Terrestrial Dryland Ecology Research at the U.S. Geological Survey's Southwest Biological Science Center

Presented by
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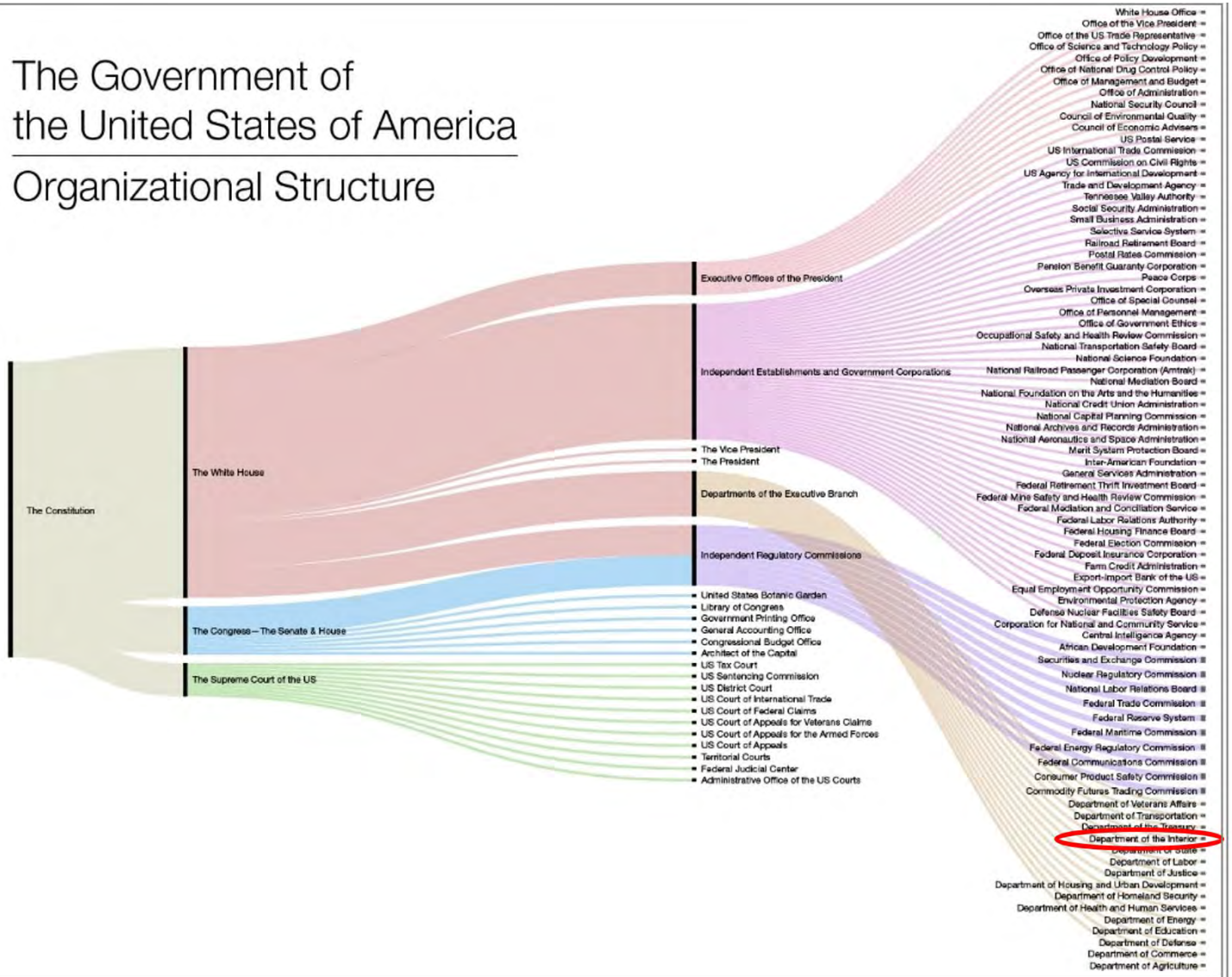
U.S. Geological Survey
Southwest Biological Science Center
Tucson, Arizona

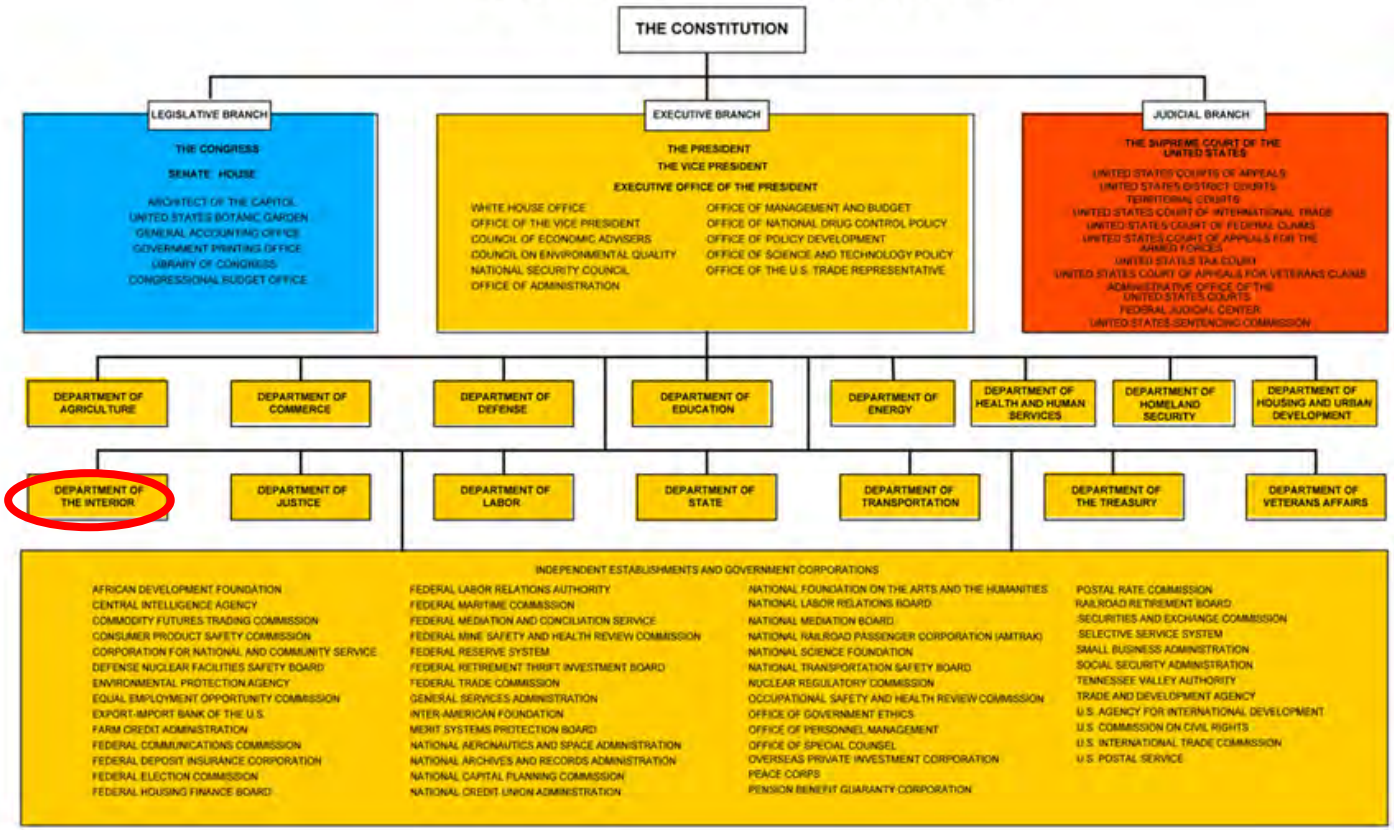
School of Natural Resources and the Environment
Seminar Series
February 26th, 2025

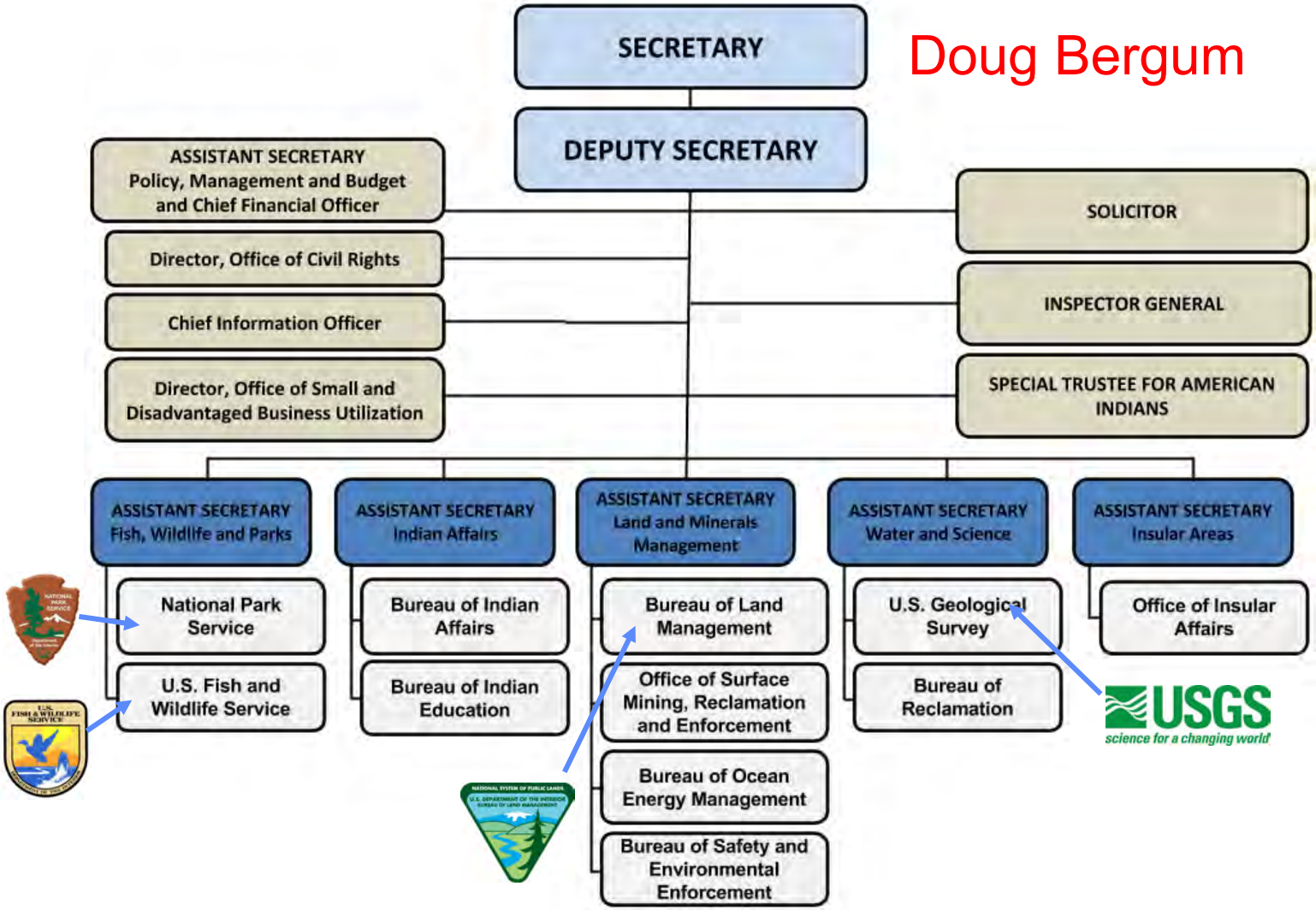
The Government of the United States of America

Organizational Structure



THE GOVERNMENT OF THE UNITED STATES




SECRETARY
Doug Bergum
DEPUTY SECRETARY
ASSISTANT SECRETARY
Policy, Management and Budget
and Chief Financial Officer
Director, Office of Civil Rights
Chief Information Officer
Director, Office of Small and
Disadvantaged Business Utilization
SOLICITOR
INSPECTOR GENERAL
SPECIAL TRUSTEE FOR AMERICAN
INDIANS
ASSISTANT SECRETARY
Fish, Wildlife and Parks
ASSISTANT SECRETARY
Indian Affairs
ASSISTANT SECRETARY
Land and Minerals
Management
ASSISTANT SECRETARY
Water and Science
ASSISTANT SECRETARY
Insular Areas
National Park
Service
U.S. Fish and
Wildlife Service
Bureau of Indian
Affairs
Bureau of Indian
Education
Bureau of Land
Management
Office of Surface
Mining, Reclamation
and Enforcement
Bureau of Ocean
Energy Management
Bureau of Safety and
Environmental
Enforcement
U.S. Geological
Survey
Bureau of
Reclamation
Office of Insular
Affairs
USGS
science for a changing world

The USGS was founded by an Act of Congress in 1879 for:

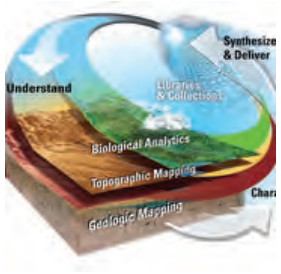
"*classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain*"

- Nation's largest water, earth, biological and civilian mapping agency
- Non regulatory
- Scientific arm of the Department of Interior

Agency Mission

The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

USGS organized around 5 Mission Areas



Core System Sciences

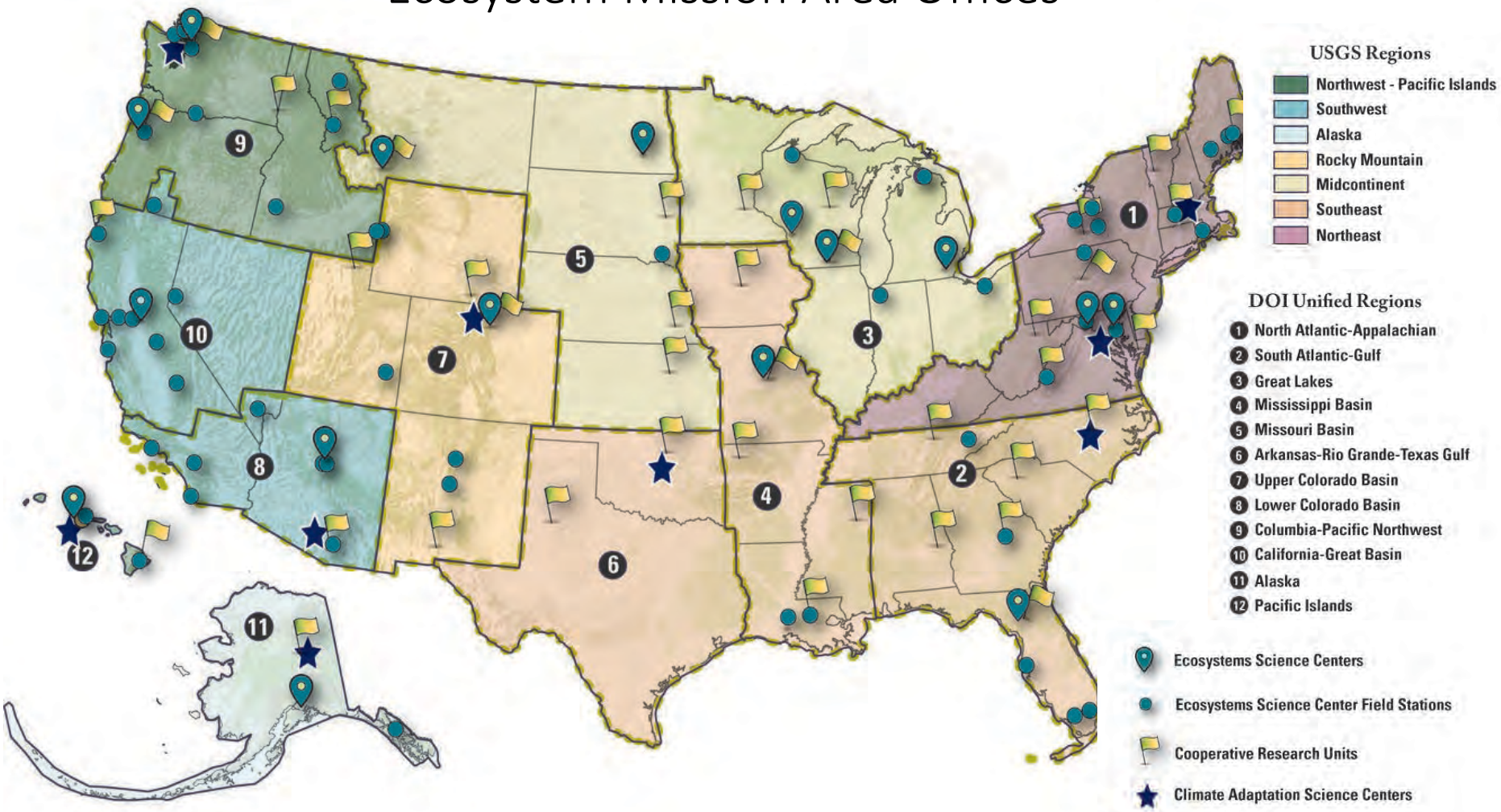
Ecosystems

Energy & Minerals

Natural Hazards

Water Resources

Ecosystem Mission Area Offices



Southwest Biological Science Center

- **Terrestrial Dryland Ecology Branch (TDE)**
- **River Ecosystem Science Branch (RES) including Grand Canyon Research & Monitoring (GCMRC)**

Terrestrial Dryland Ecology

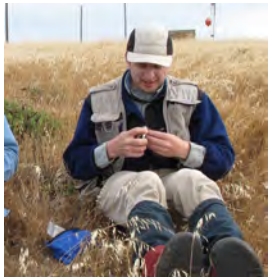
Addressing pressing DOI issues in the Desert Southwest

Flagstaff

Seth Munson

Charles Yackulic

Rob Massatti



Charles Drost

Moab

Mike Duniway

Sasha Reed

Tucson

Kathryn Thomas

Pam Nagler

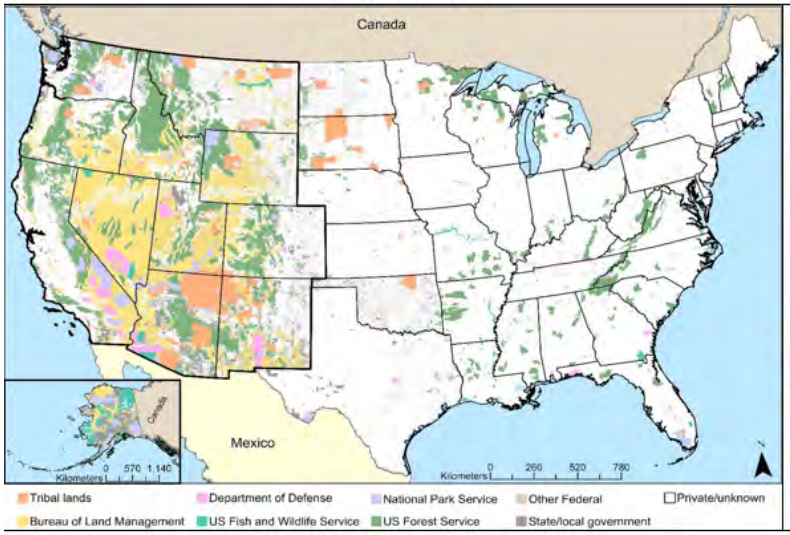
Emeritus

Jeff Lovich

Jayne Belnap

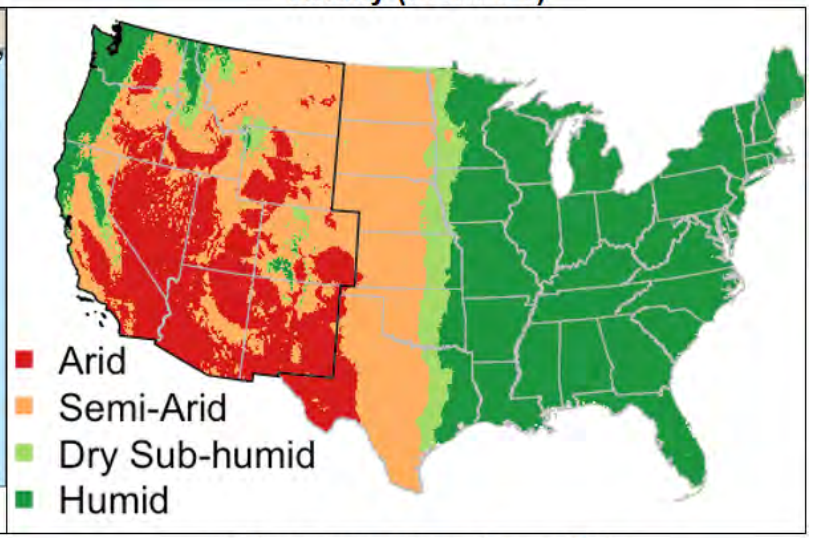
Most public land management occurs in drylands…
…areas shaped by drought & vulnerable to climate change

Public Lands



Carter et al (2020) *Landscape Ecol* **35,** 545–560.

Aridity (PET/PPT)



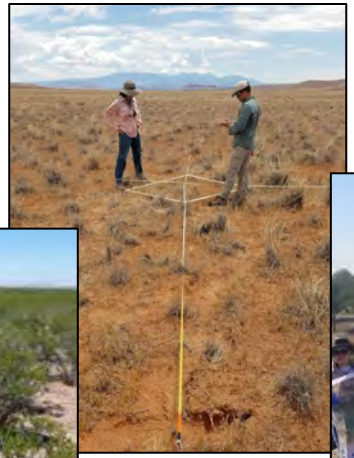
UNEP aridity index: Trabucco & Zomer (2018)

Science Theme: Aridification

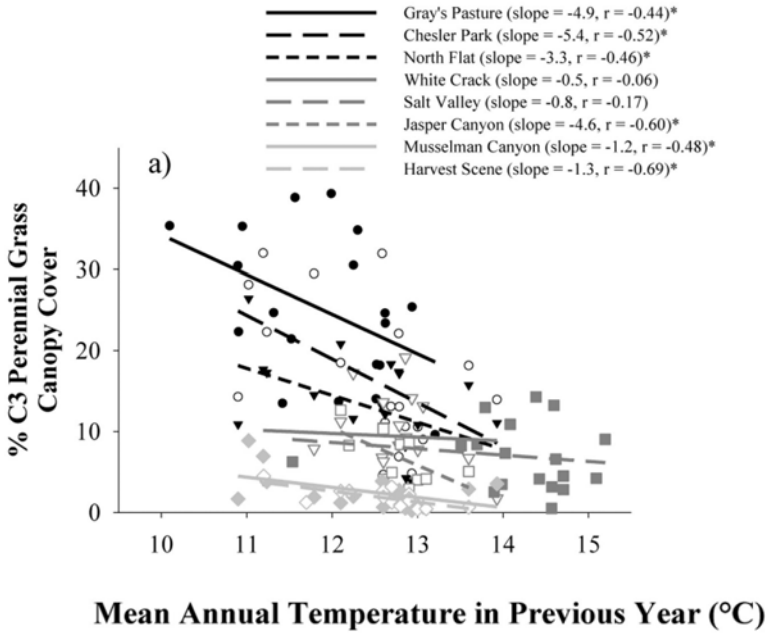
How does climate and drought impact dryland ecosystems?

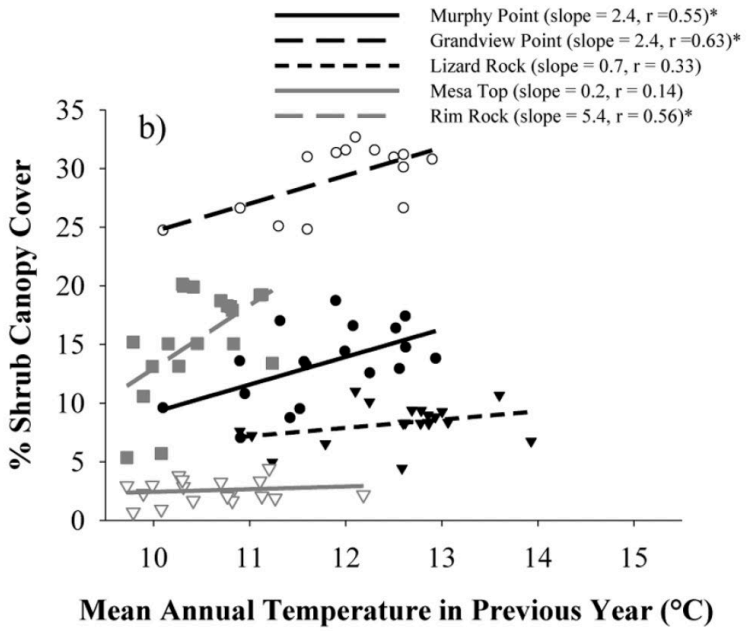
What do these impacts mean for resource management?

How can resource managers adapt to sustain services from these ecosystems?



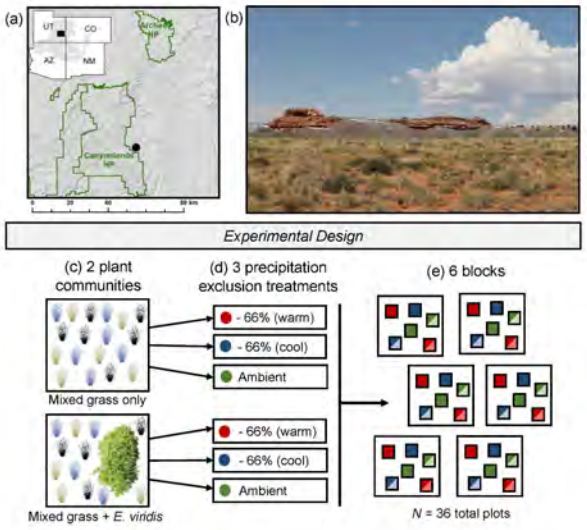
- **Long term observations**
  - USGS field monitoring
  - DOI partner datasets
  - Remote sensing



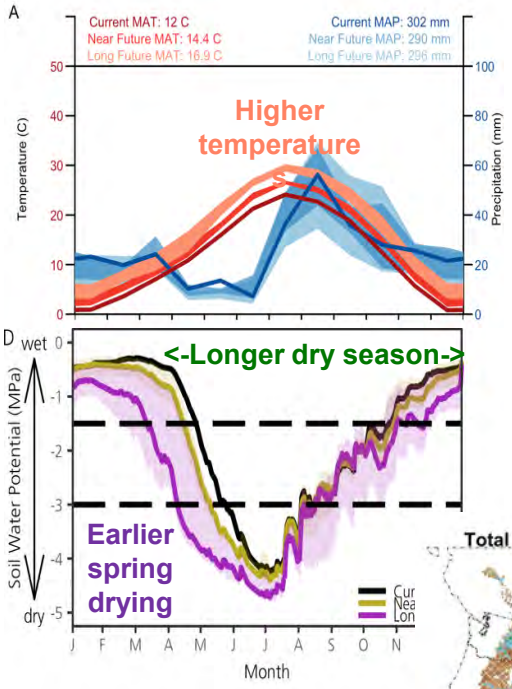


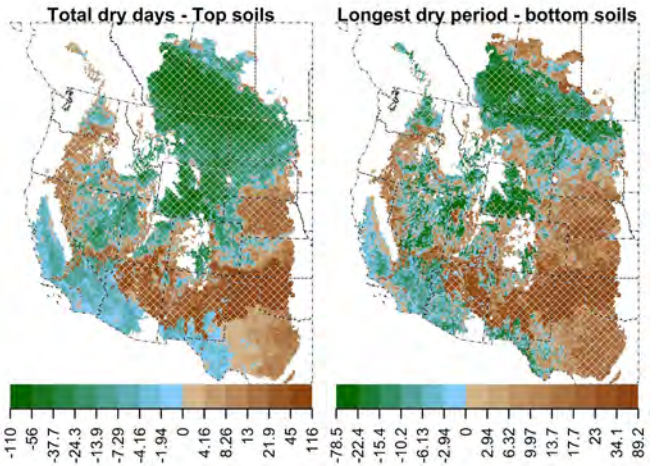
Munson et al. (2011) *Ecosphere*

- **Long term observations**
  - USGS field monitoring
  - DOI partner datasets
  - Remote sensing
- **Manipulative experiments**
  - Warming the desert
  - Drying the desert
  - &/or watering the desert

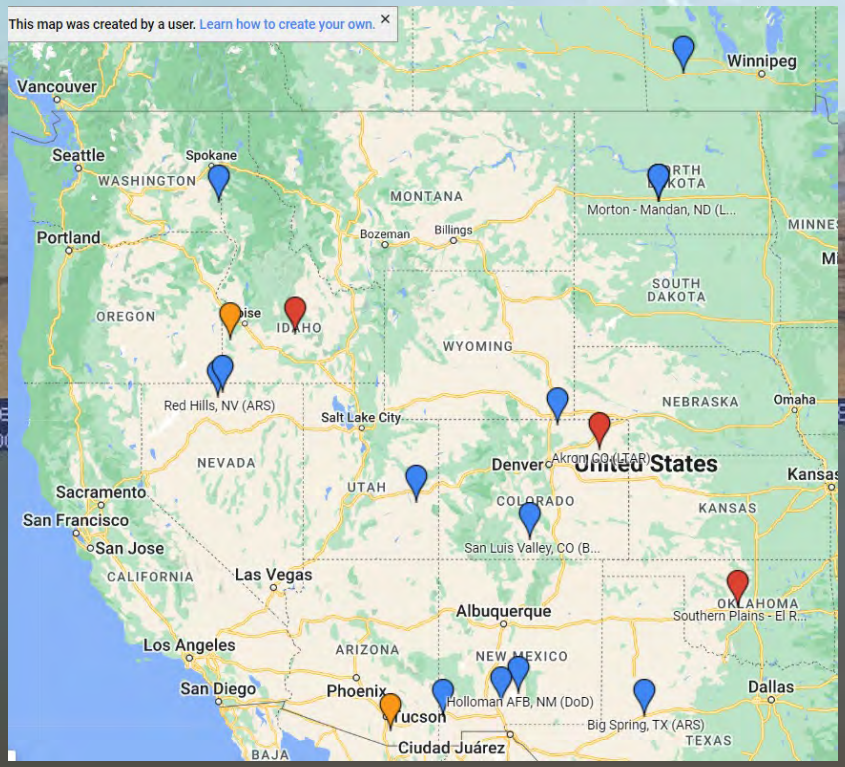


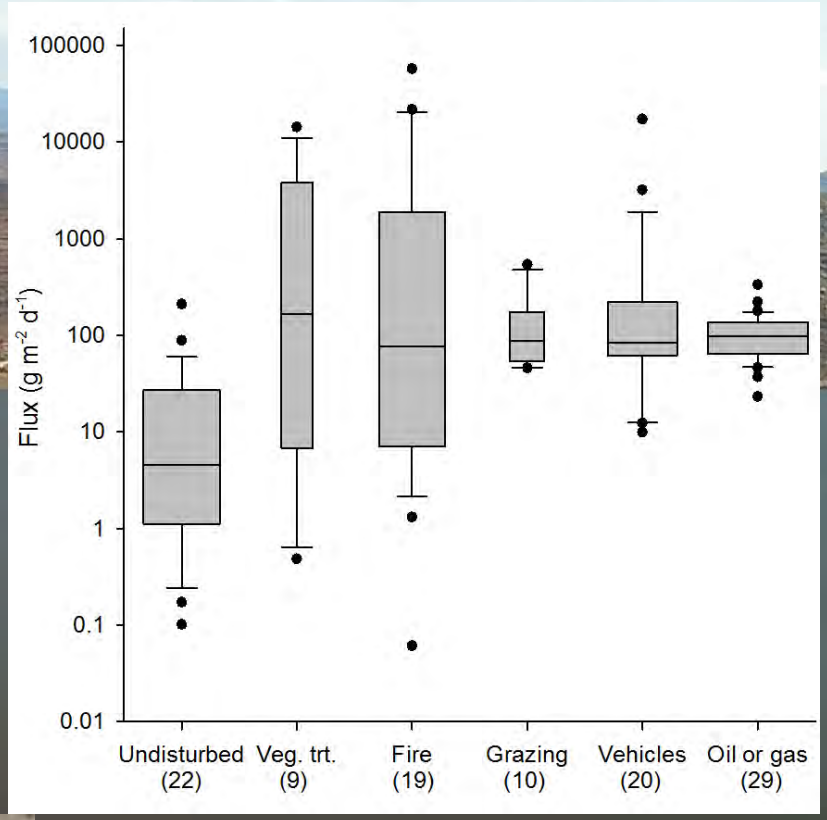
- **Long term observations**
  - USGS field monitoring
  - DOI partner datasets
  - Remote sensing
- **Manipulative experiments**
  - Warming the desert
  - Drying the desert
  - &/or watering the desert
- **Modelling future conditions**
  - Using process based models
  - Calibrated with the observational & experimental studies
  - Provide robust estimates of what future conditions are likely





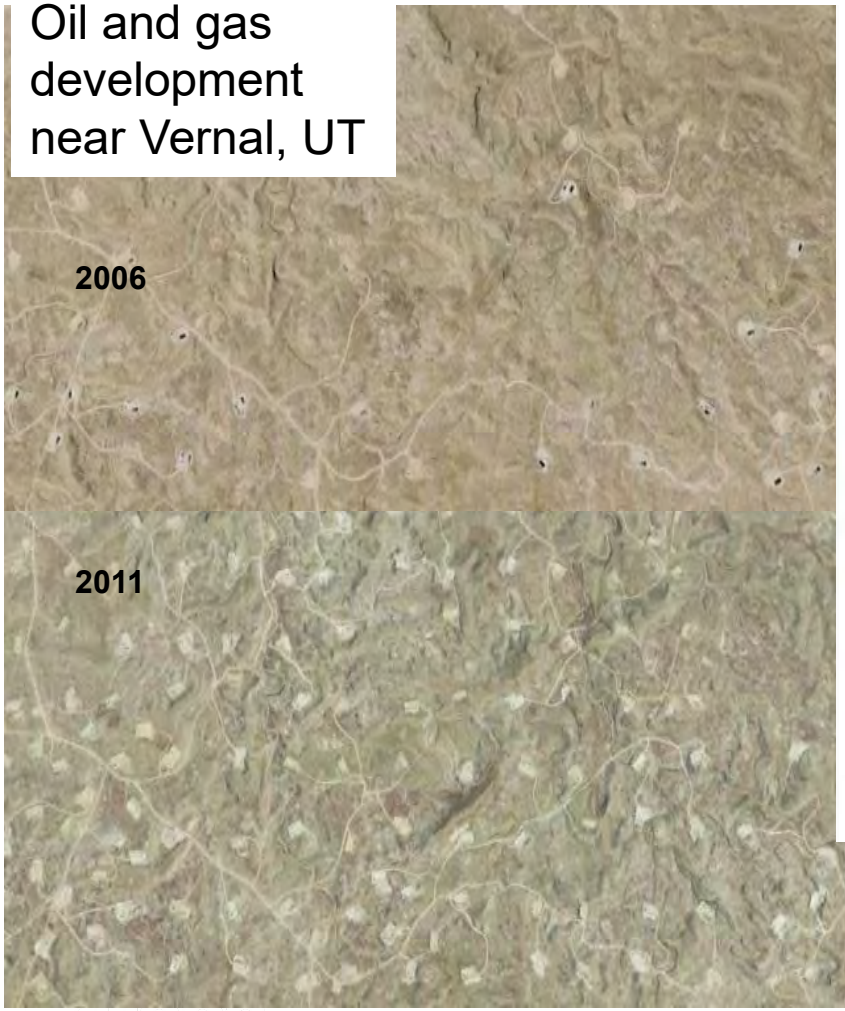
Science Theme: Dust Monitoring

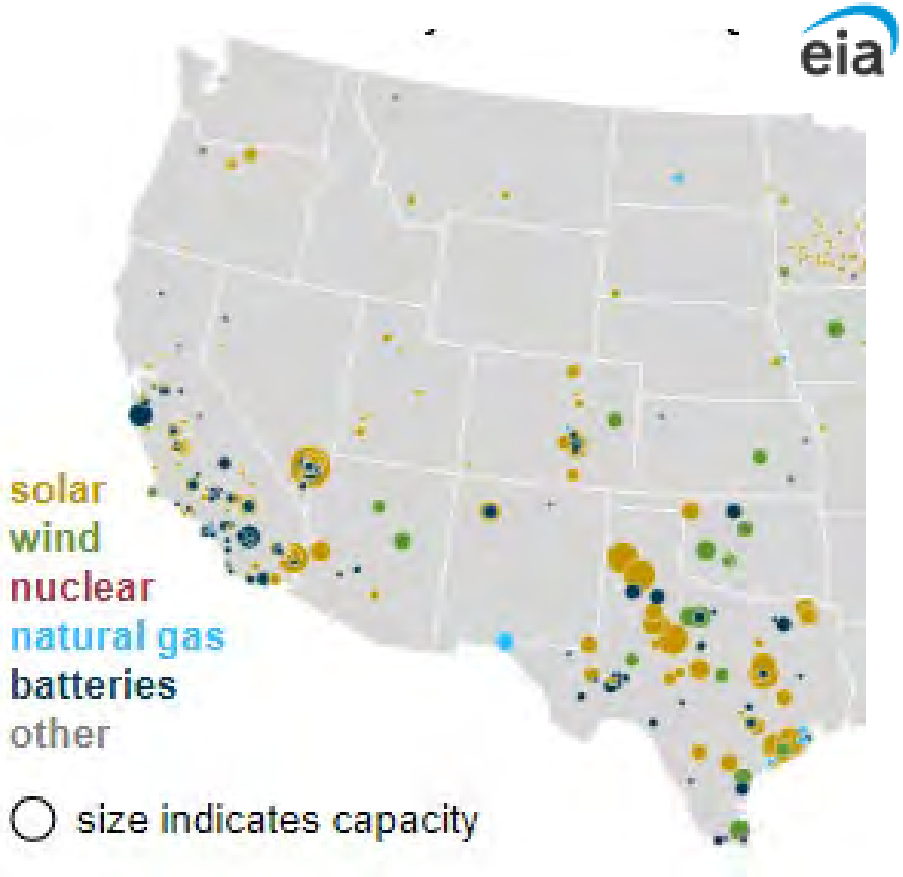




Science Theme: Energy Development

Oil and gas development near Vernal, UT



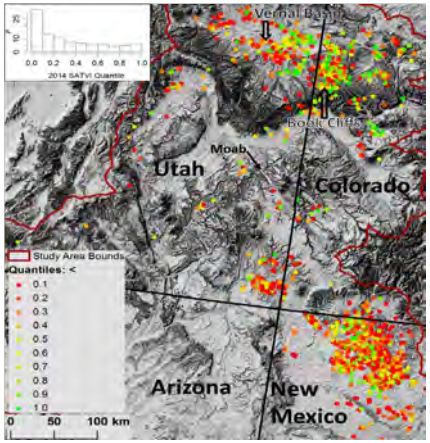


Planned 2023 electric generation additions

Understanding impacts & reclamation outcomes –

- Wildlife and habitat
- Recovery of plants & soils
- Erosion & dust

Gemini Solar Project, NV

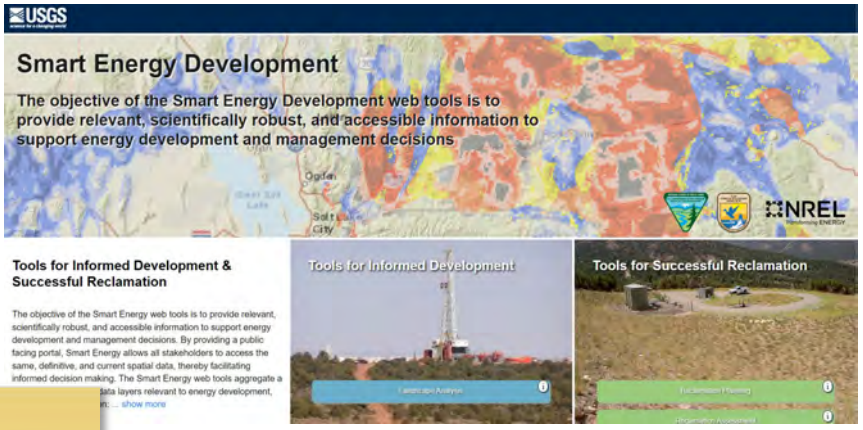


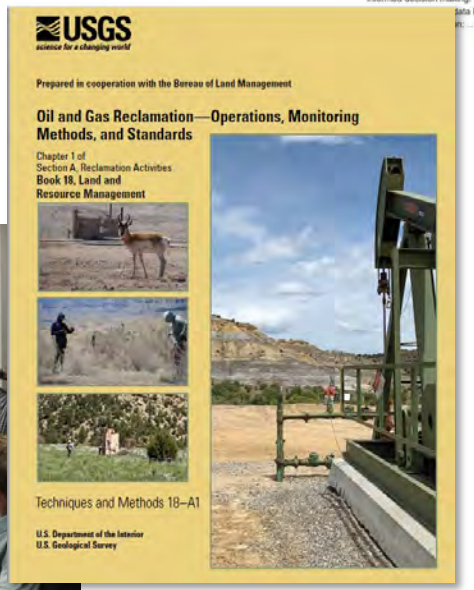
Source: Department of Energy. | GAO-18-250

- Largest solar power facility in the US, one of the largest globally (7,000+ ac.)
- First to translocate and reintroduce desert tortoise at large scale
- TDE science will help to inform new project requirements for solar development on BLM land.

Developing best-management practices, tools, and resources

- Annotated bibliography
- Oil and gas management guidance documents
- Assessment tools and approaches





Disturbance automated reference toolset (DART): Assessing patterns in ecological recovery from energy development on the Colorado Plateau

Science Theme: Restoration

Ecological stressors are abundant in the southwest

- **Historic over grazing**
- **Population growth**
- **Warming & drying**
- **Land use change & intensification**

Restoration is critical to avoid ecosystem transformation

RAMPS: Restoration Assessment & Monitoring Program for the Southwest

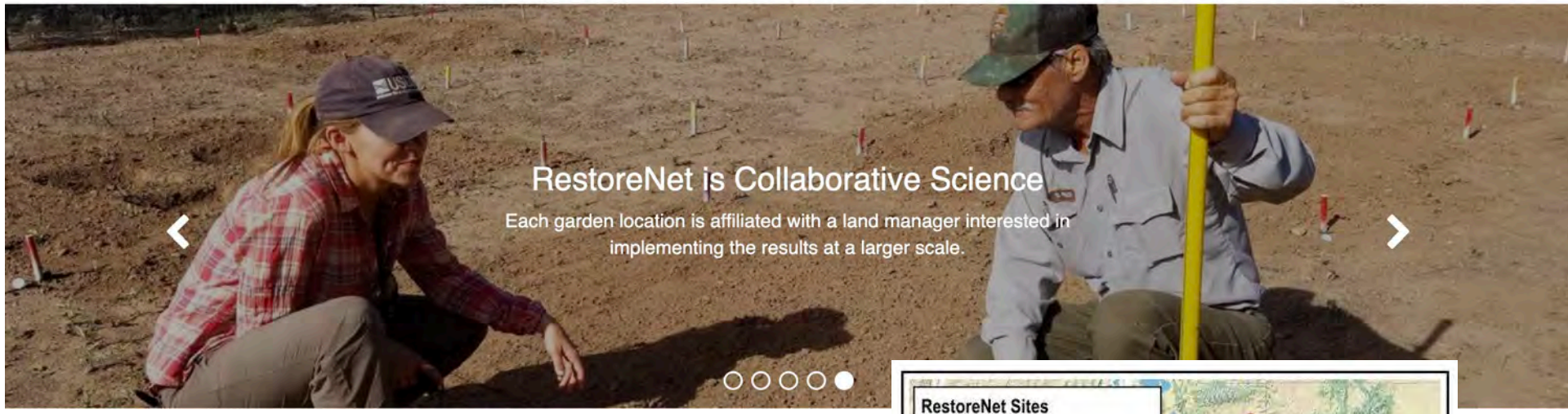
Connecting Science and Land Management

Strengthen restoration outcomes in the southwestern U.S. by providing science and guidance on effective strategies

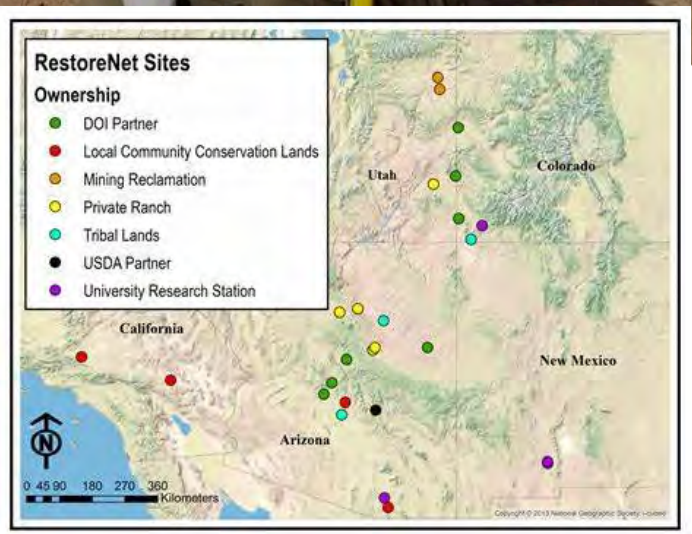
http://usgs.gov/sbsc/ramps

Southwest Biological Science Center

RestoreNet: Distributed Field Trial Network for Dryland Restoration



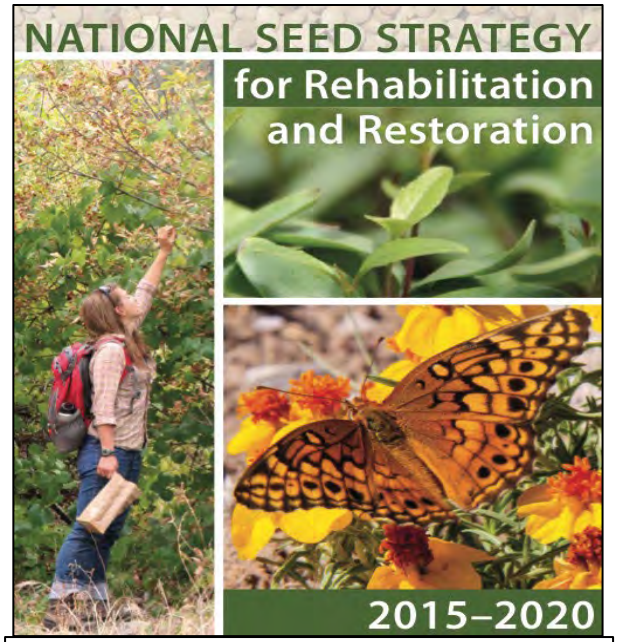
RestoreNet is a co-produced experimental network that systematically tests dryland restoration treatments and seed sources across environmental gradients in the southwestern US



The world's largest outdoor biocrust nursery

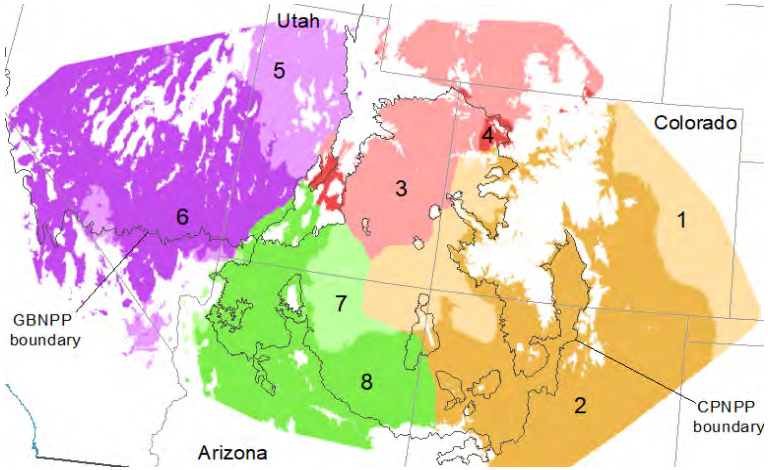
New ways to put biocrust onto disturbed sites

Seed transfer zones with BLM Native Plant Program



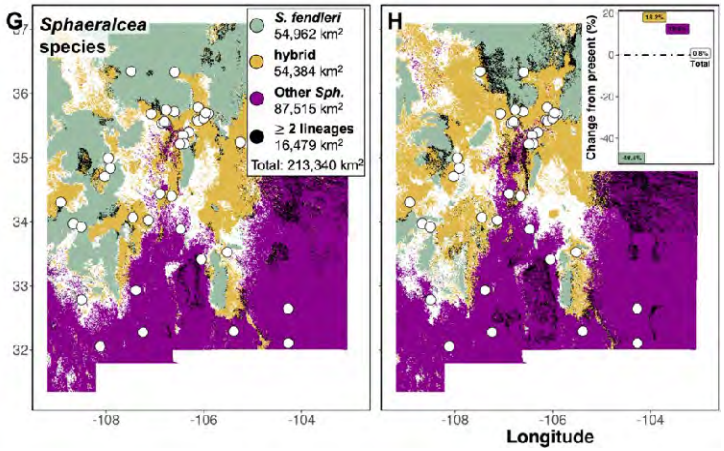
Vision: The right seed in the right place at the right time.
Mission: To ensure the availability of genetically appropriate seed to restore viable and productive plant communities and sustainable ecosystems.

Step 3: Create <u>seed transfer zones</u> that represent both differentiation and adaptation



Massatti 2019

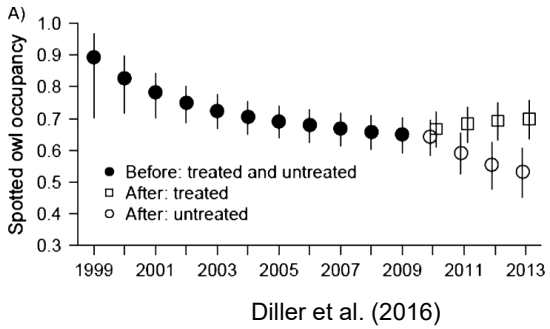
Genetics and restoration practices across the Intermountain West



Present climate Future climate

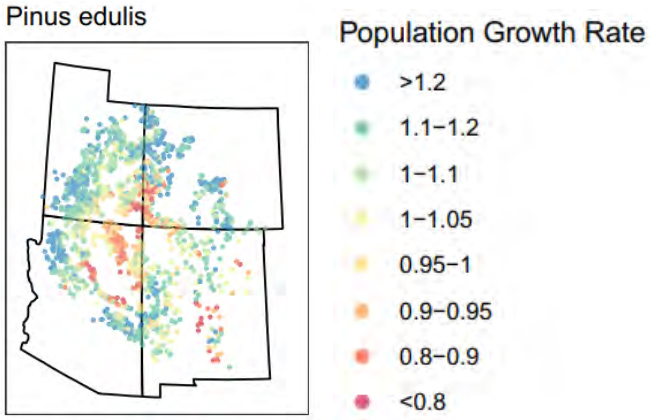
Massatti et. al, *Accepted*, PNAS

Science Theme: Wildlife

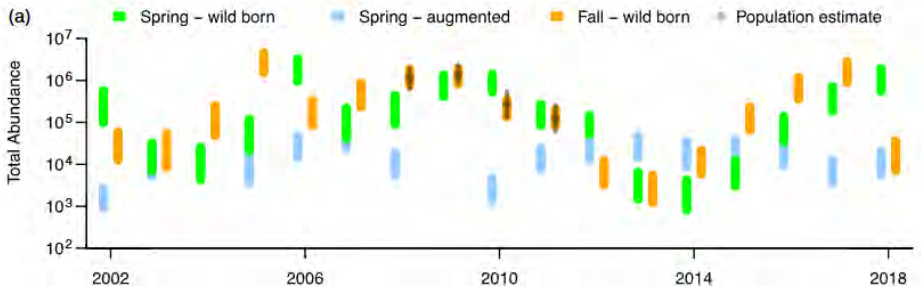


Diller et al. (2016)

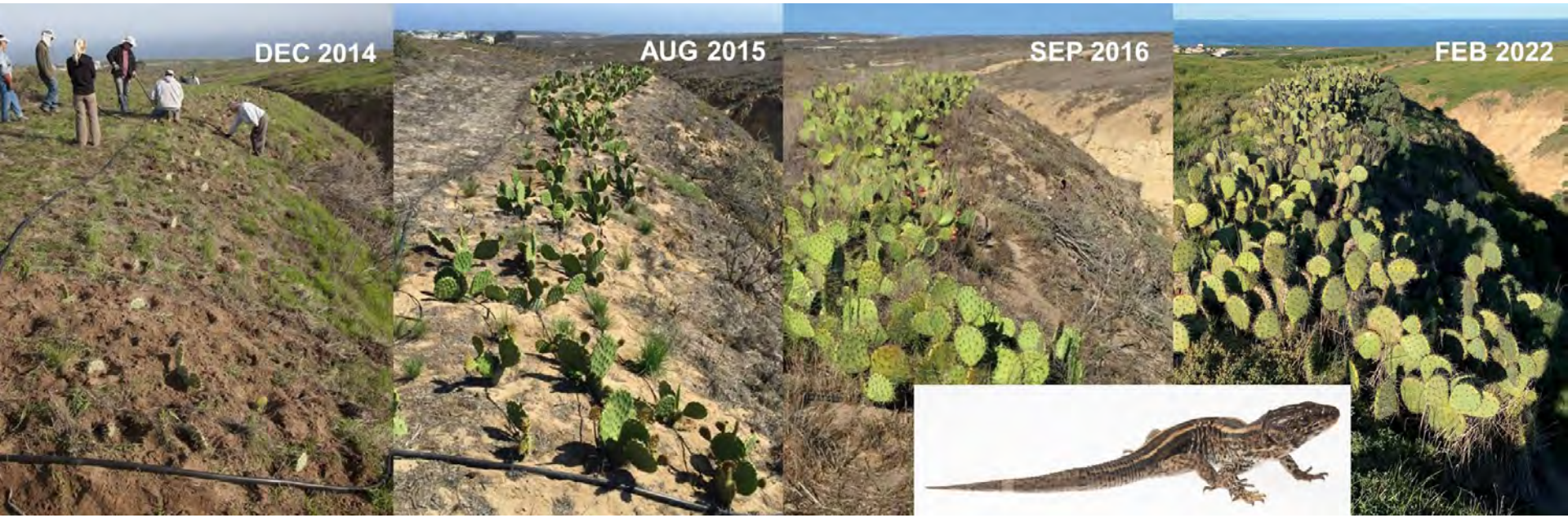
Yackulic et al. (2014) introduced two-species dynamic occupancy models that have been used in subsequent studies to estimate impacts of barred owls on spotted owls and quantify the effect of removal efforts.



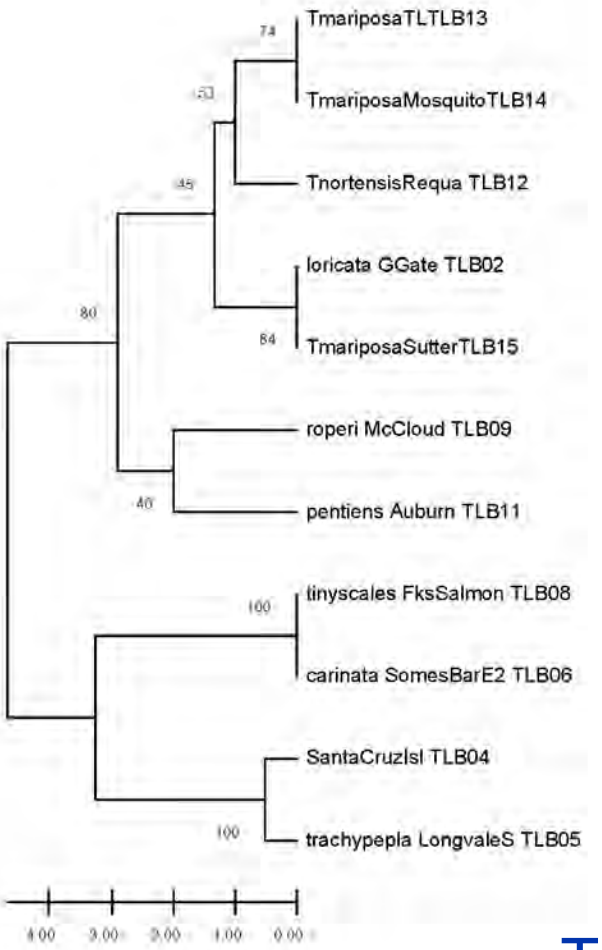
Shriver et al. (2021, 2022) developed and fit integrated range-wide demographic models for five dry forest tree species using forest inventory data to estimate population trends and climate vulnerability.



Yackulic et al. (2022) integrated lab studies, expert opinion and field data into a population model for endangered Rio Grande Silvery Minnow that is being used to guide adaptive management efforts.



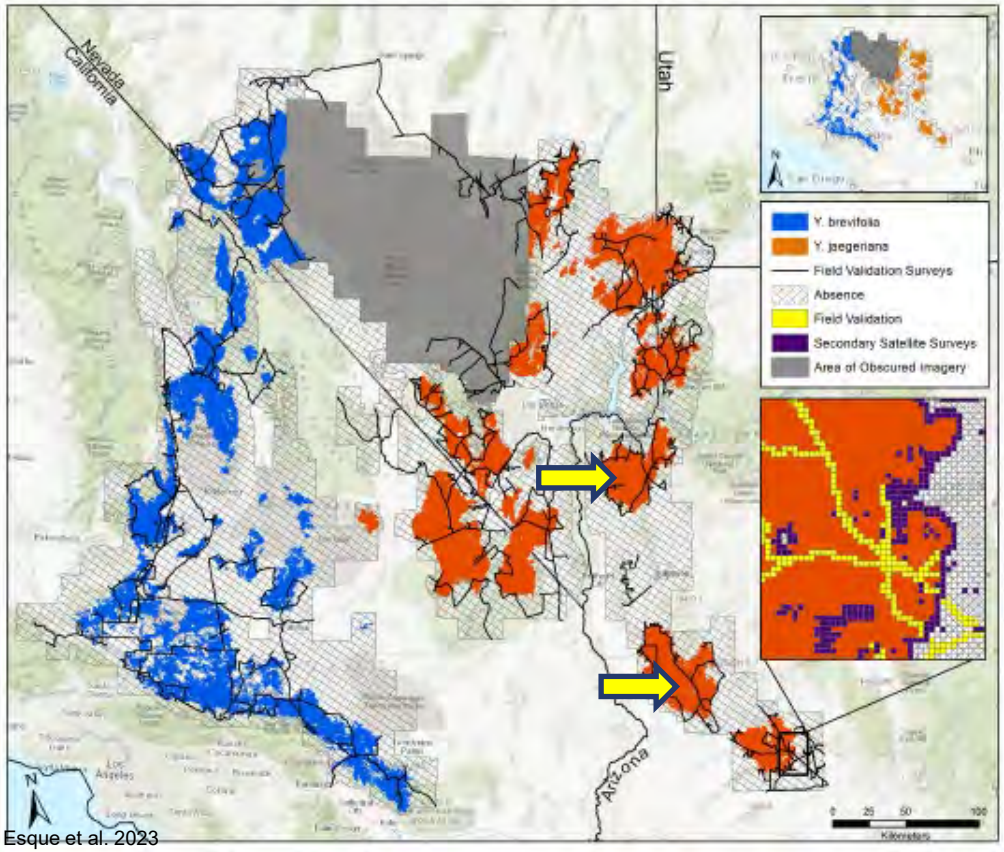
Habitat restoration for Island Night Lizard on San Nicolas Island, California Channel Islands



Taxonomic studies of rare western land snails

Science Focus: Plants & Insects

Pollination of the Eastern Joshua Tree in Arizona



Esque et al. 2023

Meadview, Arizona 2022 & 2023

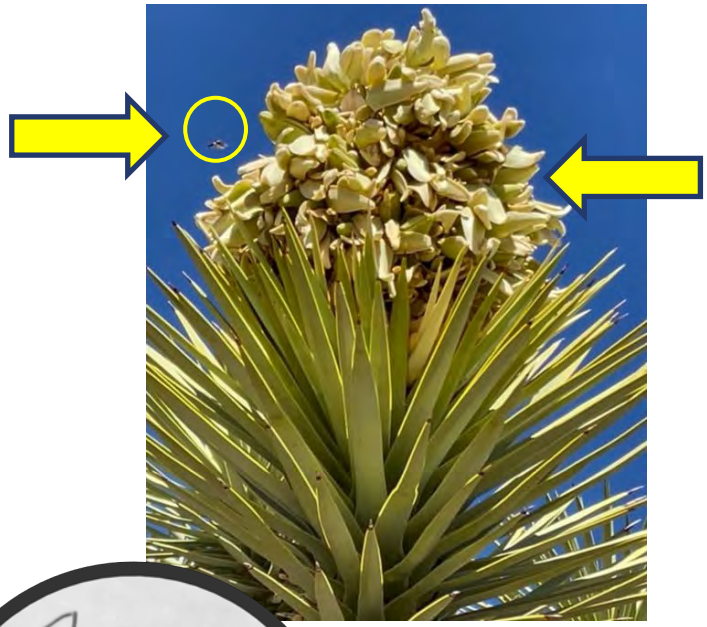
Sandy – 3149 ft. (low elevation)
Glen – 3681 ft (mid-low elevation)
Roundabout – 4130 ft (mid-high elevation)
Horse – 4481 ft (high elevation)

Wikieup, Arizona 2023 only

Alamo – 3112 ft (low elevation)
Chick – 3665 (mid-low elevation)

The mutualism stars

All images in this presentation courtesy of the USGS unless otherwise noted.



Tegeticula antithetica:

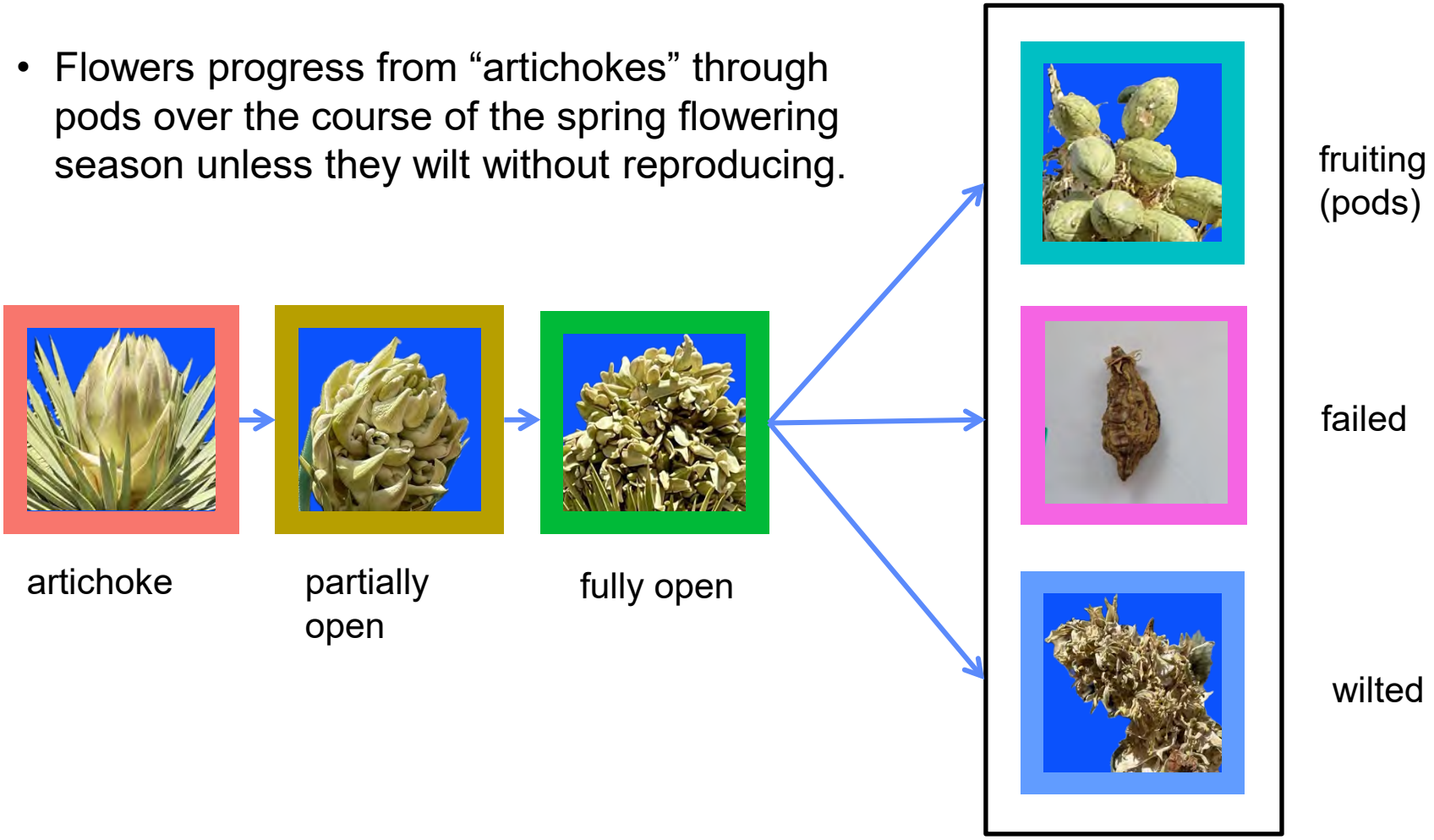
An obligate mutualist

We examined visitation of *Y. jaegeriana* flowers by its pollinating moth along an elevational gradient, and the timing of the association between moth occurrence, inflorescence stage, and seed production.

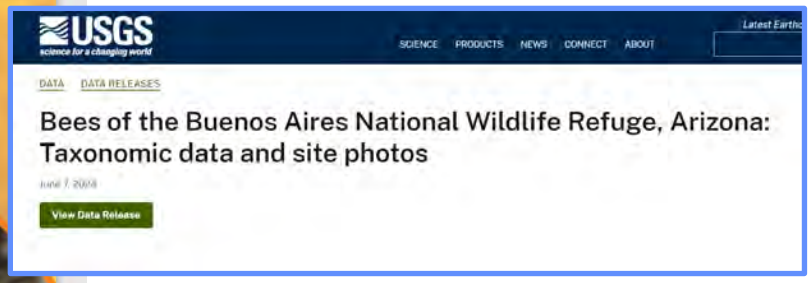
- Installed sticky traps at each site
  - Flower traps: Six per site
  - Control traps: One per site
- Recorded tree metrics and flower stages
- Collected pods
- Identified insects on sticky traps and counted pollinating moths
- Recorded environmental parameters

Floral Phenology and Moths

- Flowers progress from “artichokes” through pods over the course of the spring flowering season unless they wilt without reproducing.



Bees of the Buenos Aires National Wildlife Refuge—A preliminary report on a bee survey in a vulnerable semi-desert grassland of the Sonoran Desert https://pubs.usgs.gov/publication/ofr20241032



Field Collection

- 2 trap types
- Late May 2019 through early February 2020
- Recorded landscape characteristics

Figure 5. Photographs of *A*, a blue-vane trap and *B*, bee bowl deployed at Buenos Aires National Wildlife Refuge. Both trap types use soapy water to catch insects. Unlike the bee bowls, blue-vane traps were secured using aluminum stakes and were always placed in the exact same location for each collection event. Bee bowls were only used during collections from May 30 through July 25th. Photographs by Kathryn Thomas.

Curation

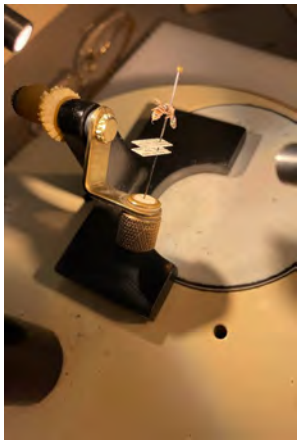
Wash and dry bee specimens

Separate bees from non-bees, then sub-sample

Pin

Label

Identification



Visual
DNA barcoding

Results: Occurrence Patterns

- 4 Families—this represents most of existing bee Families in western hemisphere
- 39 Genera

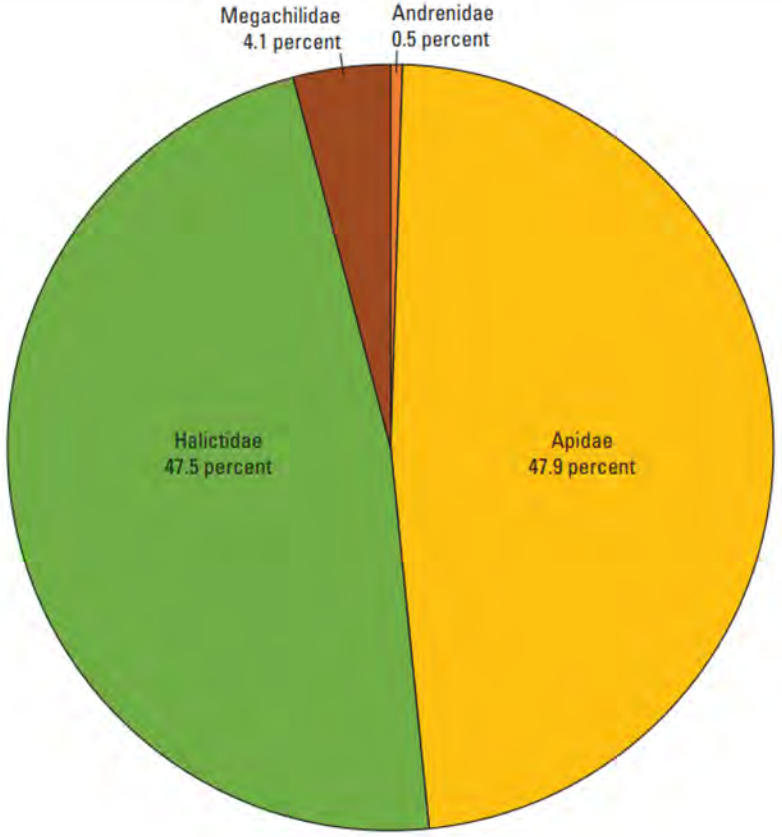
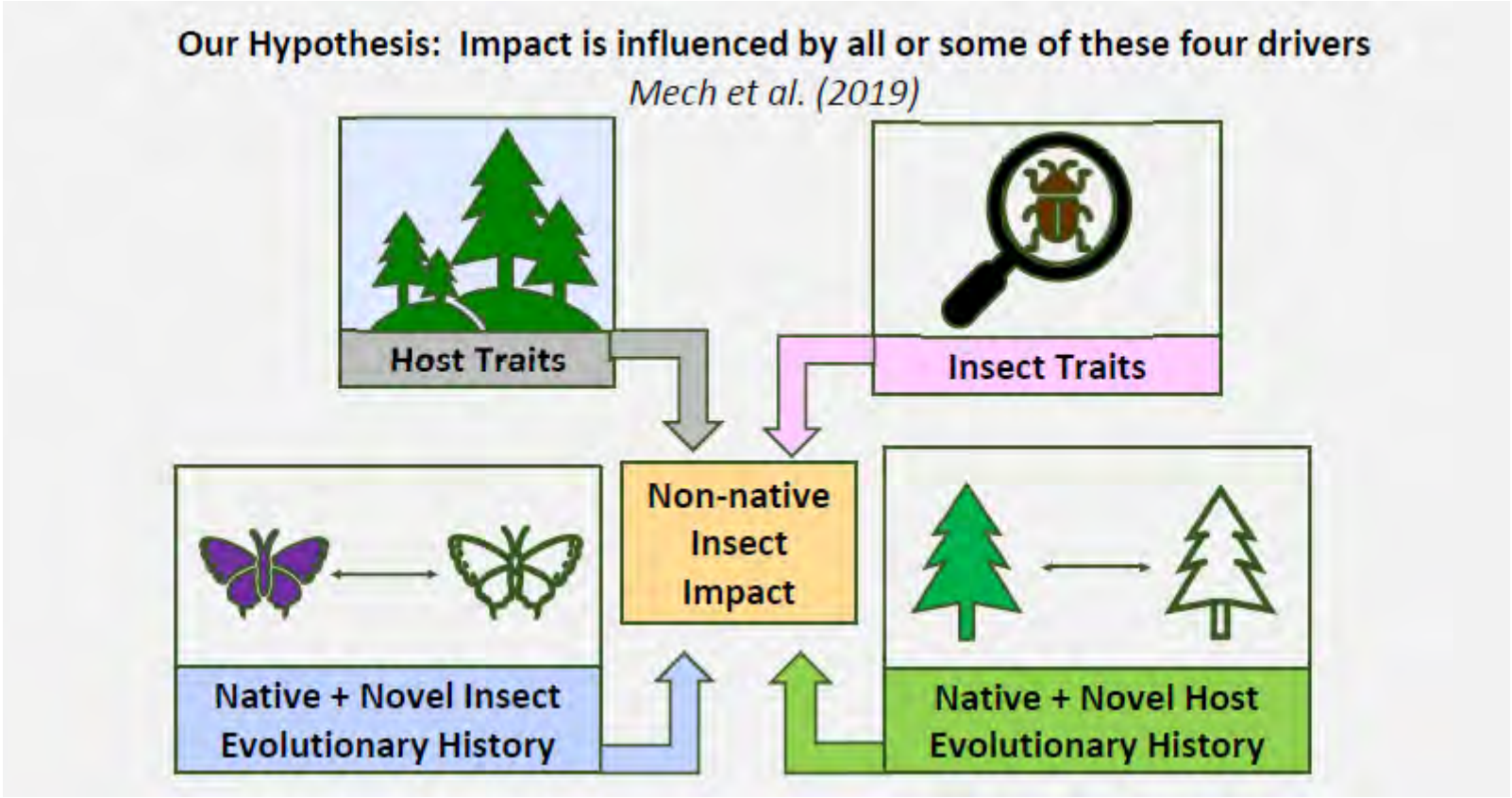
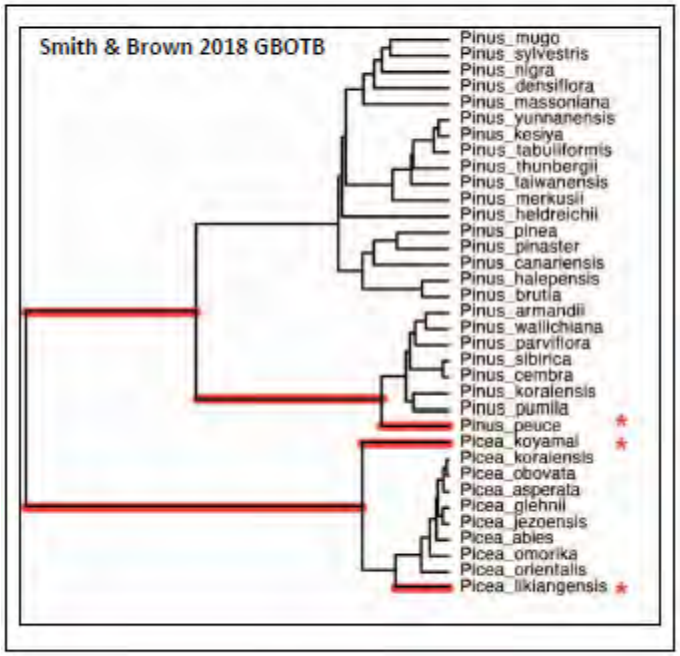


Figure 6. Pie chart showing bee family composition across all eight Refuge collection sites. Of the 3,353 bees sampled, 95.4 percent were in the families Apidae and Halictidae. This figure is based on project data in Hoover and others (2024).

Predicting the next high-impact insect invasion



Phylogenetic Diversity (PD)



- Measure of native host breadth
- PD = sum of the branch lengths
- Range of 0 (only one documented native host) to 7,723 (diverse range of hosts)

PD < 2,250 = narrow host breadth = "specialists"

PD > 2,250 = broad host breadth = "generalists"

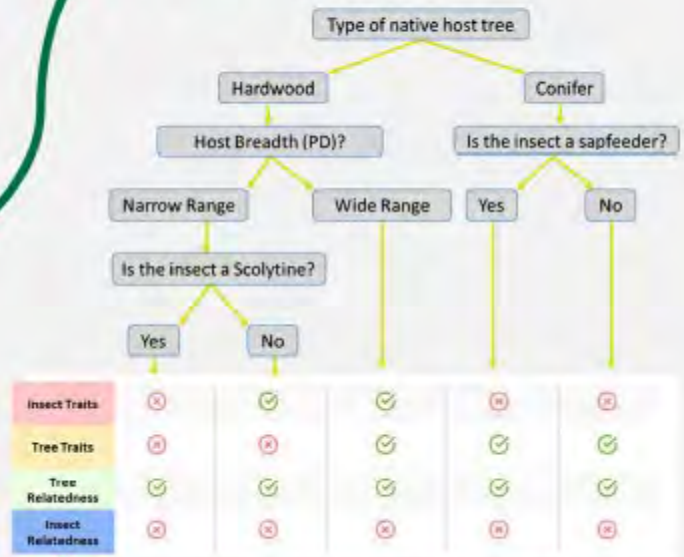
Matsucoccus matsumurae, PD = 17
2 tree spp. in 1 family

Xylosandrus germanus, PD = 7,723
152 tree spp. in 48 families

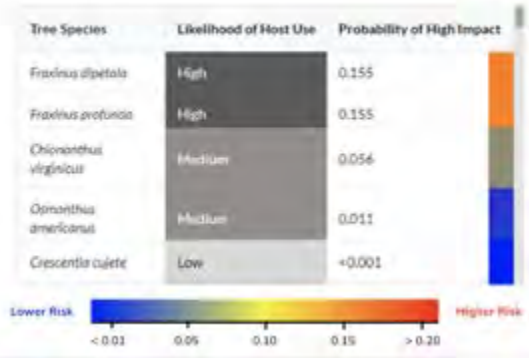
The i-Tree Pest Predictor (iTPP) tool

1. Input data

2. Run model(s)



Just an example; not actual output



3. Likelihood & predicted risk output

The "risky insects" analysis: Pathways from other biomes

- Imports from China and Latin America
- Range expansions from Mexico
- Hurricane flown from Caribbean

Ongoing analysis: 300+ potential invaders from Europe

- Which insects have the potential to cause highest impact?
- Which trees are at risk of high impact?
- What is the overall risk of high impact to entire ecosystems?

In Memorium

Charles van Riper III

USGS Senior Scientist
Research Ecologist
Emeritus Researcher 2015-2025

For more information:

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Pam Nagler pnagler@usgs.gov