Environment and Climate Change Canada
Environnement et Changement climatique Canada

THE 2020 ANNUAL REPORT ON THE FEDERAL PROGRESS IN IMPLEMENTING OPEN SCIENCE AND ITS BENEFITS

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Abstract

The Government of Canada is committed to making federal science, scientific data, and scientists more accessible. The 2020 Annual Report on the Federal Progress in Implementing Open Science and its Benefits describes the Government of Canada's progress towards that commitment. Progress in implementing open science and the benefits open science can provide is measured through a combination of core metrics designed to capture general progress across all Science-based Departments and Agencies (SBDAs), and supplemental metrics to highlight individual department/agency efforts.

Results show an increase in the number of federal peer-reviewed publications available in open access. They also show that although the percentage of overall eligible federal datasets released in the open have only slightly increased, more datasets were made available through Open Maps, an application that provides access to federal geospatial datasets. In terms of public engagement, SBDAs participated in a range of activities allowing Canadians to engage with federal scientists and their research.

The reach of federal open science goes far beyond academia. This report shows federal science appears regularly in patents, social media and news outlets. This report also illustrates the benefit associated with open science, for the federal government. Federal science publications that are available in open access are more likely to be cited in other scientific contributions and in patents, which confirms than an open science advantage exists for federal science --meaning that federal scientists who publish in open access can expect their work to be more impactful.

While progress in implementing open science has been made, more remains to be done for federal science, scientific data, and scientists to be more accessible. The results of this annual report indicate progress, but fall short of the ambitious targets set out in the Roadmap for Open Science for 2022 and subsequent years. Continued commitment and support of open science is necessary to meet these goals.

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1. Introduction

As part of the open science commitment in the Government of Canada's *2018-20 National Action Plan on Open Government*, Environment and Climate Change Canada (ECCC), with support from federal science-based departments and agencies (SBDAs), committed to:

- Publish an indicators report on the benefits of open science for Canadians; and,
- Publish yearly reporting measuring the implementation of open science by SBDAs.

This is the second annual report measuring federal open science progress, and is the first to include indicators on the benefit of open science.

This report was developed in close collaboration with members of an interdepartmental working group on open science metrics (see Annex 3 for a list of members).

Further details on the metrics and how they were developed can be found in the *Monitoring Open Science Implementation in Federal Science-based Departments and Agencies: Metrics and Indicators* report.

2. What is Open Science?

The Chief Science Advisor of Canada's *Open Science Roadmap*[1] defines open science as:

> The practice of making scientific inputs, outputs and processes freely available to all with minimal restrictions. Scientific research outputs include (i) peer-reviewed science articles and publications, (ii) scientific and research data and (iii) public contribution to and dialogue about science. Open science is enabled by people, technology and infrastructure. It is practised in full respect of privacy, security, ethical considerations and appropriate intellectual property protection.

It is also important to view open science as more than just making scientific output accessible. Opportunities to adopt open practices are present, at every stage of the scientific research process. For the purposes of this report we will use "research" and "researchers" to refer to work and individuals, respectively, that work in and with science. Four broad categories of open science practices align with the research life cycle:

1. Ideation;
2. Data collection & analysis;
3. Publications, and;
4. Knowledge mobilization and associated scientific practices.

Together, these categories of open science practices make up the open science life cycle, as illustrated in Figure 1:

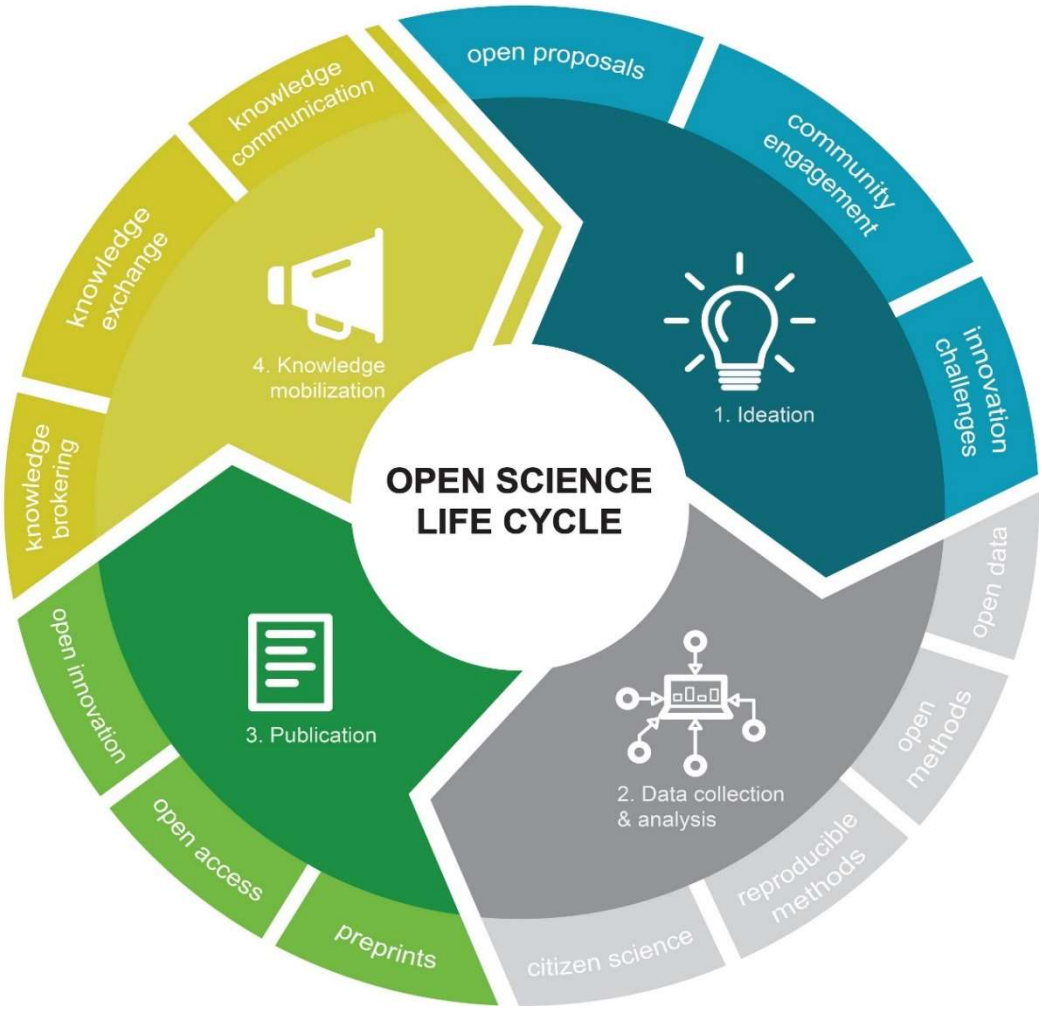

Figure 1. The Open Science Life Cycle. The inner circle of the Open Science Life Cycle comprises four broad categories of open science practices that align with the research life cycle: ideation; data collection & analysis; publications; and knowledge mobilization. The fourth category, knowledge mobilization, feeds back into the first, ideation. The outside circle shows examples of open science practices for each category.

Open science is becoming an internationally accepted approach to advance scientific endeavours. Countries such as France have developed their *Open Science Plan* and non-government granting agencies such as the Wellcome Trust and the Bill & Melinda Gates Foundation have established open access policies for research they fund. The onset of the COVID-19 pandemic brought renewed attention to open science around the world, spurring calls for researchers, journals and funders to ensure that research

findings and data relevant to the outbreak are shared freely[2]. It has also led to the development of COVID-19 data sharing platforms and science communication products[3]. In Canada, SBDAs continued to make progress on implementing open science.

3. Snapshot of Federal Progress in 2019

Four core metrics were used to assess progress in implementing open science by SBDAs, while respecting and promoting an understanding of the differing cultures, mandates, and priorities of each organization. Evaluating progress relies on a combination of core metrics, using data from most SBDAs, and supplementary metrics using data from participating SBDAs only. Core metrics may be viewed as overarching measurements on progress while supplementary ones demonstrate additional work by SBDAs to make their science more open.

The core metrics used in this Report to measure open science progress across SBDAs are:

1. Open Access Publications;
2. Open Scientific Data;
3. Open Science Public Engagement; and,
4. Open Maps (as an example of other open science products).

The supplementary metrics used to measure progress on open science of some SBDAs are:

1. Open Access Publications in Funded Research; and,
2. Altmetrics.

3.1. Core Open Science Metrics

3.1.1 Open access publications

For the purposes of this report, open access publications[a] refer to those that are externally peer-reviewed, in digital format, available online, and free of charge. Toll access publications are defined similarly, except they are not available free of charge, usually requiring a subscription or fee to read. For reporting against this metric, only peer-reviewed publications were considered. Conference papers are not included in the calculation given that norms vary, from one discipline to another, about their publication

[a] Mainly journal publications but anything indexed in Scopus excluding conference presentations

and whether they are considered peer-reviewed. The key indicator used to track progress for open science publications is the percentage of publications from authors affiliated with SBDAs made openly accessible either directly by the publisher (here defined as gold open access), or by the author(s) (here defined as green open access).

Findings

- Federal SBDAs have made progress in making their publications open. From 1998 to 2018, about half (or 48.8%) of federal peer-reviewed publications are publicly accessible;
- Year-to-year progress in terms of open access happens more rapidly for recent publication years compared with earlier publication years;
- When considered individually, most federal SBDAs (9 out of 15) are making their publications open at a higher rate than researchers in general, including Canadian researchers overall and researchers in other G7 countries;
- Generally, the number of federal SBDA open access publications is expected to grow as publications are made available through open repositories following the expiration of the publisher's embargo period, which can last between 12 to 24 months.

Figure 2 shows the progress in making publications open by comparing the share of federal SBDA open access publications observed in 2018 to the same indicator measured again in 2019 for the same publication years:

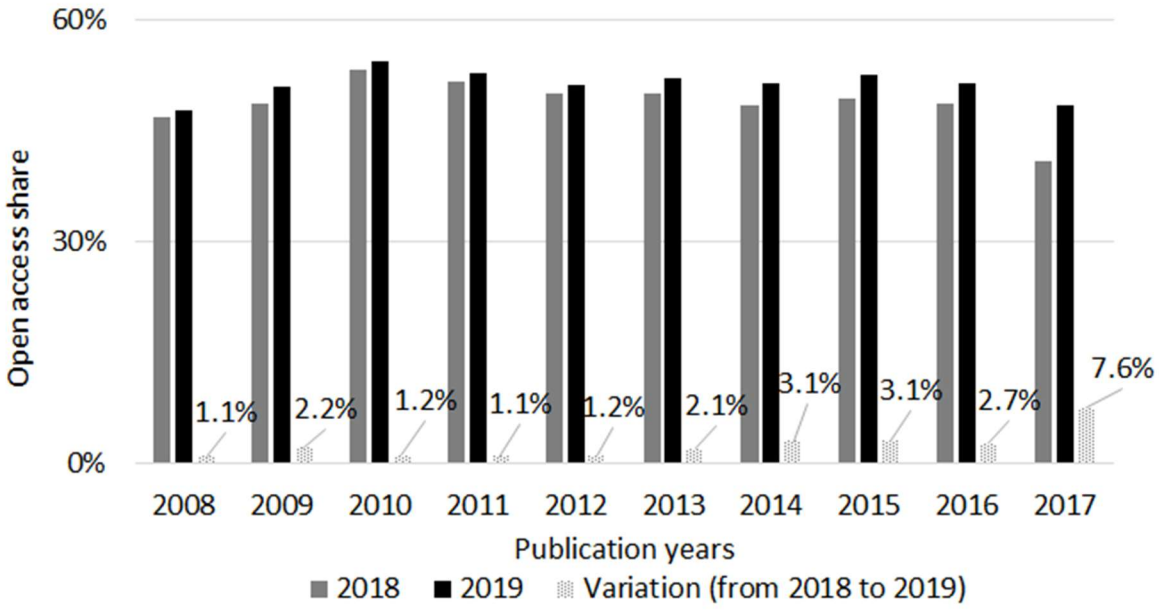

Figure 2. Comparing share of open access peer-reviewed articles of federal SBDAs observed in
2018 and 2019, for publication years from 2008 to 2017.

On average, SBDAs have increased the share of publications available in open access from 48.8% in 2018 (in grey, in Figure 2) to 51.3% in 2019 (in black), for papers published between 2008 and 2017 (inclusively). Yearly variation (dotted bar in Figure 2), shows the difference between the percentage of publications available in open access observed in 2019 compared to 2018, which is increasing more rapidly in recent publication years (after 2013), compared with earlier publication years. For instance, for SBDA articles published in 2017, an increase of 7.6% in the percentage of publications available in open access was observed in 2019, compared with the same measurement in 2018.

The changes in observed open access share for earlier publication years may be attributable to both the embargo effect and the "back-filling" effect. The former is dictated by academic journal policies, while the latter is incumbent on the authors. The embargo effect describes a reduction in open access publications due to the fact that some publications are still under embargo, meaning they cannot yet be made available in open access due to the academic journals' policy. The embargo period can last up to 24 months but generally apply only to some versions of the articles, including the final published version of record. The "back-filling" effect, on the other hand, is caused by the practice of researchers to delay making their publications open access for a wide host of reasons, including publishers' embargo or other challenges, such as the time and effort needed to post the appropriate version of the article. Figure 3 shows open access share of SBDA publications in comparison with total publications from publication years 1998-1999 to 2017-2018 as observed in 2019. While only a third of SBDA publications published between 1998 and 2002 were available in open access (36% to 38%), nearly half of articles published in more recent years are openly available (46% to 52%).

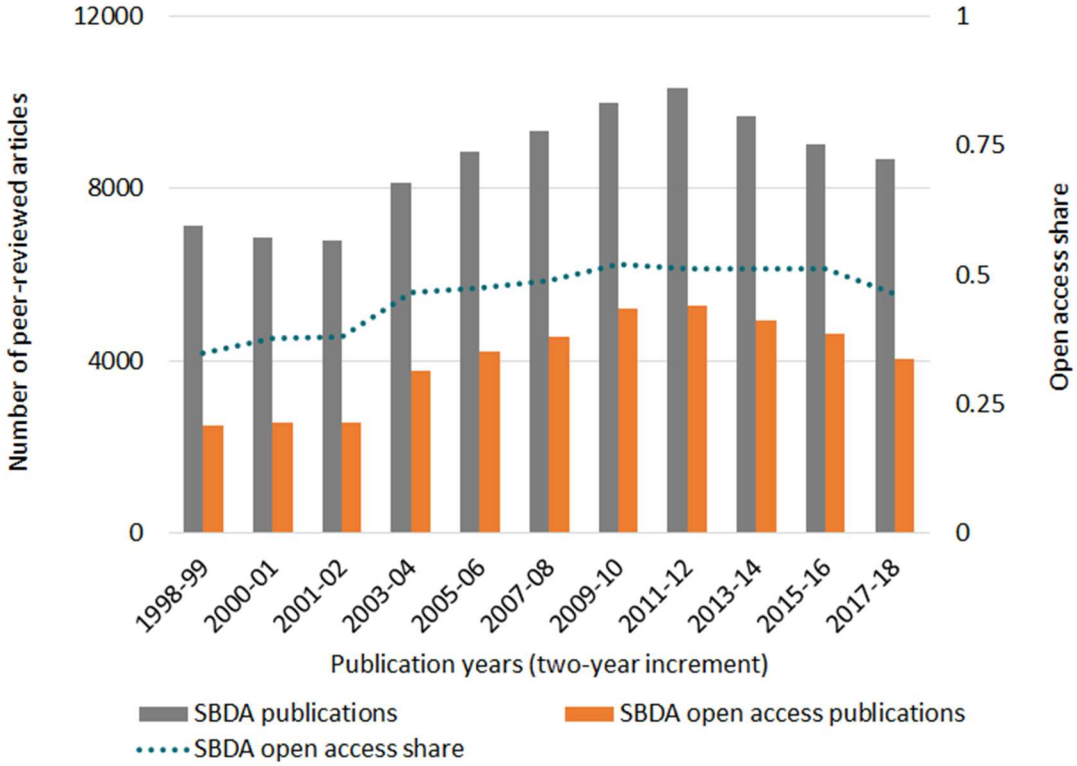

Figure 3. Percentage and number of SBDA open access peer-reviewed publications (orange) and total number of publications (grey), for publication years 1998 to 2018, in two-year increments

The share of open access publications appears to steadily increase until 2015-2016, and then decrease for the most recent years (2017-18). However, this is again likely the impact of the embargo and the “back-filling” effects. It is expected that future reporting will see the percentage for 2017-2018 rise to a level comparable to previous years.

Figure 4 compares the share of open access publications for each SBDA (in black) with open access publications for Canadian researchers overall (yellow dotted line), G7 researchers (green dotted line), and all federal SBDAs combined (blue dotted line).

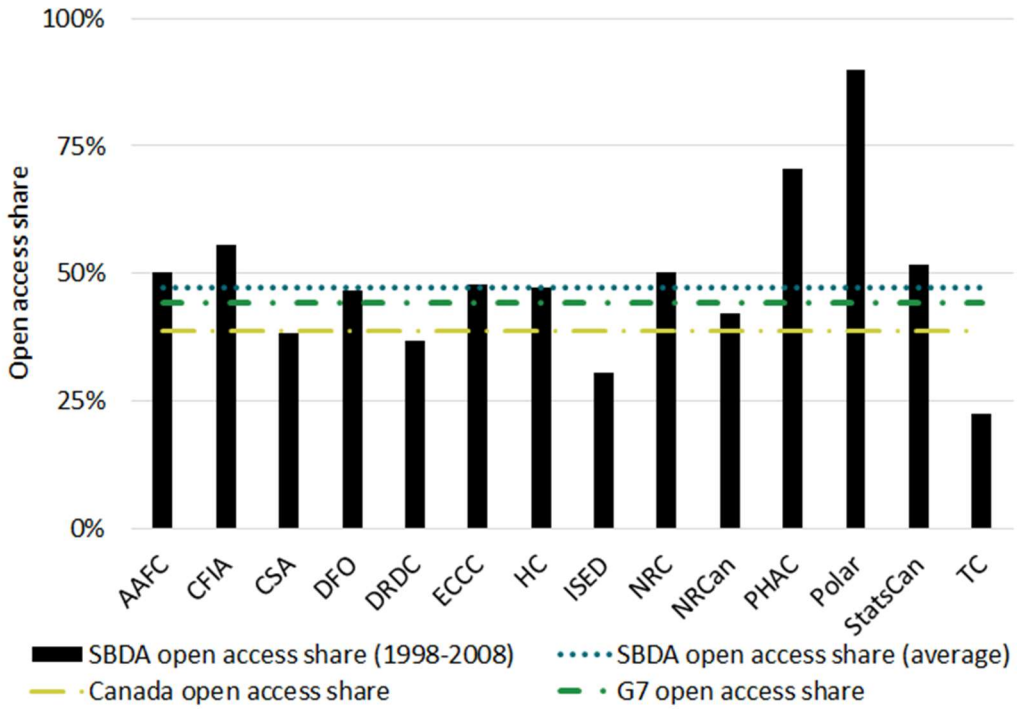

Figure 4. Percentage of open access publications per SBDA and SBDA open access average from 1998 to 2008.

At 47.8%, the overall SBDAs' share of open access articles is above the levels achieved by Canadian researchers overall, G7 researchers, and the world average; (45.7%, 44.2%, and 38.8%, respectively). Comparison with G7 countries is appropriate, given the similarity in terms of government intervention to support Research & Development (R&D), investment in higher education systems, and support for open science.

There is a wide variation in open access share among SBDAs. This is likely the result of their specific circumstances that limit their ability to publish in the open, such as their mandate, the nature of their work (ex. scientific versus regulatory) and the disciplines in which their scientists belong (i.e., some disciplines, including health sciences, have a strong culture of making their science open). There is also a marked variation in the number of articles published by each SBDA. While some publish only a few peer-reviewed articles every year and conduct most of their science via grants and contributions to support science activities by external-to-government partners, other departments and agencies publish hundreds of publications per year. The level of effort to reach a specific level of open access varies across SBDAs.

3.2 Open scientific data

Findings

- The percentage of eligible datasets released has slightly increased between 2018 (83.1%) and 2019 (84%).

SBDAs regularly release their datasets both on government open portals, such as Treasury Board Secretariat's (TBS) Open Government Portal, and through partner organization portals. As the Open Government Portal is the main portal for government data, its contents and information in the associated TBS Open Data Inventory have been used to determine the number and percentage of released datasets for each SBDA, shown in Table 1. These results have been supplemented in some instances by data provided by SBDAs. To be considered released, a URL link to the data must be present in the inventory. To calculate the percentage of dataset released, the number of released datasets was divided by the total of the number of datasets in the inventory for each SBDA. Only data from participating SBDAs are shown.

Table 1. Number and percent of released datasets found on the Open Data Inventory from participating SBDAs

SBDA	Datasets		2019	2018
	Released	Eligible	Percentage of eligible SBDA datasets released[1]	Percentage of eligible datasets released[2]
AAFC	280	414	67.6%	67.6%
CFIA	24	75	32.0%	100%
CSA	29	29	100%[2]	72.7%
ECCC	92	362	25.4%	25.7%
DFO	206	708	29.1%	17.2%
HC	41	64	64.1%	64.1%
ISED	59	85	69.4%	69.4%
NRC	13	23	56.5%	100%
NRCan	162	401	40.4%	35.7%
PHAC	10	16	62.5%	100%
StatsCan	6563	6563	100%	100%
TC	16	167	9.6%	9.6%
Total	**7466**	**8878**	**84%**	**83%**

Notes

1. The number of released datasets was divided by the total of the number of datasets in the inventory for each SBDA
2. Calculated from data obtained at the end of 2018

The Open Data Inventory was assembled through an exercise initiated in 2016-17, intended to create an inventory of datasets from federal departments and agencies. It includes different types of data such as corporate, operational, and scientific. Additional limitations include the frequency to which updates are made, which vary among departments, and differences in the contributors' understanding of what constitutes an eligible dataset.

Comparing datasets is a complex endeavour, given that there can be differences in size, time coverage, and data management practices. Privacy and security legislations and policies prohibit some SBDAs from making certain sensitive data open. For example, at Statistics Canada, certain datasets are deemed sensitive and as such must

be viewed only at secure physical locations, such as Research Data Centres. Other SBDAs like the CSA have additional data available on their open data website. As a result, this report focuses on the percentage of eligible datasets that have been released to this specific portal, rather than the number of open datasets, to demonstrate progress made. Despite these limitations, the method used to collect the information above is the best available but caution should be exercised when extrapolating these metrics outside the boundaries of the open data inventory.

Additional information on open datasets available beyond the inventory can be found on the Open Government Portal or by consulting the Open Government Analytics page.

3.3 Open science public engagement

Findings

- Activities/events from eight SBDAs for this purpose have been reported in 2019. They include social media campaigns, pro-active media calls, webinars, video conferences (including from space!), podcasts, conferences, and citizen science projects.

Open science is more than just making science physically accessible though tools like open access. To gauge public engagement, a list of events and activities was compiled (see Annex 1) as a way to demonstrate the wide variety of open science public engagements that took place from January 1 to December 31, 2019. While the list of 45 activities/events is not comprehensive, it includes examples of both “Public Participation”, defined as opportunities to foster mutual exchanges between scientists and the public to make contributions to science (two-way flow), and “Communication and Outreach Activities”, defined as activities conducted by scientists to inform the public (one-way flow).

SBDAs engaged in a wide range of activities designed to make the science performed in their department or agency more accessible to the public. Some events took place online as webinars or through social media posts so that any Canadian with access to the internet could participate. Other activities allowed Canadians to directly engage in science by participating in data collection, through citizen science projects. SBDAs continue to use innovative ways to connect to Canadians and make science not just physically accessible, but more understandable.

3.4 Open maps

Findings

- The number of SBDA open maps increased in 2019, with 68 additional maps uploaded and made available in the Open Government Portal, for a total of 387.

Figure 5 shows the number of maps made available by SBDA as of December 31, 2019, on Open Maps, a specialized data portal accessible through the Open Government Portal. Open Maps provides users with access to federal geospatial data and tools for users to combine, visualize, and analyze this type of data. It is worth noting that open maps are not common for all SBDAs, given differences in their respective mandate. AAFC, DFO, ECCC, and NRCan release the majority of Open Maps.

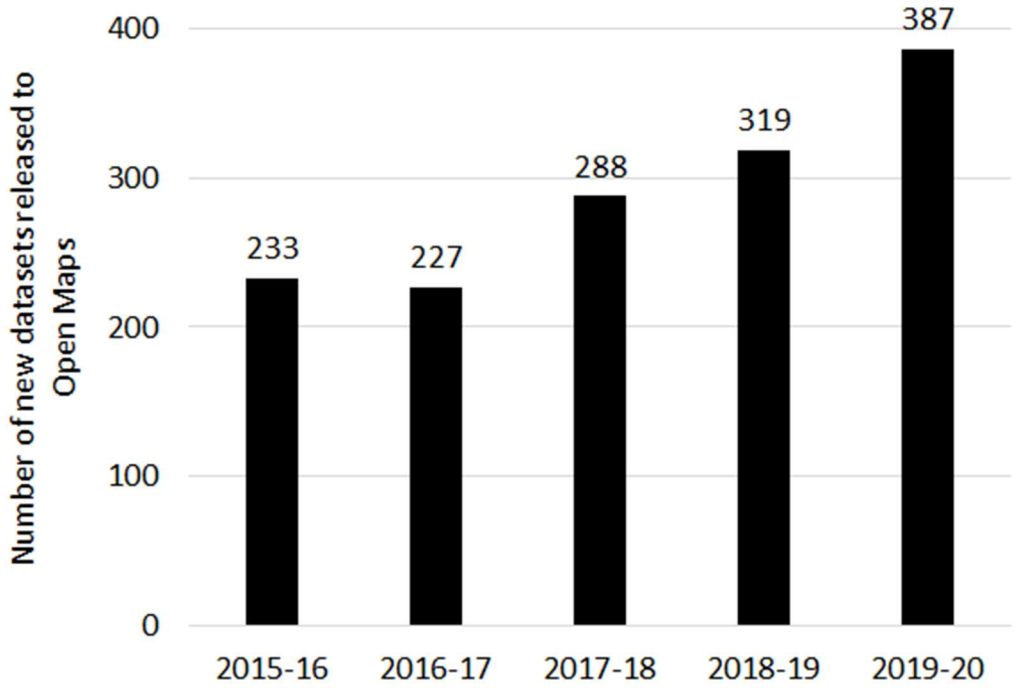

Figure 5. Number of new SBDA open maps available on the Open Government Portal for each time period.

3.5 Supplementary Open Science Metrics

The supplementary metrics are designed to supplement core metrics to present a more comprehensive overview of the work SBDAs are doing to make their science open. These metrics have been generally implemented only by participating SBDAs.

3.5.1 Open access publications in funded research

Findings

- From 1998 to 2018, SBDAs have funded extramural research projects that have generated an estimated 6,899 scientific publications. A total of 50% of these publications were available in open access.

Several SBDAs engage in grant and contribution activities whereby funds are transferred to extramural partners to conduct scientific research. These external activities can result in scientific peer-reviewed publications. To get a sense of these outputs, the Scopus publication database was searched for mentions of any SBDA in the acknowledgement section. As these mentions usually involve acknowledging the receipt of a grant, we can by proxy estimate the number of publications resulting from federal grants and contributions. A total of fifteen SBDAs were included in this analysis: AAFC, ECCC, CSA, NRC, NRCan, HC, DFO, ISED, PHAC, PC, DRDC, StatsCan, AECK, TC and CFIA.

Figure 6 shows that the number of funded publications has increased over the course of the 2013-2018 study period. The number of open access publications exceeds toll access publications up to and including 2016. After 2016, the number of total publications increased, with a higher share published in toll access. This is likely again due to the “back-filling” and embargo effects that reduce the availability of publications in green open access. However, the difference between the number of open and toll-access publications remains small.

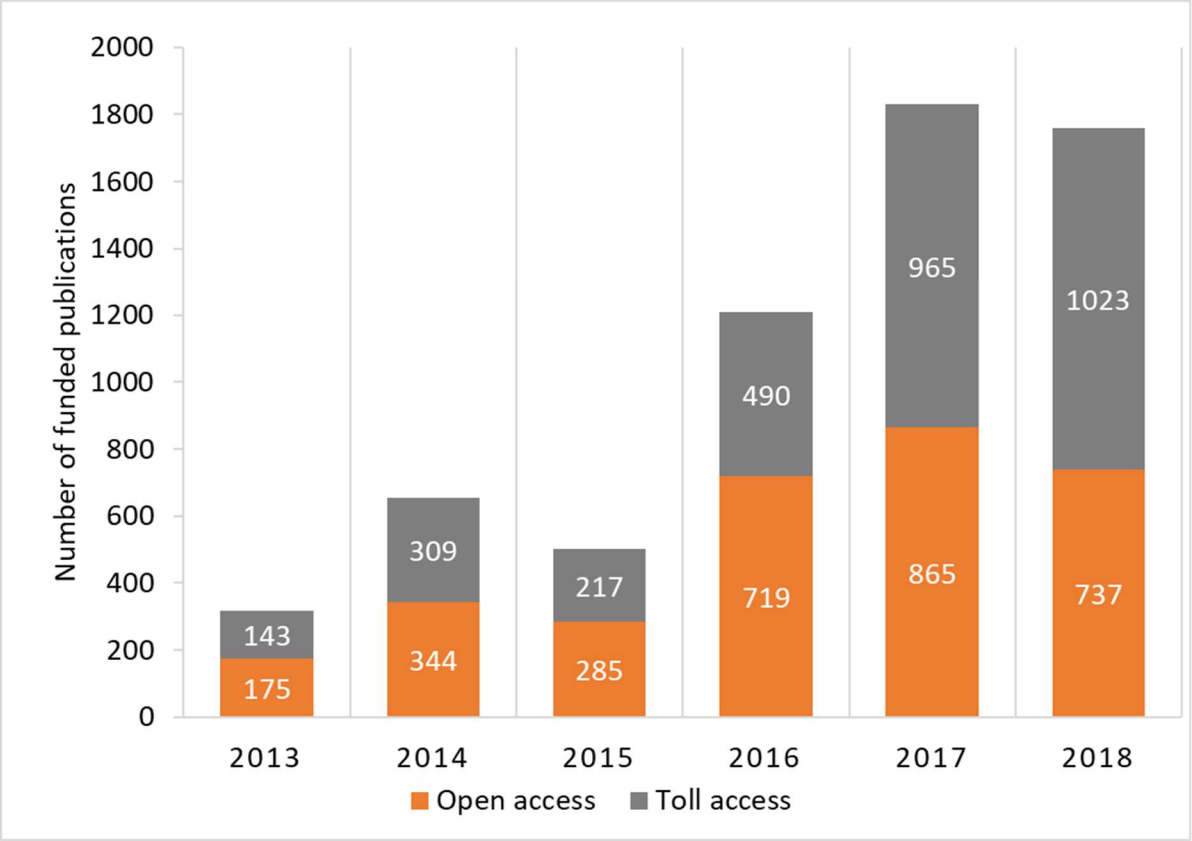

Figure 6. Number of peer-reviewed articles in toll access (grey) and open (green + gold) access (orange) which acknowledge SBDA funding from 2013-2018.

3.5.2 Altmetrics

Findings

- Open access research products had higher uptake than non-OA research products across all SBDAs examined;
- Open access products received almost triple the mentions of non-OA products, even though only 9% more open access products were tracked.

Altmetrics, as their name suggests, are alternatives to traditional metrics in research. Altmetrics are a way to measure the reach of a research product[b] beyond just citations and can be an important tool in to show the impact of open access publications. The Altmetric Explorer tool from Digital Science provides information on research products to measure their online visibility (or uptake) by counting the number of times a research

[b] Publications, maps, datasets, images or anything that can be tracked with a DOI or other type of identifier they track

product appears across a wide variety of public facing mediums. This is primarily enabled for research products (such as publications and datasets) that have an associated Digital Object

Identifier (DOI). Altmetric Explorer provides information on news coverage, blog posts, tweets, policies, and other social media mentions associated with research products. These metrics are a complement to the more traditional core metrics.

For this metric, 33,000 research products from over 16 SBDAs were tracked, including publications, books or book chapters only. The earliest entry for this particular analysis was from 1940, given the data available through Altmetric. Since curation errors can result from variations in the affiliation and author's name used at the time of publication, the analysis was performed on a subset of the total in Digital Science's Altmetric database that could be readily verified. The DOIs of the research products identified by Altmetric Explorer and associated with a particular SBDA were verified using Web of Science from Clarivate Analytics. This step reduced the total number of publications by 30%, to 23,826. From there, the analysis looked at which of these research products were tracked by Altmetric Explorer and which received attention (i.e. a mention on social media, blog posts, policy documents, traditional media or any other medium that Digital Science tracks).

Open access research products (green and gold) had more mentions than toll access research products across all the SBDAs examined. Even though only 9% more open access products than toll access products were tracked, open access products received more than triple the mentions of non-OA products: 143,109 versus 42,075. Twelve out of 16 SBDAs had over 80% of their tracked open research products with at least one mention, meaning a majority of research products are getting a mention. Across departments and agencies, mentions of research products ranged from 28% to 90% for toll access and 58% to 100% for open access research products, respectively (Figure 7). Figure 7 also shows that, across the Government of Canada, 81% of open access and research products received at least one mention, compared to 66% of toll access research products.

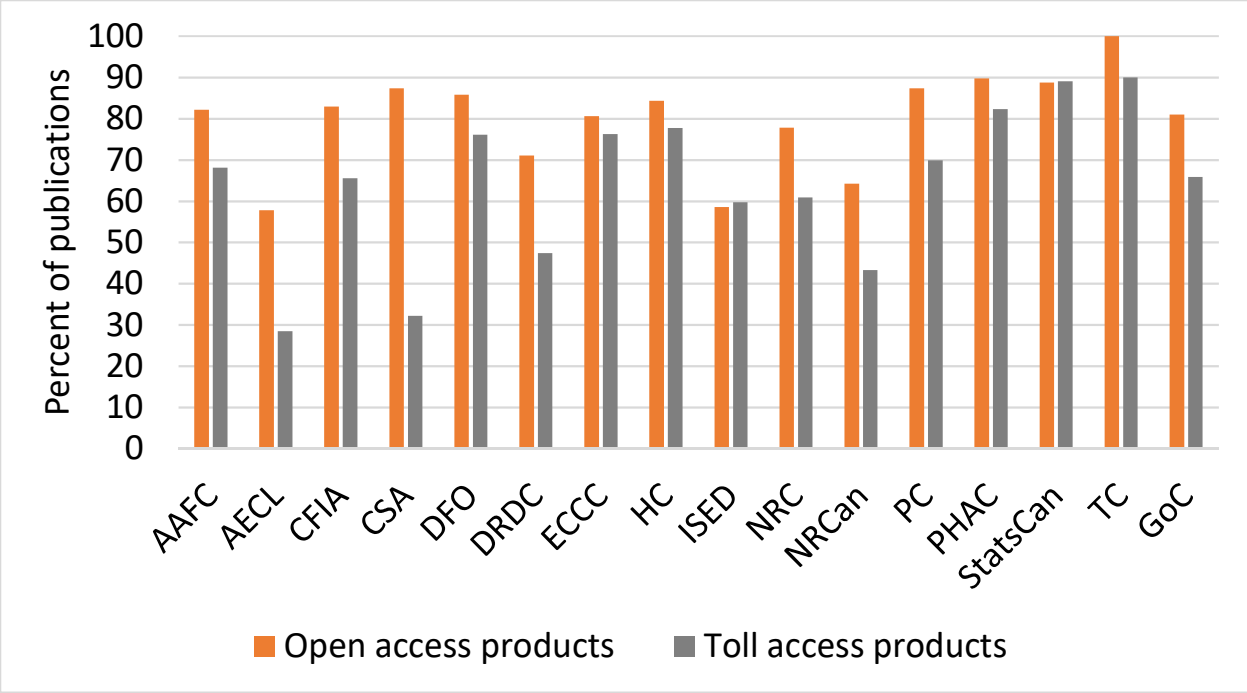

Figure 7. Percent of publications in open (green+ gold) access (orange) and toll access (grey) that had at least one online mention out of the total number of research products in that category.

4. How Federal Open Science is Benefiting Canadians

Federal implementation of open science enhances the reach and availability of science conducted by the federal government, benefits Canada's economy, promotes scientific discovery, and strengthens democratic institutions[2]. Open science means that industry can build open innovation and accelerate discoveries. It gives Canadians access to information about medical treatments and outcomes. It makes federal science accessible to all Canadians.

The commitment to federal open science has never been more important than during the recent COVID-19 epidemic. In March 2020, Canada's Chief Science Advisor joined counterparts from 15 other countries in calling for the publishing community to make COVID-19-related publications and data immediately accessible. Canada, under the leadership of the Chief Science Advisor also created CanCOVID, an expert network of Canadian COVID-19 researchers, clinical collaborators, and healthcare stakeholders to facilitate communication and collaboration.

The benefit of federal science in general is that it seeks to advance knowledge on national priorities (e.g., COVID-19, climate change, plastics science) rather than field or

industry-specific needs. Furthermore, the vast range of areas investigated by federal science helps fill knowledge gaps. For example, the government produces one-third of Canadian research publications on agriculture, fisheries, and forestry[4]. Making federal science open also facilitates access to these benefits. To highlight the benefits of open federal science, diverse indicators were used to demonstrate how Canadians access to federal science, how it influences innovation, and how it impacts other scientists.

4.1 Reach of open data

Findings

- In 2019, datasets and information products from SBDAs were downloaded 403,159 times from the Open Government Portal for that calendar year.

Examining the downloaded datasets from the Open Government Portal can provide some indication of the reach of federal open data. Some of the top downloaded SBDA datasets include NRCan's fuel consumption ratings (20,339) and TC's Civil Aircraft Register Database (4,704). Having these datasets in the open allows greater access for all Canadians, regardless of geographic location. Open datasets can be used not only by scientists for research purposes, but can also be used in a school setting. The number of downloads provides information about how useful an SBDA's datasets are for Canadians to advance their own work and interests (Table 2).

Table 2. Number of total dataset downloads of SBDA datasets by each SBDA

Science Based Departments and Agencies	Number of Downloads1
AAFC	27,399
CFIA	3,188
CSA	1,914
DFO	22,443
DRDC	59
ECCC	53,237
HC	22,087
ISED	17,990
NRC	585
NRCan	148,859
PHAC	5,933
StatsCan	76,928
TC	22,537
Total	**403,159**

Notes

1. For the period between January 1 - December 31, 2019

Having these datasets available for all to access and use contributes to a more open government by allowing think tanks, civil society and the media to provide independent oversight of government policies and encourage civil discussion through evidence. For example, the Canadian Centre for Policy Alternatives cites and uses ECCC's "Canada's Official Greenhouse Gas Inventory" for their "Adapting Canadian Work and Workplaces to Respond to Climate Change: Canada in International Perspective" project[5]. The Canadian Broadcasting Corporation used the same dataset for its article on September 10, 2019, titled "B.C. greenhouse gas emissions still near 2007 levels, ministry says"[6].

Making federal science available can also create economic opportunities, such as businesses using that information to develop processes or new products, which may lead to increased productivity or new industries and employment for Canadians. An example is Store Crossing, which helps local makers and artisans find retail spaces to host pop-up shops in high-traffic areas across Toronto and Etobicoke to increase their sales.[7]

4.2 Patent uptake of federal peer-reviewed publications

Findings

- Federal science articles available in open access are slightly more likely to be found in patents compared with toll access papers. This open access advantage is even greater in the case of Canadian or G7 research.

An important impact of federal science is its contribution to innovation and the development of new technologies, goods or services. Uptake of publications in patents is one metric to demonstrate how open science contributes to innovation.

Within the federal Canadian context, from 1998 to 2016, an estimated 5,018 patents cited at least one federal science publication, which represents 4.9% of all SBDA peer-reviewed articles. Divided into open and toll access, open access federal articles are slightly more likely to be cited in patents. As shown in Figure 8, 5.4% of the federal open access publications are cited in patents, whereas 5.2% of federal toll access papers are cited in patents.

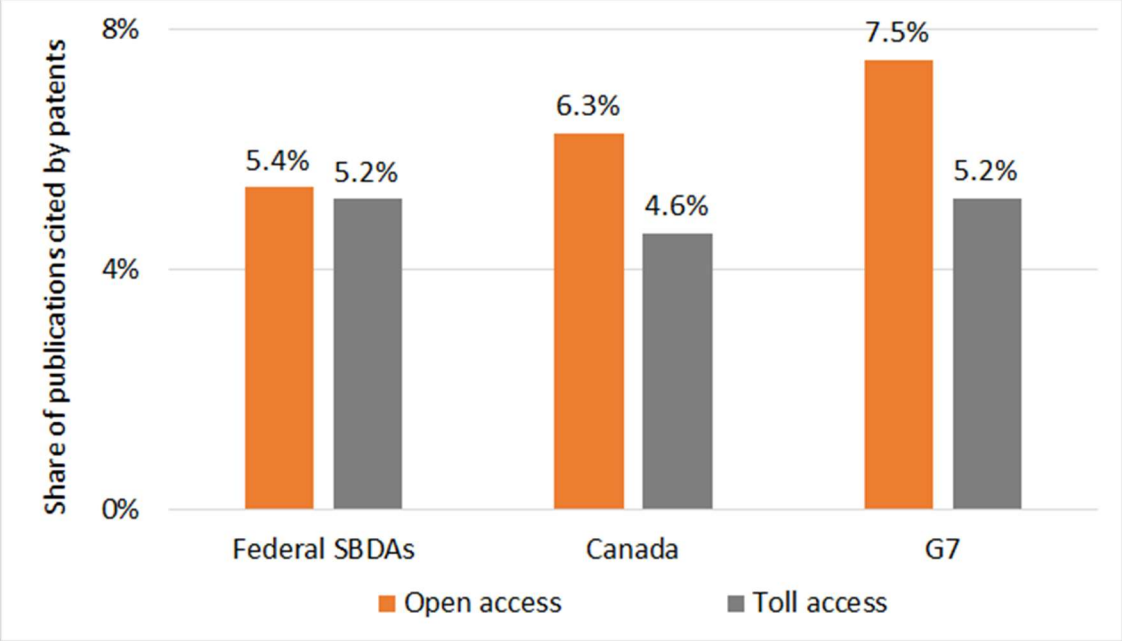

Figure 8. Share of publications cited by patents, for publication years 1998-2016

Figure 8 also shows that this open access advantage is greater for G7 countries and Canadian researchers, in general. For instance, for research authored by scientists from G7 countries, the share of publications cited in patents is higher (7.5%) for open access papers compared with toll access papers (5.2%).

It is important to consider that this metric would be most relevant for SBDAs that focus on the development of science with potential commercial applications, and less relevant for those that do not. Therefore, some SBDAs will have higher uptake than others.

4.3 Increased influence of federal science internationally

Findings

- Federal publications in open access have a higher Average Relative Citation score than toll access publications.

Open access allows Canadian's investment in research to go further. One metric to measure this is the average relative citation (ARC) of an article. A relative citation is the number of citations of an individual publication relative to the average number of citations for publications in the same subfield. This metric controls for the differences in citation rates across disciplines. The ARC is normalized to 1, which represents the world average. A score higher than 1 means that it has a higher-than-citation count. A higher score may mean that other researchers are expanding on the work.

Looking at Figure 9, over the 10-year period of available data, SBDA articles in the open tend to have a higher score at 1.73 vs 1.20 for toll access publications. This demonstrates that open articles are cited more often, which in turn could lead to other researchers using these publications to accelerate science.

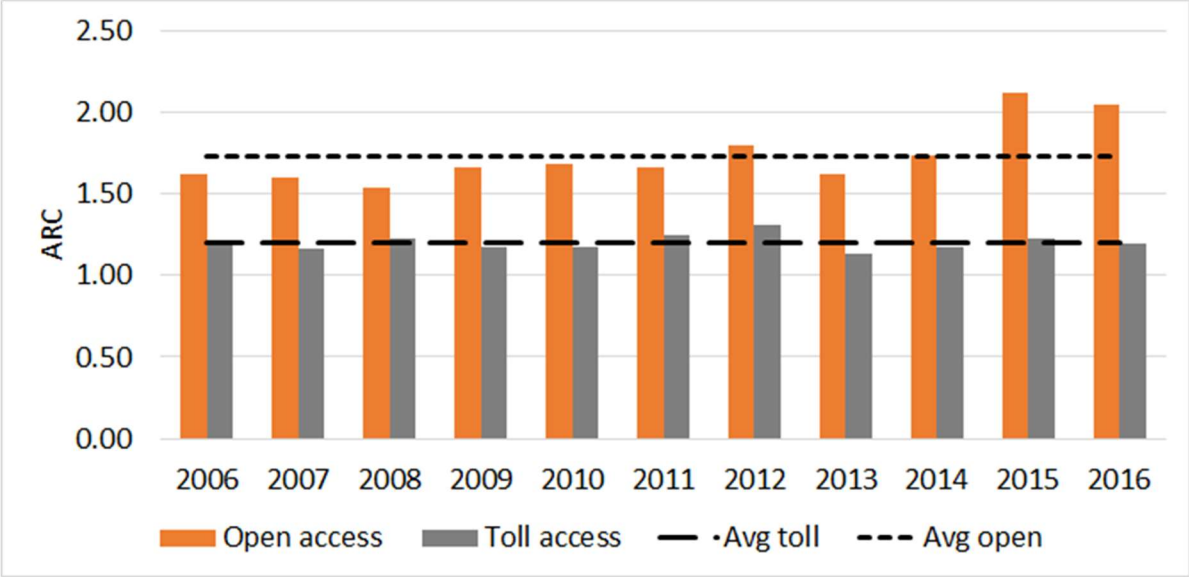

Figure 9: ARC of toll and open SBDA publications from 2006-2017. ARC is the average of the relative citation score of all articles published by an entity

5. Moving Forward

In response to the Report to the Clerk of the Privy Council: A Data Strategy Roadmap and the Chief Science Advisor's Roadmap for Open Science, SBDAs are making their data, information products, and science publications more open. This report shows that progress has been made in providing access to federal publications to Canadians, as about half of recent federal peer-reviewed publications are now available in open access. This report also measured annual progress made in 2019, following the first federal open science report in 2018. For all publication years investigated, an increase in the number of open access publications can be observed from 2018 to 2019. This increase is greater for most recent publication years. Yearly increases in the number of open datasets and open maps were also observed. The benefit of open science to other scientists and industry is also highlighted, while demonstrating that Canadians are accessing open science.

The Roadmap recommends ambitious new targets for open federal science publications along with the creation of departmental open science action plans. The creation of such plans is also a commitment under Canada's 2018-2020 National Action Plan on Open Government. In addition, the Roadmap calls for SBDAs to adopt metrics to track their progress in implementing their open science action plans. While metrics to measure open access journal publications are fairly straightforward to implement (at least for peer-reviewed publications), more work remains to develop metrics to measure open and FAIR data in a systematic and consistent manner, both in terms of concept definitions, and in data collection and tracking. To better represent the scope of SBDA efforts to make their science open, new indicators could be examined to measure progress. One such potential indicator would be to use the DOIs available through the Data Cite Canada Consortium to measure how many datasets associated with DOIs are made available in the open.

While the current COVID-19 crisis has very likely accelerated the release of scientific studies in open access and open data in 2020, it remains to be seen if this will herald new attitudes toward open access in the scientific community in general. The findings of this report suggest that achieving the ambitious open science goals of the Roadmap would most likely require additional actions.

References

1. Office of the Chief Science Advisor, 2020. The Roadmap for Open Science. https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97992.html#1
2. “Call for Open Access to COVID-19 Publications”. Government of Canada, https://www.ic.gc.ca/eic/site/063.nsf/eng/h_98016.html
3. “Ongoing initiatives on COVID-19”. Government of Canada, https://www.ic.gc.ca/eic/site/063.nsf/eng/h_98027.html
4. Council of Canadian Academies, 2018. Competing in a Global Innovation Economy: The Current State of R&D in Canada. Ottawa (ON): Expert Panel on the State of Science and Technology and Industrial Research and Development in Canada, Council of Canadian Academies.
5. Canadian Centre for Policy Alternatives. Adapting Canadian Work and Workplaces to Respond to Climate Change: Canada in International Perspective (ACW). 2019.
6. “B.C. greenhouse gas emissions still near 2007 levels, ministry says”. *CBC News,* CBC, 10 September 2019, https://www.cbc.ca/news/canada/british-columbia/bc-greenhouse-gas-emissions-carbon-tax-1.5277439.
7. “Store Crossing”. Government of Canada, https://open.canada.ca/en/story/store-crossing

Annex 1.List of SBDA Public Engagement Activities

Name of Public Engagement	SBDA	Category	Links (if available)
Media calls	AAFC	Communication & outreach	NA
New media	CRCC (ISED)	Communication & outreach	http://www.crc.gc.ca/eic/site/069.nsf/eng/h_00075.html
Outreach	CRCC (ISED)	Communication & outreach	http://www.crc.gc.ca/eic/site/069.nsf/eng/h_00005.html
Outreach	CRCC (ISED)	Communication & outreach	NA
Open Research System	CRCC (ISED)	Communication & outreach	NA
Outreach	CRCC (ISED)	Communication & outreach	https://ingeniumcanada.org/events/cool-science-saturday
New media	CRCC (ISED)	Communication & outreach	http://science.gc.ca/eic/site/063.nsf/eng/h_97679.html
Stakeholder Webinar	HC	Communication & outreach	NA
Network Activity	HC	Communication & outreach	NA
Education Seminar	HC	Communication & outreach	https://takeactiononradon.ca/events/
Stakeholder Webinar	HC	Communication & outreach	https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/pesticide-safety-videos.html
Information Campaign	HC	Communication & outreach	brochure

Simply Science Podcast	NRCan	Communication & outreach	https://soundcloud.com/nrcan/what-type-of-batteries-do-electric-vehicles-use-natural-elements
Simply Science Video	NRCan	Communication & outreach	https://www.youtube.com/watch?v=7DSOTziifWY
Social Media Campaign	NRCan	Communication & outreach	NA
Social Media Campaign	NRCan	Communication & outreach	NA
Exhibit	NRCan	Communication & outreach	NA
Conference	NRCan	Communication & outreach	NA
Technical Briefing Session for Media	NRCan	Communication & outreach	NA
Media Interview from Proactive Media Pitch	NRCan	Communication & outreach	NA
Citizen Service Activities	NRCan	Communication & outreach	NA
Simply Science Podcast	NRCan	Communication & outreach	https://soundcloud.com/nrcan/what-type-of-batteries-do-electric-vehicles-use-natural-elements
Simply Science Video	NRCan	Communication & outreach	https://www.youtube.com/watch?v=7DSOTziifWY
Social Media Campaign	NRCan	Communication & outreach	NA
Social Media Campaign	NRCan	Communication & outreach	NA
Exhibit	NRCan	Communication & outreach	NA
Conference	NRCan	Communication & outreach	NA

Technical Briefing Session for Media	NRCan	Communication & outreach	NA
Media Interview from Proactive Media Pitch	NRCan	Communication & outreach	NA
Citizen Service Activities	NRCan	Communication & outreach	NA
Citizen science	CFIA	Public participation	https://twitter.com/search?f=tweets&vertical=default&q=box%20tree%20moth&src=typd
Citizen science	CRCC (ISED)	Public participation	https://www.ic.gc.ca/eic/site/101.nsf/eng/00065.html#ar2
Videoconference with Astronaut David St-Jacques	CSA	Public participation	https://www.youtube.com/watch?v=EudymsGzrBc
Friday Night Live Information Kiosk	CSA	Public participation	NA
FIRST robotics information Kiosk	CSA	Public participation	https://www.firstroboticscanada.org/event/festival-de-robotique-montreal/
Canada-wide Science Fair information Kiosk	CSA	Public participation	https://cwsf.youthscience.ca/fr/fair/bienvenue-fredericton-2019
Citizen science	DRDC	Public participation	https://apps.apple.com/ca/app/r2mr/id1148743063
Research Study	HC	Public participation	NA
Sweepstakes	HC	Public participation	https://takeactiononradon.ca/radon-reduction-sweepstakes/ Annual reports of the sweepstakes and radon data collected are shared with participants and the public: https://takeactiononradon.ca/radon-reduction-sweepstakes-report-2018-2019/
Consultations	HC	Public participation	https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/consultations.html

Community Engagement	HC	Public participation	NA
Research Symposium	TC	Public participation	https://www.tc.gc.ca/eng/tdg/tdg-research-symposium.html
Workshop	TC	Public participation	https://www.tc.gc.ca/en/services/marine/marine-pollution-environmental-response/cumulative-effects-marine-shipping.html
Demonstration Day	TC	Public participation	https://www.tc.gc.ca/en/programs-policies/programs/ecotechnology-vehicles-program/etv-technical-papers/fuel-economy-testing-three-vehicle-truck-platooning-system.html
Research Seminar	TC	Public participation	https://www.railcan.ca/event/rail-government-interface-rgi-transport-canada-rail-research-seminar-2019/

Annex 2. Methodology and Source of Metrics

Metric	Indicator	Type	Data source	Observation period
3.1.1 Open access publications	Percentage of peer-reviewed articles available in open access per SBDAs	Quantitative	ECCC Science Metrix contract	2009-18
3.1.2 open science data	Percentage of releasable/eligible SBDA datasets identified in the open data inventory. To be considered “released,” the dataset must be associated with an URL.	Quantitative	TBS Open Data Inventory	December 31, 2019
	Number of datasets per SBDA listed in the Open Government Analytics	Quantitative	TBS Open Government Analytics	January 2020
3.1.3 Open science public engagement	Inventory of open science public engagement	Qualitative	Internal SBDA tracking system	January 1 – December 31, 2019

	activities involving members of the public and federal scientists and science contributors.			
3.1.4 Other open science products	Summary of SBDA datasets available through Open Maps	Quantitative	Open Maps	December 31, 2019
3.2.1 Open Access Publications in funded research	Percentage of federally funded peer-reviewed articles available in open access per SBDAs	Quantitative	ECCC Science Metrix contract	2009-18
3.2.2 Altmetrics	Percent of tracked research products that received attention	Quantitative	Altmetrics	1940-June 2020
4.1 Reach of open data	Number of downloads per SBDA from the Open Government Analytics	Quantitative	TBS Open Government Analytics – “Downloads per organization, last 12 months dataset”	January – December 2019
4.2 Patent uptake of federal peer-reviewed publications	Share of publications cited by patents	Quantitative	Science Metrix	1998-2018
4.3 Greater influence of federal science internationally	Share of open access and toll publications	Quantitative	Science Metrix	1998-2018

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Annex 4. Abbreviations

Agriculture and Agri-Food Canada	AAFC
Average Relative Citation	ARC
Canadian Food Inspection Agency	CFIA
Canadian Institute of Health Research	CIHR
Canadian Space Agency	CSA
Communications Research Centre	CRC
Defence Research and Development Canada	DRDC
Environment and Climate Change Canada	ECCC
Fisheries and Oceans Canada	DFO
Group of Seven	G7
Health Canada	HC
Innovation, Science and Economic Development Canada	ISED
National Research Council of Canada	NRC
Natural Resources Canada	NRCan
Natural Sciences and Engineering Research Council	NSERC
Office of the Chief Science Advisor of Canada	O-CSA
Polar Knowledge Canada	POLAR

Public Health Agency of Canada	PHAC
Science-based Departments and Agencies	SBDA
Social Science and Humanities Research Council	SSHRC
Statistics Canada	StatsCan
Transport Canada	TC
Treasury Board of Canada Secretariat	TBS