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OPEN SCIENCE ACTION PLAN

NATURAL RESOURCES CANADA
August 2021



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Message from the Deputy Minister

I am pleased to present Natural Resources Canada's (NRCan's) Open Science Action Plan, an evergreen approach to providing greater access, transparency, and openness to NRCan scientific research and activities. The Plan outlines how our Department can navigate the delicate balancing act of being as 'open as possible and as closed as necessary' in order to maximize access and collaboration, while maintaining respect for privacy, security, ethical considerations and appropriate intellectual property protection.

In February 2020, the Office of the Chief Science Advisor of Canada (OCSA) released the [Roadmap for Open Science](#), which provides overarching principles and recommendations to guide Open Science practices for science and research funded by federal government departments and agencies. NRCan has made great progress in advancing Open Science since the launch of the Open Government Initiative in 2011, and has already adopted several of the Roadmap's recommendations in developing our Open Science Action Plan.

I am very happy to announce that the Department has designated its Chief Scientist and Chief Science Advisor as NRCan's Chief Scientific Data Officer, whose role is to promote coordination between the Open Data, Open Science, and Science Data Management initiatives happening within the Government of Canada.

As a science based department, we recognise the contribution that our scientists make in advancing the culture of Open Science at NRCan. Consequently, we started consulting with our scientific community to better understand their perspectives on Open Science, which has helped to shape the direction of our Open Science Action Plan. We will continue to engage with our scientific community, our key partners in the federal family and outside, as we work together to implement this Action Plan.

I am confident that NRCan has the commitment, resources and expertise needed to make NRCan's scientific outputs open and accessible to all Canadians. This Action Plan represents an opportunity for us to increase public engagement and trust, broaden participation in our research, create new opportunities for innovation and prosperity, and advance the diversity of knowledge systems and perspectives.

Jean-François Tremblay, Deputy Minister
Natural Resources Canada

Introduction

Background

Open Science is “*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 practiced in full respect of privacy, security, ethical considerations and appropriate intellectual property protection*” (Roadmap for Open Science, 2020).

Natural Resources Canada (NRCan) has been active in advancing Open Science since the launch of the Open Government Initiative in 2011, and remains committed to openness and transparency regarding science performed in support of the department’s programs, policies and decision-making. Existing and newly developed policies at NRCan that also address how transparency and open access can be integrated into the science and research funded by NRCan include the:

- NRCan Intellectual Property Policy (2017);
- Scientific Integrity Policy (2018); and,
- NRCan Scientific and Technical Publications Policy (2019).

NRCan is committed to both advancing research in partnership with Indigenous peoples respecting protocols around data and research, and also committed to principles of Open Science. NRCan recognizes that these goals are not always aligned, and that all research projects must be considered on a case-by-case basis.

NRCan’s scientific publications are made discoverable and freely available when possible to the public via online tools like the Federal Science Libraries Network (FSLN)¹, GEOSCAN² and the CFS Publications. Researchers sign up for unique identifiers such as ORCID (Open Researcher and Contributor ID), for easy identification of NRCan science outputs. New publications and datasets are routinely assigned Digital Object Identifiers (DOIs), providing permanent identifiers to increase accessibility and transparency. International standards for metadata are applied through other catalogues, including the Federal Science Libraries Network portal and the [Open Science and Data Platform](#). A complete list of existing NRCan policies and platforms supporting Open Science in the department is provided in [Appendix 3](#).

The Roadmap for Open Science

In February 2020, the Office of the Chief Science Advisor of Canada (OCSA) released the [Roadmap for Open Science](#) (Roadmap) which provides overarching principles and recommendations to guide Open Science practices for science and research funded by federal government departments and agencies. The Roadmap was informed by the work of the Open Science Roadmap Advisory Committee, with input from experts across Canada’s scientific community. The ultimate objective of the Roadmap is to “make Canadian science open to all, and to maximize benefits for the well-being, health and economy of the country.”

¹ (EN) <https://fsl-bsf.scitech.gc.ca/eng/intranet/home/>, (FR) <https://fsl-bsf.scitech.gc.ca/fra/intranet/accueil/>

² (EN) https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/geoscan_e.web, (FR) https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/geoscan_f.web

The [Roadmap](#) lays out 10 recommendations, which are as follows:

1. Canada should adopt an Open Science approach to federally funded scientific and research outputs.
2. Federal departments and agencies should conduct intradepartmental consultations with the science community before June 2020 to seek feedback on, and address in the action plan, the challenges and opportunities of Open Science. These should be led by the Department's Open Science Champion(s), e.g., Departmental Science Advisor, Chief Science Officer, Assistant Deputy Minister and Vice President Science.
3. To achieve the overall objective of Open Science, and taking into consideration feedback from intradepartmental consultation (Recommendation 2), departments and agencies should develop action plans for Open Science by October 2020. This should include plans for a common, phased approach towards making federal science open (taking into account Recommendations 4, 5 and 7) and readily and easily available to Canadians.
4. Federal departments and agencies should make federal science articles openly accessible by January 2022 and federal science publications openly accessible by January 2023, while respecting privacy, security, ethical considerations and appropriate intellectual property protection.
5. Federal departments and agencies should develop strategies and tools to implement FAIR data principles³ to ensure interoperability of scientific and research data and metadata standards by January 2023, with a phased plan for full implementation by January 2025.
6. In order to enable the "Open by Design and by Default" model for scientific research outputs, the Chief Science Advisor will work with the federal science community and other government departments and agencies to develop by December 2020 a framework identifying criteria for when restricting access to federal scientific research outputs is warranted.
7. The Data Strategy Roadmap and the Open Science Action Plan should be aligned. For this to happen, consideration should be given to scientific and research data when developing and implementing data strategies in response to the 2018 Data Strategy Roadmap for the Federal Public Service. To facilitate that, deputy heads should designate a Chief Scientific Data Officer by June 2020. As relevant, this can be a stand-alone position or responsibility can be integrated into the scope of an existing position, e.g. Departmental Science Advisor, Assistant Deputy Minister and Vice President Science.
8. Successful and harmonized implementation of the Open Science Action Plans should be supported by a new high-level Open Science Steering Committee co-chaired by the Chief Science Advisor and either or both the Chief Information Officer of Canada and the President of Shared Services Canada.

³ The FAIR data principles assert that data collections should be Findable, Accessible, Interoperable, and Reusable, and each of the four translate into specific requirements to the data management system. **Findability** refers to the capacity to search for and discover data collections, and involves requirements on metadata, identifiers, and indexing. **Accessibility** is a measure of the ease with which information can be directly obtained or accessed once discovered. **Interoperability** is the degree to which independent data sets can be combined and integrated with one another, which can be facilitated by using consistent standards, encoding, and vocabularies. **Reusability** means that the data can be put to multiple uses beyond its original purpose, and includes requirements on usage licences, provenance, and community standards.

9. An Open Science strategy for federally funded research conducted outside of federal government agencies and departments should also be developed. The Chief Science Advisor could conduct such an exercise in partnership with the federal granting agencies (e.g. through the Canada Research Coordinating Committee), learned societies and provincial and territorial funders. These consultations should target scientific communities and their administrative leadership. The consultation should be completed by December 2021.
10. The Chief Science Advisor should monitor the dynamic international context and make recommendations to ensure that the Open Science strategy for federally supported intramural and extramural science continues to keep pace with international developments.

The Roadmap was developed in the context of existing federal policies and directives, including the [Directive on Open Government](#), the [Model Policy on Scientific Integrity](#) and the [Data Strategy Roadmap for the Federal Public Service](#). It builds on the [Tri-Agency Open Access Policy on Publications](#) and the [Tri-Agency Statement of Principles on Digital Data Management](#).

Individual departments and agencies are required to develop their action plans and respond to the recommendations in the Roadmap based on their unique operational context.

Chaired by the Office of the Chief Scientist and the Corporate Management and Services Sector (Chief Information Officer and Security Branch), the Open Science Committee is responsible for overseeing and advancing Open Science at NRCan, including the development of NRCan's Open Science Action Plan. An Open Science Working Group, composed of representatives from NRCan's sectors, led the development of the Action Plan.

NRCan Open Science Consultation

In developing the Action Plan, the department's scientific community was consulted throughout 2020 and 2021. In May 2020, the OCS launched an NRCan Science Activities Survey, which featured 16 questions related to Open Science and was completed by roughly 30% of all NRCan scientists. Additionally, to engage directly with NRCan scientists on Open Science, the OCS organized a series of virtual lab-tours in the summer of 2020 and a departmental Open Science Engagement Session on June 2, 2021 that was attended by 100 participants.

During this consultation, it became evident that along with Open Science (OS) activities that have long been undertaken, discussions on Open Science are not novel at NRCan. A consistent theme was that advancing Open Science at NRCan will require shifting the culture beyond the recommendations in the Roadmap, creating tools for improving sharing and access, as well as providing support and training on the adoption of best practices and tools, and importantly, funding available to scientists to publish in Open Access. NRCan scientists identified the need to strengthen our digital infrastructure by developing an Open Institutional Repository (OIR), improving network bandwidth and speed, and increasing local and digital data storage capacity. The consultation process highlighted that the implementation of the Action Plan must be flexible so that we can respond to changes in our work environment, recognising that the future of work has been transformed by the COVID-19 pandemic experience.

NRCan also engaged with other science-based departments and agencies (SBDAs) during the development of the Action Plan to ensure that the plans were aligned as consistently as possible. NRCan is a co-chair of the Interdepartmental Open Science Working Group, as well as a member of the Interdepartmental Indigenous Science, Technology, Engineering, and Mathematics (I-STEM) Cluster,

which aims to increase interdepartmental collaboration and reconciliation efforts around Indigenous peoples participation in science, in part, by providing training on [the First Nations Principles of OCAP®](#) (Ownership, Control, Access, and Possession).

NRCan's Vision for Open Science

Objectives

The Action Plan builds on the existing culture of Open Science within NRCan and presents a phased approach for making the department's science open and readily and easily available to Canadians.

The objectives of the Action Plan are to:

- 1) create and foster a culture to enable best practices of Open Science;
- 2) make NRCan's science articles openly accessible by January 2022 and its publications openly accessible by January 2023, while respecting privacy, security, Indigenous protocols, ethical considerations and appropriate intellectual property protection; and,
- 3) fully implement the FAIR data principles by January 2025.

These objectives are consistent with the Model Policy on Scientific Integrity and the Government of Canada's Directive on Open Government, and align with the Data Strategy Roadmap for the Federal Public Service.

Vision Statement

The NRCan Open Science Action Plan is intended to guide senior managers, middle managers, science staff, and policymakers in furthering the implementation of a culture of Open Science at NRCan. It anticipates Open Access publication of NRCan scientific articles without embargo periods, and that open scientific information and data are FAIR in order to maximize their impact. Where possible, the Action Plan seeks a common approach with the federal science community to achieve the objectives. The Action Plan envisions that all newly generated scientific research outputs are "open by design and by default." The Plan identifies circumstances in which other considerations, such as research with, by and for Indigenous people, may apply.

The Action Plan is aspirational in nature and includes recommendations to increase the visibility, accessibility and accountability of NRCan's scientific research outputs, scientific research outputs that are contracted by NRCan, and external research funded by NRCan, and performance metrics.

Scope

Following the adoption of the Action Plan, NRCan will seek to define the specific responsibilities, timelines, and actions needed to deliver the Action Plan, and identify monitoring and reporting mechanisms. The implementation of the Action Plan will take into consideration the assumptions ([Appendix 1](#)) and external factors ([Appendix 2](#)) related to NRCan's operating circumstances and Open Science.

Audience

The NRCan Open Science Action Plan is intended to reach all NRCan employees, including senior managers, middle managers, scientific staff, and policymakers, and will in turn reach colleagues in other departments, external stakeholders and other collaborators as NRCan science becomes more open and

accessible to scientists beyond NRCan. NRCan science, policy, and Indigenous employees who work in policy, science and related fields, are considered the highest priority group. The Open Science Committee and working groups will continue to include representation from the science community across all NRCan sectors throughout the implementation of the Action Plan.

NRCan will work collaboratively with interdepartmental colleagues and also inform external research collaborators, funding recipients, and/or contractors about Open Science. These parties will be engaged in the department's commitment for Open Science.

Principles

NRCan's Action Plan will uphold and strive to achieve the following Open Science principles:

- **People:** Open Science is a shared commitment between all stakeholders, partners, and collaborators. A culture shift requires engagement and commitment at all levels and must include requirements and perspectives as identified by Indigenous employees. The scientific community is integral to Open Science and needs to be meaningfully engaged at every stage of the process, including the design, implementation and evaluation of its effectiveness and impact.
- **Transparency:** Scientific research outputs are "Open by Design and by Default"; they are "FAIR". Scientific research outputs requires a valid reason consistent with a framework (to be developed) on which scientific information will be kept private or confidential.
- **Inclusiveness:** In achieving Open Science, diverse and inclusive approaches are used, reflecting the breadth of perspectives across scientific communities and knowledge systems.
- **Collaboration:** Open Science enables collaborations between and among intramural and extramural science communities, within Canada and globally.
- **Sustainability:** The practice of Open Science requires a sustainable approach with concrete steps forward and the commitment necessary to achieve the long-term vision.

A Diversity of Science and Knowledge

In advancing reconciliation with Indigenous peoples, NRCan recognizes the importance of a multidisciplinary approach, including the diversity of perspectives on science and knowledge. Accordingly, NRCan will advance the recommendations and guidelines pertaining to Indigenous knowledge systems and data included within the [Data Strategy Roadmap for the Federal Public Service](#) and OCSA's [Framework for Implementing Open-by-Default with Federal Government Science](#).

While Indigenous knowledge and rights to self-determination are not explicitly covered in the Roadmap and its recommendations, the federal approach to supporting Indigenous data strategies is outlined in the Data Strategy Roadmap for the Federal Public Service, Recommendation 8: *"Recognizing that Indigenous Peoples have an inherent right to self-determination, and to co-develop with Indigenous partners, distinctions-based strategies to advance Indigenous data governance and institutional capacity, the Government of Canada should also work with Indigenous partners, who are the custodians of their data, to co-develop indicators and data collection strategies."*

The Framework for Implementing Open-by-Default recognizes that *"Federal departments and institutions are legally obliged to respect Indigenous peoples' inherent, treaty and constitutional rights to self-determination and self-government. The Crown has made commitments to adhere to free, prior and informed consent; respect Nation-to-Nation (for First Nations), Crown-Inuit and government-to-*

government (for the Métis Nation) relationships; and recognize the distinct customs of Nations in any interaction involving the public release of Indigenous data and information.” Accordingly, “federal scientists should consult with Indigenous Nations and/or governing bodies as necessary when considering the release of Indigenous data and information or scientific outputs that rely on such data and information.”

To uphold these commitments, the NRCan Open Science Action Plan will support the implementation of [the First Nations Principles of OCAP®](#), which assert that First Nations have control over data collection processes, and that they own and control how this information can be used, as they understand best their own needs. Likewise, the Action Plan will support the implementation of the [National Inuit Strategy on Research](#), which describes expectations for partnership in research premised on self-determination, respect and transparency in terms of Inuit access, ownership and control over data and information on Inuit peoples. Additionally, Métis Nation organizations have Métis-specific, culturally competent, ethical health research principles that are a starting point for engaging Métis communities in ethical research ([Principles of Ethical Métis Research](#)).

A distinction-based approach for data generated through NRCan collaboration with Indigenous communities and organizations, including the First Nations, Métis and Inuit, will be extended to all Indigenous partners as we recognize that these guidelines will evolve and our partners might have their own protocols related to research and data management. This includes considering interactions between the FAIR and [CARE \(Collective benefit, Authority to Control, Responsibility, and Ethics\)](#) Principles for Indigenous Data Governance.

Path Forward to Open Science at NRCan

The key activities needed to create a culture of Open Science at NRCan include resource commitments, NRCan governance, actions toward open access publications, information management, activities aimed towards implementation of the FAIR data principles, communication, and engagement. These will frame NRCan's activities for implementing the Open Science Action Plan. Activities in the Action Plan align with the principles of People, Transparency, Inclusiveness, Collaboration and Sustainability, as described in the Roadmap.

Resource Commitments

- Provide funding for open access publications, open data, IM/IT, and other open initiatives to support the Action Plan and NRCan's progress towards Open Science.
 - Providing enhanced access to OA publishing, and enterprise access to open digital content, and the dissemination of research through open access publishing (e.g. scientific articles, data, and results) have associated costs and financial implications. Other financial considerations also include costs related to measuring and monitoring impact, open data, Official Language accessibility, information management, governance, and consultations and support from Subject Matter Experts and Indigenous communities, organizations and governments.⁴
 - In the spirit of reconciliation with First Nations, Métis and Inuit peoples, resources are required to enhance awareness of research methodologies and protocols, as well as investments in systems required to respect those protocols (e.g. IT security infrastructure).
 - Creating open-by-design principles involve significant financial investments. For example, the provision of open data by governments at all levels requires careful planning of both direct and indirect costs. Costs related to data infrastructure may include data collection, publishing and sharing, maintenance and updates, all factors increasingly driving governments to third-party providers to help with hosting, standardization and analytical tools for data inspection. This may also incur derivative costs on enhanced security to meet government security policies and protocols.
- Understand and address the potential implications (e.g., financial, time) of Open Science initiatives on NRCan's employees, which may necessitate designating full-time equivalents (FTEs) or hiring new staff.

NRCan Governance

- Continue to mobilize the NRCan Open Science Committee and working groups to support the development and implementation of the Action Plan.
- Ensure alignment of the Action Plan with the [Data Strategy Roadmap for the Federal Public Service](#) and NRCan's Data Strategy, which will be facilitated by the Chief Scientific Data Officer.
- Advance the development of NRCan data governance by leveraging existing executive committees and the co-leadership of data under the Chief Data Officer (Policy), Chief Science Advisor (Science), and Chief Information Officer (Operations).

⁴A preliminary analysis on the underlying cost implications of Open Science can be found in the following draft report on GCDocs: [OS Financial Implications](#).

- NRCan data governance will enhance data management practices through the establishment and monitoring of data principles (FAIR being a subset of these), and set data priorities and strategic direction that emphasize data use.
- Identify appropriate indicator(s) in the Action Plan for inclusion in the Departmental Results Framework (DRF).
- Collaborate across SBDAs to advance a harmonized, federal approach to Open Science, through participation in the Interdepartmental Working Group on the Development of Open Science Action Plans.

Actions towards Open Access Publications

- Explore appropriate models to support and facilitate open access, including negotiating with journals, committing to fund open access fees, and supporting Government of Canada efforts to implement transformative agreements with publishers.
- Explore funding considerations and trends over time with respect to costs of open access publishing, including costs for language requirements.
- Explore posting accepted manuscripts on pre-print servers
- Explore tools to measure the reach and impact of science across social media (e.g. “altmetrics”).
- Explore steps to expand NRCan publications in the Open Science and Data Platform, which currently includes GEOSCAN and CFS Publications.

Information Management Activities

- Adopt the NRCan’s Information Management (IM) Strategic Action Plan and ensure its harmonisation with the Open Science Action Plan, the Data Strategy and Digital Strategy.
- Increase awareness and promote best practices in Information Management, Open Science, and Open Data (e.g. Leveraging NRCan’s ORCID / DataCite membership to ensure that every NRCan scientist and dataset have unique digital identifiers by 2025).
 - Currently, NRCan can register datasets with DOIs, via the DataCite registration service.
- Establish the following repositories and systems, which have been proposed under the Experimental and Innovation Fund (EIF):
 - [EIF NRCan Open Institutional Repository](#): An Open Institutional Repository (IR) that will align with Canada’s commitments to Open Government and Open Science, and comply with NRCan’s S&T Publications Policy and Guidelines. It will also lead to a digital preservation plan so that NRCan’s publications remain accessible and usable.
 - [Science and Technology Publications System](#): A departmental S&T publications tool that supports our researchers and allows the department to deliver on its commitments to Open Science.
 - [Scientific Data Repository](#): An architecture solution and implementation for storage and sharing of public ready scientific data. The project proposes to provide a scalable cloud solution for the publicly available data sets.

FAIR Data-related Activities

The Action Plan will work to include future conversations on FAIR data and will increase in clarity as conversations progress.

- Prioritize data acquisitions (including scientific) against departmental priorities, such that science data articulates its intended value, its relevance to the department’s mandate and priorities, and how it may influence stakeholders and Indigenous partners to leverage the data as a competitive advantage (these represent the three pillars of NRCan’s Data Strategy).
- Adopt processes and permissions to encourage full implementation of FAIR data principles (e.g. scientific promotions might consider recognizing data outputs as options for publications, in order to entice the scientific community to apply these principles to their work).
- Create standardized templates for data management plans for researchers across NRCan.
- Provide data literacy training to staff who produce or use science data to support efforts to make data FAIR (e.g. best practices in data management, data citation, analytics, protecting IP and privacy).
- Identify and develop key standards, in collaboration with standards development organizations, to facilitate storing, sharing and integrating data across NRCan and with stakeholders (e.g. open data formats like CSV, “frictionless data” standardized data packages, Open Geospatial Consortium application programming interfaces (APIs) or markup languages).
- Enable sectors to produce more complete dataset inventories, and explore options to increase their use.
- Foster greater use of APIs to share data across and external to NRCan.
- Implement a distinction-based approach for the data generated through NRCan collaboration with Indigenous communities, organizations and governments including the First Nations, the Métis and the Inuit, which include the First Nations Principles of OCAP, [Principles of Ethical Métis Research](#) and the [National Inuit Strategy on Research](#).

Communications and Engagement Activities

- Continue to engage with NRCan’s S&T community on the implications of Open Science for scientists, the necessary measures to achieve a culture of Open Science at NRCan, and the operational changes needed to enhance Open Science and Open Data in the Department.
- Continue to engage with interdepartmental working groups and communities of practice to share learned experiences and best practices related to Open Science.
- Continue to engage and consult with Indigenous partners, NRCan’s Indigenous Employees Network (IEN), and I-STEM to better understand and address their concerns and priorities on Indigenous data.
- Develop a three-year communications strategy in partnership with Chief Information Officer and Security Branch (CIOSB), Strategic Policy and Innovation Sector, Communications and Portfolio Sector (CPS), and science-based sectors to harmonize strategic messages and products.
- Conduct Science Activities Surveys, Chief Scientist Lab Tours, and internal engagement sessions with the science community, to inform, enable, and monitor the implementation of the Action Plan.
- Enable CPS to connect Open Science-related activities, including: Simply Science highlights, social media activities, issue management function in support of S&T publications, and communications support for promotion of S&T results.
- Hold training for NRCan staff in science, technical, policy and management roles, to increase awareness and understanding of Open Science and FAIR data principles, objectives and best practices.
- Celebrate and showcase NRCan Open Science and Open Data success stories and best practices.

NRCan Open Science Outcomes

NRCan has identified milestones that the Department aims to achieve in the short, medium term, and long term to build Open Science culture in the department. The long term outcomes identified align with the long term vision of the Roadmap. Achieving the outcomes, and meeting the Roadmap recommendations will be dependent on availability of funding to share publications and data openly. The desired outcomes of the Action Plan are summarized below, and the corresponding indicators are summarized in [Appendix 4](#).

[Appendix 5](#) includes potential indicators to measure success and monitor implementation of the desired outcomes, some of which may be included in the DRF. Furthermore, the indicators will ultimately include the metrics for monitoring and performance management. The outcomes and indicators in the Action Plan are adaptive in nature and their implementation may evolve as the context within which NRCan scientists operate evolves.

Immediate (1-2 years) Outcomes

1. **Increased awareness on Open Science, Open Data, and Open Access publishing.** The Roadmap Recommendation #2 mandates departments to consult with the science community to seek feedback on, and address in the action plan, the challenges and opportunities of Open Science. OCS and senior management will continue to consult on a biannual basis via survey, based on the 2020 Science Activities Survey and re-evaluate.
2. **Increased knowledge of the range of business models and costing structures currently used within the Open Access publishing industry.** Note that funding includes upfront payments and long-term transformation. This may also include conducting a cost-benefit analysis of various models and costing structures.
3. **Clear linkages and synergies made with other Open Data and Science initiatives within and outside of the department.** This may include Open Data, Open Government, and related policies/initiatives such as the Scientific Integrity Policy.

Intermediate (3-5 years) Outcomes

1. **NRCan scientists publish as open access by default.**
“Federal departments and agencies should make federal science articles openly accessible by January 2022 and federal science publications openly accessible by January 2023, while respecting privacy, security, ethical considerations and appropriate intellectual property protection.”
– Roadmap for Open Science, Recommendation #4.

This outcome will also be informed by Recommendation #6. NRCan will aim for a zero embargo period. Tracking OA publishing, publication access levels and other impact metrics will allow NRCan to demonstrate progress made on reaching open access publication goals. A clearly articulated assessment methodology will continuously guide NRCan’s implementation of open-by-default and open-by design. NRCan should continue to engage and collaborate with the Interdepartmental Metrics Working Group. NRCan may consider developing a costed business case, distinguishing the value between the use of outsourced impact evaluation services, and the creation of an in-house

impact evaluation business tool /unit. Both include costs and benefits and may depend on which reporting metrics are sought.

2. **NRCan will implement FAIR data principles, including a distinction-based approach for the data generated through NRCan collaboration with Indigenous peoples, including the First Nations, the Métis and the Inuit.**

“Federal departments and agencies should develop strategies and tools to implement FAIR data principles to ensure interoperability of scientific and research data and metadata standards by January 2023, with a phased plan for full implementation by January 2025.”

– Roadmap for Open Science, Recommendation #5.

This outcome will also be informed by Recommendation #6. The implementation of FAIR data principles will include the following sub-outcomes for each FAIR data principle:

- **Findable:** Catalogues’ content can be shared machine to machine to power other portals; Science and data are loosely coupled via unique identifiers; Discovery via web-friendly standards that web search engines can index; Data are described with rich metadata (preferably using broadly accepted open standards, vocabularies, or schemas) and should be registered or indexed in a searchable resource.
- **Accessible:** Machine to machine access is realized; Open data should be persistently available and a DOI is assigned for each dataset; Use of APIs is encouraged; Scientific methodology is separated from cultural values via multi-cultural access; Improved access for those with low bandwidth; Improved accessibility for individuals with disabilities.
- **Interoperable:** Papers and data are published as standards-based services; existing publication databases such as GEOSCAN, evolve to include a data warehouse with standards based access that is efficient for scientists; EIF-funded Scientific Data Repository is realized.
- **Reusable:** External parties can reuse science with the associated data or with their own data; Scientific assumptions and values can be modified by external parties (e.g. An Indigenous community may want longer term values embedded into the analysis or over a specific area).
- **Distinctions-based approach:** First Nations Principles of OCAP as well as a distinction-based approach for the data generated through NRCan collaboration with Indigenous peoples, including the First Nations, the Métis and the Inuit are implemented.

Ultimate (5+ years) Outcomes

1. **Culture of Open Science at NRCan.** Fully embracing Open Science at NRCan requires a culture shift towards Open Science to ensure a common understanding and full adoption by NRCan scientists, policymakers, and senior management. Furthermore, the departments’ external stakeholders and collaborators will need to be informed, consulted and engaged in order to advance NRCan’s Open Science commitments.
2. **Strong data management practices.** Implementation of FAIR data principles at NRCan should contribute to strong data management practices in the long term. Strong data management practices will be informed by and adhere to standards laid out in the FAIR data principles.
3. **Achieving the 8 benefits described in the Roadmap.** As laid out in the Roadmap, the eight identified benefits include: ensuring accountability, increasing reproducibility, creating open engagement, reducing duplication, creating opportunities for impact, leveraging diversity and inclusion,

accelerating knowledge transfer, and building synergies with international and domestic Open Science movements.

Conclusion

The NRCan Open Science Action Plan reaffirms the Department’s commitment to maximize the release of information and data to support transparency, accountability, citizen engagement, and measure the socio-economic benefits of Open Science. In implementing the Action Plan, NRCan will build on existing policies and initiatives to develop a culture that embraces Open Science.

NRCan’s Open Science Committee will oversee the implementation of the Action Plan, including defining the specific responsibilities, timelines, and actions needed to deliver the Action Plan, and identifying monitoring and reporting mechanisms.

Implementation of the Action Plan will be supported by guidance documents and recommended tools (e.g. decision trees, workflows, criteria checklist) on Open Science best practices.

Accordingly, NRCan will seek to leverage horizontal inter-departmental solutions, adapt and adopt them to meet NRCan’s operating circumstance. For example, in accordance with Recommendation 6 of the Roadmap, OCSA has developed a framework for identifying criteria when restricting access to federal scientific research outputs is warranted ([Framework for Implementing Open-by-Default with Federal Government Science](#), January 2021).

The Action Plan’s implementation will respect Indigenous peoples’ inherent, treaty and constitutional rights to self-determination and self-government, including data management and Open Science. Moreover, it will support ongoing and future collaboration as we develop new ways to conduct inclusive research and generate innovation through meaningful partnerships and Indigenous-led initiatives.

Furthermore, the implementation of the Action Plan will include continuing the dialogue around Open Science with NRCan employees, including the scientific community. Key areas for further consideration and development through the implementation phase include:

- Opportunities to integrate Open Science objectives/outcomes with departmental reporting;
- Building a culture that rewards openness; and,
- Balancing Open Science objectives with the associated financial implications.

Ultimately, open and accessible science improves the quality and integrity of NRCan science to the benefit of all Canadians. By fully implementing the principles of “Open by Design and by Default” and “FAIR,” NRCan will increase public engagement and trust, broaden participation in research, create new opportunities for innovation and prosperity, and leverage and advance the diversity of knowledge systems and perspectives. This will ultimately contribute to NRCan achieving its mandate and maximize the benefits of our science for Canada.

“Solutions to the great challenges we face require more knowledge, more science and more applications of technology. Opening up federal science will help pave a quicker path to discovery and at the same time ensure that the results of research paid for by Canadians is fully available to them”

– Dr. Mona Nemer, Chief Science Advisor of Canada

Appendix 1: Open Science Action Plan Assumptions

NRCan will operate under the following assumptions to implement the Open Science Action Plan:

Collaborations at the Federal level

NRCan is collaborating with other SBDA on central approaches to common elements. The Chief Science Advisor has laid out in the Roadmap that they will facilitate, as necessary, exploring opportunities to develop shared tools and infrastructure to make articles open. NRCan will also collaborate with the federal science community in developing a common approach towards the development of strategies and tools to implement FAIR data principles, as co-led by the Treasury Board Secretariat (Chief Information Officer) and the Office of Chief Science Advisor.

Support for Open Science

The NRCan Action Plan assumes that there will be both sectoral support and support from senior management in implementing Open Science at NRCan.

Consultation Efforts

NRCan's consultation and engagement efforts will inform and feed into the Action Plan, and will include consultation with Indigenous partners when seeking Indigenous perspectives. NRCan has consulted internally with the department's scientific community via a Labs Tour and Science Activity Survey in spring and summer 2020, as well as discussed the draft Action Plan with senior management committees and held an Open Science Engagement Session with staff. NRCan will continue to engage within the department throughout the implementation of the Action Plan.

Accessibility Considerations

Where possible, NRCan's Open Science Action Plan will incorporate accessibility considerations. Recognizing that Canadians vary in accessibility needs as well as accessibility to Internet and other electronic forms of information.

Shift to Open Science Culture

The Action Plan recognizes the need for a shift in NRCan science culture to an "Open Science Culture." It is recognized that this cultural shift requires additional time and may require effort to embrace Open Science culture by the broader (i.e. non-federal) science community. It may also require organizing training for scientists to work in an Open Science context, including data generated through NRCan collaboration with Indigenous communities, as well as clear guidance and proper training on decision making for knowledge dissemination, and effective processes to follow through on these decisions.

The shift to an Open Science culture also requires responsible use of data. Users of Open Data must be responsible in how they use data to ensure appropriate use. Responsible use of data and science falls under the NRCan Scientific Integrity Policy, which applies to all NRCan employees.

Support for Partnership with Indigenous Peoples

The cultural shift to Open Science needs to contribute to reconciliation with Indigenous peoples by recognizing their rights in areas such as data sovereignty and ethics in science and research. For example, scientists working with First Nations may be required to take appropriate cultural literacy training and training in OCAP principles.

Appendix 2: Open Science Action Plan External factors

It is important to note that NRCan's ability to fully implement the Open Science Action Plan may be influenced by the following factors, which are external to the department:

Intellectual Property

NRCan's Open Science Action Plan will aim for Open Science while also respecting privacy, security, ethical, and cultural considerations and appropriate intellectual property protection as is appropriate for the scientific information therein.

COVID-19

The COVID-19 pandemic has inherently caused shifting priorities. However, it has also highlighted the need for Open Science in a virtual world to allow for quick and efficient use, analysis, and application of scientific information.

Scientific Funding

When a research project and resulting publication have received support from multiple funders, the federal government will uphold the most open of the Open Access policies, if possible. In alignment with the global Open Science movement, NRCan will continue to strive to increase its Open Science and may include Open Science considerations in funding provision.

Guidance from OCSA

As the Roadmap for Open Science is driven by the OCSA, any subsequent guidance or information resulting from this body will affect the implementation of the NRCan Open Science Action Plan.

Typical Constraints

Implementation of the NRCan Open Science Action Plan will be affected by budgetary schedules, resources and opportunities.

Official Languages

Recognizing federal official languages requirements, NRCan's Open Science Action Plan aims to make NRCan publications and data open while ensuring official languages requirements are upheld. NRCan will strive to balance these requirements to ensure we meet federal official language requirements while building towards Open Science.

Appendix 3: State of Open Science at NRCan

NRCan Policies Supporting Open Science

Open science in NRCan is supported by several policies, which include:

The NRCan Intellectual Property Policy (2017), in striving to maximize the impact of its IP for Canada, NRCan recognizes that its IP must be properly identified and managed from conception through deployment, by creators through to senior management, using harmonized approaches across the Department that respect the uniqueness of each opportunity. Intellectual Property (IP) is a valuable asset created or funded by NRCan in the course of fulfilling its mandate. NRCan is committed to the concepts of open data and open innovation, while recognizing that under certain circumstances protection and commercialization strategies may promote broader uptake of innovative products. NRCan's Intellectual Property Portfolio is available for viewing on the department's website, raising awareness of NRCan's IP assets and enabling deployment of federally created innovations. NRCan is also an active contributor to Explore IP: Canada's IP Marketplace for publicly owned IP.

The Scientific Integrity Policy (2018) is intended to foster a culture that promotes integrity in NRCan science activities, for example in the way they are planned, reviewed and communicated. It enhances public trust in NRCan's science results and how they are used. It also aims increase employees' understanding of the contributions that NRCan scientists make to evidence-informed decisions, and that of others in management, policy and communications roles in the development of government policy and advice.

The NRCan Scientific and Technical Publications Policy (2019) is intended to support excellence, quality and impact of NRCan scientific and technical publications and support Canada's commitments to open government and Open Science. It also defines the roles and responsibilities of all parties at NRCan involved in scientific and technical publications.

NRCan has also been active in advancing Open Science through developing several platforms to share data with the broader science community, including:

- [National Forest Inventory](#) monitors a network of twenty thousand sampling points across Canada on an ongoing basis to provide information on the state of Canada's forests and a continuous record of forest change. We provide data and products to forest science researchers, forest policy decision-makers and interested stakeholders.
- [Canadian Wildland Fire Information System](#) creates daily fire weather and fire behavior maps year-round and hot spot maps throughout the forest fire season, generally between May and September.

The Federal Geospatial Platform is a cross-departmental initiative of 21 different departments and agencies working together to supply the government's most relevant geospatial information to support decision-making, foster innovation, and provide better service for Canadians. It is also fundamentally changing the way government shares, uses and manages its geospatial information. FGP's primary objective with the Open Government Portal (OGP) is to provide a single, comprehensive publishing path for all federal governments geospatial data eligible for release as open data to the open government catalogue found on the OGP. NRCan is the lead department for the FGP. NRCan's Deputy Minister is the project sponsor; the FGP Management Board and Board of Directors are both co-chaired by NRCan executive. NRCan provides the majority of FTEs working on the project team.

The Open and Science Data Platform provides access to environmental data and scientific publications that can be used to understand cumulative effects and the impacts of development activities in Canada. The goal of the platform is to help Canadians learn about cumulative effects in their communities. The information comes from many federal and provincial science and data contributors. The information available will evolve as we continue to connect with additional data holders to ensure we are providing access to the best available information relevant to cumulative effects and development activities in Canada.

The Earth Observation Data Management System provides access to Earth observation data for all of Canada. This consists of satellite imagery from multiple sources (e.g., RADARSAT-2, RADARSAT Constellation Mission), as well as millions of aerial photographs from the National Air Photo Library. EODMS employs a mixed model, with some data provided openly and free of charge while access to other data requires purchase. NRCan leads the EODMS initiative, providing a critical service to the many federal government departments and individual Canadians who access its data on a daily basis.

The Arctic Spatial Data Infrastructure is a collaborative initiative amongst the 8 Arctic nations (i.e., Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States of America) to make authoritative, pan-Arctic geospatial information available to everyone. Arctic SDI's diverse data, ranging from environmental to social/economic information, represents a key resource for understanding the Arctic, particularly in the context of climate change. NRCan leads Canada's participation in Arctic SDI.

The National Forest Information System provides key information about Canada's forests to scientists and the public. A collaborative activity between Canada's provinces, territories, and the federal government, NFIS plays a key role in demonstrating sustainable forest management practices in Canada. NRCan leads development of NFIS.

The Federal Science Libraries Network self-serve portal makes government research and resources available to researchers everywhere by connecting them with the collections of the seven libraries. The portal's citation index and search features allow researchers to view or request items from a vast collection of scientific publications. Wherever possible, departmental publications, reports, data sets and other content are freely available for anyone to access or download.

The Groundwater Information Network works to improve knowledge of groundwater systems, and enhance groundwater management, across Canada. GIN provides diverse authoritative groundwater information (e.g., water monitoring data, aquifer and geology maps, etc.) through collaborations with the provinces and territories. GIN also enables understanding of cross-border groundwater characteristics through a collaboration with the United States Geological Survey. NRCan leads the federal government's participation in GIN.

GEOSCAN is a bibliographic metadata database for NRCan scientific publications. It is used by groups across the department to list their internally or externally published research papers intended for specialized audiences in the scientific community. GEOSCAN indexes content related to a specific set of NRCan's S&T publishing in order to meet policy requirements. This includes Geological Survey of Canada publications, National Atlas maps, topographic maps, remote sensing and geodesy publications, and is continually growing with records on mining, materials and energy. GEOSCAN also contains records on external publications authored by NRCan scientists and specialists

In addition to establishing the above policies and platforms, NRCan actively participates in international efforts to advance Open Science. NRCan works closely with international standards bodies developing best scientific practices in an open manner (e.g. NRCan's involvement in ISO committees and its Strategic membership in the Open Geospatial Consortium) and with multilateral agencies and organizations (e.g., UN, Arctic Council).

NRCan's Action Plan builds upon results achieved by the above policies, platforms and collaborations and responds to the unique challenges and opportunities related to Open Science, as identified by consultation efforts. The Action Plan takes into account NRCan's current level of scientific openness – e.g. the existing science publisher business models/negotiations and the proportion of openly accessible articles, publications and data. Likewise, the Action Plan will address limitations to further adoption of Open Science at NRCan, including cost, culture, policies, tools, resources, and reasons to not be fully open (e.g., public misinterpretation of results, preventing the release of data that has not been vetted for accuracy, and data licensing restrictions). As one example, many satellite imagery datasets managed by NRCan on behalf of the Government of Canada cannot be made available openly due to security restrictions or commercial licensing levels (e.g., purchased image only available for use by Government of Canada departments).

Open Access at NRCan

NRCan continues to increase the findability, accessibility and open access of the department's publications (See Figure 1 below). However, there is no uniform process, pattern or business model used for Open Access (OA) publishing activities across the department. Some of NRCan publications are made available under Canada's Open Government Licence, which is designed to provide public bodies with a consistent means of licensing their information and enable free re-use.

An OA document search in June 2021 in the Scopus database revealed that in 2020, 33% of journal articles authored or co-authored by NRCan scientists were published as Gold or Hybrid open access – an

increase from 2017, when only 21% were published in OA Gold or Hybrid⁵. A further examination into two types of gold OA publications reveals a slow but steady increase of hybrid OA publications over the past four years. This confirms that the Article Processing Charge (APC) model, or a variation of it, is likely to remain an efficient and viable publisher pathway for OA science for the foreseeable future.

Efforts will be enhanced to get to 100% open access. In the same time period, NRCan's Green OA reflects a consistent trend (**Error! Reference source not found.**). There are multiple factors to consider for Green OA including: NRCan does not yet have an Open Institutional Repository, science publishers have different embargo periods, and an increase in Gold OA can impact Green OA numbers.

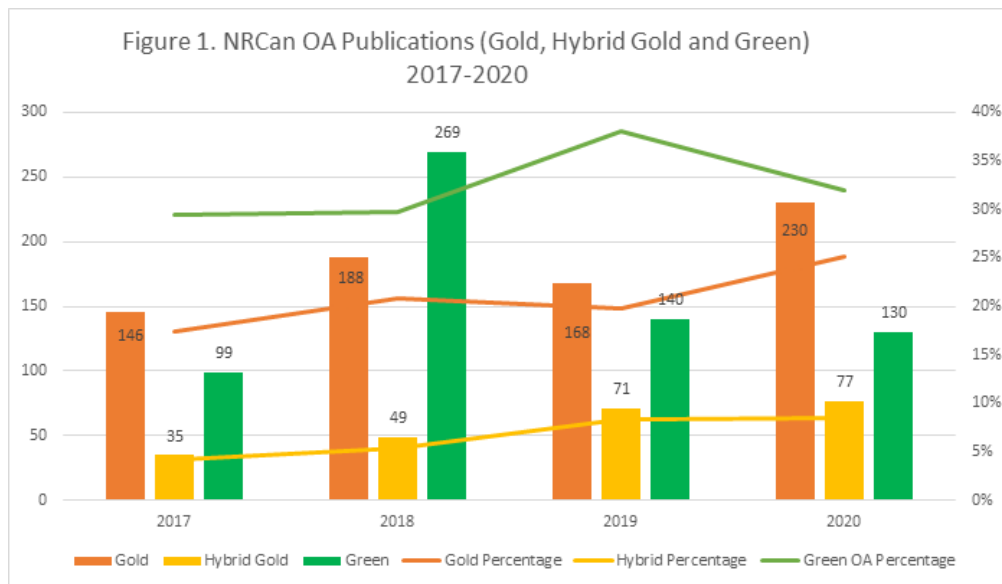


Figure 1. Comparison of "Gold" and "Green" NRCan open access articles from 2017-2020.

Similarly, data is more and more open by default: datasets are assigned DOIs to increase their findability and the department publishes an annual list of datasets to help users find the data they are looking for. Thousands (~4500) of spatial datasets are accessible via the Federal Geospatial Platform (FGP) and tens of thousands of datasets are accessible on the Government's open data portal and [Government of Canada's Open Data Inventory](#).

NRCan also makes a substantial amount of data, from maps, to images, to statistics, available on its website via various portals and applications (e.g. <https://www.nrcan.gc.ca/science-and-data/21444>) and works with provinces and territories to compile and publish national datasets, such as wildfire-related data via the Canadian Wildland Fire Information System. Increasingly, metadata use internationally

⁵ Gold: Documents are in journals which only publish open access. Hybrid: Documents are in journals which provide authors the choice of publishing open access Source: Scopus filters for Open Access type and 5.5 million more OA articles. URL: <https://blog.scopus.com/posts/scopus-filters-for-open-access-type-and-55-million-more-oa-articles-17-million-in-total>. Accessed March 8, 2021.

agreed standards and data are shared in non-proprietary formats to aid in interoperability and machine readability. Similar to publications, the Open Government Licence – Canada is applied to many datasets, enabling greater re-use.

Appendix 4: Open Science Action Plan Logic Model

Table 1. Natural Resources Canada Open Science Action Plan high-level logic model.

ULTIMATE OUTCOMES What are ultimate changes we're aiming to enable?	<ul style="list-style-type: none"> • Culture of Open Science at NRCan. • Strong data management practices. • Achieving the 8 benefits described in the Roadmap for Open Science. 		
INTERMEDIATE OUTCOMES What will occur over time, as a result of our activities and outputs?	<ul style="list-style-type: none"> • Federal science articles openly accessible by January 2022. • Federal science publications openly accessible by January 2023. • Full implementation of FAIR data principles by January 2025. 		
IMMEDIATE OUTCOMES What will occur as a direct result of our activities?	Increased awareness on Open Science, Open Data, and Open Access publishing.	Clear linkages and synergies made with other Open Science/data initiatives within and outside of the department.	Role of Federal Science Libraries Network in negotiating transformative agreements is shared and understood.
ACTIVITIES What activities will we undertake to achieve the objectives of the Action Plan?	Cross-cutting Activities		
	Resource Commitments <ul style="list-style-type: none"> • Funding for Open Science activities • Human resources considerations 		
	NRCan Governance <ul style="list-style-type: none"> • Internal committees and working groups • Designation of Chief Scientist as Chief Scientific Data Officer • Alignment with the Departmental Results Framework • Establishing an Open Science metrics plan • Building a data governance model • Working collaboratively across SBDAs 		
	Outcome Specific Activities		
	Communications and Engagement Activities <ul style="list-style-type: none"> • Working groups / Communities of practice • Communication strategy • Intradepartmental consultation • Interdepartmental consultation • Follow-up surveys • Showcasing Science-related activities 	FAIR Data-related Activities <ul style="list-style-type: none"> • Develop FAIR-based processes and standards for digital infrastructure and integrate data across NRCan and with stakeholders • Prioritize data acquisitions • Data literacy training • Greater use of APIs, "frictionless-data", and more complete datasets inventories 	Actions towards Open Access Publications <ul style="list-style-type: none"> • Explore models for supporting and facilitating open access • Explore funding considerations of open access publishing • Develop costed business cases to acquire tools and other resources to measure reach and impact of science • Expand NRCan publications in the Open Science and Data Platform

Appendix 5: Proposed Open Science Indicators

The table presents a list of potential indicators that NRCan will strive to measure as the Action Plan is implemented.

Outcome	Indicators
Increased awareness on Open Science, Open Data, and Open Access publishing	<ul style="list-style-type: none"> • Percentage of employees from the scientific community who identify as: being aware of Open Science activities; taken part in Open Science Training; and/or have practiced Open Science as identified from subsequent Science Activities Surveys. • Survey employees to gauge level of Open Science culture and practices at NRCan as well as proportion of NRCan staff who have taken part in Open Science training and/or practices. • Number of communications, press calls, and other public engagement undertaken by NRCan scientists. (Public engagement)* • Number of scientific products related to natural sciences accessed by Canadians (Departmental Results Framework) • Number of times stakeholders acknowledge using NRCan’s S&T products in making their decisions. (Departmental Results Framework)
Increased knowledge of the range of business models and costing structures currently used within the Open Access publishing industry.	<ul style="list-style-type: none"> • Increase in savings and collaborative / transformative agreements (including Article Processing Charges reductions; discounts; immediate gold access; transforming embargo periods)
Clear linkages and synergies made with other Open Data and Science initiatives within and outside of the department.	<ul style="list-style-type: none"> • Level and frequency of engagement with other Open Data and Science initiatives, for example: <ul style="list-style-type: none"> ○ The Open Science Interdepartmental Working Group ○ Scientific Integrity Interdepartmental Working Group • Development of Ethics guidelines for Indigenous research
NRCan scientists publish as open access.	<ul style="list-style-type: none"> • Percentage of publications, datasets, and other science products (e.g. maps) that are open access, including SBDA-funded products (e.g. extramural partners)*; • Percentage of releasable/eligible SBDA datasets identified in the open data inventory. To be considered “released,” the dataset must be associated with an URL.* • Number of datasets per SBDA listed in the Open Government Analytics • Number of publications cited by patents to measure patent uptake of federal peer-reviewed publications*

	<ul style="list-style-type: none"> • Altmetrics (i.e. uptake, mentions, use, etc.) may be used to measure success of social reach of NRCan science*; • Number of publisher agreements and number of publications under those agreements.
<p>Full implementation of FAIR data principles</p>	<p>Findable indicators:</p> <ul style="list-style-type: none"> • Number of newly implemented open standards at the catalogue level • Percentage of data** that can be harvested via machine to machine interfaces. • Percentage of data and metadata which meet the standards of the relevant scientific domain • Percentage of data released with a clear and accessible data usage license and detailed provenance <p>Accessible indicators:</p> <ul style="list-style-type: none"> • Statistics on what science is accessed vis-à-vis associated data access • Number of external portals that harvest our scientific content via standardized machine readable services • Number of standards adopted that support low bandwidth environments • Level of conformance with Accessible Canada Act. <p>Interoperable indicators:</p> <ul style="list-style-type: none"> • Number of external portals that can harvest supporting data via standardized machine readable services and apply that against the scientific methodology • Amount of NRCan funds and implements supporting infrastructure <p>Reusable indicators:</p> <ul style="list-style-type: none"> • How global communities re-use science and data based on their own geographies and values • Proportion of publications, eligible datasets, and other science products that have all FAIR components

*Indicator is currently tracked in *Annual Report on the Federal Progress in Implementing Open Science and its Benefits*.

**Data will be tracked and accessed with careful consideration in scope. (E.g. possible exclusion of data from research completed with Indigenous partners)

Appendix 6: Open Science Glossary

Altmetrics: Altmetrics are alternative ways of recording and measuring the use and impact of scholarship. Rather than solely counting the number of times a work is cited in scholarly literature, alternative metrics also measure and analyze social media (e.g., Facebook, Twitter, blogs, wikis, etc.), document downloads, links to publishing and unpublished research, and other uses of research literature, in order to provide a more comprehensive measurement of reach and impact.

Source: Open Science Training Handbook: <https://open-science-training-handbook.gitbook.io/book/glossary>

Application Programming Interface (API): An API is a set of functions that allows applications to access data and interact with external software components, operating systems, or micro services.

Source: Big Commerce: <https://www.bigcommerce.com/blog/what-is-an-api/#what-is-an-api>.

Author Processing Charge (APC): All articles published in our journals are open access and freely available online, immediately upon publication. This is made possible by an article-processing charge (APC) that covers the range of publishing services we provide. This includes provision of online tools for editors and authors, article production and hosting, liaison with abstracting and indexing services, and customer services.

Source: SpringerOpen: <https://www.springeropen.com/get-published/article-processing-charges>

Creative Commons (CC) Licenses: Creative Commons Licenses give everyone from individual creators to large institutions a standardized way to grant the public permission to use their creative work under copyright law. There are six different license types and the Creative Commons Public Domain Dedication. They provide creators with a range of options to distribute the material, allowing copyright holders to grant some rights to users by default.

Source: Creative Commons: <https://creativecommons.org/about/cclicenses/>

Data Mining: Data mining is an analytic process designed to explore data in search of consistent patterns or systematic relationships between variables, transforming data into information for future use.

Source: Open Science Training Handbook: <https://open-science-training-handbook.gitbook.io/book/glossary>

Digital Object Identifier (DOI): A unique alphanumeric string assigned by a registration agency (the International DOI Foundation) to identify content and provide a persistent link to its location on the Internet.

Source: American Psychological Association. 2018. Open Science by Design: Realizing a Vision for 21st Century Research. <https://www.ncbi.nlm.nih.gov/books/NBK525407/#>

Directory of Open Access Journals (DOAJ): Directory of Open Access Journals is a community-curated online directory that indexes and provides access to open access and peer-reviewed journals.

Source: DOAJ: <https://doaj.org/>

FAIR Data: FAIR Data (according to FORCE11 principles and published in Nature Scientific Data) are Findable, Accessible, Interoperable, and Re-usable, in order to facilitate knowledge discovery by assisting humans and machines in their discovery of, access to, integration and analysis of, task-appropriate scientific data and their associated algorithms and workflows.

Source:

FORCE11 Principles: <https://www.force11.org/group/fairgroup/fairprinciples>

Nature Scientific Data: <https://www.nature.com/articles/sdata201618>

Federal science articles: Scholarly articles authored or co-authored by federal scientist(s) or researcher(s) in peer-reviewed academic journals.

Source: Roadmap for Open Science: https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97992.html#8

Federal science publications: Scientific communications that scientists and researchers use to share their work. These include research or scientific reports, monographs, edited books, book chapters, conference proceedings, conference papers, conference contributions, posters, plain language summaries and technical scientific products. These publications have been validated by a peer-review process.

Source: Roadmap for Open Science: https://www.ic.gc.ca/eic/site/063.nsf/eng/h_97992.html#8

Frictionless Data: Frictionless data is about removing the friction in working with data through the creation of tools, standards, and best practices for publishing data using the Data Package standard, a containerization format for any kind of data. It offers specifications and software around data publication, transport and consumption.

Source: <https://data-blog.gbif.org/post/frictionless-data-and-darwin-core/>

Impact Factor: A numerical measure that indicates the average number of citations to articles published over the previous two years in a journal. It is frequently used as a proxy for a journal's relative importance. Its transfer to the impact of individual articles published in a journal is considered to be problematic.

Source: Open Science Training Handbook: <https://open-science-training-handbook.gitbook.io/book/glossary>

Metadata: Metadata is data providing information about data that makes findable, trackable and (re)usable. It can include information such as contact information, geographic locations, details about units of measure, abbreviations or codes used in the dataset, instrument and protocol information, survey tool details, provenance and version information and much more.

Source: Open AIRE: [https://www.openaire.eu/what-is-metadata#:~:text=Metadata%20is%20data%20providing%20information,trackable%20and%20\(re\)usable](https://www.openaire.eu/what-is-metadata#:~:text=Metadata%20is%20data%20providing%20information,trackable%20and%20(re)usable).

Open Access (OA): “Open access (OA) means free access to information and unrestricted use of electronic resources for everyone. Any kind of digital content can be OA, from texts and data to software, audio, video, and multi-media.”

Source: UNESCO: [What is Open Access?](#)

OA Colour Scheme Terminology:

Gold OA

- Published in an OA journal.
- May require an article processing charge (APC).

Hybrid OA

- OA copy in a subscription journal after paying Article Processing Charges (APC).

Green OA

- Fee for the subscription journal article, but an OA copy is available in a repository.
- May be a pre-print.
- Embargo period may apply.

Bronze OA

- Articles are free to read on the publisher page.
- Free access could be removed at any time.
- No indication on how users may reuse these articles (i.e. downloading, distribution).

Diamond/Platinum OA

- Journals which publish OA without charging APCs.
- Funding provided by external sources (e.g. academic institutions, government grants).

Source: Gill, D. 2019. [Shades of OA: Open Access colour classifications](#)

Open Access Repository: An open access repository is defined as a collection of full-text documents available in online databases on the Internet that can be accessed freely and instantly.

Source: Xie, I. and Matusiak, KK. 2016. Introduction to digital libraries. Discover Digital Libraries: Theory and Practice. <https://www.sciencedirect.com/science/article/pii/B9780124171121000016>

Open Data “Open data is data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike.”

Source: What is Open Data? Open Data Handbook: <https://opendatahandbook.org/guide/en/what-is-open-data/>

Open Government: “Open Government is about making government more accessible to everyone. This means giving greater access to government data and information to the Canadian public and the businesses community.”

Source: Government of Canada: [About Open Government](#)

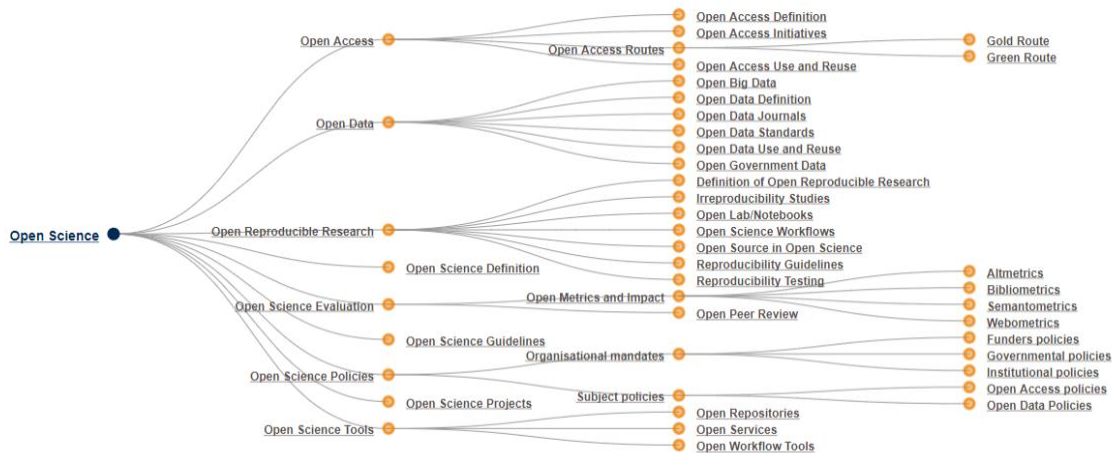
Open Peer Review: An umbrella term for a number of overlapping ways that peer review models can be adapted in line with the aims of Open Science, including making reviewer and author identities open, publishing review reports and enabling greater participation in the peer review process.

Source: Open Science Training Handbook: <https://open-science-training-handbook.gitbook.io/book/glossary>

Open Research Data: The European Commission’s definition is: “information, in particular facts or numbers, collected to be examined and considered and as a basis for reasoning, discussion, or calculation.”

Source: Guidelines to the Rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020. 2017. Version 3.2. http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf.

Open Science (OS): “..the practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods.”



Source: FOSTER: <https://www.fosteropenscience.eu/foster-taxonomy/open-science-definition>

Open Science is commonly held to encompass: Open Source Software, Open Data, Open Access, and Open Notebooks.

Open Source Software: “Open source software is software with source code that anyone can inspect, modify, and enhance.”

Source: What is open source? <https://opensource.com/resources/what-open-source>

ORCID: ORCID stands for Open Researcher and Contributor ID. The ORCID is a unique, persistent identifier free of charge to researchers. It enables transparent and trustworthy connections between researchers, their contributions, and their affiliations. It is used as they engage in research, scholarship, and innovation activities.

Source: ORCID. <https://info.orcid.org/what-is-orcid/>

Predatory Journals & Publishers: “Predatory journals and publishers are entities that prioritize self-interest at the expense of scholarship and are characterized by false or misleading information, deviation from best editorial and publication practices, a lack of transparency, and/or the use of aggressive and indiscriminate solicitation practices.”

Source: Grudniewicz, A et al. 2019. [Predatory journals: no definition, no defence](#). Nature Comment.

Preprints & Postprints: “A complete study report shared with a public audience without peer review. Often, preprints are also submitted for peer review and publication in a traditional scholarly journal.

Source: Center for Open Science (2017). Preprint FAQs, Open Science Framework website. <http://help.osf.io/m/preprints/l/726873-preprint-faqs>

“The SHERPA/RoMEO database makes the following distinction: preprints are all the versions of an academic article or other publication before it has been submitted for peer review, while the postprint is the form of the article after all the peer review changes are in place.”

Source: PUBLISSO. 2017. What are the differences between preprint and postprint versions? <https://www.publisso.de/en/advice/publishing-advice-faqs/preprint-and-postprint/>

Reproducibility: Methods reproducibility is the degree to which the methods described in a study report can be performed again. This may be limited by vague description in the study report, or lack of openness in the data. Results reproducibility is the degree to which the same results are produced, in a new study with the same method. Inferential reproducibility is the degree to which the same inferences are drawn, either in a new study with the same method and results, or in a re-analysis of the original study.

Source: Goodman, S. N., Fanelli, D., & Ioannidis, J. P. (2016). What does research reproducibility mean? *Science Translational Medicine*, 8(341), 1-6. DOI: [10.1126/scitranslmed.aaf5027](https://doi.org/10.1126/scitranslmed.aaf5027)

Research Impact: Involve academic, economic and societal aspects, or some combination of all three. Impact is the demonstrable contribution that research makes in shifting understanding and advancing scientific, method, theory and application across and within disciplines, and the broader role that this plays outside of the research system.

Source: Open Science Training Handbook. <https://open-science-training-handbook.gitbook.io/book/glossary>

Scholarly Communication: Scholarly communication can be thought of as the system through which research and scholarship is created, evaluated, distributed, and preserved. This system includes traditional or formal publications, such as scholarly journal articles, scholarly chapters or monographs (single-volume books offering research into a specialized area of knowledge), and conference proceedings. It also includes continually emerging publications, such as data sets, data visualizations, working papers, and blogs.

Source: Association of College & Research Libraries, Principles and Strategies for the Reform of Scholarly Communication. <http://www.ala.org/acrl/publications/whitepapers/principlesstrategies>



Canada