METHODOLOGY BOOKLET

Biodiversity Indicators for Quebec Investors

September 2024

Fondaction

SNAP QUÉBEC

CDPQ

Biodiversité Québec

UDS Université de Sherbrooke

Title:

Biodiversity Indicators for Quebec Investors – Methodology Booklet

Authors:

Gravel, Dominique
He, Jie
Cameron, Victor
Varin, Marie-Pierre
Bayili, Edwige
Creimer, Diego

Publisher:

Société pour la nature et les parcs – SNAP Québec

Graphics and illustrations:

Larose design

Publication:

September 2024
ISBN 978-1-988870-13-7

TABLE OF CONTENTS

Introduction

International agreements and treaties to limit global greenhouse gas emissions have had an impact on a range of climate policies. They have initiated the technological and behavioural transition that the climate crisis requires. Increasingly, economic and political decisions are being made with an eye to their impact on the climate. We expect a similar transition to halt the loss of biodiversity caused by human activity. Targets 14 and 15 of the new Kunming-Montréal Global Biodiversity Framework adopted at the 15th Conference of the Parties (COP15) exhort businesses and governments to consider, measure, disclose and mitigate the impact of economic activity on biodiversity. A reporting framework and a set of indicators are required to achieve them.

The development of biodiversity indicators has received increasing attention from the research community in recent years, whether to improve monitoring and identify trends, or to assess the impact of ad hoc projects. New methods are constantly being introduced to take account of the state of nature and the changes brought about by economic development. This data, combined with modelling and predictive artificial intelligence tools, provides a growing body of information that the financial sector can use to understand, measure, report and reduce its impact on the natural world.

Although the development of biodiversity impact indicators is progressing rapidly, the outlines of what needs to be measured globally and locally have yet to be defined. The research we present in this methodology booklet is a first step in our effort to identify and measure a limited number of local biodiversity impacts that a financial institution operating in Québec can consider, with the available data, as a decision-making tool in the investment analysis phase. The following indicators relate to the direct impacts of the projects' development perimeter and a buffer zone declared by the developer. Although desirable, the supply chain is not considered at this stage. At first glance, our methodology can be applied to the entire territory of Québec.

Motivated by COP15 in Montréal, and following targeted consultations with major financial institutions, Fondaction and the Caisse de dépôt et placement du Québec have joined forces with the Société pour la nature et les parcs (SNAP Québec), the Centre de la science de la biodiversité du Québec and the Biodiversité Québec research team, based at the Université de Sherbrooke's Department of Biology, to support the development of a number of indicators that will enable investors to predict the impact on local biodiversity and conservation of the projects they are considering financing. The project's guidelines are as follows: these indicators must i) reflect the multiple dimensions of expected ecosystem changes; ii) be consistent with the Global Biodiversity Framework targets and be based on the best available science; iii) be calculated using open and scientifically credible data; iv) require a minimum of information to be provided by the developer and financial institutions; v) be interpretable by users unfamiliar with natural sciences. Moreover, these indicators must meet the criteria suggested in the reporting frameworks of the Taskforce on Nature-related Financial Disclosures (TNFD) and in the recommendations of the Science Based Targets Network.

The first step was to conduct a literature review of available indicators. The first observation was that most of the proposed approaches remain at a high level of interpretation and do not lend themselves well to the analysis of local projects. We have identified a number of metrics to assess the impact of investments on a portfolio, such as mean species abundance per unit area and impact on the International Union for Conservation of Nature's Red List by activity and region concerned. However, these indicators could not answer the question of the

impact of specific local projects. Our team then drew up a list of around 20 biodiversity issues specific to Québec. In parallel, we assessed data accessibility for the proposed indicators. Nine themes were selected on the basis of an enhanced SMART (specific, measurable, achievable, realistic and timely) analysis grid. These indicators use information provided by the developer and information from open-access, high-quality scientific databases that are updated on an ongoing basis.

Interpreting the results in a pre-investment decision-making context was an additional challenge. We conducted a user design study to better understand the decision-making context and adapt our methodology to make it operational. The main recommendation of the typical analyst characterization is to express the result of the indicators with a score bounded between 0 (no impact) and 1 (maximum impact). The transposition of the metrics used – usually in absolute values (e.g. number of hectares) – to this relative scale is based on a scientific assessment; the arbitrary values are discussed at the end of this report. The Indicators presented in this report measure the impact of the implementation of an economic project (e.g. industrial, tourism, real estate) in Québec on 1) ecosystem services provided within the perimeter concerned; 2) species at risk and of cultural interest; 3) conservation; 4) habitat destruction; 5) pollution; 6) introduction and spread of invasive alien species; 7) ecological connectivity; 8) cumulative stressors; and 9) destruction of natural carbon sinks.

The methodology sheets present the definition, interpretation, methodology and source of the data used.

Without being prescriptive, these indicators provide quantifiable pre-investment information of a project's impact on local biodiversity and conservation, which can help our financial institutions make decisions that are better aligned with their biodiversity and disclosure strategy. Using Biodiversité Québec's and other publicly available databases, as well as geographical information and self-reporting forms produced by the project's developer, our indicators will soon be accessible to the entire financial community without intermediaries.

Each indicator's methodology presented below is a first version that will be revised and improved. It's part of a larger-scale testing and continuous improvement process.

Ecosystem services

1. OVERVIEW

Definition

Measurement of the project's impact on the loss of certain predefined ecosystem services within the project's development perimeter. The value of ecosystem services is weighted according to the density of the local population in each dissemination area within the impact radius and the distance between them and the project's impact zone.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 5 Restore, maintain and enhance nature's contributions to people, including ecosystem functions and services.

Alignment with the TNFD framewor

Metric A6.0 Ecosystem services

2. DATA

Type of data required	Source	Disponible
Data on studies that have estimated the monetary value of different types of ecosystem services in relation to the eight other indicators	Jérôme Dupras et al, 2013	✓
Geolocalized data on population density, total population and breakdown of dissemination areas	Statistics Canada (Dissemination Area)	✓
Geolocalized data on land use types in Québec	Données Québec	✓

Data description

The total economic value of nature includes the direct, quantifiable and market use values that it can provide to society, but also the indirect, non-market use values that affect human well-being and the maintenance of our societies, as well as option and bequest values that have an intergenerational dimension and existence values. In the context of our indicator, we focus on the non-market value of nature through nine main ecosystem services (climate regulation, air quality, water supply, flood regulation, pollination, habitat for biodiversity, recreation and tourism, erosion control, biological control) by different soil types, following the example of the paper by Dupras et al. (2013).

It should be noted that these 9 ecosystem services are based jointly on the 18 nature's contributions to people identified by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, as well as the 8 ecosystem services identified by the Government of Québec. In terms of land use types, for the purposes of our two projects, the different types of land are grouped into four categories to simplify calculations: forests, agricultural land, aquatic areas and wetlands.

3. METHODOLOGY

Summary

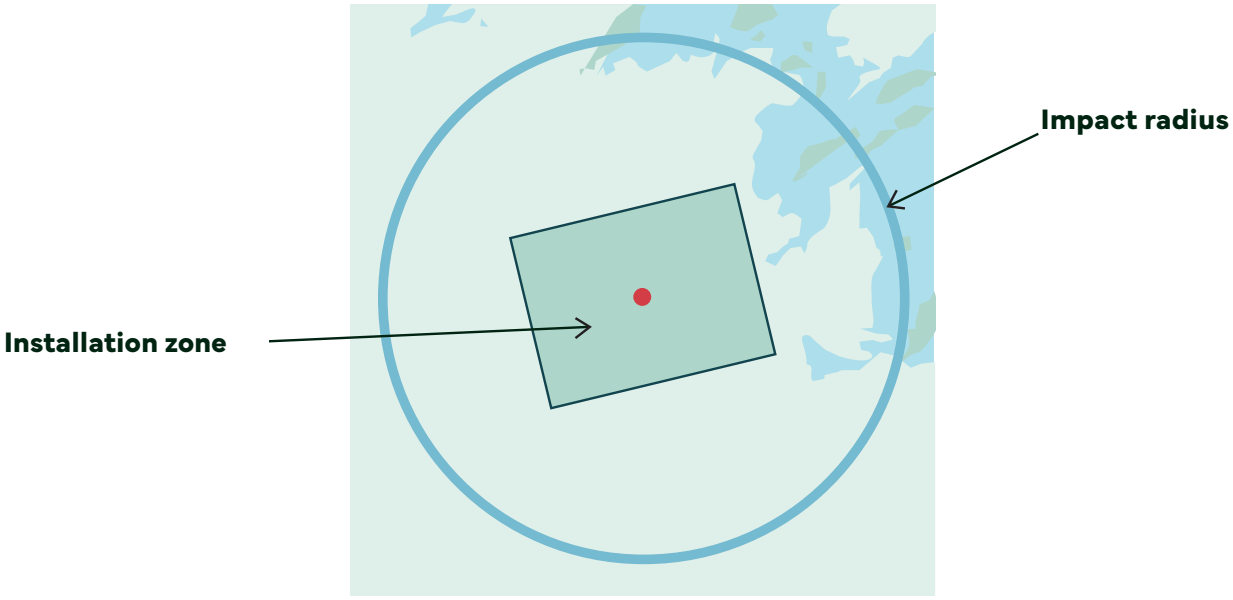
Calculation of the monetary value of all functional ecosystem services (i.e. produced by ecological functioning that provides one or more benefits to humans) and structural ecosystem services (i.e. produced by the presence and physical form of an ecosystem or natural element within the development perimeter), weighted by a function of decreasing distance.

We draw on studies of the monetary value of ecosystem services in similar regions and economic contexts and apply consistent monetary values V (dollars/person/hectare).

Formula

Inspired by the logic of the spatial solution proposed in the InVEST model (Integrated Valuation of Ecosystem Services and Tradeoffs), which takes into account both the location of ecosystem services and the location of the population that benefits from them, our calculation consists of the following steps:

- First, we list the area (in hectares) of each soil type that will be modified by the project in its installation zone, S_j
- For each soil type, we calculate the loss of the total economic value of ecosystem services according to the value per hectare, per year and per person, V_j based on data from Dupras et al. (2013), $S_j \times Vj$.
- We add up the total value of ecosystem services for one person in relation to the installation of the project, $\sum_j S_j \times V_j$.
- We define the impact radius for all the ecosystem services considered d. This impact radius determines the greatest distance over which a person can actually be affected by the loss of ecosystem services associated with the project. The determination of d depends on the nature of the project and its potential ecosystem impacts. The following figure shows the project's impact radius and installation zone.



- Based on 2016 census data[1], we identify the dissemination areas i within the impact radius to define the affected population pop_i
- Based on a Gaussian function of decreasing distance from the project site, we calculate the intensity of impact from the loss of ecosystem services for each affected dissemination area.

$$f(d_{ij}, d_i) = \begin{cases} \dfrac{e^{-\frac{1}{2}\left(\frac{d_{ij}}{d_j}\right)^2} - e^{-\frac{1}{2}}}{1 - e^{-\frac{1}{2}}} & si \quad d_{ij} \leq d_j \\ 0 & si \quad d_{ij} > d_j \end{cases}$$

- We then calculate the total economic value of ecosystem services likely to be lost as a result of the development of the project for each dissemination area i, weighted by distance:

$$f(d_{ij}, d_i) \times pop_i \times \sum_j S_j \times V_j$$

- We add up the total value of ecosystem services associated with the installation of the project for all the affected dissemination areas:

$$\sum_i f(d_{ij}, d_i) \times pop_i \times \sum_j S_j \times V_j$$

- Finally, in order to standardize the value of ecosystem services to an indicator between 0 and 1, we compare the total value calculated above with that of a fictitious project located in Montréal, where the population density is the highest in Québec (worst case reference scenario), using the following function:

$$SE = \frac{\sum_i f(d_{ij}, d_i) \times pop_i \times \sum_j S_j \times V_j}{\sum_{i,Montréal} f(d_{ij}, d_i) \times pop_{i,Montréal} \times \sum_j S_{j,Montreal} \times V_{j,Montreal}}$$

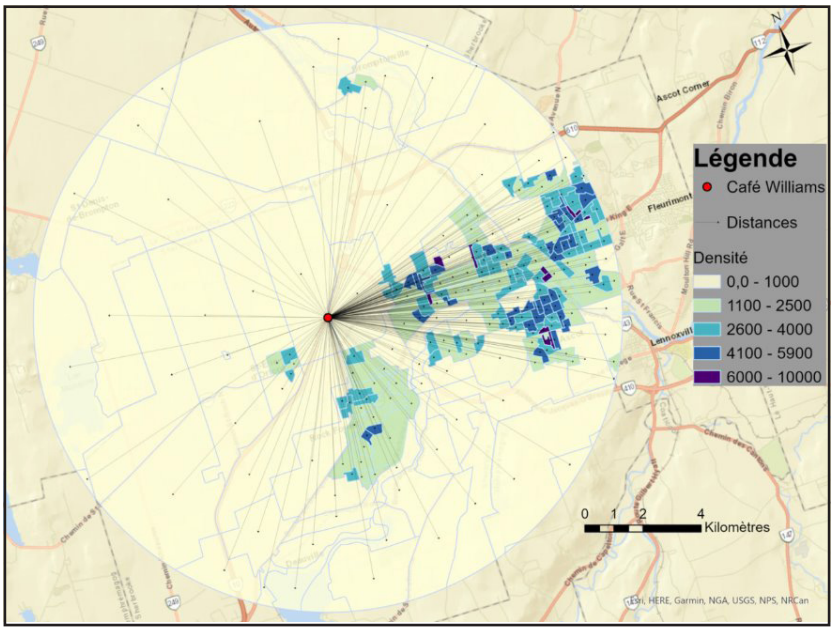
[1] We use data from the 2016 census because it provides a breakdown of demographic characteristics by dissemination area.

4. RESULTS

Communication of results

The indicator gives a score between 0 and 1 indicating the severity of the loss of ecosystem services in the development perimeter, where 0 corresponds to no services lost, and 1 corresponds to the loss of all ecosystem services.

Visualisation of results



Interpretation key

The score expresses the overall impact on the loss of ecosystem services. Additional information can be used to:

1) Estimate the monetary value of lost ecosystem services;

2) Put into perspective the loss of monetary value depending on the location of the project by considering two dimensions: the population density impacted and the richness of the ecosystem services affected.

Points of caution for interpretation

- There is a need to establish ecosystem services specific to northern and indigenous regions, and to use a different weighting method that takes into account the low population density and high cultural value of certain services provided by nature.
- The reference values of the ecosystem services considered in the formula for this indicator are constantly evolving. In some cases, they need to be adjusted for inflation and according to the latest relevant economic evaluation studies.
- Aggregating soil types into four categories remains an important simplification. However, the sensitivity of the calculated indicator based on this simplification needs to be tested.

Species at risk and of cultural interest and of cultural interest

1. OVERVIEW

Definition

Measurement of the project's impact on species at risk and of cultural interest that may be found within the project's perimeter of influence (development perimeter and zone of influence).

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 4 Ensure urgent management actions to halt human induced extinction of threatened species.

Alignment with the TNFD framework

Métric C5.0 State of nature – Species extinction risk

2. DATA

Type of data required	Source	Availability
Probability of presence of species at risk and of cultural interest	Biodiversité Québec, produit de modélisation des probabilités de présences des espèces à statut	✓
Occurrences	CDPNQ	✓
Presence of species at risk and of cultural interest	Biodiversité Québec	✓
Designation level of species at risk and of cultural interest	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) List of plant species designated as threatened or vulnerable or likely to be so [https://www.environnement.gouv.qc.ca/biodiversite/especes-designees-susceptibles/index.htm] MELCCFP. List of threatened or vulnerable wildlife species [https://www.quebec.ca/agriculture-environnement-et-ressources-naturelles/faune/gestion-faune-habitats-fauniques/especes-fauniques-menacees-vulnerables/liste]	
Spatial footprint of the project	Self-reporting	✓

3. METHODOLOGY

Summary

Sum of the maximum probability of presence of a species at risk and of cultural interest in the project's territory of influence. If the presence of a species at risk and of cultural interest is confirmed on the development site, the indicator automatically assumes the maximum impact risk value, i.e. 1.

Formula

An indicator score ***I*** is defined to measure the maximum probability of presence P_i of species at risk and of cultural interest i in the project's development perimeter:

$$I = \begin{cases} 1, \text{ si } P_i = 1 \\ 1 - \prod (1 - P_i), \text{ si } P_i < 1 \end{cases}$$

The indicator score takes the value of 1 if $P_i = 1$, i.e. an occurrence is confirmed for species at risk and of cultural interest i on the project's development site. If no occurrence is confirmed $P_i < 1$, the indicator score is given by the product of the probability of presence of the species P_i.

This score is given within the interval [0, 1]. It measures the probability presence of a species at risk and of cultural interest .

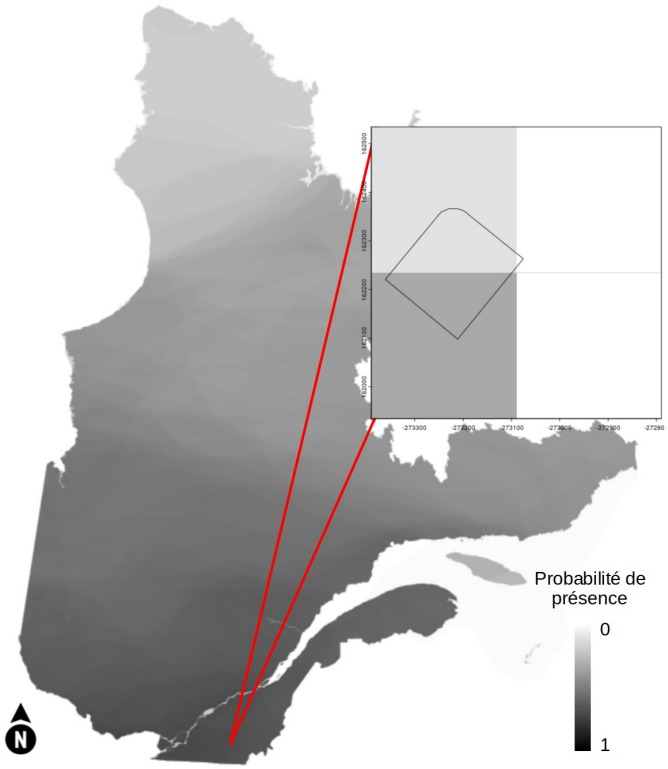
4. RESULTS

Communication of results

The impact on a species at risk and of cultural interest represents a major risk to its persistence and therefore to biodiversity. The indicator's result will be returned in the interval [0, 1] representing the probability of finding a species at risk and of cultural interest in the project's spatial footprint (development perimeter and zone of influence).

Visualization of results

Map showing the probability of observing a species at risk and of cultural interest for the Café William project



Interpretation key

The score for this indicator shows the probability that one or more species at risk and of cultural interest will be impacted by the project.

Points of caution for interpretation

• The total footprint is discretionary and its definition can greatly influence the result. It may include the zone of influence set by the developer.

• Given the precariousness and high risk of extinction of threatened and vulnerable species, we automatically give the maximum indicator score if an observation of one of these species is confirmed in the development zone.

Conservation

1. OVERVIEW

Definition

Measurement of the project's impact on existing or planned protected areas.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 3 Ensure and enable that by 2030 at least 30% of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved.

Alignment with the TNFD framework

Métric C1.0 Land use change – Total spatial footprint
Metric C1.1 Land use change – Extent of land use change

2. DATA

Type of data required	Source	Availability
Registry of protected areas	MINISTÈRE DE L'ENVIRONNEMENT, LUTTE CONTRE LES CHANGEMENTS CLIMATIQUES, FAUNE ET PARCS. Registre des aires protégées au Québec, [Jeu de données], dans Données Québec, 2018, mis à jour le 23 février 2024. [https://www.donneesquebec.ca/recherche/dataset/aires-protegees-au-quebec], (consulté le 23 février 2024).	✓
Key biodiversity areas	BirdLife International. The World Database of Key Biodiversity Areas. Developed by the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:wild, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. 2024. [www.keybiodiversityareas.org], [consulté le 23 février 2024].	
SNAP Québec's conservation projects	SNAP Québec	✓
Areas of indigenous interest	SNAP Québec	✓

3. METHODOLOGY

Summary

The indicator measures the encroachment of the project and its zone of influence on protected areas and territories of interest.

Formule

An indicator score ***I*** is defined to measure the direct and indirect encroachment of the project on protected areas (existing or planned) or territories of interest:

$$I = \begin{cases} 1 & \text{si } X_i = 1 \\ 0{,}5 & \text{si } X_i < 1 \end{cases}$$

where $\boldsymbol{X_i}$ represents the variable corresponding to the presence of a protected area project or a territory of interest project ***i*** within the perimeter of influence. $\boldsymbol{X_i}$ takes on a value of 1 if the project's development perimeter encroaches on an existing or planned protected area, and 0.5 if it encroaches on the zone of influence.

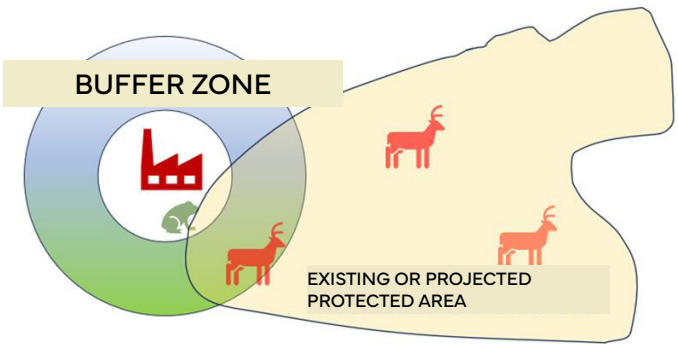
4. Results

Communication of results

Protected areas and territories of interest for biodiversity represent conserved habitats that help maintain biodiversity in Québec. The result will be communicated as a numerical value that can take a value of 0, 0.5 or 1 to represent respectively no encroachment of the project on a protected area, an encroachment on the buffer zone or an encroachment on the protected area.

Visualization of results

Encroachment of a project on a territory targeted for a conservation project:



Interpretation key

The score for this indicator shows the project's impact on areas that promote biodiversity conservation.

Points of caution for interpretation

- The total footprint is discretionary and its definition can greatly influence the result. It may include the zone of influence, which is to be set by the developer and the analyst.

Habitat destruction

1. OVERVIEW

Definition

Measurement of the impact of habitat loss, taking into account the spatial footprint of the project, the area of habitat affected, and the regional uniqueness and ecological integrity of the habitat.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 1 Ensure that all areas are under participatory, integrated and biodiversity inclusive spatial planning and/or effective management processes addressing land- and sea-use change.

Alignment with the TNFD framework

Métric C1.0 Land use change – Total spatial footprint
Metric C1.1 Land use change – Extent of land use change

2. DATA

Fixed data

Type of data required	Source	Availability
Land use	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Utilisation du territoire (Land use), [Dataset], in Données Québec, 2018, updated on June 28, 2023. [https://www.donneesquebec.ca/recherche/data-set/utilisation-du-territoire]	✓
Ecological value of habitats	Assessment of ecological integrity for each habitat type in three ordered classes (0 = highly anthropized environment, 0.5 = semi-natural environment, 1 = natural environment)	✓
Spatial footprint of the project	Self-reporting	✓

3. METHODOLOGY

Summary

Actual value of habitats affected by the project, weighted by the rarity of the habitats lost.

Formula

An indicator score ***I*** is defined which integrates the area lost, the rarity of the habitat and the ecological value of the habitat into a weighted average:

1. Rarity of the habitat (R_i): The rarity of each habitat type ***i*** in the region defined as the inverse of the total area of that habitat type in the region before the loss.
R_i = 1 – regional proportion of habitat type i.

2. Ecological value of the habitat (V_i): The ecological value for each habitat type ***i*** defined as natural (1), semi-natural (0.5) or highly anthropized (0).

The impact score ***I*** is defined as the weighted average of the ecological value of the habitats affected by the project:

$$I = \sum R_i \cdot V_i / \sum R_i$$

This score measures the impact of the loss of different habitats, taking into account the regional context and focusing on rare habitats.

This score is given within the interval [0, 1] giving a composite measure of habitat loss, with an emphasis on the destruction of rare habitats.

4. Results

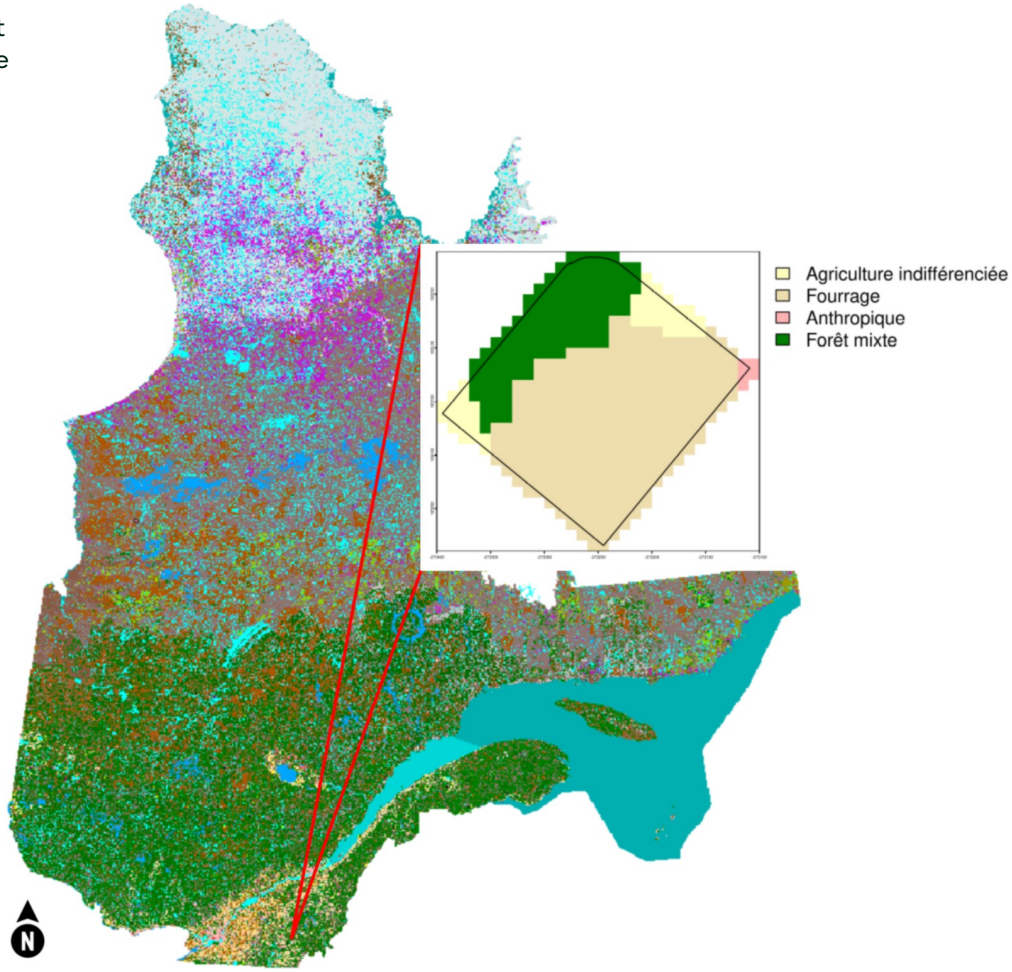
Communication of results

Habitat destruction is one of the main causes of biodiversity loss. The result will be communicated as a numerical value within the interval [0, 1] representing the ecological value of the habitats affected.

Visualization of results

Map showing the intersection between the project's spatial footprint and existing habitats:

Café William's development perimeter in the Sherbrooke industrial park; footprint on different types of habitat.



Interpretation key

A high score for this indicator shows a significant impact on habitats that are important for regional biodiversity.

Points of caution for interpretation

- The aggregation of land use classes is a proxy for favourable habitats for species. It is assumed that an available habitat can be occupied by species.

Pollution

1. OVERVIEW

Definition

Measurement of the potential impact of the project's pollutant releases on local biodiversity. It expresses the combined effect of the total number of substances emitted and the number of substances close to or above the mandatory reporting threshold. These mandatory reporting thresholds are set by the National Pollutant Release Inventory, managed by Environment and Climate Change Canada.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 4 Ensure urgent management actions to halt human induced extinction of threatened species.
Target 10 Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably.
Target 11 Restore, maintain and enhance nature's contributions to people.

Alignment with the TNFD framework

Metric C2.0 Pollution/pollution removal – Pollutants released to soil split by type
Metric C2.1 Pollution/pollution removal – Wastewater discharged
Metric C2.2 Pollution/pollution removal – Waste generation and disposal
Metric C2.4 Pollution/pollution removal – Non-GHG air pollutants

2. DATA

Fixed data

Type of data required	Source	Available
List of pollutant releases established by the Canadian Environmental Protection Act	Environment and Climate Change Canada – Toxic substances list (Canada/Interior list) National Pollutant Release Inventory (NPRI)	✓
List of pollutant discharges planned by the promoter	Self-reporting	✓

Description

A computerized self-reporting form completed by the developer is used to obtain the list of pollutants listed in the NPRI that the developer expects to release into the environment during the development phase or from the start of operations.

3. METHODOLOGY

Summary

Integration of the number of pollutants released, as required by the NPRI, and the quantities released. Pollutants released in very large quantities adversely affect the indicator's score.

Formula

An indicator score ***I*** is defined. It incorporates the number of substances reported close to (90%) or above (up to 200%) the NPRI threshold **N**, with the emphasis on pollutants released in very large quantities (>200%):

$$I = \begin{cases} 1 & \text{si } C_i > 2 \\ 1-e^{-(\beta * N)} & \text{si } C_i <= 2 \end{cases}$$

where $\mathbf{C_i}$ is the ratio of pollutant release i to reporting threshold and $\boldsymbol{\beta}$ is a constant defining the sensitivity of the indicator to **N**. $\boldsymbol{\beta}$ takes the value of 0.29, so that the indicator score I is 0.25 if a substance is released close to or above the reporting threshold (**N** = 1), without exceeding twice the threshold ($\mathbf{C_i}$ <= 2).

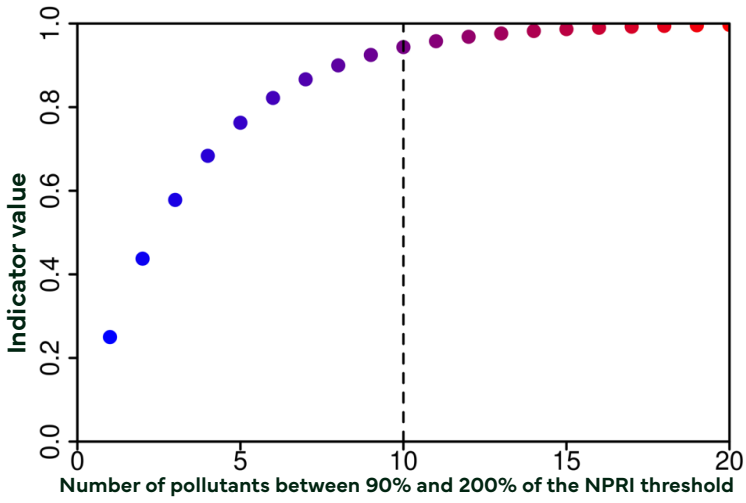
This indicator assigns a score within the interval [0, 1] giving a composite value that reflects the number of pollutants released in relation to the NPRI reporting threshold value. If a pollutant exceeds twice the reporting threshold, the indicator is given a score of 1.

4. RESULTS

Communication of results

The number and quantity of pollutants released into the environment are exerting pressure on ecosystems. Our indicator is sensitive to the number of pollutants released into the environment when they are emitted in a quantity approaching or exceeding the NPRI mandatory reporting threshold. An indicator score close to zero indicates a limited number of pollutants approaching or exceeding the threshold. A higher indicator score, between 0.5 and 0.99, indicates that a significant number of pollutants are being released, approaching or exceeding the concentration threshold, while a score of 1 implies that at least one pollutant is being released in a quantity greater than twice the NPRI threshold value.

Visualization of results



The dotted line represents a test case with 10 pollutants reported between 90% and 200% of the reporting threshold. As soon as a declared pollutant exceeds the reporting threshold by 200%, the impact indicator score changes to 1.

Interpretation key

The level of pollution is correlated with the potential risk to biodiversity. Although it's not an exact measurement of cumulative impacts, specific to different combinations of pollutants, the indicator is sensitive to the quantities released in relation to the mandatory reporting threshold for each pollutant and to the number of pollutants released. Basic data comes from a self-reporting form provided by the developer.

Points of caution for interpretation

- The score reflects the cumulative effect of the number of pollutants released into the environment, but our formula does not take into account the toxicity of each substance nor the toxicity of specific combinations of substances.
- Reporting thresholds are established by the NPRI and refer to pre-existing toxicological assessments.
- We consider a substance released at more than twice the NPRI reporting threshold to be a high risk to biodiversity. We then automatically assign the indicator its maximum value.

Introduction and spread of invasive alien species

1. OVERVIEW

Definition

Measurement of the potential impact on local biodiversity of the introduction of invasive alien species of concern through commercial activities.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 5 Ensure that the use, harvesting and trade of wild species is sustainable, safe and legal, preventing overexploitation, minimizing impacts on non-target species and ecosystems, and reducing the risk of pathogen spillover.

Target 6 Eliminate, minimize, reduce or mitigate the impacts of invasive alien species on biodiversity and ecosystem services.

Alignment with the TNFD framework

Metric C4.0 Invasive alien species and other

2. DATA

Données fixes

Type of data required	Source	Availability
Observation of invasive alien species	Atlas (Biodiversité Québec Portal)	✓
Priority invasive alien species	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, List of priority invasive exotic plant species, 2021 [https://www.environnement.gouv.qc.ca/biodiversite/especes-exotiques-envahissantes/index.asp]. Québec, Agriculture, environment and natural resources, List of invasive alien species, 2024 [https://www.quebec.ca/agriculture-environnement-et-ressources-naturelles/faune/gestion-faune-habitats-fauniques/gestion-especes-exotiques-envahissantes-animales/liste].	✓
Commercial activities that include the transport of wooden pallets	Self-reporting	✓

Type of data required	Source	Availability
Use of maritime transport in the supply chain, commercial activities or the transport of goods	Self-reporting	✓
Inter-regional movement of materials, soil, mineral material, plant material, fruits, vegetables, organisms, machinery or workers between regions or bodies of water	Self-reporting	✓
Use of non-native species for landscaping, cultivation, aquaculture or biocontrol purposes or captivity of exotic species	Self-reporting	✓
Introduction of irrigation canals and other water diversions	Self-reporting	✓

3. METHODOLOGY

Summary

Assessment based on confirmed presence of invasive alien species, exotic pathogens and activities associated with their introduction. The indicator assesses the number of activities involving risks in order to correlate the impact risk with the activities identified as being sources of invasive alien species introduction.

Formule

An indicator score ***I*** is defined. It incorporates the effect of activities involving risks ***R*** and the confirmed presence of invasive alien species ***P***:

1. **Probability of presence (P_i):** probability of presence of species ***i***.
2. **Practice involving risks (R_i):** practice n that could lead to the spread of invasive alien species.
3. **Number of elements (|R|):** number of elements taken into account in the invasive alien species risk analysis grid.

$$I = \begin{cases} 1 & \text{si } P_i = 1 \\ \sum (R_n) / |R| & \textbf{si } P_i < 1 \end{cases}$$

where $R_n = 1$ if practice n is confirmed and $P_i = 1$ if an observation of the species ***i*** is confirmed on the project's development site.

This score is given within the interval [0, 1]. It shows the risk of invasive alien species being introduced by the project, focusing on the confirmed presence of invasive alien species in the project's development perimeter.

4. RESULTS

Communication of results

The introduction of invasive alien species is a primary cause of biodiversity loss. The indicator score will be communicated as a numerical value within the interval [0, 1] representing the risk of invasive alien species being introduced by the project.

Visualization of results

Question (Q)	Answer Q	Sub-question (SQ)	Answer SQ	SCORE (binary)	Weighting (multiplication factor by area, distance, frequency of interaction, etc.) =1 or >1	WEIGHTED SCORE (binary score X weighting factor)	Maximum possible
Have any exotic or invasive species already been identified in the region(s) where your activities will take place?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Do you intend to receive or ship pallets of wood from other countries?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Will you be moving equipment, machinery or workers in contact with organic soils between regions, provinces or countries?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Do you plan to move boats (seaplanes, ships) or equipment between different bodies of water?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Does your project involve water channelization work modifying the structure of the hydrographic network to which the new canals are connected?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Does your project involve construction in aquatic environments? (even if it only involves columns or pilings)	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Do you plan to move soil, rock, plant or animal matter plant or animal matter or organisms from one region to another?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Do you plan to use non-native species for landscaping, cultivation, aquaculture or biocontrol?	NO	Mitigation measures in place (Yes/No)	NO	0	1	0	1
Do you plan to transport wood products, fruits, vegetables or viable seeds as part of your operations?	YES	Mitigation measures in place (Yes/No)	NO	1	1	1	1
Will your operations involve the use of shipping on the St. Lawrence to the Great Lakes or to overseas countries?	YES	Mitigation measures in place (Yes/No)	NO	1	1	1	1

TOTAL WEIGHT	2
Maximum possible	10
INDICATOR (TOT POND / MAX)	**0,2**

Interpretation key

A high score indicates that one or more risk factors are present in the project's development perimeter or in project-related activities.

Points of caution for interpretation

- The risks of introducing invasive alien species are caused by certain behaviours, but such behaviours do not automatically lead to their spread.
- We assume that the confirmed presence of an invasive alien species within the development perimeter poses a significant risk to biodiversity given the activities, particularly construction, that will take place there.

Ecological connectivity

1. OVERVIEW

Definition

Measurement of the impact of the loss of connectivity in the territory on the risk of species extinction, taking into account the dispersion of individuals.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 4 Ensure urgent management actions to halt human induced extinction of threatened species.

Alignment with the TNFD framework

Metric C1.0 Land use change – Total spatial footprint

Metric C1.1 Land use change – Extent of land use change

Metric A5.2 State of nature – Ecosystem connectivity

2. DATA

Fixed data

Type of data required	Source	Availability
Connectivity of the St. Lawrence Lowlands	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Base de données sur la connectivité écologique des milieux naturels dans les basses-terres du Saint-Laurent (Database on the ecological connectivity of natural environments in the St. Lawrence Lowlands), [Dataset], in Données Québec, 2023, updated on June 26, 2023. [https://www.donneesquebec.ca/recherche/dataset/connectivite-ecologique-des-milieux-naturels-dans-les-basses-terres-du-saint-laurent]	✓
Spatial footprint of the project	Self-reporting	✓

3. METHODOLOGY

Summary

The indicator measures the maximum value of connectivity within the project's perimeter (development perimeter and zone of influence).

Formula

An indicator score ***I*** is defined. It measures the maximum connectivity in the project's development area within the interval [0, 1]:

$$I = max\{C_i\} / max\{C\}$$

where C is a variable corresponding to the connectivity values for the territory as a whole and C_i to the connectivity values for the spatial unit i intersecting the project's perimeter, represented by the development perimeter and the zone of influence.

This score is given within the interval [0, 1]. It shows the measurement of the project's impact on ecological corridors, with the emphasis on damage to the most important corridors.

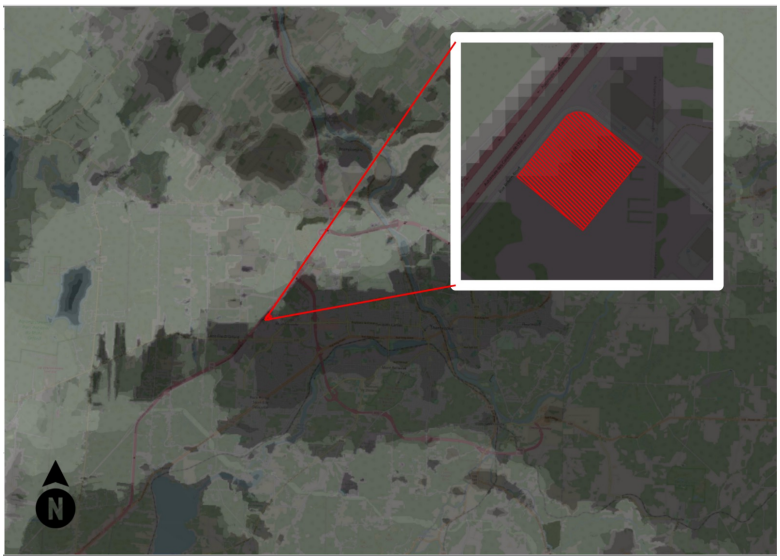
4. RESULTS

Communication of results

Habitat connectivity is essential for the persistence of biodiversity. The result will be communicated as a numerical value within the interval [0, 1] representing the effective proportion of species affected by the damage to the ecological corridor.

Visualization of results

Map showing the project's spatial footprint (blue rectangle) and connectivity value:



Café William's development perimeter in the Sherbrooke industrial park; footprint on ecological corridors. The dark areas have a low connectivity score, while the light areas are very important for species dispersion.

Interpretation key

This indicator measures the change in the spatial structure of habitats and therefore the risk of the project having an impact on species dispersion.

Points of caution for interpretation

- The total footprint is discretionary and its definition can greatly influence the result. It may include the zone of influence.
- The indicator is very sensitive to damage to the most important ecological corridors.
- In the absence of basic data on connectivity in northern environments, the indicator remains at its minimum value.

Cumulative stressors

1. OVERVIEW

Definition

Measurement of the cumulative impact of the many human activities carried out in the area.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Cible 1 Ensure that all areas are under participatory, integrated and biodiversity inclusive spatial planning and/or effective management processes addressing land- and sea-use change.

Cible 7 Reduce pollution risks and the negative impact of pollution from all sources.

Lien avec le cadre de la TNFD

Metric C1.0 Land use change – Total spatial footprint

Metric 1.1 Land use change – Extent of land use change

2. DATA

Fixed data

Type of data required	Source	Availability
Human footprint	Hirsh-Pearson, Kristen; Johnson, Chris; Schuster, Richard; Wheate, Roger; Venter, Oscar, 2022, "The Canadian Human Footprint", https://doi.org/10.5683/SP2/EVKAVL, Borealis, V3	✓
Spatial footprint of the project	Self-reporting	✓

3. METHODOLOGY

Summary

Average human footprint value for the project's development perimeter, including the buffer zone.

Formula

An indicator score ***I*** is defined. It measures the anthropogenic stress experienced by an environment:

$$I = (1 / n) * \Sigma i\ (Ei - min\{E\}) / (max\{E\} - min\{E\})$$

where ***E*** is the human footprint, E_i is the human footprint for a spatial unit ***i*** within the project's perimeter, represented by the development perimeter and the buffer zone, and ***n*** is the number of spatial units within the project's perimeter.

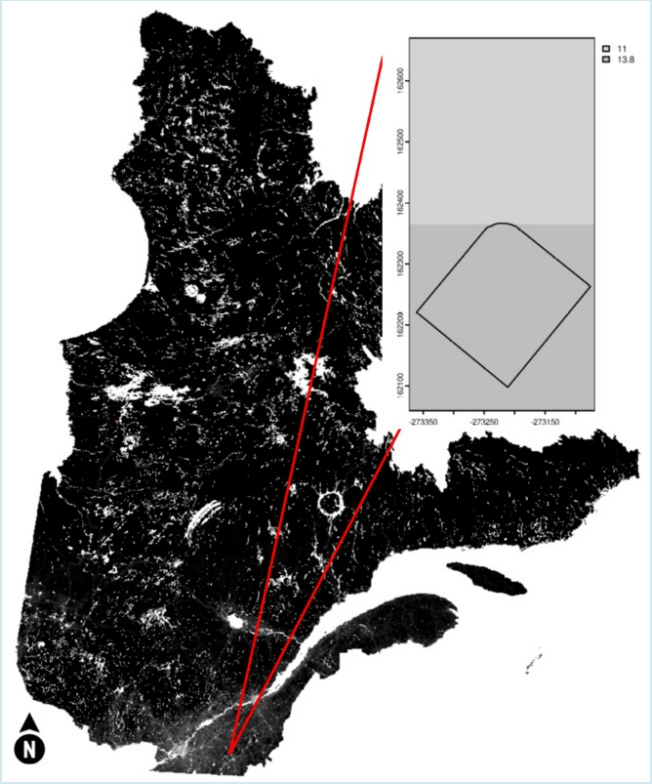
4. RESULTS

Communication of results

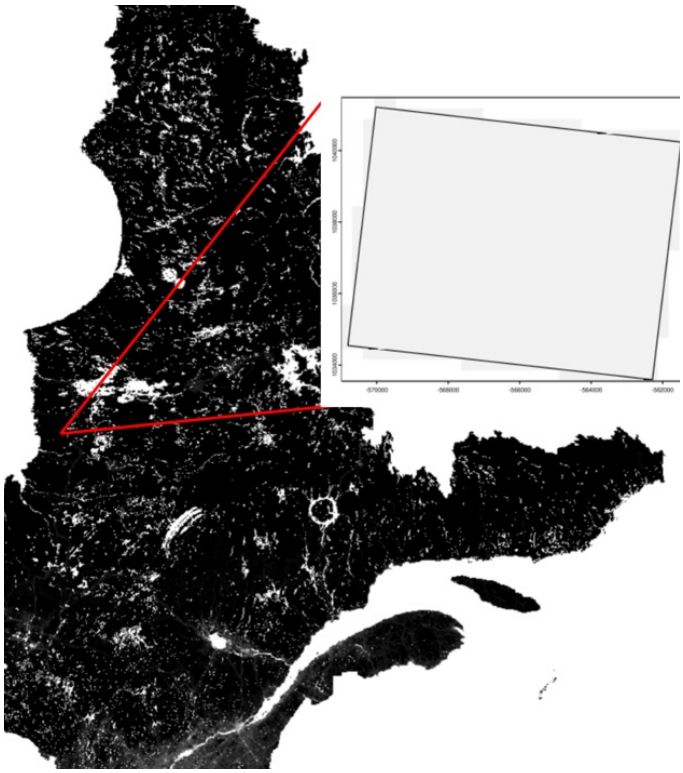
Stressors from anthropogenic sources affect biodiversity and natural habitats. The level of stress present in a particular area can influence the impact on biodiversity that the establishment of a large-scale project will have. The cumulative stressors score is given within the interval [0, 1] representing the stress experienced before the project was implemented.

Visualization of results

Map showing the project's spatial footprint and the human footprint value:



Café William's development perimeter in the Sherbrooke industrial park; human footprint in the development area



Development perimeter of the nickel mine near Dana Lake; human footprint in the development area

Interpretation key

The score for this indicator shows the level of disturbance to the environments over which the project extends.

Points of caution for interpretation

- Although the human footprint includes 12 sources of anthropogenic stress on natural environments, the impact of climate change has not yet been taken into account.
- The maximum impact is given to environments that are already highly stressed.

Destruction of natural carbon sinks

1. OVERVIEW

Definition

Measurement of the impact of climate change on biodiversity in terms of carbon stocks destroyed.

Alignment with the New Kunming-Montréal Global Biodiversity Framework

Target 11 Restore, maintain and enhance nature's contributions to people, including ecosystem functions.

Target 8 Minimize the impact of climate change and ocean acidification on biodiversity.

Alignment with the TNFD framework

Metric C1.0 Land use change – Total spatial footprint

Metric C1.1 Land use change – Extent of land use change

2. DATA

Fixed data

Type of data required	Source	Availability
Carbon stocks	Camile Sothe et. al. (2022): Carbon storage and distribution in terrestrial ecosystems of Canada. Version 5. 4TU.ResearchData. collection. https://doi.org/10.4121/c.5421810.v5	✓
Spatial footprint of the project	Self-reporting	✓

3. METHODOLOGY

Summary

Measurement of the relative intensity of the potential carbon stock loss, taking into account the area affected and the carbon density of the project's development area. .

Formula

An indicator score ***I*** is defined. It incorporates the affected area **S** and the carbon density **C**, with an emphasis on the loss of stocks with a high carbon density:

Total area ($|C|$): number of spatial units ***i*** affected.

Area affected (S_i): fraction lost from each spatial unit ***i***.

Carbon density (C_i): quantity of carbon per area unit for each spatial unit ***i***.

$$I = 1 - e^{-(k*P95)}$$

where ***k*** is an exponential weighting factor of the effect of the total quantity of carbon affected on indicator ***I***:

$$k = A * |C|^B$$

and P95 is the 95th percentile of the distribution of carbon lost per spatial unit ***i***:

$$P_{95} = P_{95}(C_i * S_i)$$

The values of constants ***A*** and ***B*** are 0.00000029 and 0.21 respectively, so that ***i***) the loss of a spatial unit at the 95th percentile of the distribution of carbon stocks in Québec produces an ***I*** of 50, and ii) the value of ***I*** is more sensitive to increases in small areas than in large areas, while ensuring a higher score for the largest areas.

This score gives a measurement of the impact of the disturbance on carbon stocks, taking into account the area affected and the carbon density in each spatial unit.

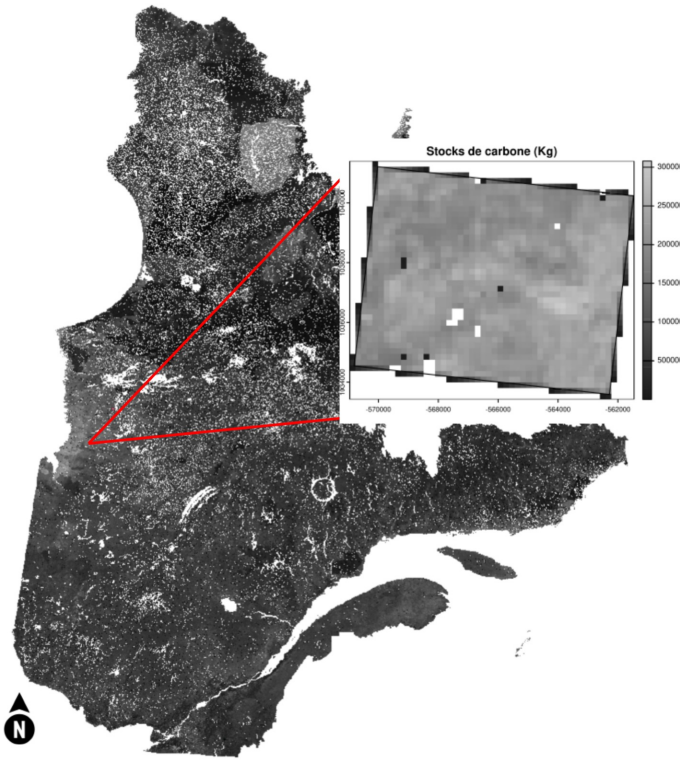
This score is given within the interval [0, 1], providing a measurement of the intensity of potential carbon stock loss, with an emphasis on high carbon density spatial units.

4. RESULTS

Communication of results

Loss of carbon stocks is a major concern for biodiversity in the context of climate change. The result will be communicated as a numerical value within the interval [0, 1] representing the relative intensity of carbon stock loss.

Visualisation des résultats



Development perimeter of the nickel mine near Dana Lake; footprint on carbon sinks.

Interpretation key

This indicator shows the potential loss of carbon stocks as a result of the use change of the environments over which the project extends.

Points de vigilance pour l'interprétation

- The total footprint is discretionary and its definition can greatly influence the result. It may include the zone of influence.

Conclusion

The development of biodiversity impact indicators for investors is receiving increasing attention from the research community, and the responsible finance community is committed to using them in decision-making. These tools are essential to initiate the ecological transition vision contained in the Global Biodiversity Framework. The issues we have identified are consistent with those outlined in the international protocols. The originality of our approach lies in the highly local nature of our indicators, which complement the global indicators more commonly used in portfolio analysis.

However, we must remain humble about the fruits of our labour. Although our indicators meet the need to measure the local impact of investments, financial institutions wishing to test them will have to be careful in their application and interpretation. These indicators are at an early stage of development and are already part of a process of iteration and continuous improvement.

Many of the points of caution and uncertainties listed in the methodology sheets are already fuelling new thinking within our team. For example, the evaluation of ecosystem services based on use by the population will be insensitive in northern and indigenous environments. Furthermore, we noted a need to subdivide the National Pollutant Release Inventory's list of substances to reflect the higher toxicity of certain releases and their cumulative effect. The methodology for assessing ecological connectivity in northern Québec also needs to be revised to better reflect ecological issues in these areas, such as the presence of old growth forests, the size of forest massifs and the density of forestry roads. Our assessment is based solely on the direct impact of a project and its indirect impacts in a neighbourhood perimeter; the analysis may eventually need to be extended to supply chains.

So far, our work has focused on the effects of investments on ecosystems. Less attention has been paid to the interdependencies with nature and aspects of dual materiality. As part of our efforts to align with the TNFD's proposals, we plan to improve the indicators in order to add this dimension to the analysis, whose importance for investors is clear, and sometimes easier to communicate.

Finally, although the indicators are planned around the new global framework's objectives and targets, it will be necessary to align them with the objectives of the Québec government's *Plan nature 2030*.

We are therefore starting today to automate the assessment process in order to test our indicators across a wide range of financial institutions and investment contexts. The typical cases studied here have allowed us to identify certain issues and to adapt the methodology; the analysis will have to be repeated to obtain a distribution of the results and thus to adjust their sensitivity and their ability to provide meaningful information. The indicators are only relevant in relative terms, and must maximize the differentiation between the projects evaluated. We are also reaching out and listening to the scientific community and private players conducting related research, whose feedback can help us move forward more quickly.

The large-scale deployment and adoption of our indicators in Québec will necessarily involve a process of automation and design, both of the database query systems and of the interface offered to users to test investment cases themselves.

Financial institutions and the Québec government are invited to join us in continuing our work, and to familiarize themselves with its results.

Remerciements

We would like to thank our partners from the beginning, Fondaction and Caisse de dépôt et placement du Québec, for their continued support. We would also like to thank the researchers who have contributed to our thinking and databases: Guillaume Larocque from the Centre de la science de la biodiversité du Québec, François Rousseau from the Canada Research Chair in Integrative Ecology, Jérome Dupras and Chloé L'Ecuyer-Sauvageau from the Université de Québec en Outaouais, as well as Véronique Bussières, Marie Cadieux and Yenny Cuellar Roncancio from SNAP Québec. We are also grateful to Fouzi Kerdouss and Tristan Lecompte of Environment and Climate Change Canada's National Pollutant Release Inventory and Substance Information Division for the availability and clarity of the information they provided. Finally, we would like to thank the Ministère de l'Économie, de l'Innovation et de l'Énergie du Québec, the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs du Québec, MITACS and the Natural Sciences and Engineering Research Council of Canada for their financial support and interest in the project.

Fondaction

SNAP QUÉBEC

CDPQ

Biodiversité Québec

UDS Université de Sherbrooke