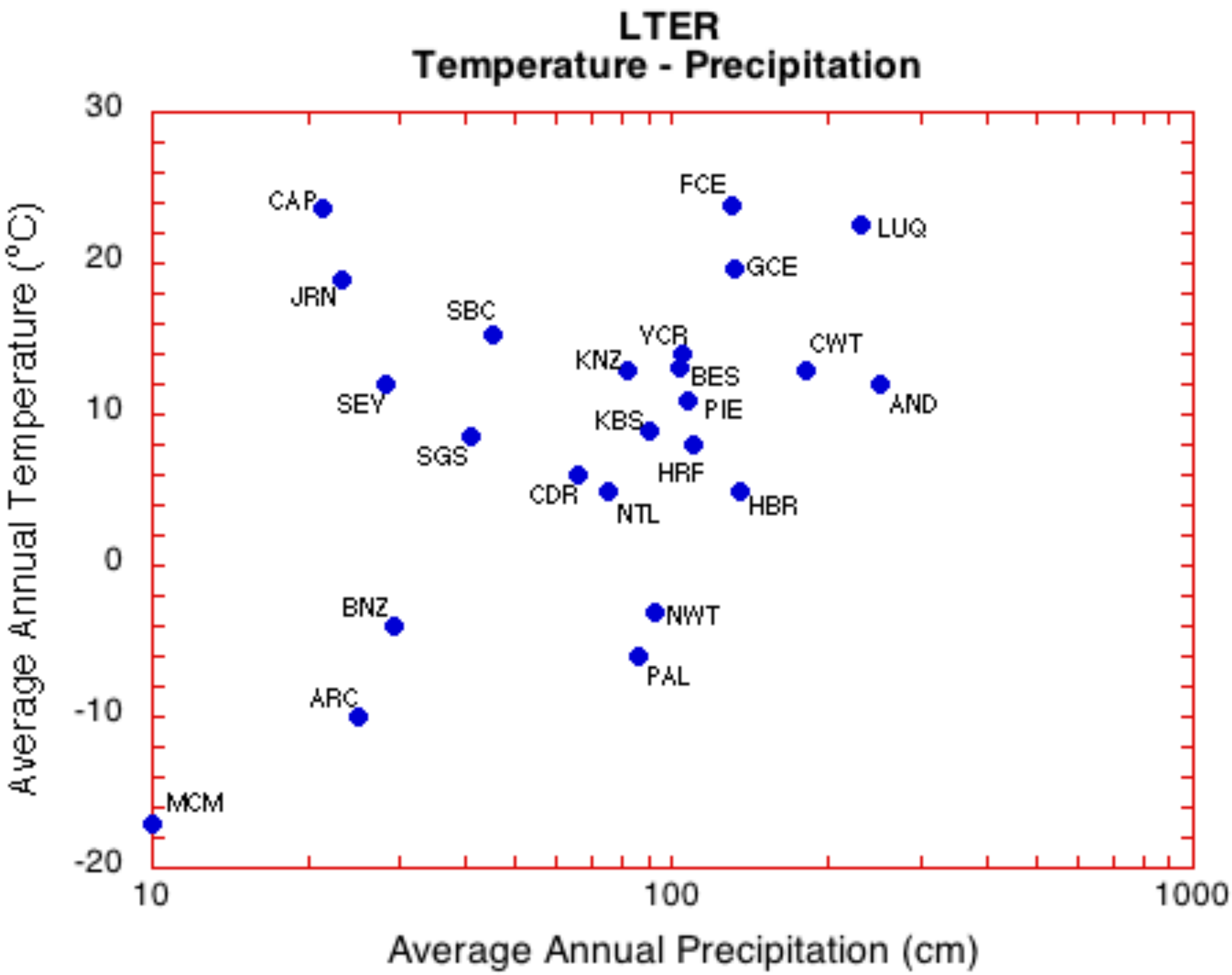
Increased Explanatory Power through International Science Coordination: *The McMurdo Dry Valleys Terrestrial Observation Network*

Byron J. Adams
McMurdo LTER &
Brigham Young University
Dept. of Biology

Presentation Outline

- Physical Context - The McMurdo (MCM) Long-Term Ecological Research Program:
  - Landscape and Ecosystem players
  - Emphasize the sensitivity of polar desert ecosystems to climate change and research activities
- Historical Context - International Collaboration:
  - Cooperation: Science & Logistics (examples)
  - Imperative for Environmental Stewardship (examples)
- The MCM Terrestrial Observation Network
  - International Coordination:
  - Key Measurements, Standards, Protocols, Information Management & Policy Assessment

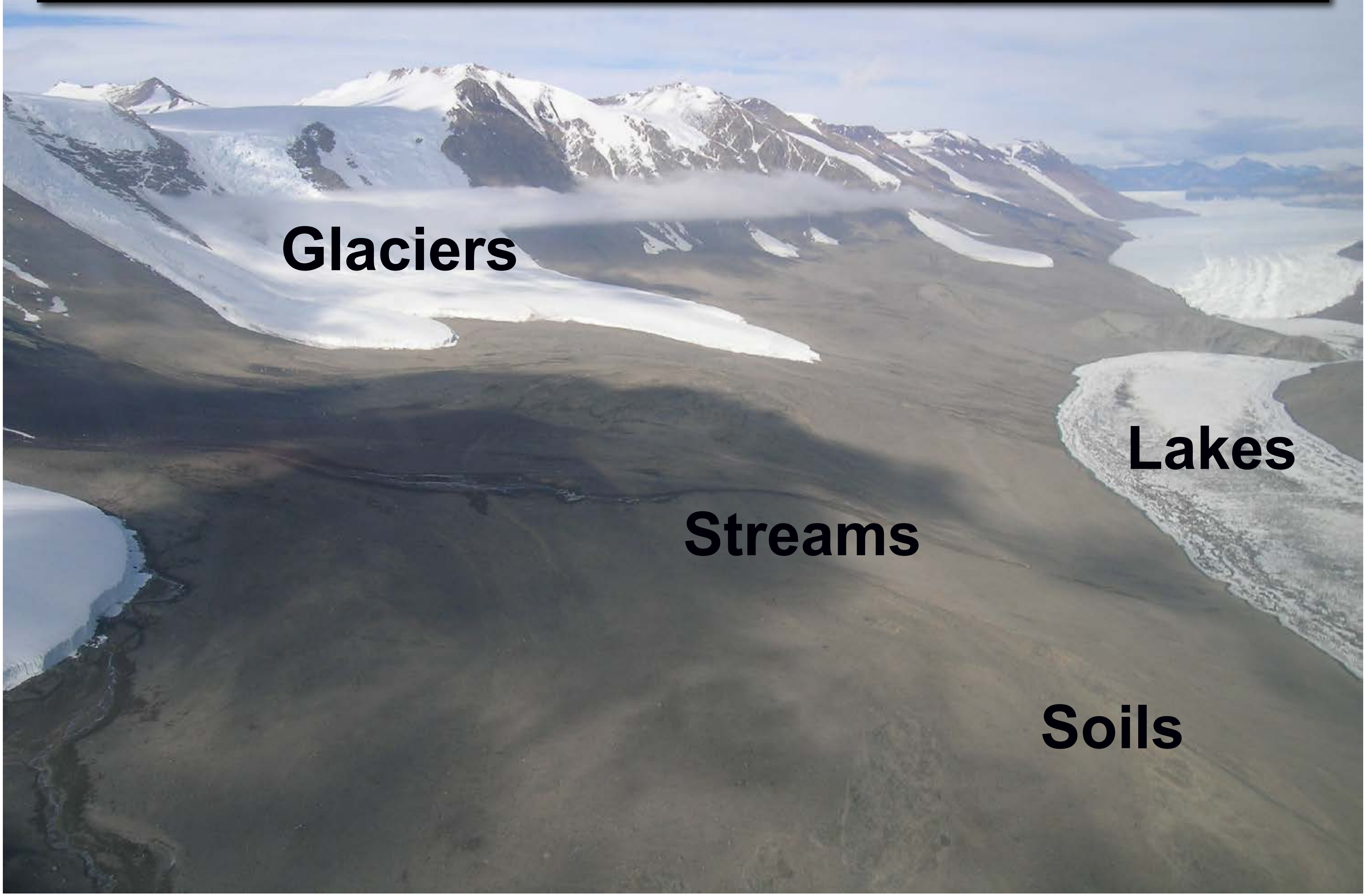


LTER
Temperature - Precipitation
Average Annual Temperature (°C)
Average Annual Precipitation (cm)
30
20
10
0
-10
-20
10
100
1000
CAP
JRN
SBC
SEV
SGS
BNZ
ARC
MCM
FCE
LUQ
GCE
YCR
KNZ
BES
CWT
AND
PIE
KBS
HRF
CDR
NTL
HBR
NWT
PAL

McMurdo Dry Valley Averages and Extremes
(1985-2012)

	C	F
Surface air temperature		
average mean annual	-17.9	-0.2
absolute maximum	9.9	49.8
absolute minimum	-47.7	-53.9
Degree days above freezing		
mean annual	21.9	21.9
Soil temperature at surface		
average mean annual	-17.6	0.3
absolute maximum	25.7	78.3
absolute minimum	-51.1	-60.0
Surface wind speed	**(ms^{-1})**	**(MPH)**
average mean annual	2.7	6.0
maximum	22.8	51.0
Precipitation	~ 4 cm per year (water equivalent)	
Sunshine	5 months of darkness	

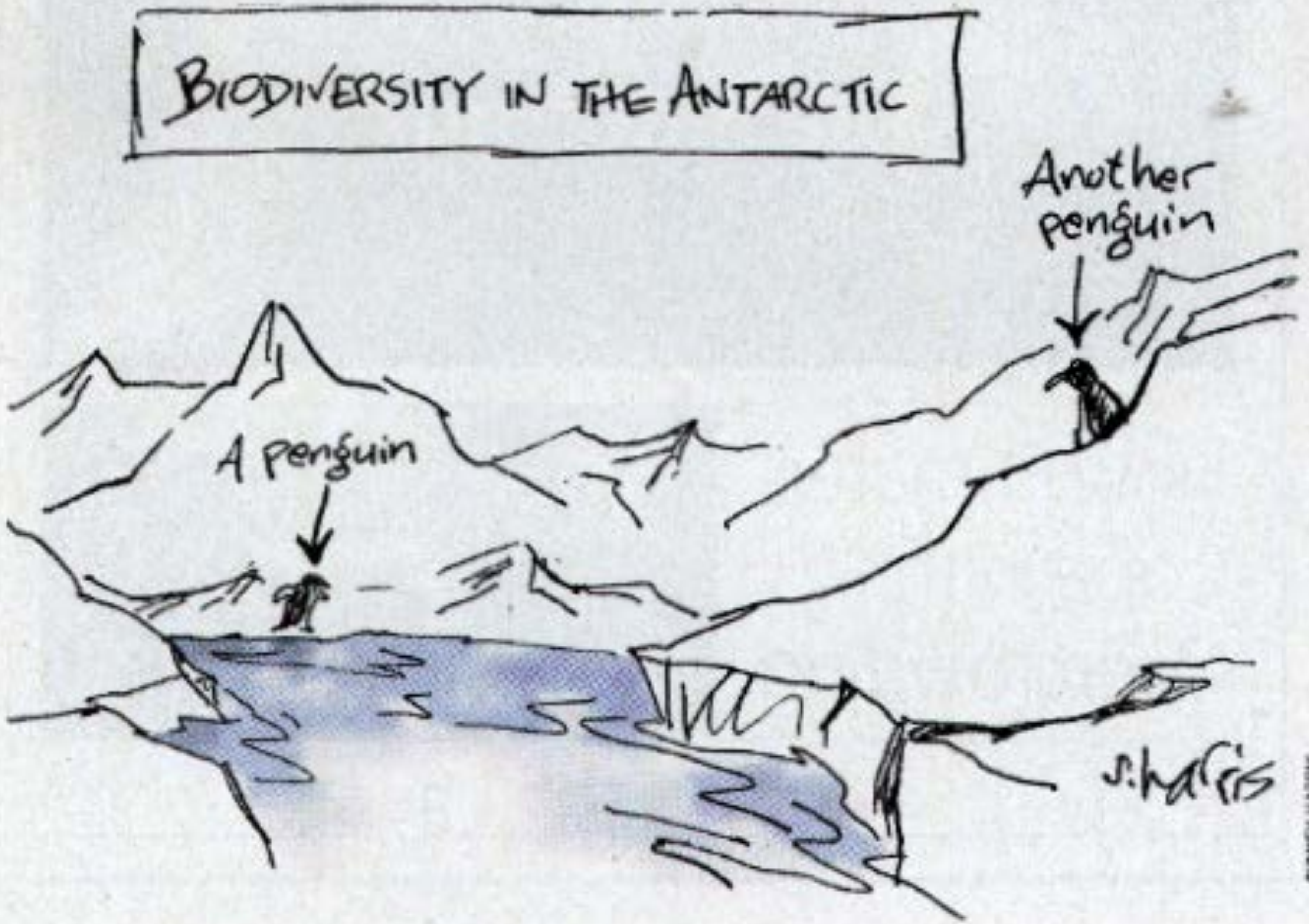
The Dry Valley Ecosystem



MCM-LTER Monitors

- Meteorological data
- Hydrologic data
  - Glacier mass balance
  - Stream discharge
  - Lake levels
  - Lake ice thickness
- Biogeochemistry
  - Stream chemistry
  - Lake chemistry
  - Glaciochemistry
  - Soil biogeochemistry
- Biological parameters
  - Biomass
  - Primary production
  - Species composition

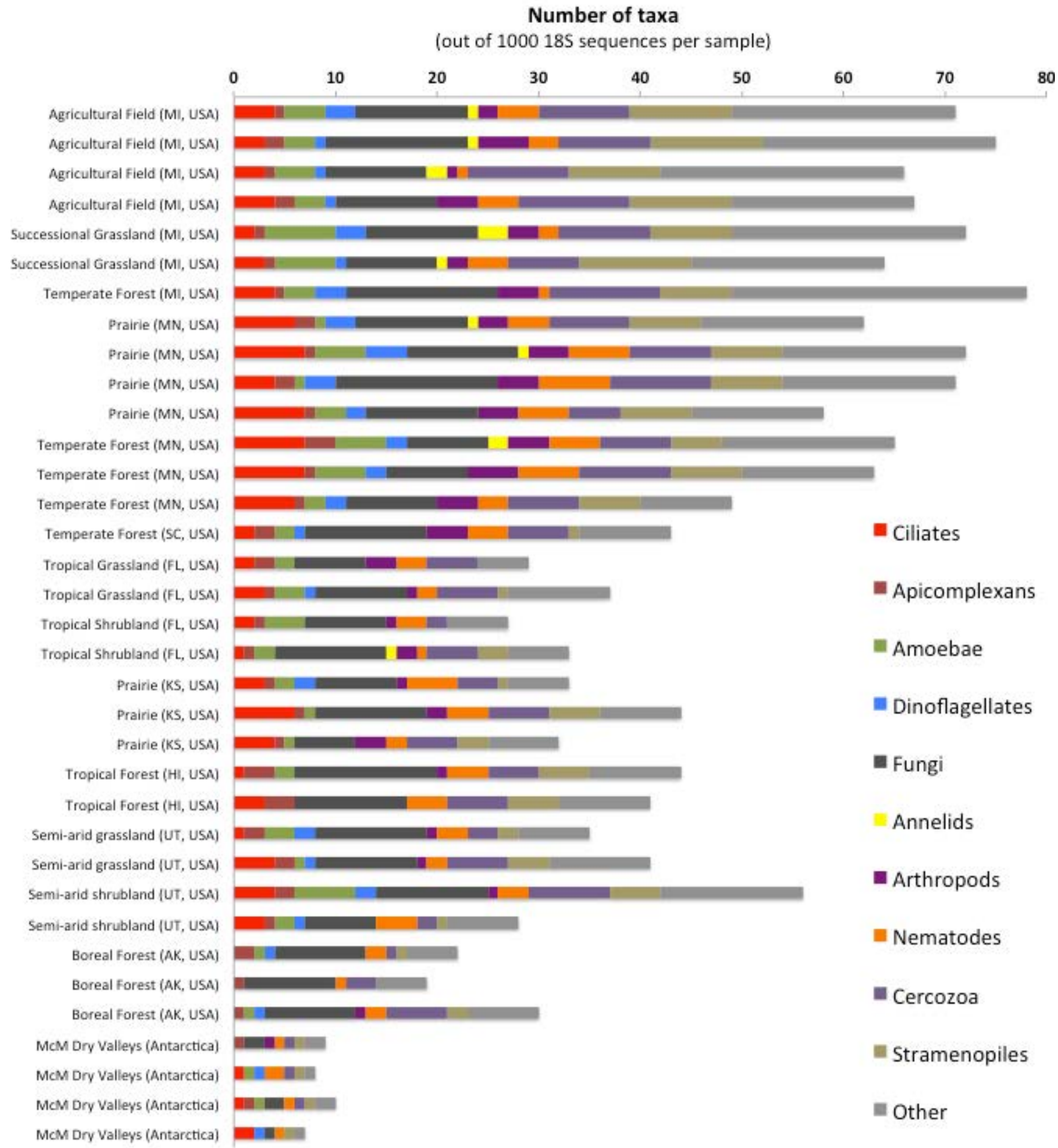
http://mcmlter.org


BIODIVERSITY IN THE ANTARCTIC
Another penguin
A penguin
S. Harris
SIDNEY HARRIS

Comparison of Eukaryotic soil diversity

Number of taxa per sample based on taxonomic level (NCBI level 5)

Taxonomic units based on 97% sequence similarity



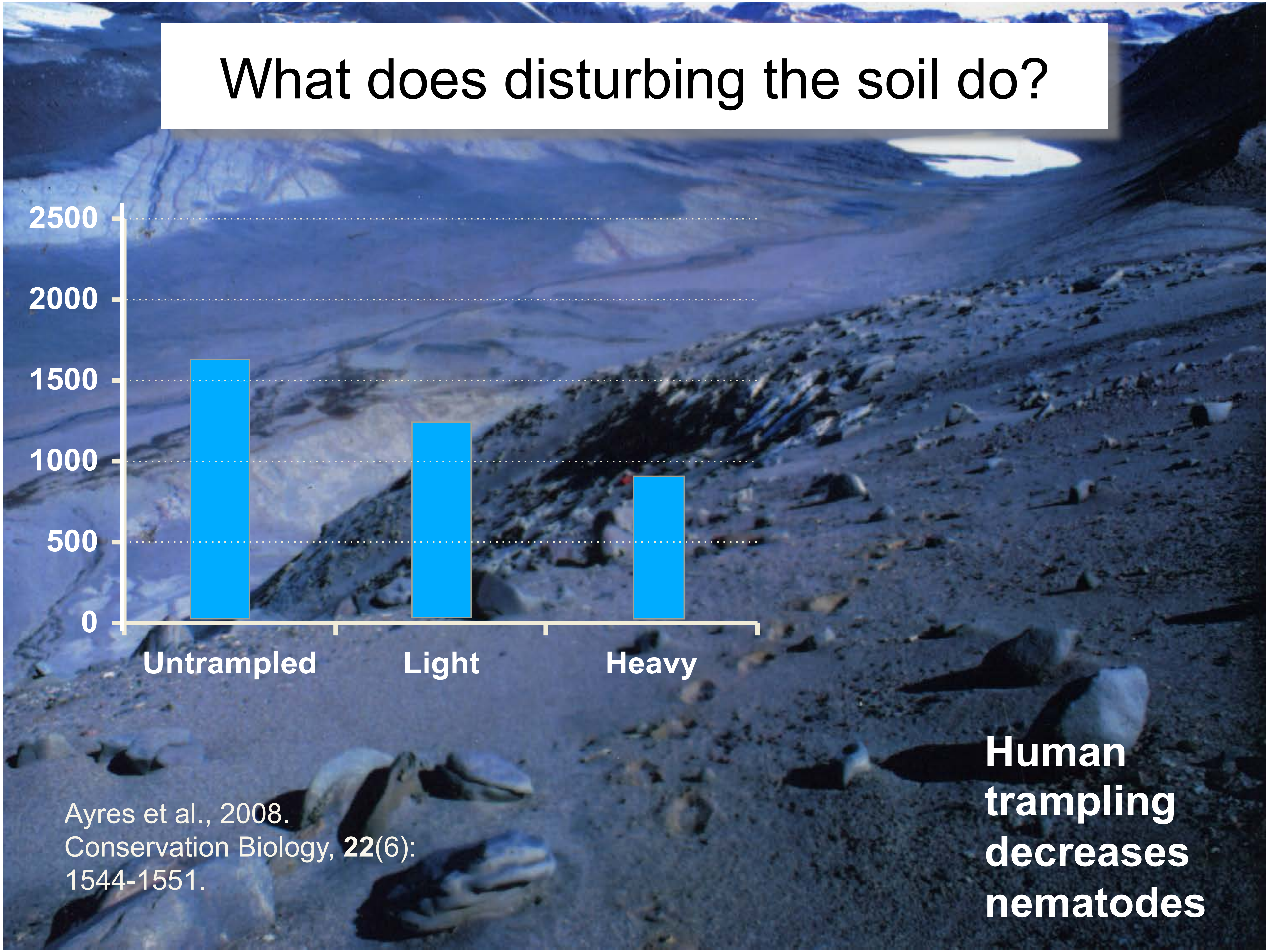
Noah Fierer

Constraints on doing field work:

Difficult environmental conditions, logistics
Limited access and duration of field time
Limited size of field teams
Restrictions on sampling & conducting experiments


BFC

What does disturbing the soil do?



Human trampling decreases nematodes

Ayres et al., 2008.
Conservation Biology, **22**(6): 1544-1551.

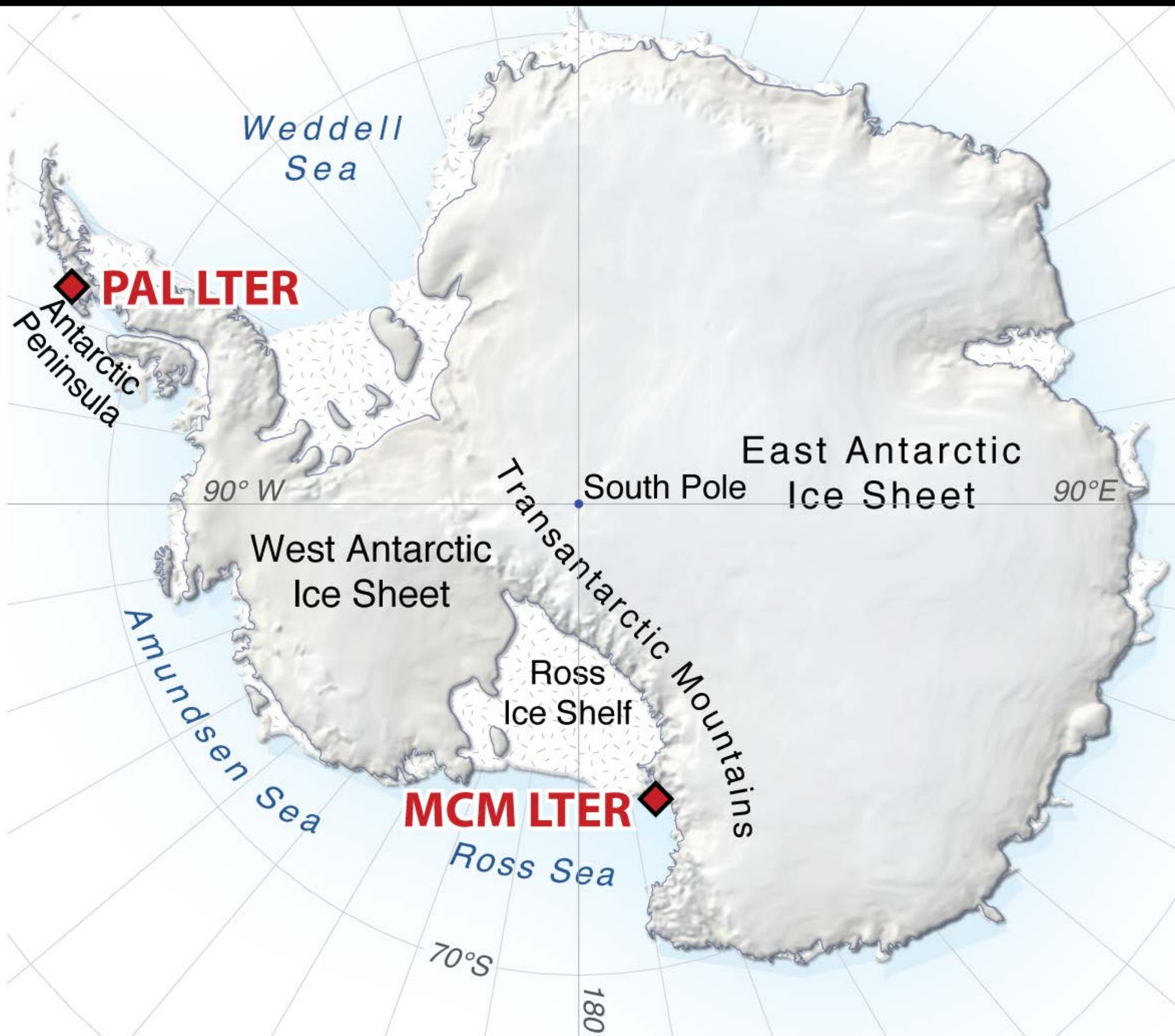
Collaborative Imperative

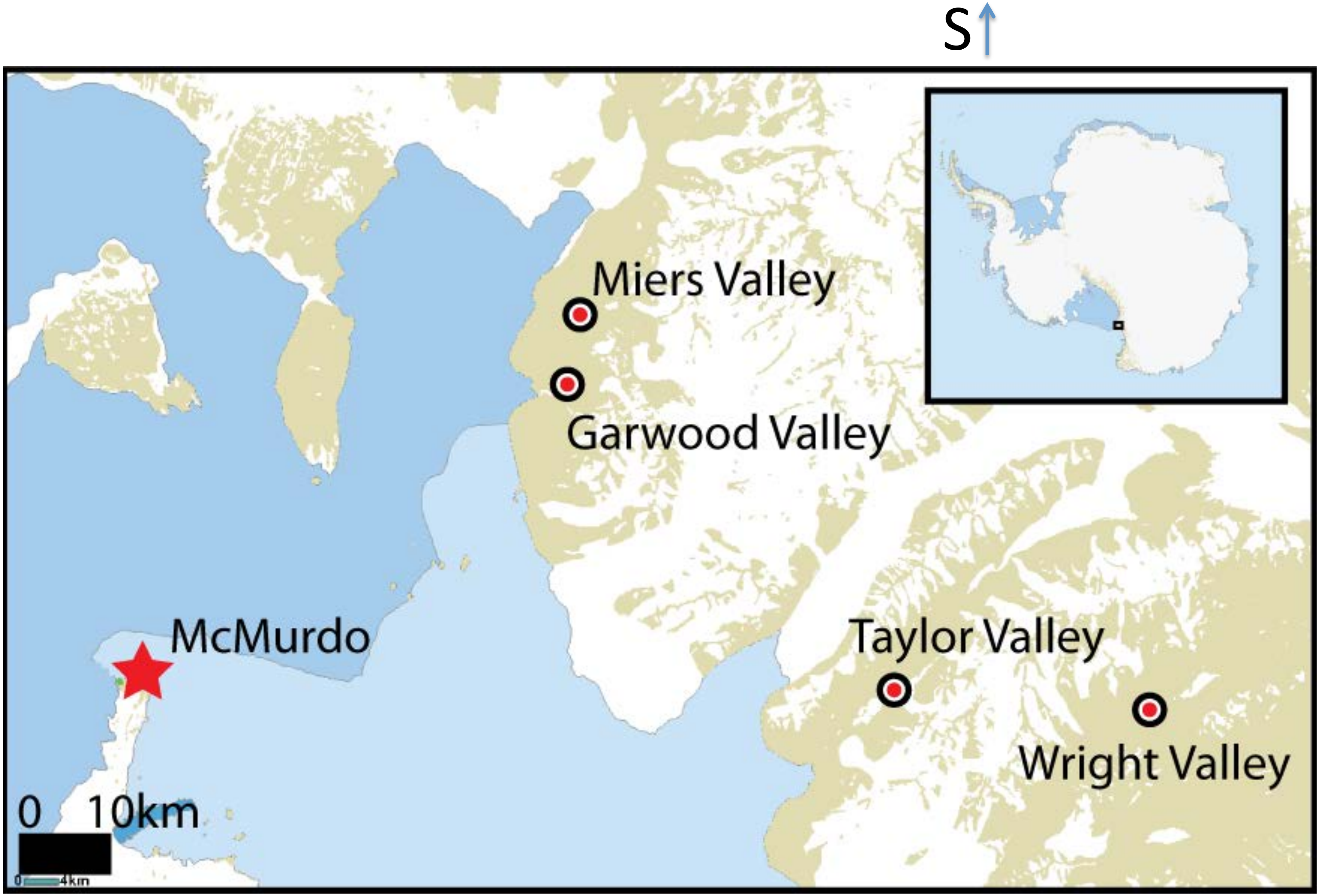
"The aim of this Management Plan is to conserve and protect the unique and outstanding environment of the McMurdo Dry Valleys by managing and coordinating human activities in the Area such that the values of the McMurdo Dry Valleys are ***protected and sustained in the long term, especially the value of the extensive scientific datasets that have been collected***." (emphasis added)

Establish environmental protection guidelines and policies

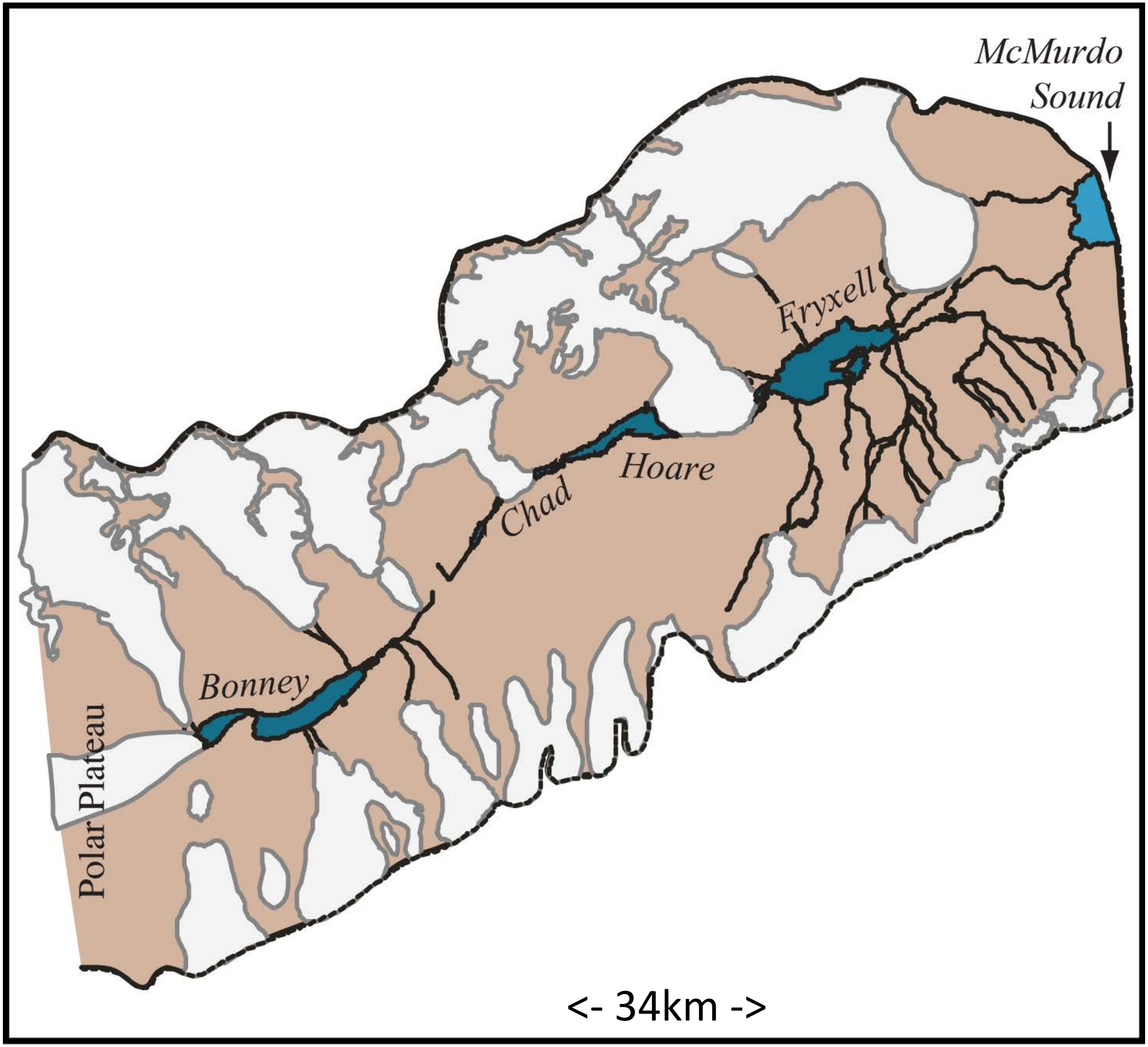
- Regulate conduct and access to especially sensitive areas
- Minimize human impacts and preserve valuable scientific attributes

A McMurdo Dry Valleys Terrestrial Observation Network

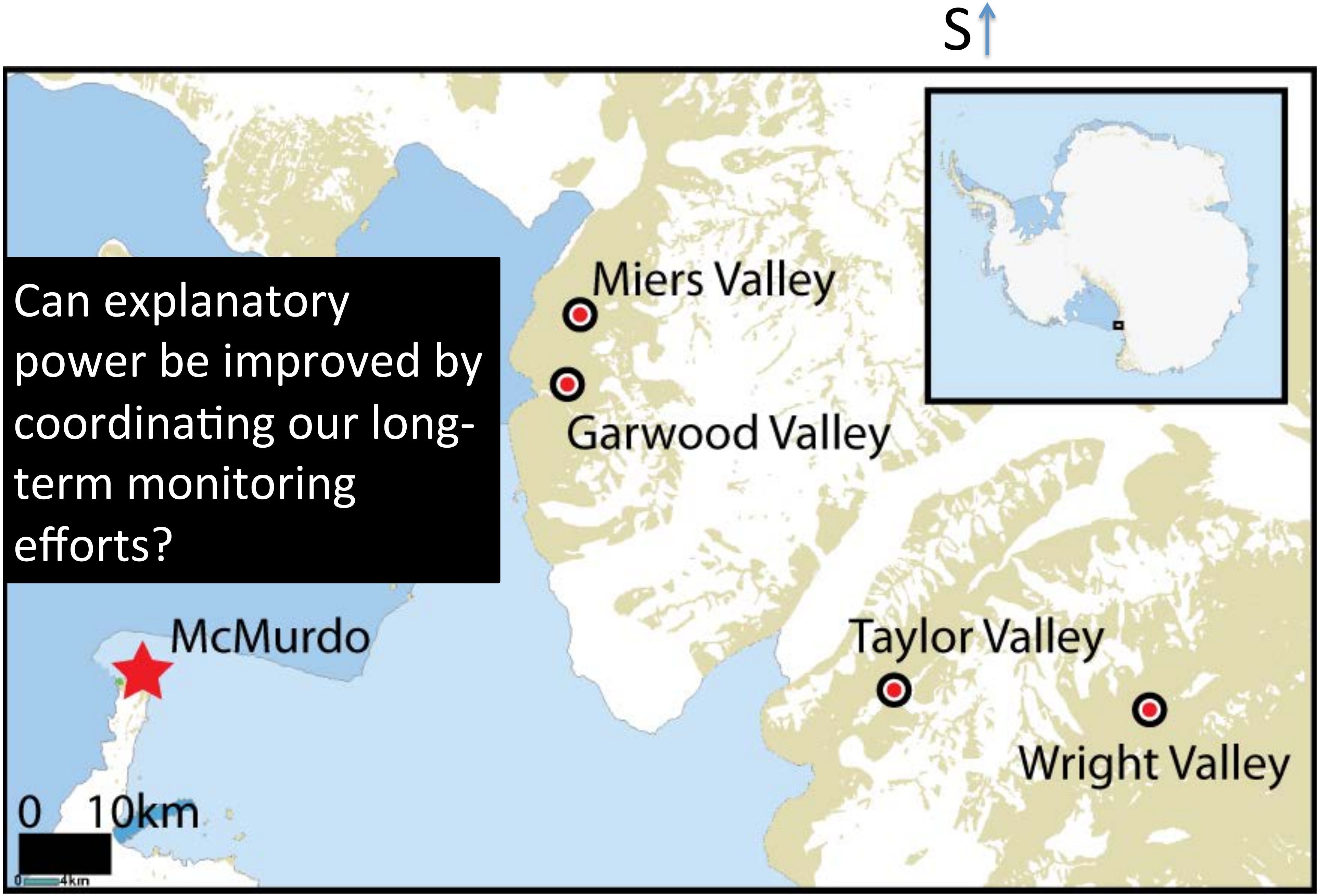




S
Miers Valley
Garwood Valley
McMurdo
Taylor Valley
Wright Valley
0 10km


McMurdo
Sound
Fryxell
Hoare
Chad
Bonney
Polar Plateau
<- 34km ->

Can explanatory power be improved by coordinating our long-term monitoring efforts?



Long-Term Data Records

Habitat	Region	Time Period	Description	Program
Lake Ice	Taylor Valley	1990-present	Ice Thickness	US
Epilithon	Northern Victoria Land	2002-present	250km transect	Italy
Mosses	Lake Fryxell Basin	1974-present	Species inventories	New Zealand, Australia
Soil (metazoans)	Taylor Valley	1989-present	ChlA, demographics	US
Soil (microbiology)	Northern Victoria Land	2002-present	16 plots in 8 locations	New Zealand
Cryoconites	Canada Glacier	1970's-present	Community data, chemistry	US
Phytoplankton	Dry Valleys	1989-present	Biomass, NPP, diversity	US
Stream Flow	Dry Valleys	1969-present	Longest stream flow record	New Zealand & US
Microbial mats	Taylor Valley & coastal regions	1980's-present	Biomass, biodiversity	New Zealand & US

The McMurdo Dry Valleys Terrestrial Observation Network: An NSF Workshop

July 14-15: Portland, OR (just ahead of the SCAR open science meeting)

Scientists studying McMurdo Dry Valley ecosystems will be invited to identify key processes of ongoing and future environmental changes and how to best measure them. Recommendations for coordinated measurements and data dissemination will be drafted, as well as a mechanism for assessing the effectiveness of current ASMA environmental protection guidelines. This workshop will also serve as a visioning effort towards extending draft recommendations for the McMurdo Dry Valleys to other Antarctic terrestrial ecosystems.

- Objectives
- Agenda
- Participants
- Steering Committee
- Venue

This material is based on work supported by the National Science Foundation under Grant No. OPP AISS 1241487. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Questions for a Terrestrial Observation Network

- What are the key Dry Valley ecological processes that need to be measured?
- How should these processes be measured?
- How can these data best be coordinated and disseminated?
- How can these measurements inform environmental stewardship and management decisions?

Objectives for a Terrestrial Observation Network

- Identify the optimal, complementary suites of measurements required to assess and address key processes associated with environmental change in Dry Valley ecosystems
- Develop standards and protocols for gathering the most critical biotic and abiotic measurements associated with the key processes driving environmental change
- Generate an IMS that will maximize the utility of these data
- Assess the effectiveness of current McMurdo Dry Valley ASMA environmental protection guidelines

What do we Measure? Abiotic States and Drivers

State/Driver	Example Measurements	Informing
Weather & Climate	Continuous meteorology over long-term; Surface energy balance components	Potential shifts in regional climate; Quantity of surface heating and ice melt; Thermal status of soils, glaciers, lakes, and streams
Chemistry	Soil, rock, water, ice, snow, air Include organic and inorganic species, dissolved and particulate	Potential shifts in biogeochemical cycling; Changes to salt distribution, nutrient status
Water	Lake volumes; soil moisture; Streamflow; Glacial runoff	Potential shifts in melt generation; Potential aquatic habitat
Aeolian Transport	Wind direction and intensity; Quantify material that is moved, source location, and fraction of organic vs inorganic	Connectivity of landscape units; Quantity of redistribution of nutrients and organic material
Snow and Ice Processes	Glacier volumes and extents; Snow cover extent; Lake ice extent and retreat during summer; thickness	Potential melt water generation changes, soil habitat changes, thermodynamics or light regime
Landscape Change	Physical and chemical weathering; Erosion and mass movements; Permafrost dynamics, extent;	Potential shifts in geomorphologic activity, biogeochemical cycling;

What do we Measure? Biological aspects and Proxies

Characteristic	Biological aspect/Proxy
Ecosystem Structure	Biomass Invasion Competition Colonization/extinction Trophic structure and interaction Abundance Reproductive state Distribution/range shifts Composition Diversity Coverage Dominance Succession Faunal impacts (seals, skuas, penguins, etc.)
Ecosystem Function	Biogenic gas flux generation Growth Metabolic rates Nutrient limitations Nutrient cycling

How do we measure Physical States/ Processes

	measurements	tools	Sampling frequency
Weather/ climate	Air temperature; precipitation; solar radiation; albedo	Met towers	Continuous
Heat content	Surface temperatures (lakes, streams, soils, glaciers, and permafrost); Active layer thickness	Soil moisture profilers	
Landscape processes	Weathering rates; Erosion and mass movements; Permafrost dynamics; Periglacial processes; groundwater sources	Electrical tomography; Isotopic signatures	Every 10 years
Aeolian transport	Wind speed/direction; Particle movement	Acoustic particle sensors	Continuous at MET towers, annual particle collection

Habitats: **How** do we measure them?

	Measurements	**Tools**	**Sampling frequency**
Snow and Ice	Glacier volume/extent* Snow cover/extent Lake ice dynamics Glacial runoff	Snow cover using satellite imagery; Ground-penetrating radar; Time-lapse imagery of snowpacks	Annually for on-the-ground measurements; every 5 years for remote sensing
Waterbodies	-Stream flow -Lake levels* -Water quality	Stream discharge and real-time telemetry; Lake level surveys Water surface color GPR; water chemistry	Continuous, annual, continuous, continuous
Soils	-Soil biogeochemistry -Elemental ratio analysis - Ground/surface water extent* Terrestrial snowpack	Conductivity* Active layer surveys Soil moisture profiling Snowpack surveys	Annual

*Can be measured using remote sensing tools

How do we measure Ecosystem Responses?

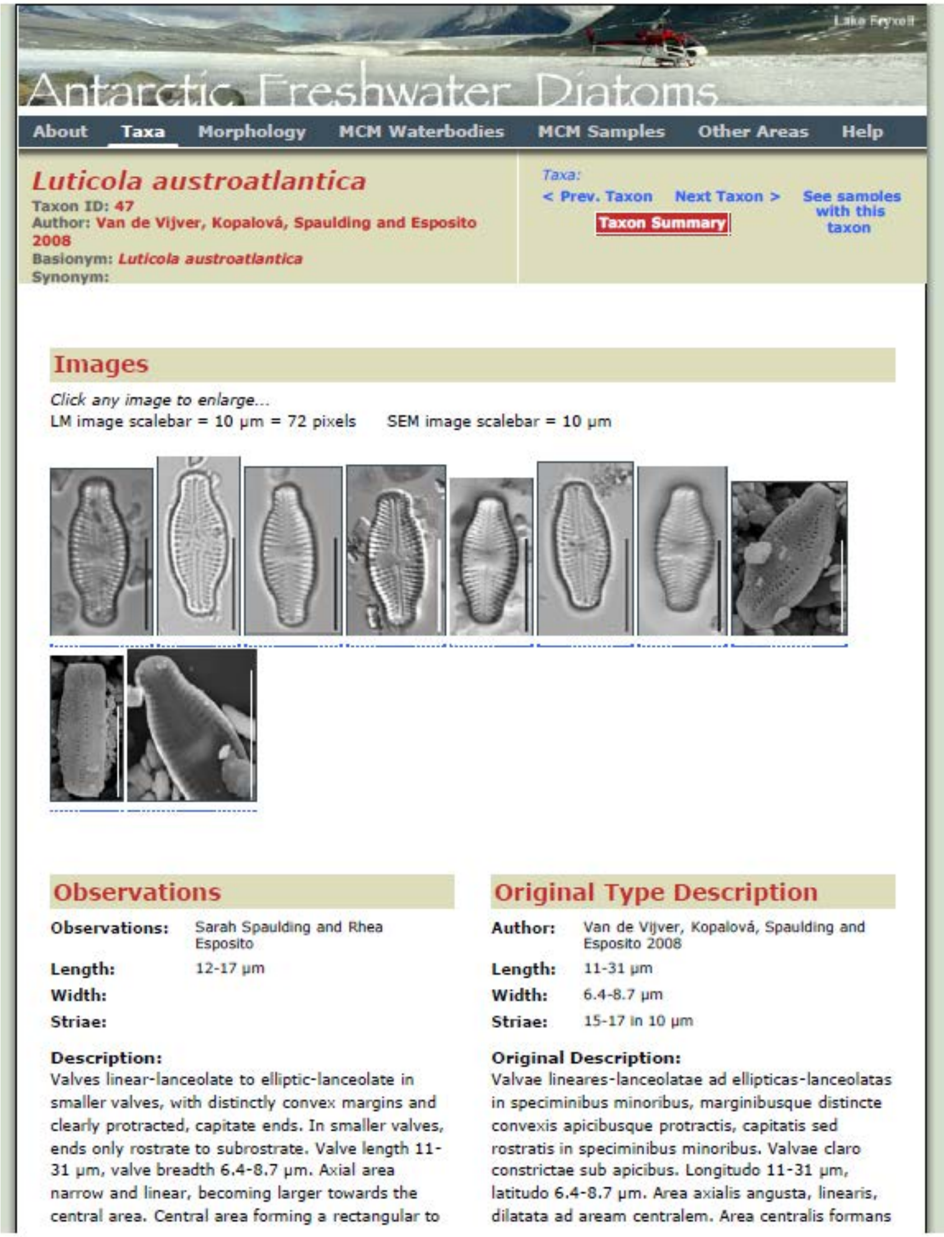
Primary metric	Purpose	Sampling frequency & Method
Bacterial/archaeal community composition	Community ecology (α,β,γ diversity, neutral processes)	3-5 years, following extreme events, using genetic tools
Eukaryotic microbial community composition,	Community ecology	3-5 years; microscopic and genetic tools
Metazoan community composition	Community ecology	"
Lichen abundances and distributions	Community ecology Climate change	5-10 years using ground-based photography
Trophic structure and interaction	Tracking changes in strength of biotic interactions	5-10 years
Faunal inputs to Dry Valley ecosystems	Tracking nutrient pulses	5-10 years
Biological activity in lakes	For modeling annual lake water production rates	Annually using in-situ stable isotope and C-14 uptake
Species invasions		Risk analysis and surveillance, 3-5 years

How do we measure Ecosystem health/ function? Assess Management Policy?

Primary metric	Purpose	Sampling frequency
CO_2 gas flux rates	Primary production rates and C cycling	Continuous using force-diffusion flux chamber
Photosynthetic rates	Primary production	Continuous using PAM fluorometry
N transformation rates	N cycling	2-5 years
Biomass (streams, soils, lake plankton and benthos)	Productivity and C cycling	Annual
Chlorophyll content	Primary productivity	Annual
Growth rates	Productivity and C cycling	3-5 years
Vegetation mapping and coverage	Regional model development, remote sensing applications	Initial surveys for validation of remote sensing tools

How do we develop and IMS for all this?

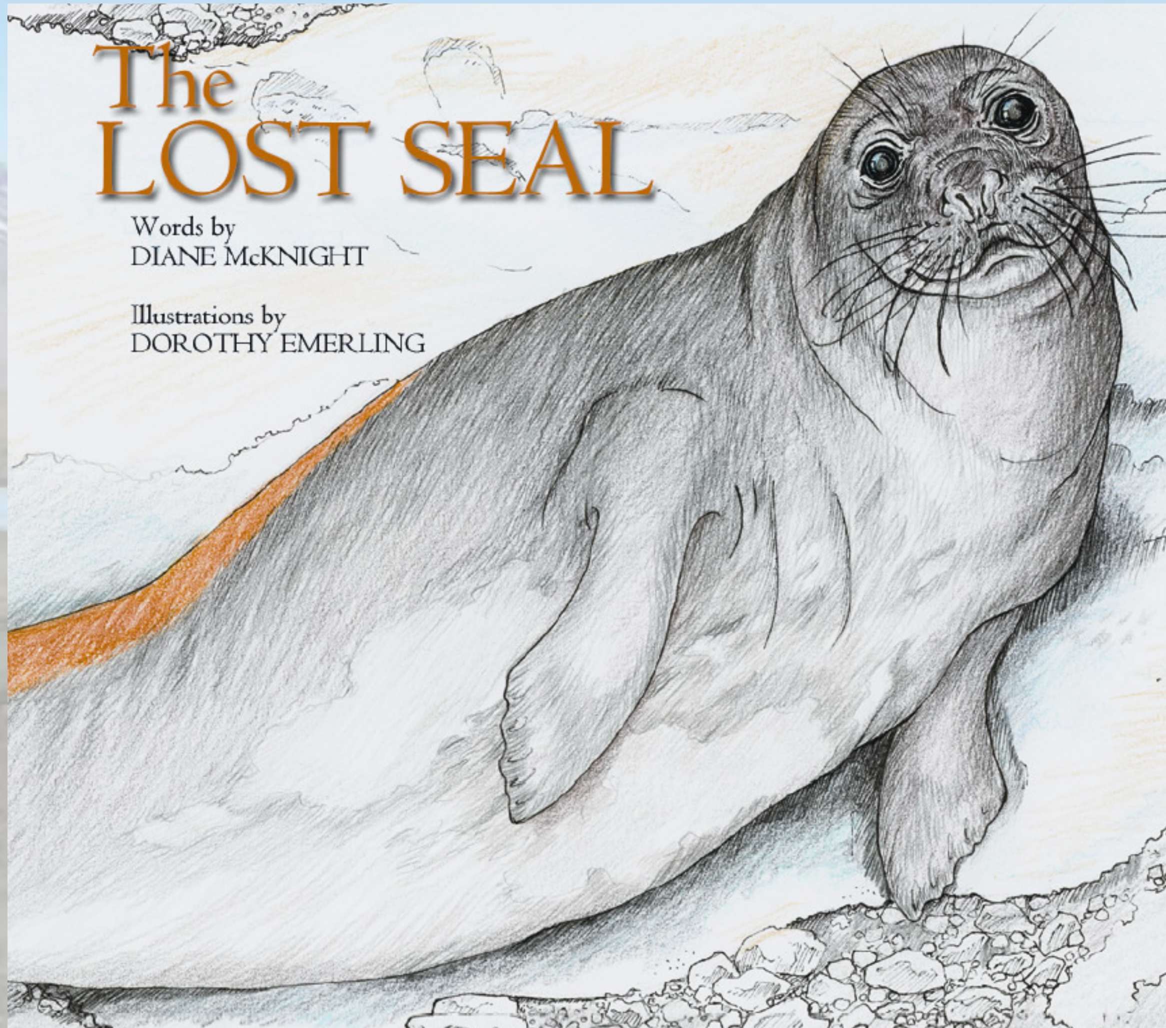
- Re-use of current data repositories
  - ANTABif, MCM LTER, SCAR Antarctic Digital Database
- Searchable through a central metadata catalogue
- All interacting databases conforming to established standards
  - EML, ISO, BDG and MIMARKS



Antarctic Freshwater Diatoms: relational database and website with over 200 taxa

http://huey.colorado.edu/diatoms/about/index.php

The Lost Seal describes the first documented encounter with a live seal in the Dry Valleys. The story provides an engaging framework for conveying how different Antarctica and the McMurdo Dry Valleys are from the environments with which children are familiar.



La Foca Perdida
International Outreach

- *Lost Seal* Schoolyard LTER book translated into Spanish
  – a wider audience, both nationally and internationally.
- The English version of the book includes pictures drawn by schoolchildren in the United States, Britain, Australia and New Zealand. The Spanish language version will have pictures drawn by children in Spanish-speaking countries.
  – We started with children in Chile and Argentina since both of these countries have longstanding scientific and political interests in the Antarctic continent.
- In March and April 2013 Seven class visits were made to three schools in Punta Arenas (Chile), Viña del Mar (Chile) and Buenos Aires (Argentina).
- Over 150 children from South America participated in this project; artwork has been uploaded to our website: http://www.mcmlter.org/lostseal/

Summary

- The McMurdo Dry Valleys are an extremely valuable contributor to Long-Term Ecological Research on environmental change
  - The sensitivity that makes them perfect for understanding ecological changes also makes them *sensitive to science activities*
  - International efforts created science conduct and management policy
- The MCM Terrestrial Observation Network
  - International, Coordinated Science:
  - Key Measurements, Standards, Protocols, Information Management & Policy Assessment

Concluding Thoughts

- The power to measure **key processes associated with environmental change** is enhanced through a landscape scale terrestrial observation network.
- International collaboration provides **improved explanatory power:**
  - **Regionalization:** local models of how our system works across a much larger geographical area
  - **Scientific Excellence:** highest caliber scientists helping us to shape our interpretation of what is going on in these ecosystems.
    - Exchanges build capacity and offer opportunities for cross-site comparisons

Special Thanks

LTER Network & the MCM LTER

Antarctica New Zealand

Australian Antarctic Division

Korean Polar Research Institute

Italian Antarctic Research Program

National Science Foundation:

Polly Penhale, Sonia Esperanca, Peter Milne, Scott Borg, Kelly Faulkner, Julie Palais, Henry Gholz, Roberta Marinelli


NSTAAR
Institute of Arctic and Alpine Research
20