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Assessing Vegetation Response to Dam Operations using the Response Guild Approach

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U.S. Department of the Interior
U.S. Geological Survey

Overview

- Review general knowledge about riparian plant species downstream from Glen Canyon Dam
  - Highlight known responses of vegetation to Glen Canyon Dam releases
- Explain monitoring using Response Guild Approach
  - Identified Guilds for the Colorado River
  - Linkages with National Parks in Upper Basin
  - Implementation of monitoring
  - Preliminary results from October 2012 sampling trip
- Conceptual-frame based modeling
- Tamarisk Beetle Status

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Drivers of Vegetation Change	
Operations	**Location on the Landscape/Landscape condition**

Inter-annual and seasonal variability in hydrology

Flood timing	→	Seed dispersal/germination
Duration	→	Scour, cover, occupancy space
Magnitude	→	Area of disturbance
Frequency	→	Species selection/successional processes

Surface water-ground water interactions –

Minimum discharge	→	Distance to water – upland, woody riparian species
Daily range	→	Inundation duration – marsh species, woody riparian species

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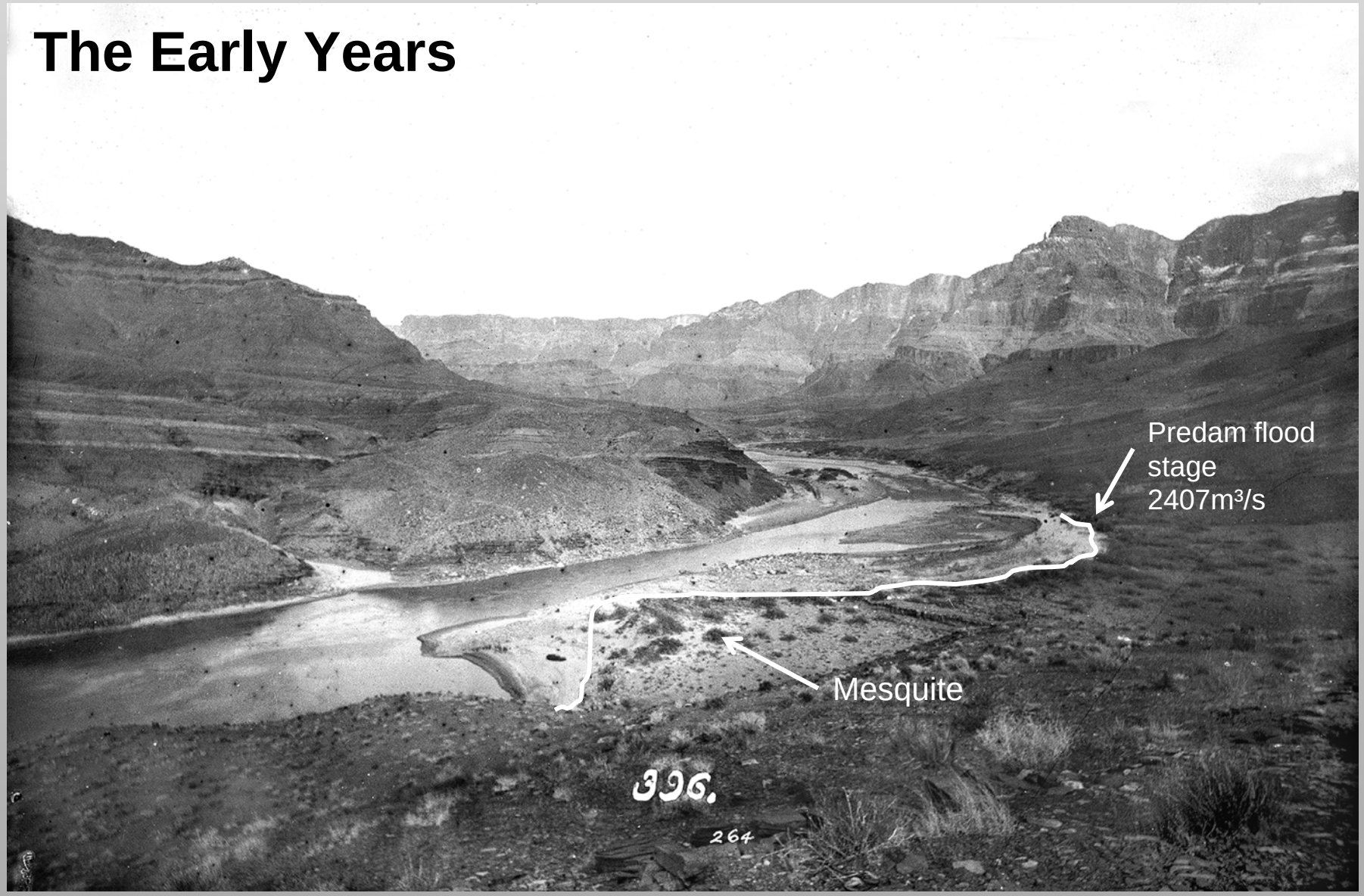
The Early Years



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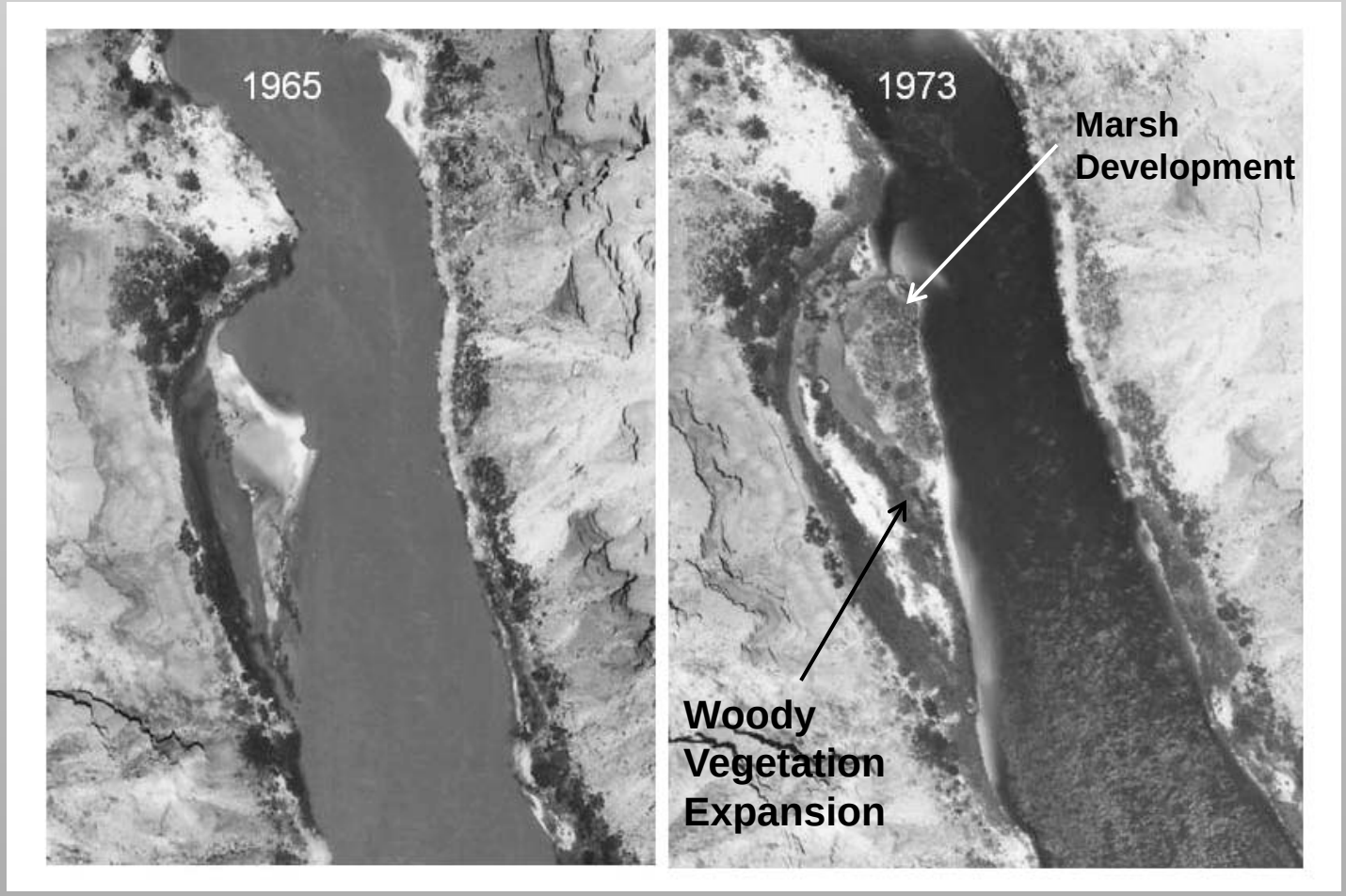
Stanton Photo 1890, Cardenas Creek, National Archives and Records Administration.

Plants along the Colorado River – historic assemblage

Period I – Flood reduction and flow stabilization



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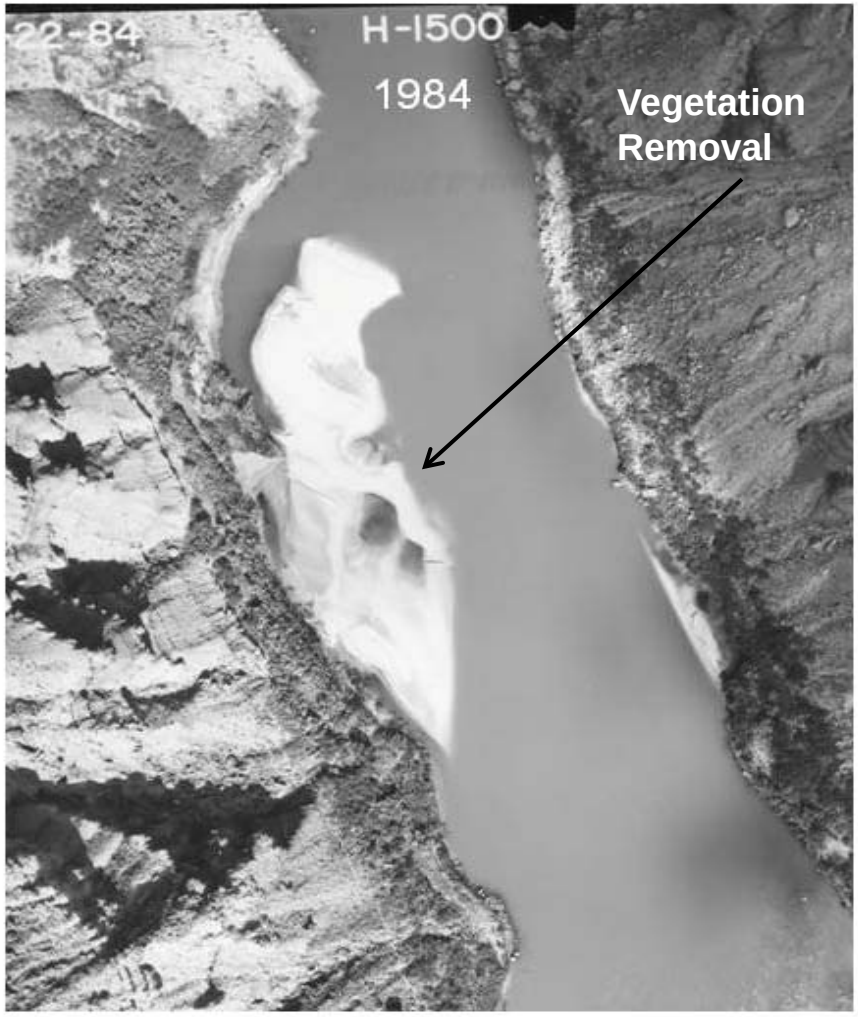
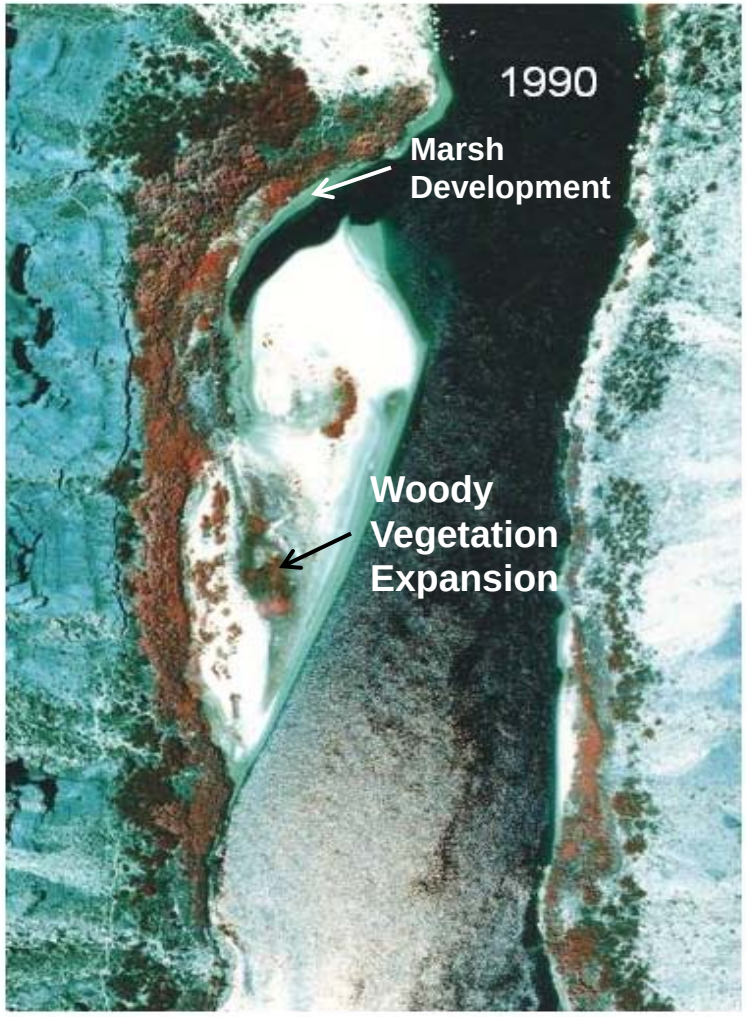
Period II – Prolonged flooding, sediment reworking & export, vegetation removal & re-establishment





Period IV 2000-2012 – Reduced fluctuations, minimum annual delivery (drought) and equilization flows (MLFF, LSSF, HFE operations)

Continued vegetation expansion →

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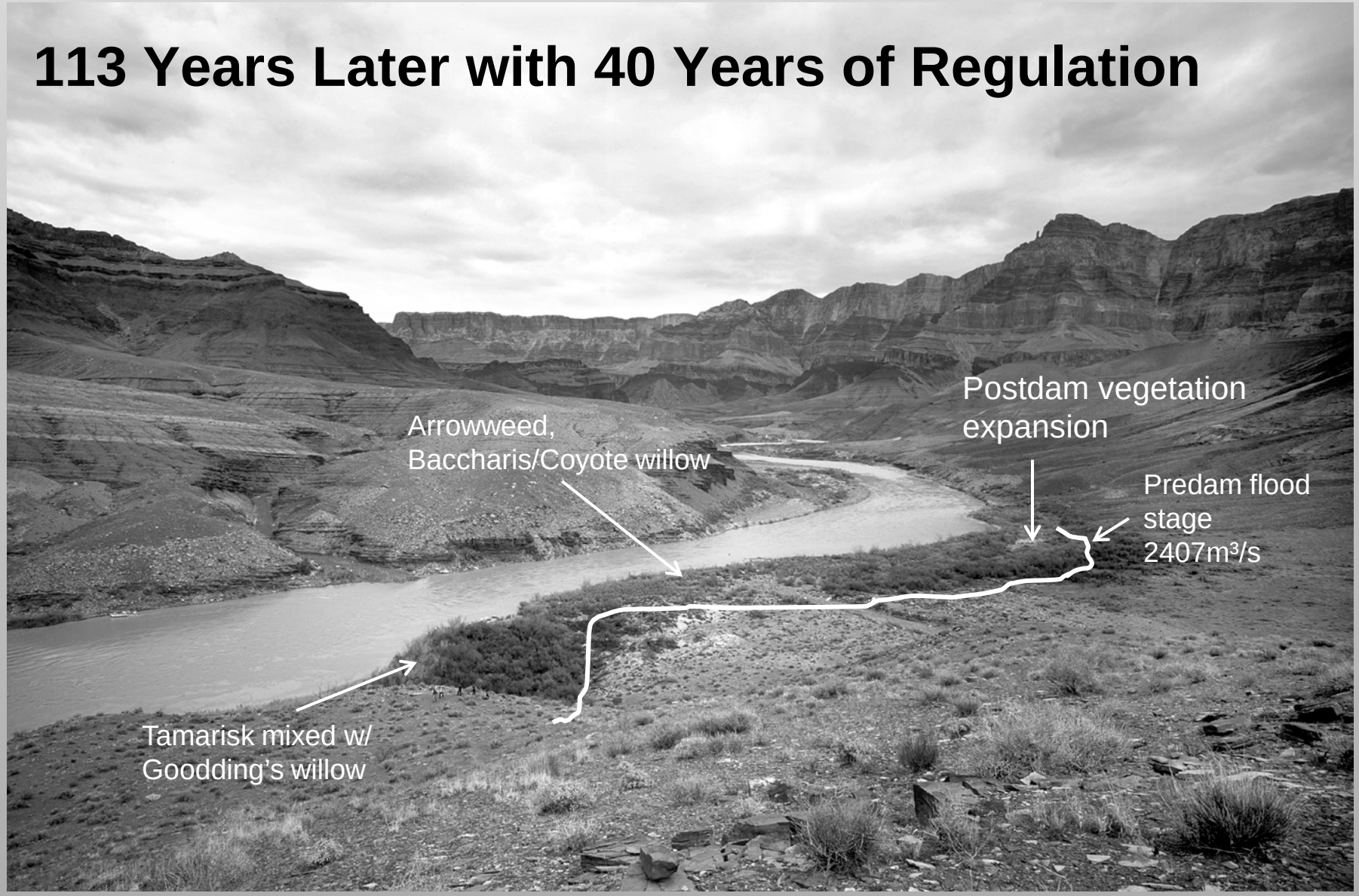
113 Years Later with 40 Years of Regulation



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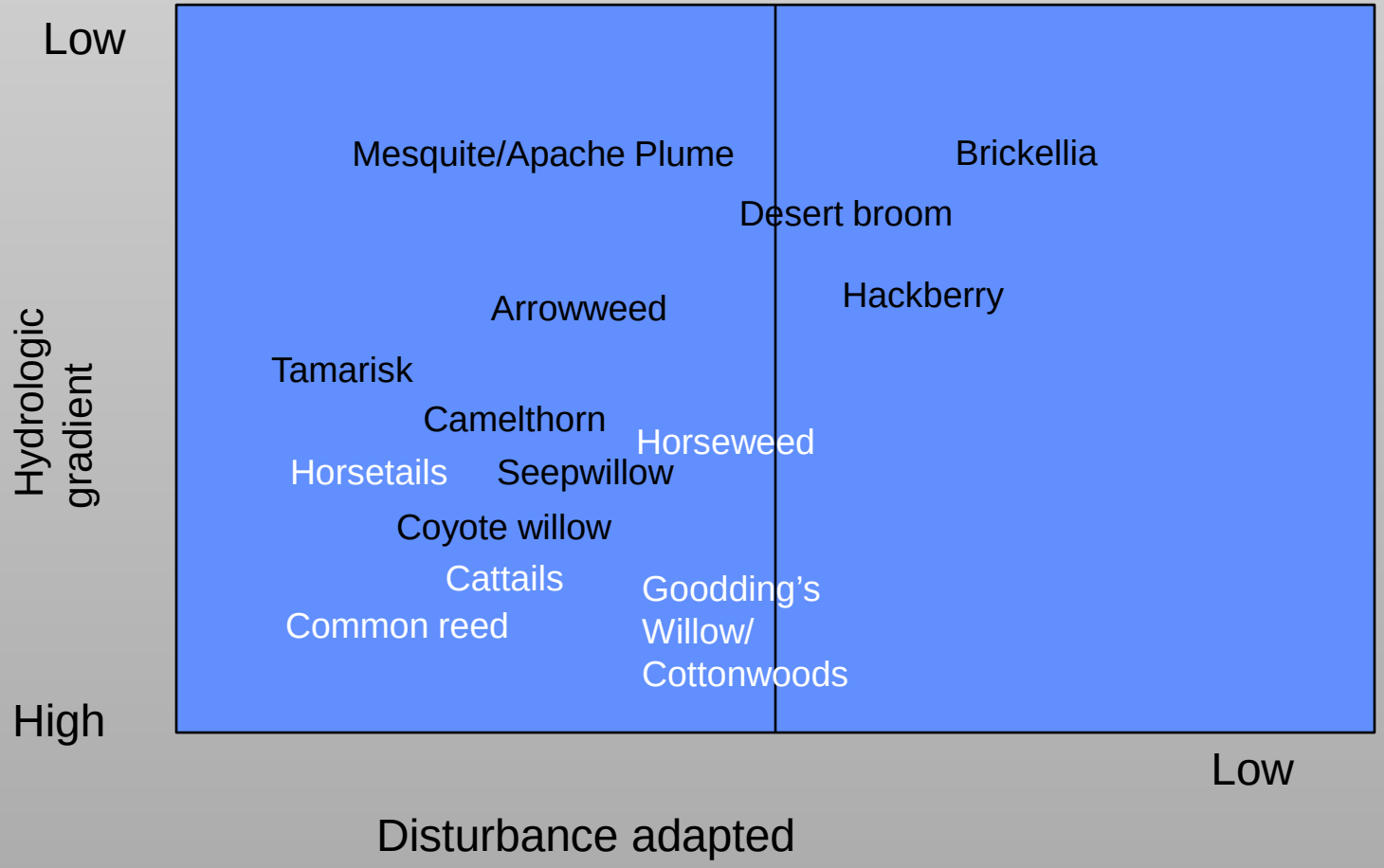
Repeat photograph 2003, Cardenas Creek
(USGS Desert Laboratory Repeat Photography Collection).

Plants along the Colorado River – post regulation



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General vegetation response

- Riparian woody vegetation is expanding
- HFEs of present magnitude/duration do not remove woody vegetation
- Coarsening sandbars favor drought adapted vegetation → shoreward migration of woody species
- Basin hydrology, daily fluctuations and maximum daily discharge affects woody vegetation expansion.
- Operations that scour sandbars followed by reduced flows → tamarisk colonization
- At lower stage elevations, increased frequency of HFEs may favor clonal species that are burial adapted over seed production

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Monitoring vegetation response to dam operations

Riparian Vegetation-Flow Response Guilds Framework

Groups of species that have shared life history traits and respond similarly to physical variables (e.g., hydrologic regime, geologic setting/substrate properties, ambient temperature)

Life history

Reproductive strategy

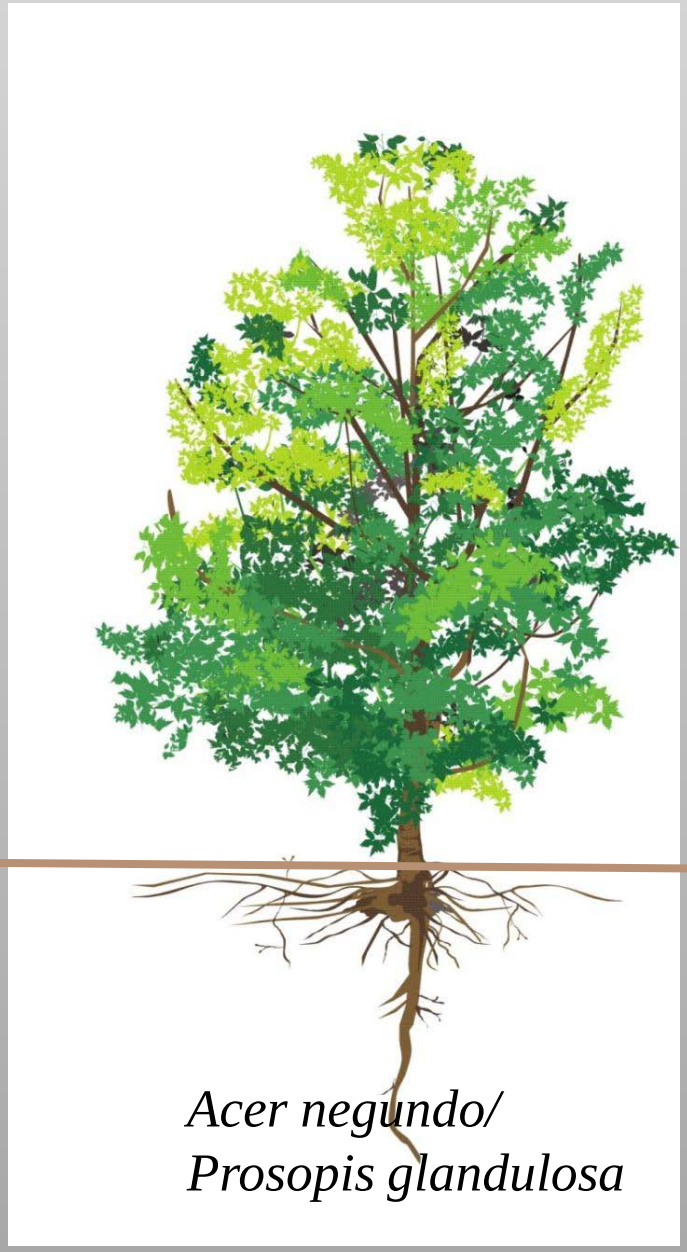
Morphology

Fluvial disturbance

Water balance

Merritt, Scott, Poff, Auble, Lytle. 2010. Freshwater Biology 55:206-225

Selection and Adaptation



Acer negundo/
Prosopis glandulosa

Tamarix ramosissima

Phragmites australis

Juncus bufoniu

Life History Guilds

Traits

- Longevity (life span)
- Annual, short- and long-lived perennial, biennial

Relevant Flow Component

- Frequency of extreme floods
- Anoxia
- Timing of floods
- Flow duration

Reproductive Strategy Guilds

Traits

- Vegetative-Sexual-Combined
- Timing in synchrony with flow component (dispersal, flower, fruit)

Relevant Flow Component

- Magnitude of extreme flow
- Timing of high & low flow
- Rate of drawdown
- Duration of inundation

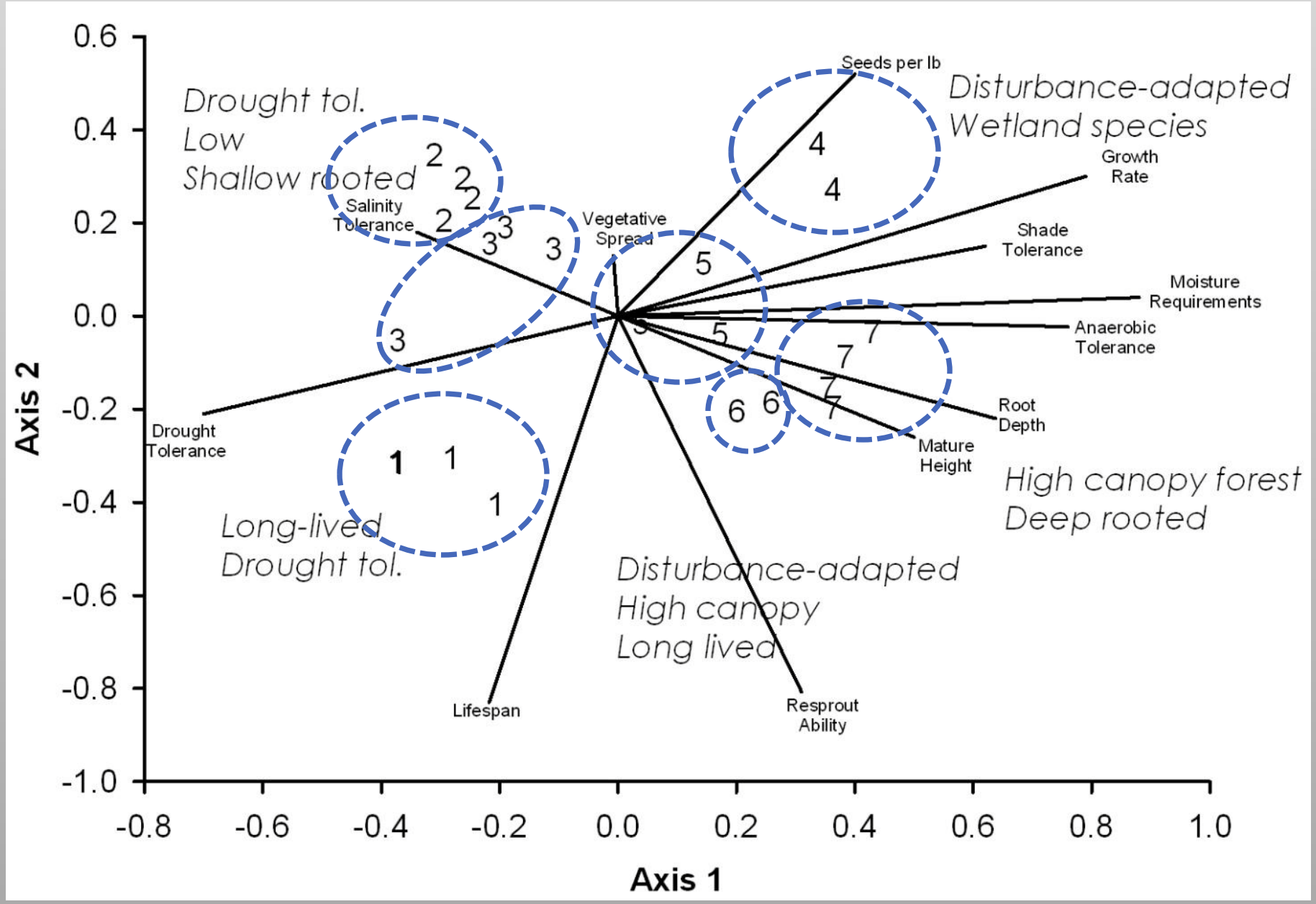
Morphology Response Guilds

Traits

- Growth form (e.g., herbaceous-woody, graminoid-shrub-tree)
- Rooting depth (phreatophytic)
- Root morphology (lateral-taproot, shallow-deep)
- Size at maturity (canopy height, vegetation volume)

Relevant Flow Component

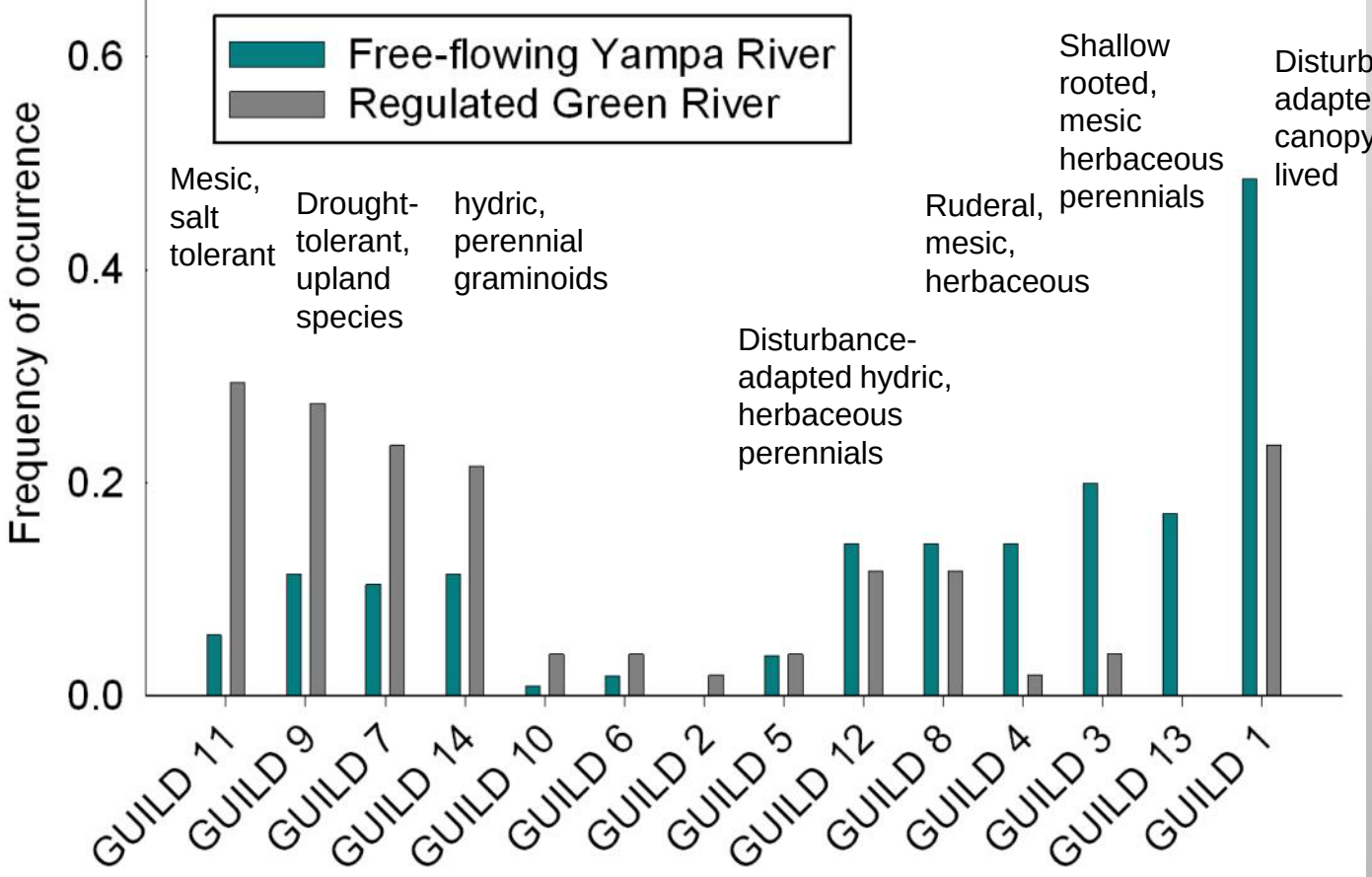
- Flow duration
- Magnitude and duration of low and high flow
- Water table depth and inter- and intra-annual variability
- Flow permanence, groundwater depth, flow variability



Merritt and Bateman, Ecological Applications 2012

Green and Yampa rivers, Colorado-Utah

Merritt, unpublished



Merritt, unpublished do not cite

Guilds Identified for Colorado River in Grand Canyon

14 biological attributes

- Growth rate
- Height at maturity
- Life span
- Resprout ability
- Anaerobic tolerance
- Drought tolerance
- Fire tolerance
- Salinity tolerance
- Vegetative reproduction
- Spread rate
- Root-depth
- Shade tolerance
- Moisture usage (inundation/duration)
- Fire tolerance
- Sexual reproduction

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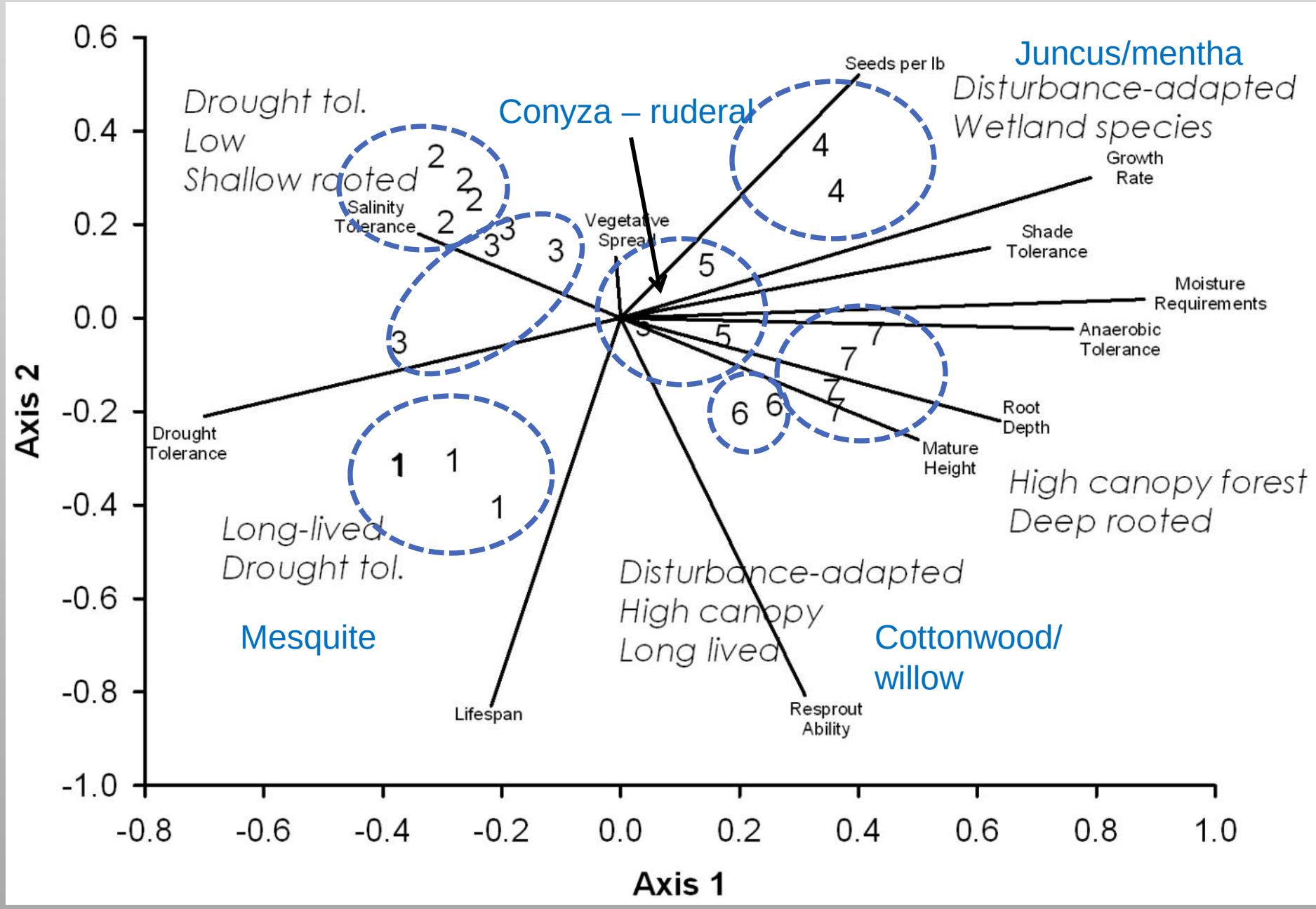
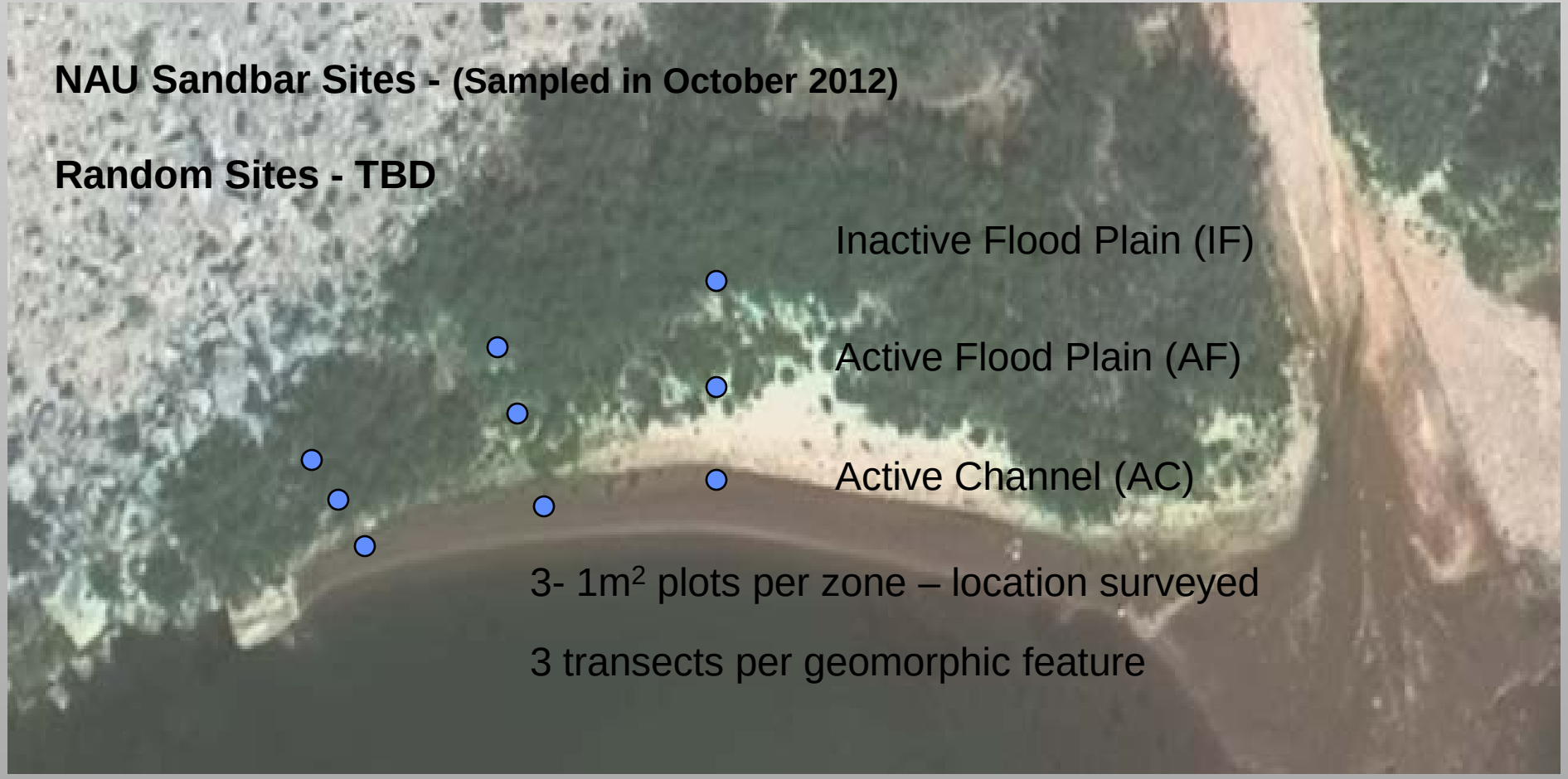

Juncus/mentha
Disturbance-adapted
Wetland species
Drought tol.
Low
Shallow rooted
Conyza – ruderal
Seeds per lb
Growth Rate
Shade Tolerance
Moisture Requirements
Anaerobic Tolerance
Root Depth
Mature Height
Resprout Ability
Lifespan
Vegetative Spread
Salinity Tolerance
Drought Tolerance
High canopy forest
Deep rooted
Long-lived
Drought tol.
Disturbance-adapted
High canopy
Long lived
Mesquite
Cottonwood/
willow
Axis 1
Axis 2
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0

Sampling Approach



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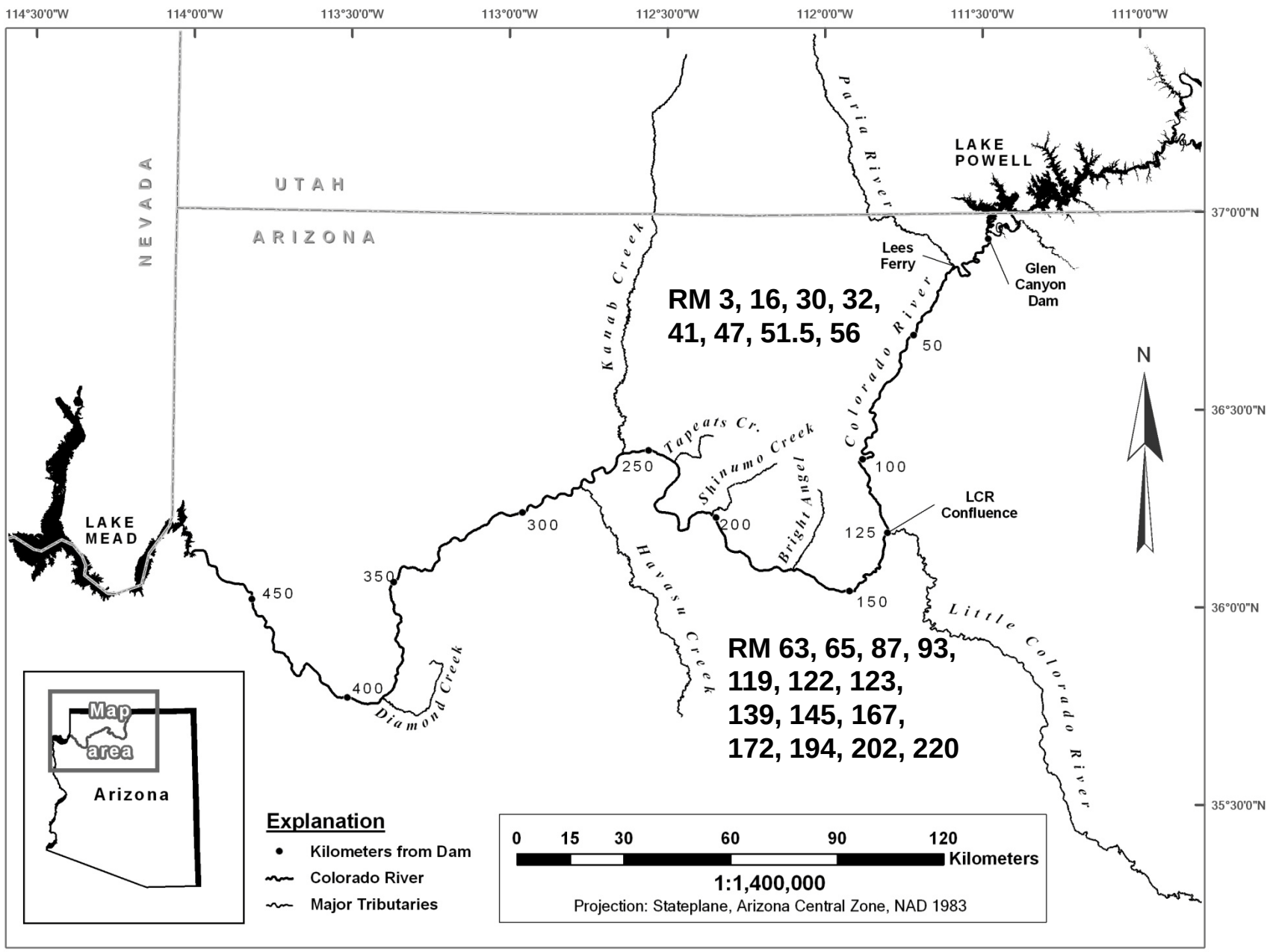
114°30'0"W
114°0'0"W
113°30'0"W
113°0'0"W
112°30'0"W
112°0'0"W
111°30'0"W
111°0'0"W
37°0'0"N
36°30'0"N
36°0'0"N
35°30'0"N
NEVADA
UTAH
ARIZONA
LAKE POWELL
LAKE MEAD
Paria River
Kanab Creek
Colorado River
Tapeats Cr.
Shinumo Creek
Bright Angel
Havasu Creek
Little Colorado River
Diamond Creek
Lees Ferry
Glen Canyon Dam
LCR Confluence
50
100
125
150
200
250
300
350
400
450
RM 3, 16, 30, 32, 41, 47, 51.5, 56
RM 63, 65, 87, 93, 119, 122, 123, 139, 145, 167, 172, 194, 202, 220
N
Map area
Arizona
Explanation
Kilometers from Dam
Colorado River
Major Tributaries
0 15 30 60 90 120
Kilometers
1:1,400,000
Projection: Stateplane, Arizona Central Zone, NAD 1983

Preliminary Results

- 22 sites, 847 plots sampled
- 73 species identified in Marble Canyon
  - 10 (AF), 0 AC
- 50 species Eastern Grand Canyon
  - 8 (AF), 0 AC
- 44 in Western Grand Canyon
  - 7 (IF), 0 AC

Richness, diversity, frequency of guilds,

Cover, native/nonnative ratio

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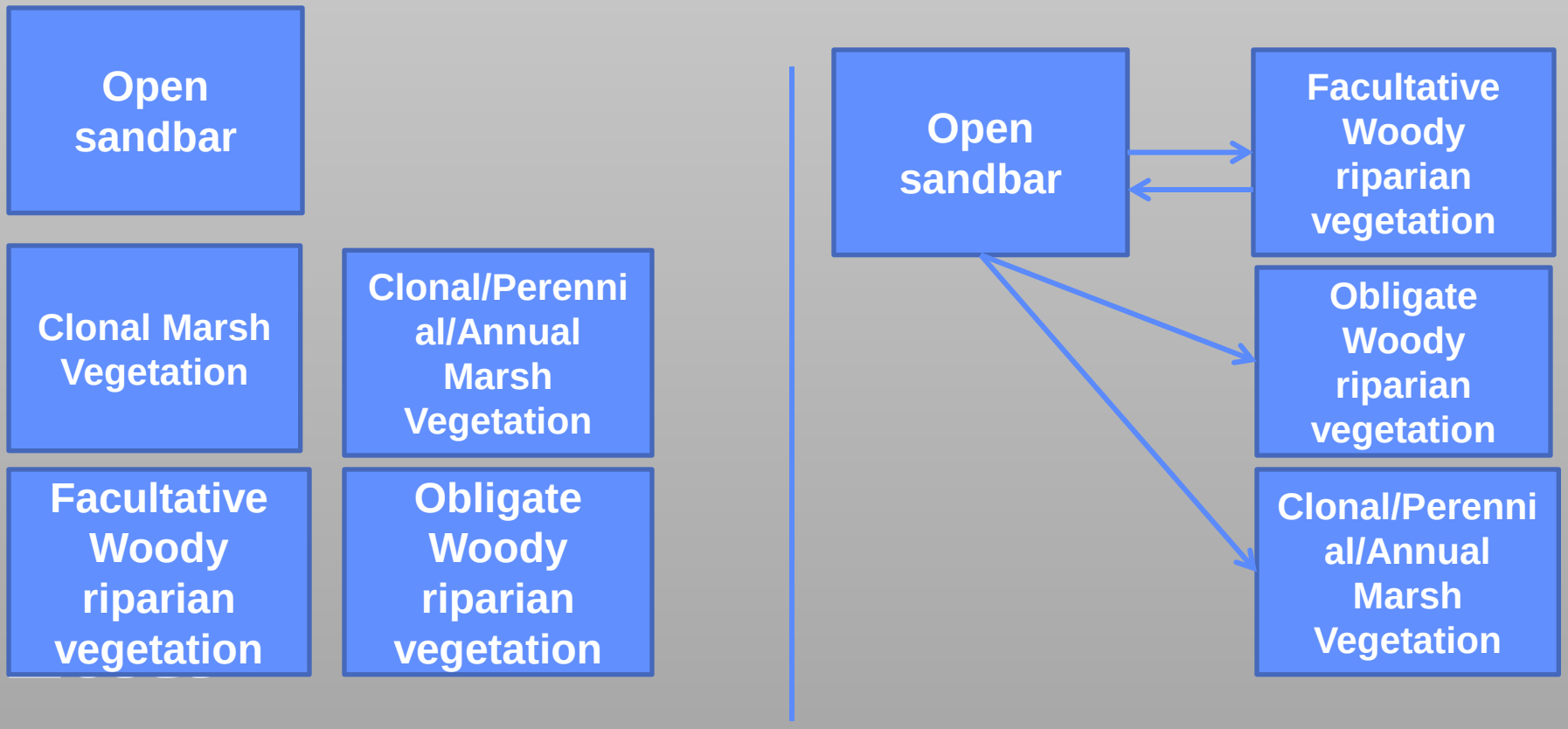
Developing a Conceptual Model for Vegetation Response

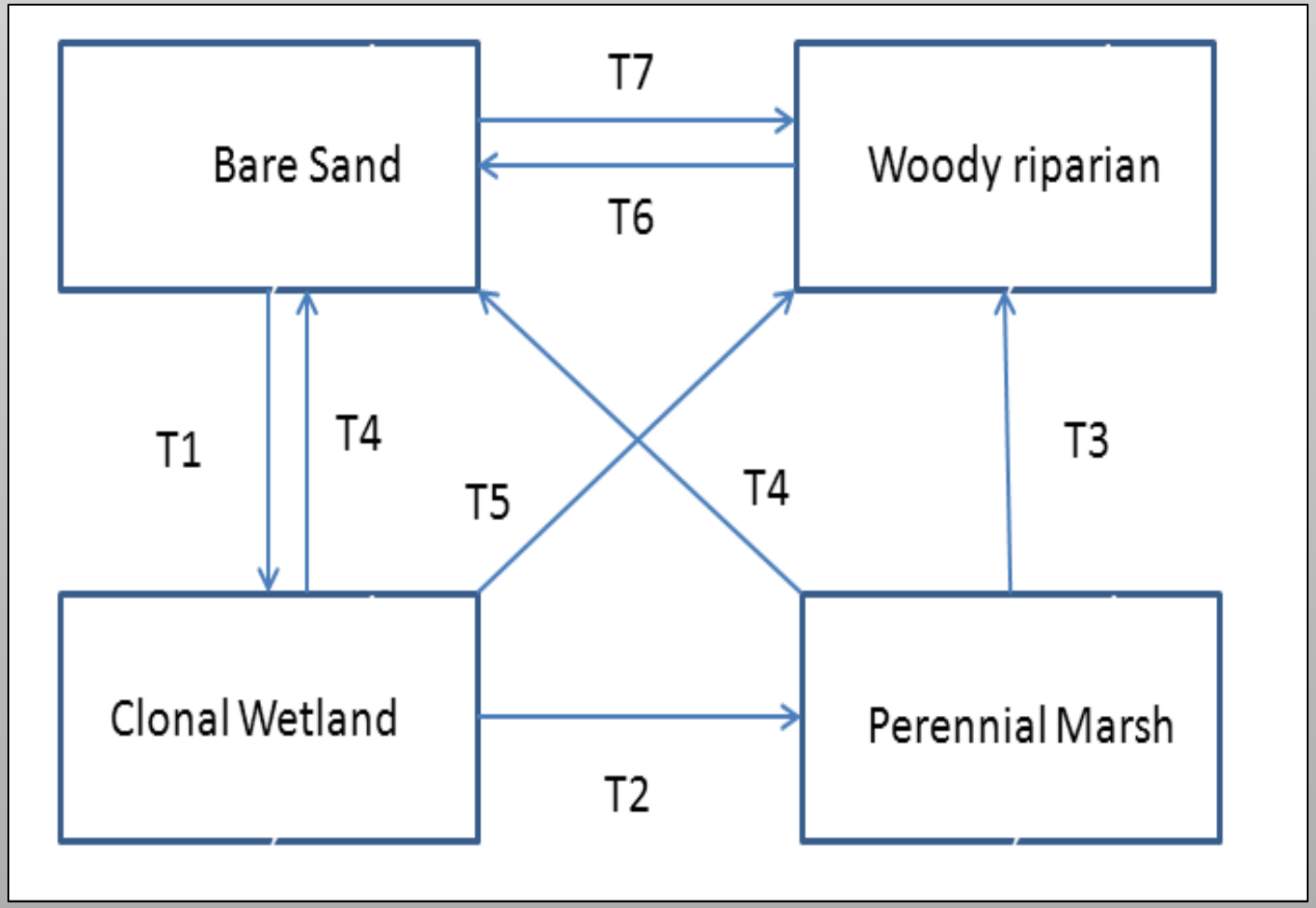
Landscape characteristics
-Low elevation sandbar
-Accumulates silts & clays – return channel side
Greater surface/gw dynamics

Ecological States

Operations that cause switches between states & rules of response



Reattachment bar



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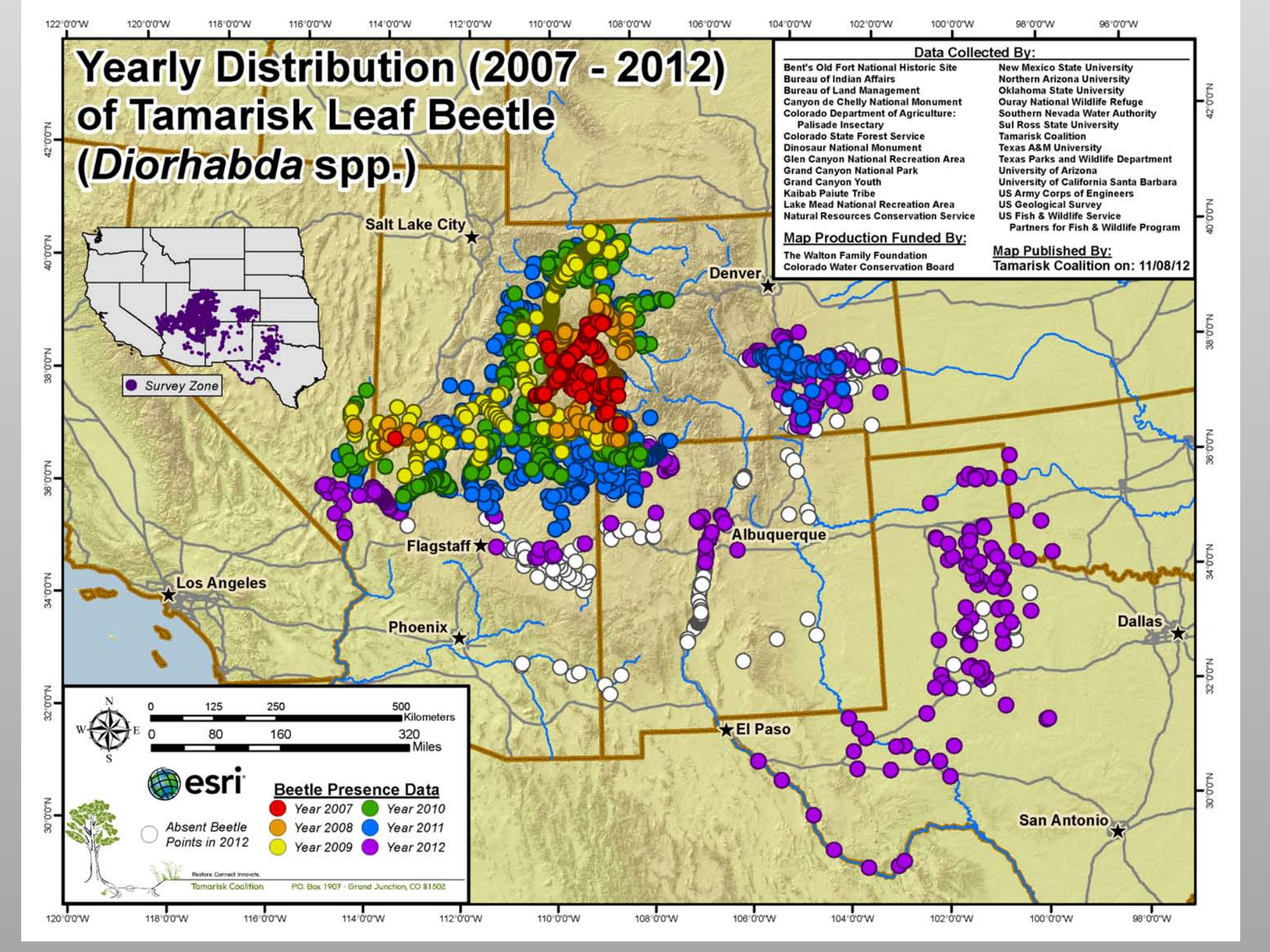
Yearly Distribution (2007 - 2012) of Tamarisk Leaf Beetle (Diorhabda spp.)
Data Collected By:
Bent's Old Fort National Historic Site
Bureau of Indian Affairs
Bureau of Land Management
Canyon de Chelly National Monument
Colorado Department of Agriculture: Palisade Insectary
Colorado State Forest Service
Dinosaur National Monument
Glen Canyon National Recreation Area
Grand Canyon National Park
Grand Canyon Youth
Kaibab Paiute Tribe
Lake Mead National Recreation Area
Natural Resources Conservation Service
New Mexico State University
Northern Arizona University
Oklahoma State University
Ouray National Wildlife Refuge
Southern Nevada Water Authority
Sul Ross State University
Tamarisk Coalition
Texas A&M University
Texas Parks and Wildlife Department
University of Arizona
University of California Santa Barbara
US Army Corps of Engineers
US Geological Survey
US Fish & Wildlife Service
Partners for Fish & Wildlife Program
Map Production Funded By:
The Walton Family Foundation
Colorado Water Conservation Board
Map Published By:
Tamarisk Coalition on: 11/08/12
Survey Zone
Salt Lake City
Denver
Albuquerque
Flagstaff
Los Angeles
Phoenix
Dallas
El Paso
San Antonio
0 125 250 500 Kilometers
0 80 160 320 Miles
esri
Beetle Presence Data
Year 2007
Year 2008
Year 2009
Year 2010
Year 2011
Year 2012
Absent Beetle Points in 2012
Restore. Connect. Innovate.
Tamarisk Coalition
P.O. Box 1907 · Grand Junction, CO 81502

Image: Tamarisk Coalition

Grand Canyon National Park:

Northern Tamarisk Beetle (*Diorhabda carinulata*)

Defoliation:

August, 2011

Grand Canyon National Park

Grand Canyon N. P.

N
W E
S

Percent Defoliation

- Absent (0%)
- Low (1-33%)
- Medium (34-66%)
- High (67-100%)

Kilometers

0 12.5 25 50 75 100

Defoliated tamarisk

Map: L. Jamison

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Impacts & implications of beetle-induced tamarisk mortality

- Ecosystem patterns & processes
  - Spatio-temporal scales
  - Flora & fauna
  - Nutrient dynamics, fire & hydrology
- Management implications
  - Natural & cultural resources
  - Recreation & visitor experience
  - Monitoring, mitigation & rehabilitation
  - Dam operations

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