Inventorying & Monitoring Springs

Identifying Issues, Prioritizing Management and Restoration

Donald W. Sada

Desert Research Institute, Reno, NV

Jerry Keir

Great Basin Institute, Reno, NV

July 26, 2006

Importance of Springs

- **Biodiversity & cultural hot spots in arid lands** (Native Americans, Rural Economies, Birds, Mammals, Riparian Vegetation, Aquatics)
- **Sole habitat for crenobiontic species** (Springsnails, Fishes, Aquatic Insects, etc.)
- **Ecology is closely associated with physiochemical characteristics of groundwater systems and environmental stress**

Groundwater Research

- Chemistry
- Aquifer provenance, dimensions, water age, etc.

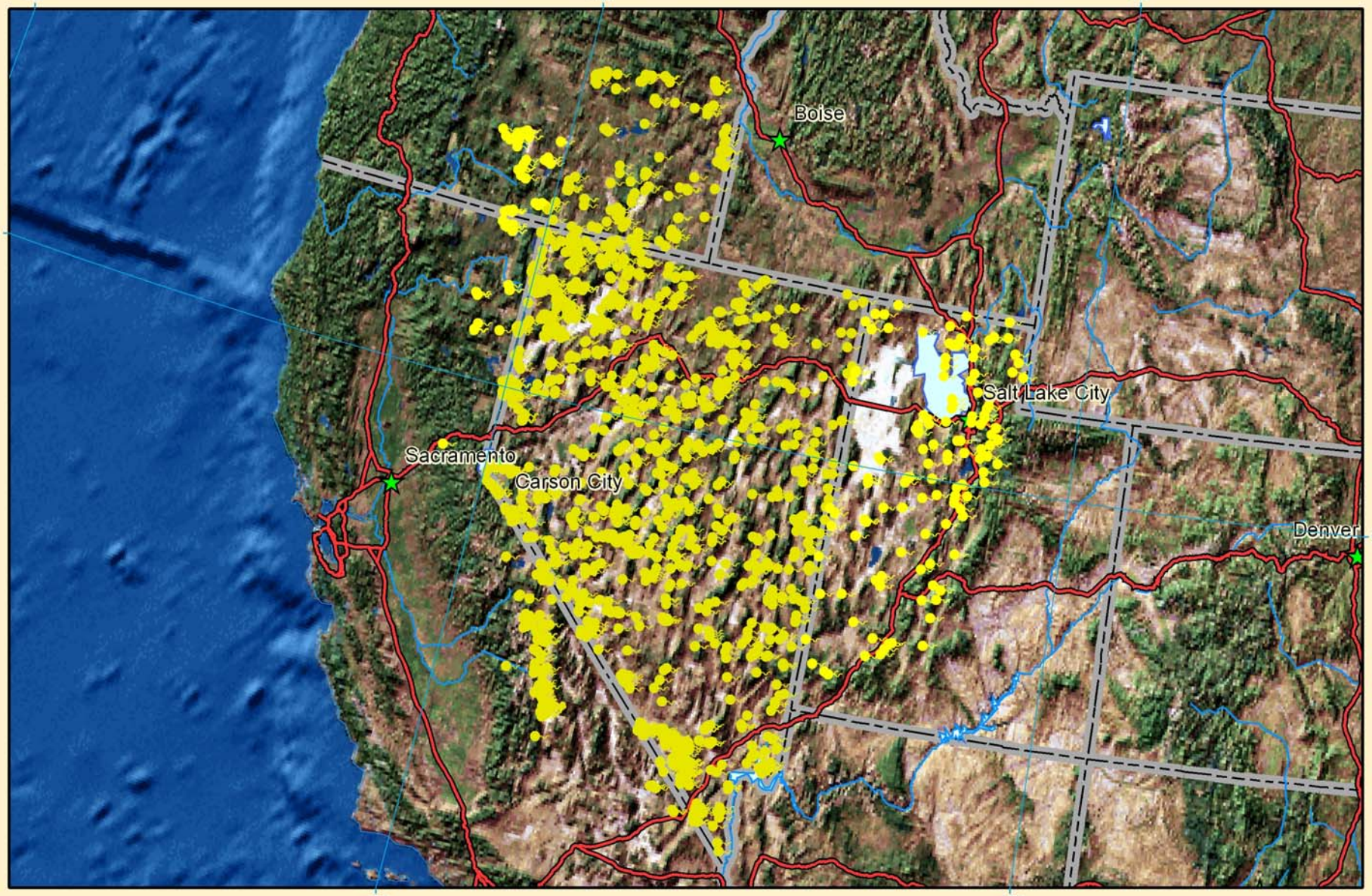
Biological Research

Fish

- Taxonomy
- Biogeography
- Physiology
- Conservation Biology
- Life History
- Ecology

Benthic & Riparian Communities

- Community Ecology
- Crenobiontics
  - Taxonomy
  - Biogeography
  - Ecology
  - Demography
- Effects of Stressors



Legend

- Capital Cities
- Interstate Highways
- Rivers
- Lakes
- State Boundaries

Albers Projection

Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

Springs of the Great Basin

N
W E
S

0 50 100 200 300 Miles

Base map courtesy of ESRI

Spring Summary

- There is little information about most springs
- Most existing information focuses on large springs
- There is a poor understanding of relationship between aquifers and spring ecology
- Most springs have been altered from natural conditions – Reference conditions unknown
- Therefore, setting management goals is difficult

Management Process

1. Inventory resources (locate and characterize)
2. Identify problems
3. Prioritize problems/issues
4. Design & implement management programs
5. Design & implement restoration programs
6. Design & implement monitoring programs
7. Design and implement research as needed

Basic Landscape Characteristics

- Comparatively small
- Individual or provinces
- Most are isolated from other aquatic systems
- Often the only water over large areas
- Each is distinctive
  - Size
  - Discharge
  - Temperature
  - Etc.

Springs vs. Streams

Springs

- Relatively Static
  - Discharge
  - Water temperature
  - Water chemistry
  - Turbidity
  - Etc.
- Weak hydraulic processes

Streams

- Relatively Variable
  - Discharge
  - Water temperature
  - Water chemistry
  - Turbidity
  - Etc.
- Strong hydraulic processes

Arid Land Aquifer Generalities

- **Perched**
  - Small (Watershed)
  - Springs Discharge on Mountain or Ridge Blocks
  - Short Residence Time (seasonal or annual)
  - Many Not Persistent, Frequently Dry
- **Local**
  - Larger (Mountain Range)
  - Springs Discharge at Lower Elevations (Bajada or Valley Floor)
  - Elevated Residence Time (> annual)
  - Persistence > 20 yr.
- **Regional**
  - Large (Basin & Range)
  - Springs Discharge on Valley Floor
  - Long Residence Time (millennial)
  - Geologically Persistent

Spring Morphology

Types

- Ephemeral
- Permanent
- Seep
- Rheocrene
- Limnocrence
- Helocrene
- Etc.

Biotic Organization

Source

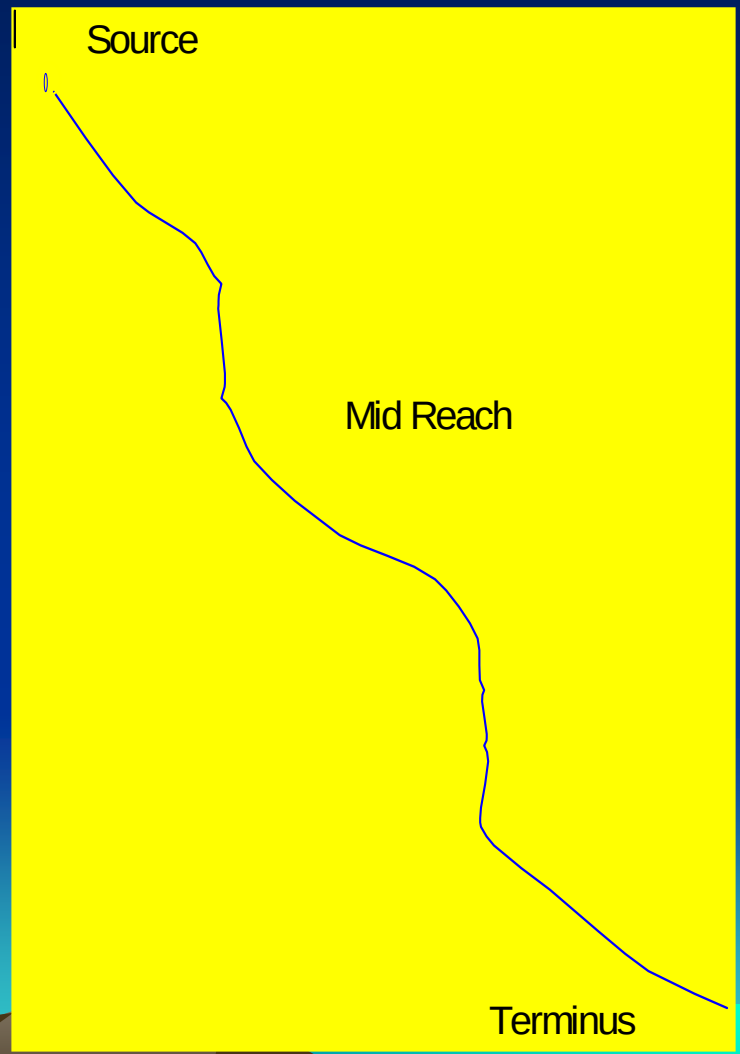
- Temporal Variation Low
- Low BMI Density, Diversity
- Crenobiontics Possible
- Intolerant BMIs
- Dense Riparian (Obligatory Wetland spp.)

Mid-Reach

- Temporal Variation Moderate
- Increased BMI Density, Diversity
- Tolerant BMIs
- Decreasing Crenobiontics
- Opening Riparian (Facultative Wetland spp.)

Terminus

- Temporal Variation High
- No Crenobiontics
- Highly Tolerant BMIs
- Decreased BMI Diversity
- Open Riparian (Upland spp.)
- Amphibians most likely



Ecologically Important Stressors

NATURAL

- Persistence
- Chemistry
  - pH
  - Conductance
  - Temperature
  - Solute Concentrations & Ratios
- Disturbance
  - Flood
  - Fire
  - Avalanche
  - Etc.

ANTHROPOGENIC

- Diversion
  - Pipe
  - Channelization
  - Impoundment
  - Groundwater Use
- Non-Native Species
  - Ungulates
    - Cattle, Horses, Burros
  - Aquatics
    - Vertebrates
      - Fishes, Amphibians
    - Invertebrates
      - Crayfish
      - Mollusks
- Recreation

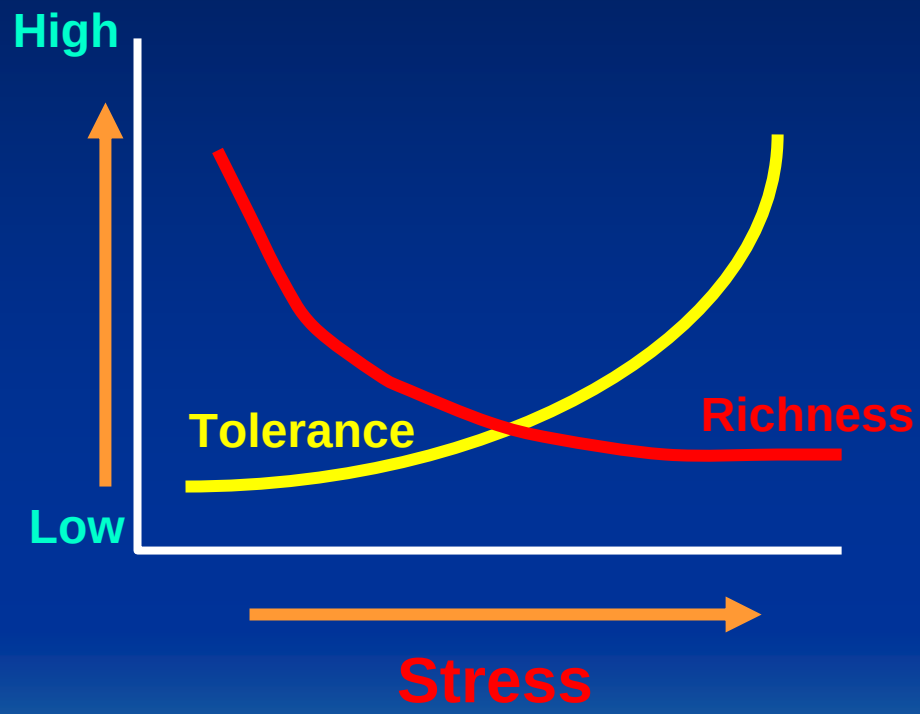
What is a Spring ?

Aquatic system supported by water discharging onto the land surface through natural processes

Ecological Effect of Stressors

Relative to:

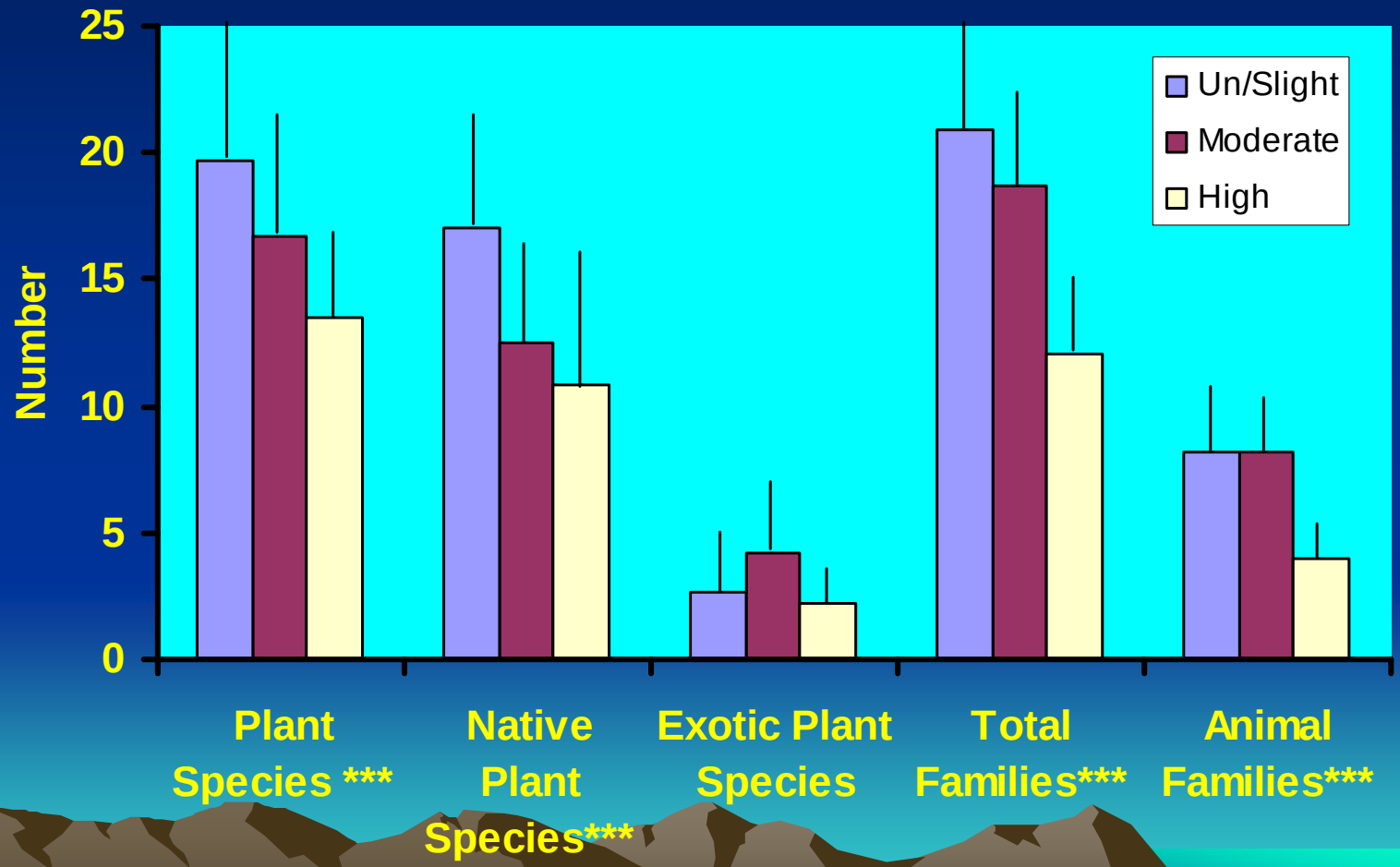
- Magnitude
- Frequency
- Duration



Stress & Taxonomic Richness

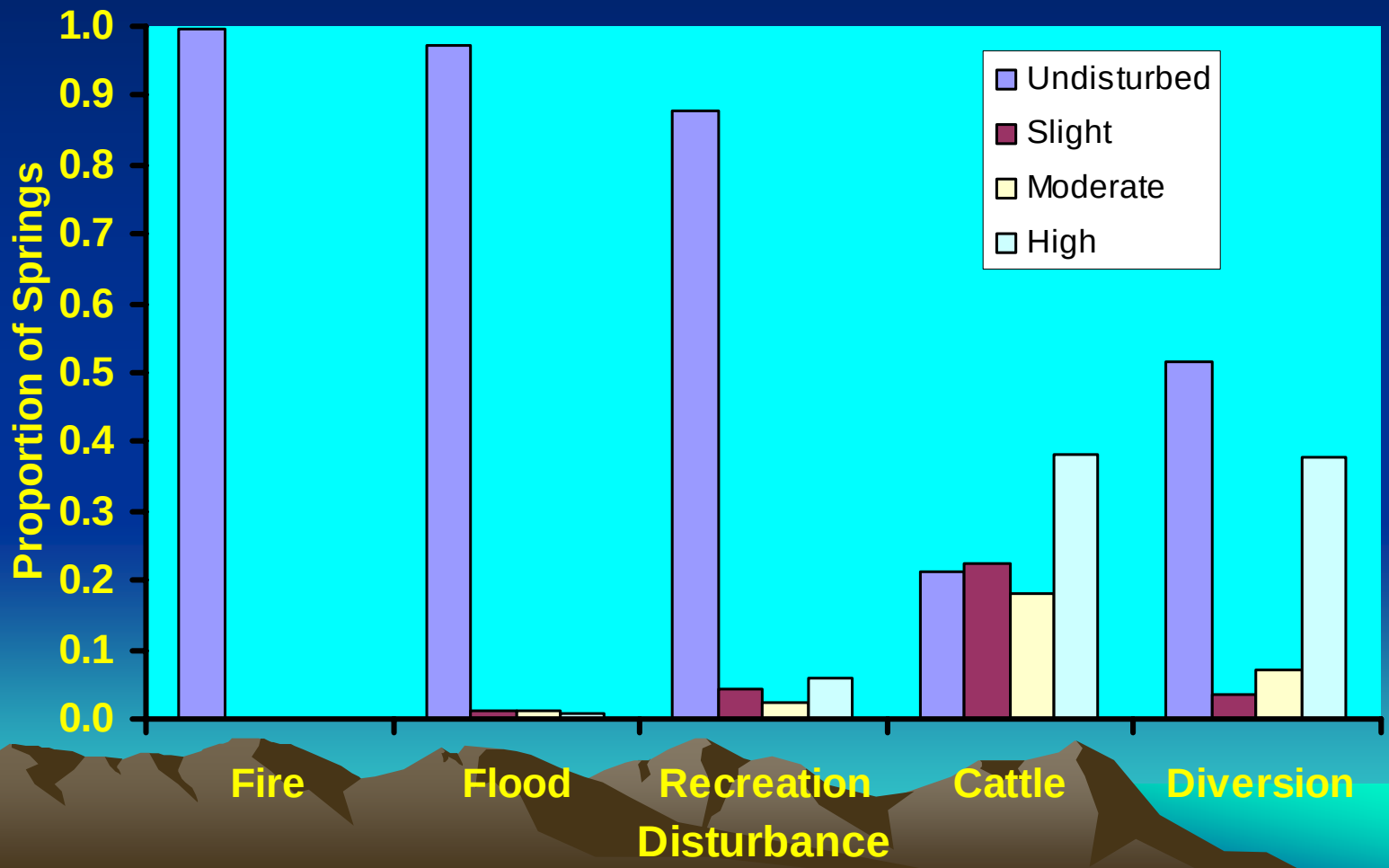
Spring Mountains, NV

*** = p < .001



Natural and Human Stressors

N = 1590



Inventory & Management Challenges

- Most springs have not been located or inventoried
- Each spring is unique
- How can information be efficiently (financially & effectively) compiled to address management issues?

Survey & Monitoring Strategy

- **Hierarchical Set of 3 Protocols**
  - **Level I** – Basic Inventory
  - **Level II** – Annual Monitoring of Physicochemical and Biological Characteristics
  - **Level III** – Seasonal Monitoring of Physicochemical and Biological Characteristics
    - Quantitative Description of Spatial and Temporal Variability
    - Habitat Preferences for Important Animals
    - Soil Moisture, Aquifer Provenance

Level I Spring Surveys
(Inventory)

- Locate and characterize springs based on abiotic and biotic features
  - Identify management issues
  - Qualitatively assess ecological potential
  - Assist with design and implementation of management and restoration programs

Level I Spring Surveys
Primary Data Elements

- Location
  - Access
- Photographs
- Water chemistry (Temp., DO, pH, EC)
- Physical characteristics
  - Morphology
  - Size (Width, Depth, Length, Discharge)
  - Important vegetation & animals
  - Stressors (Natural & Human)

Level II Spring Surveys

(Long-Term Monitoring)

- Sites selected using Level I Survey information
- Quantify temporal annual variability in biotic and abiotic Characteristics (Riparian and macroinvertebrate community structure, water chemistry, aquatic habitat, etc.)
- Track response of biotic and abiotic characteristics to existing or changing management

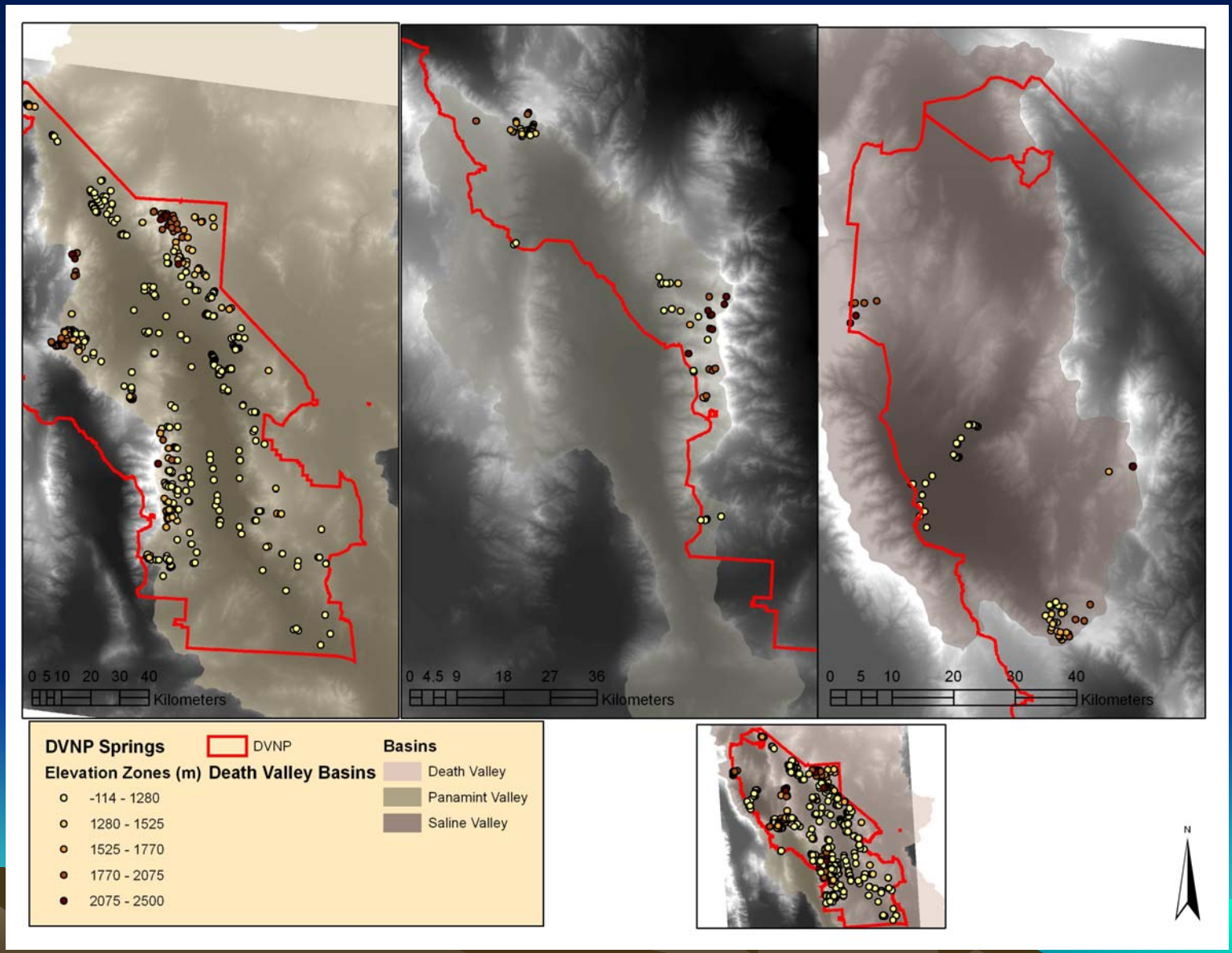
Level III Spring Monitoring
(Highly Quantitative Monitoring)

- Few, highly valuable, vulnerable springs
- Seasonal, quantitatively sampling to determine spatial and temporal variation in biotic and abiotic attributes
  - Intensive biotic sampling (density & transect sampling, eucrenal & hypocrenal along continuum)
  - Intensive water chemistry—Aquifer affinities & movement (Isotopes, Solutes, etc.)
  - Legally defensible

NPS Mojave Network Spring Survey Program

- Death Valley NP, Joshua Tree NP, Grand-Canyon Parashant NM, Lake Mead NRA, Mojave Reserve, Great Basin NP
  - Two-person crews
  - $300/ spring

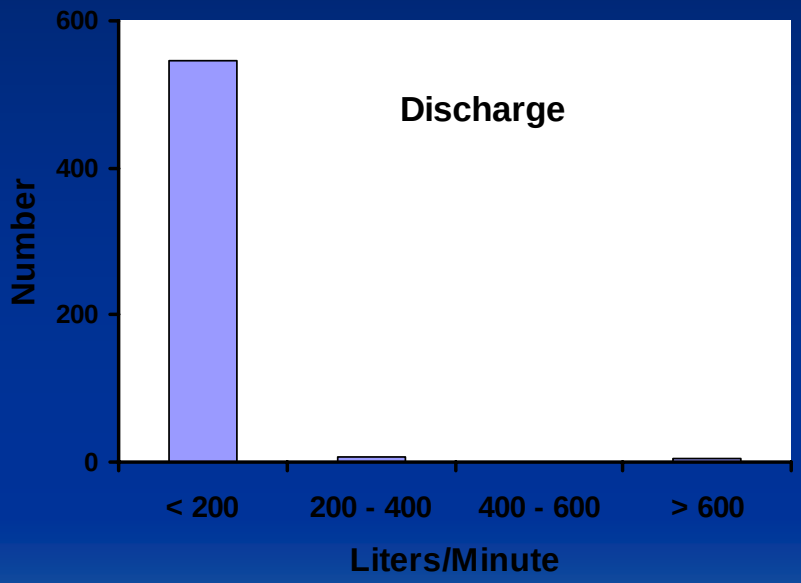
Death Valley NP Springs

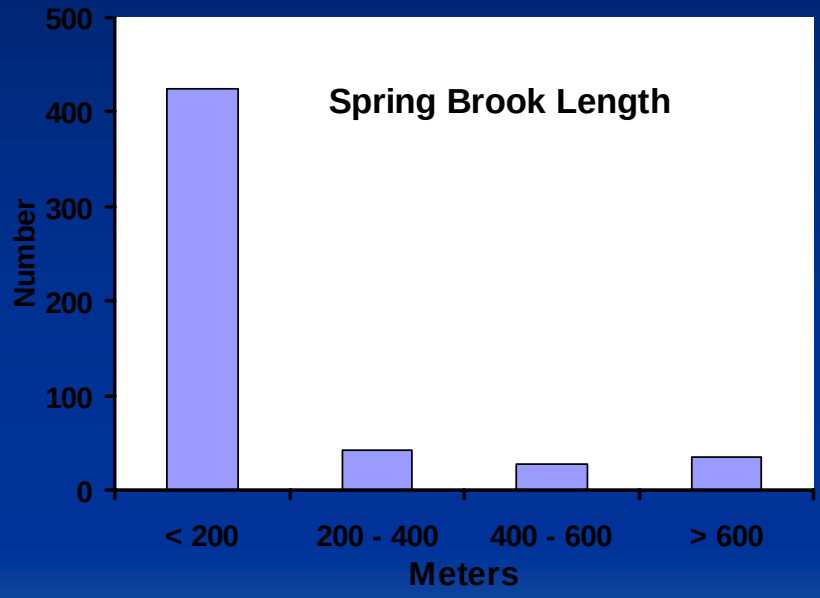


Death Valley National Park Level I Surveys

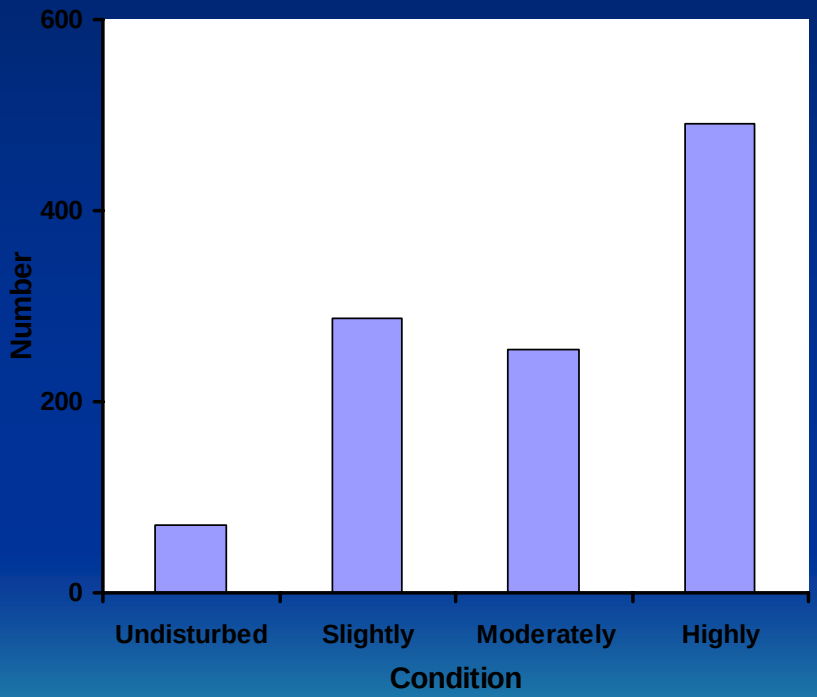
- 613 Springs
  - 1 / 22.4 km²
  - Most are:
    - Below 1280 m
    - Small, spring brooks < 200 m long
    - Moderately or Highly Disturbed
      - Drought & flooding
      - Livestock, diversion, dredging, etc.

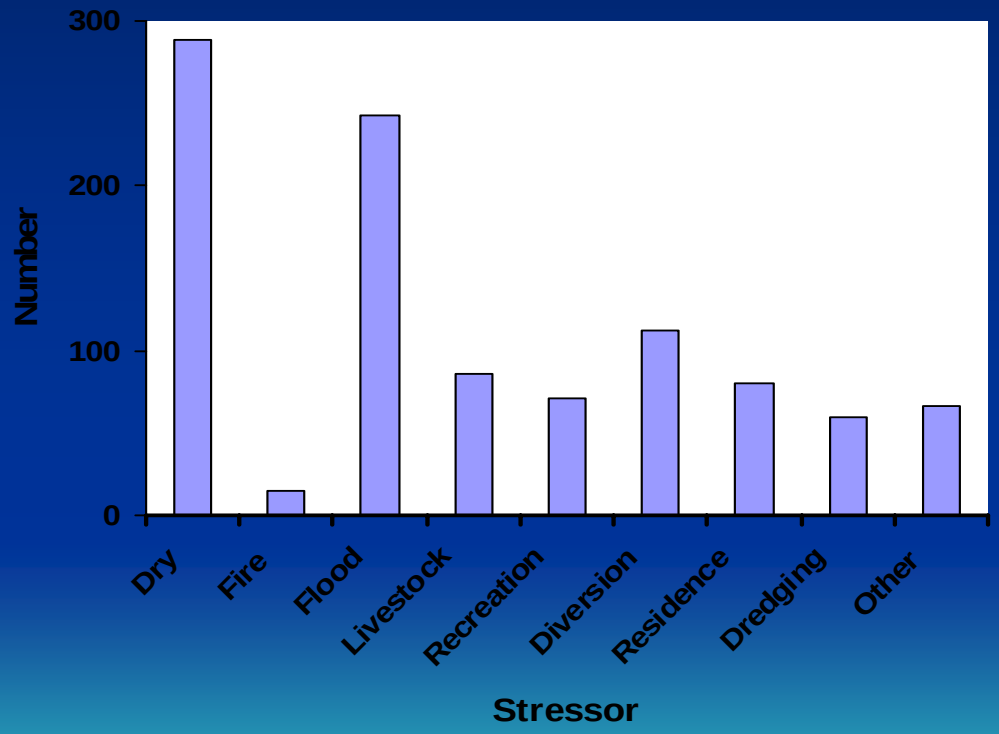
Spring Size


Discharge
Number
600
400
200
0
< 200
200 - 400
400 - 600
> 600
Liters/Minute


Spring Brook Length
Number
500
400
300
200
100
0
< 200
200 - 400
400 - 600
> 600
Meters

Condition & Stressors





Using Information from Inventories

- Database Summary
  - Data Sorting and ‘Baseline’ Summary
- Prioritizing Management
  - Matrix Analysis
    - Monitoring Primary DV Interest
      - Easily Accessed Springs
      - Minimally Stressed Permanent Springs
      - Important Macroinvertebrate Species

Matrix Analysis

- **Access** --1 & 2 = 0, 3 = 5, 4 = 10, 5 = 15
- **Crenobiontics** -- None = 0, 1 = 10, > 1 = 15
- **Size** -- <10m = 0, 10m – 50m = 5, 50m – 100m =10, >100m = 20
- **Disturbance** -- High & Moderate are Ineligible, Slight = 10, Undisturbed = 15

Matrix Product

Prioritized list of springs that are most suitable for monitoring, based on access, environmental quality, and permanence