Science-Metrix

Executive Summary

25 Years of Canadian Environmental Research

A Scientometric Analysis (1980–2004)

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26 March 2006

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Prepared for
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Executive summary

This report presents a detailed quantitative profile of Canada's contributions to environmental research. An overview of environmental research on an international scale is provided by identifying global trends in environmental research. Canada's output is compared to that of other leading countries, and its position in international networks of collaboration is subsequently examined. The report then turns to output in environmental research by province and sector of activity and identifies the most productive Canadian institutions.

Indicators presented in this study draw on three types of documents representing original contributions to science: articles, notes, and reviews, which will be referred to jointly as "papers". In building a dataset of papers published in environmental research-related journals, 434 peer-reviewed journals indexed in the Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI) from ISI Thomson Scientific were selected and classified according to seven environmental areas:

- *Climate, Meteorology & Atmospheric Sciences*
- *Ecology & Biological Resources*
- *Environmental Engineering, Chemistry & Biotechnology*
- *Environmental Planning, Management & Conservation*
- *Environmental Sciences - General*
- *Pollution, Environmental Toxicology & Health*
- *Water Resources*

The scientometric indicators applied to 580,446 papers published in these journals were: growth; national and international collaboration rates; impact factor; and specialization index (research effort dedicated to the field and particular areas).

Canada's position in environmental science research relative to other countries is very strong. Among 13 leading countries, Canada ranks third in the world in number of papers published in environmental research and second in number of papers per capita. It is also second in the world in terms of scientific impact and level of specialization measures. Canada tops the list when a multicriteria analysis is performed.

During the first half of the 1990s, the levels of Canadian scientific collaboration at the national and international levels were roughly equal. Since 1997, the international collaboration rate has exceeded that of national collaboration. In 2004, there were 28% more papers co-authored with international partners than with national partners. However, the international collaboration rate in environmental research is similar to that observed for all Canadian scientific papers.

Canada's position as a global leader is likely to change in the coming years. Canadian environmental research represented, on average, 8% of the world's total output over the last 25 years, but the level of output began a decline in 1998. Several countries experienced significant growth in their scientific production over the last decade (between 1995–1999 and 2000–2004); these include China (110%), Spain (50%), Switzerland (46%), Italy (44%), and Japan (40%).

Concerning environmental research areas, Canada has consistently ranked first in the area of *Ecology & Biological Resources* and is expected to continue having a relatively high impact in that area (10% more than the world level).

However, since 1998, Canada has not improved its position in *Climate, Meteorology & Atmospheric Science*. The Canadian annual scientific output remained at the same level (300 papers per year) and, like its scientific impact, is comparable to the world level in this field. Canada's impact in *Environmental Engineering, Chemistry & Biotechnology* has fallen considerably since the mid-1990s.

After the US, which has 31 institutions in the top 50 most productive institutions in the world, Canada has the second highest number of institutions in environmental research in the last 10 years. These four institutions—Environment Canada (7th place), Fisheries & Oceans Canada (25th place), the University of British Columbia (28th place), and the University of Toronto (47th place)—also account for the highest percentage of international collaborations. Ontario represents most of the scientific output in environmental science and 44.4% of Canadian production over the last 25 years. Canada's university sector dominates environmental research.

Environment Canada (EC), which ranks among the top 10 leading institutions in the world, is also the first among the top 25 most active institutions in environmental research in Canada, producing approximately 14% of Canadian papers in the field.

The annual scientific production of the department increased three-fold over the last 25 years, from 100 to 300 papers. In addition, EC has positioned itself strongly among the international networks of the most collaborative institutions in the field (Figure page iv). On the Canadian scene, EC is the most important source of research collaborators for 10 of the 14 other most productive institutions, making it the central hub of the Canadian network in environmental science. ■

Key findings

A. International level

- At the world level, the number of scientific papers related to environmental research increased steadily over the 25-year period, from slightly over 15,000 papers in 1980 to roughly 35,000 papers in 2004.
- This growth represents an annual average increase of 4% over the period, which is greater than the average annual increase in scientific output generally (2.3%) and greater than the increase in most established fields of research.
- Canada ranks third in papers in environmental research over the last 25 years. The annual output of Canada rose from 1,175 papers in 1980 to 2,316 in 2004 (100%). However, it has not shown substantial growth since 1996 (7%), and Germany and China may soon overtake Canada's position.
- When the number of papers is calculated per capita, Canada ranks second in the world. At the beginning of the period (1980–1984), however, Canada was ranked first, but has not continued to increase as quickly as other countries. Canada has one of the lowest levels of output growth between the 1995–1999 and 2000–2004 periods (5.8%).
- Canada also ranks second in scientific relative effort (specialization index) and scientific impact (ARIF).
- When ranked according to a multicriteria analysis using four indicators, Canada consistently ranks first across the 25-year period.
- Among environmental areas, Canada specializes in *Ecology & Biological Resources* (10% more specialized than the world) and, to a lesser extent, in *Pollution, Environmental Toxicology & Health*.
- Canada shows a scientific impact between 1% and 5% higher than the world level in all environmental areas with the exception of *Environmental Engineering, Chemistry & Biotechnology*.
- According to a multicriteria ranking of Canada's performance in different specialties, Canada has remained in the top position in *Ecology & Biological Resources* for each 5-year period and, with the exception of 1995–1999, in *Water Resources*.
- Canada also ranks first for the entire period in *Pollution, Environmental Toxicology & Health*. Canada has also performed well in *Environmental Sciences—General*, improving from fifth place in 1985–1989 to first place in the two most recent periods, averaging at second place for the whole period.
- Canada comes in ninth in the world in international collaboration over the last 25 years, and 35.9% of Canadian publications in the field were co-authored with international partners over the 2000–2004 period. The US is Canada's most important collaborator, followed by the UK, Germany and France. In addition, the annual number of papers co-authored by Canada and China has increased rapidly.
- Over the last decade, 16 Canadian institutions figure in the world's top 200 most productive institutions and four among the top 50 in environmental research.

B. Canadian level

- Ontario accounts for most of the scientific output in environmental science and represents 44.4% of Canadian production over the last 25 years. Quebec and British Columbia also experienced steady growth in terms of output (particularly Quebec).
- The university sector dominates environmental research, having authored 76.5%* of the Canadian scientific papers published between 2000 and 2004. The federal government, which contributed 33% of the national output, places second. The industry sector ranks third (7%), and provincial governments fell from 6.1% in 1995–1998 to 4.9% in 2000–2004.
- In terms of scientific impact, universities and the federal government have a slightly higher impact than Canada as a whole and than the world level in the field.
- Between 1980 and 2004, the proportion of publications co-authored with partners from other Canadian institutions rose from 14.4% to 32.0%. While the international and national collaboration rate stayed at about the same level, collaborations with international researchers surpassed national collaborations from 2001 to reach 41% in 2004.
- Provincial and industry sector collaborations took place primarily at the national level, while the federal sector's rate of collaboration with other Canadian institutions has accelerated since the beginning of 1990s. In 2004, more than 50% of the federal government's output in the field was the result of collaboration with Canadian partners.

C. Institutional level

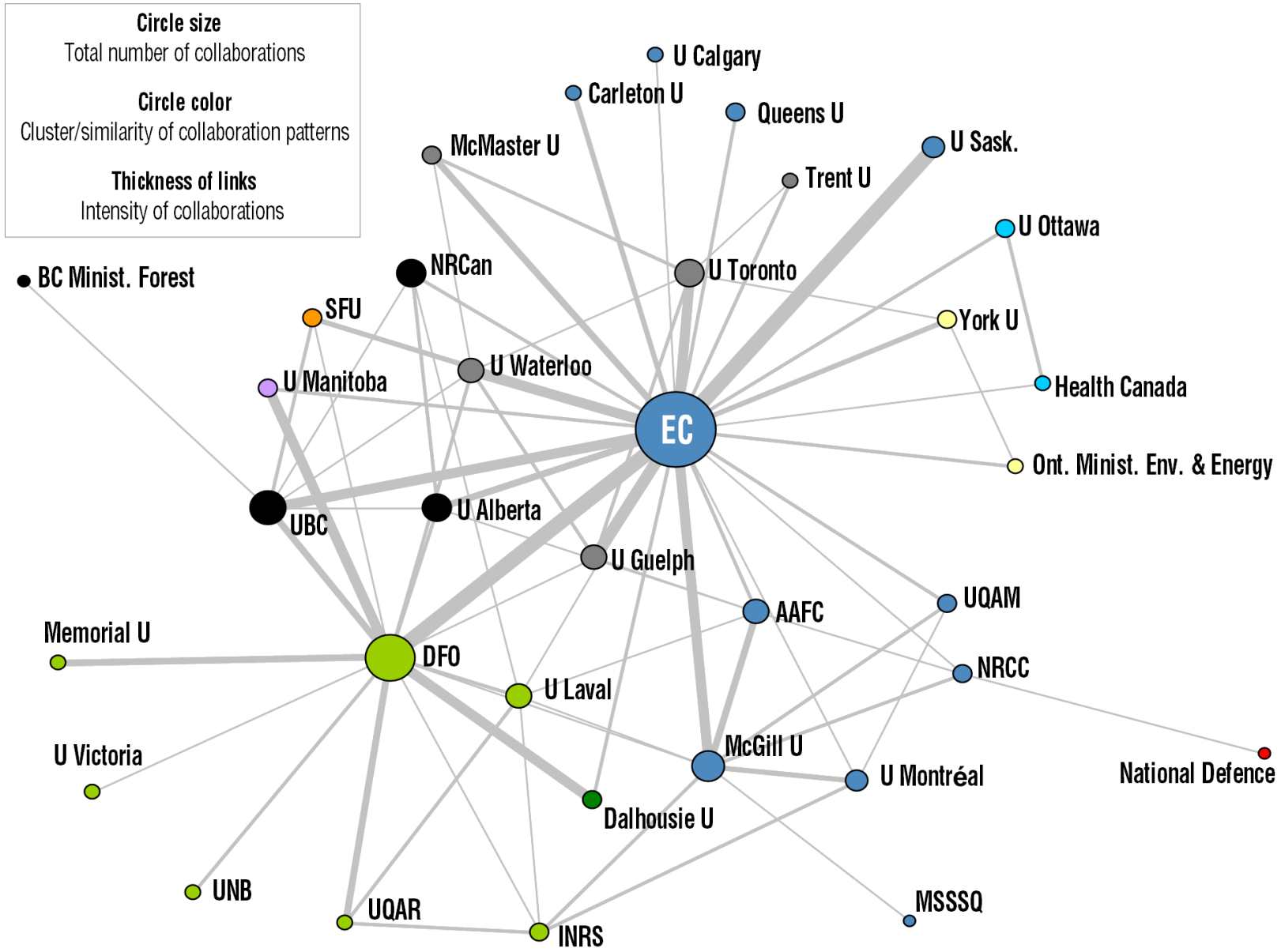
- The most productive institutions in environmental research in terms of number of papers between 1995 and 2004 were Environment Canada (3,033 papers), Fisheries and Oceans Canada (1,826), the University of British Columbia (1,761), the University of Toronto (1,327), McGill University (1,262), and the University of Alberta (1,149).
- Between the 1995–1999 and 2000–2004 periods, the institutions that increased their output in environmental research the most (by more than 25%) were the University of Ottawa (41%), the University of Toronto (33%), the University of Saskatchewan (31%), the University of Victoria (29%), Queens University (27%), and Trent University (25%).

** The sum of the percentages of papers from each sector is higher than 100% because a number of papers are subject to inter-sectoral collaborations.*

- In measures of the top 10 Canadian institutions by environmental research areas between 1995 and 2004, Environment Canada ranked first in four specialties: *Climate, Meteorology & Atmospheric Science* (935 papers); *Pollution, Environmental Toxicology & Health* (587 papers); *Environmental Sciences - General* (431); and *Water Resources* (379 papers). Fisheries and Oceans Canada ranked first for *Ecology & Biological Resources* (956), the University of Alberta for *Environmental Engineering, Chemistry & Biotechnology* (164), and the University of British Columbia for *Environmental Planning, Management & Conservation* (218).
- Two important clusters of collaboration between Canadian institutions are built around Environment Canada and Fisheries and Oceans Canada. Apart from these, collaborative links between academic institutions are relatively weak.

D. Environment Canada

- Environment Canada (EC) accounted for 15.7% of Canadian output in environmental research papers in 2003 and 12.7% in 2004. The Department was responsible for 41% of the federal government's output in the field in 2004.
- Between the 1995–1999 and 2000–2004 periods, the Department increased its output by about 9.5%. The increase began in 1994 with 230 papers and reached 300 papers in 1997, remaining fairly constant since.
- Over the last 25 years, EC published more papers in *Climate, Meteorological & Atmospheric* related-science than any other environmental area (1,450 papers). The Department's other areas of importance are *Pollution, Environmental Toxicology & Health* (978 papers), *Ecology and Biological Resources* (915 papers) and *Water Resources* (912 papers).
- The total collaboration rate of the Department was about 32% in 1980 and is now 81% (in 2004). International collaboration rate remained at around 34% over the last 10 years; concurrently, the national collaboration rate increased. EC's national collaboration rate increased from 26% in 1980 to 61% in 2004.
- Most of EC's collaborators are from Canadian institutions. In 2004, 60% of the Department's scientific output was co-authored with Canadian researchers, and 35% was co-authored with international researchers. EC has the strongest links with American institutions, despite the fact that this institution collaborates more with other Canadian institutions than with foreign institutions.
- However, the Department collaborates more at the international level in *Climate, Meteorological & Atmospheric Science* than at the national level. In 2000–2004, 46% of papers were coauthored with international counterparts, and 37% were with Canadians.
- EC is the principal collaborator with the other most productive Canadian institutions; EC constitutes the main hub of environmental research in Canada. ■



National collaboration network of the most collaborative Canadian institutions in environmental research, 1995–2004

Source: Data compiled by Science-Metrix from Thomson-Scientific data prepared by OST