

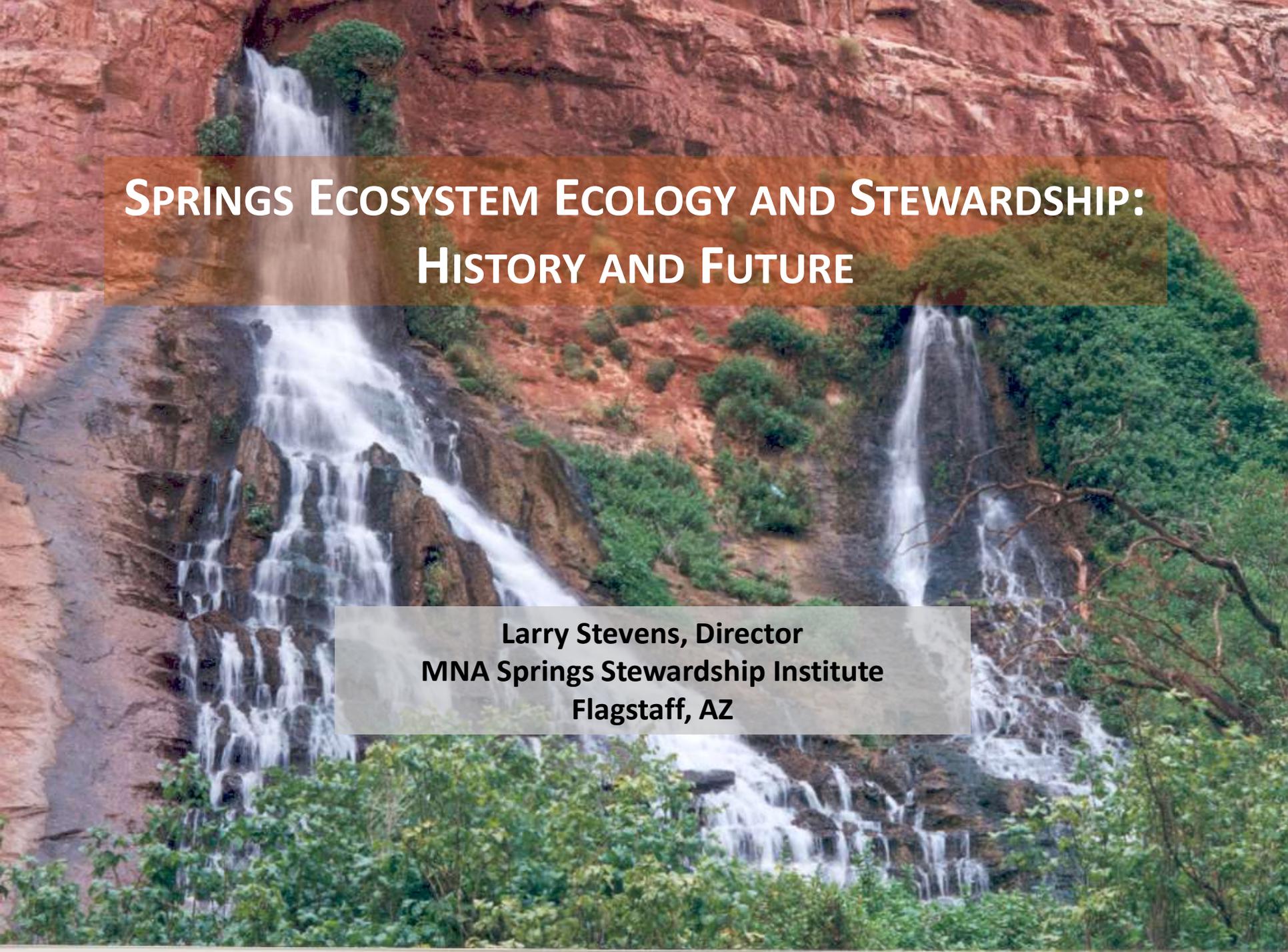


**2018 MNA SPRINGS
STEWARDSHIP INSTITUTE
AND GLEN CANYON
NATIONAL RECREATION
AREA SPRINGS TRAINING
AND WORKSHOP**

Welcome
Agenda

Housekeeping

Wireless: MNApublic!.



SPRINGS ECOSYSTEM ECOLOGY AND STEWARDSHIP: HISTORY AND FUTURE

**Larry Stevens, Director
MNA Springs Stewardship Institute
Flagstaff, AZ**

WHAT ARE SPRINGS ECOSYSTEMS?

- * Ecosystems where groundwater reaches, and usually flows from the Earth's surface
- * Subsurface-surface linked, GW-dependent
- * Subaerial or subaqueous

*"Seafloor Vent
Black Smoker"*

WHY STUDY SPRINGS ECOSYSTEMS?

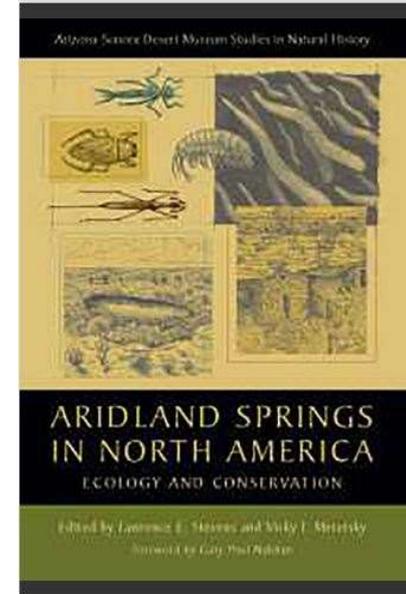
- Life's origin?
- Water recycling
- Keystone ecosystems
- Paleoreugia
- Support >10% of ES in US

- Support many rare spp.
 - Gravely threatened
 - Resilient if aquifer intact
 - Sustainable, restorable if aquifer intact
- Hotspot conservation

EVERY LAST DROP: GOALS/RECOMMENDATIONS FROM TUCSON SYMPOSIUM (EARLY 2000's)

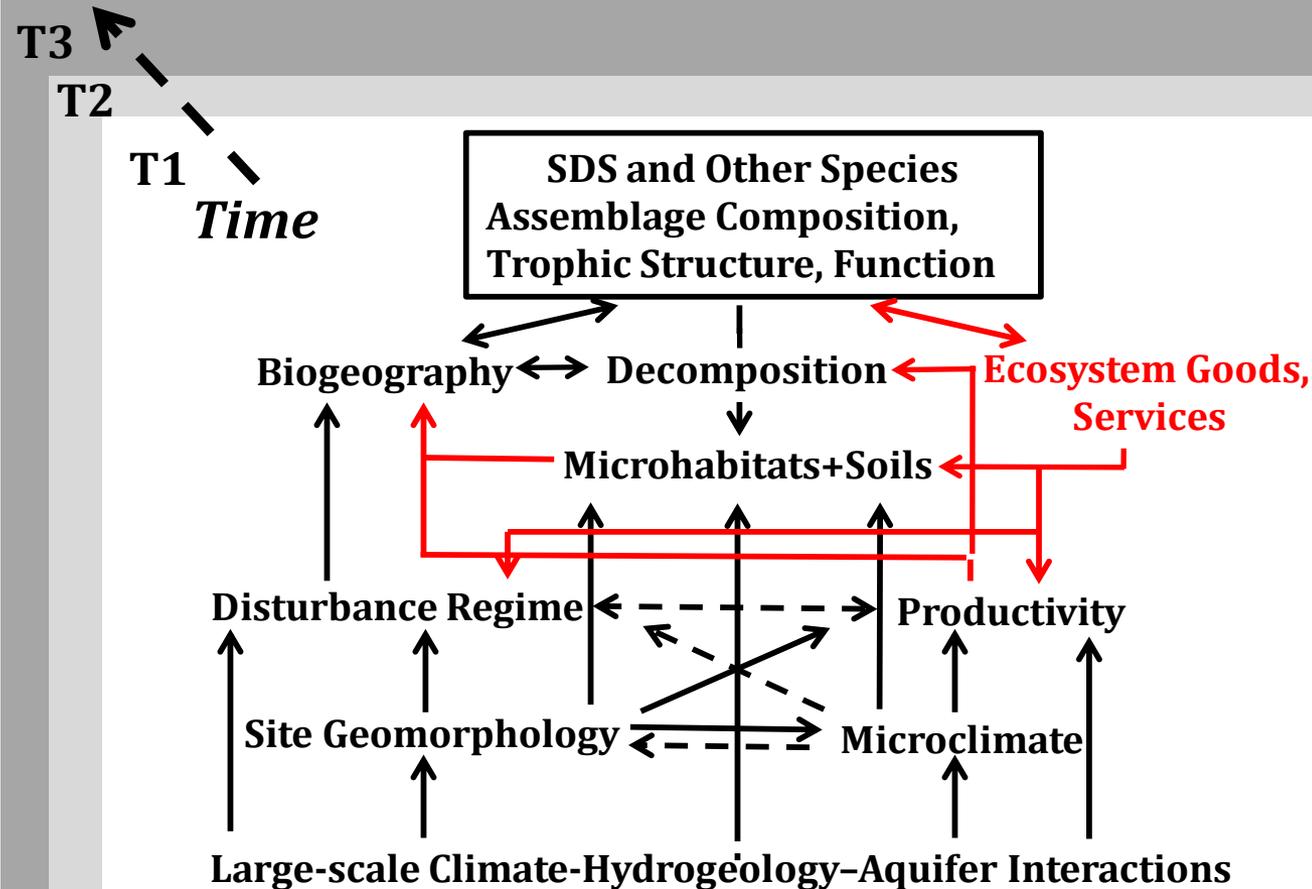
Develop, implement, test, refine:

1. Springs conceptual model and linked processes
2. Comprehensive classification system
3. Improved mapping
4. Enhanced information management
5. Inventory, assessment, monitoring protocols for mgt. and rehabilitation guidelines across spatial scale
6. Improved springs evolutionary ecohydrology



University of Arizona Press, 2008

1. SPRINGS ECOSYSTEM CONCEPTUAL MODEL (REDRAWN FROM STEVENS AND SPRINGER 2004)



VARIABILITY IN GROUNDWATER FLOWPATH LENGTH AND DURATION



Vaseys Paradise, Grand Canyon

- *Baseflow from North Rim*
- *Rapid response to precipitation*
- *Flowpath < 15 km*
- *18 hr – 10+ yr GW travel time*
(Huntoon 1974)



Montezuma Well, Central AZ

- *GW flows from Colorado Plateau*
- *Lagged response to climate*
- *Flowpath ~100 km*
- *Flow duration: 5,400 – 13,300 yr*
(Johnson et al. 2012)

Great differences in WQ, depending on sourcing, flowpath duration, aquifers, elevation

Springs support diverse microhabitats

Source

Cave

Madicolous

Terrace

Wet wall

Dry wall

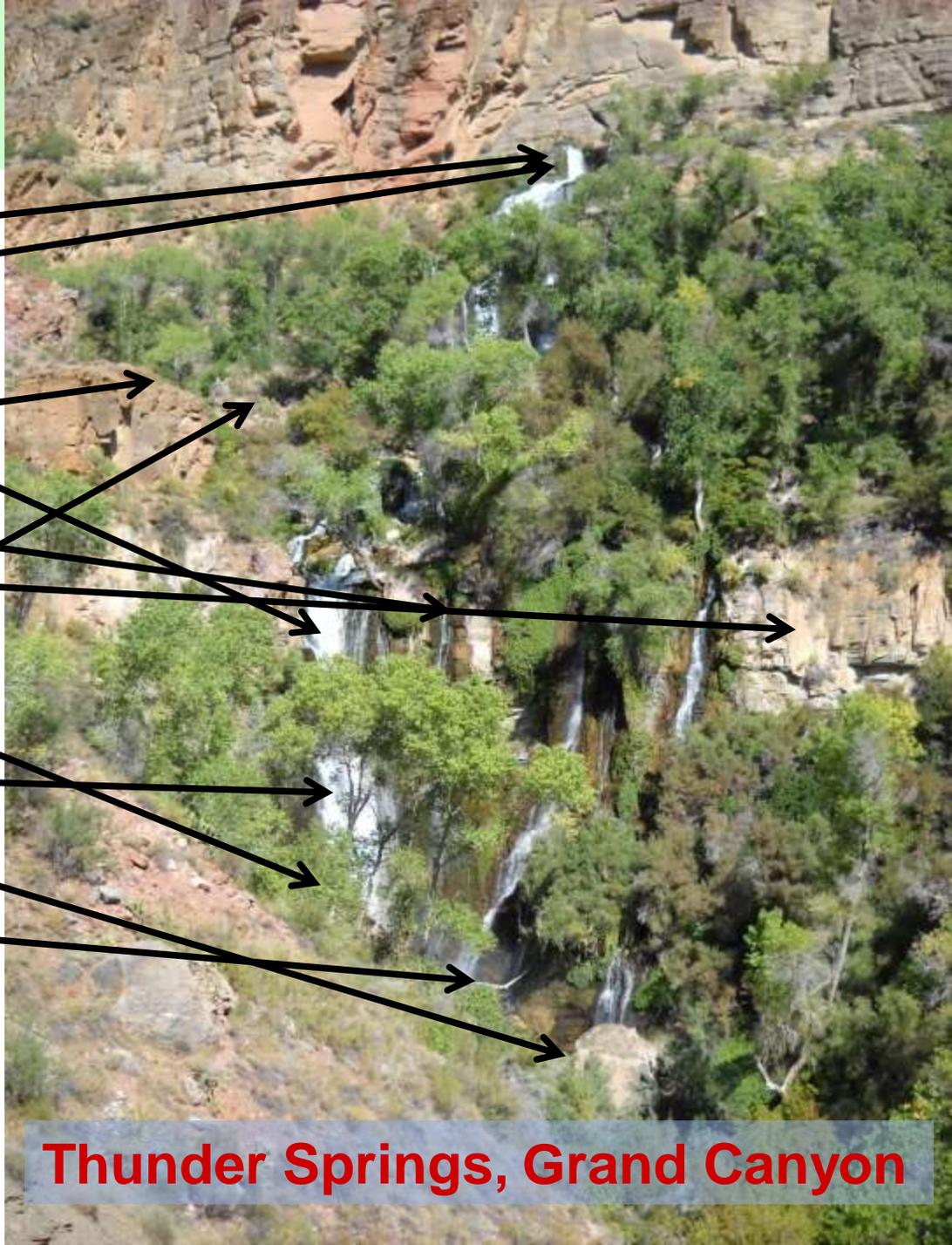
Wet meadow

Channel riparian

Sprayzone

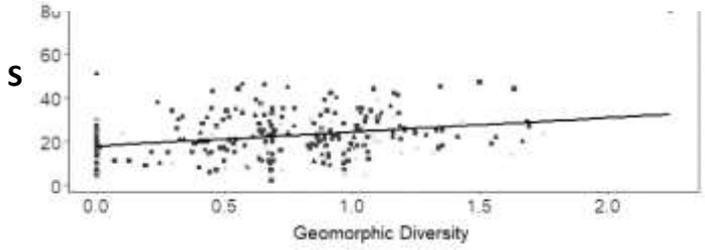
Hyporheic flow

Pool



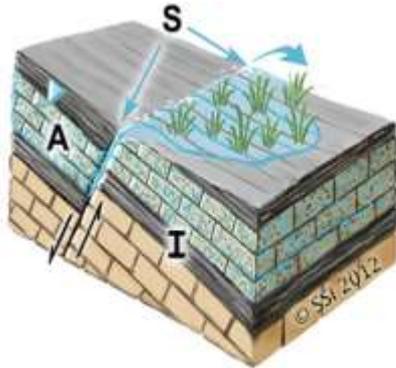
Thunder Springs, Grand Canyon

Geomorphic Diversity → Plant Species Richness

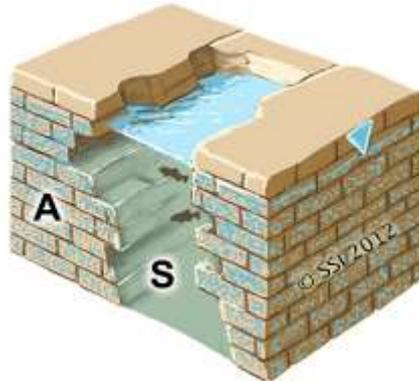


2. SPRINGS CLASSIFICATION: ~ LENTIC

Helocrene
(GDE fen, ciénega,
Wet meadows)



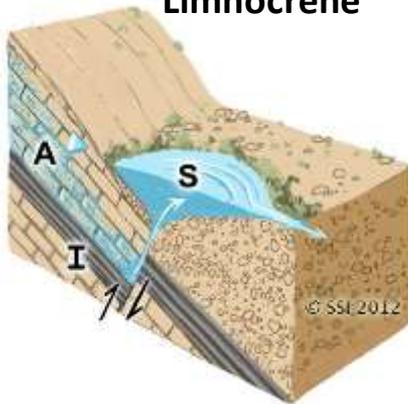
Exposure



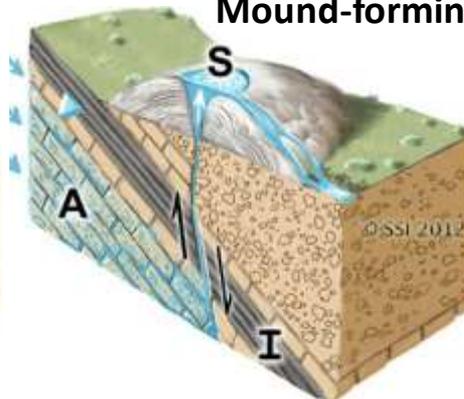
Hypocrene



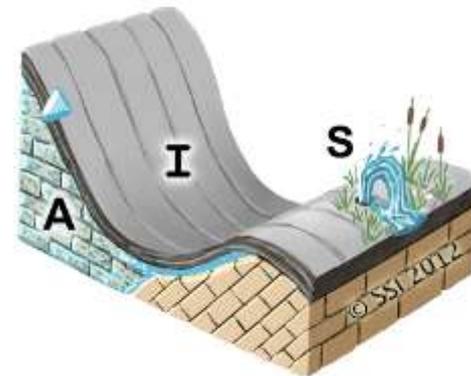
Limnocrene



(Carbonate)
Mound-forming

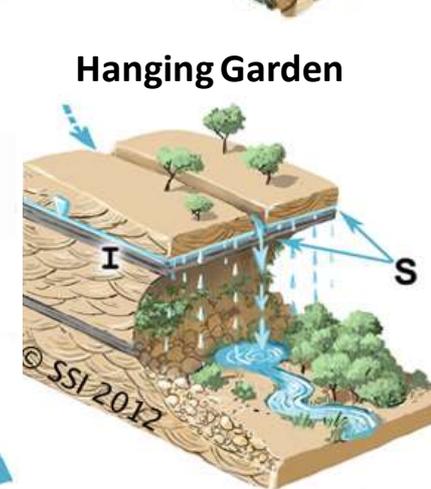
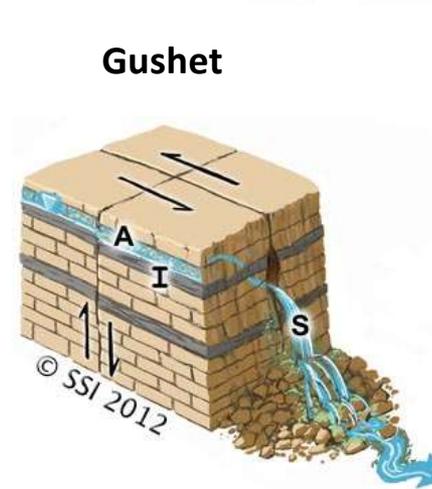
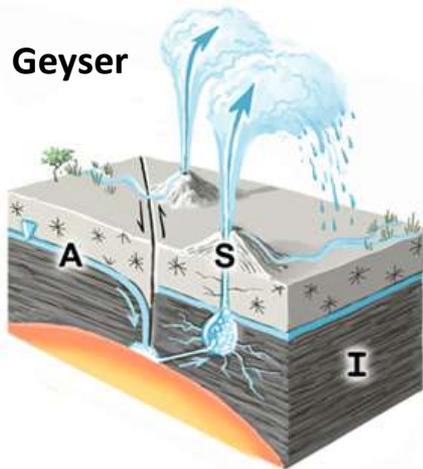
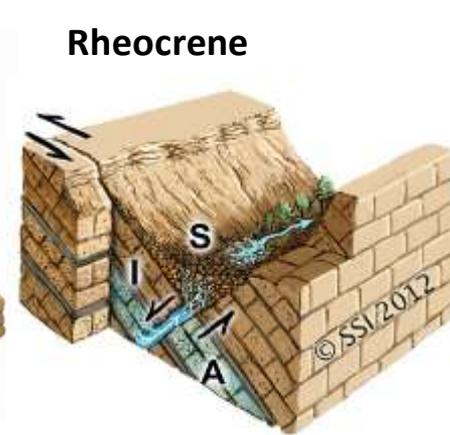
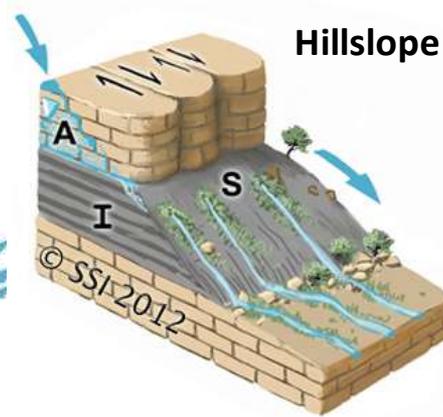
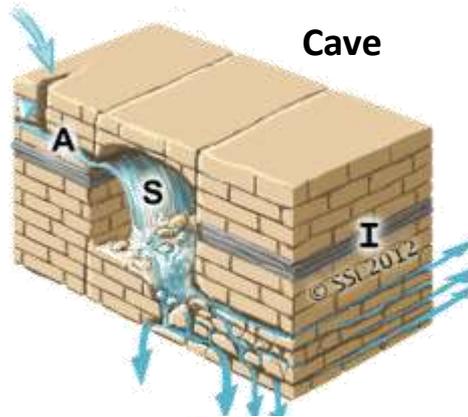


Semi-Lotic: Fountain



Paleocrenes not depicted

SPRINGS CLASSIFICATION: LOTIC



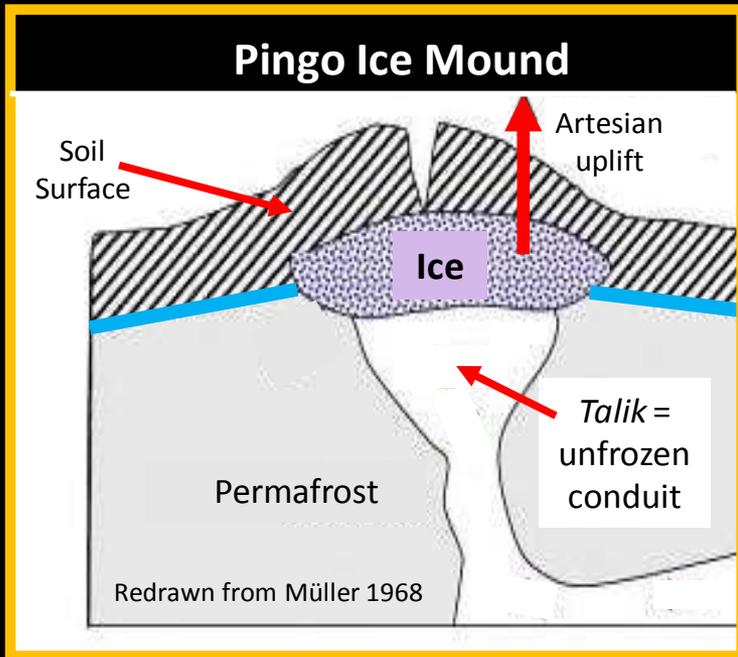
SOUTHWESTERN SPRINGS TYPES





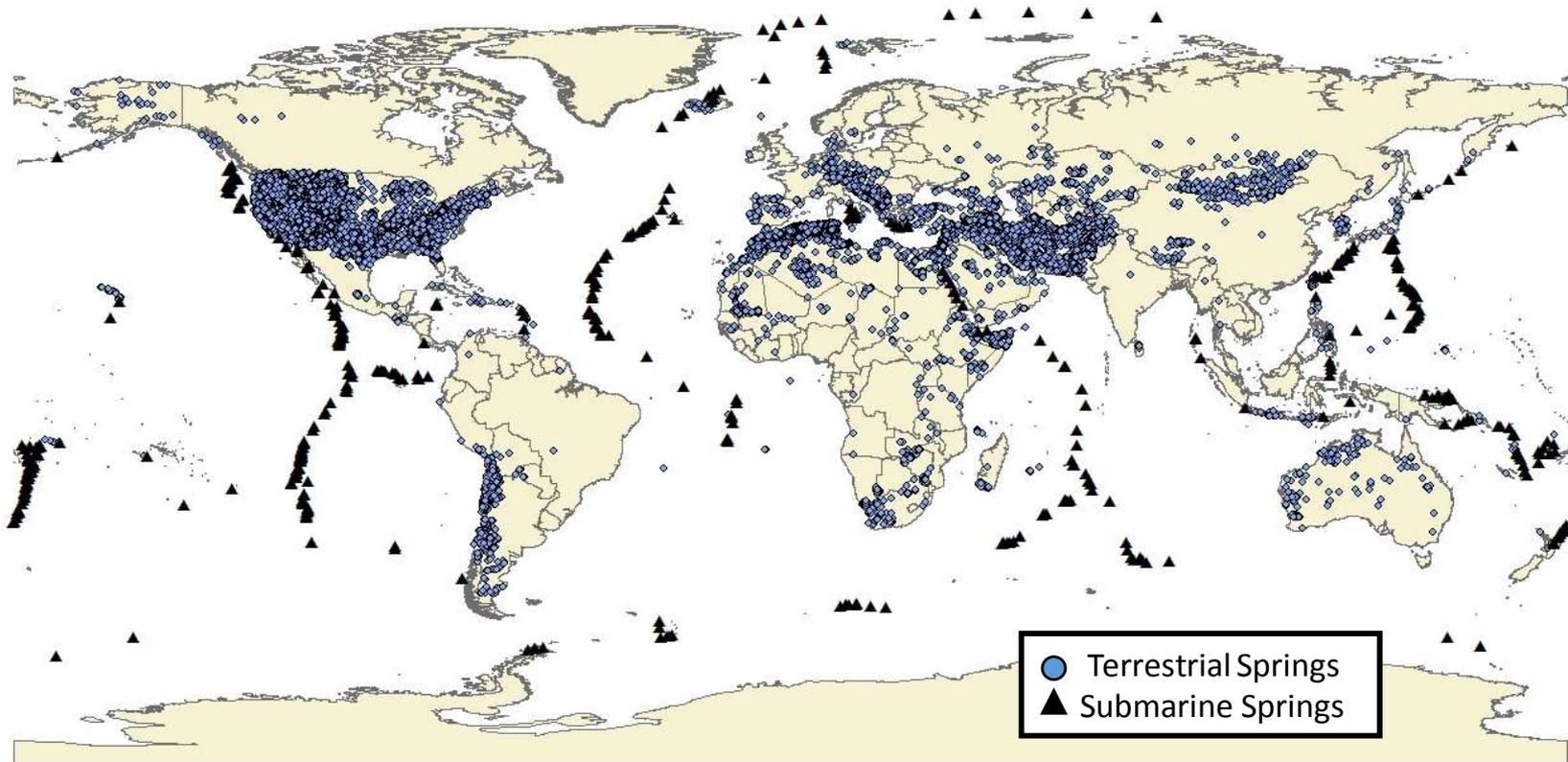
Other classifications: WQ, landscape position, vegetation cover, developments

Non-Southwestern: Pingos – Frozen Artesian Springs

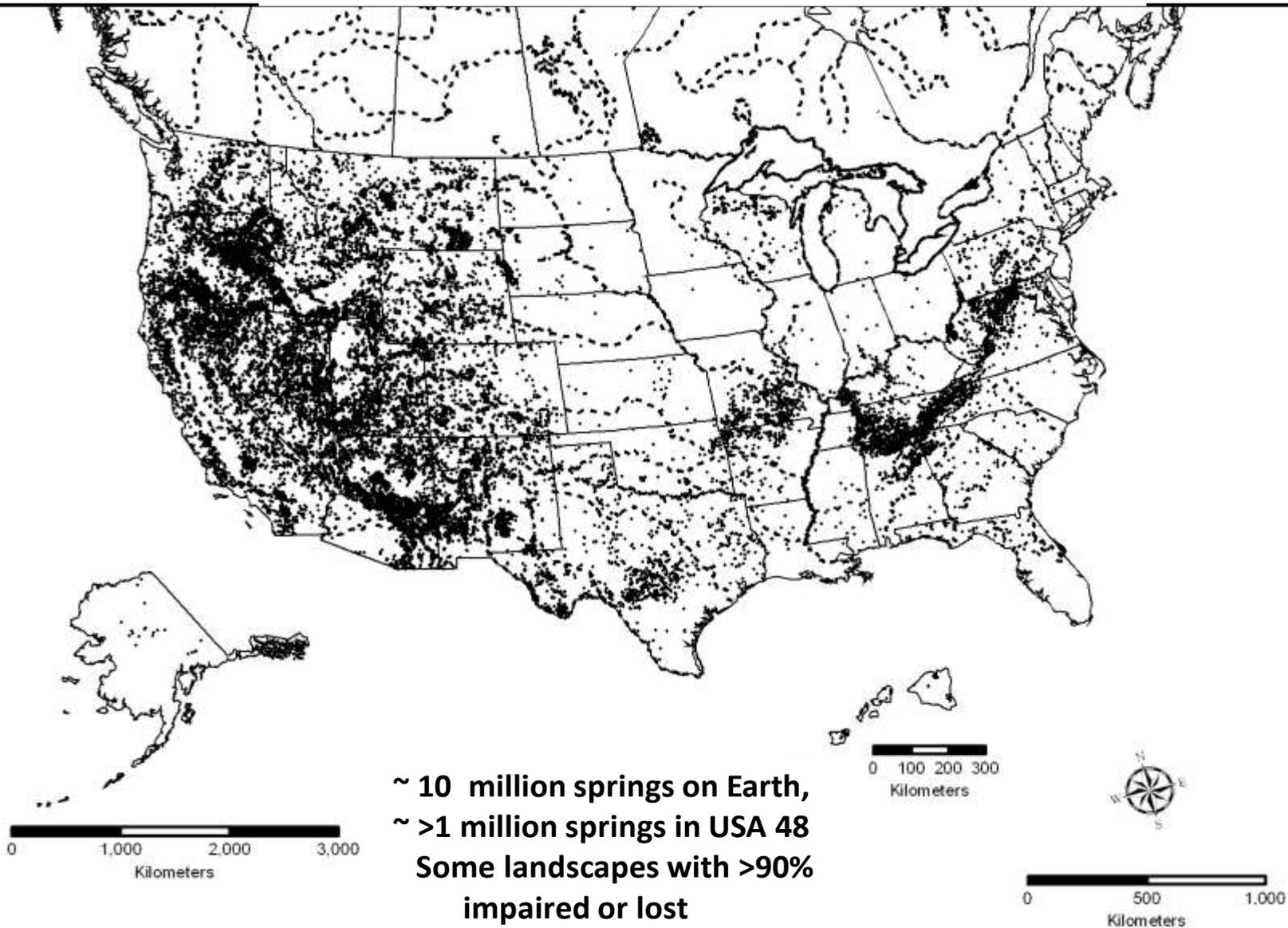


3. SPRINGS MAPPING

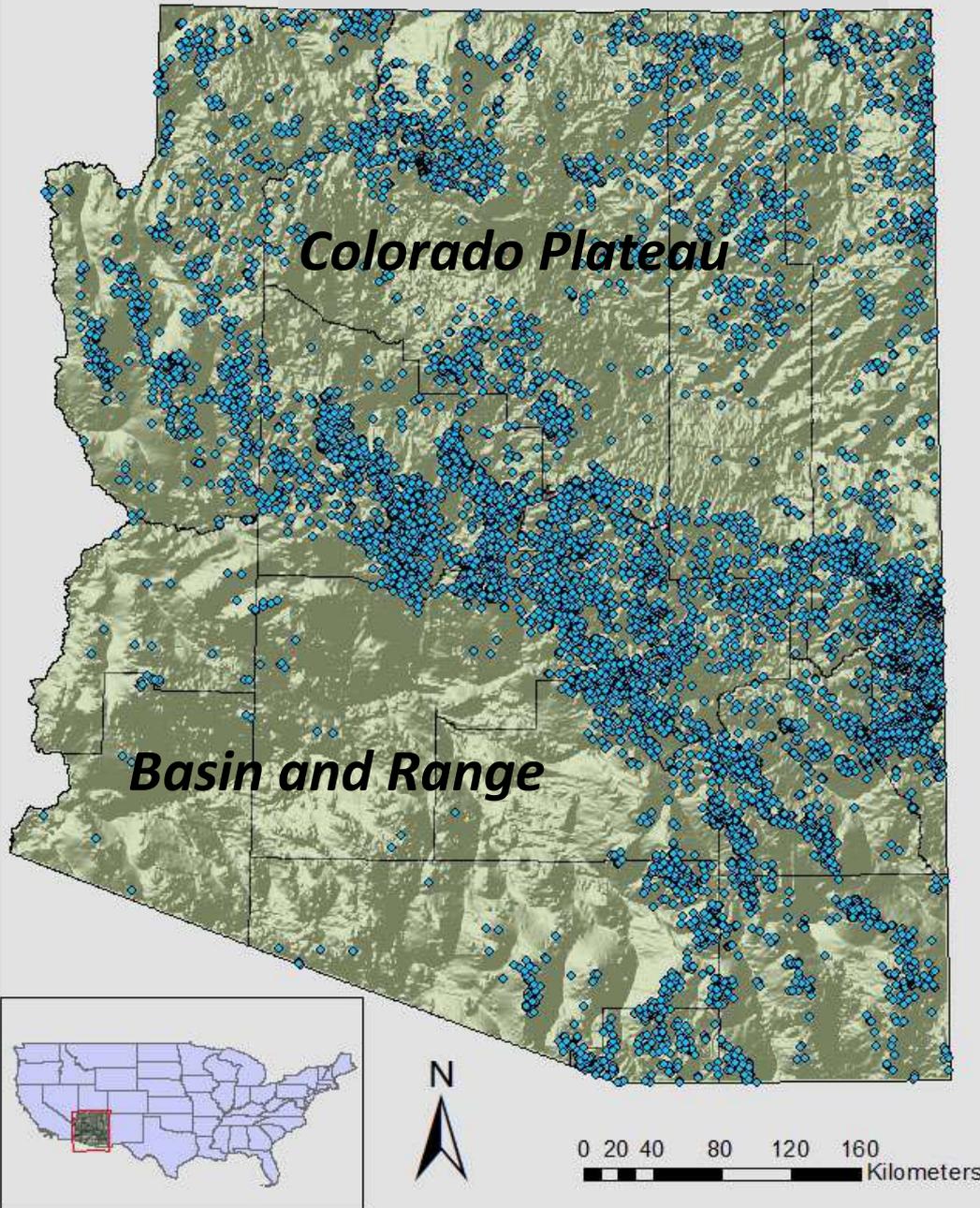
**SPRINGS ARE GLOBALLY ABUNDANT,
BUT MOST ARE SMALL, POORLY MAPPED**



Named USA Springs



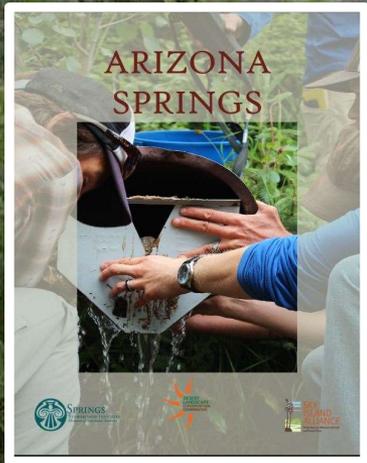
Arizona Springs



- High density of springs, >10,300+
- Incomplete mapping (NHD, AZ State Lands, etc.)
- Clustered in mountains and escarpments
- Provide 0.5 maf to state
- Only a few hundred springs inventoried
- >70->90% degraded

4-5. Springs Information Management Tools, Protocols (www.SpringStewardshipInstitute.org)

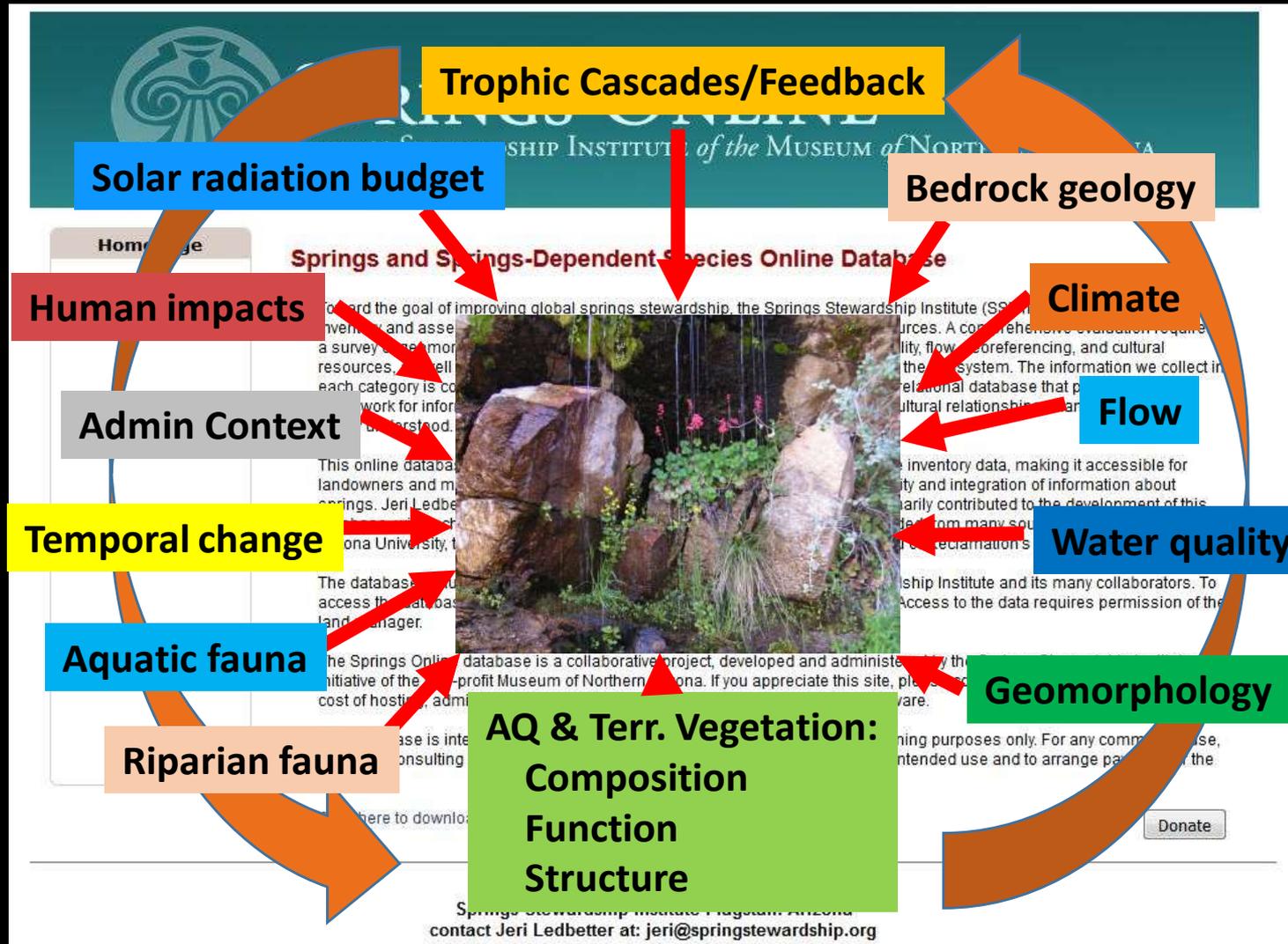
SPRINGS STEWARDSHIP INSTITUTE



LEARN MORE

**MNA Springs Stewardship Institute and Springs Online Database:
Free, secure tools and protocols for secure inventory, assessment,
monitoring, and reporting to facilitate collaborative springs stewardship**

Springs Online (SpringsData.org)



Early 2000's Leading Science Questions

Physical Science:

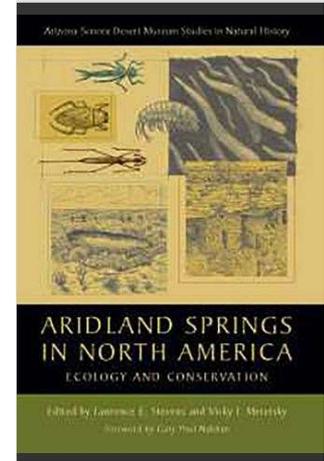
- 1) Climate change impacts
- 2) Multi-gradient interactions (e.g., tectonics, PET)
- 3) Testing geomorphic vs. other classifications
- 4) Longevity, ecosystem transitions through time

Biology:

- 1) Disturbance-productivity impacts on diversity
- 2) Springs biogeography
- 3) Keystone ecosystem ecology across humidity provinces
- 4) Trophic cascading in neo- vs. paleo-ecosystem ecology
- 5) Causes of endemism and rarity
- 6) Predictive modeling of springs biodiversity

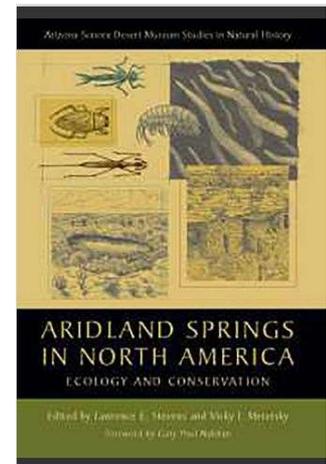
Cultural-Socioeconomics:

- 1) Extent and manner of prehistoric uses (e.g. role of fire)
- 2) Sustainability of indigenous use
- 3) Creno-ethnology
- 4) Goods and services economics



Early 2000's Leading Springs Management Issues

- State of springs across spatial scale
- Test inventory and assessment protocols
- Best practices in rehabilitation planning and implementation
- Regional groundwater protection needs
- Springs ecosystem research center and reference sites
- A springs research journal
- Enhanced springs conservation
- Resolve public-governmental polarization
- Adaptive ecosystem management



**MNA'S SPRINGS
STEWARDSHIP
INSTITUTE**

**Springs Online info
management system is
available for integrated
understanding, discussion,
and stewardship of springs
ecosystems, and is a
powerful relational
research platform**

**SpringsStewardshipInstitute.org
SpringsData.org**



Crambidae:
Petrophila bifasciatus
Aquatic SDS moth

6. Springs Science: Vegetation



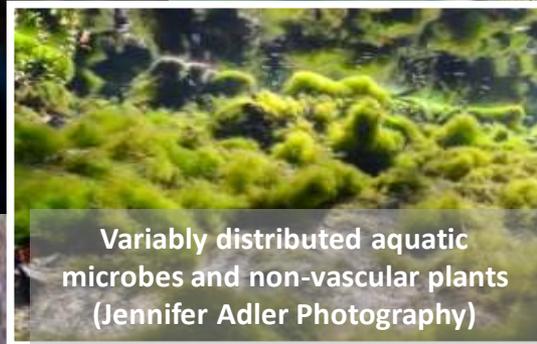
Widespread, Springs Only:
Helleborine Orchid
(*Epipactis gigantea*)



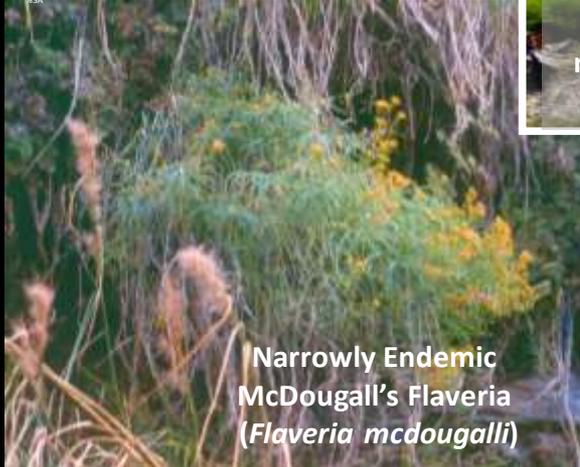
Widespread in
Wetlands Scarlet
Monkeyflower
(*Mimulus
cardinalis*)



Upland species:
Grasses, herbs,
shrubs, trees



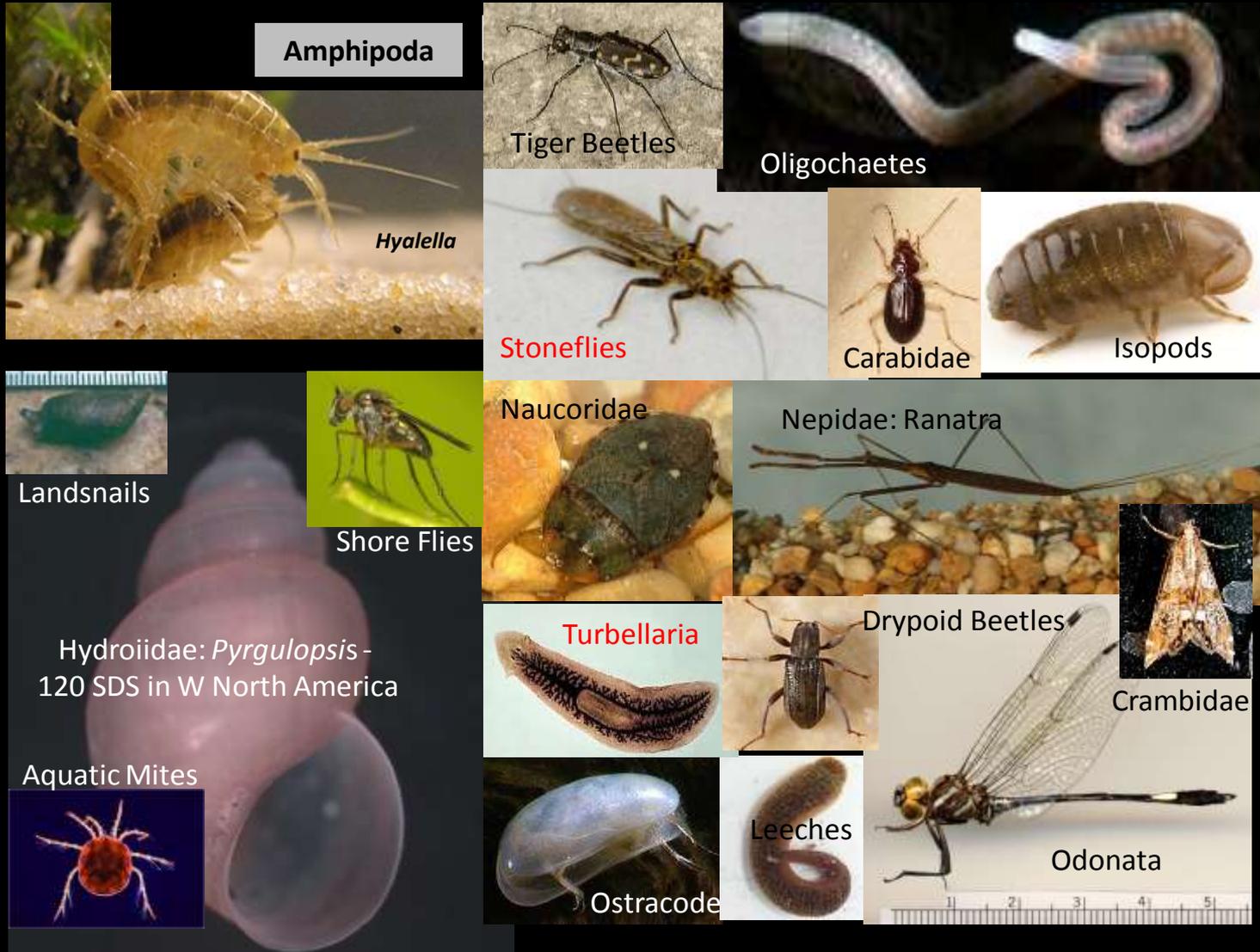
Variably distributed aquatic
microbes and non-vascular plants
(Jennifer Adler Photography)



Narrowly Endemic
McDougall's Flaveria
(*Flaveria mcdougalli*)

**UNDER-APPRECIATED BIODIVERSITY HOTSPOTS
OF SPRINGS-DEPENDENT SPECIES:
A Continuum of
Tightly-packed Aquatic to Upland Species**

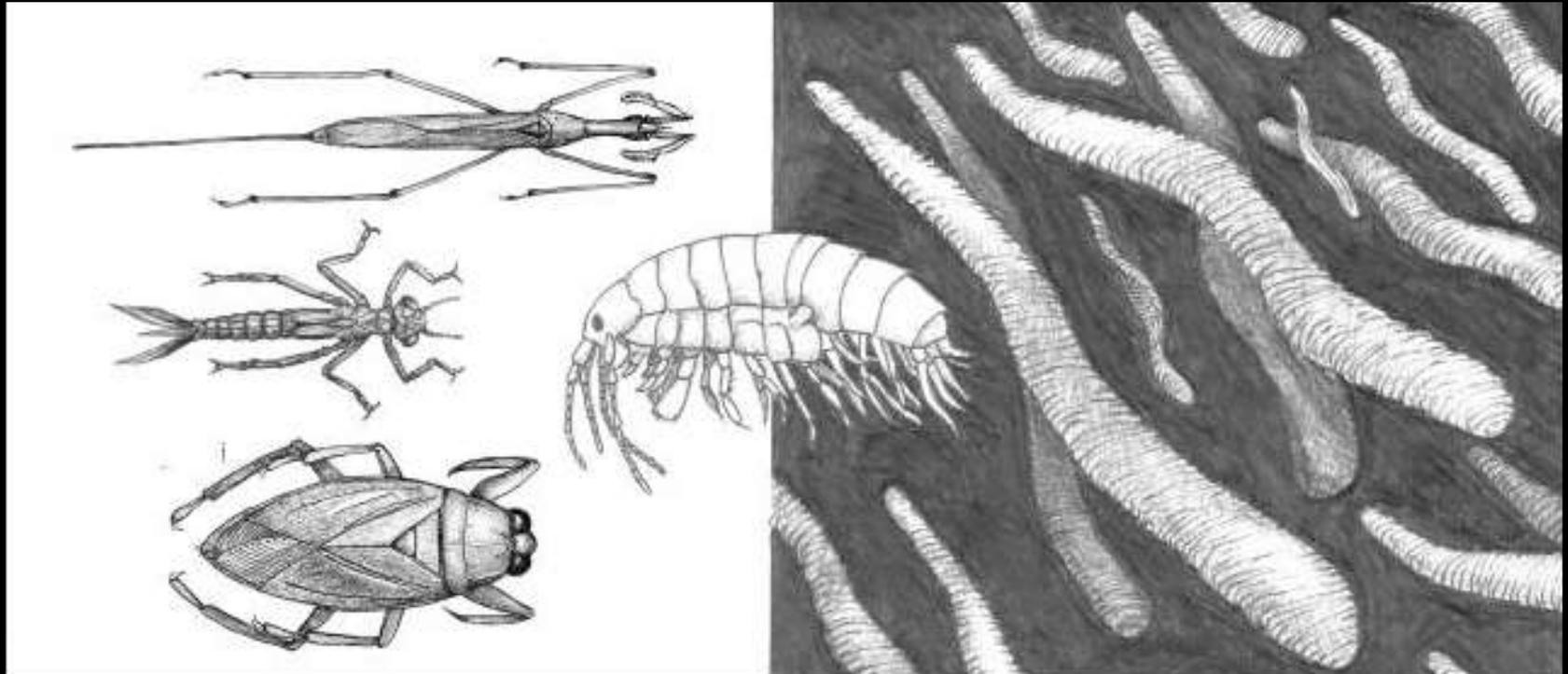
4. SPRINGS-DEPENDENT (CRENOBIONTIC) INVERTEBRATE SPECIES

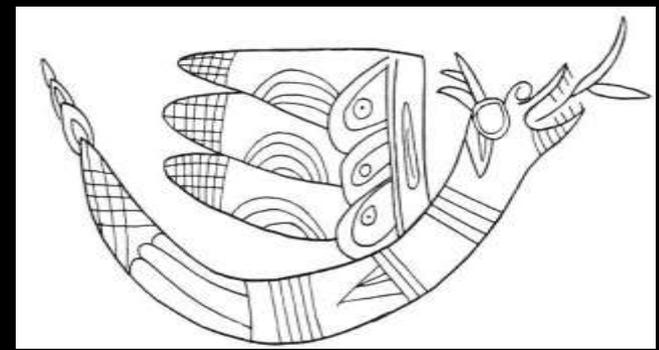


Springs-dependent Vertebrate Species



Springs as Ecosystems: Montezuma Well (Blinn 2008)





Underestimated Springs Socio-Economics:

Florida, 1992-2002 (Bonn and Bell 2002):
\$60 million added to economy from 4 large springs,
2 million springs visitors/year



US drinks 1,500 bottles of water/min, many labeled as “springs water”

MNA'S SPRINGS STEWARDSHIP INSTITUTE

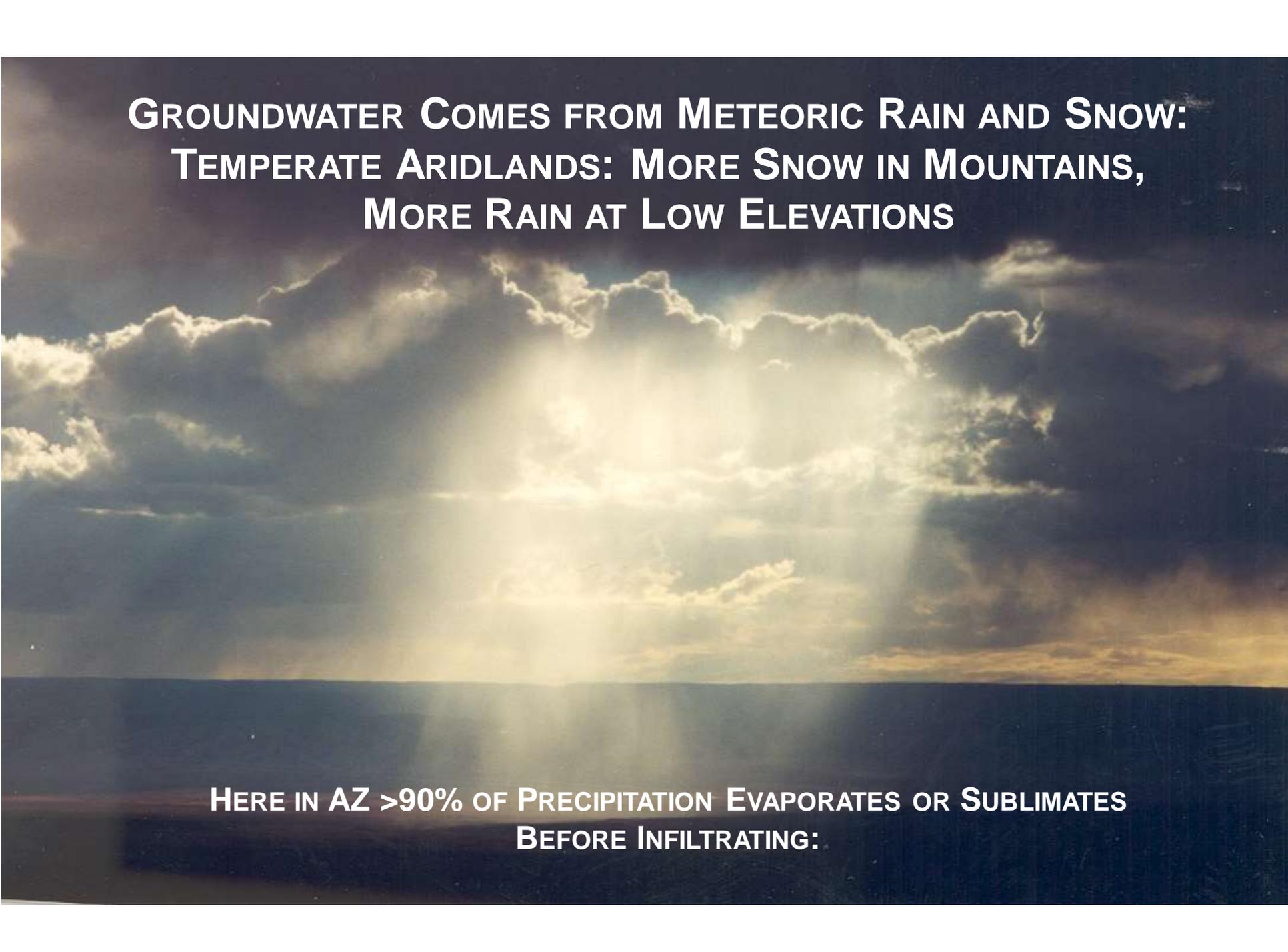
(SpringsStewardshipInstitute.org)

Springs Online (SpringsData.org)
is a secure, easy-to-use,
relational information
management system designed
to improve understanding,
discussion, and stewardship of
springs ecosystems:

- 145,000 North American
springs
- ~ 700 users, including USFS,
NPS, BLM, DOD, Tribes,
NGOs, Public



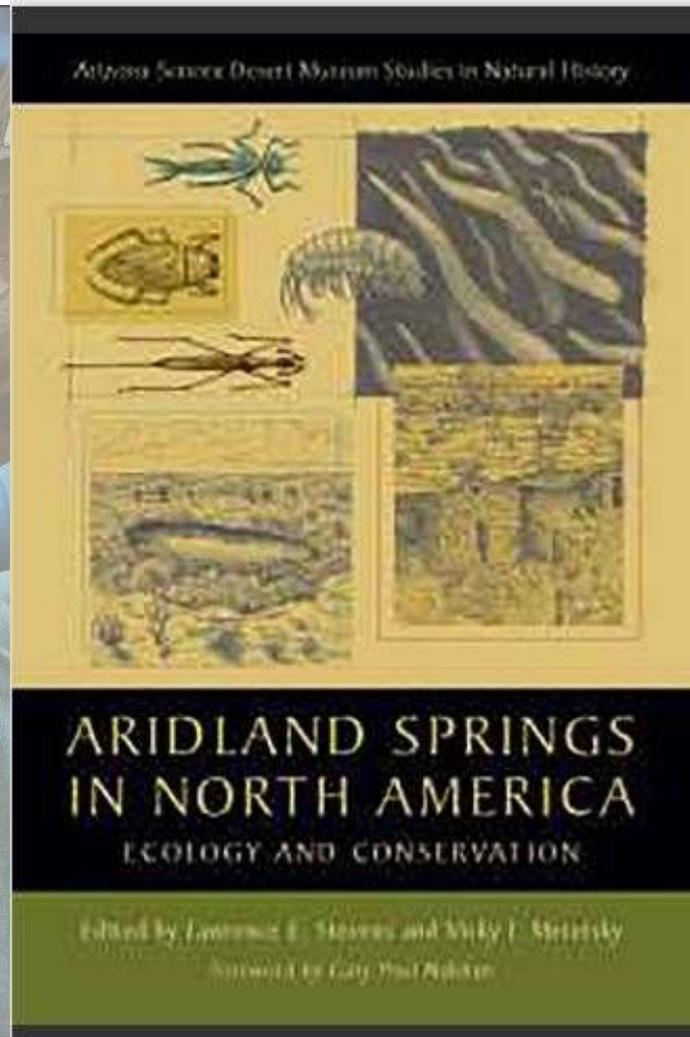
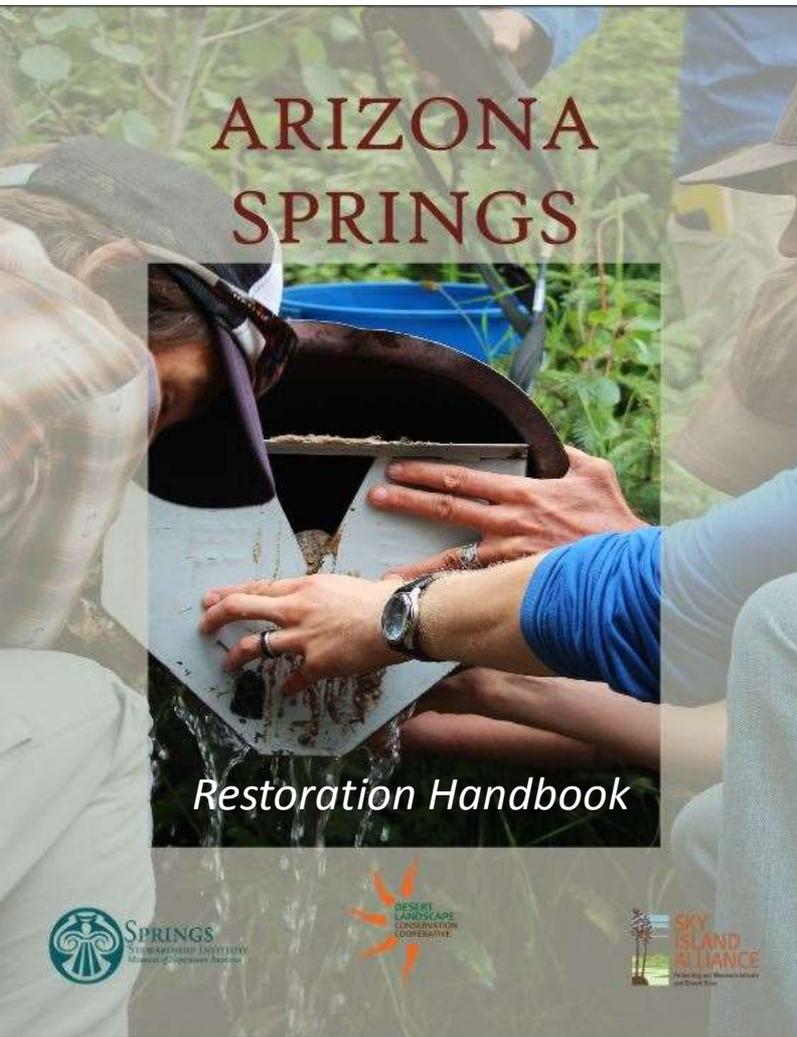
Crambidae:
Petrophila bifasciatus
Aquatic SDS moth



**GROUNDWATER COMES FROM METEORIC RAIN AND SNOW:
TEMPERATE ARIDLANDS: MORE SNOW IN MOUNTAINS,
MORE RAIN AT LOW ELEVATIONS**

**HERE IN AZ >90% OF PRECIPITATION EVAPORATES OR SUBLIMATES
BEFORE INFILTRATING:**

6. Recent Science References



Mueller, J.M., R.E. Lima, and A.E. Springer. 2017. Can environmental attributes influence protected area designation? A case study valuing preferences for springs in Grand Canyon National Park. *Land Use Policy* 63:196-205.



“Although the...pool is often barely recognizable as a spring, fish were milling about in the shallow water, moving back and forth from under cover of the ice to fully visible in the open water.” – H. Golden,
<http://frontierscientists.com/2015/02/grayling-alternate-overwintering-springs/>

Aufeis (icings) formed in winter = 27–30% of the annual groundwater discharge in the Kuparuk River (Yoshikawa et al. 2007).