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
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
The Early Years

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

Predam flood stage 2407m³/s

Mesquite
Plants along the Colorado River – historic assemblage

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**Hydrologic gradient**
- **Low**
- **High**

**Disturbance adapted**
- **Low**
- **High**

**Ephemeral**

- **Mesquite/Apache Plume**
- **Arrowweed**
- **Tamarisk**
- **Coyote willow**
- **Gooding's Willow/Cottonwoods**
- **Desert broom**
- **Hackberry**
- **Brickellia**

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USGS
Period I – Flood reduction and flow stabilization

1965

1973

Marsh Development

Woody Vegetation Expansion
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
113 Years Later with 40 Years of Regulation

Tamarisk mixed w/ Goodding's willow

Postdam vegetation expansion

Predam flood stage 2407 m³/s

Arrowweed, Baccharis/Coyote willow

Tamarisk mixed w/ Goodding's willow

Repeat photograph 2003, Cardenas Creek (USGS Desert Laboratory Repeat Photography Collection).
Plants along the Colorado River – post regulation

Disturbance adapted

Low

Hydrologic gradient

Low

High

Mesquite/Apache Plume

Tamarisk

Camelthorn

Horsetails

Coyote willow

Cattails

Common reed

Horseweed

Seepwillow

Goodding’s Willow/
Cottonwoods

Desert broom

Brickellia

Hackberry

Cattails

Common reed

Coyote willow

Camelthorn

Tamarisk

Horsetails

Hydrologic gradient

Low

High

Disturbance adapted
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
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

Selection and Adaptation

Acer negundo/
Prosopis glandulosa

Phragmites australis

Tamarix ramosissima

Juncus bufonius
**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
Green and Yampa rivers, Colorado-Utah

Merritt, unpublished
Disturbance-adapted hydric, herbaceous perennials

- Mesic, salt tolerant
- Drought-tolerant, upland species
- Hydric, perennial graminoids
- Disturbance-adapted hydric, herbaceous perennials
- Ruderal, mesic, herbaceous
- Shallow rooted, mesic herbaceous perennials

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
Sampling Approach

NAU Sandbar Sites - (Sampled in October 2012)

Random Sites - TBD

Inactive Flood Plain (IF)
Active Flood Plain (AF)
Active Channel (AC)

3- 1m² plots per zone – location surveyed
3 transects per geomorphic feature
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
Developing a Conceptual Model for Vegetation Response

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

Ecological States
- Open sandbar
- Clonal Marsh Vegetation
- Facultative Woody riparian vegetation
- Clonal/Perennial/Annual Marsh Vegetation
- Obligate Woody riparian vegetation

Operations that cause switches between states & rules of response
- Open sandbar
- Facultative Woody riparian vegetation
- Obligate Woody riparian vegetation
- Clonal/Perennial/Annual Marsh Vegetation
Reattachment bar

1. Bare Sand
2. Woody riparian
3. Clonal Wetland
4. Perennial Marsh

Flow paths:
- T1 from Bare Sand to Clonal Wetland
- T4 from Bare Sand to Woody riparian
- T5 from Clonal Wetland to Woody riparian
- T2 from Perennial Marsh to Clonal Wetland
- T3 from Perennial Marsh to Woody riparian
- T6 from Woody riparian to Bare Sand
- T7 from Woody riparian to Perennial Marsh
Yearly Distribution (2007 - 2012) of Tamarisk Leaf Beetle (Diorhabda spp.)

Data Collected By:
- New Mexico State University
- Northern Arizona University
- Oklahoma State University
- Owyhee National Wildlife Refuge
- Southern Nevada Water Authority
- SU RV 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
Grand Canyon National Park: Northern Tamarisk Beetle (*Diorhabda carinulata*)
Defoliation:
August, 2011

Map: L. Jamison

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

Defoliated tamarisk
Native vegetation
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