

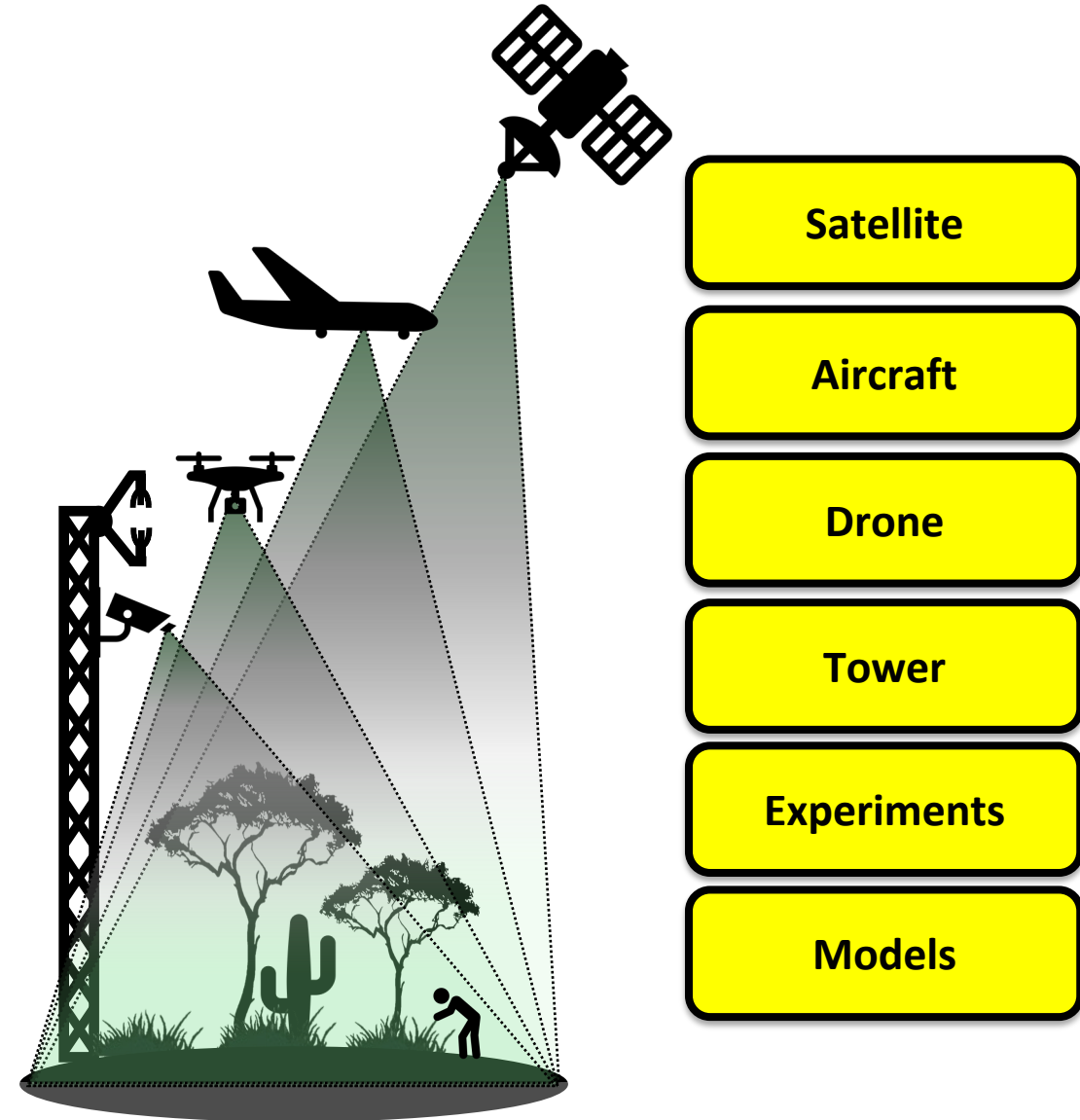
Actionable science for Earth's changing drylands



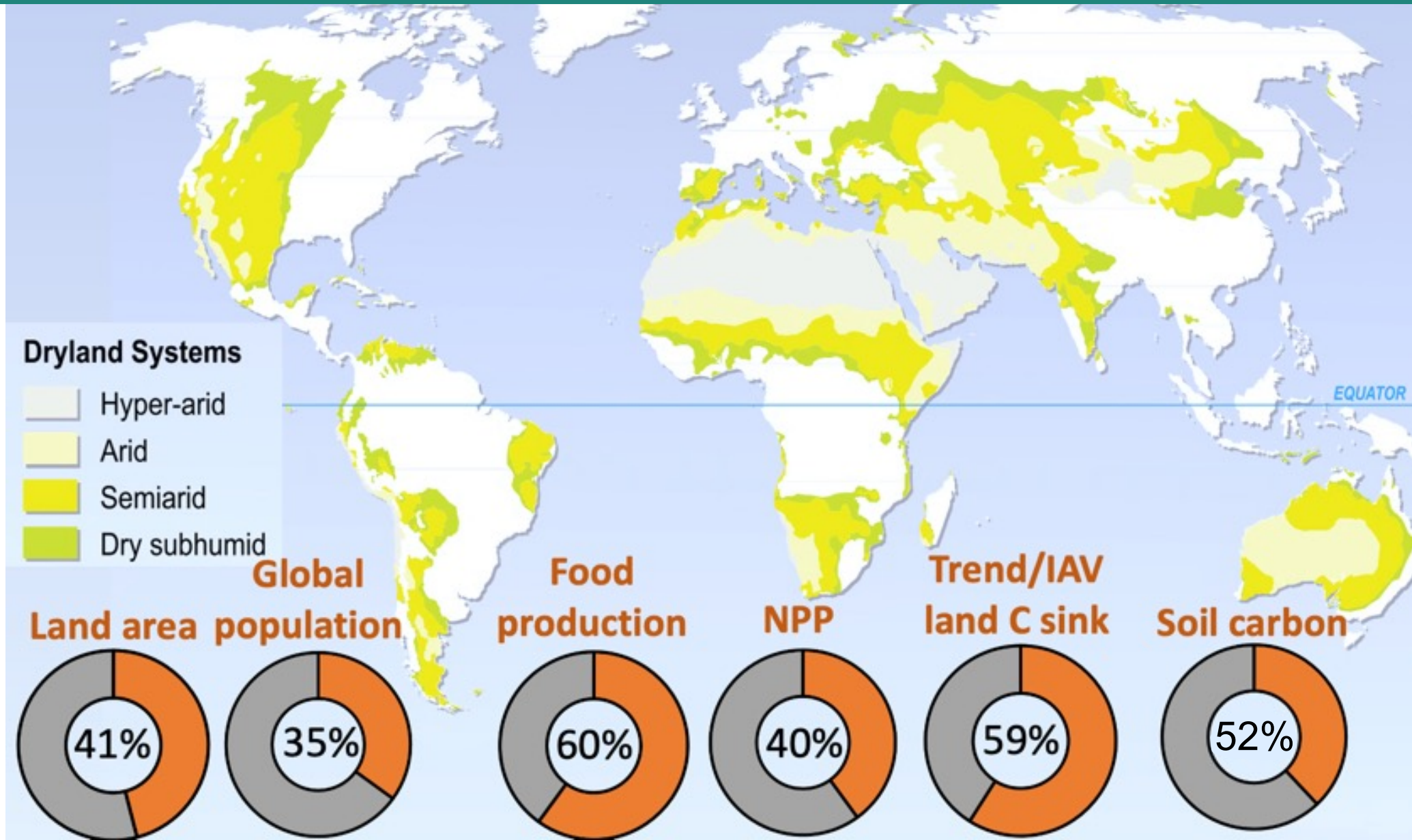
NASA Terrestrial Ecology Field Campaigns are designed to build understanding for complex systems

NASA Terrestrial Ecology field campaigns focus the community's attention on:

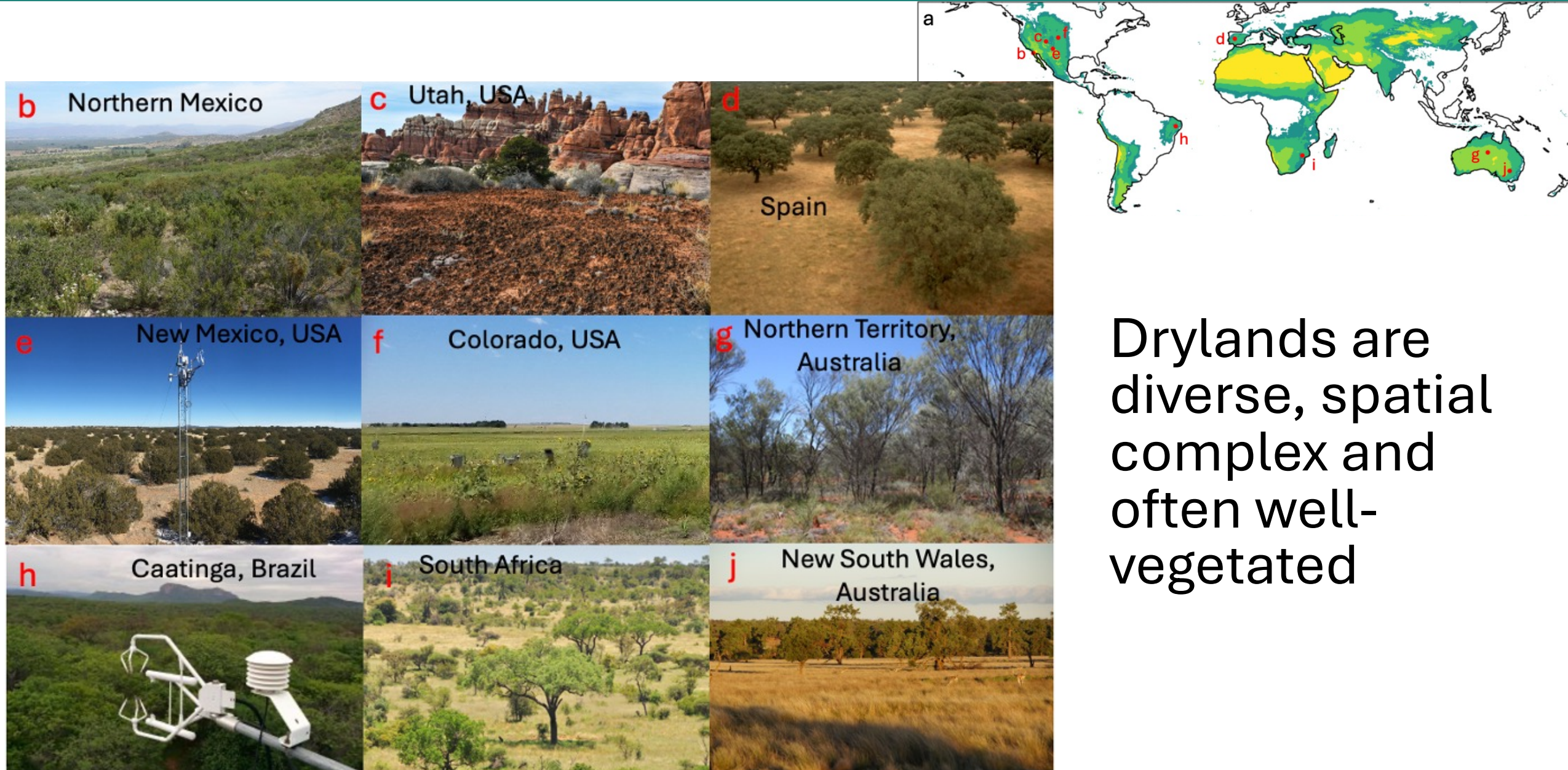
- (a) **answering big science questions** targeted on important regions or biomes
- (b) enabling **more effective interpretation** and analysis of space-based measurements
- (c) fostering **collaborative interactions** and building new relationships within the scientific community
- (d) providing valuable opportunities for training and educating the **next generation of scientists**
- (e) leaving a **legacy data** of great value for future research.



Why focus on drylands?



Drylands are often very green!



Drylands are diverse, spatial complex and often well-vegetated

Hotspots for Change: Drought + Heatwaves

Western US drought one of largest seen in over 1200 years

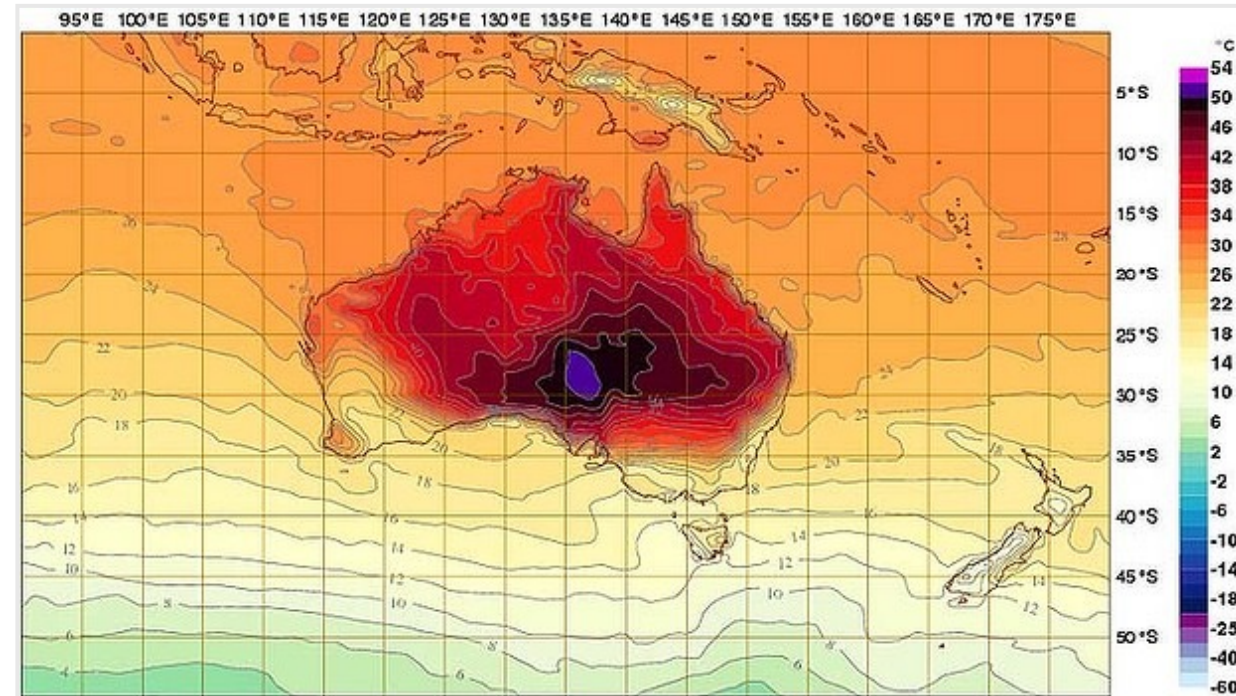
It's so hot in Phoenix, Ariz., that 42 C is considered cooler as record high temperature streak ends

Historic heat began blasting multiple regions across the U.S. in June

The Associated Press · Posted: Jul 31, 2023 9:35 PM EDT | Last Updated: July 31, 2023



Temperature map of Australia



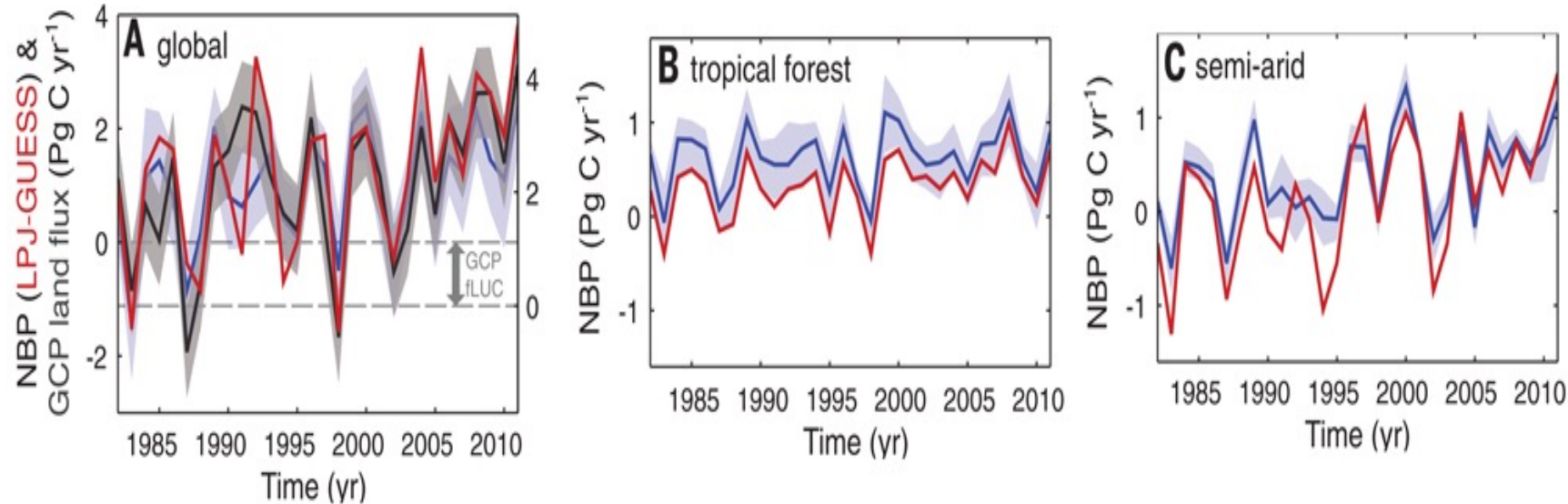
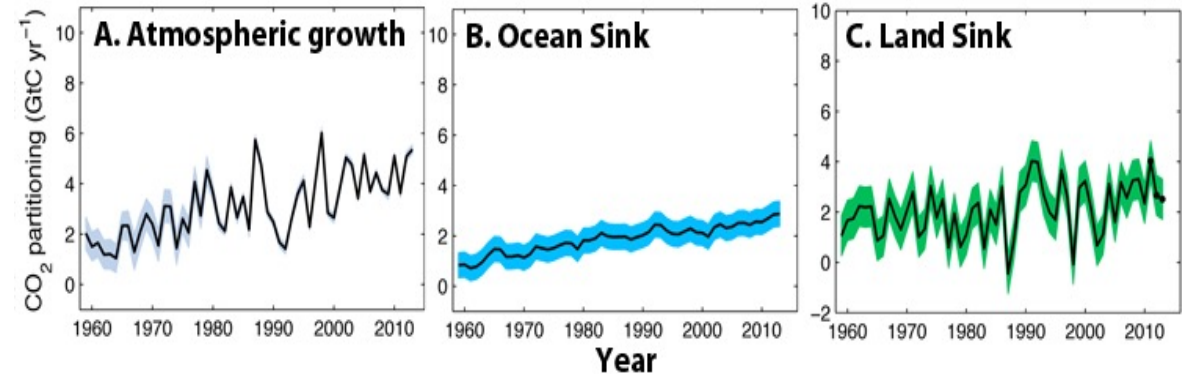
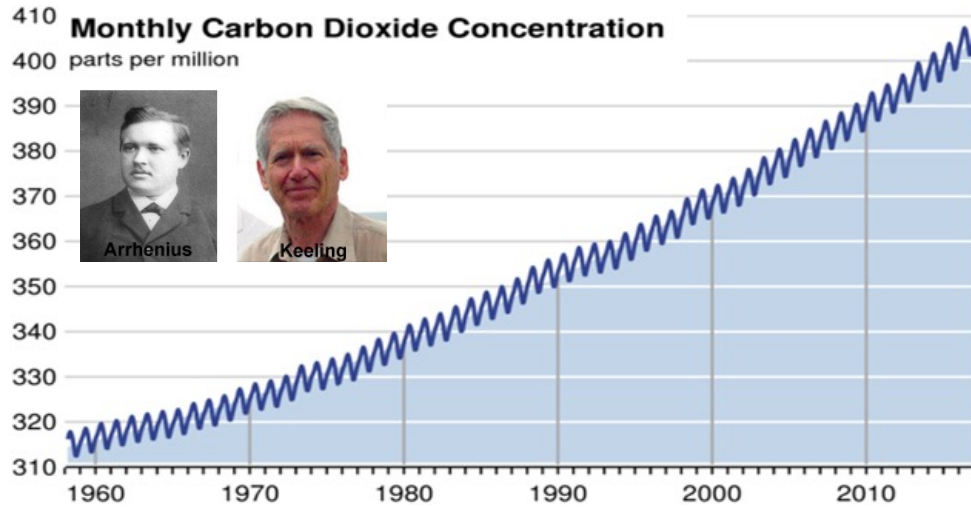
Australia's Bureau of Meteorology

Dryland systems are showing threshold-type responses to change, resulting in new communities



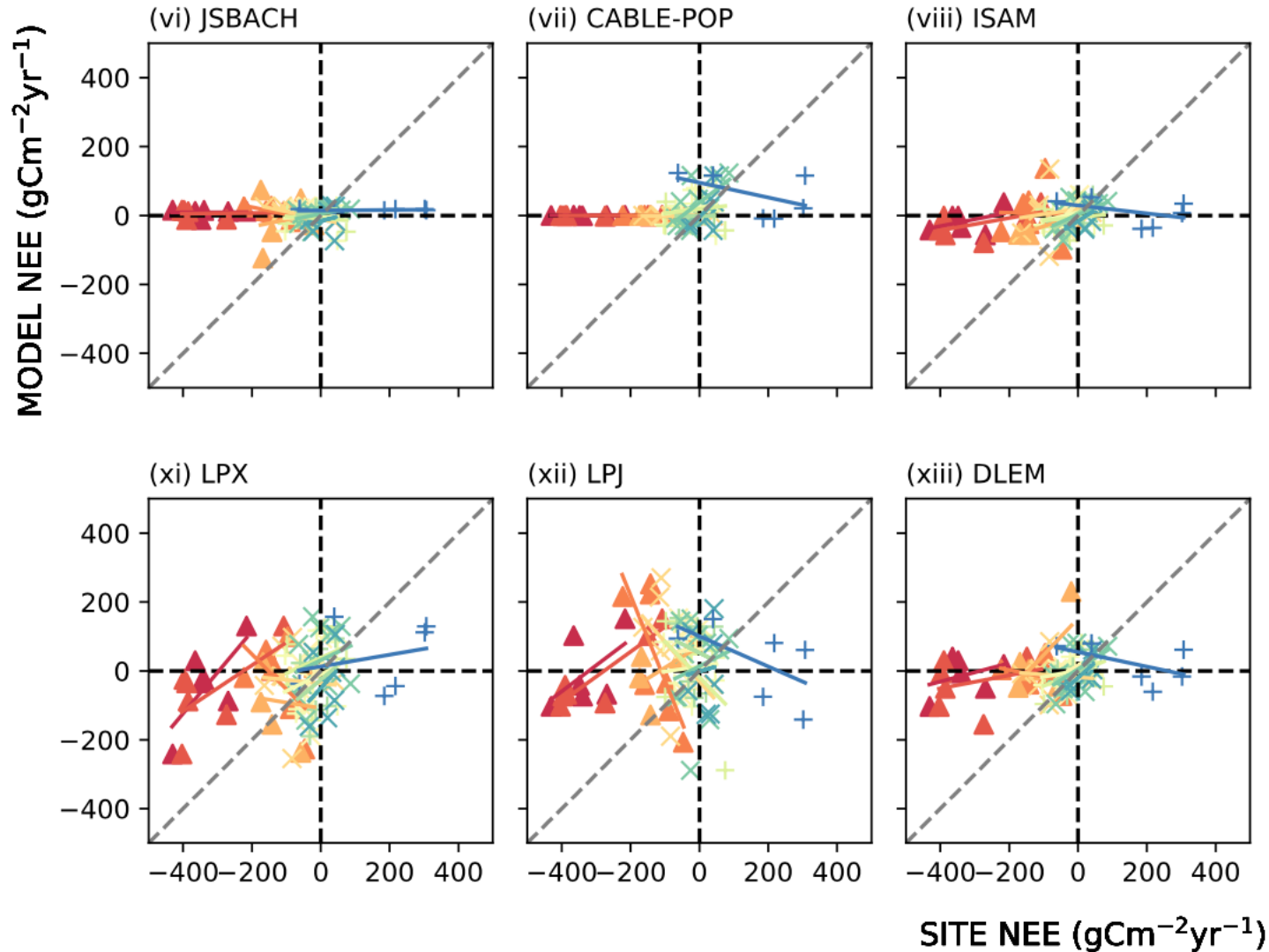
Photo by Craig Allen

Carbon Emissions & the Land Carbon Sink



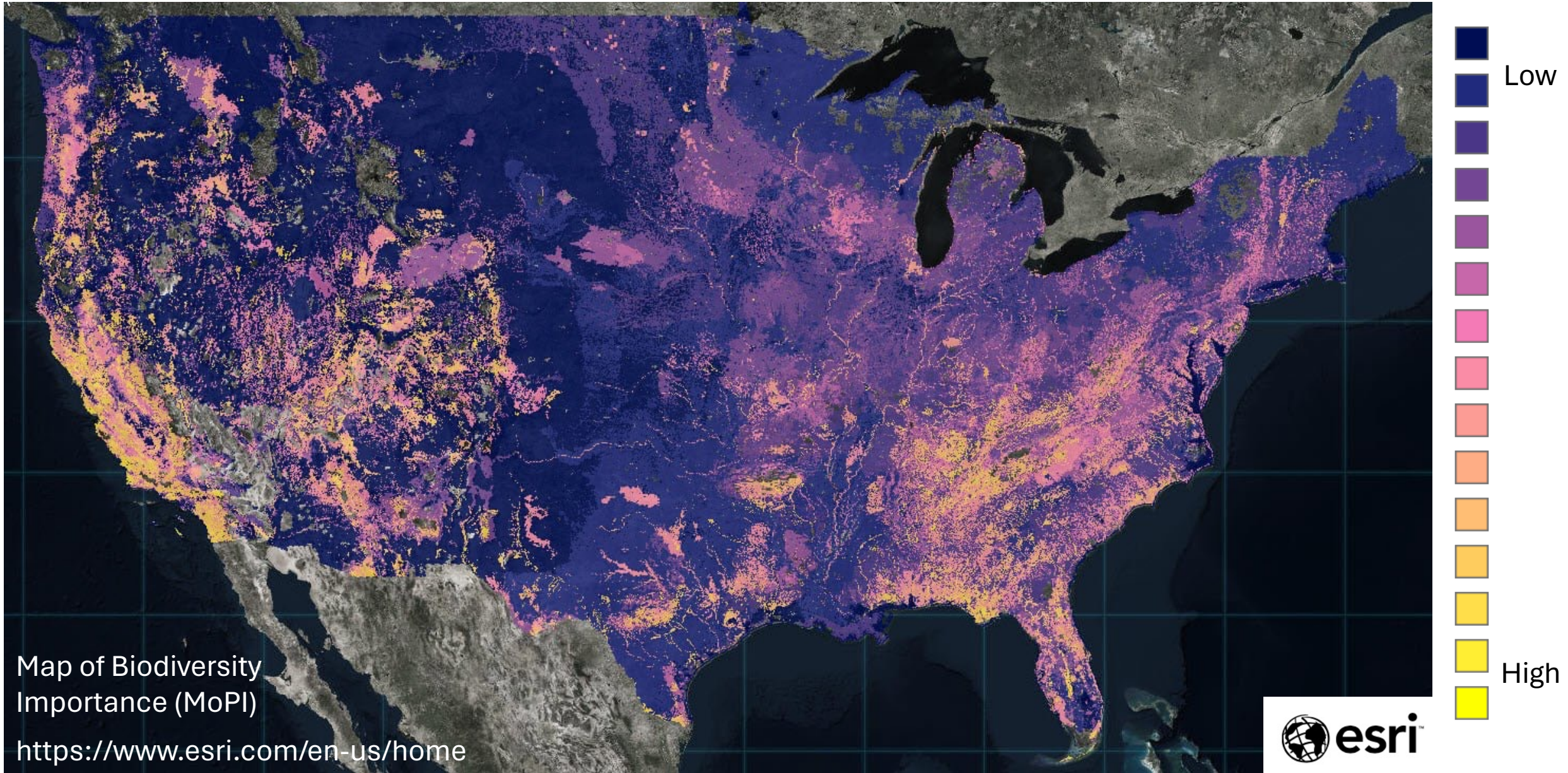
- Strong contribution of drylands to carbon interannual variability
- Challenges our ability to measure carbon emission reductions

Models do not capture dryland variability



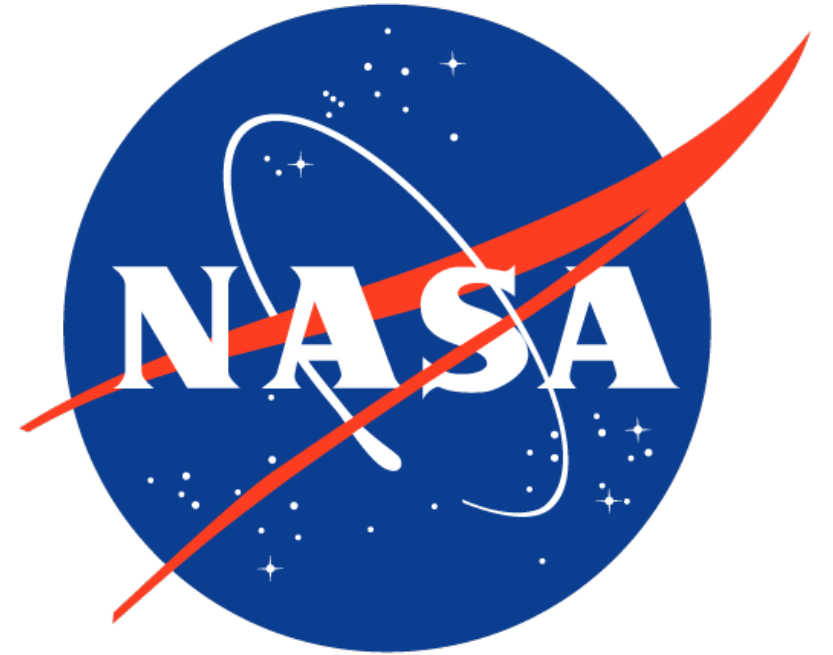
*“We find that **all the models underestimate both mean annual carbon uptake/release as well as the magnitude of net ecosystem exchange (NEE) interannual variability (IAV)**, suggesting that improvements in representing dryland regions will improve global C cycle projections...Our analysis suggests that improvements in modeling C cycle processes across more than a quarter of the Earth’s land surface could be achieved by addressing the moisture sensitivity of dryland C uptake”.*

Drylands are hotspots of critical biodiversity



The Terrestrial Ecology Field Campaign planning process

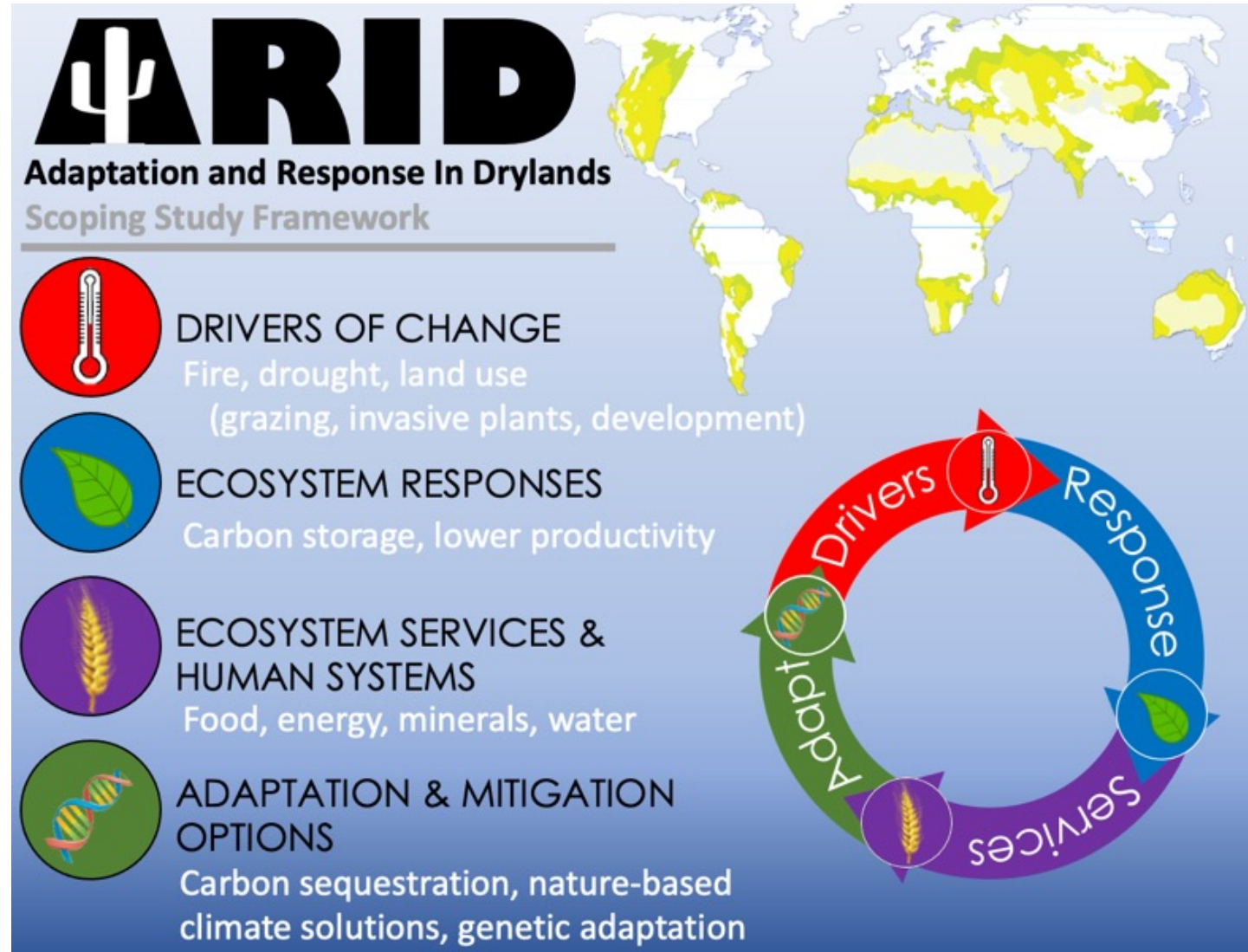
1. ✓ NASA puts out a call for scoping study proposals.
2. ✓ NASA selects two scoping studies to advance.
3. A year-long scoping study is conducted, where a plan for the larger field campaign is developed. NOW!!
4. NASA selects one (or neither or both) of the scoping study plans to advance. 2025?
5. NASA sets up Science Definition Team. 2025 – 2026?
6. The potential for a decade of impactful science with multi-million in funding open to the scientific community. 2026/2027?



Adaptation and Response in Drylands (ARID)

A multi-scale, interdisciplinary effort to revolutionize our understanding, predictions, and decision-making options for drylands

- **Fundamental science** to understand dryland processes
- **Applied science** aligned with NASA Earth Science to Action (ES2A)





Marcy Litvak
(U. New Mexico)

Flurin Babst
(U. Arizona)

Ben Poulter
(NASA)

Sasha Reed
(USGS)

Andrew Feldman
(NASA)

Bill Smith
(U. Arizona)

Konrad Wessels
(George Mason U.)

Niall Hanan
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Bob Swap
(NASA)

Russell Scott
(USDA)

Jennifer Watts
(Woodwell Climate)

Natasha MacBean
(Western U.)

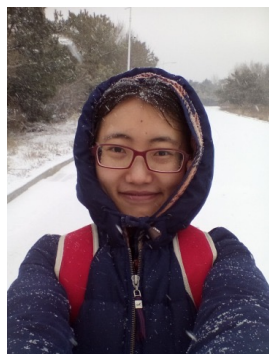
Dennis Ojima
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Cibebe Amaral
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(U. Arizona)

Wen Zhang
(U. Arizona)

Zheng Fu
(U. Arizona)

ARID Steering Committee

ARID's Goals



Photo: USDA

- **Drivers of Change:** To understand the main environmental and anthropogenic drivers of variability and change in drylands
- **Ecosystem Response:** To better understand and quantify dryland ecosystem processes and responses to perturbations, and consequently the role drylands play in the Earth system
- **Ecosystem Services:** To identify and foster conservation of dryland ecosystem services even in the face of change
- **Research Capacity Building:** Develop the **next generation** remote sensing and earth system transdisciplinary **researchers**
- **End-User and Rights Holder Capacity Building:** To foster co-development with communities of practice to inform and **enable science-informed management.**

ARID's Main Questions

- **What are drylands' contributions to the Earth System, how are these contributions shifting with anthropogenic change, and what management (e.g., mitigation and adaptation) solutions could help maintain the critical services provided by drylands?**
- **Major Themes**
 - **Climate Variability and Drought**
 - **Carbon Cycle Interannual Variability**
 - **Ecosystem Structure, Function, and Biodiversity**
 - **Social Ecological Systems**

ARID is benefitting from SO much engagement

Original Science Themes

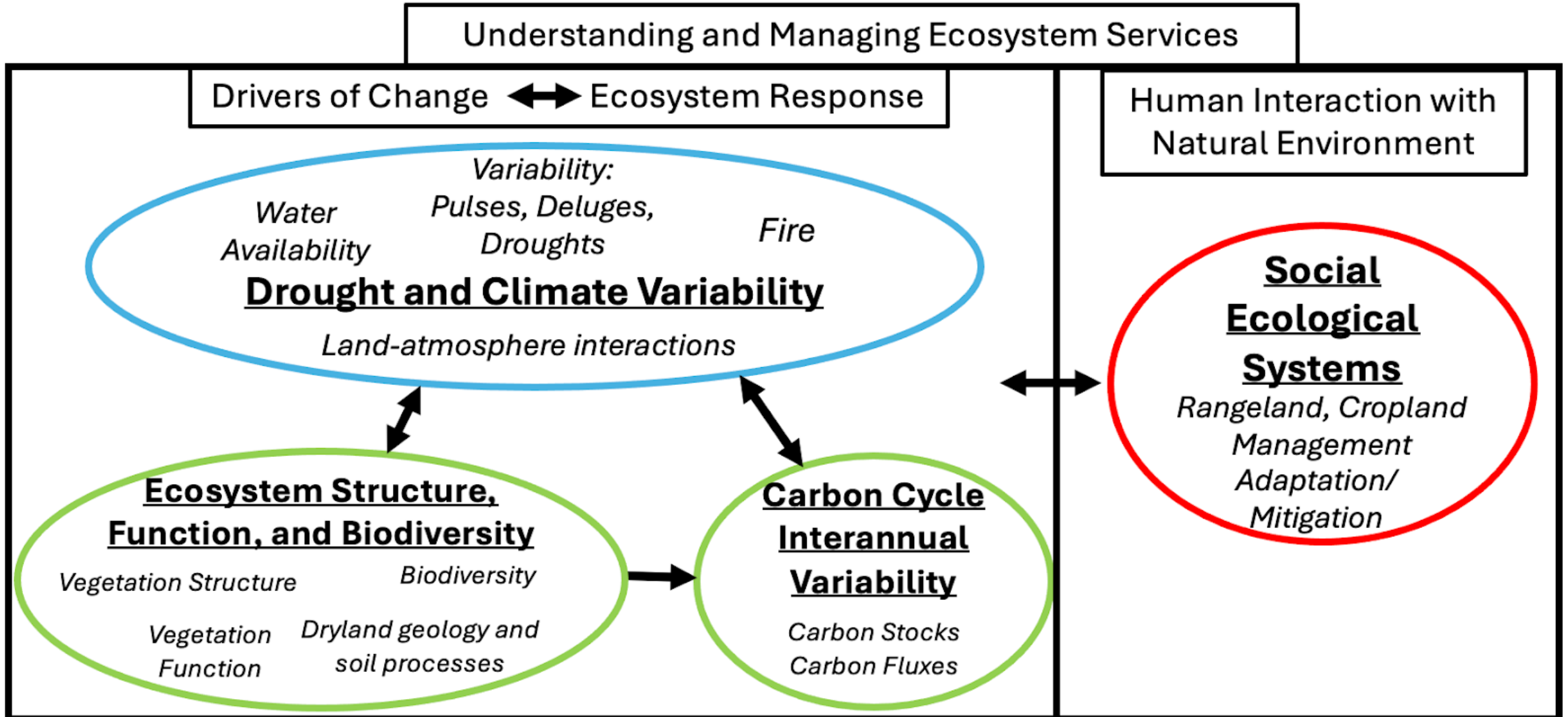
Disturbance
Precipitation change
Pulse dynamics
Ecosystem dynamics
Carbon stocks
Land-atmosphere feedbacks
Human dimensions
Adaptation and mitigation strategies

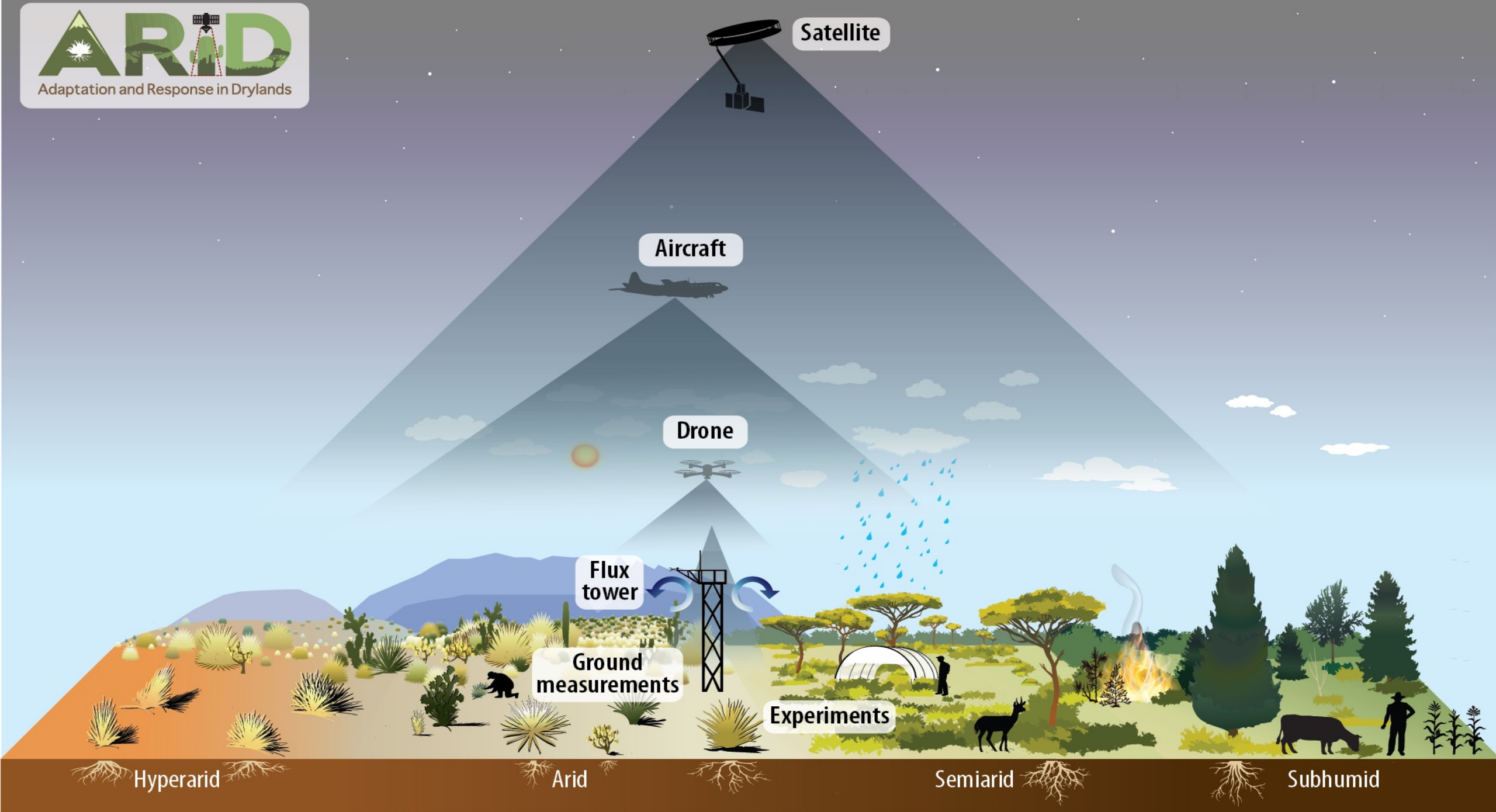


Evolving Science Themes

Water Availability
Climate Variability
Fire
Land-atmosphere feedbacks
Carbon stocks
Vegetation Structure, Biodiversity
Geology and Soil Processes
Croplands and Rangeland Management
Adaptation and mitigation strategies

ARID Science Themes





Satellite

Aircraft

Drone

Flux tower

Ground measurements

Experiments

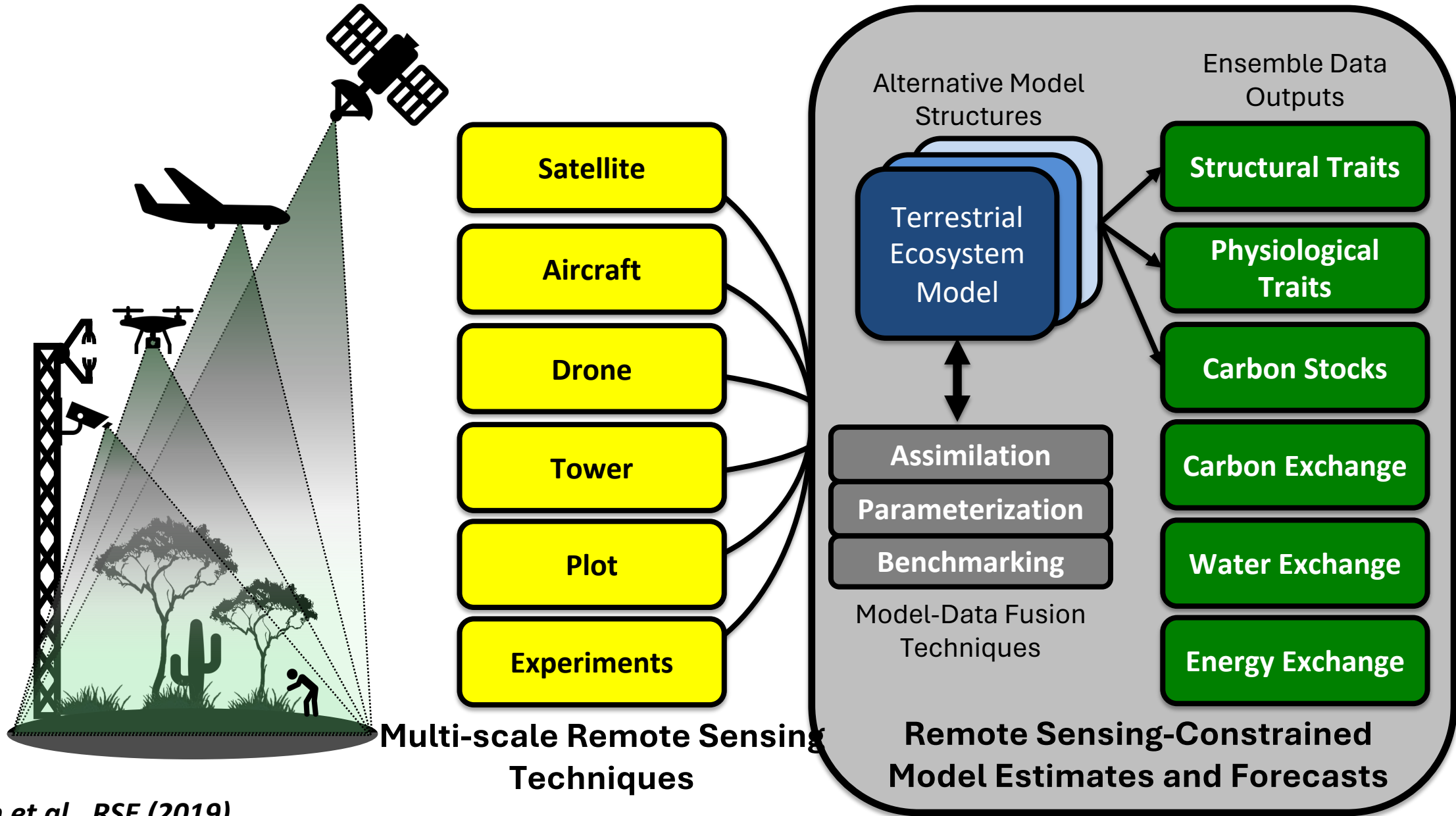
Hyperarid

Arid

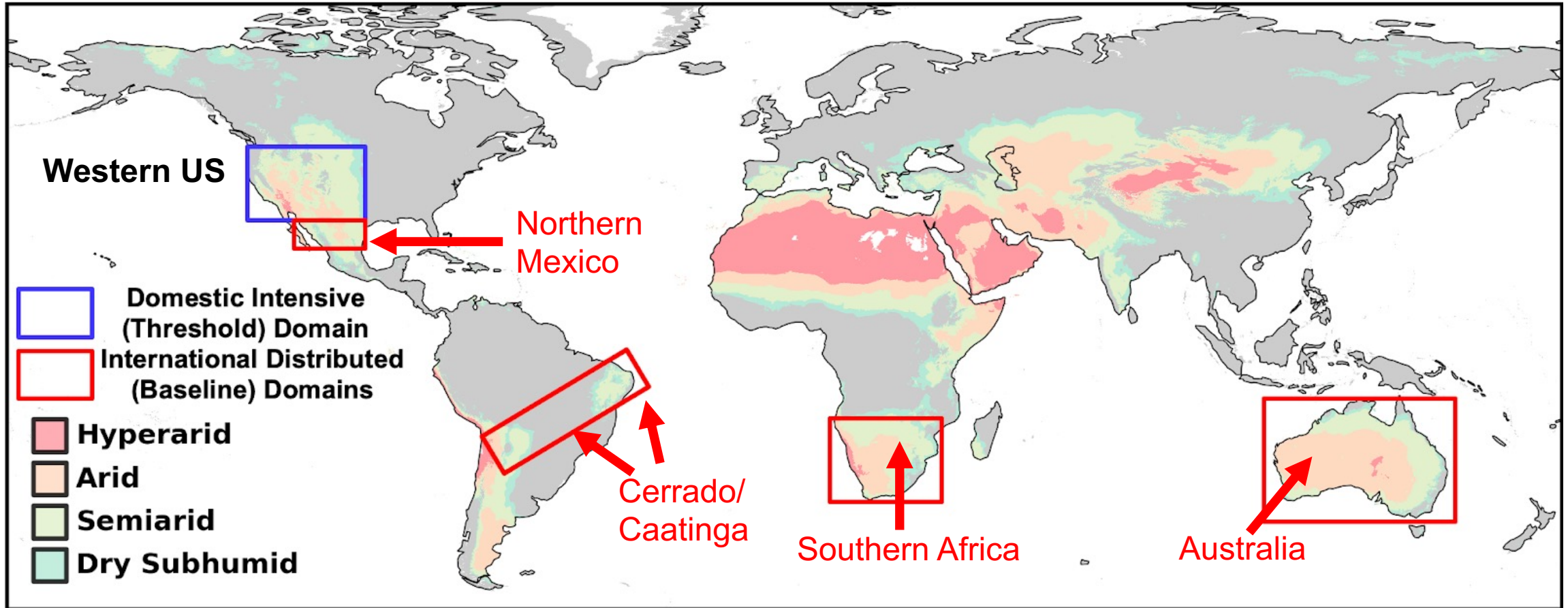
Semiarid

Subhumid

NASA ARID: General scaling logic



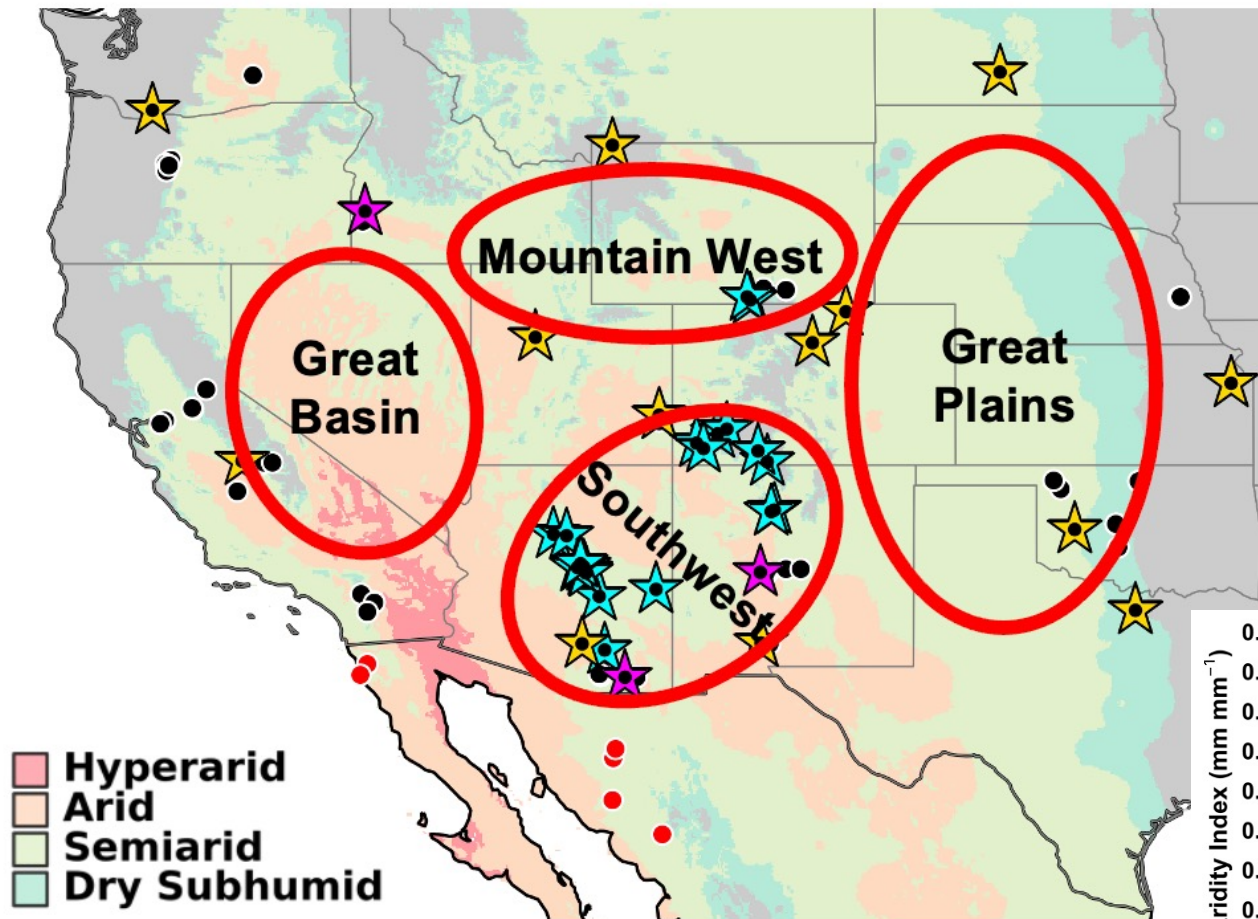
Global approach but West US focus



- International engagement started in **Red locations**
 - Interest in flights and experiments

Global approach but West US focus

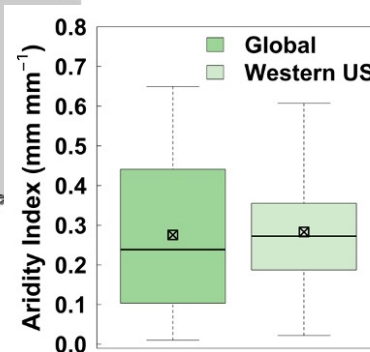
- ★ NEON
- ★ LTER/LTAR
- ★ Snowtography
- Ameriflux



- Existing instrumentation throughout western US that can be complemented with NASA campaign
- Opportunity to capitalize on gradients:
 - Hot to cold (South to North)
 - Dry to wet (West to East)
 - Land cover gradients (natural, rangeland, and cropland)

Western US aridity is near average of all global drylands

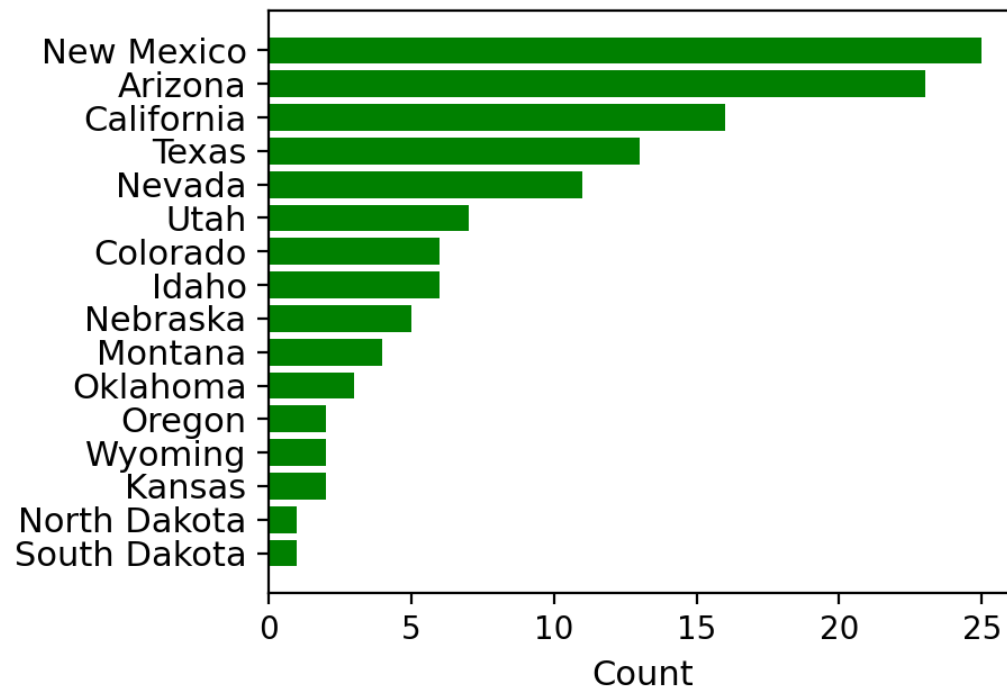
- Western US representative of global drylands



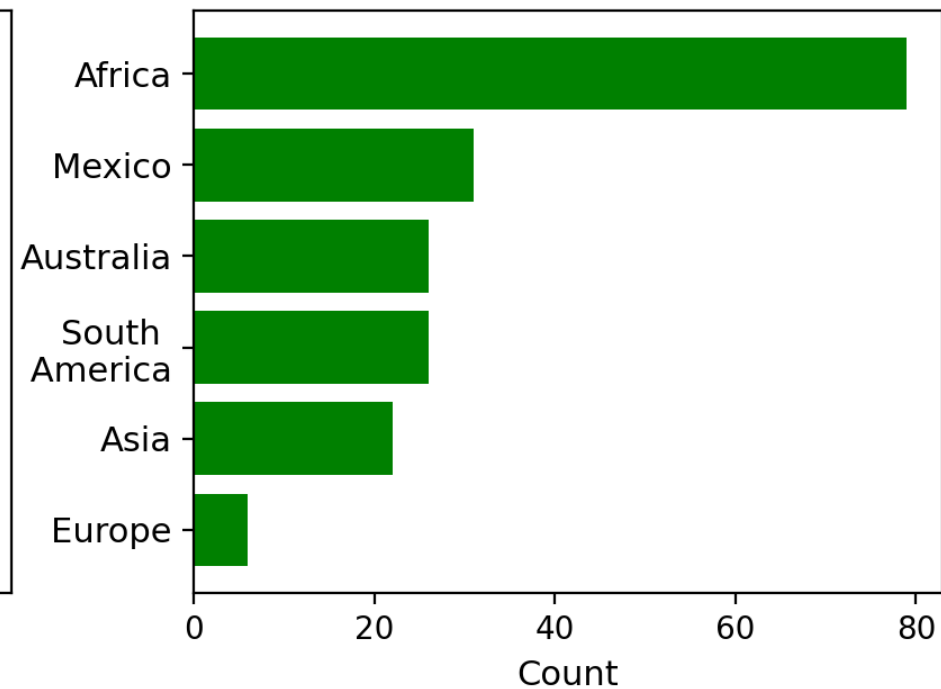
ARID Community Survey (325 Respondents by June 2024)

Domain Question: Please name a US state or non-US country or region ARID should particularly focus on.

C Suggested domestic ARID domains

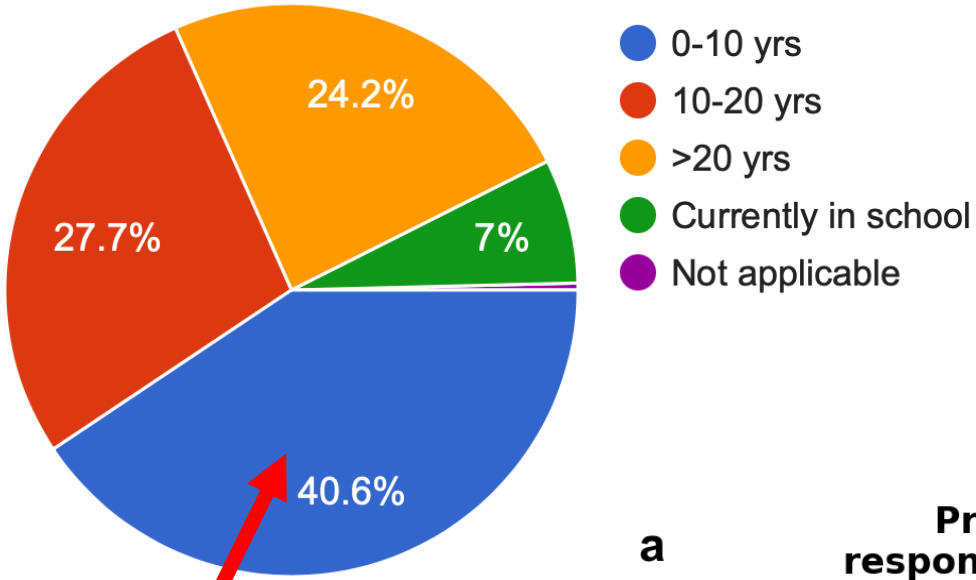


a Suggested international ARID domains



- Percent of respondents suggested nearly half domestic and half international locations
- 32% of respondents responding from international locations

6) How long has it been since your last degree?

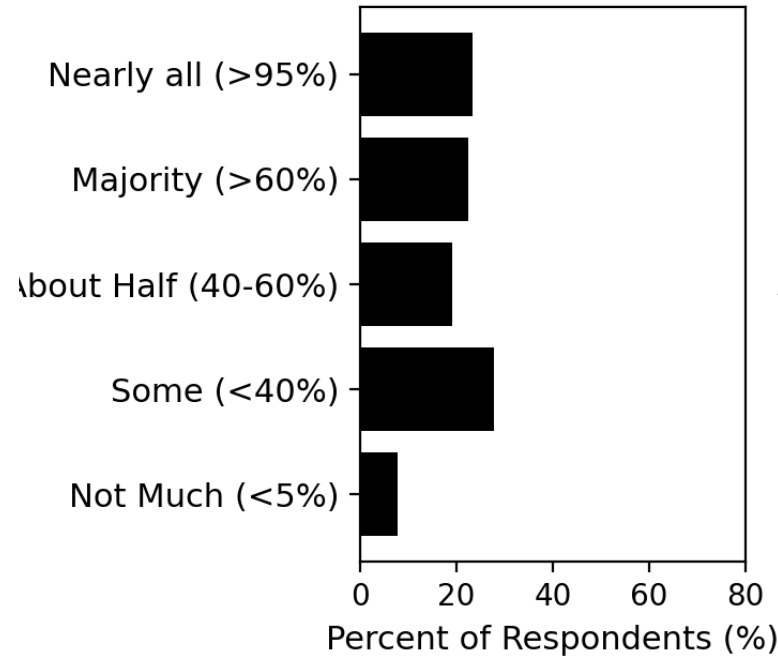


Strong early career support

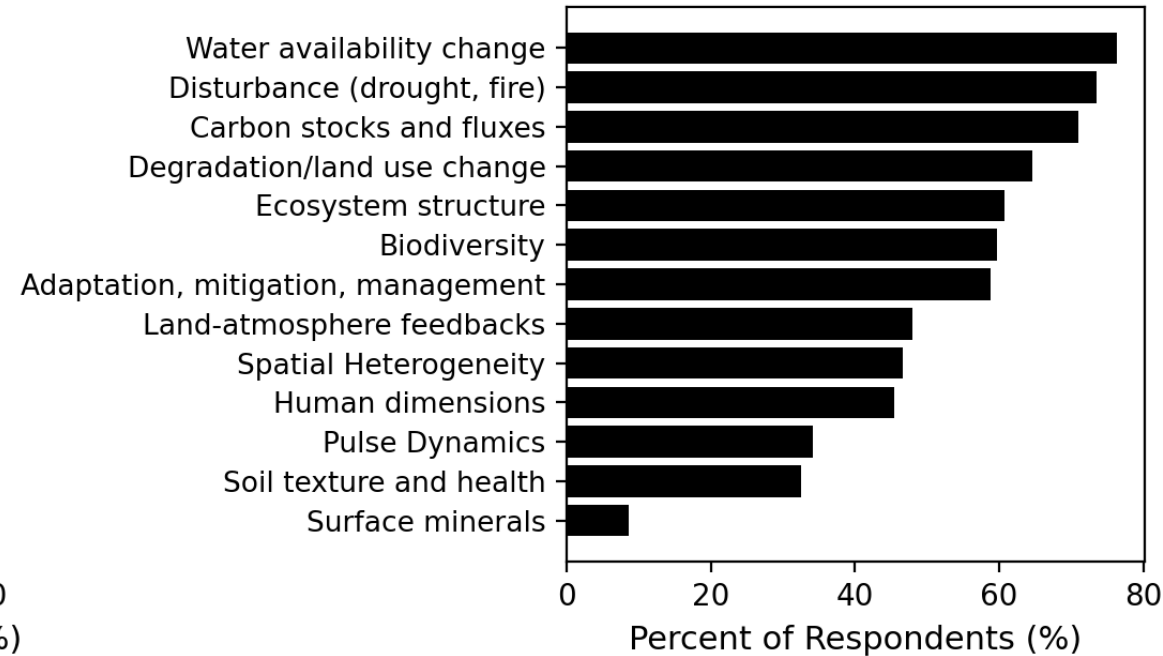
Both dryland experts and those that don't normally work in drylands are interested

Input used to update our science themes

a Proportion of research respondent conducts in drylands



b Science themes ARID should include



Subset of our ARID Supporters/Partners

Domestic

- Agencies
 - Bureau of Land Management (BLM)
 - US Geological Survey (USGS)
 - National Park Service (NPS)
 - US Department of Agriculture (USDA)
- Networks
 - AmeriFlux and FLUXNET
 - NEON
 - LTER
 - CyVerse Data Infrastructure
 - EarthLab (UC Boulder)
- Tribal
 - Several (confidential until permission obtained)

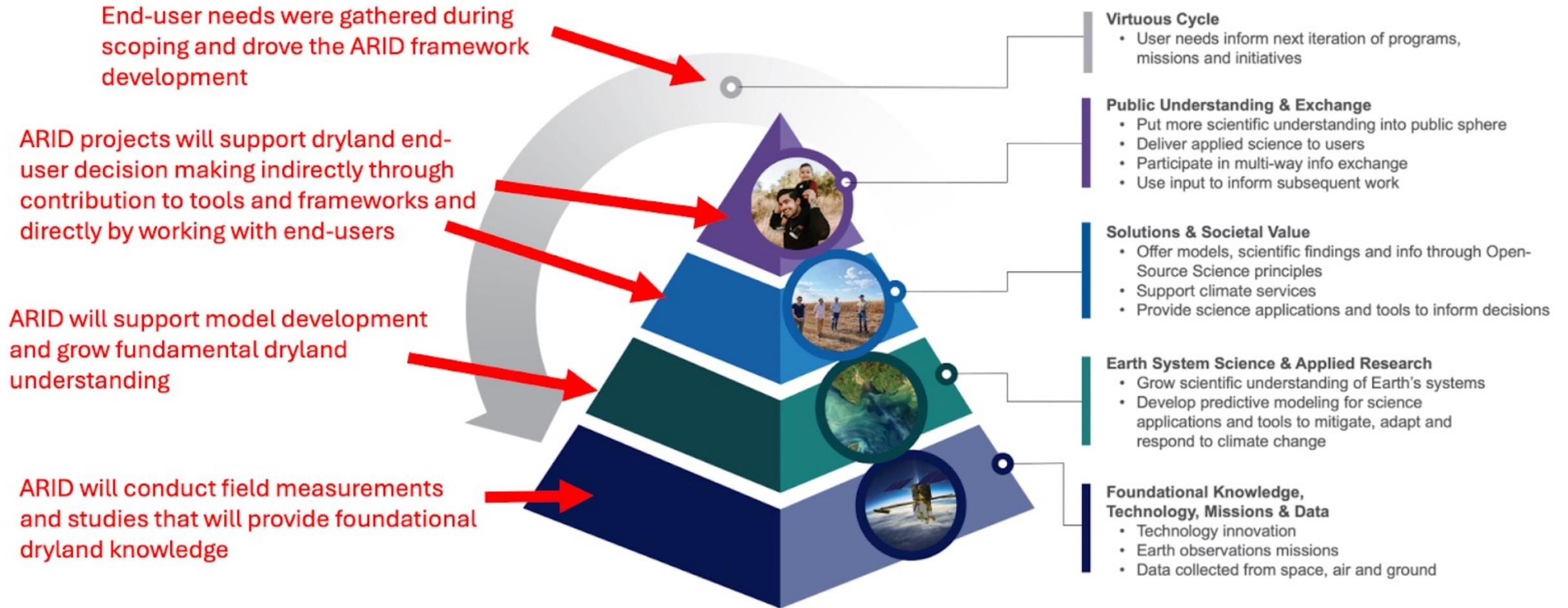
International

- Southern Africa
 - BioSCape Community (South Africa)
 - Okavango Research Institute (Botswana)
 - Gobabeb-Namib Research Institute
 - University of Namibia
- South America
 - SECO
 - DryFlor
- Mexico
 - National Autonomous U. Mexico
 - MexFlux
- Australia
 - Centre of Excellence (Western Sydney University, University of Melbourne, ANU)
 - CSIRO
- Conservation International

ARID is co-produced with end users



ARID Earth Action Strategy



ARID Earth Action Strategy

- Indirect: data products are developed and others (non-NASA funded) use them to implement into decision making frameworks
- Broad direct effort: A group of ARID-funded scientist(s) work directly with BLM to improve plant functional type and biomass estimates for LandCart and Rangeland Analysis Platform
- Individual direct effort: ARID-funded scientists work with tribal natural resources departments to use aircraft and satellite observations to improve water availability monitoring and buffalo restoration

University of Arizona Kickoff End-User Meeting (October 2023)



- 30 Data End-Users
 - Bureau of Land Management (BLM)
 - USGS
 - USDA
 - NPS
 - Non-profit Companies
 - Mining Companies
- ~300 attendees of the science component

Townhalls

Ecological Society of
America (ESA) Meeting
Townhall

~60 participants



AGU Meeting Townhall

~160 participants



Tribal Engagement Strategy Workshop (May 2024)



- 8 tribal members in attendance that are liaisons, educators (high school and university), and land managers.
- They included affiliations across the Rosebud Sioux Tribe, Navajo Nation, Hopi Tribe of Arizona, Apache tribe, Cherokee Nation, Pueblo of Isleta, and Pueblo of Santa Ana.
- We discussed development of a tribal engagement framework, educational needs, research experiences and pitfalls, and opportunities for liaison support.

Tribal Engagement Strategy

- Our engagement strategy includes mainly one-on-one relationship building
- Listening: Tribal Nations best suited to define the goals/needs
- Have their own resources, managers, and scientists
- Our scoping goals are to learn:
 - 1) Management/Technological: What are Tribal Nation land management and technological needs? Are there opportunities to co-develop?
 - 2) Educational/Career: What educational and career building opportunities could NASA and ARID provide for Tribal Nations?
 - 3) Data Sovereignty: What Tribal Nation rules and permissions need to be adhered to such that ARID field data is collected in a fair and just way?

Tribal Engagement So Far

- Tribal Liaisons and Initiatives
 - NASA Indigenous People's Initiative (IPI)
 - USGS Climate Adaptation and Science Centers (CASC)
 - NASA MUREP MAIANSE (NASA internship support for First Nations)
 - American Indian Science and Engineering Society (AISES)
- Conversations with Tribal Nation-Affiliated Scientists, Educators, and Managers
 - Navajo Nation
 - Ute Mountain Ute
 - Rosebud Sioux
 - Isleta Pueblo
 - Jemez Pueblo
 - SIPI, Greyhills Academy High School

Get Involved!

- For questions, contact:
 - Sasha Reed, PI (screed@usgs.gov)
 - Andrew Feldman, Project Manager (andrew.feldman@nasa.gov)
- Please get involved with ARID:
 - Website: <https://aridscoping.arizona.edu>
 - Survey: <https://aridscoping.arizona.edu/get-involved>

Timeline and Activities

- September 20th: White paper draft available for community comment
- September 21st-November 1st: Community comment phase
- December 6th: Final white paper submission