Genomic Enterprise Response to Federal 2030 Biodiversity Strategy

Génome Québec

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HOW GENOMICS CAN FILL EXISTING GAPS IN BIODIVERSITY OBJECTIVES

Gap: Recovery progress for species is slow, and information for assessment is lacking

- As per Canada's Aichi Biodiversity Framework[1], by 2020, species that were secure were to remain secure, and populations of species at risk listed under federal law were to exhibit trends that were consistent with recovery strategies and management plans.
- Insufficient progress was completed towards this objective, and the tracking of endangered species has proven difficult, leading to uncertainty regarding their status.
- In addition, species-level research remains the main focus of conservation science, leading to an "over-reliance on measures of abundance and population size as key indicators of the state of biodiversity."[2]

How genomics can help

- With the right tools and standards, genomic information can be used to track species recovery in precise and non-invasive ways. Tools like **iTrackDNA**'s eDNA kits will allow for the detection of various species from environmental samples and eliminates the need for direct observation, which is logistically and economically more cumbersome.
- Tracking species at risk also benefits from understanding the genetic structure within discrete populations, as is the case with the "**Use of genomics to manage and protect caribou populations**" project. Only through genetic analyses were researchers able to clearly distinguish between caribou ecotypes and therefore facilitate conservation efforts.

Gap: Pollution levels in Canadian waters remains too high

- Another Aichi Biodiversity target for Canada was to reduce or maintain pollution levels in Canadian waters in order to support healthy aquatic ecosystems.
- The progress towards this objective has been insufficient thus far, particularly in the southern part of the country where an important proportion of water is regularly threatened.
- In addition to overfishing, the pollution levels in water are an important threat to the health and maintenance of aquatic species.

How genomics can help

- Detecting contaminant chemicals in water sources can be facilitated by the right tools. The **EcoToxChip** developed through Genome Canada funding allows users to detect toxins or chemicals in environmental samples and measure their effect in the cell of an organism. Through an understanding of genomics, the chip allows users to quickly screen complex environmental samples and accelerate decision-making.
- Other tools, such as the kits developed by **ATRAPP**, allow the rapid detection of cyanotoxins in order to control and react to toxic algal bloom outbreaks, which present an important risk to human and environmental health.

Gap: Data on the status of Canada's biodiversity is fragmented and the unstructured information can't be effectively translated into decision-making.

- There is a strong need for a comprehensive observation network in Canada in addition to comprehensive and consistent data collection.
- In order for political leaders to make informed decisions on the protection of biodiversity, they need access to and an understanding of the biodiversity data available, but there is currently no such central resource.

How genomics (and the Genome Enterprise) can help

- A successful strategy will require an **Integrative Biology**-based approach: the collaboration between all "levels" of biology, from the very small scale (genomics) to the very large scale

[1] 2020 Biodiversity Goals and Targets for Canada — biodivcanada.ca

[2] Integrated Biodiversity Pathways for Sustainability in Canada, p.20

(ecology, geography, and climatology). Genomics can produce models that predict how species or communities might adapt to climate change, but not without the help of other disciplines.

- Canada's biodiversity targets highlight the need for a comprehensive observation network that considers Canada as a whole and coordinates the various local, regional, and provincial efforts. The Canadian Genomics Enterprise already constitutes a pan-Canadian network of researchers, private partners, and industries, and as such can provide important insights towards this objective. Previously, Canada missed out on the opportunity of having a Canadian Genome Project. The urgency with which our biodiversity must be protected presents an opportunity for the creation of a **Canadian Biodiversity Project** or initiative that tackles existing and emerging issues head-on.

By its nature, genomics and its associated tools and resources have and will continue to play important roles in the environmental, economic, sociocultural, and governmental aspects of Canada's biodiversity objectives. The power of genomics in detecting, managing, and understanding species (animal, insect, microscopic or plant) will only become more evident and accessible as time goes on. In addition, genomics cuts across several other sectors of vital importance, including agriculture, forestry, and human health. Each of these fields impact biodiversity and in turn, biodiversity has important implications for how these sectors will evolve over time. As a unifying technology that impacts all these areas, we strongly encourage the federal government to incorporate genomics technologies in their plans for protecting biodiversity.

HOW GENOMICS WILL CONTRIBUTE TO KMGBF GOALS AND TARGETS[3]

Target 6: Impacts of alien species on biodiversity and ecosystems are eliminated, minimized, or reduced.

- Management of invasive alien species will be facilitated by using the proper tools, including standardized eDNA assays, which allow the precise and non-invasive detection of invasive or alien species from environmental samples. (**iTrackDNA**, **Project Optimize**)

Target 7: By 2030, the negative impact of pollution from all sources is reduced to levels that are not harmful to biodiversity and ecosystem function.

- The presence and nature of environmental toxins can be detected through genomics-based assays (**EcoToxChip**, **ATRAPP**).

Target 9: The management and use of wild species are sustainable.

- Genomic tools such as eDNA assays (**iTrackDNA**, **Project Optimize**) can help manage wild species by detecting their presence in non-invasive ways. Genomics is also important for the identification of distinct populations within a species (**caribou genomics**, **FISHES**) that might require different management practices. Diversity of non-visible species is also important, as microbes and insects are essential to the health of our soils and waters. Genomics-based assays are a simple and cost-effective way of detecting species in various samples without the risk of faulty visual identification.

Target 10: Areas under agriculture, aquaculture, fisheries, and forestry are managed sustainably.

- The sustainable management of aquaculture and fisheries requires a detailed understanding of the species concerned and source populations. Complete genomes and SNP-based assays (**FISHES**) are powerful tools that can be used to track genetic diversity within a species and through an understanding of species' adaptability, ensure the sustainability of aquaculture and fishery practise.
- Genomics also plays an important role in the economic components of biodiversity targets. Proper management of fisheries through a better understanding of fish biology and genomics can ensure the long-term viability of industries and careful management of stock populations. In addition, genomics can be used to trace the food in grocery stores and markets to ensure that the proper species are being sold and that efforts by fisheries to maintain critical populations are conducted properly.
- The proper management of our forests also benefits from genomics through the study of key species and how we can make them more resistant to existing and future changes to their environment (**CoAdapTree**).

[3] 15/4. Kunming-Montreal Global Biodiversity Framework (cbd.int)

Target 13: Effective legal, policy, administrative, and capacity-building measures are taken to ensure equitable sharing of benefits that arise from the utilization of genetic resources and associated traditional knowledge.

- Genomic research projects funded by the Genomic Enterprise must include a plan for the sharing of data and findings resulting from their studies. In addition, all major projects must have a social research component to address barriers to uptake and implementation of tools and knowledge by the end users (all government levels, communities, etc.). As a specific example, the **caribou genomics** project worked closely with the Minister of the Environment, the Fight Against Climate Change, Wildlife and Parks to develop tools for use by the provincial government to ensure the proper protection and management of caribou populations.

Target 20: Strengthen capacity building and technical and scientific cooperation.

- One of the best ways to ensure technical cooperation is the use of standardized tools. Existing and emerging genomics-based technologies such as the eDNA detection kits developed by the **iTrackDNA** team require precise standards for sampling, the use of the tools, and the interpretation of the results. This allows users from across a province or across the country to compare results effectively and ensure decisions are made with the best available data.

Target 21: Ensure data, information and knowledge are accessible to decision makers, practitioners, and the public.

- Locally, Genome Centres are also examples of collaborative networks and community outreach efforts, which are in line with the socio-cultural aspects of Canada's biodiversity targets. As an example, Génome Québec's "**Mission ADN-eau**" has been teaching students about environmental DNA since 2019. This half-day event invites students to collect water samples which are then submitted for sequencing to identify the different species present in that environment. Later, the results are shared with the students, and they are encouraged to reflect on the consequences of their findings and consider why certain rivers might have more microorganisms than others, or why a specific species of fish isn't found in certain bodies of water. Importantly, what this data means for the health of the environments sampled is a key point of discussion with the participants.
- Genome Canada funded projects have also launched their own initiatives for involving various communities in their research, either by encouraging citizens to contribute samples (**ATRAPP**), or by empowering communities to conduct their own monitoring of biodiversity through training and access to resources (**iTrackDNA**).

Goal A: Connectivity and resilience of ecosystems, abundance of native wild species + halting of human induced extinction, maintenance of genetic diversity within populations of wild and domesticated species.

- Genomics allows for precise wild species management through non-invasive tracking of environmental DNA (**iTrackDNA**) and tracking of interspecies diversity with SNP chips (**caribou genomics project**).
- Invasive species can also be tracked through eDNA, and a better understanding of the genomics of these species can help identify tools and strategies to control them. In addition, invasive species have the ability to carry new pathogens with them and thereby introduce new threats to Canadian health. Genomics can help here as well by quickly identifying new pathogens, and by understanding their genome be one step closer to controlling their impact on human health.

Goal B: Biodiversity is sustainably used and managed, and ecosystem functions are valued, maintained, and enhanced, with those in decline being restored.

- In considering the role of genomics in biodiversity monitoring, management, and conservation, it will be important to consider an integrative approach. This involves the integration of Traditional Knowledge and ensuring that Indigenous communities are involved in every aspect of Canada's efforts in protecting and maintaining its biodiversity.
- Genomics provides tools to determine baseline values and changes in biodiversity between and within species currently in our environment (**FISHES, Project Optimize, Caribou genomics**). By understanding this diversity, we can take appropriate measures to protect it, restore it, and measure the effect of these actions over time, not only for the different species involved, but also on the ecosystem functions, thereby facilitating quick decision-making.

Goal C: Benefits from utilization of genetic resources and traditional knowledge are shared fairly and equitably, while ensuring traditional knowledge associated with genetic resources is properly protected.

- Existing projects have and continue to demonstrate how the acquisition and use of genetic resources can be conducted in an equitable manner (**FISHES, iTrackDNA**)
- In all research fields, Génome Québec is increasingly asking research teams to consider Indigenous Peoples in the planning and execution of research objectives, as well as the dissemination of results. We have a lot to learn from Indigenous Peoples on respectful interactions with nature and it is critical that they be involved in every step of a national biodiversity strategy.

HIGHLIGHTED PROJECTS

FISHES[4] (2018–2025)

- **F**ostering **I**ndigenous **S**mall-scale fisheries for **H**ealth, **E**conomy, and food **S**ecurity.
- Using a combination of genomics and Traditional Ecological Knowledge, this project addresses critical challenges and opportunities related to food security and Commercial, Recreational, and Subsistence fisheries of northern Indigenous Peoples in Canada.
- The team is developing genomic resources for 6 species of fish important to northern communities and using this data to identify distinct populations and assess their vulnerability to future climate changes.
- FISHES supports the cogeneration of knowledge to foster the development and co-management of sustainable fisheries, increased food security, and enhanced social well-being.

iTrackDNA[5] (2021–2025)

- Applies innovative solutions on a large scale through 1) development and validation of genomics enabled tools; 2) eDNA field kit validation in collaboration with four remote First Nations; and 3) development of a socio-ecological framework to address policy, governance and economic research and recommendations on eDNA applications in Canada.
- Fills a critical gap in eDNA resource development by supporting national eDNA standard creation, and experimental evaluation of factors affecting eDNA and eRNA detection in various environmental conditions.

EcoToxChip[6] (2016–2023 and 2023–2026)

- During the LSARP-funded project, the team developed a PCR-based tool which uses a set of carefully selected genes in order to quickly and reliably screen chemicals and complex environmental samples.
- In subsequent GAPP funding, the project team is working with ECCC and aims to advance the existing EcoToxChip system to make it more accessible, while also being consistent and reliable for informing regulatory decisions.

ATRAPP[7] (2016–2022)

- **A**lgal blooms, **T**reatment, **R**isk **A**ssessment, **P**rediction and **P**revention through genomics
- During this LSARP, the team identified key biomarkers and established methods for the detection and quantification of 26 types of cyanotoxins. They also developed a model that can use chemical and genomic data to predict total toxin concentration and time until first day of toxicity.
- The team is now in discussions with the *Centre d'expertise en analyze environmental du Québec* and a private company to use identified biomarkers in the commercialization of a test for the detection of proliferating microbes in water.
- Findings from this project have led to policy recommendations which have been incorporated in the *Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec*'s new plan for sustainable agriculture.

[4] FISHES-project (ulaval.ca)
[5] iTrackDNA
[6] Technology - EcoToxChip
[7] ATRAPP

- Through 2 citizen science initiatives[8,9], the team has assembled a large network of concerned citizens eager to contribute to research on issues related to freshwater ecosystems.

Use of Genomics to Manage and Protect Caribou Populations[10] (2018–2022)

- Through this GAPP, the researchers published a complete caribou genome using sequencing data from 150 individuals. 700 additional caribou samples were used to identify polymorphisms from distinct populations.
- Sequencing data was used to generate a SNP chip with over 63,000 sites and Québec's *Ministère de l'Environnement et de la Lutte contre les changements climatiques* has since used the chip to analyze over 2,000 samples as part of their mandate to protect and manage the endangered populations of the species.

Optimizing the eDNA approach to monitor biodiversity in Canada's Marine Protected Areas (Project Optimize)[11] (2021–2023)

- In this GAPP, researchers are working to optimize the monitoring of species in Canada's MPAs using eDNA metabarcoding.
- The team is generating an evidence-based decision support tool for use by Fisheries and Oceans Canada that will estimate the cost of eDNA biodiversity monitoring and assist in the selection of an optimal sampling design.

CoAdapTree: Healthy Trees for Future Climates[12] (2016–2022)

- Through this LSARP, researchers have identified genes for climate adaptation and disease tolerance in Douglas-fir and lodgepole pine.
- Two CoAdapTree SNP arrays were developed for the same species that detect genes associated with climate adaptation, and disease, drought, or cold hardiness.

Mission AND-eau[13] (2019-Present)

- Since 2019, Génome Québec has been working with teachers and students from local schools to collect environmental DNA from Québec's waterways. In the process, participants are educated on DNA, sequencing, and how individual species can be identified by trace amounts of material left behind in the environment.

RESSOURCES

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