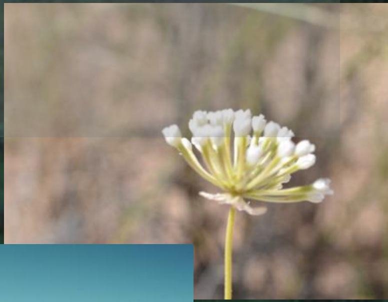
WFWARP Riparian Program

- Environmental Flow Determination
- Monitoring Protocol Development
- River Restoration
- Litigation Science Support on Water-Related Issues
- Direct Technical Support to National Forests and Grasslands







Global change

Process domain

Response

Guilds

Properly functioning

Desired condition

Lag time

Functional redundancy

Threats

Ecosystem functioning

Ecological integrity

Ecological site description

Ecological integrity

FUNCTIONAL TRAITS

Hierarchical organization

Vulnerability

Species diversity

Ecosystem services

Resistance

Resilience

Health











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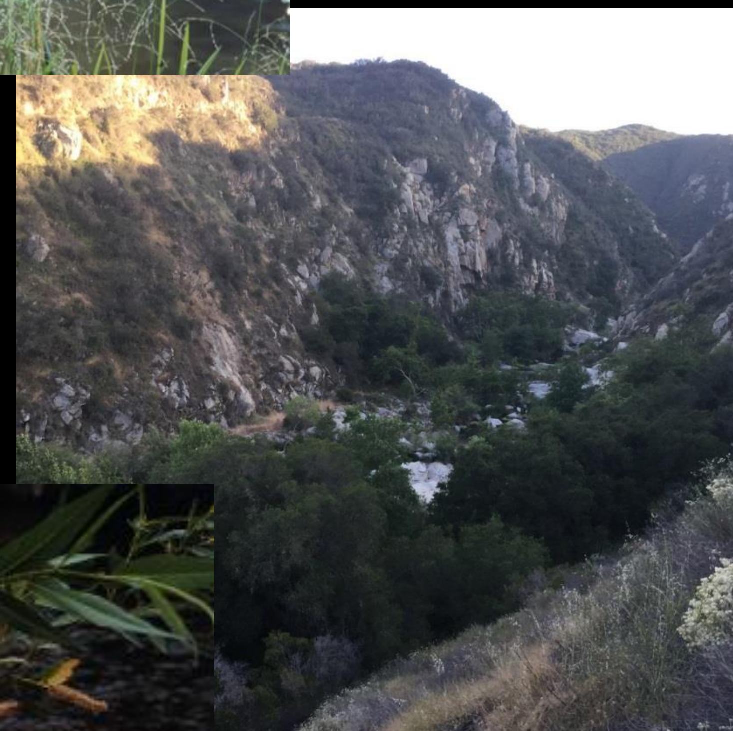
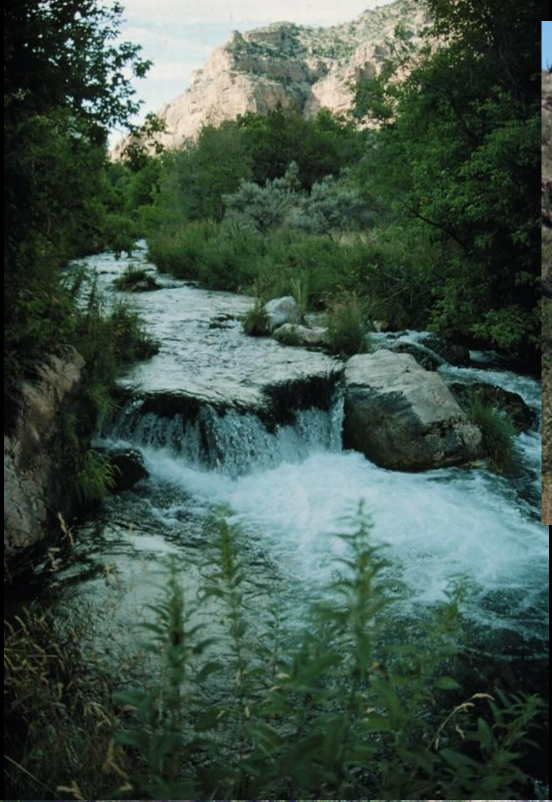
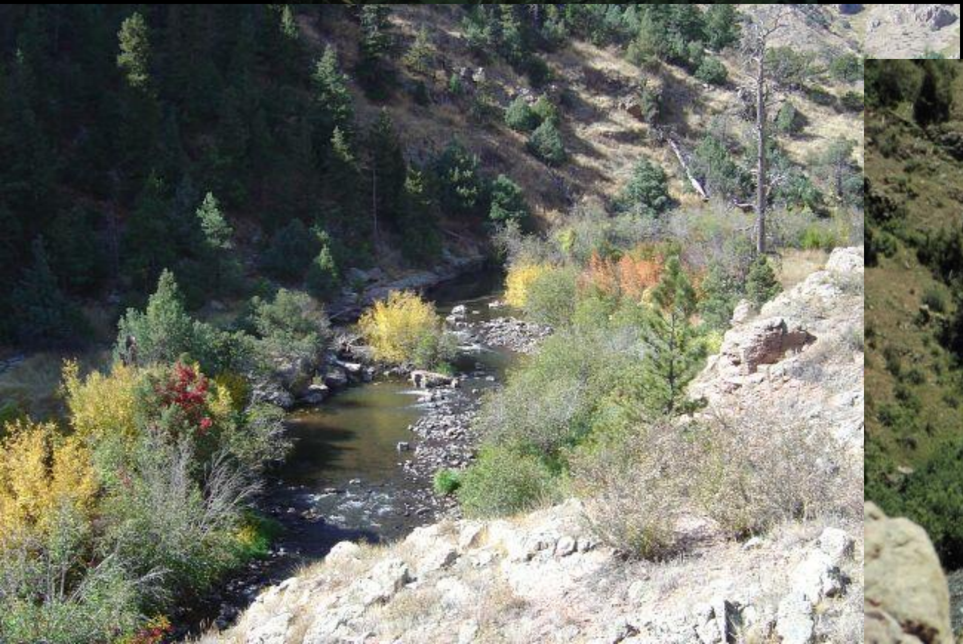



Scale

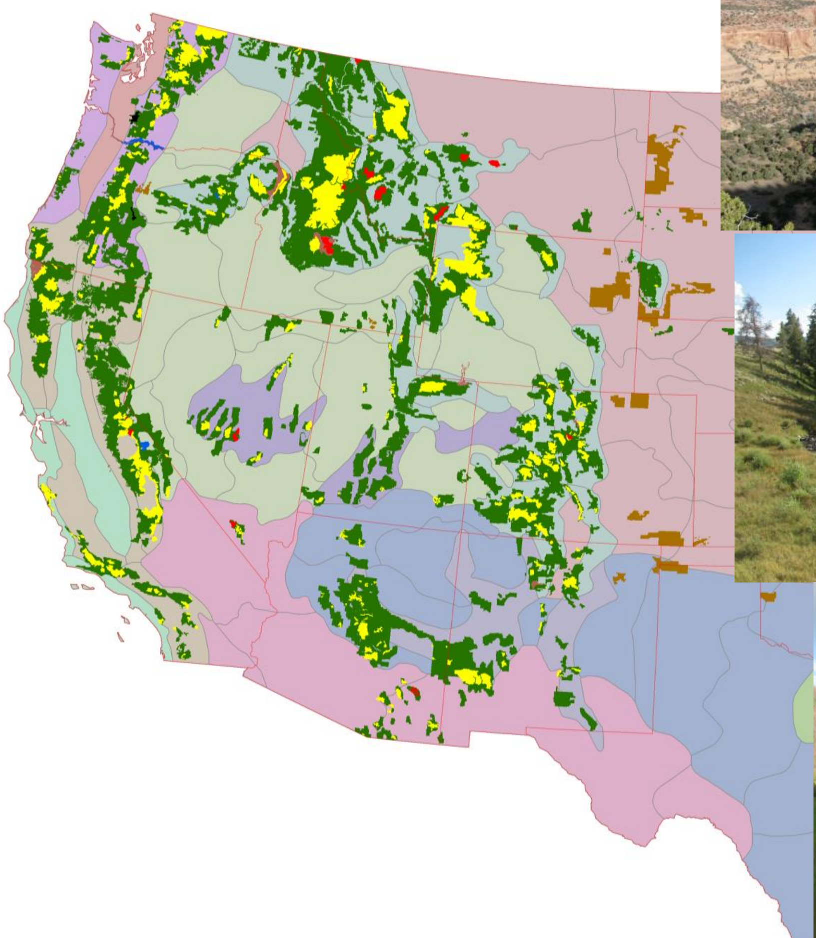
Region
↓
Segment
↓
Reach

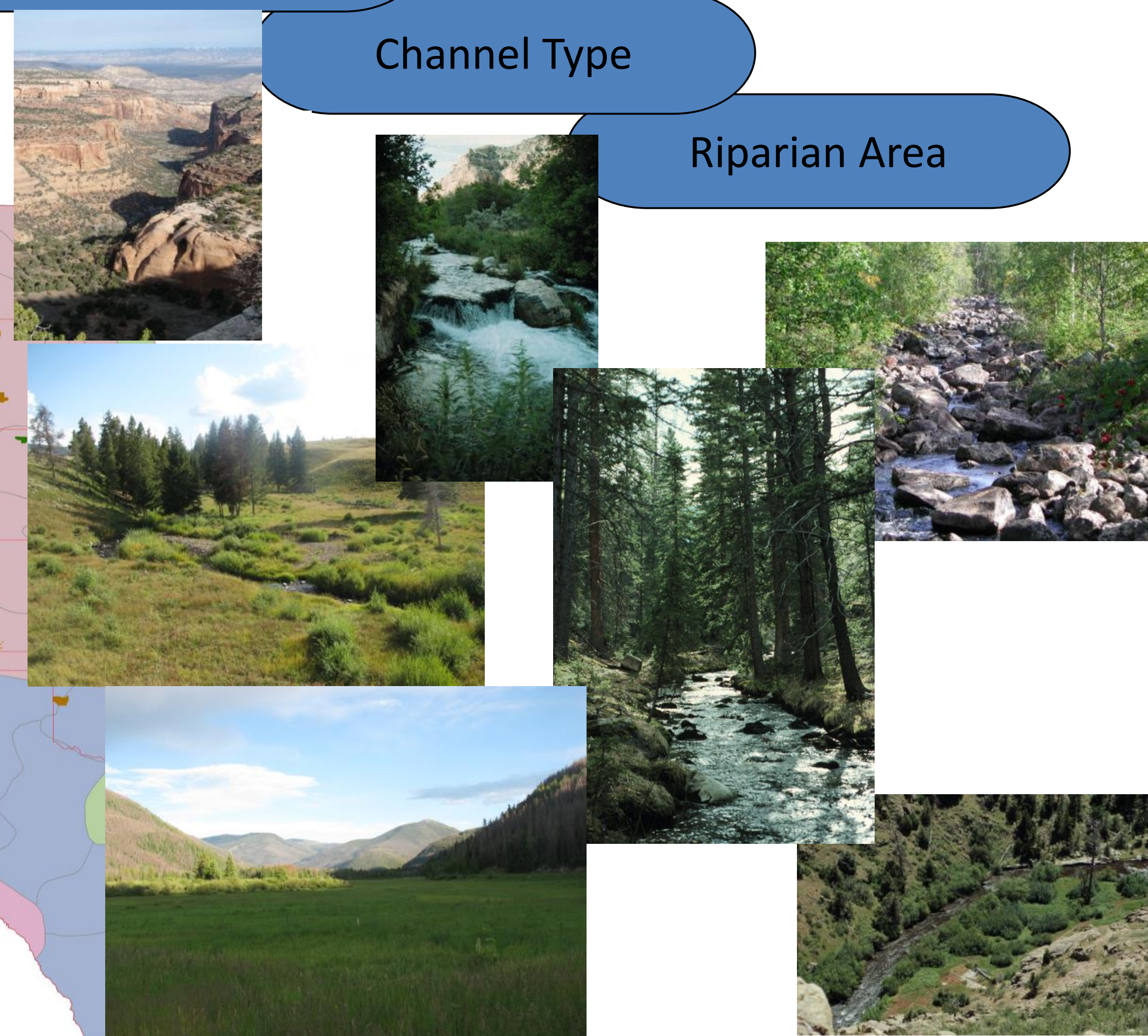
Ecoregion

Valley Form

Channel Type

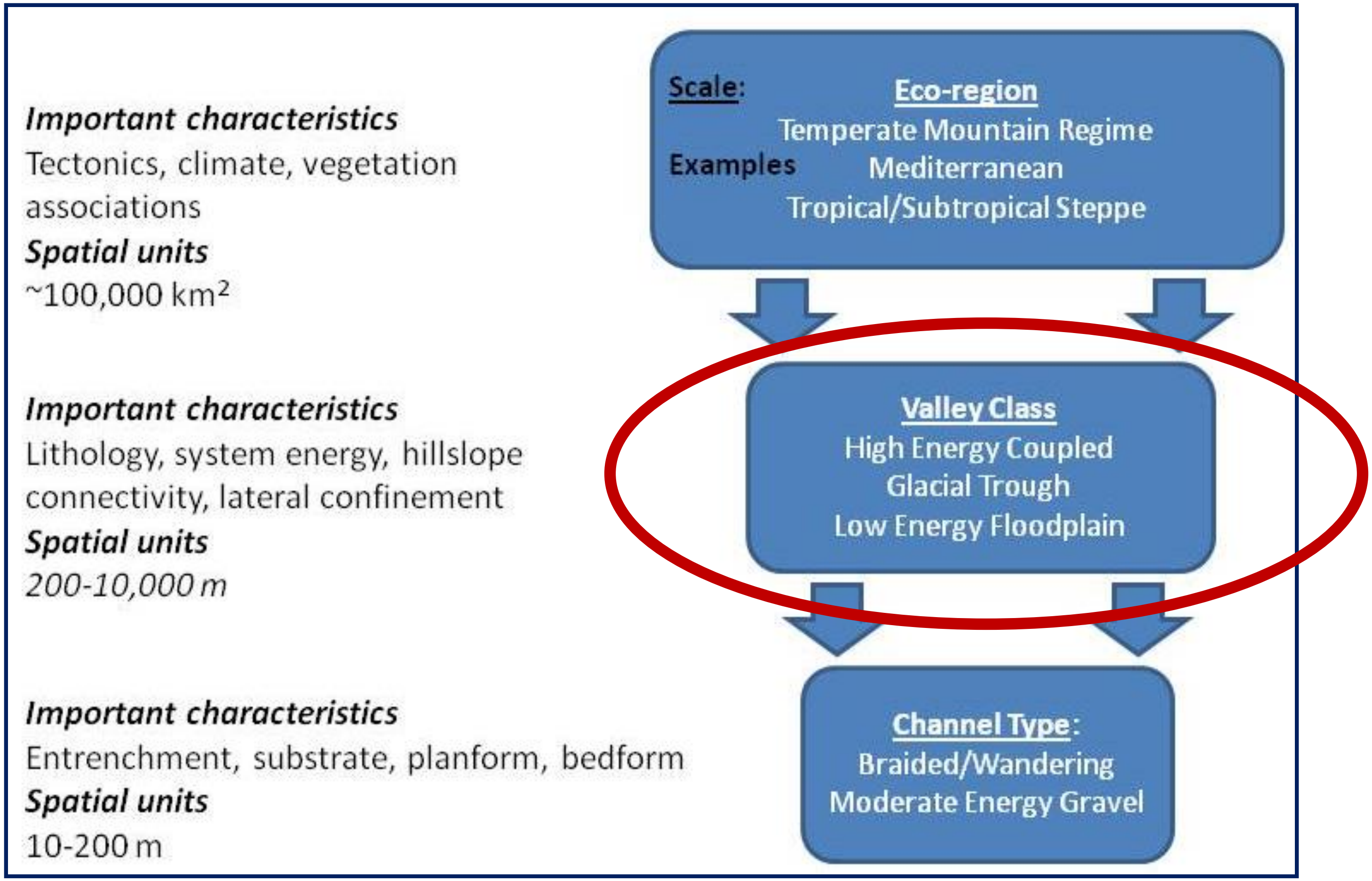
Riparian Area





HGVC organization and scale

- A **hierarchy of spatial scales**
- **Open framework** strongly urges the user to input **regional** values for some key thresholds

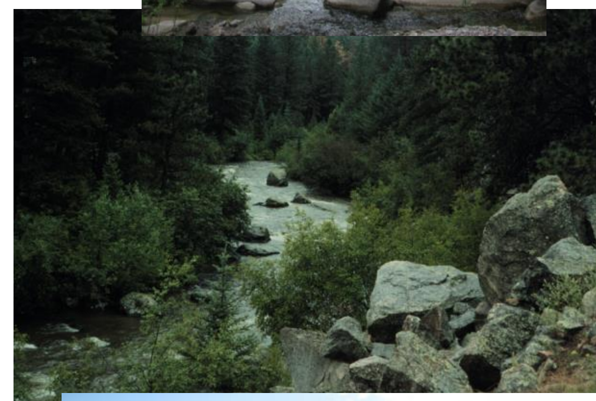


Geomorphic Valley Classification

E. Carlson and B. Bledsoe

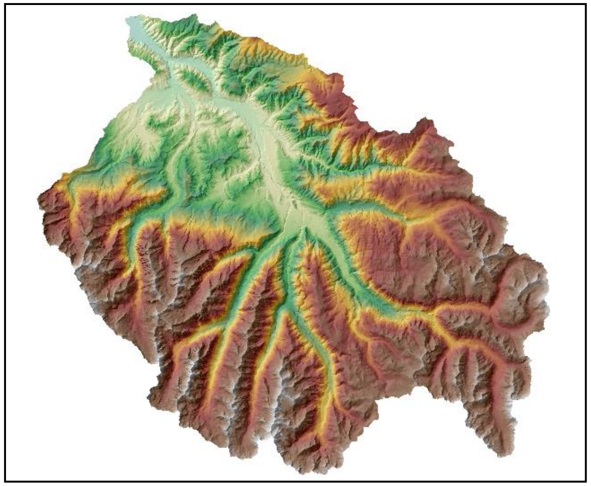
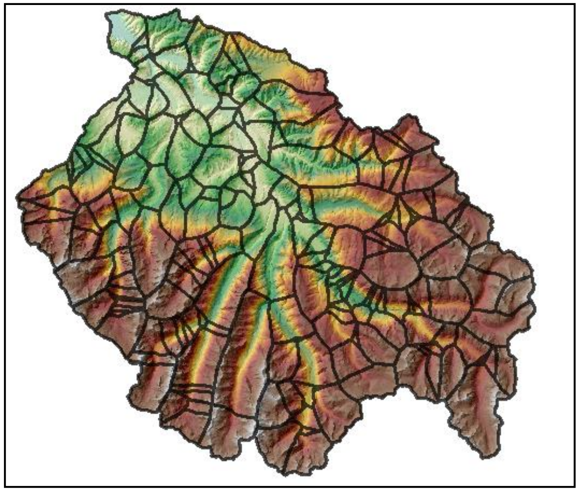
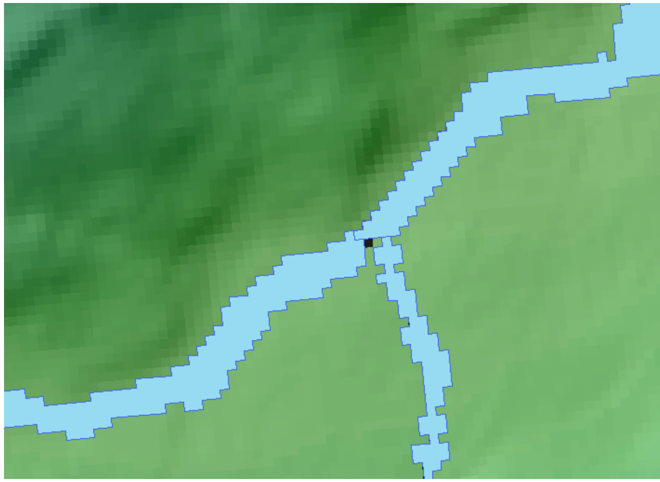
1) System energy
2) Valley confinement
3) Hillslope coupling

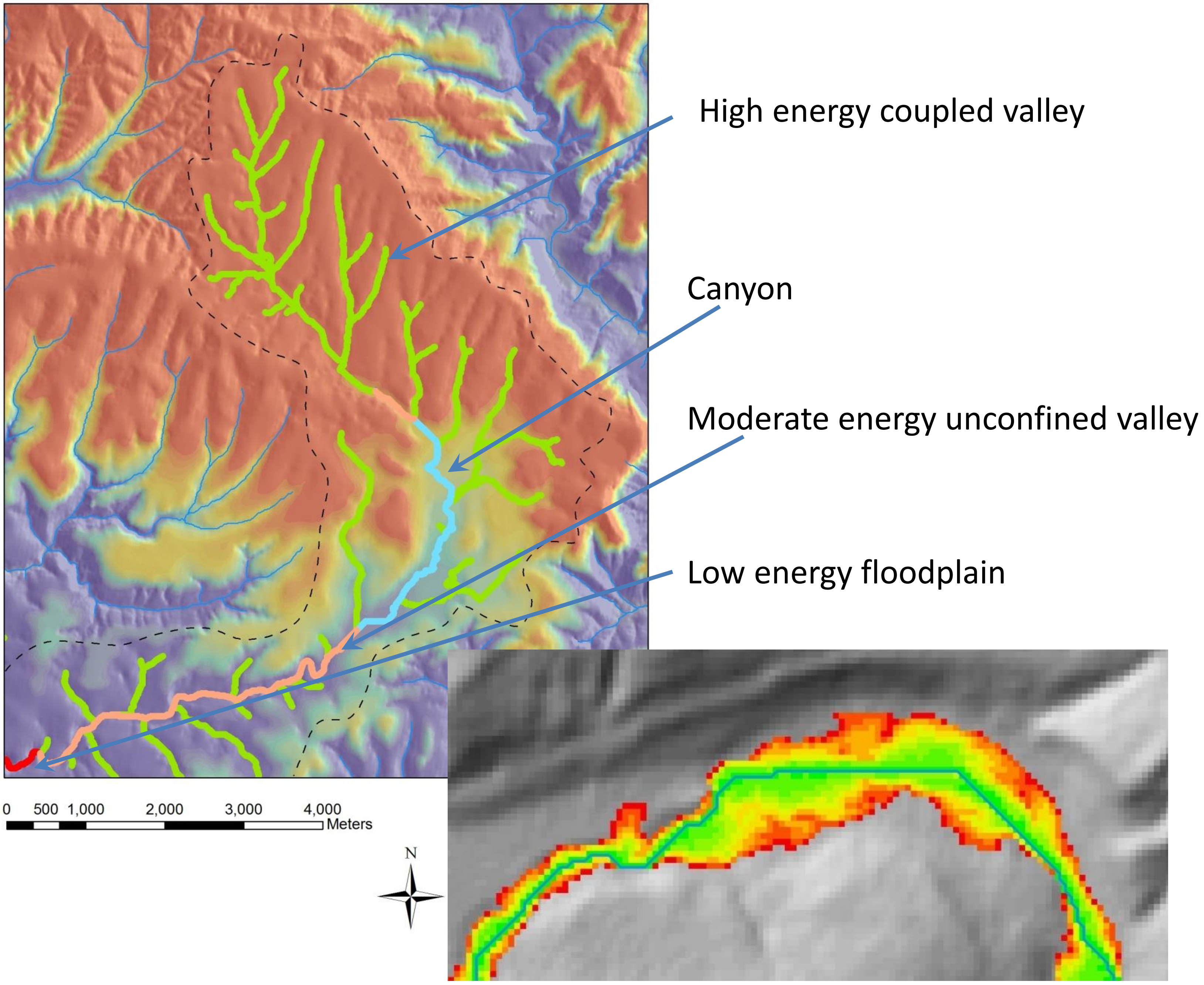
Headwater	> 4%	Confined	Steep
High-energy Coupled	> 4%	Confined	Steep
High-energy Open	> 4%	Unconfined	Steep
Moderate-energy Confined	0.1 - 4%	Confined	Low-Steep
Moderate-energy Unconfined	0.1 - 4%	Unconfined	Low-Steep
Canyon	Variable	Confined	Steep
Gorge	Variable	Confined	Steep
Glacial Trough	< 4%	Unconfined	Moderate-Steep
Low-energy Floodplain	< 0.1%	Unconfined	Low-Moderate



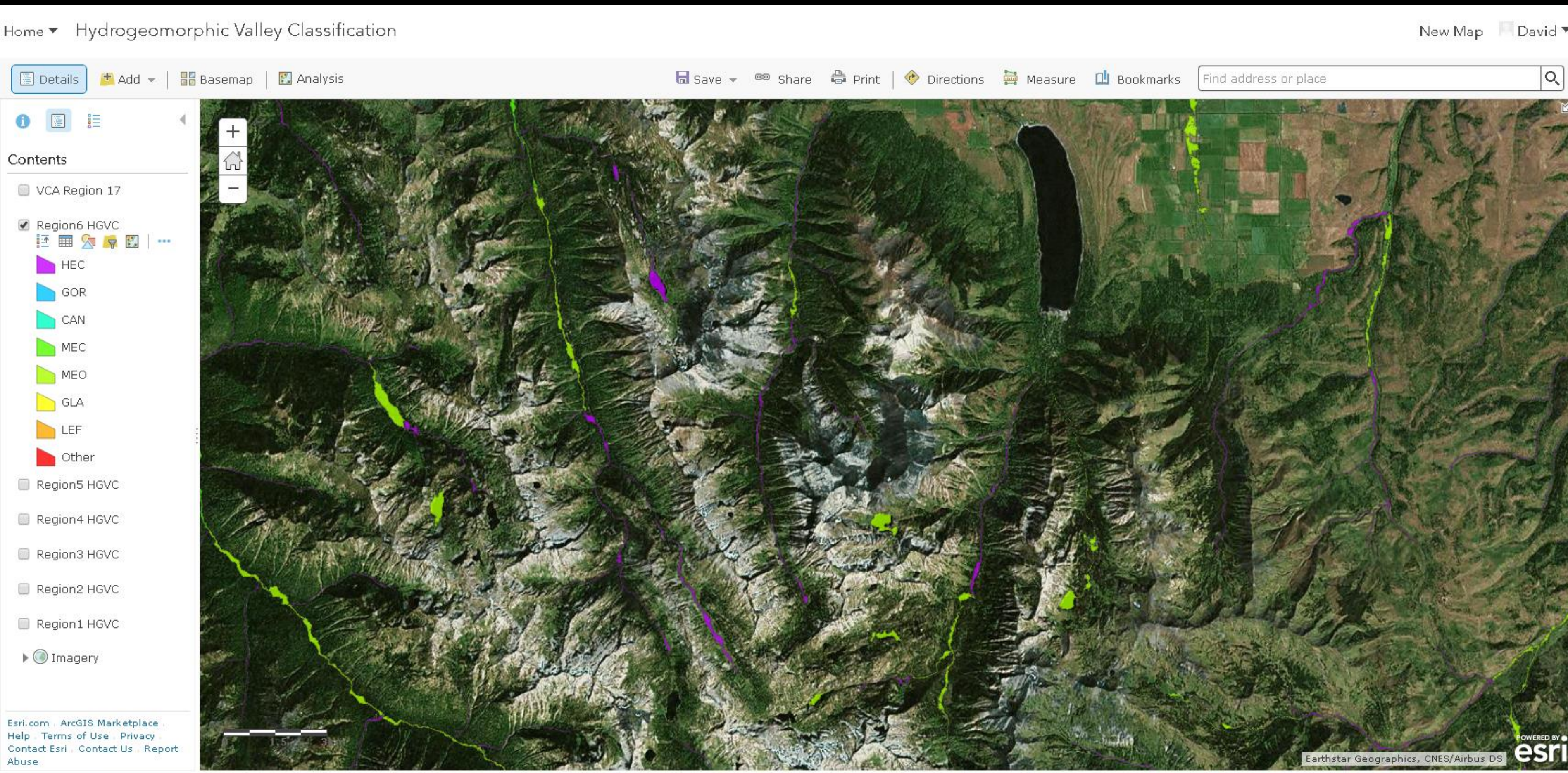
Bringing it all together

- Input Layers and Regional Metrics:
  - DEM, Q100, Hillslope angles, Bankfull width parameters, Debris flow runout
- Behind the scenes:
  - Segment by segment analysis of channel, valley and hillside components
- End products:
  - Shapefiles of valleys (Hydro, Geo, and Hydro-Geo), hillslopes
  - Rasters for streams, channel width, Q100 flow volume

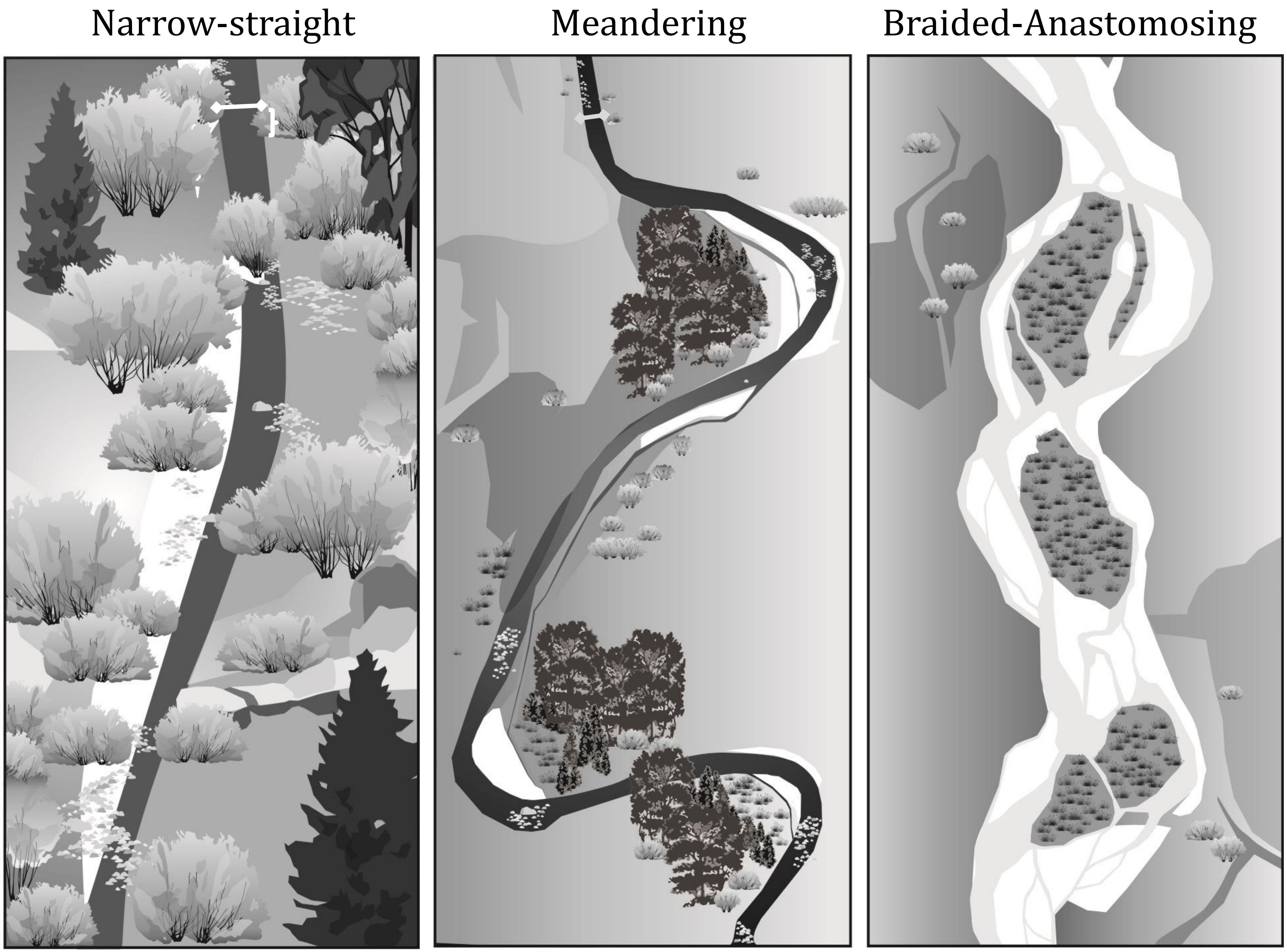






High energy coupled valley
Canyon
Moderate energy unconfined valley
Low energy floodplain
0 500 1,000 2,000 3,000 4,000
Meters
N

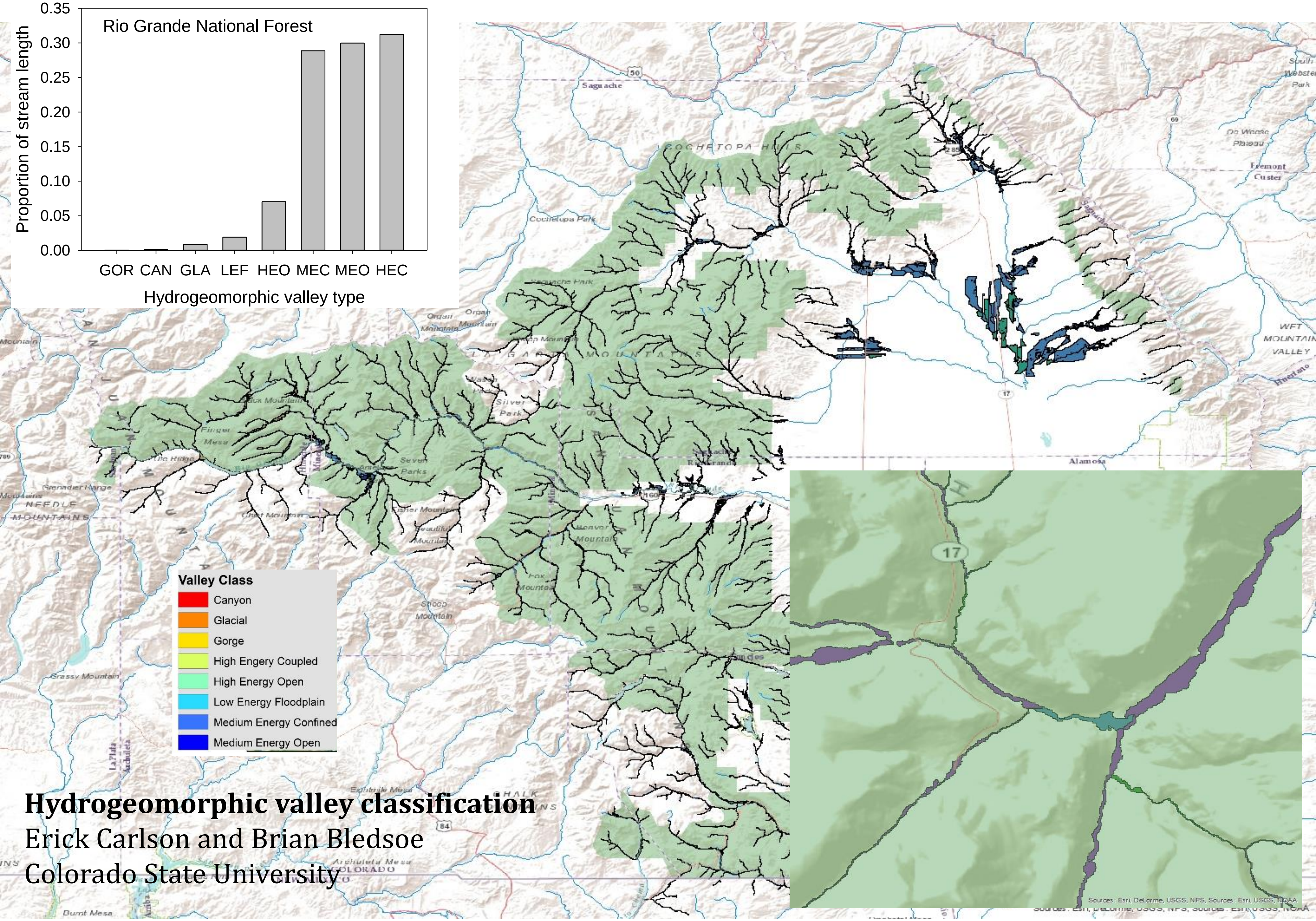


Home
Hydrogeomorphic Valley Classification
New Map
David
Details
Add
Basemap
Analysis
Save
Share
Print
Directions
Measure
Bookmarks
Find address or place
Contents
VCA Region 17
Region6 HGVC
HEC
GOR
CAN
MEC
MEO
GLA
LEF
Other
Region5 HGVC
Region4 HGVC
Region3 HGVC
Region2 HGVC
Region1 HGVC
Imagery
Esri.com . ArcGIS Marketplace . Help . Terms of Use . Privacy . Contact Esri . Contact Us . Report Abuse
Earthstar Geographics, CNES/Airbus DS
POWERED BY esri


Narrow-straight
Meandering
Braided-Anastomosing





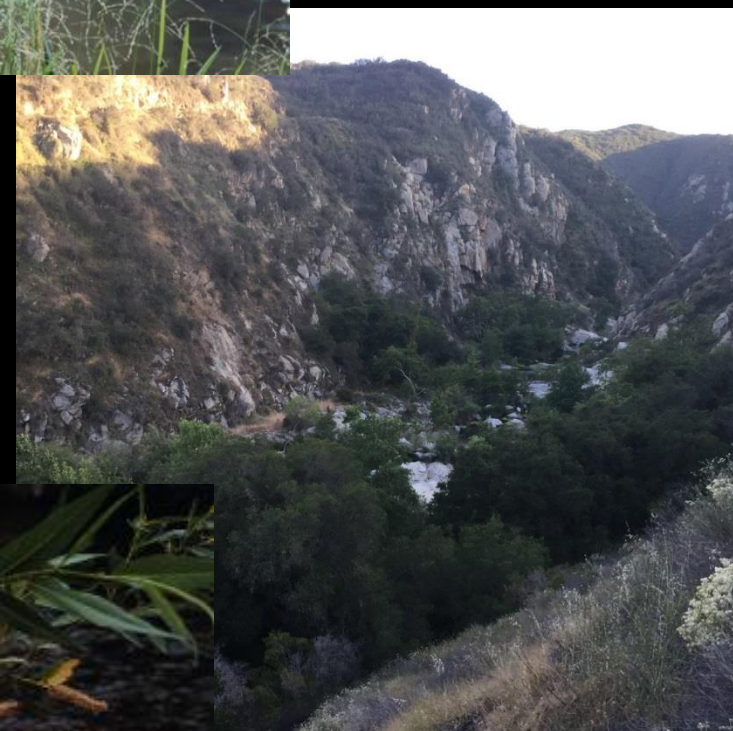


Hydrogeomorphic valley classification

Erick Carlson and Brian Bledsoe
Colorado State University

Desired conditions?

How to quantify, monitor, and set measurable goals?

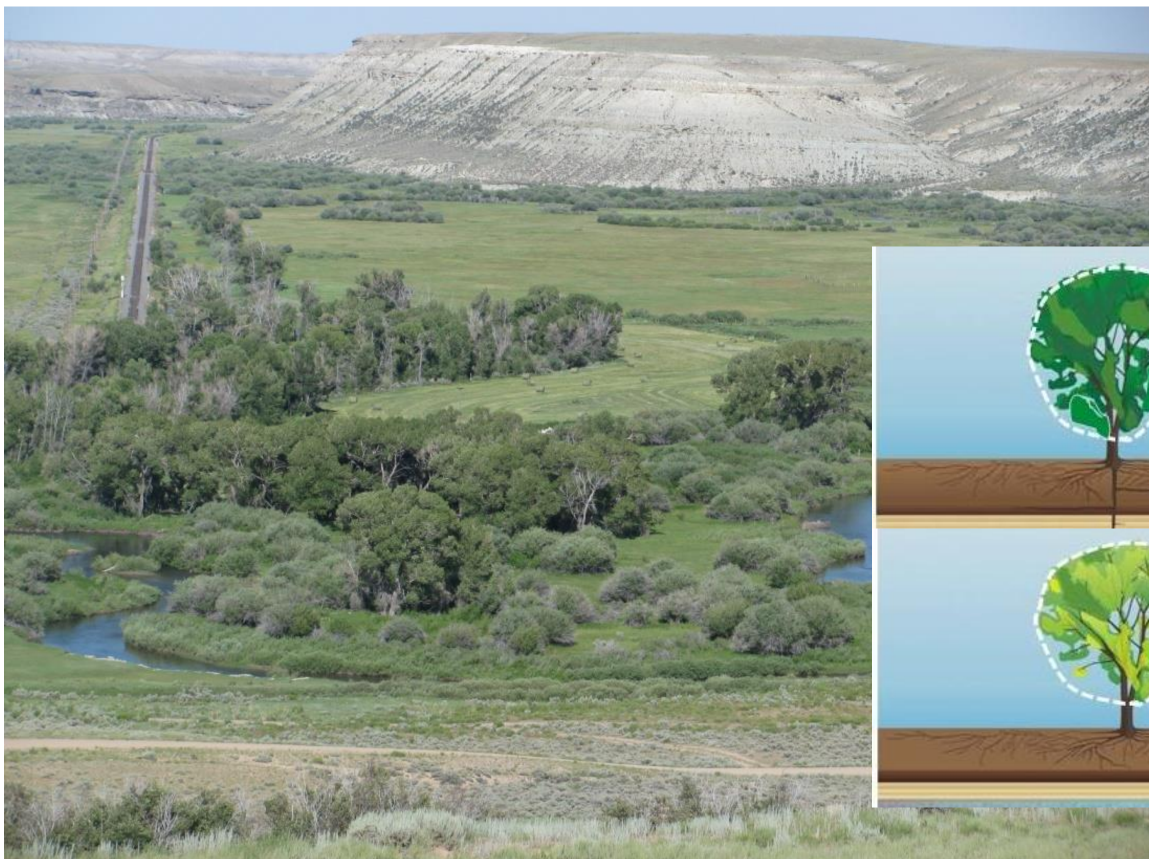


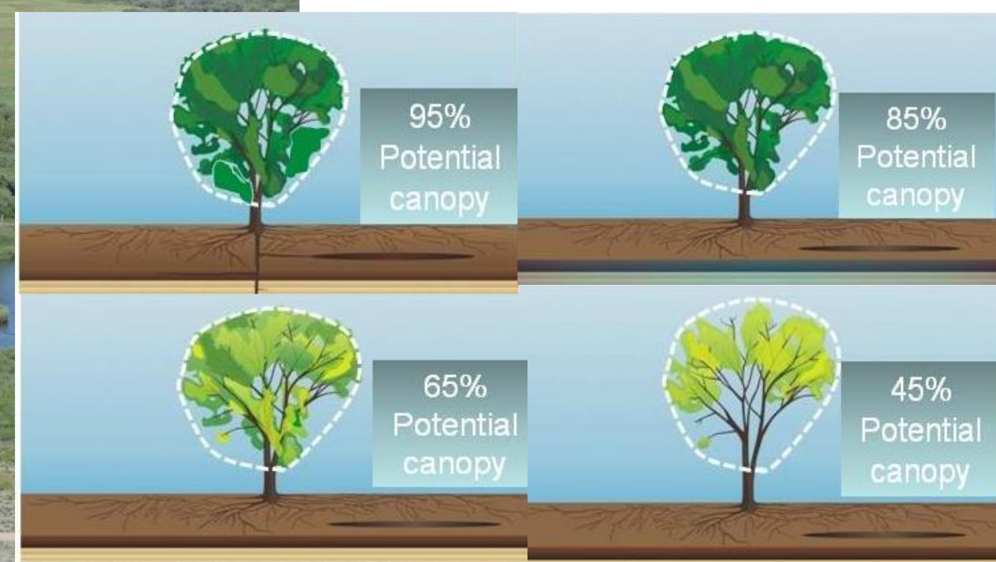
Need to identify reference or 'desired condition' sites and measure over time

Quantify reference conditions in a range of valley and channel types

Riparian vegetation monitoring:
Line-point intercept and point centered quarter sampling

- Plant species composition and vertical structure
- Tree stem density, basal area, and condition





Scott et al. 1999

- Channel cross sections and fluvial
  - Classification
  - Width to depth
  - Form

- Reach longitudinal profile
  - Gradient
  - Longitudinal profile

- Substrate characterization
  - Bare soil, gravel, cobble, boulder, bedrock, water

Combined:

- Opportunity for trend monitoring
- Ability to hydraulically model to develop rating curves
- Measurable attributes of desired or reference conditions

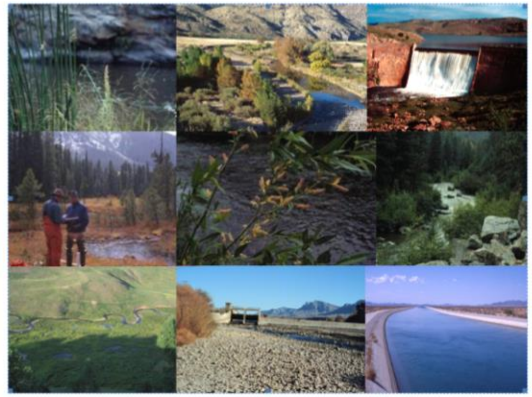
National Riparian Protocol

Project-level monitoring

Field data collection and analysis tools

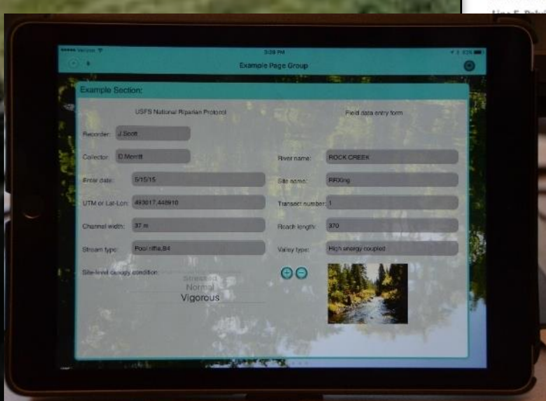
http://www.fs.fed.us/biology/watershed/riparian.html

U.S.D.A. Forest Service
National Riparian Vegetation Monitoring Protocol
Conterminous United States



USDA

Prepared by
The U.S.D.A. Forest Service
National Riparian Technical Team
July, 2011



THESIS

FLUVIAL RIPARIAN CLASSIFICATION FOR
NATIONAL FORESTS IN THE WESTERN UNITED STATES

Submitted by

Erick A. Carlson

Geomorphology 125 (2011) 504-516
Contents lists available at ScienceDirect
Geomorphology
journal homepage: www.elsevier.com/locate/geomorph

Geomorphic and process domain controls on riparian zones in the Colorado Front Range

Ellen E. Wohl, David M. Merritt

EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms 40, 586–598 (2015)
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Published online 4 October 2014 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/esp.3651

Downstream effects of stream flow diversion on channel characteristics and riparian vegetation in the Colorado Rocky Mountains, USA

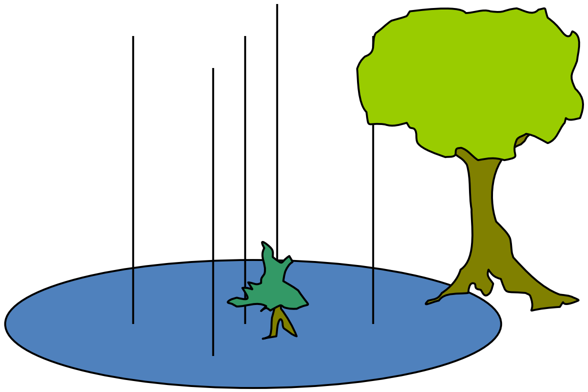
Simeon T. Caskey, Tyanna S. Blaschak, Ellen Wohl, Elizabeth Schnackenberg, David M. Merritt and Kathleen A. Dwire
Medicine Bow National Forest, Laramie, WY, USA
Lassen National Forest, Susanville, CA, USA
Department of Geosciences, Colorado State University, Fort Collins, CO, USA
Routt National Forest, Steamboat Springs, CO, USA
USDA Forest Service, NRRC, Fort Collins, CO, USA
Rocky Mountain Research Station, Fort Collins, CO, USA

ESPL

…deling the functional influence of vegetation …e on streambank cohesion

ESPL

Vegetation and habitat structure and provisions

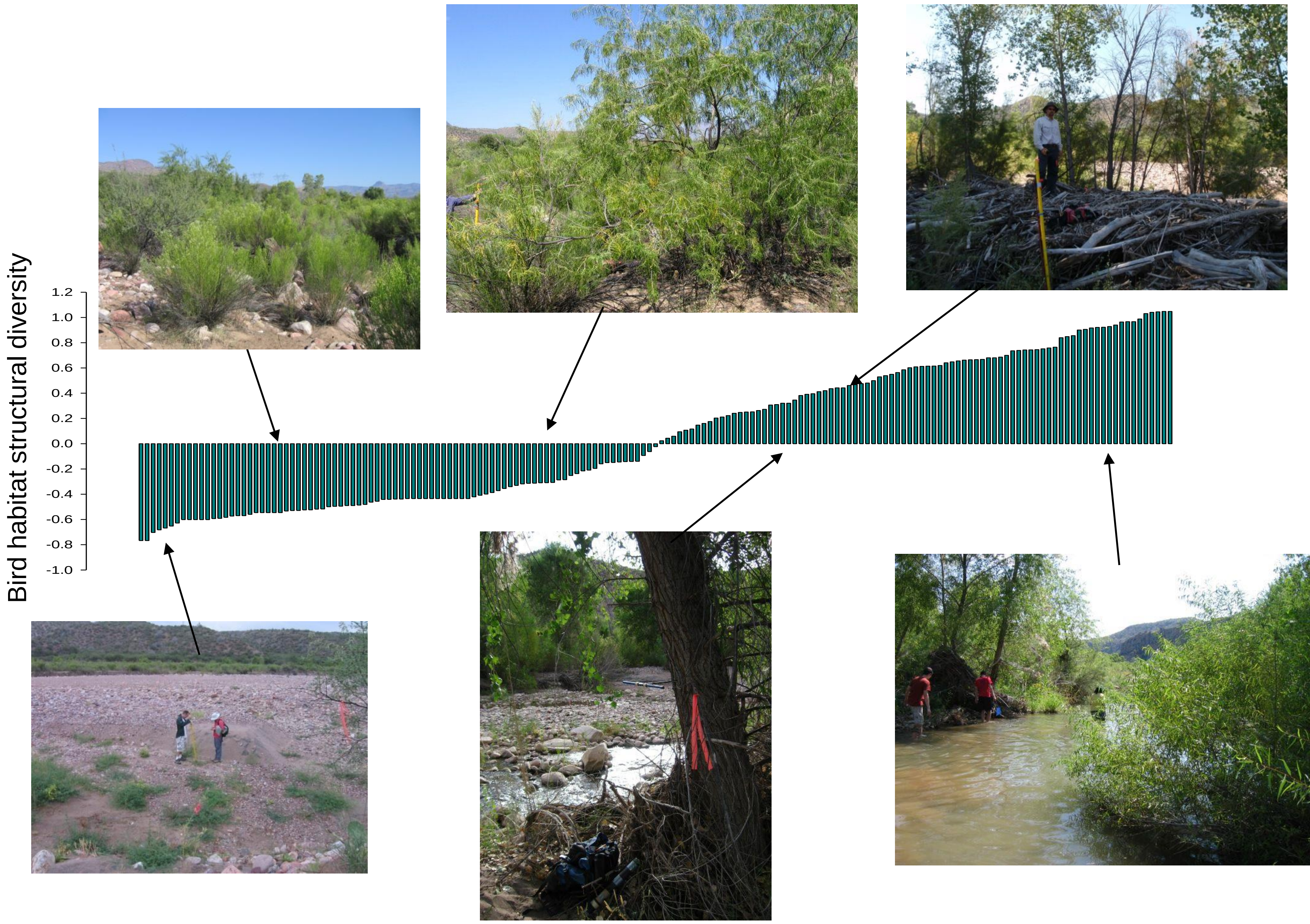


Bird Habitat
- Basal area woody vegetation
- Standard deviation woody tree diameter
- Foliage height diversity
- Mean vegetation cover (various height classes)
- Foliage hits

Mammal-Reptile Habitat
- Basal area woody vegetation
- Standard deviation woody tree diameter
- Riparian tree overstory
- Abundance of seedlings
- Mean and SD vegetation cover
- Cover sandy substrate

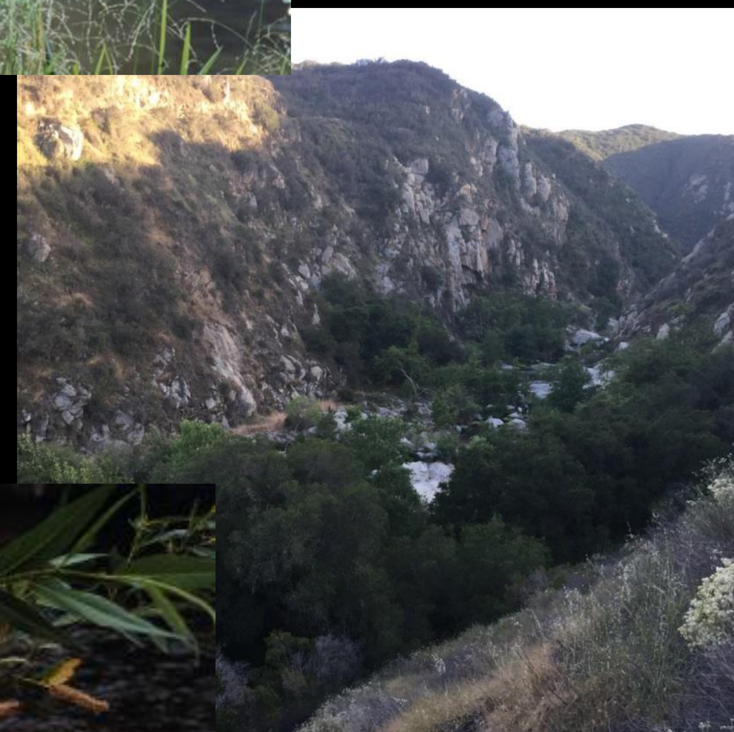
Merritt, D.M. and H.L. Bateman. Linking streamflow and groundwater to avian habitat in a desert riparian system. *Ecological Applications* 22:1973-1988.

McElhinny *et al.* 2006. An objective and quantitative methodology for constructing an index of stand structural complexity. *Forest Ecology and Management* 235:54-71.


Bird habitat structural diversity
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0

Desired conditions?

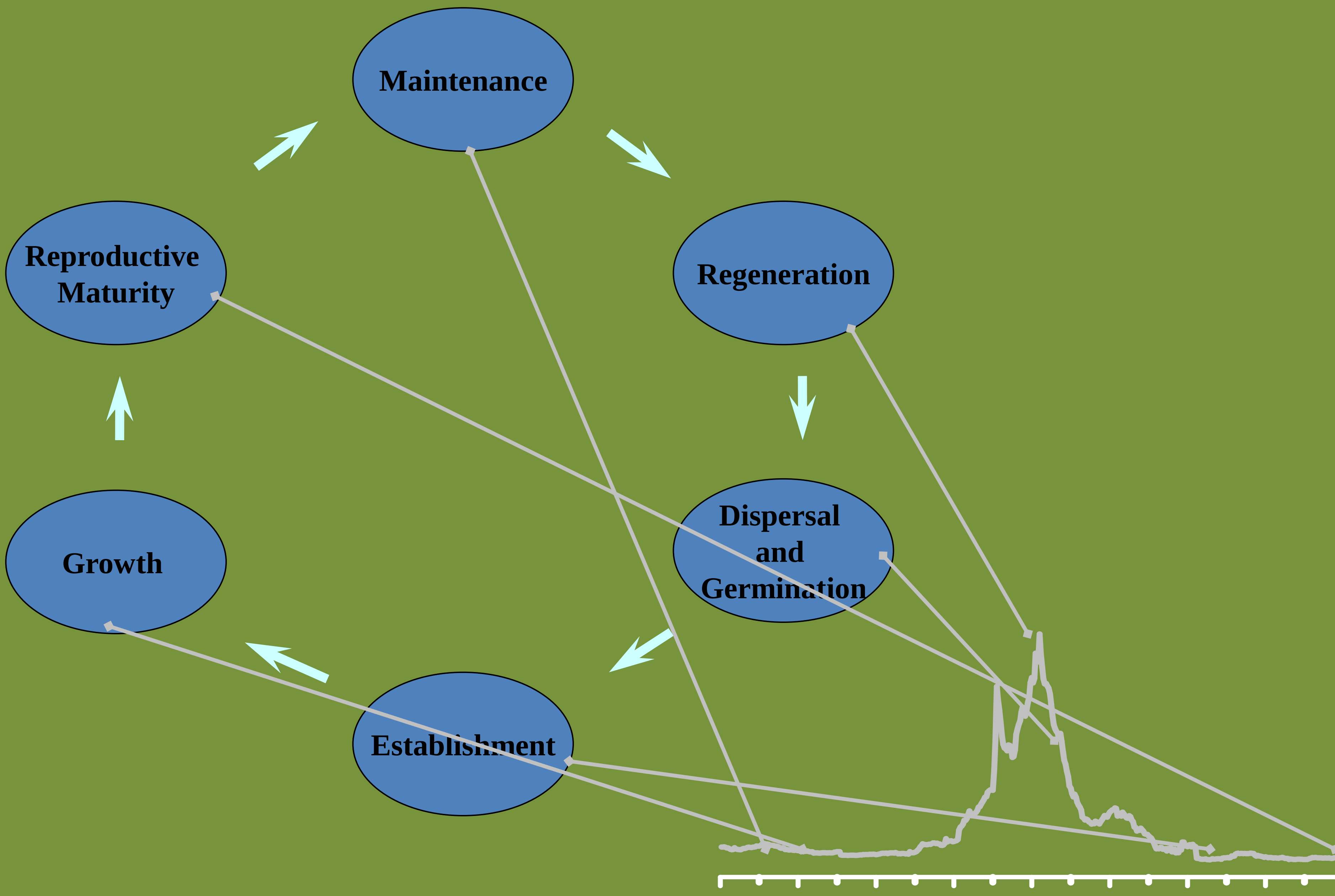
Linking pattern to process?



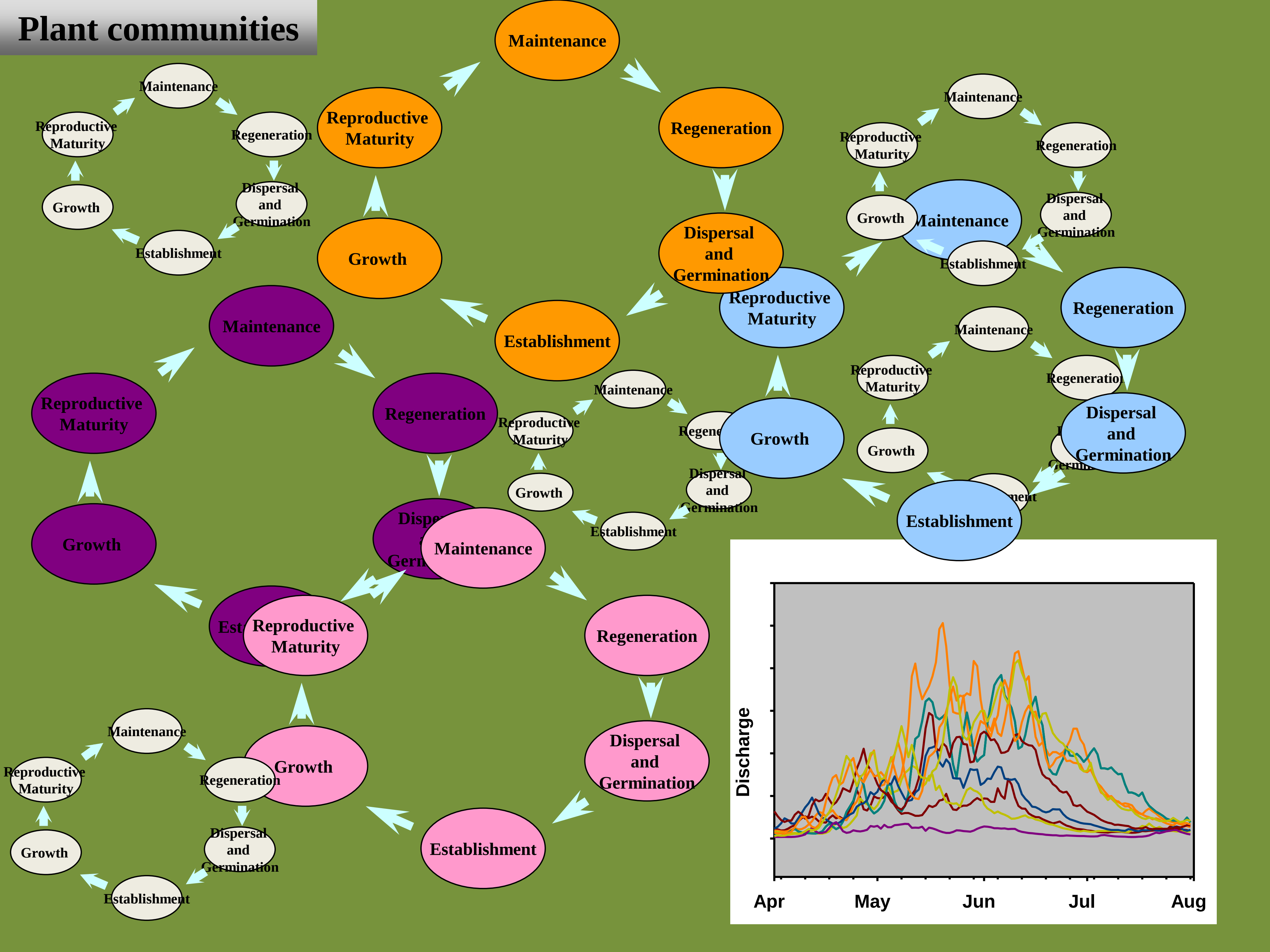
Answer is probabilistic

Link current patterns to measured processes (e.g., hydrology)

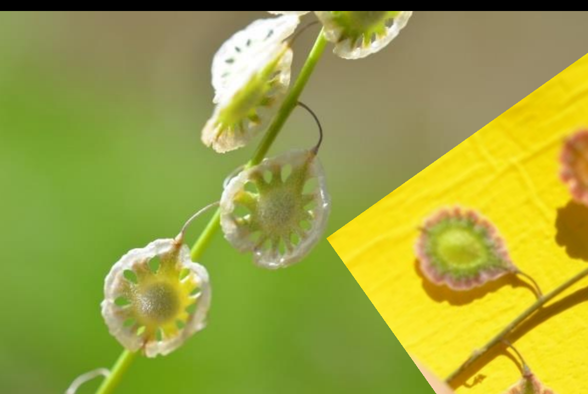
Individual plants

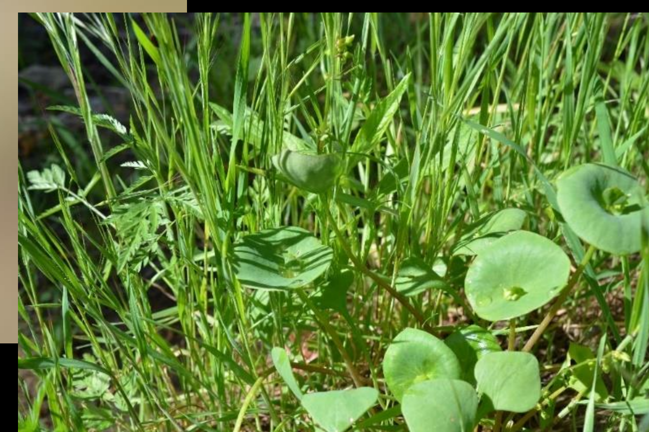


Plant communities




Spike bent grass
Small leaf bent grass
Lupinus concinnus
Bajada lupine
hairy lupine purple flowers
Deer grass.

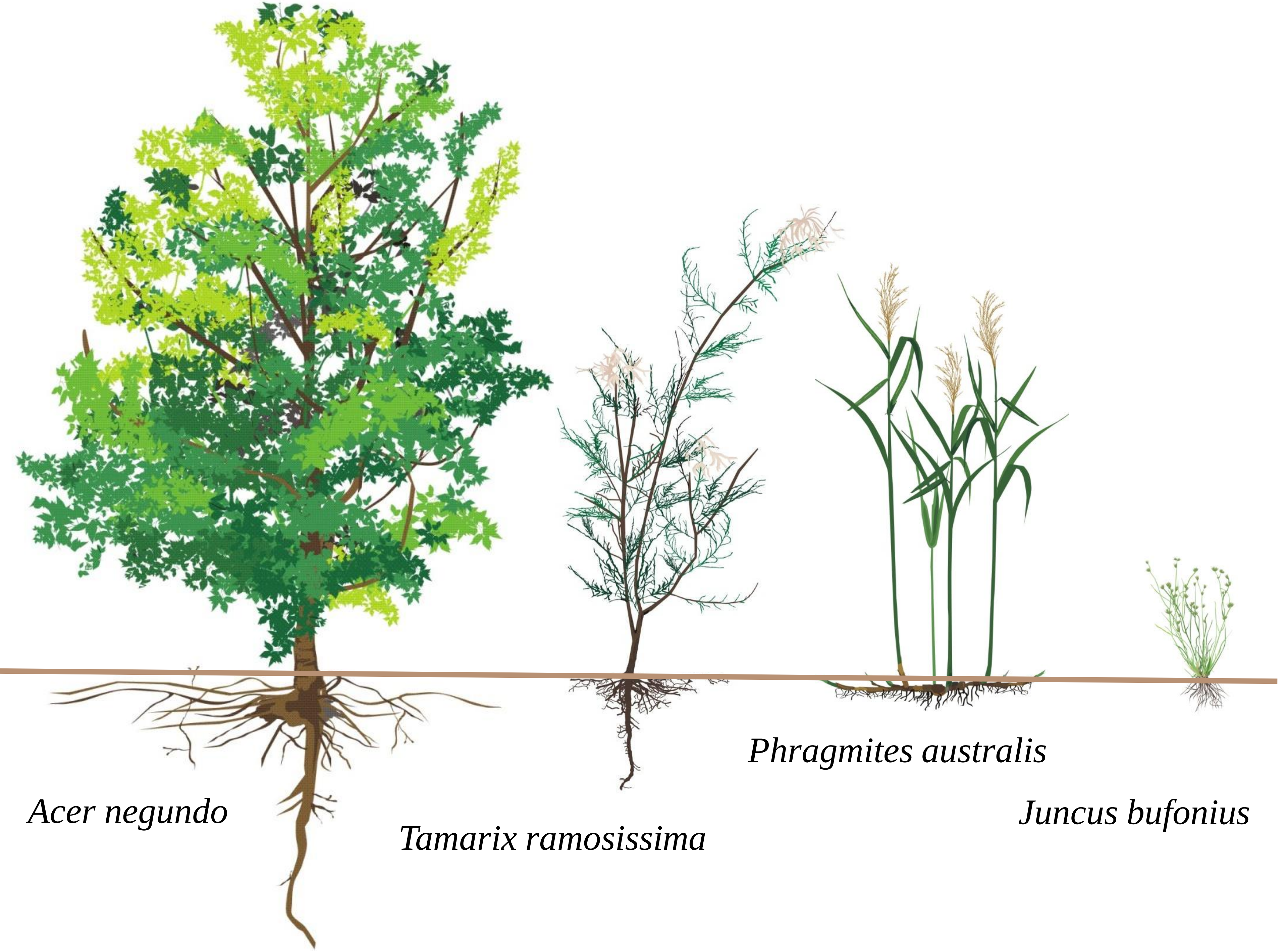




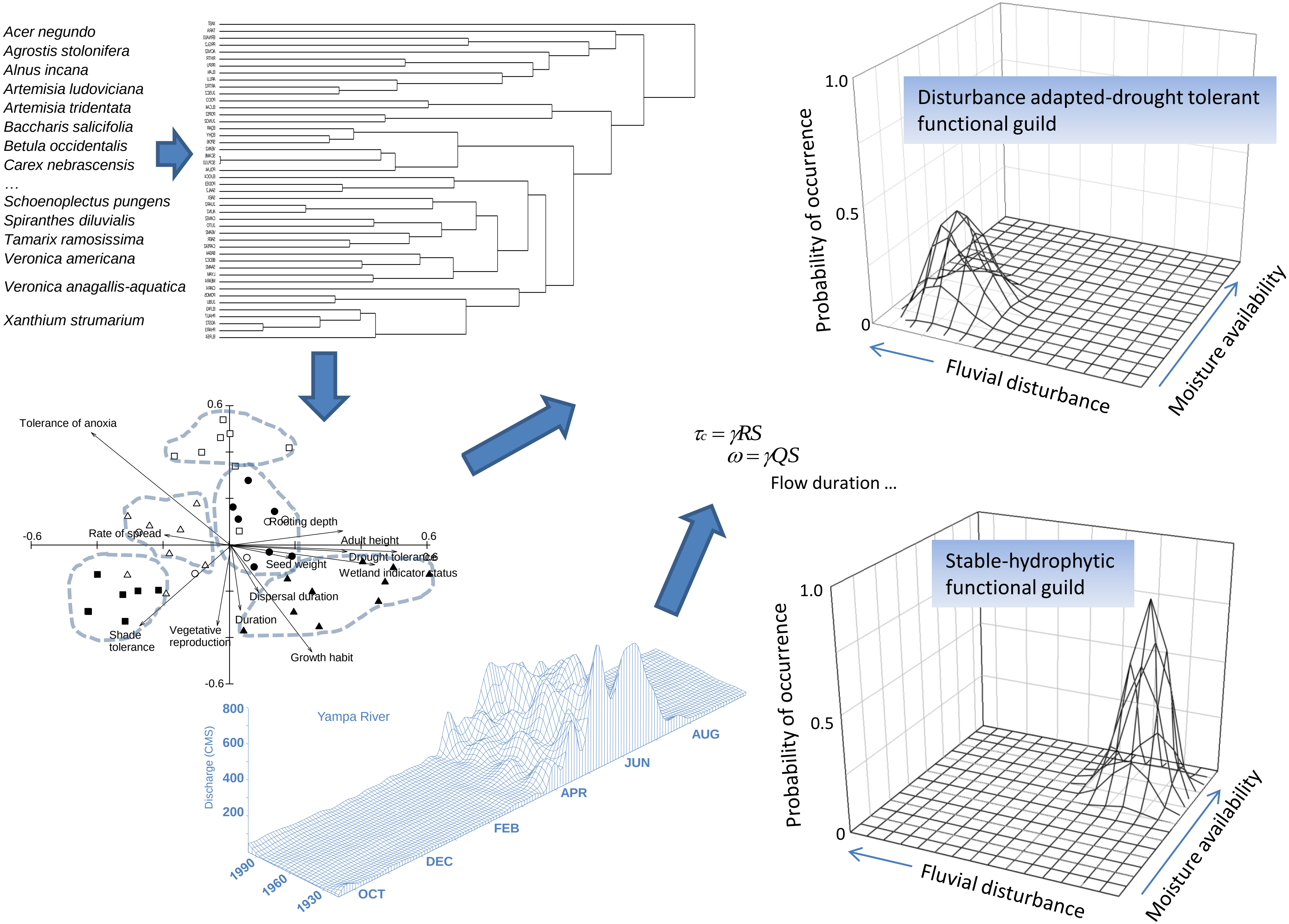

R. Son asp 2
A B C

R PLARACØ
A B C


A

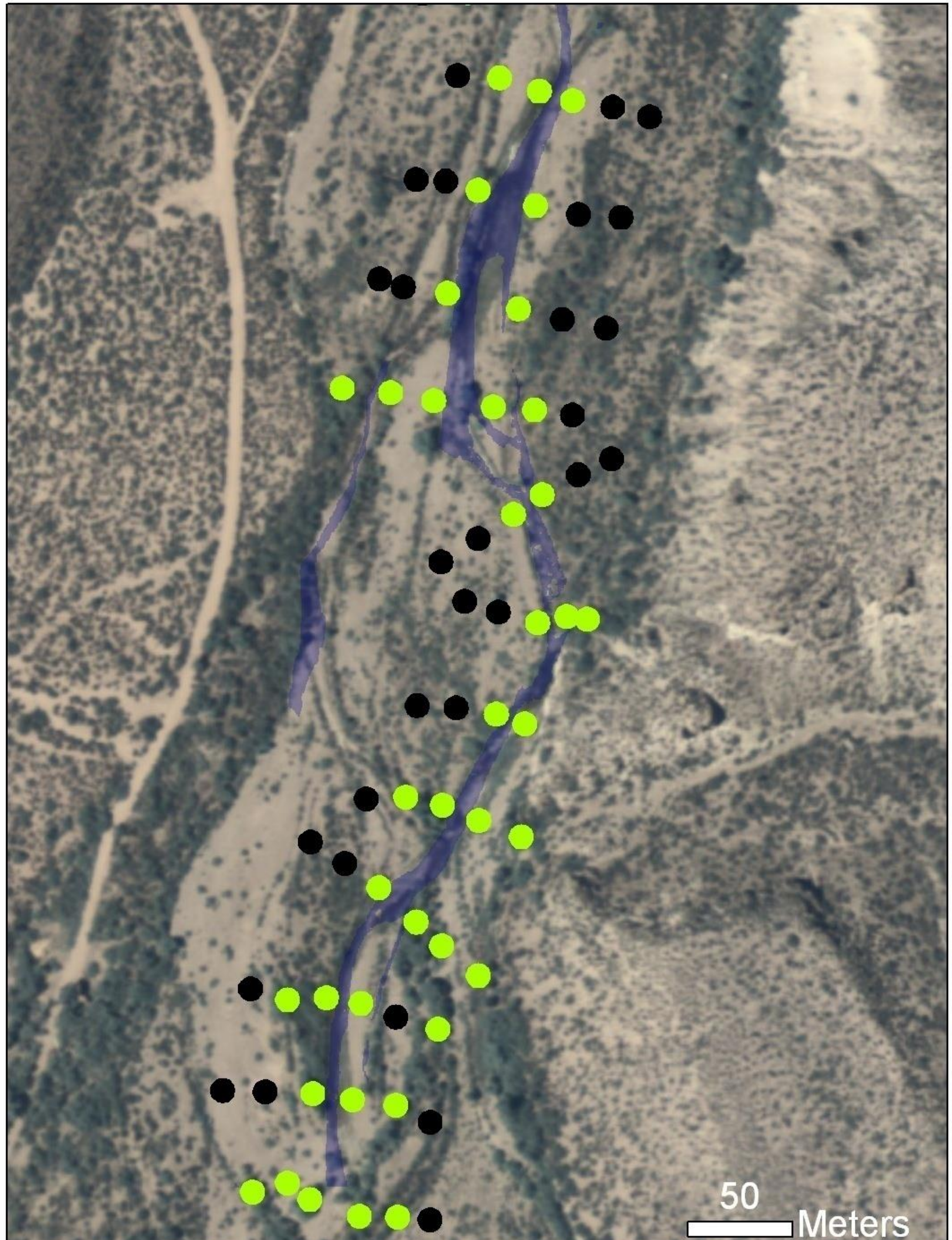
Phragmites australis
Acer negundo
Juncus bufonius
Tamarix ramosissima

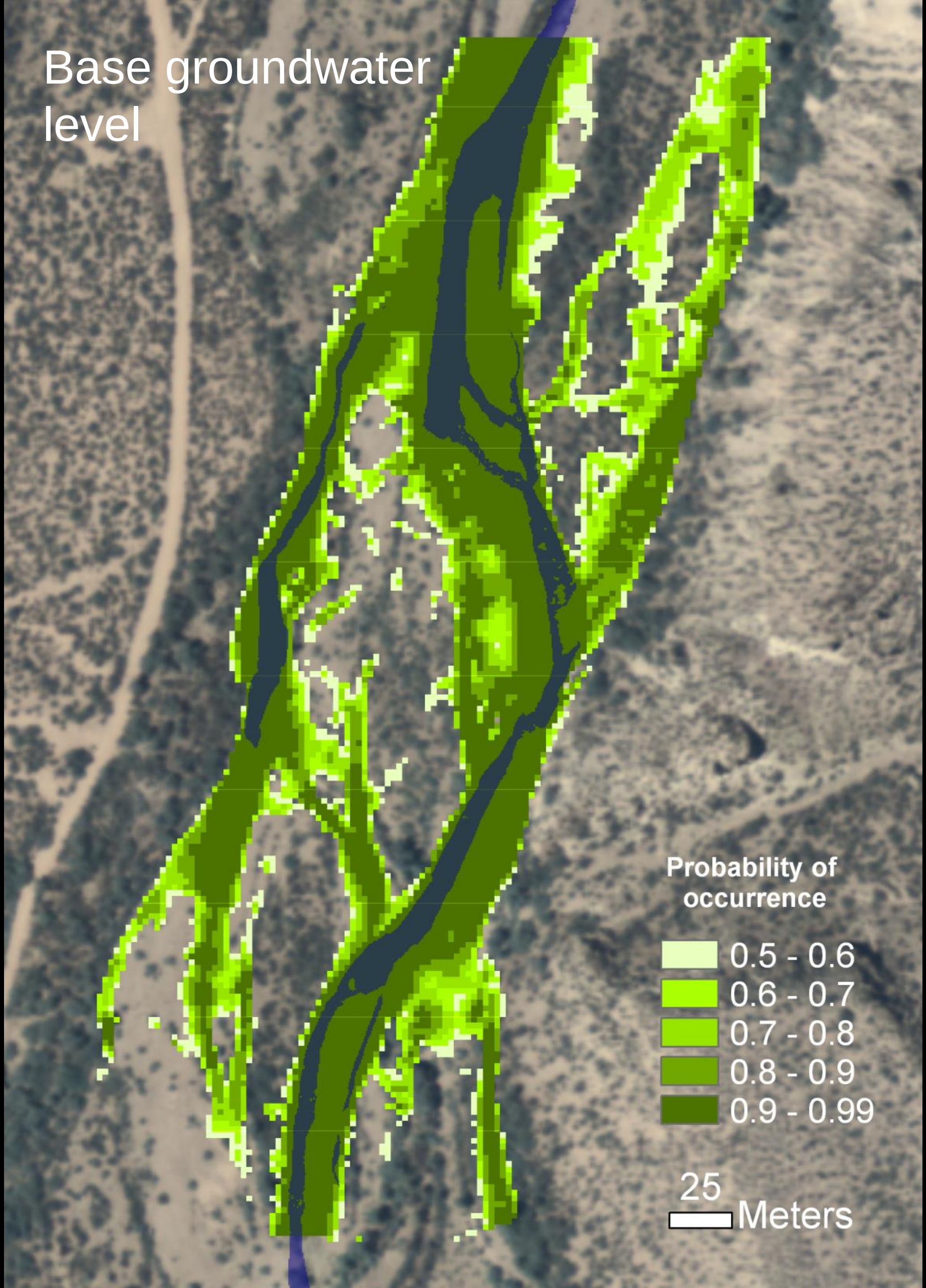


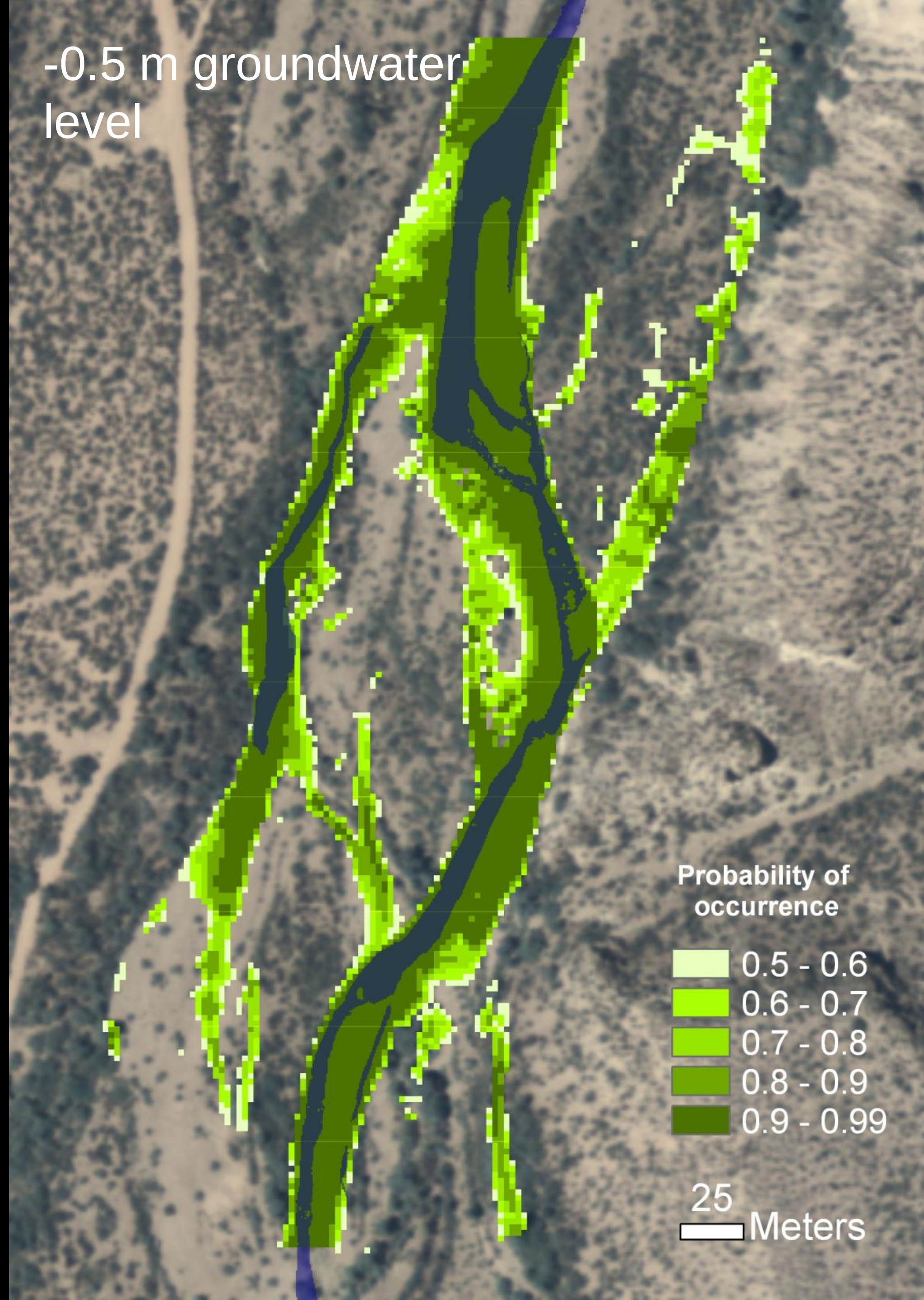
STREAM Notes October 2010

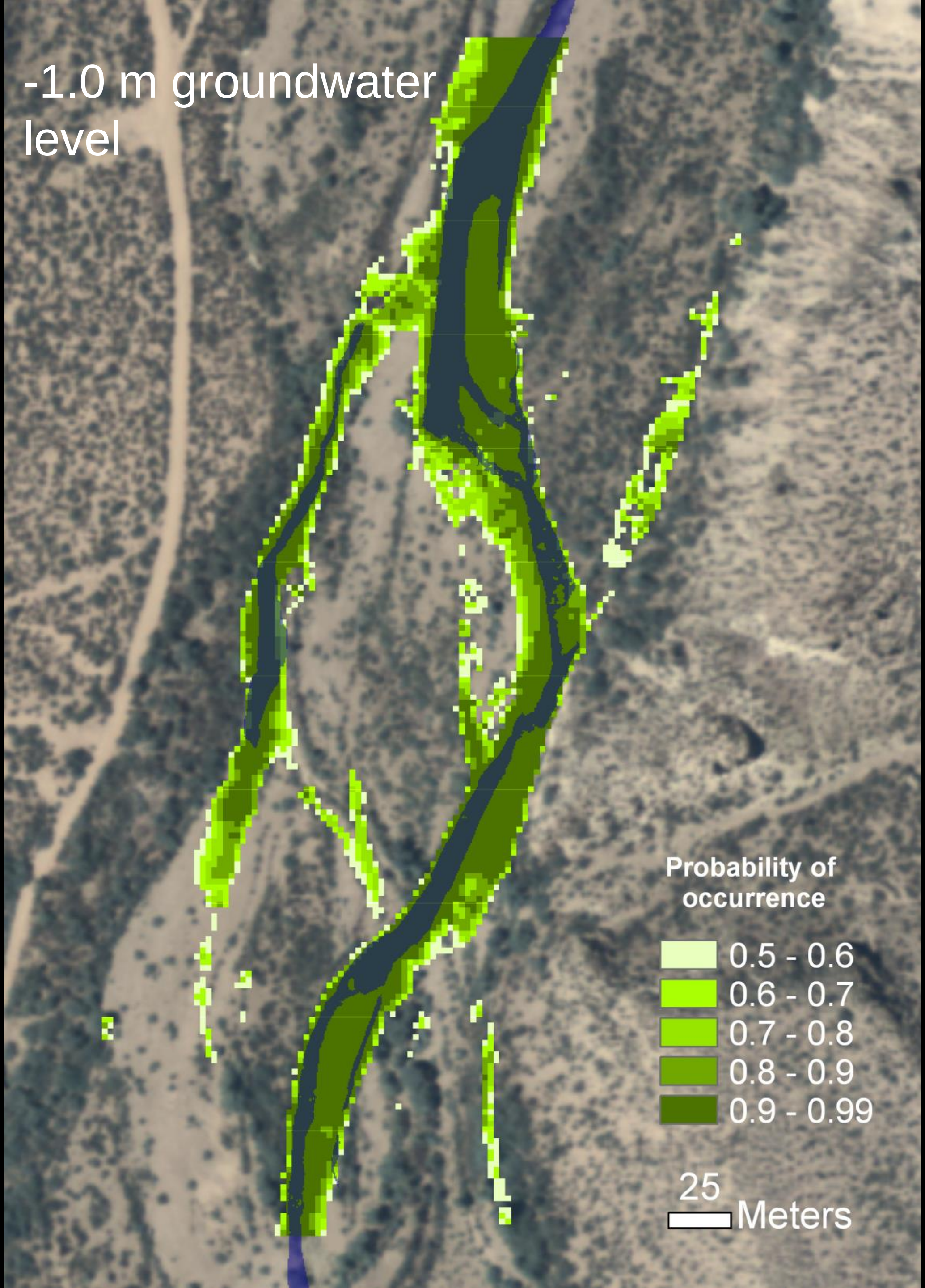
Guild 7
Riparian forest:
- High canopy
- Disturbance-adapted
- Phreatophytic
- Anaerobic

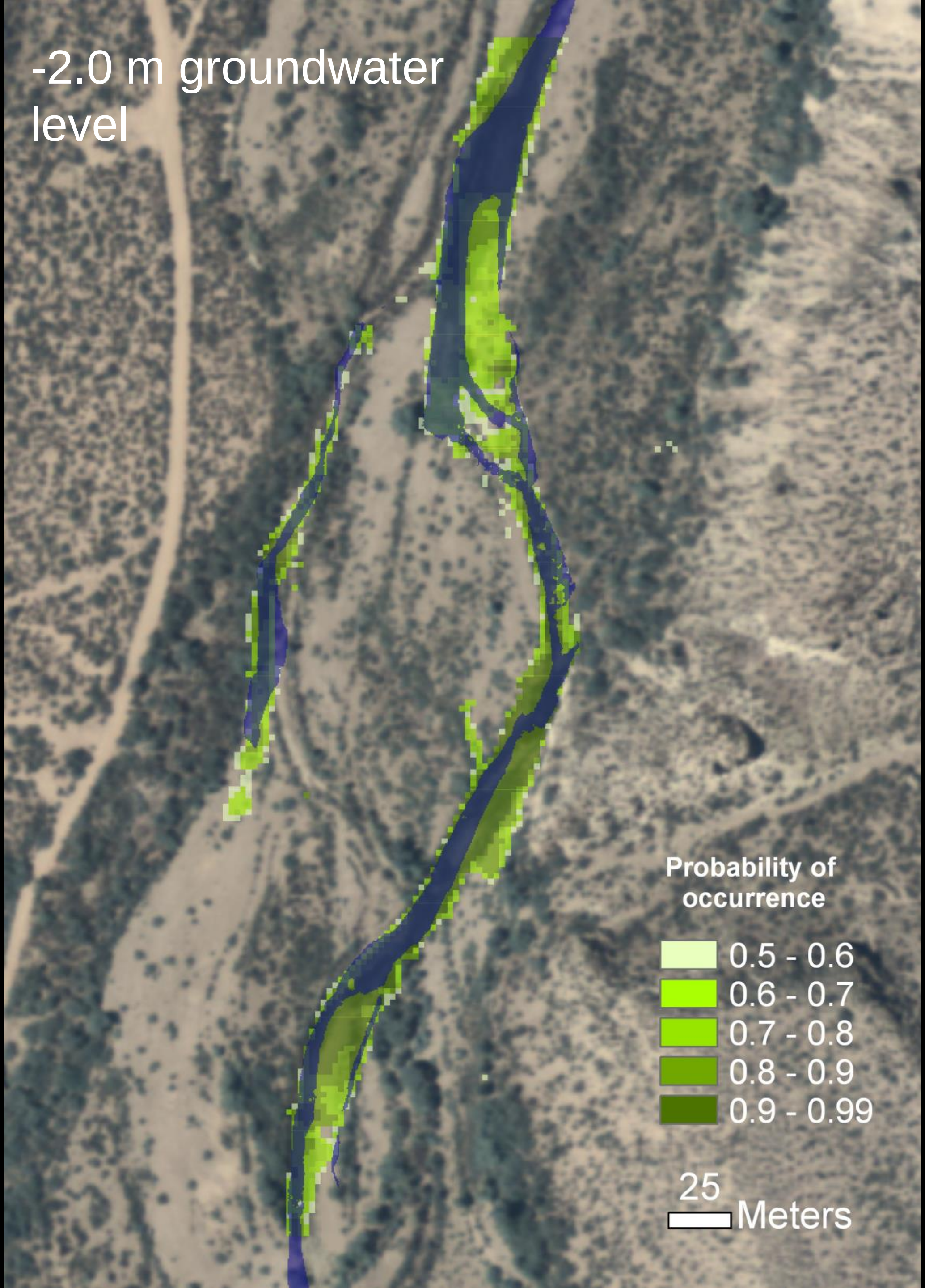
Populus fremontii
Salix gooddingii
Celtis laevigata

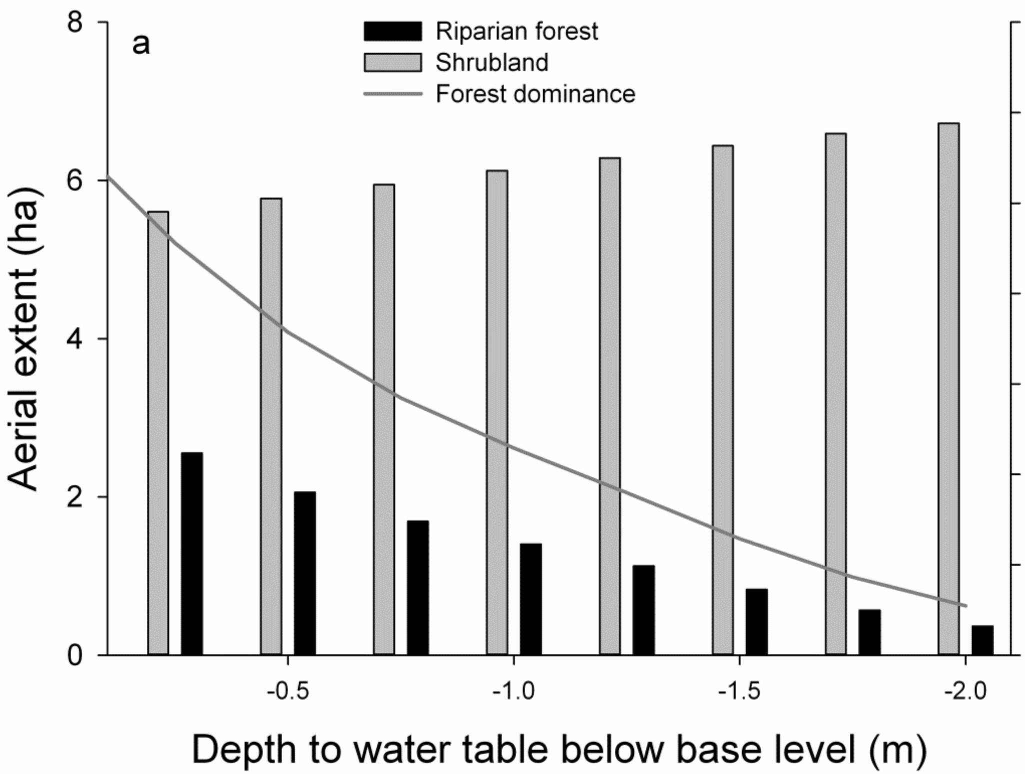


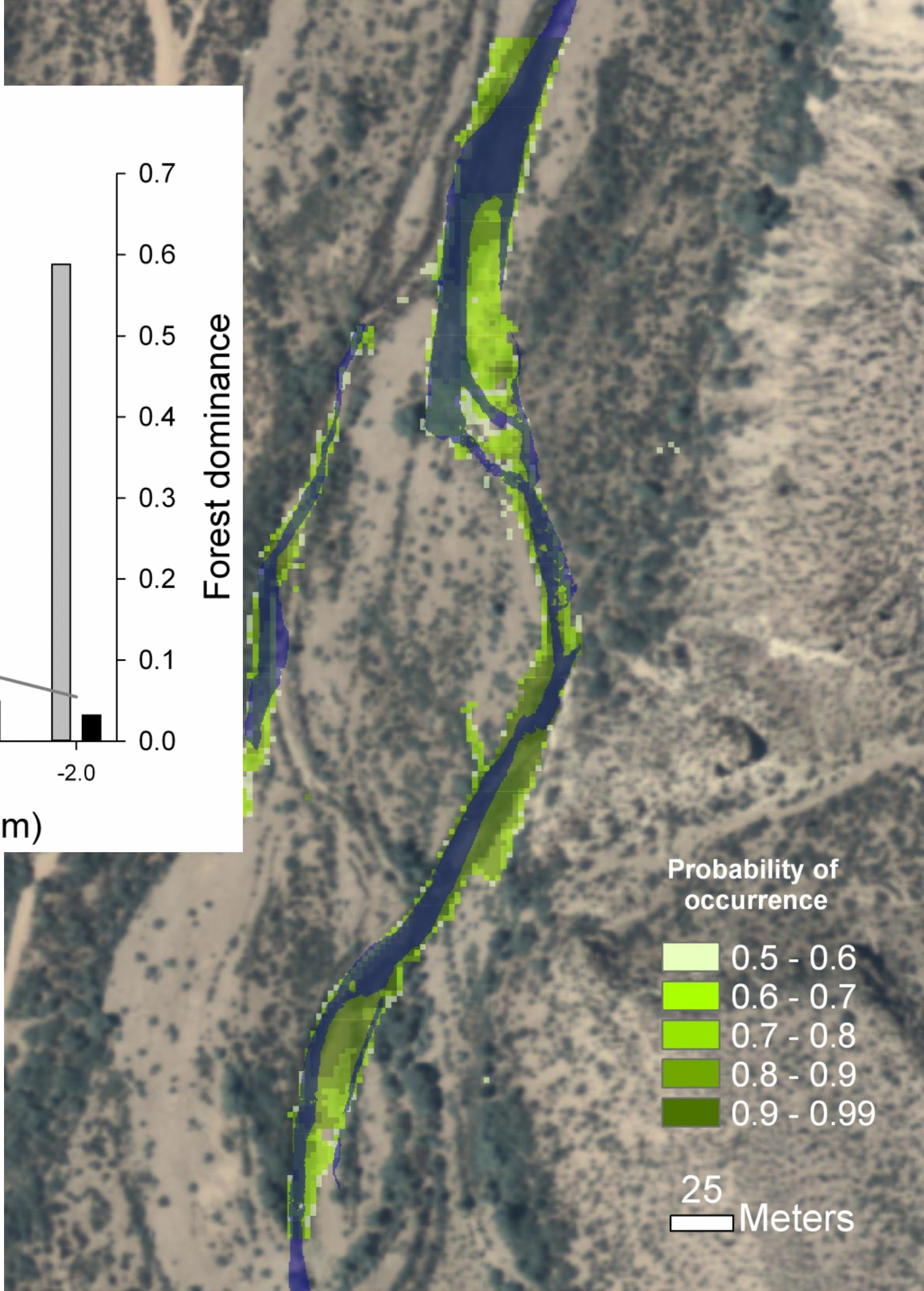

Base groundwater level
Probability of occurrence
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 0.99
25
Meters


-0.5 m groundwater level
Probability of occurrence
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 0.99
25
Meters

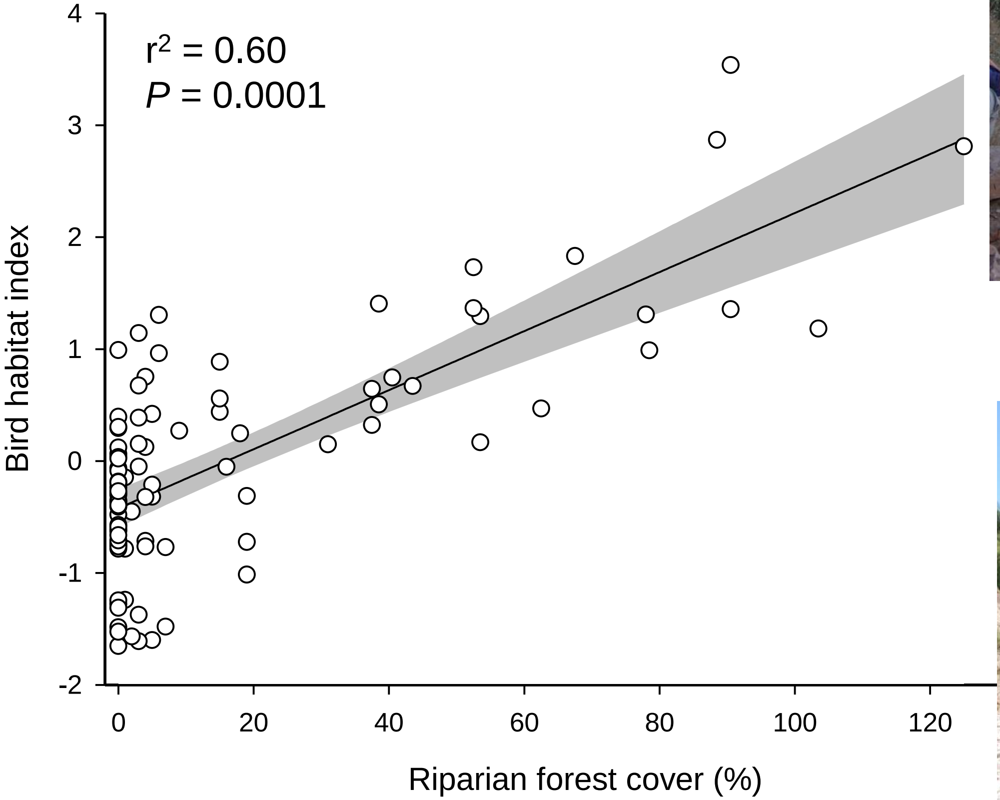

-1.0 m groundwater
level
Probability of
occurrence
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 0.99
25
Meters


-2.0 m groundwater level
Probability of occurrence
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 0.99
25
Meters

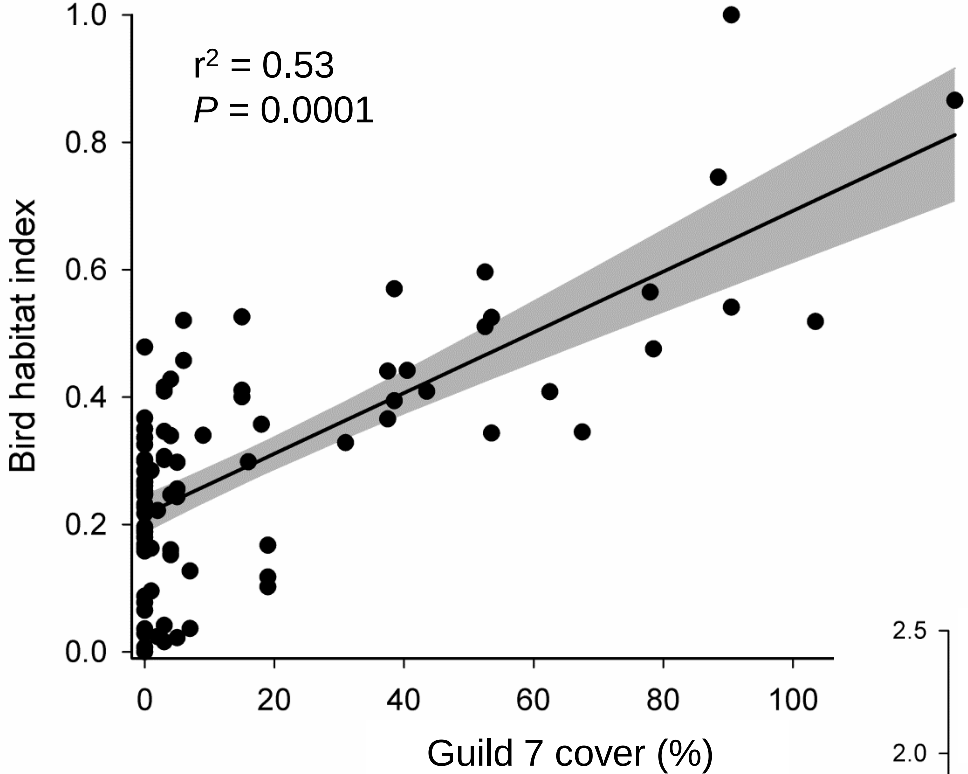




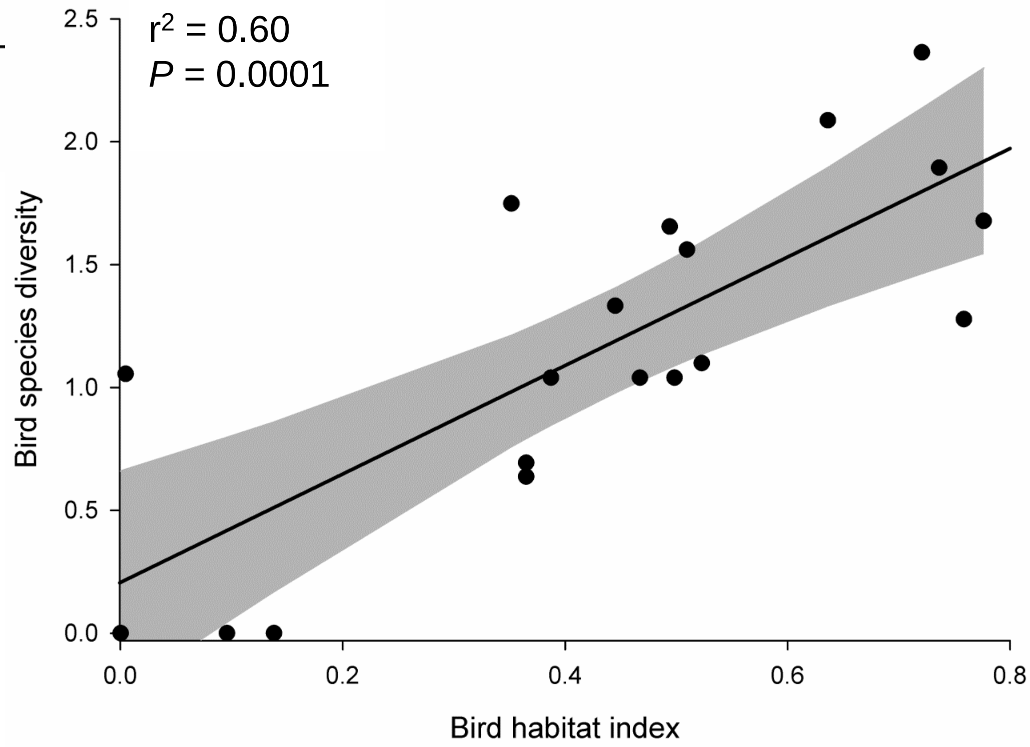
Merritt and Bateman. Ecological Applications. 2012.



r² = 0.60
P = 0.0001
Bird habitat index
Riparian forest cover (%)
4
3
2
1
0
-1
-2
0
20
40
60
80
100
120



r2 = 0.53
P = 0.0001
Bird habitat index
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Guild 7 cover (%)

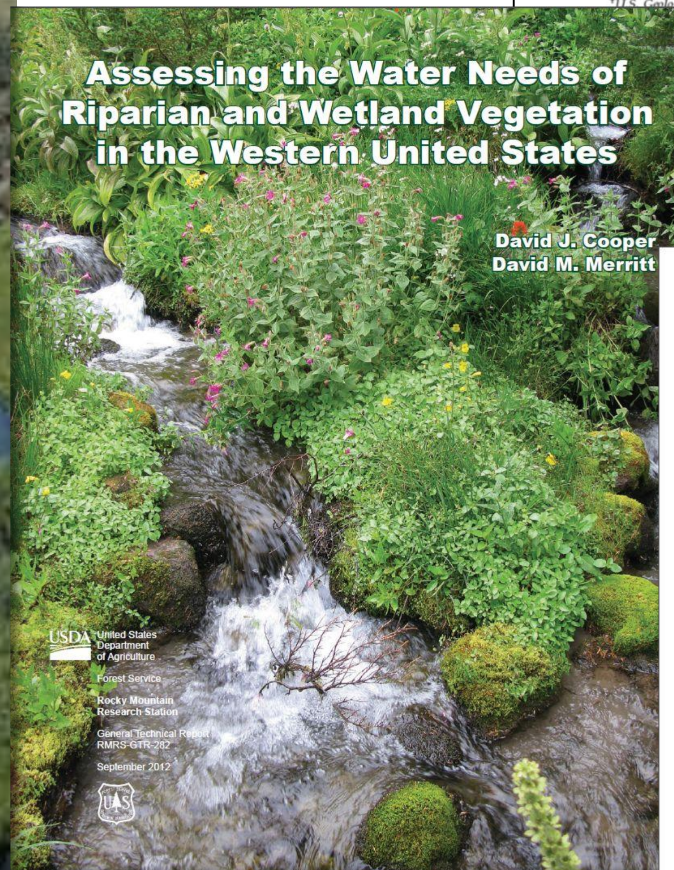


r2 = 0.60
P = 0.0001
Bird species diversity
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
Bird habitat index

B. Grice

Species, cover and guild modeling

Instream flows and groundwater levels necessary to sustain desirable *vegetation*



www.treesearch.fs.fed.us/pubs/41207

Freshwater Biology

Freshwater Biology (2010) 55, 206–225 doi:10.1111/j.1365-2427.2009.02206.x

Theory, methods and tools for determining environmental flows for riparian vegetation: riparian vegetation-flow response guilds

DAVID M. MERRITT*, MICHAEL L. SCOTT†, N. LEROY POFF‡, GREGOR T. AUBLE† AND DAVID A. LYTLE§

*National Watershed, Fish and Wildlife Program, Natural Resource Research Center, USDA Forest Service and the Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, U.S.A.
†U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, U.S.A.
... of Biology and Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO, U.S.A.
... of Zoology, Oregon State University, Corvallis, OR, U.S.A.

SUMMARY

1. Riparian vegetation composition, structure and abundance are governed to a large degree by river flow regime and flow-mediated fluvial processes. Streamflow regime exerts selective pressures on riparian vegetation, resulting in adaptations (trait syndromes) to specific flow attributes. Widespread modification of flow regimes by humans has resulted in extensive alteration of riparian vegetation communities. Some of the negative effects of altered flow regimes on vegetation may be reversed by restoring components of the natural flow regime.

2. Models have been developed that quantitatively relate components of the flow regime to attributes of riparian vegetation at the individual, population and community levels.

Freshwater Biology

Freshwater Biology (2015) doi:10.1111/fwb.12686

Riparian plant guilds of ephemeral, intermittent and perennial rivers

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*School of Life Sciences, Arizona State University, Tempe, AZ, U.S.A.
†Watershed, Fish, Air and Rare Plants, National Stream and Aquatic Ecology Center, U.S. Forest Service, Fort Collins, CO, U.S.A.

SUMMARY

1. Plant functional types (or guilds) increasingly are being used to predict vegetation response to global changes. Continued human population growth coupled with projected warmer and drier climate will alter the hydrologic regimes of many arid-zone rivers, including intermittent rivers. We aimed to identify (i) woody plant guilds associated with distinct stream types of an arid region and (ii) plant traits indicating adaptation to the selective pressures of water availability and fluvial disturbance.

2. We used hierarchical clustering to identify 11 plant guilds from floodplains, terraces and uplands of eight Arizona rivers that vary in surface flow permanence, depth to ground water and intensity of fluvial disturbance.

3. Six guilds were riparian pioneers with small, wind-dispersed seeds, three guilds were late-seral, shade-tolerant riparian taxa with large animal-dispersed seeds, and two guilds were composed of desert xerophytes. Within the riparian pioneer and seral groups, guilds varied in water acquisition and productivity traits including wood density and rooting depth.

4. The community-weighted traits varied or covaried with water availability and fluvial disturbance. Root: shoot ratio, canopy height and leaf area were influenced strongly by water availability, with the latter two showing a nonlinear response to changes in water table depth. Leaf length increased, and wood density decreased, as sites become wetter and more fluvially disturbed. Community-weighted seed mass, seed dispersal and spinesence varied most strongly with elevation above thalweg (an indicator of decreasing fluvial disturbance).

5. These analyses will enable prediction of changes in the relative abundance of plant types and plant traits in response to changes in stream flow regimes, such as shifts towards greater intermittency. The distribution patterns of guilds among riparian habitat types emphasise the importance of focusing conservation efforts not only on the limited number of perennial rivers remaining in arid regions, but also on intermittent and ephemeral rivers with shallow water tables.

Keywords: desert stream, plant functional type, riparian vegetation, trait, wood density

Introduction

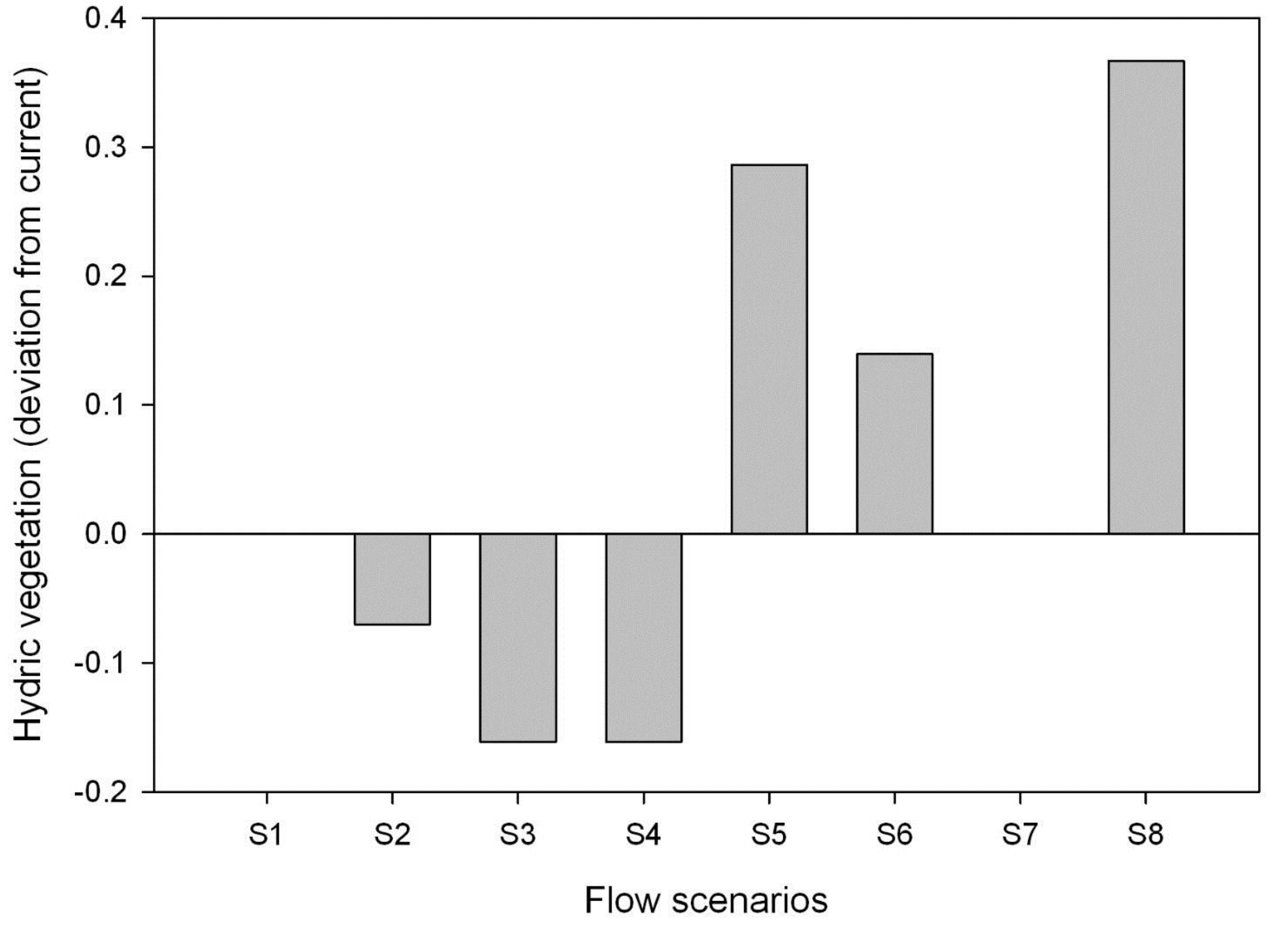
Anthropogenic changes to stream hydrology have substantially altered the distribution, abundance and species composition of riparian plant communities (Patten, 1998; Tockner & Stanford, 2002; Stella *et al.*, 2012). Increasing global pressures on freshwater resources, coupled with climate change, will drive further changes in stream surface and subsurface flows (Palmer *et al.*, 2009). Alterations are likely to be greatest in highly populated dryland regions (Döll, Fiedler & Zhang, 2009).

Water is the primary limiting factor for vascular plants in dryland regions. In some desert rivers, stream flows are increasing owing to effluent discharge, agricultural return flow and urbanisation, but for many others, flows are decreasing owing to groundwater pumping, diversion of surface water and climate-linked reductions in stream and groundwater recharge (Serrat-Capdevila

Correspondence: Juliet C. Stromberg, School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501, U.S.A. E-mail: jstrom@asu.edu

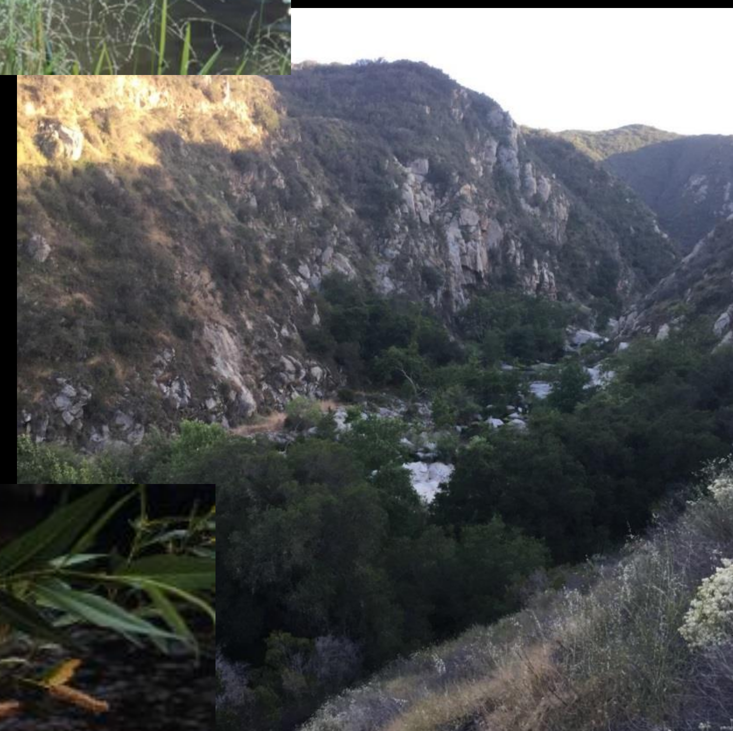
Decision support tool: consequences of alternative futures

S1 - Cct
S2 - Reservoir Exp.
S3 - S1 + Hotter, drier
S4 - S2 + Hotter, drier
S5 - S1 + Wetter, cooler
S6 - S1 + Wet, cool
S7 – S1 + Wet, cool, early
S8 - S2 + Wetter, cooler, early



Desired conditions?

Species composition or functional composition?



Not a steady end state for most rivers

Answer is probabilistic

Alternative 'stable' states

What about warmer, drier future?
NRV changes…

Opportunities for the Forest Service to influence the flow regimes of streams

- Forest Plan Standards and Guides – National Forest Management Act
- Conditioning land use authorizations (easements for ditches and points of diversion)
- Input into Federal Energy Regulatory Commission hydropower dam relicensing (4e authority)
- Negotiating with local, state, and private entities (transfers)
- Implied and expressed Federal Reserved Water Rights
- Wild and Scenic River designation
- State Water Rights systems (instream or minimum flow programs) when appropriate.

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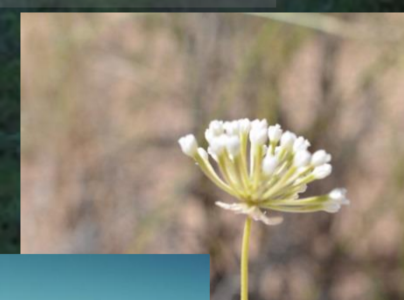

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