Canadian Museum of Nature

Science Review 2021

canadian museum of nature
nature
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Canada

RESEARCH CONDUCTED AND ENABLED BY THE CANADIAN MUSEUM OF NATURE

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Scientific collections are knowledge-based resources. They constitute important research infrastructure, enabling scientific research and discovery at local, regional, national and international levels. The collections of natural history museums are central to understanding and advancing knowledge of the past, present and future of biological and geological diversity as well as the public understanding of science. Documentation of the use of collections raises awareness of their relevance and facilitates their continued support and development.

The national natural history collection at the Canadian Museum of Nature is the foundation of the museum's scientific work on biodiversity and geodiversity in Canada and globally and has supported scientific research and public understanding of natural heritage for over 150 years. The collection is a world-class resource that enables global research and discovery about the natural world and how it is changing.

This Science Review documents the impact of the Canadian Museum of Nature on the generation of new scientific knowledge. In 2021, 271 scientific articles were published by Museum staff, associates and other researchers whose work was enabled by the Museum's collections.

The global science impact of the Canadian Museum of Nature is substantial.

ABOUT THE CANADIAN MUSEUM OF NATURE

WHO WE ARE

The Canadian Museum of Nature is Canada's national museum of natural sciences and natural history.

Our global vision is a sustainable natural future. As current environmental changes such as greenhouse gas emissions, species extinctions, and loss of natural spaces due to anthropogenic activities run counter to this vision, the museum aims to inspire change.

Our global mission is to save the world for future generations with evidence, knowledge and inspiration.

WHAT WE DO

The museum creates and delivers inspiring and memorable connections with nature through impactful research programs, collections management, exhibitions, and engagement in a 21st-century global context.

The museum's galleries and programs are based at the Victoria Memorial Museum Building, a National Historic Site of Canada, in Ottawa, Ontario.

The museum houses and curates Canada's national natural history collection at its Natural Heritage Campus in Gatineau, Quebec. The collection comprises over 14.6 million natural history specimens. These provide the evidence museum scientists, associates, colleagues and other researchers use as a base for their studies, resulting in the generation of new knowledge about the natural world.

This authoritative scientific collection spans the tree of life, including specimens of algae, animals, lichens, and plants, and documents geological diversity, including minerals, rocks, and gems. The specimens are organized into 3.4 million units or lots, of which some 3 million are accessioned into the permanent collection and the remainder exist as prepared or unprepared backlog material. The museum's National Biodiversity Cryobank of Canada, a biorepository of frozen tissues, samples, and specimens from across Canada and abroad, is a source of material for genomic research conducted by staff and the international research community.

Each year, the museum's collection grows by about 20,000 new specimens. These specimens are obtained through staff field research, exchanges with other museums, purchases, and donations from collectors.

The museum also houses vital library and archival references about nature: a large collection of books and periodicals that is particularly strong in the fields of the Canadian Arctic, ornithology, systematics and taxonomy; an archival collection; a nature art collection; and a mixed media collection.

Two research centres of excellence are located at the museum's Natural Heritage Campus: the Beaty Centre for Species Discovery and the Centre for Arctic Knowledge and Exploration.

SCIENCE REVIEW METHODS

PAPERS BY MUSEUM STAFF AND RESEARCH ASSOCIATES

Papers published in 2021 by Canadian Museum of Nature staff and associates were found using internal reporting mechanisms and literature searches.

PAPERS BY EXTERNAL AUTHORS ENABLED BY CANADIAN MUSEUM OF NATURE COLLECTIONS

External researchers access Canadian Museum of Nature collection information by personal visits to the collections, by requesting information about specimens, by borrowing museum specimens, and by retrieving museum collection data shared online. Papers published in 2021 by external authors that indicate Canadian Museum of Nature collections contributed to the published research were discovered via manual literature searches. Searches were conducted for papers that cite one or more Museum specimens, indicate that a Museum collection was searched for relevant specimens during a study regardless of whether suitable material was found, indicate significant use of Museum collections for consultation and identification of species, or indicate that specimens associated with the published work were deposited in the Museum.

To conduct these searches, the following Canadian Museum of Nature collection codes were queried in Google Scholar: CAN (vascular plant), CANA (alga), CMNAR (amphibian and reptile), CMNA (annelid), CMNAV (bird), CANM (bryophyte), CMNC (crustacean), CMNFI (fish), CMNIF (fossil invertebrate), CMNFV (fossil vertebrate), CMNI (general invertebrate), CMNEN (insect), CANL (lichen), CMNMA (mammal), CMNML (mollusc), CMNPB (palaeobotany), CMNPYM and CMNPYF (palynology), and CMNPA (parasite). The acronyms CMN and NMC (National Museum of Canada, as the Canadian Museum of Nature was formerly known) and "Canadian Museum of Nature" were also queried.

Only peer-reviewed papers were considered; theses and preprints were excluded. For each publication by authors not affiliated with the Museum, the primary author's country was used as a proxy to assess how the global community used the Museum's collections.

Papers published in 2021 that cite a GBIF dataset including one or more Canadian Museum of Nature specimens, as indexed on the Canadian Museum of Nature GBIF publisher page, were identified. Given the volume of 2021 papers that cite a GBIF-mediated dataset including Museum data, it was impractical to carefully review each study to confirm that downloaded Museum occurrence data was used in analyses reported in the paper. Instead, a subset of these papers was reviewed and summarized as examples of how GBIF-mediated Canadian Museum of Nature collection data is used by the international scientific community to address research questions that require a large amount of reliable biodiversity information from broad geographical areas.

CATEGORIES OF RESEARCH PAPERS

To characterize the types of research conducted and enabled by the Canadian Museum of Nature in 2021, each paper was assigned to one of the following four themes: Earth History and Evolution, Endangered Species and Conservation, Environmental Health, and Species Discovery. Although many papers could be placed under more than one category, the single category that best encapsulated each work was used.

A selection of papers is summarized under each theme, with an explanation of each paper's potential broader impact and contribution to advancing knowledge. These examples demonstrate the diverse science that museum researchers are engaged in and the many ways that Canadian Museum of Nature collections are used by others to generate new knowledge about the natural world.

2021 SCIENCE REVIEW

In 2021, 271 scientific papers were published by Museum staff and associates or enabled by the Canadian Museum of Nature's collections, excluding studies that used GBIF-mediated Canadian Museum of Nature data because it was impractical to comprehensively document them.

PAPERS BY MUSEUM STAFF AND RESEARCH ASSOCIATES

Museum staff authored or co-authored 77 publications, ten of which they co-authored with a Canadian Museum of Nature research associate. Canadian Museum of Nature research associates authored or co-authored 68 papers, excluding ones co-authored by a Museum staff member.

PAPERS BY EXTERNAL AUTHORS ENABLED BY CANADIAN MUSEUM OF NATURE COLLECTIONS

Canadian Museum of Nature collections contributed to research published in 125 papers authored by researchers not affiliated with the museum. Of these papers, 114 cite one or more Museum specimens, one indicates the authors searched a Museum collection for relevant material but found none, and ten indicate the authors either consulted Museum collections to help with identifying species or deposited voucher specimens from their study in the Canadian Museum of Nature. Affiliations of first authors of these papers represent 25 countries (Figure 1). Canada (39) and the United States (29) are the best-represented countries in the dataset.

CATEGORIES OF RESEARCH PAPERS

Ninety-eight publications fall under the Earth History and Evolution research theme, which includes palaeobiology and mineralogy studies. Eighty-five of these publications are in the field of palaeobiology (10 co-authored by Museum staff, 28 by Museum research associates, and 47 by researchers not affiliated with the Museum) and 13 are in the field of mineralogy (six co-authored by Museum staff, two by Museum research associates, and five by researchers not affiliated with the Museum).

Nine papers fall under the Environmental Health research theme. Museum staff co-authored four of these, Museum research associates co-authored two, and researchers not affiliated with the Canadian Museum of Nature authored three.

Twenty-one papers fall under the Endangered Species and Conservation theme. Museum staff co-authored 16 of these, a Museum research associate co-authored one, and researchers not affiliated with the Canadian Museum of Nature authored four.

One hundred thirty-eight papers fall under the Species Discovery theme. This theme includes papers focused on the taxonomy, systematics, and ecology of extant biodiversity. Museum staff authored or co-authored 41 of these, Museum research associates authored or co-authored 32, and researchers not affiliated with the Canadian Museum of Nature authored 65. Papers by external authors that cite museum specimens report the results of biodiversity inventories and checklists, evolutionary studies, biogeography studies, and taxonomic studies, including new species descriptions, and more. These papers focus on diverse groups of living organisms, including alveolates (3), beetles (24), birds (5), corals (1), diatoms (2), echinoderms (1), flatworms (1), gastropods (1), lichens (2), fishes (3), sponges (2), trematodes (1), mammals (10), minerals (3), mosses (3), reptiles (2), and vascular plants (3).

LIMITATIONS OF OUR APPROACH

Although aiming to be comprehensive, some papers have likely been missed in this review, given the manual effort required to find and confirm relevant publications that meet our criteria for inclusion and the highly variable way that museum specimens and their repositories are referred to in scientific papers. Papers that cite Museum vascular plant specimens are particularly difficult to track in the literature and almost certainly underrepresented in our list. This is because the collection’s acronym is “CAN” (a common English word), and the standard practice in botanical literature is to cite collection codes with reference to an external resource that defines those codes rather than defining the code within the text, which is routine, for example, in the entomological literature.

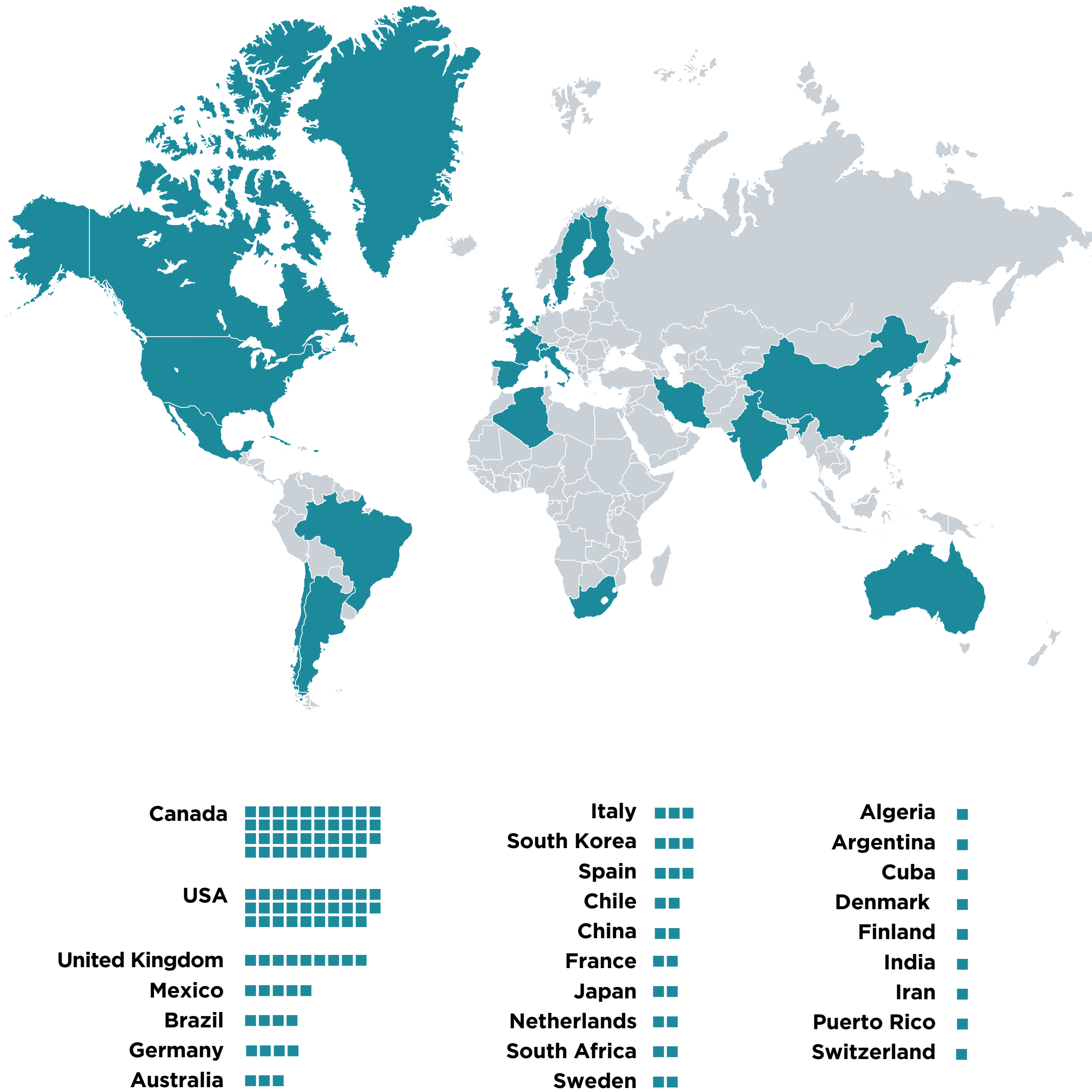


Figure 1. Summary of the geographical origins of papers, determined as the country of the paper's first author, and the number of papers from each country by researchers not affiliated with the Canadian Museum of Nature and that used Canadian Museum of Nature collections or collections data, excluding studies that used GBIF-mediated Canadian Museum of Nature.

The Canadian Museum of Nature shares data online for 916,000 (29.6%) of its more than three million accessioned specimens or lots (Table 1).

Of these, 818,411 records are mobilized via the Global Biodiversity Information Facility (GBIF) and 97,589 (algae and mineral collections) via other online databases (Table 1). The completeness of these digital records varies, ranging from a species name and high-level geographical provenance (i.e., country and province/state; “skeletal” records) to complete collection information including geographical coordinates, which often must be determined secondarily, and one or more images of the specimen. A total of 73.8% of all mobilized museum data has geographical coordinate data and 73.2% of GBIF-mobilized museum data has coordinate data. One or more images are available for 12.9% of museum specimen records mobilized online; more than 89% of records with images are herbarium specimens, primarily vascular plants, which are flat and straightforward to image and have been a museum priority for imaging. Algal collections represent 10% of the total records with images. Non-botanical specimens represent less than 1% of all records with images.

The large number of papers that cite one or more Museum specimens or a GBIF dataset including specimen data from the Canadian Museum of Nature, even though the latter was not comprehensively documented, demonstrates how the Museum’s collections contribute broadly to development of new knowledge by researchers from around the world.

The number of papers that access and use GBIF-mediated Canadian Museum of Nature data is predicted to increase in the coming years. As the global GBIF-mediated dataset grows, more and more researchers are likely to use the available information in their work. As more Canadian Museum of Nature specimens are digitized, a greater number of GBIF-mediated Canadian Museum of Nature data points will be available to the global community. As the proportion of georeferenced Canadian Museum of Nature specimens increases, a greater number of data points will be discoverable using map-based queries in the GBIF portal. As the proportion of images associated with Canadian Museum of Nature specimen records increases and those images are mobilized, the expected usage of those resources will increase, particularly in systematic and related biodiversity studies where an image may be useful or required for a specimen to be considered in a study (even if it is impossible to accurately identify a specimen to species level from an image, as is the case for many groups of organisms).

Table 1. Summary of Canadian Museum of Nature collections, including number of physical specimens or lots, number of records digitized and mobilized online, number of mobilized records that are georeferenced, and number of mobilized records with an associated image. Digital resources are hosted on an Integrated Publishing Toolkit (http://ipt.nature.ca) and mediated by the Global Biodiversity Information Facility (GBIF) unless otherwise indicated. GBIF-mediated data summarized here were captured on December 21, 2022.

Canadian Museum of Nature Collection	Number of Physical Specimens or lots[1]	Number (%) of records[2] digitized and mobilized online	Number (%) of mobilized records georeferenced[3]	Number (%) of mobilized records with one or more specimen images
Herbarium[4]	1,065,766	297,862 (28)	215,906 (72)	106,138 (36)
Algae	161,879	55,034 (34)[5]	41,606 (76)[5]	11,938 (22)[5]
Bird	119,919	101,503 (85)	90,916 (90)	206 (0.2)
Crustacea	73,728	69,004 (94)	65,502 (95)	38 (0.06)
Fish	63,482	62,401 (98)	59,040 (95)	10 (0.02)
Mammal	59,703	59,669 (100)	44,531 (75)	11 (0.02)
Mollusc	131,113	50,872 (39)	38,312 (75)	252 (0.05)
Fossil Vertebrate	54,668	51,262 (94)	- [7]	46 (0.09)
Amphibian and Reptile	37,858	37,667 (99)	35,532 (94)	62 (0.2)
Faunal Assemblage	98,437	0 (0)	0 (0)	0 (0)
Insect	1,092,237	19,061 (2)	7,786 (41)	16 (<0.01)
General Invertebrate and Annelid	42,131	30,802 (73)	27,680 (90)	44 (.02)
Parasite	18,761	15,512 (83)	13,622 (88)	5 (0.03)
Palynology	14,569	14,566 (100)	- [7]	2 (0.01)
Palaeobotany	4,872	4,872 (100)	- [7]	1 (0.02)
Fossil Invertebrate	4,552	3,358 (74)	- [7]	0 (0)
Mineral	49,638	42,555[6]	35,743 (19)[6]	0 (0)[6]
TOTALS	**3,092,628**	**916,000 (29.6)**	**676,186 (73.8)**	**118,768 (12.9)**

1. These numbers are estimates and include only accessioned material; unprocessed backlog material is excluded.
2. "Records" means catalogueable units or lots, not total number of specimens (i.e., one jar of fishes, a catalogueable unit, may contain 12 individual specimens).
3. "Georeferenced" means the digital record includes geographical coordinates that allow the record to be mapped and retrieved in map-based queries. The numbers were determined including the GBIF location flag "Include records where coordinates are flagged as suspicious."
4. Including bryophytes, lichens and vascular plants. Algae are treated separately because their data are published in a separate database.
5. Mobilized via http://www.nature-cana.ca/databases/index.php
6. Mobilized via http://collections.nature.ca/en/Search/Index
7. Locality information for palaeobiology collections is shared only upon request.

EARTH HISTORY AND EVOLUTION

The Earth has a long history of change over time. Understanding the past can be key to managing the present and predicting the future. Museum scientists study and classify mineral diversity and work with rocks to understand how the Earth was formed. They also study fossils preserved in rocks and subfossils to understand how species have evolved, what aspects of their morphology may be important in explaining their biology, where they live, and how many of them there are (or were). By studying why some groups of organisms are successful with lots of species, and others not, we can better understand extinctions and how these might be explained and possibly even prevented. Understanding Earth history is a complex blend of geology and palaeobiology.

Papers co-authored by Canadian Museum of Nature staff

LANDRY Z., S. KIM, R.B. TRAYLER, **M. GILBERT**, **G. ZAZULA**, J. SOUTHON AND **D. FRASER**. 2021.

Dietary reconstruction and evidence of prey shifting in Pleistocene and recent gray wolves (*Canis lupus*) from Yukon Territory.

Palaeogeography, Palaeoclimatology, Palaeoecology 571: 110368.
https://doi.org/10.1016/j.palaeo.2021.110368

Gray wolves (*Canis lupus*) are ecosystem engineers that regulate herbivore populations and, indirectly, shape plant and animal communities. They are also one of a minority of large-bodied (≥44 kg) mammals that survived the end Pleistocene (~11,700 years ago) extinction. Graduate student Zoe Landry and colleagues, including Museum research scientist Danielle Fraser, Museum research assistant Marisa Gilbert, and Museum research associate Grant Zazula, asked whether dietary flexibility may have enabled gray wolves to survive a period that otherwise marked the extinction of megafauna like mammoths and short-faced bears. They compared the dietary ecology of Pleistocene and modern wolves from the Yukon Territory using dental microwear, analysis of microscopic marks on the teeth for inferring feeding behavior, and stable isotope analyses ($\delta^{13}C$, $\delta^{15}N$), indicators of diet and trophic level. They found no change in the parts of the carcass wolves preferred to eat (i.e., bone or flesh) but did find a dietary shift from Pleistocene horse to moose and caribou. They concluded that survival of caribou through the end Pleistocene extinction and dietary flexibility may have been the key to wolf survival.

Landry was the recipient of the Canadian Museum of Nature's 2021 Outstanding Student Award. The Museum awards the Outstanding Student Award each year to a museum-affiliated student who has made major contributions to research, collections, education, and/or outreach.

Artist's reconstruction of gray wolves attacking a horse on the mammoth-steppe habitat of Beringia during the late Pleistocene, around 25,000 years ago. Source: Julius Csotonyi/Yukon Government.

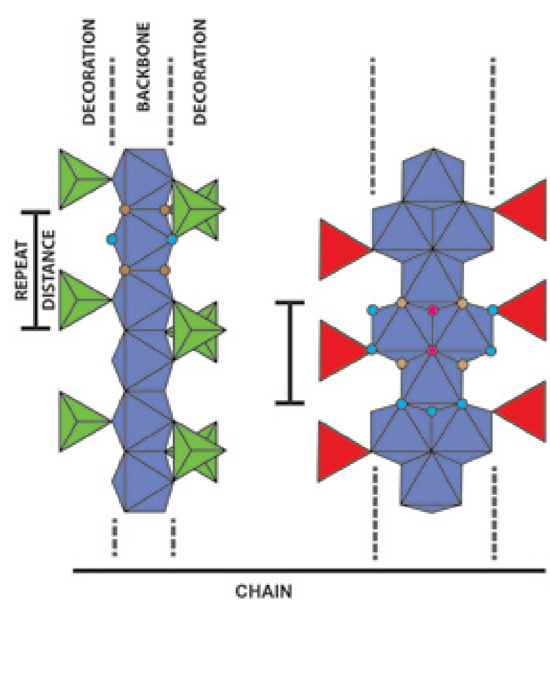
LUSSIER, A.J. AND F.C. HAWTHORNE. 2021.

Structure topology and graphical representation of decorated and undecorated chains of edge-sharing octahedra.

Canadian Mineralogist 59: 9–30.
https://doi.org/10.3749/canmin.2000061

Understanding the structure of minerals contributes to our understanding of the formation and evolution of Earth's geology objects and is required for designing new materials with useful properties from mineral resources. Chains of edge-sharing octahedra are fundamental building blocks in the structures of several hundred mineral species and synthetic compounds. Octahedrons are eight-faced polyhedrons, three-dimensional shapes with flat polygonal faces, straight edges and sharp corners. These chains consist of a backbone of octahedra that may be decorated by other polyhedra. In the minerals in which they occur, these chains often form part of the mineral's structural unit (i.e., the strongly bonded part). Investigating chain topology, configuration, and arrangement may yield fundamental insights into the stability of minerals in which they occur. In this study, Canadian Museum of Nature research scientist Aaron Lussier and his colleague characterized the topological variability of these complex chains. They also developed mathematical and graphical approaches to describe them.

Basic components of infinite chains composed of edge-sharing octahedra, including backbone structure (purple shapes) and decoration polyhedra (green and red shapes). Source: Lussier and Hawthorne (2021).



MIYASHITA, T., R.W. GESS, K. TIETJEN AND M.I. COATES. 2021.

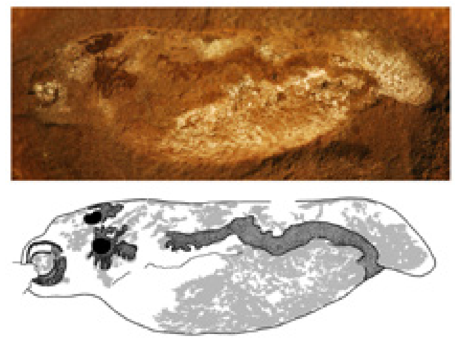
Non-ammocoete larvae of Palaeozoic stem lampreys.

Nature 591: 408–412.
https://doi.org/10.1038/s41586-021-03305-9

The ontogeny of modern lampreys, a lineage of jawless fish with ancient origins, involves the transition from a filter-feeding larva to a predatory adult. Lamprey ontogeny has been used as a model for the evolution of vertebrates because it appears to reflect many long-held hypotheses concerning morphological change during vertebrate evolution. However, the validity of inferences made from lamprey larval development have never been independently verified. In this study, Canadian Museum of Nature research scientist Tetsuto Miyashita and colleagues report on larvae and juveniles of four ancient lampreys, including a developmental series from the late Devonian (~383–372 Ma). None of the ancient larvae resemble the larvae of modern forms, suggesting that modern lamprey larvae are of more recent origin and represent a specialization to the modern lamprey lifestyle. The authors thus challenge the ways in which vertebrate evolution has been studied, likely changing approaches in evolutionary developmental biology for decades to come.

Miyashita et al. (2021) was awarded the 2021 Brock Award. The Canadian Museum of Nature awards the Brock Award each year for best scientific paper published by a staff member.

Fossil of a hatchling Paleozooic lamprey from Illinois. Source: Miyashita et al. (2021).



Artist's reconstruction of the life stages of the fossil lamprey Priscomyzon riniensis. This species lived around 360 million years ago in a coastal lagoon in what is now South Africa. Illustration by Kristen Tietjen.

ENVIRONMENTAL HEALTH

With increasing human population, our natural world is changing. Understanding human impacts on the natural world, such as those related to climate change, introduction of invasive species, and habitat loss, is key to ensuring a sustainable future. In many instances, knowledge about plants and animals can be used to measure and assess the general health of today's ecosystems. Identifying indicator species, those whose presence or absence are indicative of changes in ecosystem health, is often a simple and fast way to detect change. Border security and the prevention of introduced species is also a concern, as invasive species can often have profound impacts on the ecosystems to which they are newly introduced.

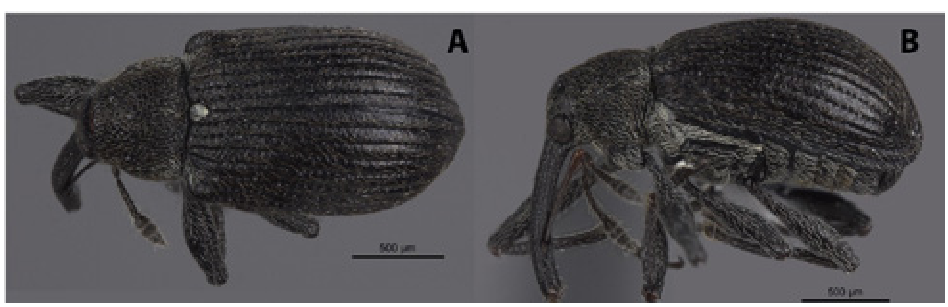
Papers co-authored by Canadian Museum of Nature staff

FRANKLIN, M.T., T.K. HUEPPELSHEUSER, P.K. ABRAM, P. BOUCHARD, **R.S. ANDERSON** AND G.A.P. GIBSON. 2021.

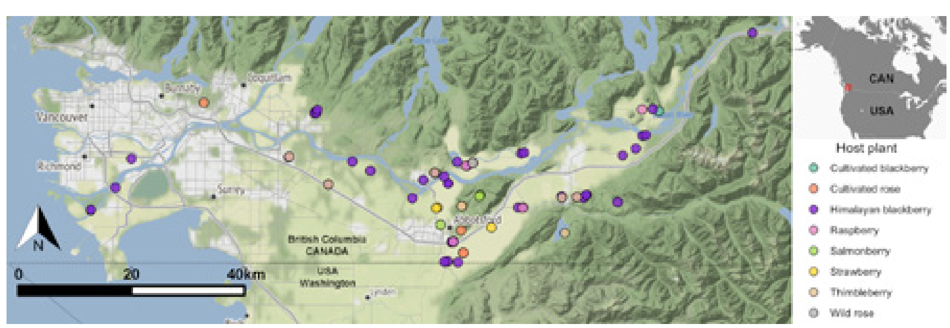
The Eurasian strawberry blossom weevil, *Anthonomus rubi* (Herbst, 1795), is established in North America.

The Canadian Entomologist 153: 579–585.
https://doi.org/10.4039/tce.2021.28

New invasive species continue to be recorded around the world. Among animals, insects are the most common invaders. Many insect species are economically significant agricultural pests. Because of the threats they pose to food security and crop production, intercepting invasive species before they become established in new areas and continually monitoring areas for new invasive species is essential. In this study, Franklin and colleagues, including Canadian Museum of Nature research scientist Robert Anderson, report the first records of the strawberry blossom weevil, *Anthonomus rubi*, in North America. Strawberry blossom weevil is a pest of plants in the family Rosaceae, including berries like strawberries (*Fragaria* Linnaeus) and raspberries (*Rubus idaeus* Linnaeus). Franklin and colleagues identified the specimens using published information, by comparing them with European specimens housed in Canadian collections, including the Canadian Museum of Nature's extensive beetle collection, and using DNA barcode data. The authors also deposited collections of this species from British Columbia in the Canadian Museum of Nature, where they are available for study by others. They concluded that the species is established in British Columbia's Lower Mainland region, where it has been recorded on multiple native and cultivated host plants in Rosaceae. This study reminds us that it is important for Canada to maintain and continually develop globally representative biodiversity collections and taxonomic expertise.



Strawberry blossom weevil (Anthonomus rubi) collected from Watson Glen Park, Chilliwack, British Columbia, Canada. Source: Franklin et al. (2021).



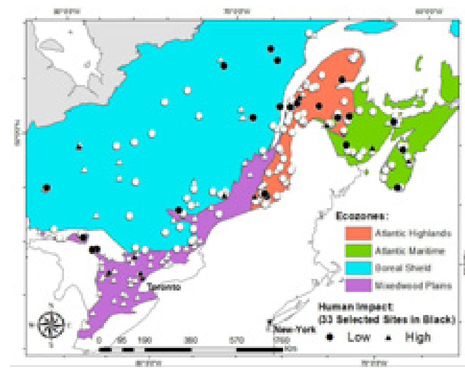
Map of locations where Strawberry blossom weevil (Anthonomus rubi) was found associated with various host plants in British Columbia, Canada in 2020, indicated with coloured points. Source: Franklin et al. (2021).

GRIFFITHS, K., A. JEZIORSKI, C. PAQUETTE, Z.E. TARANU, A. BAUD, D. ANTONIADES, B. BEISNER, **P.B. HAMILTON**, J.P. SMOL AND I. GREGORY-EAVES. 2021.

Multi-trophic level responses to environmental stressors over the past ~150 years: Insights from a lake-rich region of the world.

Ecological Indicators 127: 107700.
https://doi.org/10.1016/j.ecolind.2021.107700

Inland fresh waters, the quality of which are affected by multiple factors (e.g., heavy metal pollution and calcium decline), are essential to human well-being and survival. However, our understanding of which factors have the greatest impact on water quality, whether fresh waters have undergone historical shifts in water quality, and how organisms are affected are woefully incomplete. To address these shortcomings, sampling efforts must occur over large spatiotemporal scales. As part of LakePulse, a nationwide project examining a wide range of problems affecting Canada's lakes sampling, Griffiths and colleagues, including Canadian Museum of Nature senior research assistant Paul Hamilton, retrieved sediment cores from lakes across Eastern Canada, spanning the Boreal Shield, the Mixedwood Plains, the Atlantic Highlands, and the Atlantic Maritimes. They assessed how three different indicator taxa (diatoms, cladocerans, and chironomids) have changed through time. They identified diatoms using the Canadian Museum of Nature's scanning electron microscope facility. All three indicator groups showed changes across land use and environmental gradients. The greatest turnover occurred among diatoms from high human impact sites when comparing modern and pre-industrial assemblages. They also showed that ecological change can vary among ecozones and buffer (or not) human impacts.



Location map of lakes in Canada sampled in 2017 (n = 217) as part of the LakePulse project. Source: Griffiths et al. (2021). Available under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International licence.

Papers by external researchers that cite Canadian Museum of Nature collections

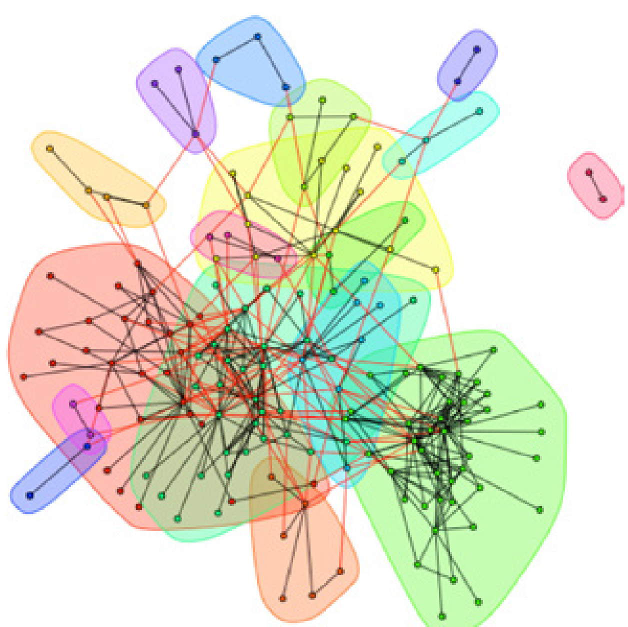
PFENNING-BUTTERWORTH, A.C., T.J. DAVIES
AND C.E. CRESSLER. 2021.

Identifying co-phylogenetic hotspots for zoonotic disease.

Philosophical Transactions of the Royal Society B: Biological Sciences 376: 20200363.
https://doi.org/10.1098/rstb.2020.0363

Zoonotic diseases, or diseases that are transmitted from animal hosts to humans, are increasing as human populations continue to rise (e.g., the COVID-19 pandemic). Given the tremendous public health implications of zoonotic parasites, identifying host-parasite pairs liable to be sources of spillover events to humans is critical. In this study, Pfenning and colleagues assembled a global mammal host-parasite database and a museum-verified dataset containing associations between helminths (parasitic worms) and free-range mammals. They studied the associations and phylogenetics of helminths and free-ranging mammals to understand how host and parasite evolutionary history might influence their associations. Their museum-verified dataset included host-parasite associate data from the Canadian Museum of Nature. The authors showed that the evolutionary history of host species is most important in helminth-mammal associations and that zoonoses are most common among closely related species. Critically, they also demonstrated that studying host-parasite associations in a phylogenetic context can help in identifying future zoonoses.

Host–parasite network from a museum-verified dataset of parasitic worms infecting mammals. Source: Pfenning-Butterworth et al. (2021).

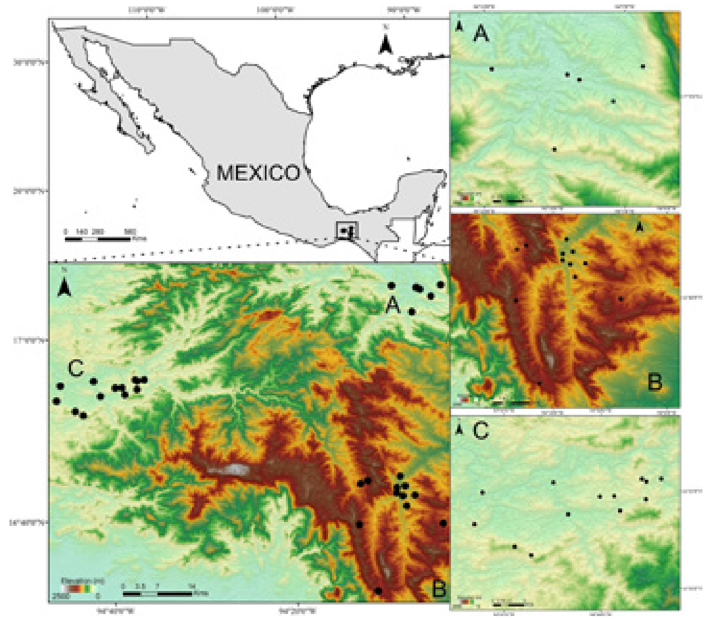


MOCTEZUMA, V. 2021.

Spatial autocorrelation in a Mexican dung beetle ensemble: Implications for biodiversity assessment and monitoring.

Ecological Indicators 125: 107548.
https://doi.org/10.1016/j.ecolind.2021.107548

Insects are incredibly diverse and important determinants of ecosystem health and function. Thus, surveys of insect biodiversity, particularly of dung beetles, an indicator group, are important in conservation. However, many of the statistical methods used to assess spatial variation in biodiversity assume sample independence, which is violated when samples are spatially autocorrelated (i.e., samples closest together are most similar). In insect monitoring, trap spacing has been recommended as a means of obtaining independent samples. In this study, Mexican scientist Victor Moctezuma assessed spatial autocorrelation in samples of Mexican dung beetles using 1,240 pitfall traps. He showed that increased trap spacing was insufficient to eliminate spatial autocorrelation. Thus, he advocated for statistical approaches to test for and, when unavoidable, controlling for spatial autocorrelation. Such approaches will improve the accuracy of biodiversity estimates from surveys. Moctezuma deposited dung beetle specimens obtained as part of this research in the Canadian Museum of Nature, which curates a globally important beetle collection.



Location of dung beetle biodiversity sampling sites in Mexico. Source: Moctezuma (2021). Available under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International licence.

Canthidium chimalapense, a recently described species of dung beetle from Mexico. Moctezume (2021) recorded this species in his surveys in southern Mexico. Source: Moctezuma, V., J.L. Sánchez-Huerta and G. Halffter. 2019. New species of Canthidium (Coleoptera: Scarabaeidae: Scarabaeinae) from Mexico. The Canadian Entomologist 151: 432-441. https://doi.org/10.4039/tce.2019.25

Papers by external researchers that used Canadian Museum of Nature occurrence data mediated by the Global Biodiversity Information Facility

DARU, B.H., T.J. DAVIES, C.G. WILLIS, E.K. MEINEKE, A. RONK, M. ZOBEL, M. PÄRTEL, A. ANTONELLI AND C.C. DAVIS. 2021.

Widespread homogenization of plant communities in the Anthropocene.

Nature Communications 12: 6983.
https://doi.org/10.1038/s41467-021-27186-8

This study aimed to characterize how non-native naturalizations and recent native extinctions have impacted local plant species diversity and between community changes in the turnover of species diversity across spatial scales. The authors compiled a dataset of >200,000 plant species, including more than 200,000 GBIF-mediated occurrence records based on specimens housed in the Canadian Museum of Nature's National Herbarium of Canada. Results show substantial homogenization within major biomes that is largely explained by naturalizations of non-native species.

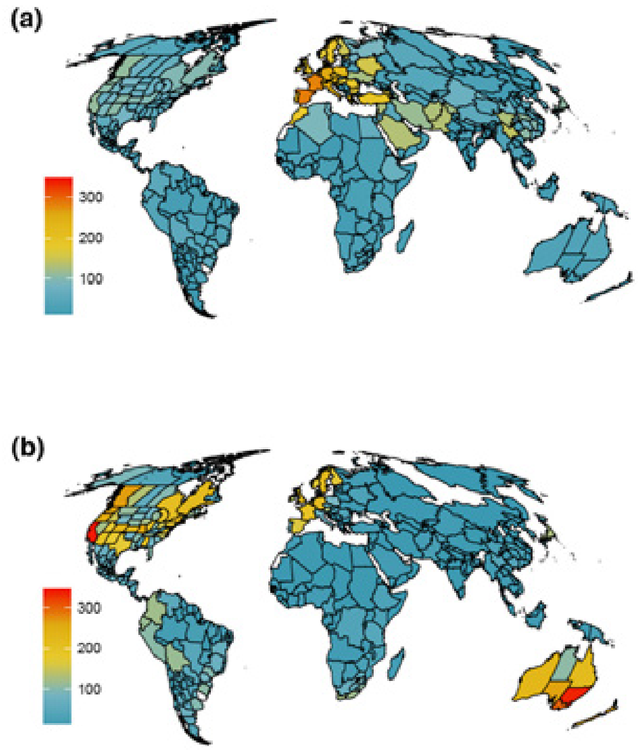
Exchange of vascular plant species among continents. Arrows indicate the direction of flows from donor to recipient continent. The numbers within parenthesis and circle size represent the number of non-native species in each region. Source: Daru et al. (2021), available under a Creative Commons Attribution 4.0 International license.

HÄKKINEN, H., D. HODGSON AND R. EARLY. 2022.

Plant naturalizations are constrained by temperature but released by precipitation.

Global Ecology and Biogeography 31: 501–514.
https://doi.org/10.1111/geb.13443
[published 15 December 2021]

This study evaluated whether the conditions in which climatic niche expansions occur (i.e., when species spread into new climates) can provide information about common niche expansion drivers. The authors compiled native and naturalized occurrence data for 606 terrestrial plant species, including GBIF-mediated occurrence records based on specimens housed in the Canadian Museum of Nature's National Herbarium of Canada. The study found climatic niche expansion in 45% of naturalizations of the 606 species. Niche expansion occurred mainly into climates wetter than species' native ranges.



(a) Number of native vascular plant species that occur in each global administrative area.

(b) Number of naturalized vascular plant species that occur in each global administrative area. Source: Häkkinen et al. (2021), available under a Creative Commons Attribution 4.0 International license.

OH, D.-H., K.P. KOWALSKI, Q.N. QUACH,
C. WIJESINGHEGE, P. TANFORD,
M. DASSANAYAKE AND K. CLAY. 2022.

Novel genome characteristics contribute to the invasiveness of *Phragmites australis* (common reed).

Molecular Ecology 31: 1142–1159.
https://doi.org/10.1111/mec.16293
[published 28 November 2021]

This study generated reference genomes for two subspecies of common reed: *Phragmites australis* subsp. *australis*, a taxon introduced to North America that is major threat to wetland ecosystems in Canada and the United States, and *P. australis* subsp. *americanus*, a taxon native to North America. To map the subspecies' global distributions, the authors compiled GBIF-mediated occurrence data, including records based on specimens housed in the Canadian Museum of Nature's National Herbarium of Canada. A key result of the study was the identification of variation in gene expression correlated with invasiveness. Furthermore, the new reference genomes provide a genomic foundation for development of new approaches to managing the invasive subspecies.

Invasive giant reed (Phragmites australis subsp. australis) growing in a roadside ditch in western Quebec, Canada. Photo: Paul Sokoloff/Canadian Museum of Nature.

SPECIES DISCOVERY

Knowledge about the diversity of life on our planet, how life responds to short and long-term local, regional, and global change, as well as its geological underpinnings, continues to grow, with numerous new species of plants, animals and minerals being discovered, named, and classified every year by scientists around the globe. Identifying species and their inter-relationships is also an important part of understanding the processes and impacts of environmental change. Museums play a central but underappreciated role in developing knowledge about biodiversity and geodiversity by acquiring, studying, and sharing scientific specimens in their collections. Through programs of off-site loans, visiting scientists and online data mobilization, museum collections are mined for previously unstudied or 'lost' specimens, which often represent new additions to the tree of life. Museum scientists also use evidence from DNA from extant species to reconstruct the evolutionary history of life on Earth and monitoring approaches to track ecological and evolutionary changes.

Papers authored or co-authored by Canadian Museum of Nature staff

BRODO, I.B., R.E. LEE, C. FREEBURY, P.Y. WONG, C.L. LEWIS AND **R.T. MCMULLIN**. 2021.

Additions to the lichens and lichenicolous fungi of the Ottawa region in Ontario and Quebec, with reflections on a changing biota.

Canadian Field-Naturalist 135: 1–27.
https://doi.org/10.22621/cfn.v135i1.2557

Researchers have been studying the biodiversity of lichens and allies within a 50-km radius of the city of Ottawa in Ontario and Quebec since the late 19th century. In this study, Canadian Museum of Nature researcher emeritus Irwin (Ernie) Brodo and colleagues, including Museum research scientist Troy McMullin, updated knowledge of the biodiversity of lichens, allied fungi, and their parasites of the Ottawa region. The resulting revised checklist is based on extensive fieldwork over the last 30 years, re-identification of specimens on which previous reports have been based, and taxonomic changes. Since the last synthesis of the regions' lichen biota, which Brodo and colleagues published in 1988, the number of recorded species has increased from 391 to 543. Among the new Ottawa records, one species is new for North America, five species and one variety are new for Canada, four species are new for Ontario, and nine species are new for Quebec. The study documents change in the region's biota over time caused by changes in landscape and habitat diversity, including the impacts of air quality, and identifies local hot spots of diversity. The comprehensive checklist, supported by vouchered material in the Canadian Museum of Nature's National Herbarium of Canada and similar collections elsewhere, provides a new baseline for further study of the region's lichen biota.

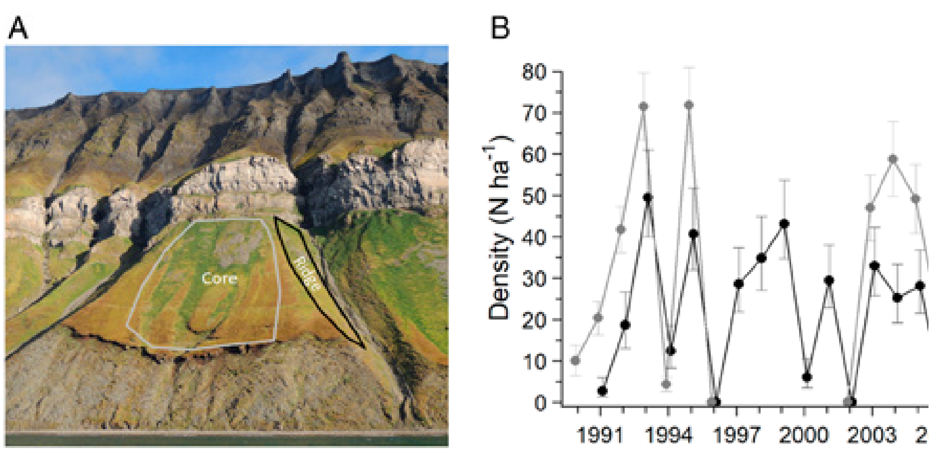
Map of the Ottawa region in Ontario and Quebec, Canada, where researchers have been studying the biodiversity of lichens, allied fungi, and their parasites for more than 125 years. Most of the collections underpinning our knowledge of the region's lichen biota are housed in the Canadian Museum of Nature's National Herbarium of Canada. Source: Brodo et al. (2021).

FAUTEUX, D., A. STIEN, N.G. YOCCOZ, E. FUGLEI AND R. IMS. 2021.

Climate variability and density-dependent population dynamics: Lessons from a simple High Arctic ecosystem.

Proceedings of the National Academy of Science 118: e2106635118.
https://doi.org/10.1073/pnas.2106635118

Small mammals in northern ecosystems undergo “boom and bust” population cycles. These cycles may be driven by plant-herbivore or predator-prey interactions, in addition to climate seasonality and stochasticity in weather. However, teasing apart drivers has been difficult in ecosystems characterized by complex food chain dynamics. In this study, Canadian Museum of Nature research scientist Dominique Fauteux and colleagues analyzed the drivers of a simple High Arctic food web, i.e., a food web not regulated by predation. They used data from a long-term study to characterize population dynamics of a grass-feeding vole species (East European vole, *Microtus levis*) in Svalbard, Norway. They found that a decrease in population growth with increasing population density explained most of the variation in the vole population. Further, voles showed noncyclic population dynamics, and some variation was driven by stochastic weather events. The authors concluded that the lack of predictable cyclicity in this vole population implies that predator-prey interactions play an important role in regulating small mammal populations in more complex systems.



(A) Photo of the locality in Svalbard, Norway, where researchers studied the densities of East European vole populations from 1990 to 2007.

(B) Time series of vole densities estimated in August in the Core area (gray shape, lines, and points; years 1990 to 1996 and 2002 to 2006) and the Ridge area (black shape, lines, and points; years 1991 to 2007). Error bars represent 95% confidence intervals. Source: Fauteux et al. (2021), available under a Creative Commons Attribution 4.0 International license.

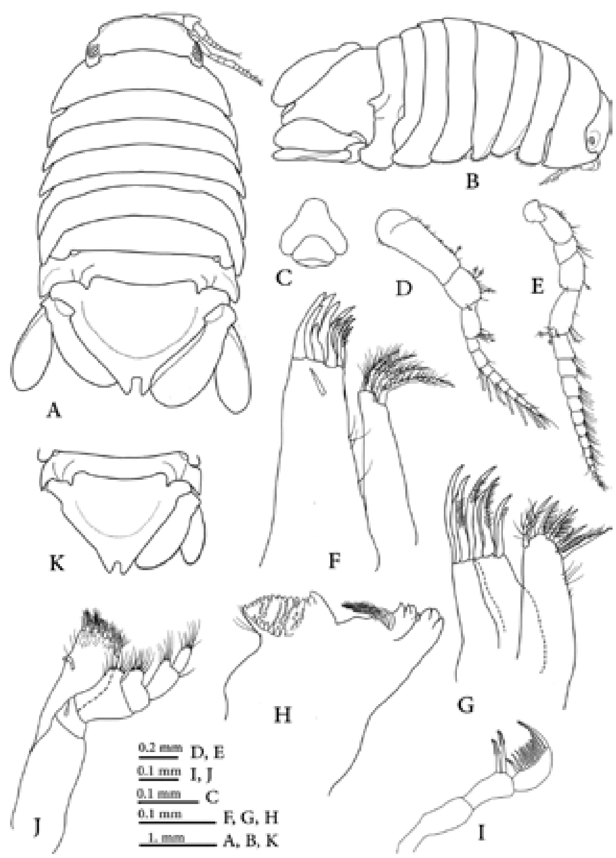
KHALAJI-PIRBALOUTY, V. AND **J.-M. GAGNON**. 2021.

A new species of *Dynoides* Barnard, 1914 (Crustacea, Isopoda, Sphaeromatidae) from Canada, with notes on geographic distribution of the north-eastern Pacific Ocean species.

Marine Biology Research 17: 12–20.
https://doi.org/10.1080/17451000.2021.1892766

Dynoides is a genus of 18 isopod crustaceans that occur in the Pacific Ocean and Indian Ocean. In this study, Valiallah Kahalaji-Pirbalouy, recipient of a Canadian Museum of Nature Visiting Scientist Award in 2019, and Canadian Museum of Nature curator and chief scientist Jean-Marc Gagnon, describe a new species, *Dynoides canadensis*, from the south-western coast of British Columbia, Canada. The new species is based on specimens collected in the 1950s to 1970s by former Museum researcher Edward Bousfield and deposited in the Museum's collections. *Dynoides canadensis* is the fifth species recorded from the north-eastern Pacific Ocean. Based on existing collections, the species occurs in British Columbia from the Victoria area on southern Vancouver Island north to Graham Island, Haida Gwaii. Its conservation status is unknown.

Illustration of the holotype specimen of Dynoides canadensis. Source: Khalaji-Pirbalouty and Gagnon (2021), available under a Creative Commons Attribution 4.0 International license.



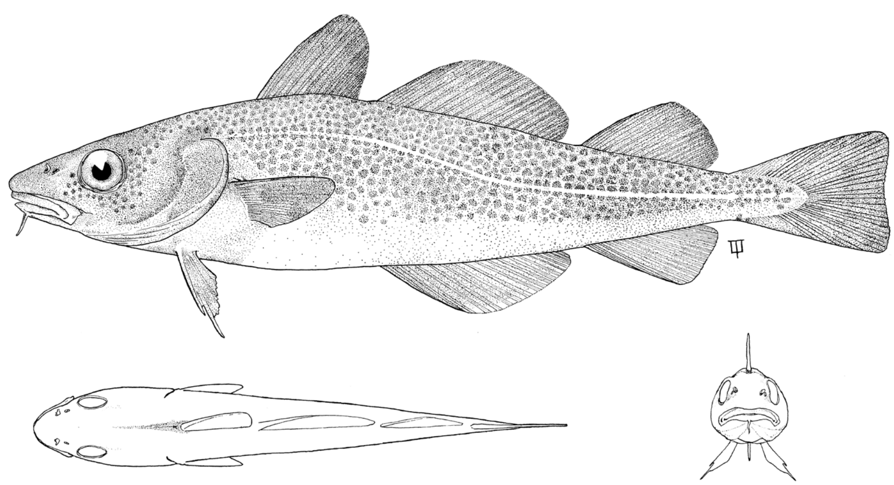
Papers by external researchers that used Canadian Museum of Nature occurrence data mediated by the Global Biodiversity Information Facility

COTE, D., C.A. KONECNY, J. SEIDEN, T. HAUSER, T. KRISTIANSEN AND B.J. LAUREL. 2021.

Forecasted shifts in thermal habitat for cod species in the northwest Atlantic and eastern Canadian Arctic.

Frontiers in Marine Science 8: 764072.
https://doi.org/10.3389/fmars.2021.764072

This study aimed to predict habitat distribution shifts and compare vulnerabilities of cod fish species and their life stages with changing ocean conditions due to climate change. The occurrence dataset compiled for the study includes more than 800 GBIF-mediated occurrence records of Polar cod, Atlantic cod, and Greenland cod based on specimens housed in the Canadian Museum of Nature. The results indicate that response of cod species to ocean warming will be species- and life stage dependent and that, by 2100, suitable habitat for the three species will shift northward.



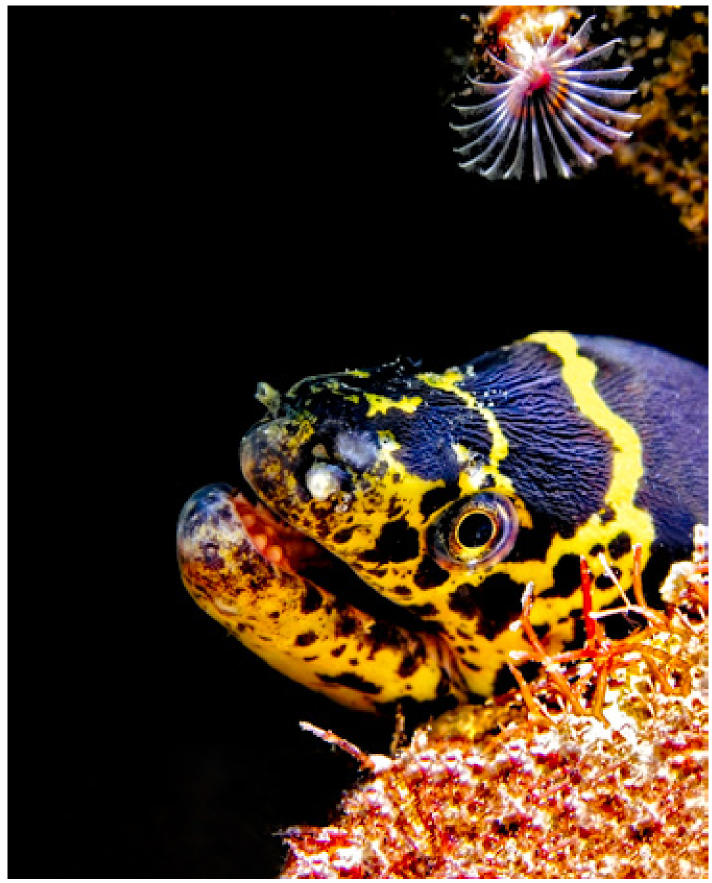
Black and white line drawing of an Atlantic Cod (Gadus morhua), lateral, dorsal and anterior perspectives. Illustration by John L. Tottenham/Canadian Museum of Nature.

LAVENDER, E., C.J. FOX AND M.T. BURROWS.
2021.

Modelling the impacts of climate change on thermal habitat suitability for shallow-water marine fish at a global scale.

PLOS ONE 16: e0258184.
https://doi.org/10.1371/journal.pone.0258184

Ocean temperatures are changing due to climate change. Temperature is an important driver of organism abundance in marine communities through its influence on thermal habitat suitability, an index based on the relationship between organismal physiology and temperature. These authors developed a method to predict global-scale changes in thermal habitat suitability for shallow-water marine fish. They compiled a large occurrence data set for more 2,200 species, including over 2000 GBIF-mediated occurrence records based on specimens housed in the Canadian Museum of Nature's fish collection. The results indicated that climate change will likely have a large impact on thermal habitat suitability for shallow-water marine fish during the 21st century, with predicted declines in thermal habitat suitability in the tropics versus predicted increases at higher latitudes.



Chain moray (Echidna catenate) below a feather duster worm. Models predict that the habitats of shallow-water marine fish species like this one, which lives in the western Atlantic Ocean, will be affected by climate change. Photo: Betty Wills (Atsme), Wikimedia Commons, available under a Creative Commons Sharealike 4.0 International license.

SCHWEIGER, A.H., G.M. ULLMANN, N.M. NÜRK, D. TRIEBEL,
R. SCHOBERT AND G. RAMBOLD. 2022.

Chemical properties of key metabolites determine the global distribution of lichens.

Ecology Letters 25: 416–426.
https://doi.org/10.1111/ele.13930
[published 16 November 2021]

This study characterized how fungal-derived metabolites, their UV absorbance capability, and their probability of being leached in warm and humid environments shape the global distribution of lichenized fungal species. To test their hypotheses, the authors compiled a large, global occurrence dataset of 10,114 lichen species, including thousands of GBIF-mediated occurrence records based on specimens housed in the Canadian Museum of Nature's lichen collection. The results indicated that fungal-derived metabolite factors are important drivers of global lichen distribution from ecological and evolutionary perspectives.

Arctic tumbleweed lichen (Masonhalea richardsonii) growing in Kugluk Territorial Park, Nunavut, Canada. Photo: Paul Sokoloff/Canadian Museum of Nature.

ETHIER, J.P., A. FAYARD, P. SOROYE, D. CHOI, M.J. MAZEROLLE AND V.L. TRUDEAU. 2021.

Life history traits and reproductive ecology of North American chorus frogs of the genus *Pseudacris* (Hylidae).

Frontiers in Zoology 18: 40.
https://doi.org/10.1186/s12983-021-00425-w

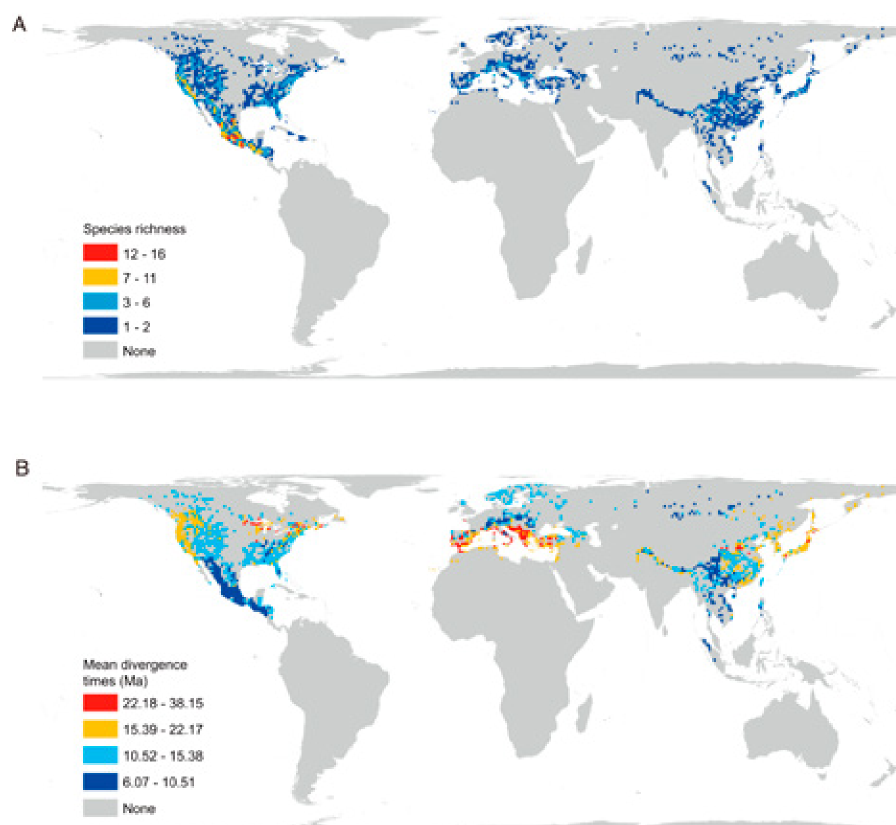
This study characterized biodiversity in North American chorus frogs. In this species group, several populations have experienced significant declines – including within Canada. As part of their summary of the ecology, life history strategies, and conservation status of North American chorus frogs, the authors generated updated distribution maps of the 18 species found throughout North America using GBIF-mediated occurrence data, including some 2,000 records housed in the collections of the Canadian Museum of Nature.

JIN, W.-T., S. GERNANDT DAVID, C. WEHENKEL, X.-M. XIA,
X.-X. WEI AND X.-Q. WANG. 2021.

Phylogenomic and ecological analyses reveal the spatiotemporal evolution of global pines.

**Proceedings of the National Academy of Sciences 118: e2022302118.
https://doi.org/10.1073/pnas.2022302118**

This study investigated the spatiotemporal evolution of *Pinus*, the largest conifer genus. In addition to generating a new species phylogeny and estimating divergence times of global pines, the authors used GBIF-mediated occurrence data, among other data sources, to map the distributions of global pine (*Pinus*) species. Their occurrence dataset included 158 georeferenced records of pine from the Canadian Museum of Nature. The results have implications for biodiversity conservation and forest management.



(A) Global patterns of species diversity in the pine genus (Pinus), which comprises about 113 species.

(B) Mean divergence times of pines plotted in grid cells of 100 km × 100 km. Source: Jin et al. (2021), available under a Creative Commons Attribution 4.0 International license.

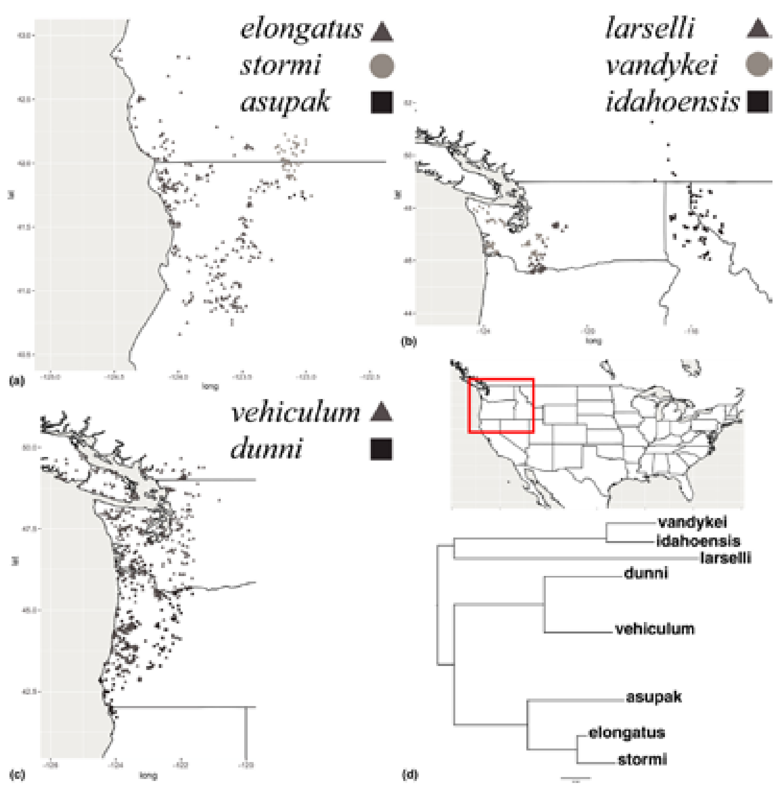
PUBLICATION PROFILES
SPECIES DISCOVERY

NOTTINGHAM, S. AND T.A. PELLETIER. 2021.

The impact of climate change on western *Plethodon* salamanders' distribution.

Ecology and Evolution 11: 9370–9384.
https://doi.org/10.1002/ece3.7735

This study characterized how species of *Plethodon* salamanders in the Pacific Northwest may respond to climate change. The authors estimated species distribution models for present and future climate scenarios. They reconstructed the current distributions of species using species occurrence data mediated by GBIF, including numerous records from the Canadian Museum of Nature's collections. Results indicate that the overall distribution of species in this group of salamander species is unlikely to be significantly affected by climate change.



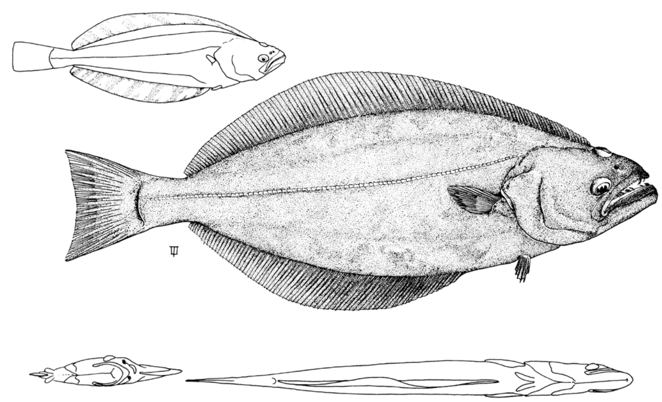
Distribution in the Pacific Northwest of eight species of Plethodon salamanders and their phylogenetic relationships based on mitochondrial DNA. Source: Nottingham and Pelletier (2021), available under a Creative Commons Attribution 4.0 International license.

VIHTAKARI, M., R. HORDOIR, M. TREBLE, M.D. BRYAN, B. ELVARSSON, A. NOGUEIRA, E.H. HALLFREDSSON, J.S. CHRISTIANSEN AND O.T. ALBERT. 2021.

Pan-Arctic suitable habitat model for Greenland halibut.

ICES Journal of Marine Science 78: 1340–1356.
https://doi.org/10.1093/icesjms/fsab007

This study aimed to estimate the potential distribution of Greenland halibut (*Reinhardtius hippoglossoides*), a commercially important flatfish. As part of the study, the authors compiled a distribution dataset for the species, including records based on collections from the Canadian Museum of Nature mediated by GBIF. Results indicate that bottom depth and temperature constrain Greenland halibut distribution.



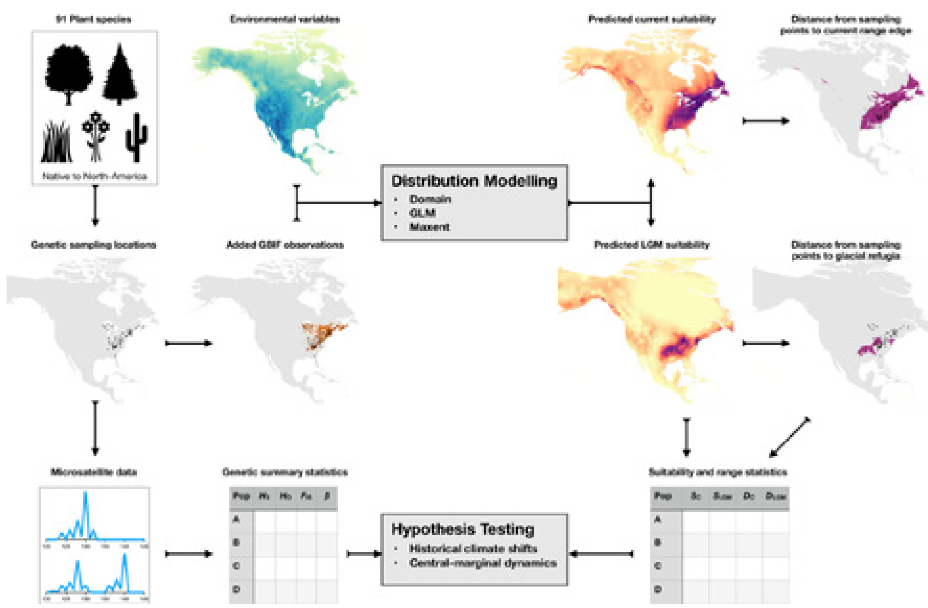
Black and white line drawing of a Greenland halibut (Reinhardtius hippoglossoides), multiple perspectives. Illustration: John L. Tottenham/Canadian Museum of Nature.

LÓPEZ-DELGADO, J. AND P.G. MEIRMANS. 2022.

History or demography? Determining the drivers of genetic variation in North American plants.

Molecular Ecology 31: 1951–1962.
https://doi.org/10.1111/mec.16230
[published 18 October 2021]

Understanding patterns of genetic variation within species and the processes resulting in those patterns is necessary for developing conservation strategies and for predicting how species may respond to the changing climate. The authors developed species distribution models for 91 plant species from georeferenced species occurrence records mediated by GBIF, including records based on specimens housed at the Canadian Museum of Nature. They used these models and genetic data to characterize the spatial structure of population genetic variation across the North America. The results indicated that demography and history have contributed almost equally to shaping genetic variation within the studied plant species since the Pleistocene glaciation.



Overview of López-Delgado and Meirmans' (2022) methodological approach, which couples genetic data and species distribution modelling to test the contributions of historical climatic shifts and the central-marginal hypothesis on the spatial distribution of genetic variation. The distribution data and modelling output are for eastern hemlock (Tsuga canadensis). Source: López-Delgado and Meirmans (2022). Available under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International licence.

ENDANGERED SPECIES AND CONSERVATION

Over the last few decades, natural habitats are being lost, species diversity on Earth is declining and we may be entering the next great period of extinction. Museum collections represent huge databases of relevant information about species presence in space and time. By studying collections, scientists can identify centres of diversity (hotspots), areas of endemism and ecosystems undergoing change. Through partnerships with organizations concerned with conservation, museums are irreplaceable sources of information in assessing species for their endangered status.

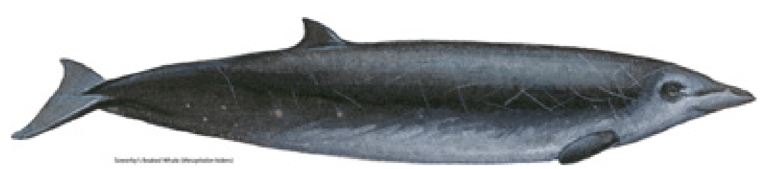
Papers by external researchers that cite Canadian Museum of Nature collections

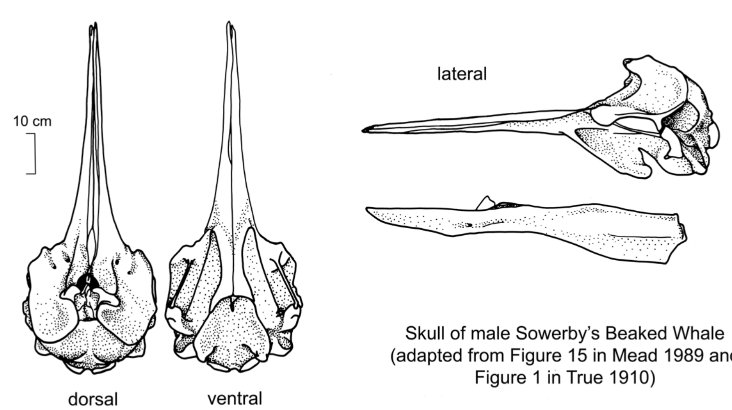
SMITH, K.J., J.G. MEAD AND M.J. PETERSON. 2021.

Specimens of opportunity provide vital information for research and conservation regarding elusive whale species.

Environmental Conservation 48: 84–92.
https://doi.org/10.1017/S0376892920000521

The biology and ecology of many of the world's species are poorly known. Conservation and management of these species can be challenging given large gaps in the knowledge needed to inform conservation approaches. Beaked whales, a group of some 23 species, are among the most poorly known mammals. These deep-water marine species are difficult to locate and study in their natural habitat. Much of our understanding of beaked whale diversity, morphology and biology comes from study of museum specimens, many of which have originated as salvaged carcasses or fisheries bycatch. One poorly known member of this group is Sowerby's beaked whale (*Mesoplodon bidens*). Although this species has been known to science for more than 200 years, we have much to learn about its biology and behaviour. In this study, Smith and colleagues collated data on 180 Sowerby's beaked whale specimens housed in museum and research institutions in North America and Europe, including five specimens housed in the Canadian Museum of Nature. The authors demonstrated the effectiveness of the technique they used, called snowball sampling, to locate museums with Sowerby's beaked whale specimens given that many museums have not fully digitized their collections and made them searchable online. They also demonstrated how new morphological information obtained from the studied specimens could be relevant to future conservation initiatives for Sowerby's beaked whale.





Skull of male Sowerby's Beaked Whale (adapted from Figure 15 in Mead 1989 and Figure 1 in True 1910)

Sowerby's beaked whale (Mesoplodon bidens). Illustration by Paul Geraghty/ Canadian Museum of Nature.

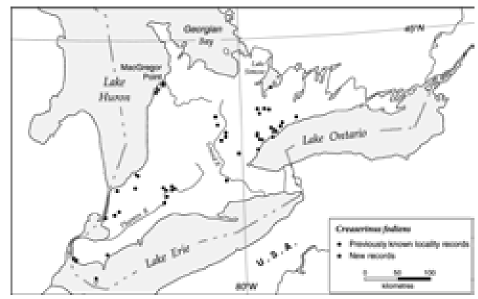
Skull of Sowerby's beaked whale (Mesoplodon bidens). Illustration by Donna Naughton/Canadian Museum of Nature.

GUIAĐU, R.C. 2021.

Range expansion of the vulnerable crayfish *Creaserinus fodiens* (Cottle, 1863) (Decapoda, Cambaridae) in Ontario, Canada, with added notes on the distribution, ecology and conservation status of this species in North America.

Crustaceana 94: 467–486.

Digger crayfish, *Creaserinus fodiens*, is a species of burrowing, semi-terrestrial crayfish that ranges from Texas, Louisiana and Florida to southern Ontario. In Ontario, the only Canadian province in which the species occurs, the conservation status rank for the species is Vulnerable. The species lives in wetland and drainage ditch locations across southern Ontario, where clay soil is suitable for burrowing. Habitat destruction and degradation are the main threats to the species in the province. In this study, York University's Radu Guiașu updated our knowledge of the distribution of *Creaserinus fodiens* in Ontario. He reported new records for the species from along the shores of Lake Huron, which represent a northwestern range expansion for the species in southern Ontario. Guiașu also analysed the history of collecting of this species in Ontario by reviewing records in the databases of the Royal Ontario Museum and the Canadian Museum of Nature. Collections of the species in the Canadian Museum of Nature cover a 25-year period whereas collections in the Royal Ontario Museum cover an 87-year period. No specimens of the species have been added to the Canadian Museum of Nature collections since 1976, according to the available data. Guiașu concluded that *C. fodiens* collection efforts in Ontario have been sporadic, rare, and are incomplete and thus our understanding of this species' changing distribution in the province is poor. Guiașu reminded us that species' distribution maps are usually based on cumulative records obtained over time, but species may sometimes no longer be present at the older locations, which is the case for some sites in southern Ontario where *C. fodiens* once occurred. To make informed conservation decisions about species, we need up to date and accurate information about their distribution.



Distribution of digger crayfish (Creaserinus fodiens) in Ontario, showing new locations along the the shores of Lake Huron. Source: Guiașu (2021), available under a Creative Commons Attribution 4.0 International license.

PUBLICATION PROFILES
ENDANGERED SPECIES AND CONSERVATION

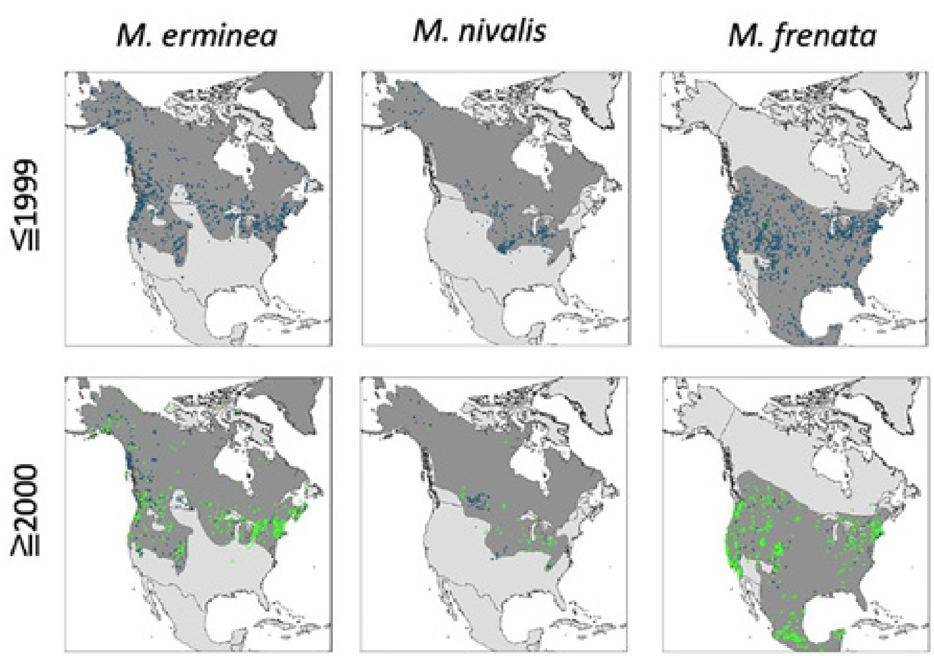
Papers by external researchers that used Canadian Museum of Nature occurrence data mediated by the Global Biodiversity Information Facility

JACHOWSKI, D., R. KAYS, A. BUTLER, A.M. HOYLMAN AND M.E. GOMPPER. 2021.

Tracking the decline of weasels in North America.

PLOS ONE 16: e0254387.
https://doi.org/10.1371/journal.pone.0254387

There is an urgent need to assess conservation status and trends of small carnivores, a group of animals that has received much less attention than large carnivores. This study investigated the status and trends of three species of weasel across the United States and Canada: *Mustela erminea* (ermine, stoat or short-tailed weasel), *M. nivalis* (least weasel), and *M. frenata* (long-tailed weasel). One of the datasets the researchers examined consisted of GBIF-mediated occurrence records based on museum collections, including hundreds of records from the Canadian Museum of Nature's collection. The authors concluded that weasel populations have declined in North America, and they proposed hypotheses that may explain the declines.



Distribution of records for three Mustela species from museum specimens (blue dots) and iNaturalist citizen science observation (green squares) from two time periods. Dark gray shading shows the range map for each species. Source: Jachowski et al. (2021), available under a Creative Commons Attribution 4.0 International license.

HUGHES, A.C., M.C. ORR, Q. YANG AND H. QIAO. 2021.

Effectively and accurately mapping global biodiversity patterns for different regions and taxa.

Global Ecology and Biogeography 30: 1375–1388.
https://doi.org/10.1111/geb.13304

Accurate species distribution maps are needed to establish conservation priorities and manage biodiversity. This study aimed to understand the representativeness and accuracy of expert-generated range maps, including those from the International Union for Conservation of Nature (IUCN), and to explore alternative methods for mapping species distributions accurately. The researchers focussed on terrestrial vertebrates (amphibians, birds, and mammals) and dragonflies and damselflies. The study compared range maps based on GBIF-mediated occurrence data, including thousands of terrestrial vertebrate records based on specimens housed in the Canadian Museum of Nature, with expert-produced range maps to assess their accuracy. The authors found that expert range maps are often biased, particularly along administrative borders. They concluded that we need data-driven approaches for developing distribution maps that account for uncertainty. They emphasized the need to better fund digitization and taxonomic verification of museum collections, which represent real point data that should be the basis for understanding global species distributions.

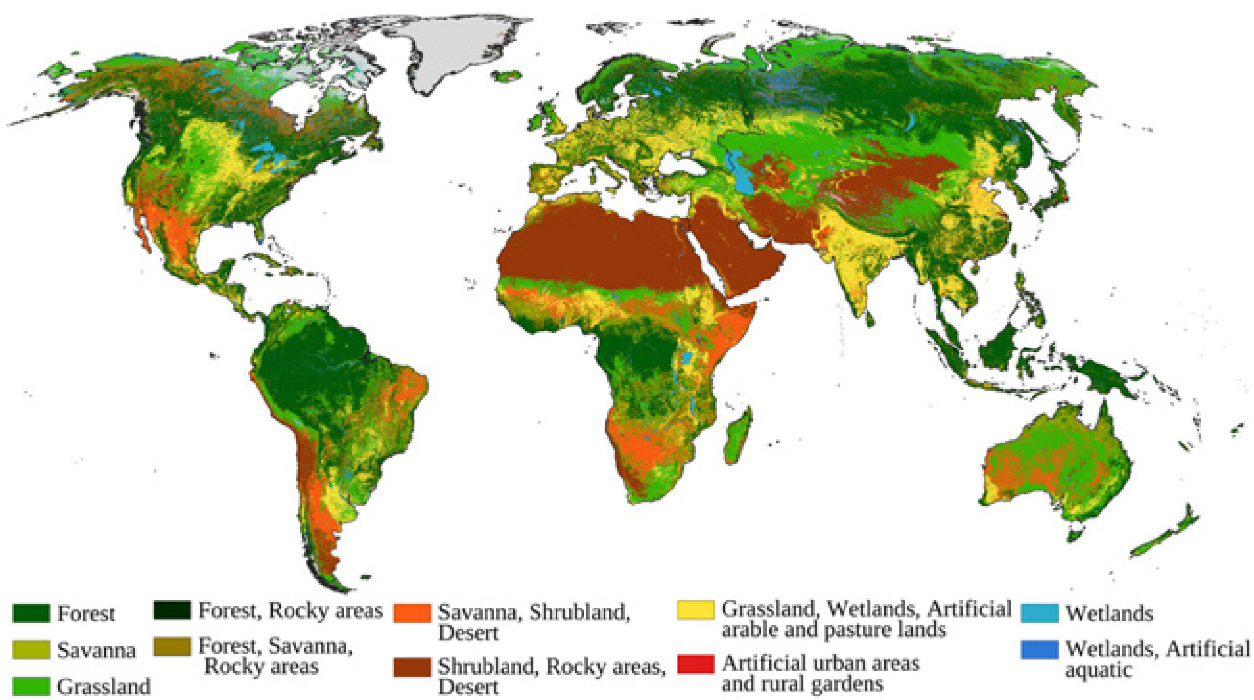
LUMBIERRES, M., P.R. DAHAL, M. DI MARCO, S.H.M. BUTCHART, P.F. DONALD AND C. RONDININI. 2021.

Translating habitat class to land cover to map area of habitat of terrestrial vertebrates.

Conservation Biology 36: e13851.
https://doi.org/10.1111/cobi.13851

This study aimed to develop a method to translate International Union for the Conservation of Nature (IUCN) habitat classes to land cover based on point locality data for 6986 species of terrestrial mammals, birds, amphibians, and reptiles. The dataset included GBIF-mediated occurrence records of reptiles collected between 2005 and 2018, including data from specimens housed in the Canadian Museum of Nature's amphibian and reptile collection. Results show that the new method provided greater standardization, objectivity, and repeatability in translating habitat class to land cover compared to expert opinion.

Map of habitat classes (level 1) from the International Union for the Conservation of Nature Habitat Classification Scheme. Source: Lumbierres et al. (2021), available under a Creative Commons Attribution 4.0 International license.



2021 PUBLICATIONS ENABLED BY THE CANADIAN MUSEUM OF NATURE

Under each theme, publications are organized in three groups: Canadian Museum of Nature Staff, Canadian Museum of Nature Research Associates, and Other Authors. Staff and research associate authors are in boldface.

Evidence of use of Canadian Museum of Nature collections or collection data in papers by authors not affiliated with Canadian Museum of Nature are indicated as follows:† – publication cites one or more Canadian Museum of Nature specimens; ‡ – publication indicates Canadian Museum of Nature collections were searched for material relevant to a study; # – publication indicates Canadian Museum of Nature collections were consulted to aid identification of species, or indicates the authors deposited voucher specimens in the Canadian Museum of Nature

Publications with a 2022 date were first available online in 2021.

Earth History

CANADIAN MUSEUM OF NATURE STAFF

Mineralogy

Bao, Z., T. Al, M. Couillard, **G. Poirier**, J. Bain, H.K. Shrimpton, Y.Z. Finfrock, A. Lanzirotti, D. Paktunc, E. Saurette, Y. Hu, C.J. Ptacek and D.W. Blowes. 2021. A cross scale investigation of galena oxidation and con trols on mobilization of lead in mine waste rock. Journal of Hazardous Materials 412: 125130. https://doi.org/10.1016/j.jhazmat.2021.125130

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Lykova, I., **R. Rowe**, **G. Poirier**, A.M. McDonald and G. Giester. 2021. Nioboheftetjernite, ScNbO4, a new mineral from the Befanamo pegmatite, Madagascar. The Canadian Mineralogist. https://doi.org/10.3749/canmin.2000070

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Fraser, D., L.C. Soul, M.A. Balk, W.A. Barr, A.K. Behrensmeyer, A. Du, J. Eronen, J.T. Faith, N.J. Gotelli, G. Graves, A.M. Jukar, C.V. Looy, J.H. Miller, S. Pineda-Munoz, A.B. Shupinski, A.B. Tóth, A. Villaseñor and S.K. Lyons. 2021. Investigating biotic interactions in deep time. Trends in Ecology and Evolution: 38: 61–75. https://doi.org/10.1016/j.tree.2020.09.001

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McDonald, A.M., D.E. Ames, I.M. Kjarsgaard, L.J. Cabri, W. Zhe, K.C. Ross and D.J. Good. 2021. Marathonite, Pd25Ge9, and palladogermanide, Pd2Ge, two new platinum-group minerals from the Marathon deposit, Coldwell Complex, Ontario, Canada: Descriptions, crystal-chemical considerations, and genetic implications. The Canadian Mineralogist 59: 1865–1886. https://doi.org/10.3749/canmin.2100022 [†]

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