Photo: D. Murray; Diamond Lake, Sierras

The Environmental Responsibility Framework: a toolbox for recognizing and promoting ecologically-conscious research

Desneiges S. Murray, Isabel Cole, Nicholas Nunez, Eric M. Parker, Anna Mikulis, Allison M. Herreid, Mitchell Donovan, Hannah M. Fazekas and Adam S. Wymore

Forest Ecosystem Monitoring Cooperative
NEBI (Water): Connecting N'dakinna (Land), Bilowagizegad (Climate), and Alnobak (People)
12/12/2024

ECOSHEDS: Ecosystem ecology and watershed science

The ECOSHEDS lab group at the University of New Hampshire resides on the traditional lands (N'dakinna) of the Abenaki, Pennacook and Wabanaki Peoples past and present. We acknowledge and honor with gratitude the land (aki) and water (nebi), flora (olakwika), and fauna (awaasak), and the people (alnobak) who have stewarded it throughout the generations.
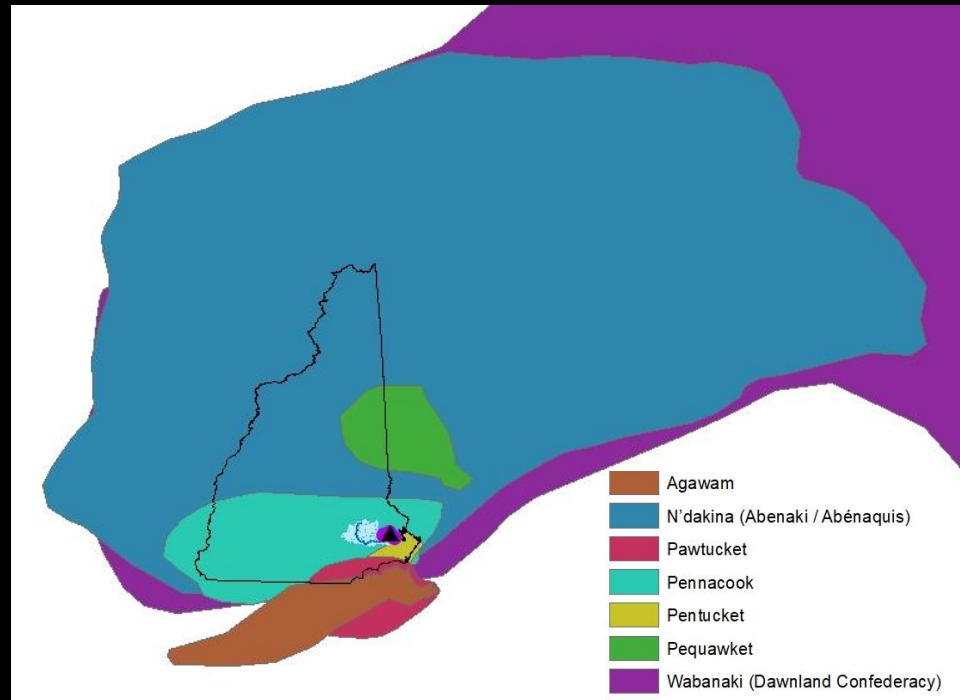
Project Nebi (Water)

- Connecting N'dakinna (Land), Bilowagizegad (Climate), and Alnobak (People) through the NSRC

- Focused on various perspectives of natural resources, including most importantly water.

- The ER5F was an emergent outcome of Project Nebi

- How can we do scientific research through the lens of reciprocity?

Northeastern States Research Cooperative

Knowledge to guide the future of Northern Forest communities

| About | Interest Areas | Projects | Resources |

Indigenous Forest Knowledge Fund: NEBI (Water): Connecting N'dakinna (Land), Bilowagizegad (Climate), and Alnobak (People)

Project Title: NEBI (Water): Connecting N'dakinna (Land), Bilowagizegad (Climate), and Alnobak (People)

Award Year: 2021

Principal Investigator:
ADAM WYMORE
University of New Hampshire
adam.wymore@unh.edu

Collaborator(s):
DENISE POULIOT
Cowasuck Band of the Pennacook-Abenaki People
PAUL POULIOT
Cowasuck Band of the Pennacook-Abenaki People

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Talk outline

Overview of the Environmental Responsibility Framework

Our path to researching and developing the framework

Framework details and example implementation

Resources

Earth's Future

Key Points:
- Human ethos has provided a cornerstone for research on human and vertebrate subjects
- We propose a framework for explicitly incorporating environmentally focused ethics into scientific research

The Environmental Responsibility Framework: A Toolbox for Recognizing and Promoting Ecologically Conscious Research

Desneiges S. Murray[1] (ID), Isabel Cole[2], Nicholas Nunez[1], Eric M. Parker[1] (ID), Anna Mikulis[1], Allison M. Herreid[1], Mitchell Donovan[3], Hannah M. Fazekas[1] (ID), and Adam S. Wymore[1] (ID)

[1]Department of Natural Resources and the Environment, University of New Hampshire, Durham, NH, USA, [2]Department of Agriculture, Nutrition, and Food Science, University of New Hampshire, Durham, NH, USA, [3]Terra Informatics LLC, Dover, NH, USA

THE ENVIRONMENTAL RESPONSIBILITY FRAMEWORK

5 - R'S

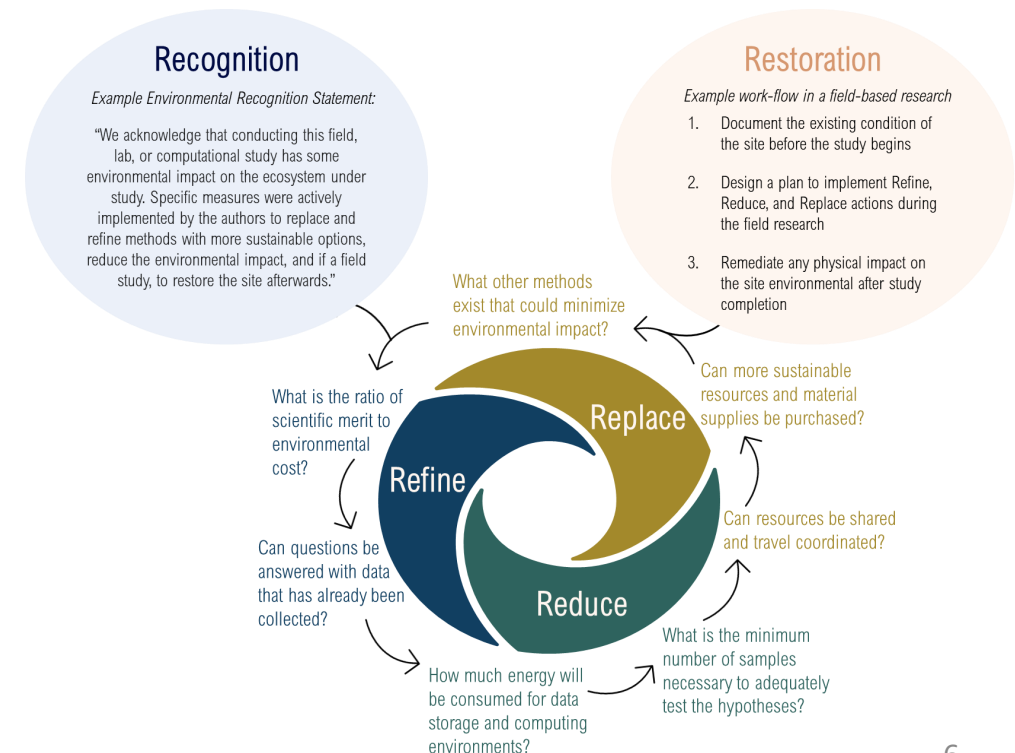| RECOGNITION	REFINEMENT	REDUCTION	REPLACEMENT	RESTORATION
Recognize that research has environmental consequences	Refine questions and methods to have the least impact on the environment	Reduce the amount of resources consumed	Replace methods, techniques, and materials with more sustainable options	Restore the environment to the same condition or better as it was before the study

Recognition

Example Environmental Recognition Statement:

"We acknowledge that conducting this field, lab, or computational study has some environmental impact on the ecosystem under study. Specific measures were actively implemented by the authors to replace and refine methods with more sustainable options, reduce the environmental impact, and if a field study, to restore the site afterwards."

Restoration

Example work-flow in a field-based research

1. Document the existing condition of the site before the study begins
2. Design a plan to implement Refine, Reduce, and Replace actions during the field research
3. Remediate any physical impact on the site environmental after study completion

What other methods exist that could minimize environmental impact?

What is the ratio of scientific merit to environmental cost?

Can more sustainable resources and material supplies be purchased?

Can resources be shared and travel coordinated?

Refine

Replace

Reduce

Can questions be answered with data that has already been collected?

How much energy will be consumed for data storage and computing environments?

What is the minimum number of samples necessary to adequately test the hypotheses?

Our path to the ER⁵F

Fall 2021 → covid-19 is still influencing daily life so most people are remote working

lab meeting reading material

Why don't we have the same ethical guidelines used for human research for environmental research?

Isabel Cole

Photo of waste from an introduction to Biology course after one lab demonstration

Actual footage of ECOSHEDs lab group frantically trying to see if someone else has proposed this idea

Ethical guidelines have provided a cornerstone for morally appropriate research on human or other vertebrate animal subjects since 1945.

Nuremberg Code, 1945 & Declaration of Helsinki, 1964
- There are potentially harmful impacts of science
- Prioritize ethically appropriate research over advancement in knowledge.

Like the environment, animals cannot consent to research

In human and animal subjects research, the dictum 'do no harm' has fueled the development of foundational protocols that provide boundaries and structure to such research.

IACUC: Responsible for ensuring that all care of animals, use programs, and facilities are in accordance with the regulations of the Animal Welfare.

IACUC reviews proposed research through a four R Framework: replacement, reduction, refinement, and rehoming.

Replacement: ways to remove animals from the research to achieve scientific goals.

Reduction: ways to reduce the number of animals that are used for the study.

Refinement: ways to reduce animal pain and/or distress within the study.

Responsible and ethical research requires scientists to consider the impact of research on organisms, and on our planet's environment

- Research can generate unintended consequences on the environment itself

- *Ecosystem personhood*: ecosystems are self-organizing systems with their own health, performance, stress, and rights

A framework for gauging the environmental impacts of scientific research is overdue.

Photo: M. Donovan; Colorado

Precedence for viewing ecosystems with the same rights as people

Quebec's Magpie River becomes first in Canada to be granted legal personhood

By Chloe Rose Stuart-Ulin | News | February 24th 2021

The Magpie River in Côte-Nord, Que., is the first in Canada to granted legal personhood rights. Photo by Boreal River

Managing the Rights of Nature for Te Awa Tupua

BY ANNA M. GADE · PUBLISHED SEPTEMBER 5, 2019 · UPDATED OCTOBER 12, 2019

Version as at 28 October 2021

Te Urewera Act 2014

Public Act 2014 No 51
Date of assent 27 July 2014
Commencement see section 2

Note

The Parliamentary Counsel Office has made editorial and format changes to this version using the powers under subpart 2 of Part 3 of the Legislation Act 2019.

Note 4 at the end of this version provides a list of the amendments included in it.

This Act is administered by the Department of Conservation.

Scientific research using field, laboratory, and computational approaches inevitably generates an environmental impact

examples: fossil fuel emissions; energy consumption; material use; sample extraction

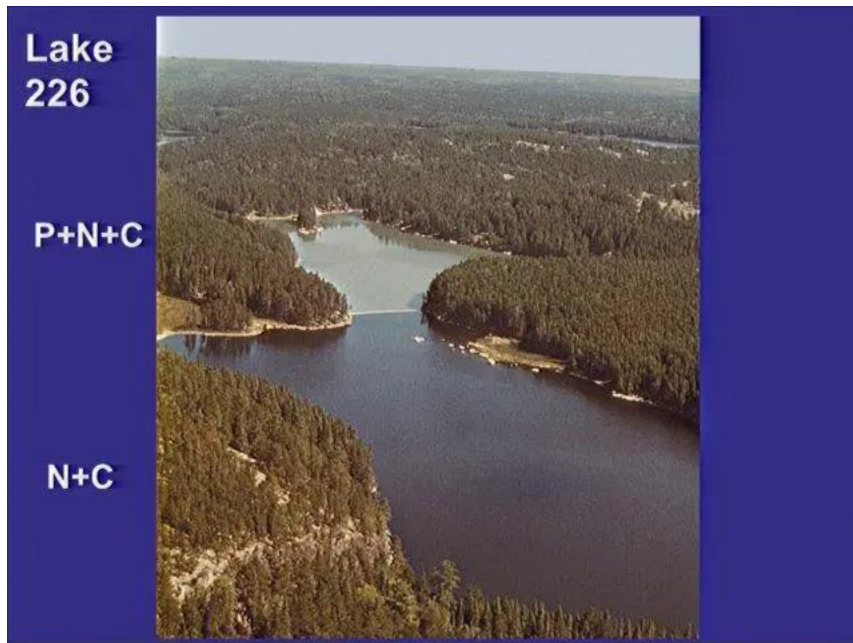Photo: M. Donovan;
Arthurs Pass,
New Zealand

How does the scientific community accomplish meaningful stewardship-based science while limiting unintended detrimental consequences to environmental and ecological systems that support life?

- The scientific method inherently requires making measurements and/or the consuming natural resources and materials to conduct experiments in and on the environment

- Advancing scientific discoveries while simultaneously pursuing stewardship of the environment and ecological systems has been an ongoing dialogue

- Current efforts do not extend to acknowledging the impact of the research process itself, and associated protocols, on the environment.

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Cost/benefit analysis of research methods

- Some of the most impactful science has come from manipulative experiments on the environment, for example:

Schindler et al. 1977

Why scientists have pumped a potent greenhouse gas into streams on public lands

AUGUST 15, 2022 · 5:00 AM ET
HEARD ON ALL THINGS CONSIDERED

Nell Greenfieldboyce

4-Minute Listen   + PLAYLIST

Resulted in foundational understandings of limiting nutrients in aquatic ecosystems and provided evidence for water policies.

We can still study greenhouse gas fluxes without pouring a potent greenhouse gas into the stream! So, the cost/benefit analysis can change!
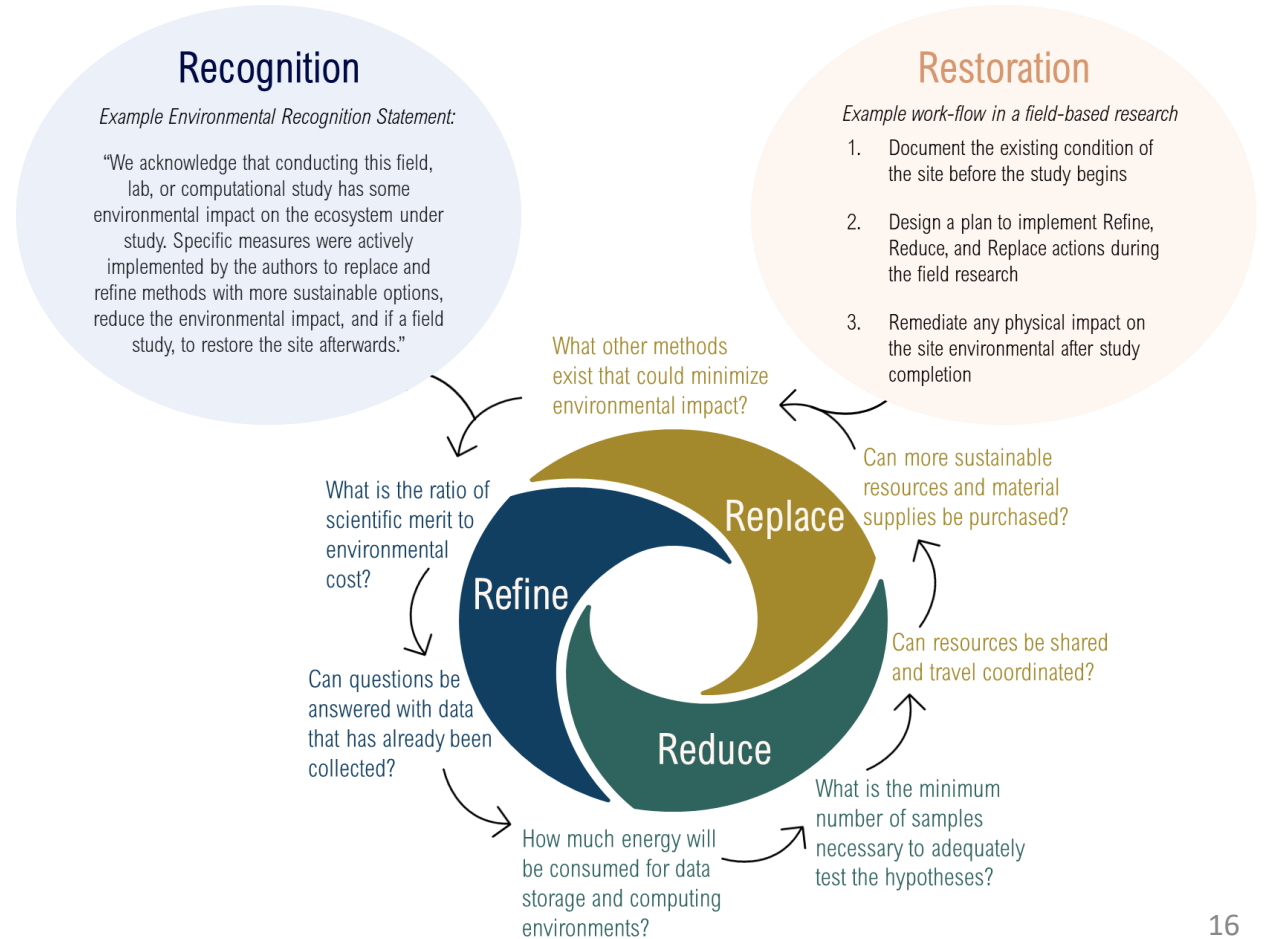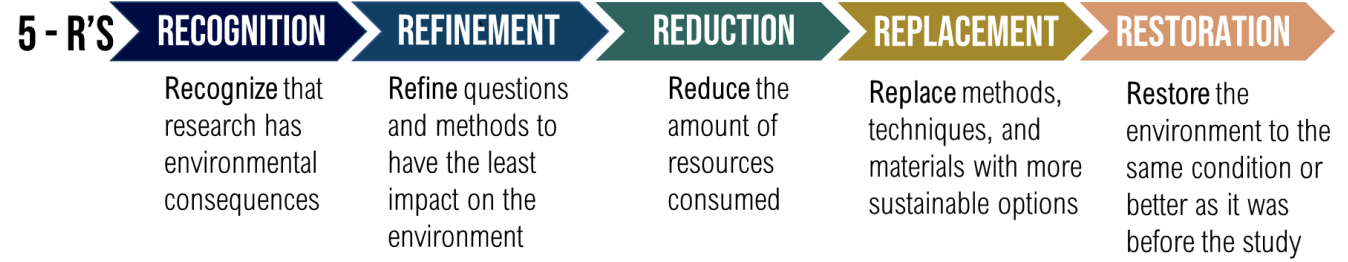
We propose a framework for explicitly incorporating environmentally focused ethics into scientific research.

- Like animals and other non-human organisms, ecosystems cannot consent to participate in research.

- Existing IACUC frameworks can be used as a guide to ethical decision-making associated with avoiding, reducing, or mitigating environmental impacts of research.

- The 3-R approach of IACUC: Replacement, Reduction, and Refinement

- The 5-R approach of ERF: Recognition, Refinement, Reduction, Replacement, Restoration

Photo: M. Donovan;
Death Valley National Park

THE ENVIRONMENTAL RESPONSIBILITY FRAMEWORK

The Environmental Responsibility 5-R Framework is centered around:

**Recognition
Refinement
Reduction
Replacement
Restoration**

5 - R'S

RECOGNITION	REFINEMENT	REDUCTION	REPLACEMENT	RESTORATION
Recognize that research has environmental consequences	**Refine** questions and methods to have the least impact on the environment	**Reduce** the amount of resources consumed	**Replace** methods, techniques, and materials with more sustainable options	**Restore** the environment to the same condition or better as it was before the study

Recognition

Example Environmental Recognition Statement:

"We acknowledge that conducting this field, lab, or computational study has some environmental impact on the ecosystem under study. Specific measures were actively implemented by the authors to replace and refine methods with more sustainable options, reduce the environmental impact, and if a field study, to restore the site afterwards."

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Refine

Replace

Can more sustainable resources and material supplies be purchased?

Can questions be answered with data that has already been collected?

Can resources be shared and travel coordinated?

Reduce

How much energy will be consumed for data storage and computing environments?

What is the minimum number of samples necessary to adequately test the hypotheses?

Photo: M. Donovan;
Grand Teton National Park

Recognize that all research has environmental consequences.

- Field work, lab analyses, and computational approaches

- Recognition can be articulated through declaration statements in publications or proposals

- Statements can include an evaluation of the carbon footprint of workflows

- Recognition is intrinsic to each of the iterative and action-based goals within the framework

Refine methods to minimize impacts on ecosystems and the environment

- Seek alternative methods that may maximize the net impact (i.e., minimize the cost/benefit ratio) of their study.

- Has data or code already been collected or written through open-source data platforms?

- Leverage data from well-established field sites with long records

- Do remote sensing proxies for field data exist?

- Optimize codes or data movement for minimal resource usage

Photo: M. Donovan;
Death Valley National Park
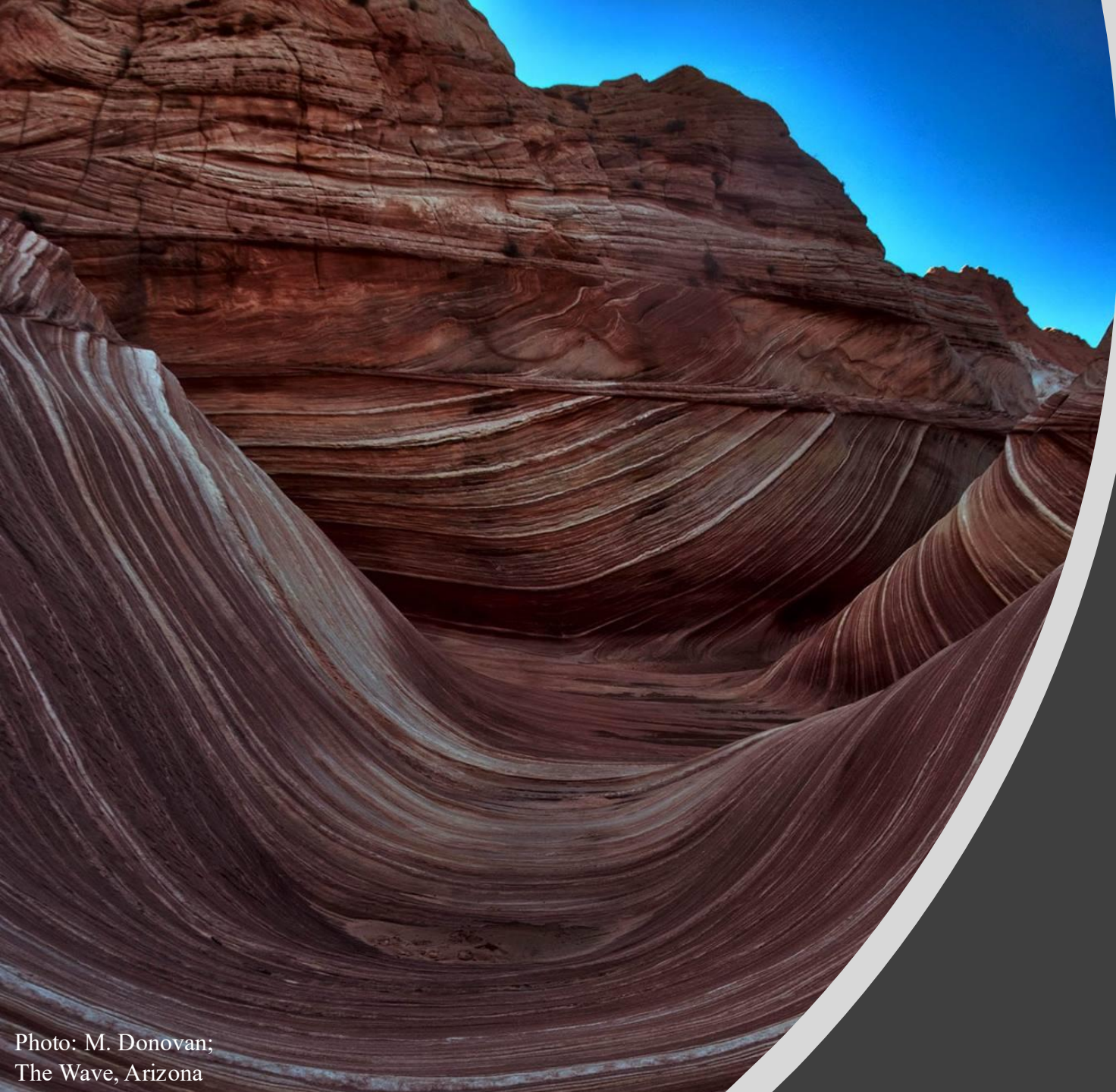
Reduce a project's environmental footprint by minimizing resources and energy consumed

- Coordinate group travel to field sites

- Reduce single-use items while continuing to recycle and reuse materials that will not jeopardize sample quality

- Conduct a statistical power analysis

- Use open-source codes and minimize model runs

- Educate researchers on efficiency-based code compilers, optimizing codes, and implementing data storage efficiency protocols

Photo: M. Donovan;
The Wave, Arizona

Replace methods, techniques, data, and materials for more sustainable options

- Purchase more long-lifetime and sustainable options such as energy efficient instruments, reusable sample vials, or reusable pipettes

- Replace their targeted data collection approaches based on previously available datasets

- Urge organizations seeking sustainable alternatives to existing fossil-fuel based energy infrastructure

- *Example*: measurements of gas evasion from aquatic ecosystems can replace sulfur hexafluoride (SF_6)- a potent greenhouse gas - with argon (zero global warming potential)

Restore the environment to the same condition or better as it was before the study

- Specific to field-based science research

- Document the existing conditions of the site before the study begins and remediate any physical impact on the site after study completion (e.g., photos before and after, baseline measurements)

- Supports the concept of reciprocity with the environment; an essential concept that has served as the basis for sustaining many cultures and is the last of the 6-R's of Indigenous research methods

- Research should be framed within a mutually beneficial relationship to the environmental systems researchers seek to understand.

Goal: acknowledgement of the research's environmental impact and generate effective change towards mitigating the direct and indirect consequences of scientific practices.

- Supports important efforts to <u>decolonize research methods</u>

- Compliments recent developments in ethical research like:

  - **6-R's of Indigenous research** methods – Respect, Relationship, Representation, Relevance, Responsibility, and Reciprocity

  - **CARE principles** of Indigenous data governance – Collective Benefit, Authority to Control, Responsibility, and Ethics

  - **FAIR principles** – Findability, Accessibility, Interoperability, and Reusability

  - **ICON framework** – intentional design of research that Integrates discipline, Coordinates protocols, Openly shares data, and Networks for mutual benefit
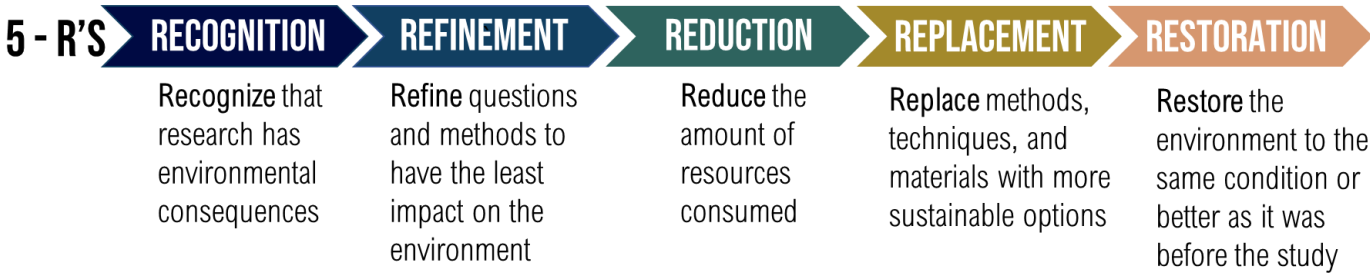
Tangible applications of ER^{5}F:

- Manuscript acknowledgement section
- Proposal broader impacts and merit
- Thesis and dissertation appendices
- Research ethics courses for graduate and undergraduate students
- Research group discussions
- Important to note is that sometimes there will be no place for ER5F in your methods, and that is perfectly OK!
- The process of reflection is a starting point to execution

Discussion

1. How have I, or could I, implement the ER5F in my research objectives moving forward?

2. Do we as environmental scientists have a responsibility to hold up environmental stewardship as part of the scientific process?

3. How do we conduct cost/benefit assessments without knowing whether society will benefit from research in the long term?
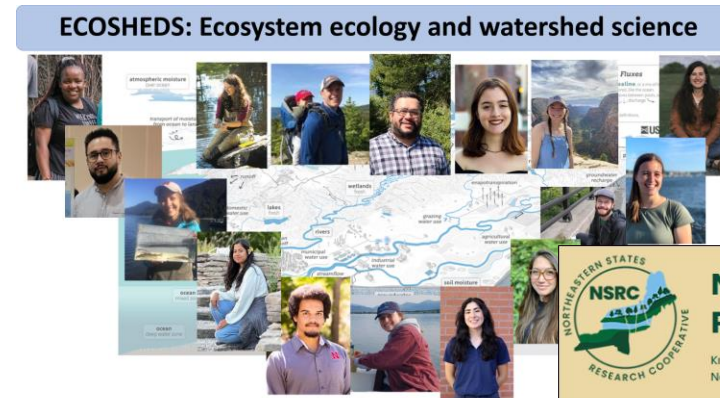

THE ENVIRONMENTAL RESPONSIBILITY FRAMEWORK

5 - R'S | RECOGNITION | REFINEMENT | REDUCTION | REPLACEMENT | RESTORATION

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Reduce

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How much energy will be consumed for data storage and computing environments?

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ER⁵F on the road…

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Acknowledgements

We acknowledge that formulating and writing this study has an environmental impact including fossil fuel energy associated with internet and computer use (252 g CO2e or 2.13 kWh; Green Algorithms calculated 01/12/2023).

Data science: Example implementation of the ER^{5}F

studies can even **replace** their targeted data collection approaches with existing datasets, found in online repositories, catalogs, and historical archives, collectively referred to as 'dark data'
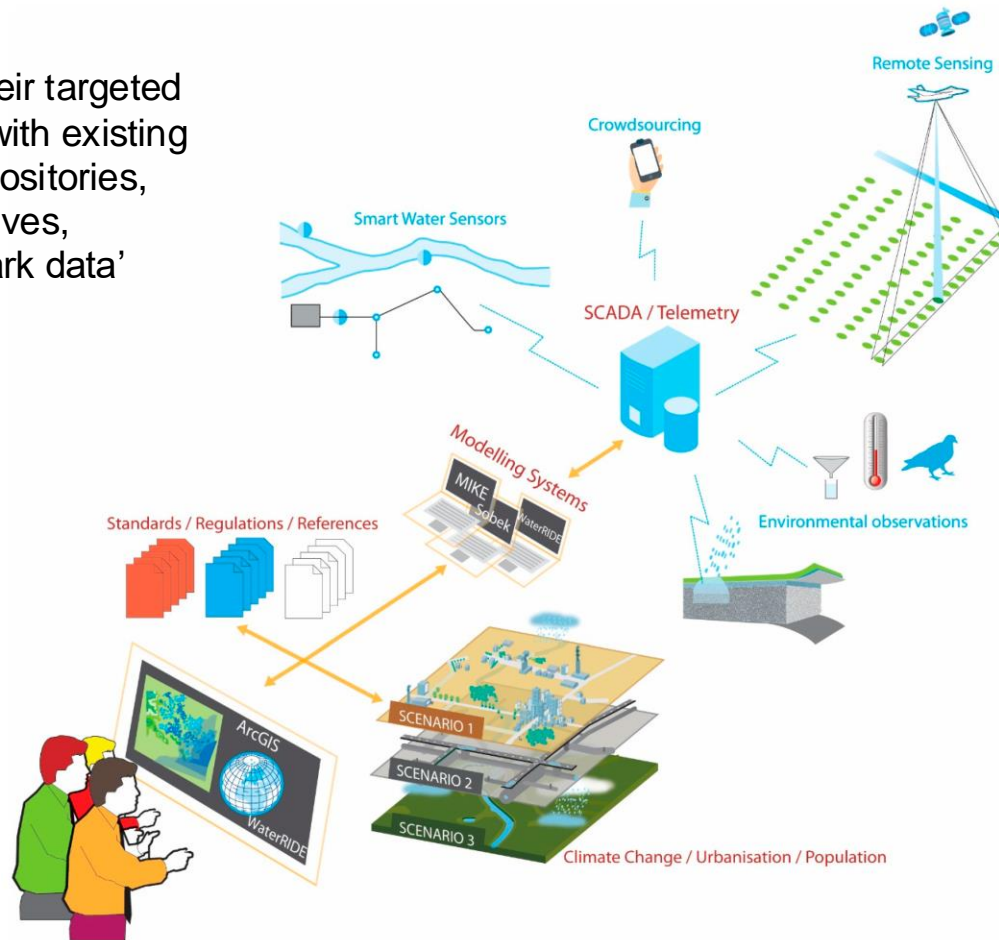
refining research questions by exploring whether relevant data or code already exists through open-source environmental data platforms like HydroShare, Environmental Data Initiative, and National Ecological Observation Network, and remote sensing proxies like NASA data products

Hydroinformatics

Remote Sensing

Crowdsourcing

Smart Water Sensors

SCADA / Telemetry

Modelling Systems

MIKE
Sobek
WaterRIDE

Standards / Regulations / References

Environmental observations

ArcGIS
WaterRIDE

SCENARIO 1
SCENARIO 2
SCENARIO 3

Climate Change / Urbanisation / Population

Open-source data and coding platforms are crucial for scientific progress as well as **reducing** the environmental impact of research.

mid- to high-performance computing resources, have a significant carbon footprint especially with the gaining popularity of machine and deep learning algorithms, researchers can **refine** their approach to optimize code or data movement for minimal resource usage. For example, educating researchers on efficiency-based code compilers, optimizing codes or re-using open-source codes, minimizing model runs and implementing data storage efficiency protocols

Conceptions of Space in National Forest Governance

Kristin Green – PhD Candidate

Dept. of Natural Resources & the Environment

University of New Hampshire

FEMC Conference – December 12, 2024

Nez Perce Tribe

Overview

GEOGRAPHY   CONTEXT   PURPOSE   DESIGN   CURRENT PHASE

Nimiipuu Homelands

Reserved "the right of taking fish at all usual and accustomed places in common with citizens of the territory, and of erecting temporary buildings for curing, together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle **upon open and unclaimed land**" (1855 Treaty, Article 3).

Columbia River Inter-Tribal Fish Commission

National Forest System: "Open & Unclaimed Lands"

➤ Tribal consultation required as part of National Forest planning (36 C.F.R. § 219.4(a)(2)).

➤ Significant implications for water and fisheries resources.

➤ Encompass Wild and Scenic River segments.

National Forest
National Grassland

U.S. Forest Service
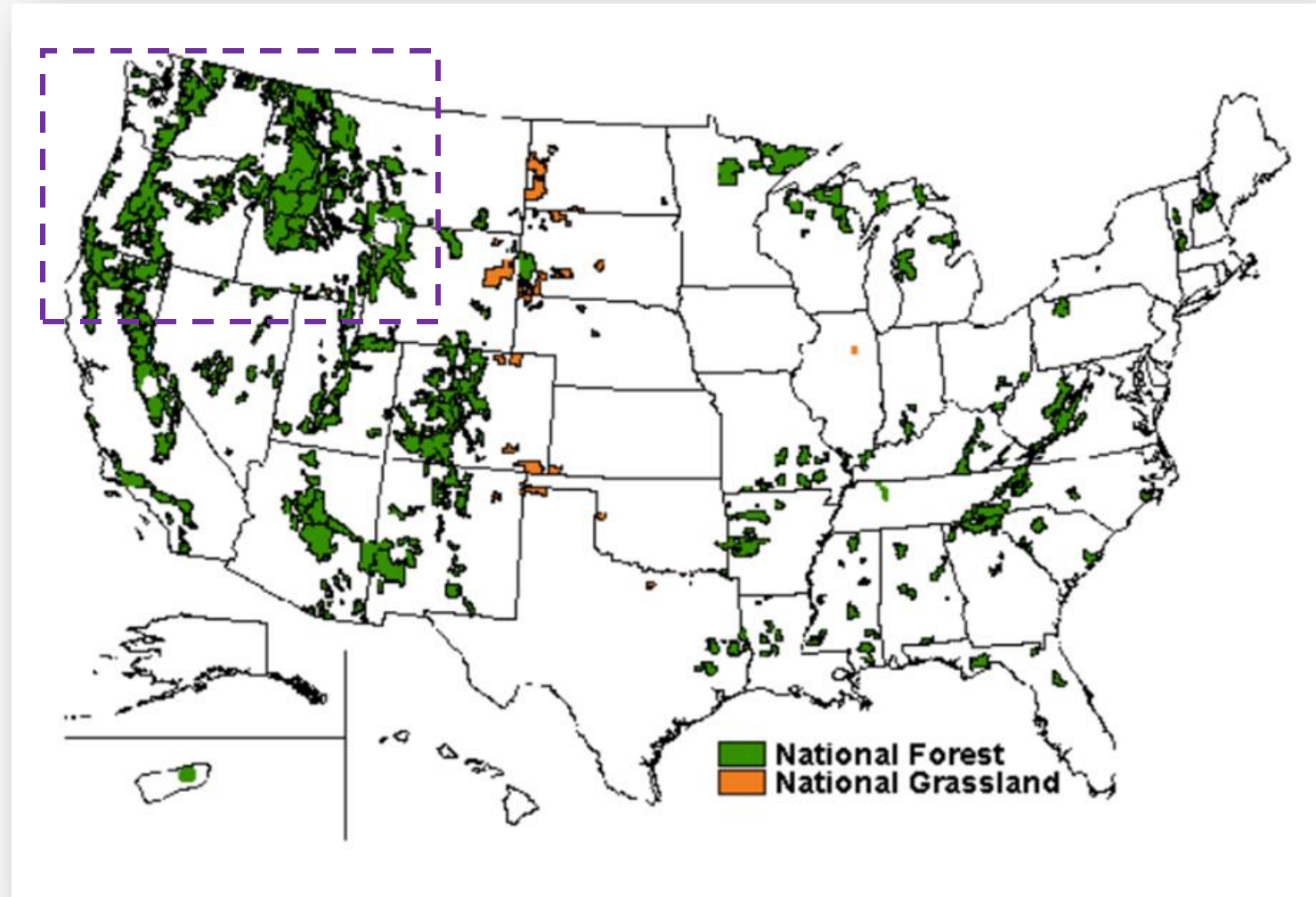
Meaningful Consultation

Cultural Resources Program

www.nezpercecultural.org

The mission of the Cultural Resource Program (CRP) is to promote the understanding and use of *nimiipuu'neewit* (traditional Nez Perce life-ways) as integral components of Tribal culture and regional management. The CRP fulfills its programmatic purpose by:

- Assisting Tribal Leadership in treaty rights protection
- Documenting traditional and ancestral knowledge
- Integrating *nimíipuutimpt* within our Tribal community and infrastructure
- Protecting sites, landscapes, and associated knowledge integral to the perpetuation of *nimíipu'neewit* through meaningful consultation

➢ Many federally-led consultation processes lead to decisions that are unacceptable to the consulted Tribes (Green & Cohn, 2023; Dongoske et al., 2015; Harper & Harris, 2011).

Two Eyed Seeing

- ➤ *A conceptual framework detailing the flow of knowledge (IK, Indigenous knowledge; WS, Western science);*
- ➤ *that underpins researchers' understandings or views of reality, and;*
- ➤ *ultimately guides their research and management decisions (Reid et al. 2020).*
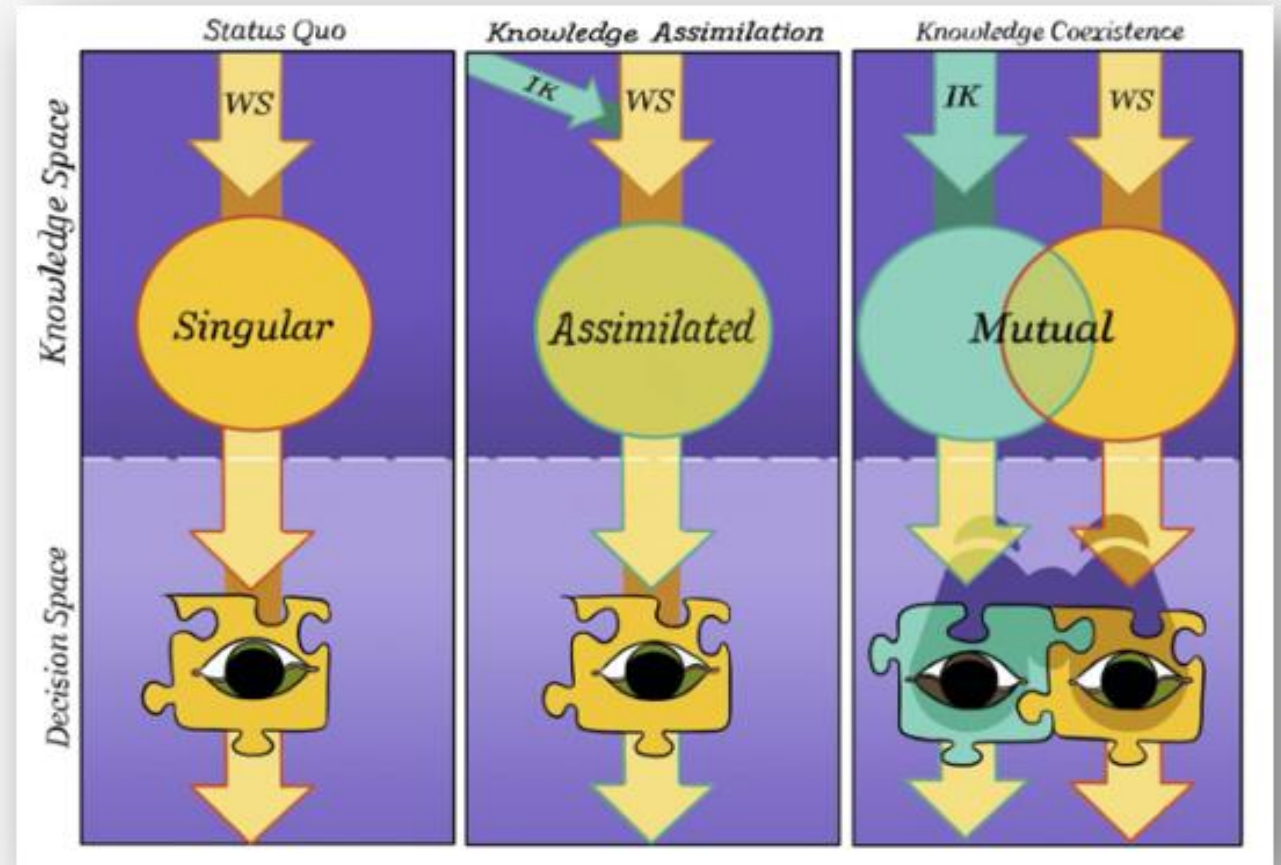
Reid et al. 2020

Importance of Spatial Knowledges

➤ Maps legitimize certain realities:

through the process of mapping certain spatial knowledge and not others and then managing the space (including resources and people) accordingly (Goldman, 2021).
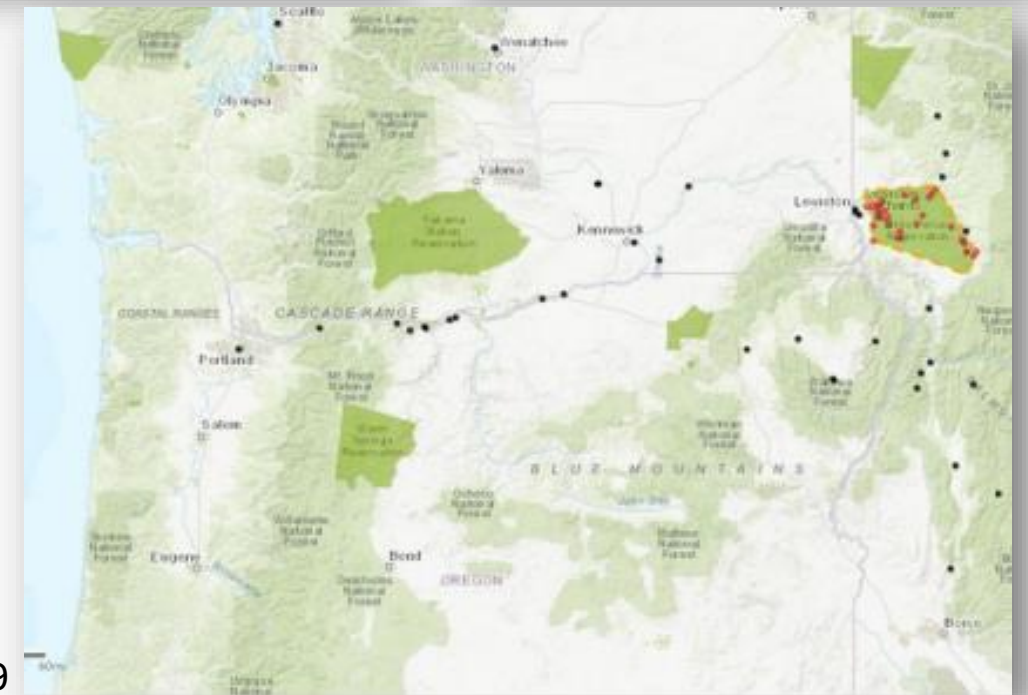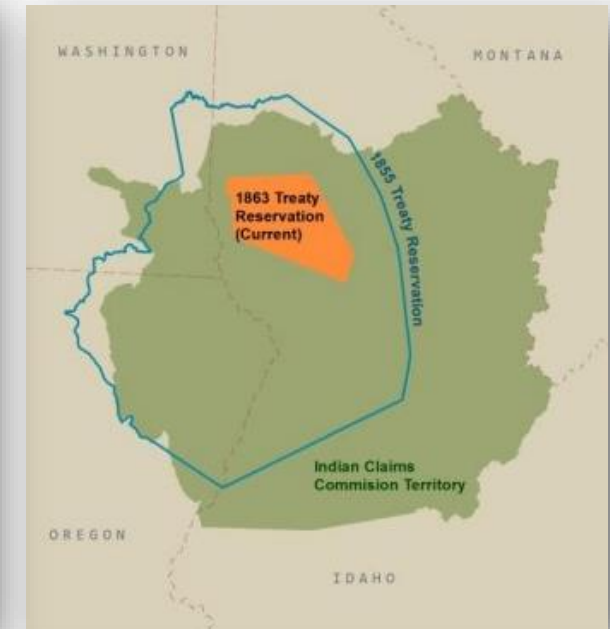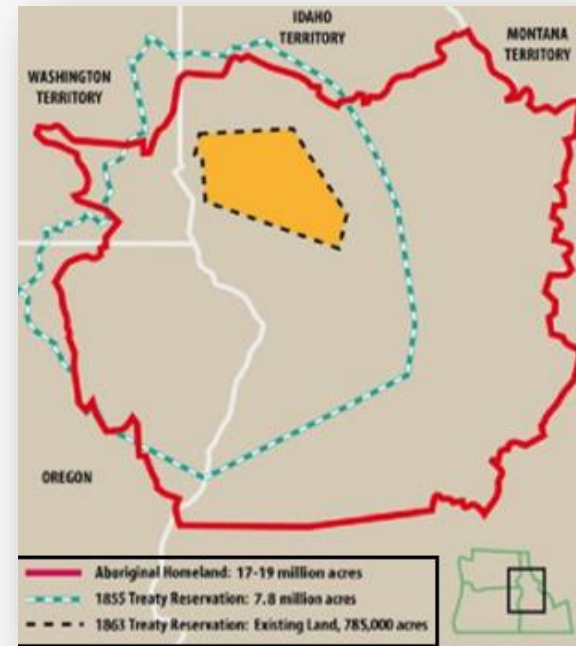
Top right: Nez Perce Tribe
Top left: U.S. Forest Service
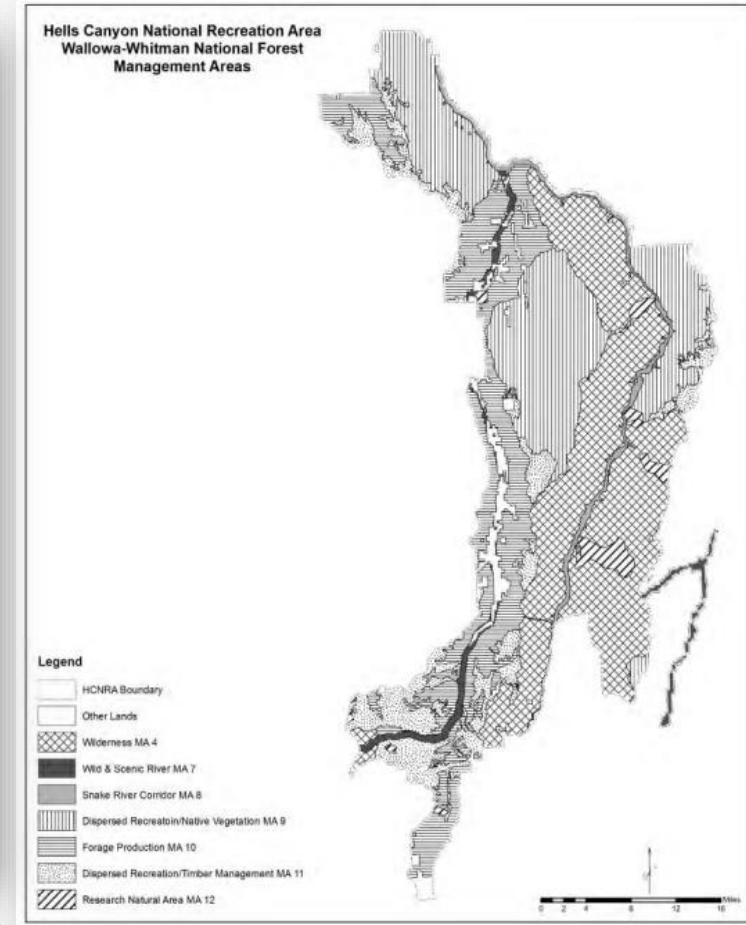Bottom: Higheagle et al., 2019

RQ1) What belief systems are reinforced or challenged in existing USFS maps?

RQ2) In what ways does map analysis using an Equity Mapping Framework (EMF) align with or deviate from Nez Perce community member analysis of USFS maps?

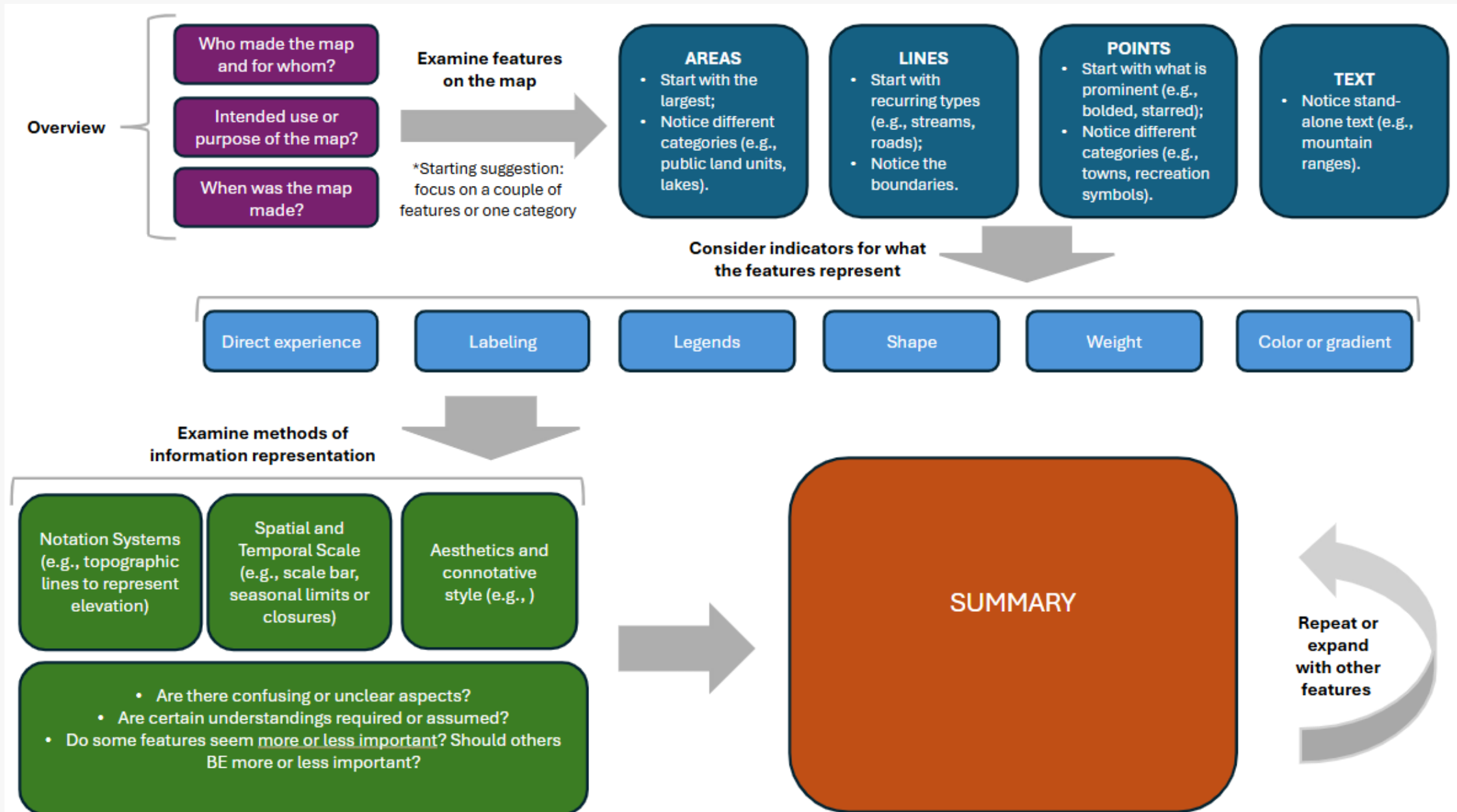**RQ3) To what extent is an EMF effective in supporting the centering of tribal perspectives in USFS maps?**

Columbia River Inter-Tribal Fish Commission

U.S. Forest Service

Draft Analysis Framework

Overview
- Who made the map and for whom?
- Intended use or purpose of the map?
- When was the map made?

Examine features on the map

*Starting suggestion: focus on a couple of features or one category

AREAS
- Start with the largest;
- Notice different categories (e.g., public land units, lakes).

LINES
- Start with recurring types (e.g., streams, roads);
- Notice the boundaries.

POINTS
- Start with what is prominent (e.g., bolded, starred);
- Notice different categories (e.g., towns, recreation symbols).

TEXT
- Notice stand-alone text (e.g., mountain ranges).

Consider indicators for what the features represent

Direct experience | Labeling | Legends | Shape | Weight | Color or gradient

Examine methods of information representation

Notation Systems (e.g., topographic lines to represent elevation)

Spatial and Temporal Scale (e.g., scale bar, seasonal limits or closures)

Aesthetics and connotative style (e.g.,)

- Are there confusing or unclear aspects?
- Are certain understandings required or assumed?
- Do some features seem more or less important? Should others BE more or less important?

SUMMARY

Repeat or expand with other features

9

Early Coverage & Next Steps

➢ Refining and applying the framework.

➢ Interviews with Nez Perce community members.

Rachel Wieme

Eos

ABOUT   SECTIONS   TOPICS ⌄   PROJECTS ⌄   NEWSLETTER   SUBMIT TO *EOS*

Maps Strengthen Collaboration Between Tribes and Federal Agencies

As U.S. agencies commit to better incorporating Indigenous viewpoints, maps could be one important tool.

By Grace van Deelen   9 January 2024

"*Information presented on maps is harder to discount,* said Margaret Pearce, a cartographer and Citizen Potawatomi Nation member who was not involved in the research. *What I see in maps is the potential for all our unspoken assumptions to be laid bare,* she said."

https://eos.org/articles/maps-strengthen-collaboration-between-tribes-and-federal-agencies

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Whyte, K. Powys (2013). On the Role of Traditional Ecological Knowledge as a Collaborative Concept. *Ecological Processes* 2:1. https://doi.org/10.1186/2192-1709-2-7.