November 2010

Report in Focus

CANADIAN TAXONOMY: EXPLORING BIODIVERSITY, CREATING OPPORTUNITY

The diversity of life on Earth is an irreplaceable natural heritage crucial to the function of the biosphere and human well-being. Biodiversity is being lost in Canada and around the world at a rate unprecedented in human history, with massive consequences to ecosystems, culture, the economy, innovation potential, and society. The five major drivers of biodiversity loss are habitat loss, exploitation, pollution, climate change, and invasive species.

Against this backdrop, the Minister of Canadian Heritage, on behalf of the Canadian Museum of Nature, posed the following question to the Council of Canadian Academies:

What are the state and trends of biodiversity science in Canada? Are we equipped to understand the challenges of our biodiversity resources?
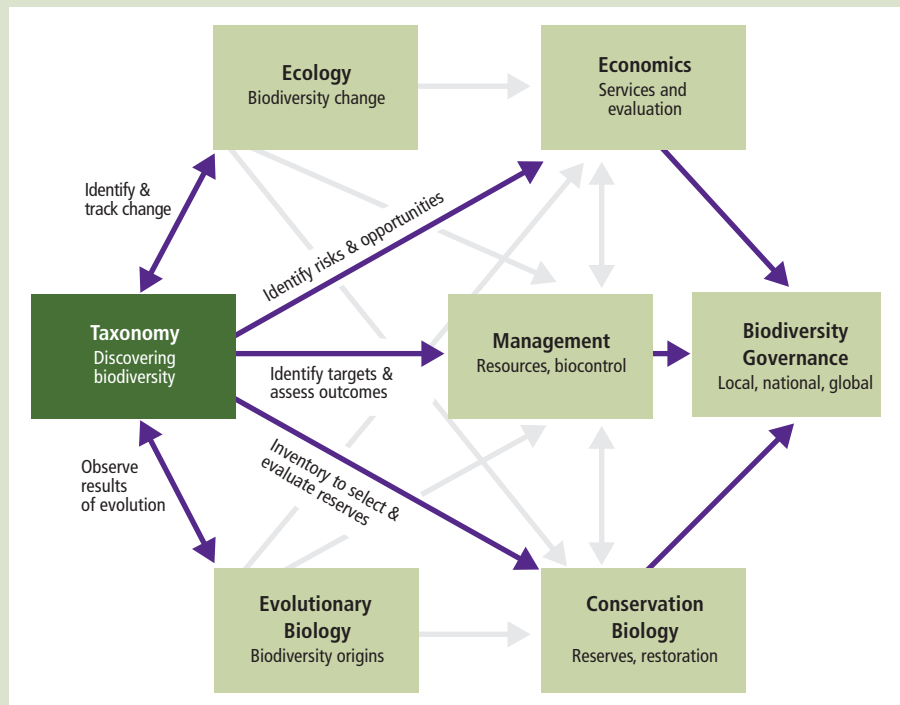
The charge focused specifically on taxonomic research.

Taxonomy discovers, distinguishes, classifies and documents living things. As such, taxonomy is central to biodiversity research and to understanding the world around us.

The Council assembled a multidisciplinary group of 14 Canadian and international experts, chaired by Dr. Thomas E. Lovejoy, Biodiversity Chair at the Heinz Center for Science, Economics and the Environment in Washington, D.C. The Panel met over the course of 12 months to produce a comprehensive, evidence-based report.

TAXONOMY: THE FOUNDATION OF BIODIVERSITY SCIENCE

Environmental problems associated with rapid biodiversity change cannot be solved by conventional and narrowly focused approaches.

Biodiversity science has emerged as a transdisciplinary field that uses tools and theories from many areas of study. Taxonomy is foundational; advances in biodiversity science are built upon the discovery and accurate identification of the species that compose ecosystems.

The components of biodiversity science and their interconnections

Courtesy of the Canadian Museum of Nature

Assessing the Evidence

Taxonomic Expertise

Despite Canada's history of world-class contributions to taxonomic research, the Panel's examination of the state of expertise revealed cause for concern. The Panel's online survey, which attracted 432 respondents, showed that while student interest in taxonomy remains and taxonomists continue to be trained, most trainees emanate from only a handful of labs, limiting expertise to certain groups of species. The Panel also documented a loss of taxonomic expertise in highly diverse and poorly understood taxonomic groups, and noted that as taxonomists retire, they are not being replaced.

Job openings in taxonomy have virtually ceased, despite a rising trend in biodiversity science jobs in general. For those taxonomists who do find employment, the field has suffered from stagnant levels of inflation-corrected funding per researcher, in direct contrast with the dramatic rise in research costs. A bibliometric analysis of species descriptions revealed that among the G20 and European Union countries, Canada's ranking dropped from 6th in the 1980s to 14th in the 2000s.

Increased collaboration is essential among taxonomists in universities, government and industry, as well as Aboriginal Traditional Knowledge holders and naturalists.

If the expertise gap continues to widen, Canada risks the misidentification of invasive species and inaccurate information about their spread and potential for harm. Canada may also become incapable of assessing decline in certain native species.

Biodiversity Collections

The many specimens contained in Canadian biological collections are an essential resource for taxonomic research — a legacy of past work and a basis for future investigations. They must be preserved for generations. The Panel collected data on collections through an online survey in which 120 biodiversity collections across the country participated.

There are over 50 million specimens in Canadian collections, ranging from a few hundred specimens in some, to the almost 17 million specimens held by the national collections at Agriculture and Agri-Food Canada. An extremely conservative estimate by the Panel puts the value of Canadian specimens at over a quarter of a billion dollars. However, many specimens are irreplaceable and therefore priceless.

Conditions under which specimens are stored vary considerably in Canadian collections. Although most collections reported that over 75 per cent of their specimens are currently stored in adequate conditions, many are still housed in aging facilities with little physical room for growth. Collections are governed and managed under an array of different organizational schemes, with no national collections strategy or standards.

If this collections gap continues, Canada may lose long-term information essential to understanding changes in Canadian biodiversity and the ability to make informed policy and management decisions.

TAXONOMY — MAKING A DIFFERENCE

Through taxonomy we can:

- Identify invasive species like the mountain pine beetle or zebra mussel before they cause damage to our ecosystems.

- Discover life's natural innovations, including compounds and biochemical pathways for use in medicine or new manufacturing processes.

- Understand the effects of climate change by looking at past and present records of species in ecosystems.

The Panel considered the assets and gaps related to Canadian taxonomy and concluded that Canada is not yet fully equipped to understand its biodiversity resources. But there is reason for optimism.

Courtesy of the Canadian Museum of Nature

Biodiversity Data

Studying and managing Canada's biodiversity resources — including understanding environmental change, identifying and controlling alien species, and identifying and conserving species at risk — require online open access to taxonomic data.

Although Canada has impressive specimen collections and a strong digital infrastructure, most specimen information is trapped in cabinets rather than accessible on the internet. This needs resolution, not just for the sake of taxonomy, but for the well-being of other disciplines in biology that depend upon this information.

Canada's data sharing efforts compare poorly internationally, as evidenced by its low participation in the Global Biodiversity Information Facility. Approximately 80 per cent of Canada's online biodiversity information is being held outside Canada.

This data gap means that Canada risks making policy decisions related to the management of biodiversity resources on the basis of inadequate data, with potentially enormous impacts for the economy and the well-being of Canadians.

THE ROLE OF TAXONOMY IN CANADA'S KNOWLEDGE-BASED FUTURE

The science of taxonomy is in flux. Recent advances, especially in the fields of genomics and computer science, are revolutionizing both the pace of taxonomy and access to taxonomic information. A growing number of nations are making major investments in taxonomy in response to these opportunities.

The Panel concluded that not only is Canada well-positioned to close its gaps in taxonomic expertise, collections, and data, but it could also build on its strengths to become an international leader in the field if there is bold vision from its scientific community, policy leaders, Traditional Knowledge holders, non-governmental organizations (NGOs), and industry. This would reinvigorate taxonomy in Canada.

Over the past decade, new scientific linkages have been established and administrative capacity has been built as a result of regional collaborative initiatives in Québec, Ontario and British Columbia. Additionally, the creation of Canadensys, a national initiative aimed at unlocking biodiversity information held in collections across Canada, as well as the success of NSERC-led collaborations, have helped to set the stage for Canada's biodiversity science community to lead a major endeavour.

Taxonomy has high strategic relevance for Canada, particularly as natural resources play a central role in the economy and overall well-being of Canadians. Through taxonomy, we are able to understand our natural resources, how to use and protect them, and how to best conserve ecosystems and species. Understanding the connection between taxonomy and natural resources ensures that Canada remains a responsible world citizen.

Reinvigorated taxonomy would support innovation, the discovery of compounds and biochemical pathways for the creation of bio-fuels, the protection of human health, and the development of new manufacturing processes. Strong taxonomy would also help protect Canada from the devastating effects of invasive species.

Inside the Full Report

- Survey results of taxonomic experts and those responsible for housing and maintaining Canada's specimen collections

- Bibliometric analysis of trends in publications by taxonomic researchers

- Analysis of changes in taxonomic funding over the past 30 years

- An overview of how new technologies are changing taxonomic research

- Insights on citizen science and the connection between biodiversity and culture

- A discussion on Canada's assets, gaps, and opportunities in taxonomy

The Panel's full report, *Canadian Taxonomy: Exploring Biodiversity, Creating Opportunity*, is available for download in both official languages from the Council's website, **www.scienceadvice.ca/biodiversity**.

DID YOU KNOW?

Estimates suggest Canada is home to over 100,000 species but only 65% of them have been identified.

Canada's National Collection of Insects, which provides information essential for agriculture, environmental monitoring, and health, has approximately 17 million specimens.

Among all countries contributing to species' descriptions, Canada has fallen from 6th place in the 1980s to 14th place in the 2000s.

Expert Panel Membership: Thomas E. Lovejoy (Chair), Biodiversity Chair, Heinz Center for Science, Economics and the Environment, Washington, D.C. **Luc Brouillet**, Professor and Curator of the Marie-Victorin Herbarium, University of Montréal, Québec. **W. Ford Doolittle**, FRSC, Professor, Dalhousie University, Halifax, Nova Scotia. **Andrew Gonzalez**, Professor and Canada Research Chair in Biodiversity Science, and Director of the Quebec Centre for Biodiversity Science, McGill University, Montréal, Québec. **David M. Green**, Professor and Director of the Redpath Museum, McGill University, Montréal, Québec. **Peter Hall**, Honourary Research Associate (retired), Agriculture and Agri-Food Canada, Ottawa, Ontario. **Paul Hebert**, FRSC, Professor and Director, Biodiversity Institute of Ontario, University of Guelph, Ontario. **Thora Martina Herrmann**, Professor and Canada Research Chair in Ethnoecology and Biodiversity Conservation, University of Montréal, Québec. **Douglas Hyde**, Executive Director, NatureServe Canada, Ottawa, Ontario. **Jihyun Lee**, Environmental Affairs Officer, Marine and Coastal Biodiversity and Ecosystems Approach, United Nations Environmental Programme Secretariat of the Convention on Biological Diversity, Montréal, Québec. **Wayne P. Maddison**, Professor and Canada Research Chair in Biodiversity and Systematics, and Director of the Beaty Biodiversity Museum, University of British Columbia, Vancouver. **Sarah P. Otto**, FRSC, Professor and Director of the Biodiversity Research Centre, University of British Columbia, Vancouver. **Felix Sperling**, Professor and Curator for the E.H. Strickland Entomological Museum, University of Alberta, Edmonton. **R. Paul Thompson**, Professor, University of Toronto, Ontario

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