

Applying the ‘CARE Principles for Indigenous Data Governance’ to ecology and biodiversity research

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Indigenous Peoples are increasingly being sought out for research partnerships that incorporate Indigenous Knowledges into ecology research. In such research partnerships, it is essential that Indigenous data are cared for ethically and responsibly. Here we outline how the ‘CARE Principles for Indigenous Data Governance’ can sow community ethics into disciplines that are inundated with extractive helicopter research practices, and we provide standardized practices for evolving data and research landscapes.

Since time immemorial and across [intergenerational time scales](#), Indigenous Peoples have been land stewards. Today, Indigenous Peoples govern about 40% of the most biodiverse terrestrial lands globally¹. Indigenous rights and title to land – paired with place-based knowledges – make Indigenous governance critical to the stewardship of global biodiversity and ecosystem services².

Indigenous Peoples have tracked climate change, changes in species composition and ecosystems for millennia, and are increasingly being sought out for research partnerships that incorporate Indigenous Knowledges (such as Traditional Ecological Knowledge, Traditional Knowledges and Indigenous Ecological Knowledges)³. However, settler colonial research and data collection methods often extract, distort and apply Indigenous Knowledges inappropriately, without meaningful recognition of Indigenous rights and responsibilities in relation to Indigenous data⁴. This can result in poor-quality data, restricted access to data and the inability to make evidence-supported decisions.

This Comment advocates for applying Indigenous stewardship methods over traditional and contemporary knowledges. The concepts described in this Comment inform practitioners of ecological disciplines about the data rights of Indigenous Peoples in digital environments. These recommendations support inherent sovereignty and reaffirm the United Nations Declaration on the Rights of Indigenous Peoples⁵.

Increase in demand for Indigenous Knowledges

Although engagement with data from Indigenous Knowledges has increased, most scientific training neglects the data rights, data

relationships and ethics protocols that Indigenous communities have regarding their knowledge systems. Researchers will benefit from recognizing that Indigenous Data Sovereignty can be exercised only by Indigenous Peoples as rights holders through the retention and control of their data⁶. Indigenous Data Sovereignty expands Indigenous jurisdiction to non-geographically bound relational contexts, including digital environments. Indigenous Data Sovereignty can be implemented through Indigenous Data Governance, which harnesses the values, applications, traditions and roles that communities have for the care and use of their knowledges⁶. Here we offer guidance for researchers, academic institutions, industry and data repositories on how Indigenous Data Sovereignty can be supported by embedding Indigenous Data Governance into mainstream data infrastructures, policies and practices within the fields of biodiversity and ecology.

Concerns in the era of open science. With increasing calls for open science, the FAIR (findable, accessible, interoperable and reusable) Principles aim to increase data usability and accessibility⁷. Applications of FAIR Principles have the potential to neglect the rights of Indigenous Peoples and their protocols for cultural, spiritual and ecological information⁸. Extractive data collection methods⁹ and open data practices¹⁰ can create tensions regarding sensitive Indigenous Knowledges¹¹.

Legal rights to reproduce or publish information raise questions about who the principal stewards and beneficiaries of Indigenous Knowledges are within databases, especially as large regional and global datasets merge multiple data sources – often losing the local intentionality of the data¹⁰. As Indigenous Peoples continually seek methods to protect and control their knowledges (including data that are stewarded by nontribal entities such as governments, nonprofit organizations, universities and researchers), the question emerges of how scientists can embed the rights, interests, expectations and responsibilities of Indigenous Peoples into the creation of information infrastructures to enhance Indigenous governance of Indigenous data.

CARE principles

To address open science concerns and limited opportunities for Indigenous control, scholars developed the ‘CARE [collective benefit, authority to control, responsibility and ethics] Principles for Indigenous Data Governance’⁹. The CARE principles (Fig. 1) guide data actors to include Indigenous Peoples in data governance to increase their access to, use of and benefit from data¹⁰.

The CARE principles shift the focus of data governance from consultative to values-based relationships and have enriched the discussion of collective rights that Indigenous Peoples assert in data¹².

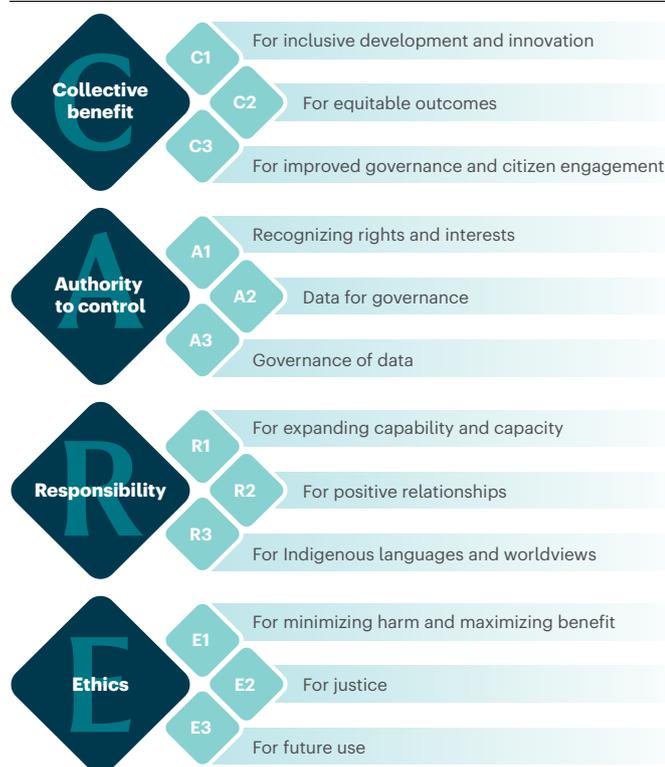


Fig. 1 | The CARE Principles of Indigenous Data Governance. The CARE Principles of Indigenous Data Governance were created to advance the legal principles underlying collective and individual rights by considering power differentials and historical contexts of data in advancing Indigenous innovation self-determination. Image adapted from ref. 9, © Carroll, S. R. et al. CC-BY 4.0.

Indigenous Data Governance applies beyond Indigenous Knowledges to include scientific data pertaining to Indigenous Peoples and their ecosystems⁶. The CARE Principles complement, enhance and extend the FAIR Principles by advancing Indigenous self-determination and Indigenous standards to be used alongside mainstream data guidelines¹⁰.

Currently, the majority of Indigenous data – ranging from ethnographic and biological materials to Earth observations – neglect FAIR and CARE Principles. Data often lack critical metadata that record Indigenous provenance; protocols for use, reuse and sharing; and permissions¹⁰. Most data are mislabelled and lack appropriate identification of Indigenous rights holders¹³. These missing metadata render the data largely unsearchable¹⁴.

The CARE Principles have been operationalized in the ecology data repositories¹⁵, are appearing in grantor calls (for example, by the US Geological Society and National Science Foundation) and are recognized as a future priority in forestry practices¹⁶. However, effective Indigenous Data Governance requires Indigenous Knowledge standards for data, research relationships and data practices in ecology. This requires changes in policies, ethics and infrastructure to support Indigenous rights throughout the data lifecycle and across the data ecosystem¹⁴.

The following discussion offers guidance in relation to Indigenous data, but we acknowledge that there is no ‘one size fits all’ approach.

Table 1 and the following examples (Box 1) highlight key responsibilities and recommendations for enhancing Indigenous Data Governance to promote more equitable and just frameworks that enhance research and data practices. Although we offer recommendations, we recognize that the most actionable first step in implementing the CARE Principles remains education about and awareness of Indigenous Data Sovereignty concepts among all who contribute to these fields (Table 1).

Applying CARE to biodiversity research

Collective benefits. Collective benefits within biodiversity research reflect intergenerational time scales and restore and maintain the relationships and responsibilities of Indigenous Peoples to personal, collective and environmental data¹⁷. To realize collective benefits, environmental data ecosystems must be designed to align and function with community aspirations. Benefits fall into two categories: self-determination and economics¹⁷.

Self-determination benefits require that research and potential results are of value, led by or in partnership with community experts, and have long-term community investments. The means to achieve benefits of self-determination include capacity building and sharing, using community-defined codes and coding (including for large datasets, and geospatial or global datasets), the return of and/or access to findings, employment or training, and technical assistance to improve community wellbeing.

Economic benefits focus on equitable outcomes and community empowerment. This may include compensation, value from commercialization or profit from intellectual property of research outcomes, royalties, authorship, and acknowledgement or credit in publications.

Authority to control. Indigenous communities have the authority to control data about their lands, community members and cultural traditions.

Data about Indigenous communities, their lands and cultural traditions should support Indigenous Data Governance in a usable format, with provenance attributed, and free of charge. Data management plans ensure the authority to control by identifying the current and long-term stewardship of Indigenous data, protocols, governance and knowledge. The authority to control is enhanced through publication standards that require documentation of community support, participation and approval for publication¹⁸. Community–researcher partnerships need to co-establish principles and protocols for research, including ongoing free, prior and informed consent¹⁹ within agreed-upon data management and publication plans throughout the project lifespan.

Responsibility. Community–researcher partnerships must be driven by community needs and aspirations, and inclusive of Indigenous values, worldviews and methodologies. These partnerships should be built around long-term relationships and community investments. These include community-defined benefit sharing and capacity sharing²⁰, such as developing a sustained data workforce with fair compensation for community researchers and reviewers.

Ethics. Researchers working with Indigenous communities have ethical obligations that should guide their conduct and partnerships.

This includes learning the history of research relationships in the community, determining community-defined needs for future research relationships and going beyond the minimum required

Table 1 | How institutions and researchers can apply the CARE Principles

CARE Principles	Issues raised by communities	Actions for institutions and researchers
Collective benefit	Research that benefits communities	Prior to research, explain and demonstrate how your research and potential results are relevant and are of value to the interests of the community and individual members; research should support community-led initiatives and secure funding for long-term investments in community.
	Data grounded in community values, aspirations and well-being	Develop and/or use Indigenous data classification and analysis frameworks that reflect community values, needs and aspirations; include and value local community experts in the research team.
	Data for self-determined development	Collect and code using categories that identify Indigenous communities and individuals in ways that they define; disaggregate data, especially in global or large geospatial datasets, to increase relevance for Indigenous communities.
	Compensate local experts	Compensate community experts throughout the research process, including research proposal development, data collection, manuscript writing and community review of prepublication manuscripts.
Authority to control	Recognize Indigenous Peoples' rights to and interests in their knowledges and data	Establish institutional principles or protocols for research development, data management and publication (for example, scholarly works, presentations and datasets) that support Indigenous Data Sovereignty; include metadata fields available for disclosure of Indigenous rights and interests.
	Recognize the rights of Indigenous People to free, prior and informed consent	Ensure data use is consistent with individual and community consent provisions; ensure ongoing consent processes, including the ability to refuse, withdraw and reconsent.
	Data available for Indigenous governance	Ensure Indigenous communities have access to data, metadata about their people, communities and non-human relations in a usable format; return all outputs to the appropriate tribal authorities.
	Develop and enact Indigenous Data Governance protocols	Ensure community control and ownership of data and data protocols; use Indigenous frameworks and principles to inform data management protocols and processes; Indigenous community control of how, what, who and where research is conducted, and stewardship of data; publication standards require documentation of community support, participation and approval for publishing data and authorship.
Responsibility	Enable capability and capacity sharing for research design and digital infrastructure	Create and expand opportunities for community capacity through (1) participatory methodologies including planning and design, knowledge management and data workforce capacity building, and (2) initiatives to enable the design, collection, management, storage, security, governance, collective privacy and application of data.
	Respect reciprocity, trust and mutual understanding with those to whom data relate	Record the Traditional Knowledge and biocultural labels of the Local Contexts Hub in metadata; ensure review of draft publications before dissemination; identify and address sensitive data, including privacy issues for individuals and communities.
	Data-generating resources for languages, worldviews and lived experiences	Use the languages of Indigenous Peoples; affirm community worldviews; upload data with appropriate metadata labels (that is, Traditional Knowledge and biocultural labels, and provenance) in culturally accessible formats (digital storytelling, seasonal calendars, visual art forms and so on).
	Community-defined benefit sharing	Conduct research that is of mutual benefit, consent driven, inclusive and relevant to the needs of Indigenous communities and individuals.
Ethics	Align with Indigenous ethical frameworks	Assess research using Indigenous ethical frameworks; community-defined review processes and appropriate reviewers (for example, community advisory boards) for activities delineated in data management plans.
	Maximize benefits from the perspectives of Indigenous Peoples	Researchers explain benefits to Indigenous communities; identify and contribute to community-defined benefits; disclose potential financial gain and share benefits with communities from research outputs and/or economic value of data.
	Minimize harms from the perspectives of Indigenous Peoples	Use Indigenous ethical frameworks; community-defined code of conduct is accessible; data-access protocols consider the potential for community harm and remedied through sharing data; ensure ongoing consent.
	Data governance accounts for potential future use	Apply community protocols for infrastructure, metadata and secondary use; include Traditional Knowledge and biocultural labels and metadata fields for community and/or tribal affiliation; use community guidelines for the use and reuse of data; allow data removal and/or disposal requests from aggregated datasets; record and recognize provenance.

protections. It is critical to recognize historical research harms and to identify ways to maximize positive research outcomes. Worldviews and ethics frameworks differ across communities. Thus, researchers need to learn appropriately deemed methods of applying these frameworks to guide research in each community. These frameworks should be integrated into data management plans and recognize provenance of samples, purpose, use and reuse of certain data for future governance. Guidelines should enable removal of data access as deemed necessary from aggregated datasets.

Towards ethical data stewardship

Ecology often neglects to consider the ethics and responsibilities relating to the data and intergenerational data relationships we create about complex ecosystems. The CARE Principles and application of Indigenous Data Governance help to guide researchers to recognize, retain and shift control in project guidelines, leading to intentional and collaborative partnerships. By going beyond voluntary and aspirational guidelines, research partnerships increase in value and are rooted in community and intergenerational expertise. Formalizing

BOX 1

CARE in practice

The examples below demonstrate the application of the CARE Principles for enhancing Indigenous governance of data. These examples also demonstrate innovation by non-Indigenous partners and researchers with critical support and expert guidance from Indigenous partners to address five actions that researchers can take around acknowledgement, attribution, authorship, access and authority¹³.

Applications

Mechanisms that promote the CARE Principles, including authority to control and responsibility, exist in various stages of development and use. For example:

- The [Local Contexts Hub](#) offers a platform for researchers, institutions and Indigenous communities to disclose Indigenous interests in digital records or datasets ('notices') and to outline appropriate protocols and permissions for use ('labels'). Labels address issues of provenance, ownership, access, control and governance over Indigenous digital collections and data, including metadata. Notices function as placeholders on collections, data or in a sample field until a Traditional Knowledge or a biocultural label is added by a community.
- The [University of Maine's environmental DNA programme](#) uses the 'Open to Collaborate' notice from the Local Contexts Hub for environmental DNA samples. This notice affirms the programme's commitment to new modes of collaboration, engagement and partnerships with Indigenous Peoples for the care and stewardship of past and future heritage collections²¹. Tribal historic preservation officers in Maine receive notifications about environmental DNA samples collected from their tribal lands and can apply specific labels, which enables them to more effectively monitor research activities and future data applications, recognizes data provenance and ensures adherence to tribal protocols and permissions.
- The [Systematics Collection Data](#) adoption of biocultural and Traditional Knowledge labels through the Local Contexts Hub is a good example of how small changes to digital infrastructures in research organizations can have major effects and improve provenance, transparency and the recognition of cultural authority. The database provides access to specimen and culture data from a variety of national collections. Over 675,000 records in the Systematics Collection Data now include notices that disclose the potential for Indigenous interests in the specimens and data from biological samples. All entries include notices of possible Indigenous interests in the specimens and data.
- [Native Lands Digital](#) is a not-for-profit mapping tool that is useful for identifying the territories of Indigenous Peoples. This georeferenced tool offers a user-friendly entry point (desktop and mobile) and is useful for scientists who wish to learn about the tribal stewards of research sites, treaties and tribal personnel to contact. Data points link to Indigenous Peoples' websites, languages and treaty information, and additional relevant sources.

Formalizing guidelines

A growing number of science organizations are leading the field by implementing the CARE Principles in support of Indigenous Data Sovereignty.

- Global entities that exercise CARE include the United Nations Educational, Scientific and Cultural Organization (UNESCO) [Recommendation on Open Science](#), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [Data and Knowledge Management Policy](#), and the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) [Code of Ethics for Aboriginal and Torres Strait Islander Research](#). Other organizations, repositories and research projects continue to explore the voluntary application of CARE.
- The [Earth Science Information Partners](#) have established [recommendations for repositories](#), endorsing guidelines that improve data management through alignment with CARE Principles. These voluntary guidelines include understanding Indigenous legal rights, the consequences of publishing without permissions, having transparent practices and defensible data management policies, and ensuring that depositing researchers have done their due diligence.
- The [Local Indicators of Climate Change Impacts](#) (LICCI) research platform aims to amplify local knowledge and expertise in climate research and policy. LICCI includes a data sovereignty statement that recognizes the interests of Indigenous Peoples, including specific data protection rights and management in line with the CARE Principles. Their OpenTEK program is a free and open-source technology to document, visualize and share different types of environmental information from local and Indigenous communities. OpenTEK uses Local Contexts Hub notices, including 'Open to Collaborate' and 'Attribution Incomplete' (to recognize incomplete metadata). Traditional Knowledge labels are used to recognize that there are accompanying cultural rights and responsibilities in the sharing of the materials, and biocultural labels are used to recognize the rights of Indigenous Peoples in granting permission for the use of data and digital sequence information generated from the biodiversity and genetic resources associated with traditional lands, waters and territories.

Enhancing metadata

Shifts in Indigenous metadata practices offer valuable solutions for non-Indigenous and Indigenous partners.

- The [European Reference Genome Atlas](#) (ERGA) is streamlining the collection and storage of ethical and legally compliant metadata for all genomic data across Europe. Recognizing that research portals are collections of repositories with different metadata brokers, ERGA has partnered with the Local Contexts Hub to implement the Traditional Knowledge and biocultural labels, to translate across data ecosystems and to create requirements for disclosing Indigenous rights and interests in biodiversity data as users upload metadata. Additionally, ERGA manifest files (computing files that explain metadata versions, licences and constituents) include

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data fields with options for regulatory compliance, recognition of Indigenous rights, associated Traditional Knowledge contacts, and the identification of whether ethics, sampling and/or Nagoya permits are required and obtained.

- The Coeur d'Alene Tribe and University of Idaho established 'Best Practices for Metadata Creation on TEK Data Products in ISO19115', which defines recommendations for Traditional

Knowledge-related data products (such as language, locale, credit, point of contact, resource-specific usage, legal constraints, limits of access and use, and temporal extents). These guidelines also define intellectual property rights in university–community partnerships, with detailed descriptions of community intellectual property rights, project intellectual property rights, ongoing consultation guidelines and data confidentiality protocols.

these changes and nurturing relationships across multiple levels – individual researcher practices, community support, funding institutions and cooperation from governmental entities – will increase accountability, collective benefit, responsibility and ethics in relation to Indigenous data. Ultimately, the implementation of the CARE Principles will ground ecology and adjacent fields in more ethical ecological and data stewardship practices, infrastructures and technologies.

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Author contributions

L.J., T.A., A.M., R.S., D.D.C., I.G., M.H., N.A.G. and S.R.C. contributed to writing, editing, and reviewing the paper and Table 1. L.J., T.A., A.M., M.H. and S.R.C. conceived the idea for the paper. L.J. led the writing. A.M. designed the original version of the figure. L.J. and S.R.C. conceptualized Table 1.

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Competing interests

The authors declare no competing interests.