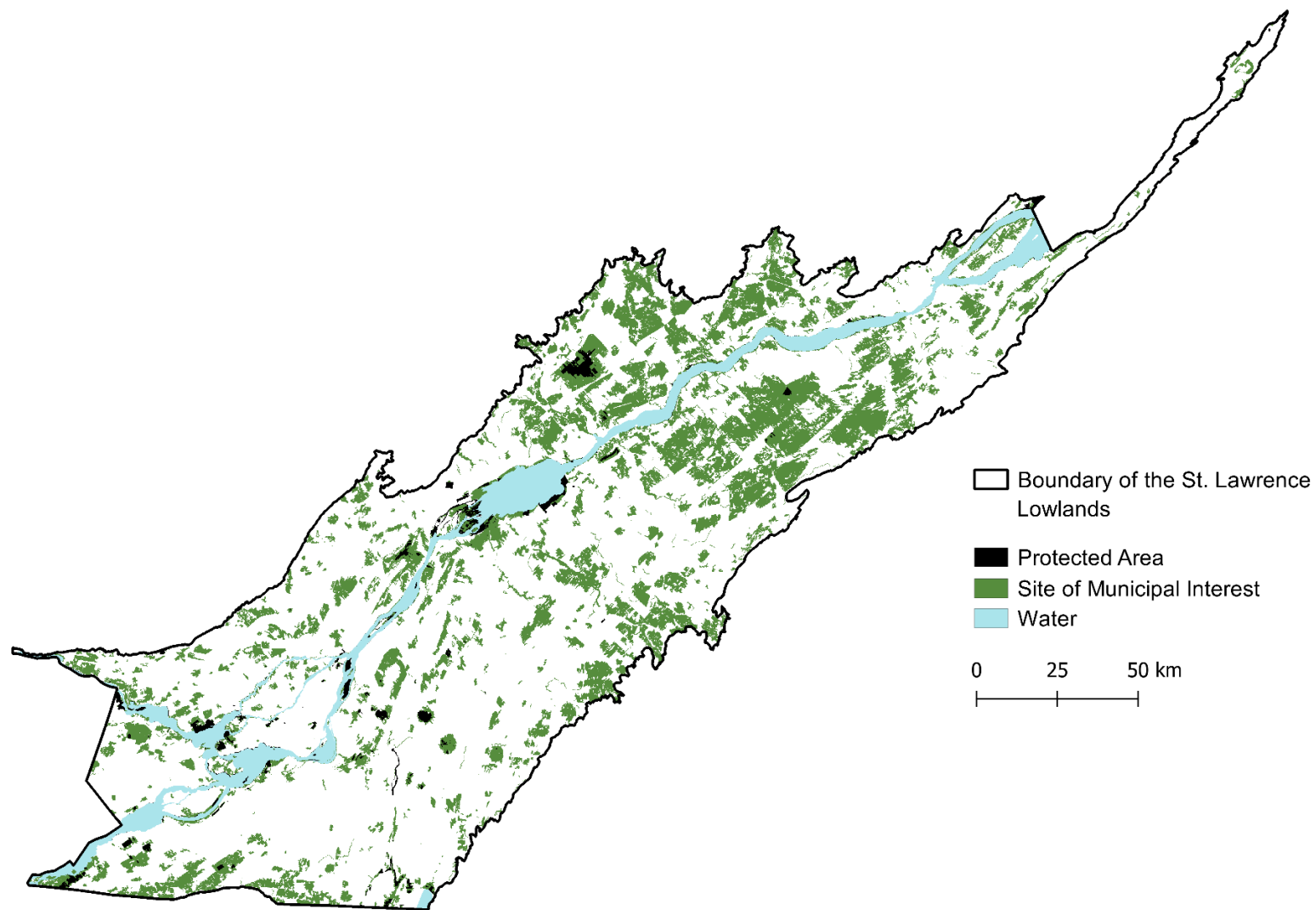Figure A2. Regional county municipalities within the St. Lawrence Lowlands.

9

Figure A3. Protected area and sites of conservation interest within the St. Lawrence Lowlands.

Section 2. Conservation scenario description

We devised a conservation scenario to illustrate the impact of modifying model parameters on connectivity outcomes when simulating LULC and climate change. In this scenario, we examined the effect of protecting natural areas of interest as recommended in the Atlas des territoires d'intérêt pour la conservation dans les Basses-terres du Saint-Laurent by Jobin et al. (2019; Figure A3). Issued from the Plan d'action Saint-Laurent, the Atlas identifies natural and semi-natural areas of high conservation importance. It aims to retain 20% representativity of key vegetation types (e.g. wetlands, forests, open field habitats, riparian areas) across the Lowlands including those used by species at risk or classed as exceptional forest ecosystems. In this scenario, we prevented forests and wetlands found within the areas of interest identified by Jobin et al. (2019) from being lost to urbanization or agricultural intensification over the course of the 100-year timeseries. We did so by imposing a spatial multiplier in ST-Sim designating which areas to protect. In total, 26% of the St. Lawrence Lowlands was classed as protected in this scenario. This included Atlas priority areas (24% of the landscape) and currently protected areas (5% of the landscape), accounting for some overlap between the two layers. When identifying which areas to protect using data from Jobin et al. (2019), we focused on sites designated as 'multicibles', meaning those satisfying more than one conservation target for either aquatic or terrestrial habitats. Landscape connectivity results for the conservation scenario are included in the Supplemental Material Directory of the report, including a tabular summary of codes used to designate conservation scenarios (e.g. CON_NC, CON_45, CON_85).

Section 3 Additional connectivity analyses

This section has been removed at the request of the Ministère de l'Environnement et de la Lutte contre les changements climatiques. The georeferenced data will be released separately and accompanied by a user guide.

References

Jobin, B., Gratton, L., Côté, M.J., Pfister, O., Lachance, D., Mingelbier, M., et al. (2019). Atlas des territoires d'intérêt pour la conservation dans les Basses-terres du Saint-Laurent - Rapport méthodologique version 2, incluant la région de l'Outaouais. Environnement et Changement climatique Canada, Ministère de l'Environnement et de la Lutte contre les changements climatiques, Ministère des Forêts, de la Faune et des Parcs. Plan d'action Saint-Laurent, Québec, QC, 170 p.

Rayfield, B., Larocque, G., Daniel, C., Gonzalez, A. 2019. Une priorisation pour la conservation des milieux naturels des Basses-Terres du Saint-Laurent en fonction de leur importance pour la connectivité. Centre de la science de la biodiversité du Québec (CSBQ), Montréal, QC. 36p.