



**Riparian Areas: Invasive Plant
Species and Revegetation along
Rivers, Streams, and Levees in
California**

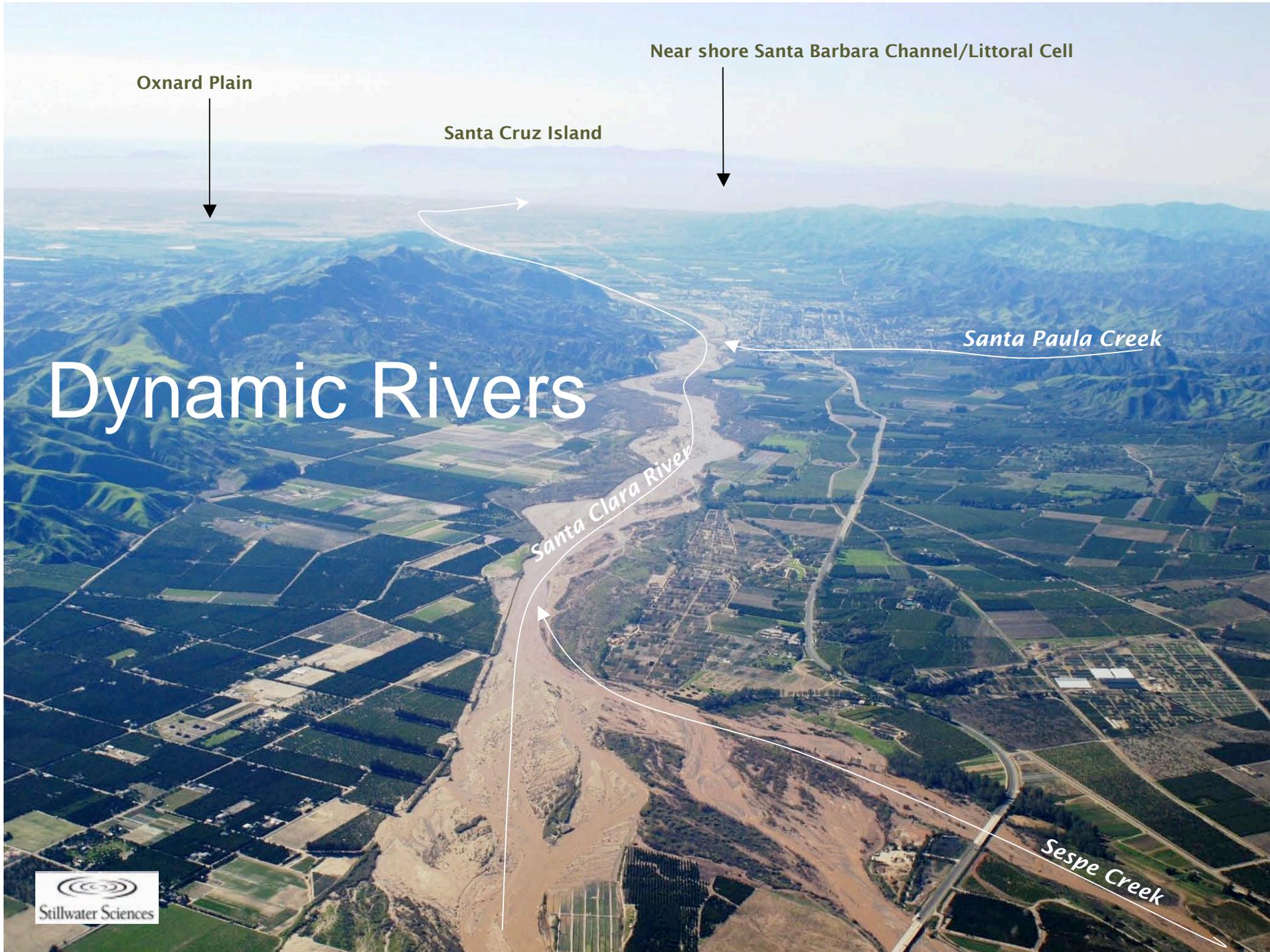
**Gretchen Coffman
UCSB
July 23, 2007**

Riparian Ecosystems

- Riparian Vegetation in California
- Problem of Plant Invasion
- Removal and Control of Invaders
- Revegetation
 - Passive vs. Active
 - Approach
 - Timing
 - Monitoring and Adaptive Management
 - Cost
 - Special considerations for USACE levees

Riparian Ecosystems in California





Oxnard Plain

Near shore Santa Barbara Channel/Littoral Cell

Santa Cruz Island

Santa Paula Creek

Dynamic Rivers

Santa Clara River

Sespe Creek

0 0.125 0.25 0.5 Miles

September 2004



0 0.125 0.25 0.5 Miles

February 2005 (post flood)



Levee Systems

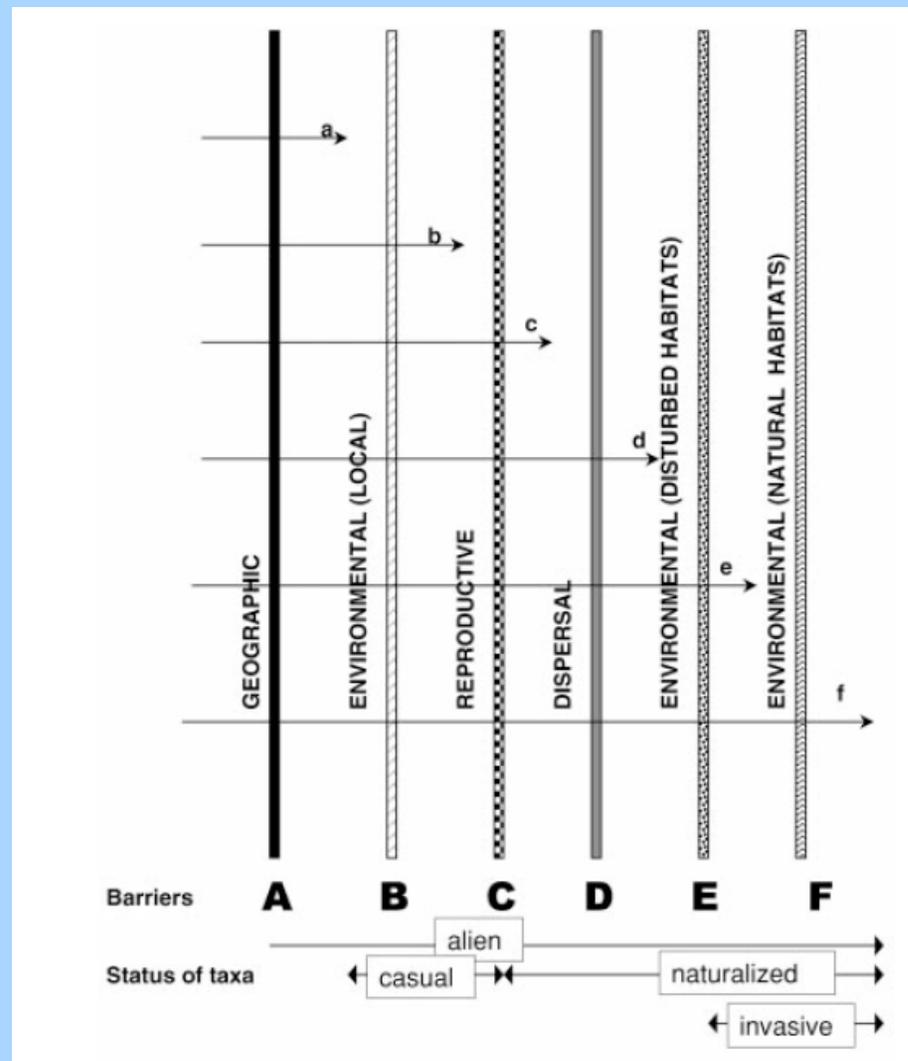


**PLANT INVASION
in RIPARIAN ECOSYSTEMS**

Plant Invasion

- Spread of plants outside their original geographic range
- River systems among most impacted ecosystems
- Problems
 - Threatens biodiversity
 - Creates unnatural fire and flood hazards
 - Use large quantities of water
 - Reduces wildlife habitat quality

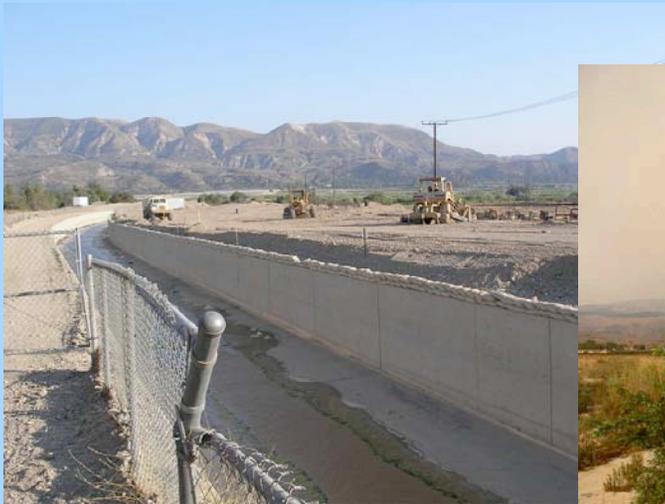
Plant Invasion Process & Barriers to Invasion



(Richardson et al. 2000)

Factors Thought to Contribute to Invasion

- Water
- Nutrients
- Light
- Fire



Most Invasive Riparian Plant Species in CA



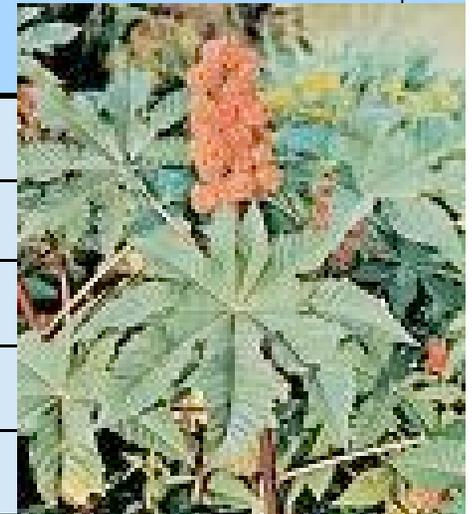
Arundo donax
Giant Reed

Tamarix spp.
Salt Cedar

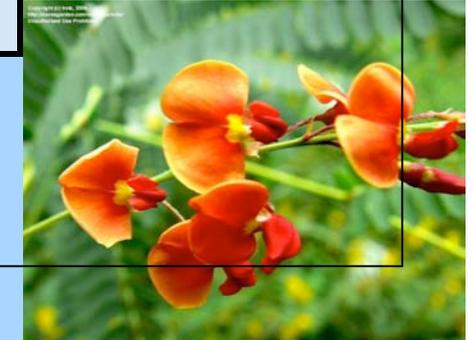


Eichornia crassipes
Water Hyacinth

Other Highly Invasive Riparian Plant Species in CA



Scientific Name	Common Name
<i>Ailanthus altissima</i>	tree-of-heaven
<i>Delairea odorata</i>	Cape ivy
<i>Lepidium latifolium</i>	perennial pepperweed
<i>Ludwigia</i> spp.	water primrose
<i>Lythrum salicaria</i>	purple loosestrife
<i>Ricinus communis</i>	castor bean
<i>Rubus armeniacus</i>	Himalaya berry
<i>Sesbania punicia</i>	scarlet wysteria



CallIPC website: <http://portal.cal-ipc.org/weedlist>

Calflora: <http://www.calflora.org/>

Arundo (*Arundo donax* L.)

- One of the most successful invaders in CA
- Indigenous to northern India and southern Nepal
- Bamboo-like member of Grass family (Poaceae)
- 8-10 meters tall
- Clonal propagation by rhizomes only
- Novel life history form in rivers of Mediterranean-type climates



PROBLEM

- Introduced globally for use in erosion control, ceilings, roofs, fences, and baskets
- Successful invader in river systems of CA
- Increase flooding risk
- Creates fire hazard
- Outcompetes indigenous plants
- Reduces wildlife habitat value

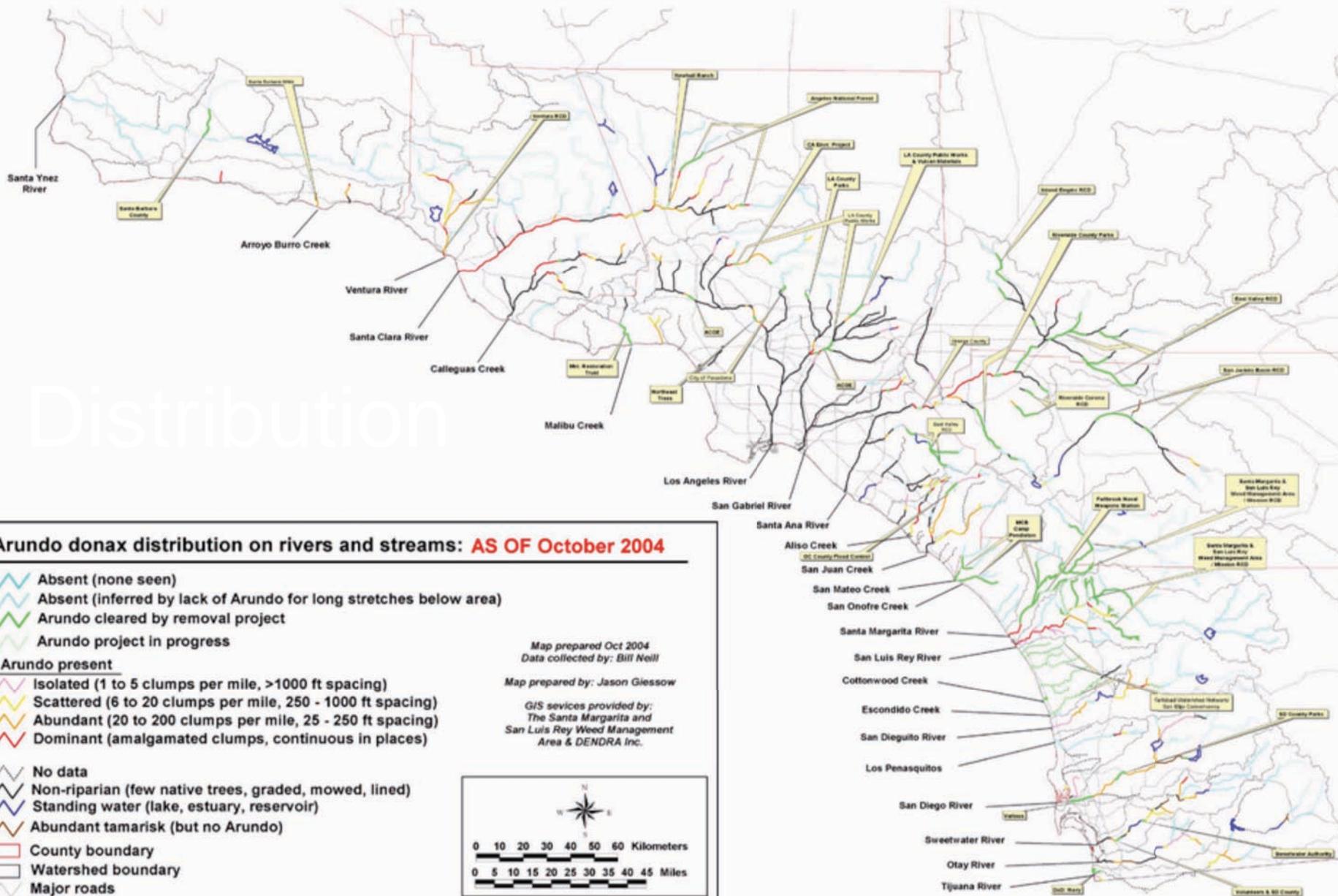


DISTRIBUTION OF ARUNDO DONAX IN COASTAL WATERSHEDS OF SOUTHERN CALIFORNIA: **AS OF October 2004**

This map and accompanying text descriptions of distribution data are available at: <http://smslrwma.org>

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Arundo donax distribution on rivers and streams: **AS OF October 2004**

- Absent (none seen)
- Absent (inferred by lack of Arundo for long stretches below area)
- Arundo cleared by removal project
- Arundo project in progress

Arundo present

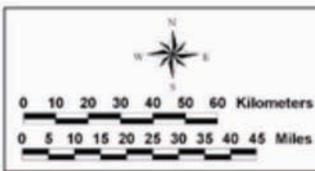
- Isolated (1 to 5 clumps per mile, >1000 ft spacing)
- Scattered (6 to 20 clumps per mile, 250 - 1000 ft spacing)
- Abundant (20 to 200 clumps per mile, 25 - 250 ft spacing)
- Dominant (amalgamated clumps, continuous in places)

- No data
- Non-riparian (few native trees, graded, mowed, lined)
- Standing water (lake, estuary, reservoir)
- Abundant tamarisk (but no Arundo)
- County boundary
- Watershed boundary
- Major roads

Map prepared Oct 2004
Data collected by: Bill Neill

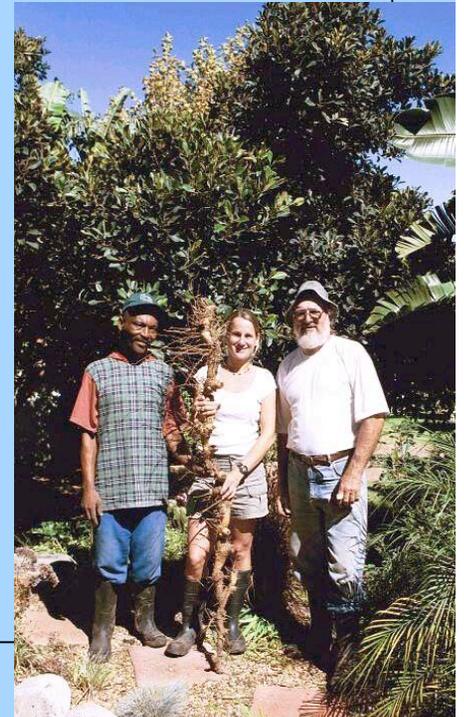
Map prepared by: Jason Glessow

GIS services provided by:
The Santa Margarita and
San Luis Rey Weed Management
Area & DENDRA Inc.



Arundo Invasion Process

- Introduced globally to warm climates for multiple uses where it thrives
- Easily dispersed in floods via rhizomes
- Disturbance colonizer
- Adapted to Mediterranean-type climate
 - fast growing (up to 7 cm per day)
 - grows 3-4 times faster than native plants
 - resprouts immediately after fire
- **Outcompetes indigenous plant species for resources** (Bell 1994)



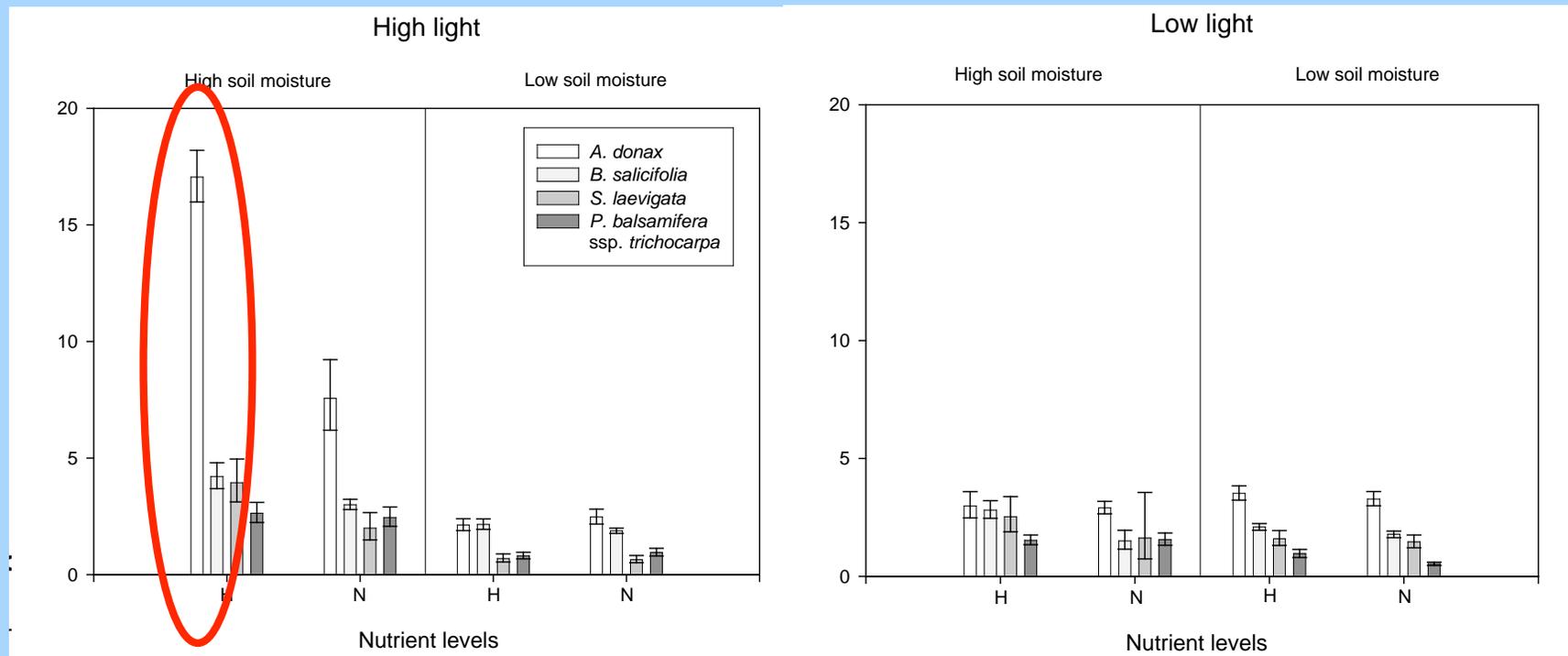
Arundo donax Invasion

- *A. donax* is 'super invader' (Daehler 2003) – thrives under all resource levels
- *A. donax* grows exceptionally well under high levels of water, nutrients, and light
- Novel life form in riparian ecosystems of Mediterranean-type climate important in invasion
- Anthropogenic nutrient enrichment of riparian ecosystems contributes to *A. donax* invasion
- Fire promotes *A. donax* invasion and may lead to an 'invasive plant – fire regime cycle'

Biomass Production

Plants Grown in Monoculture

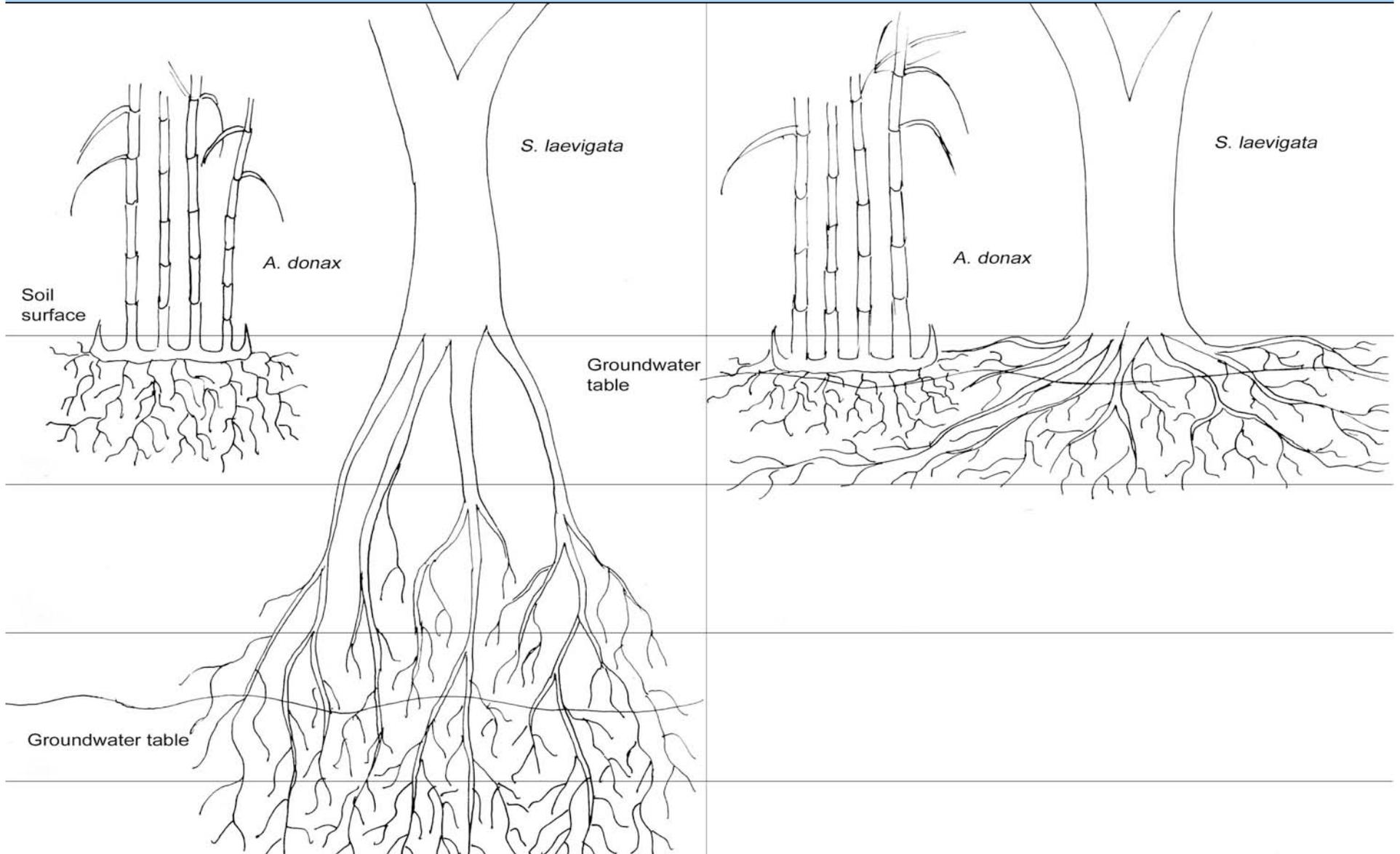
2004

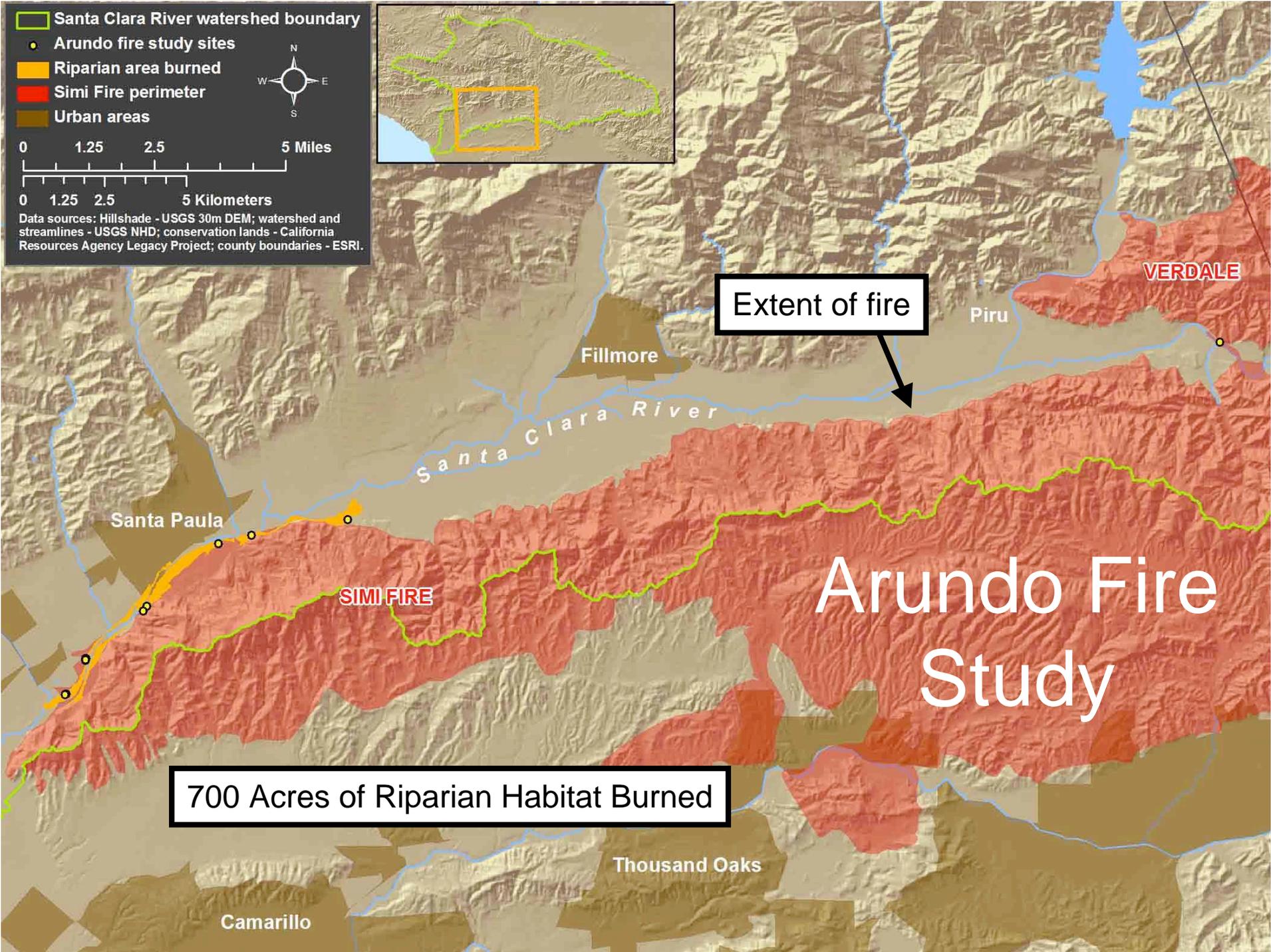


Rooting Structure

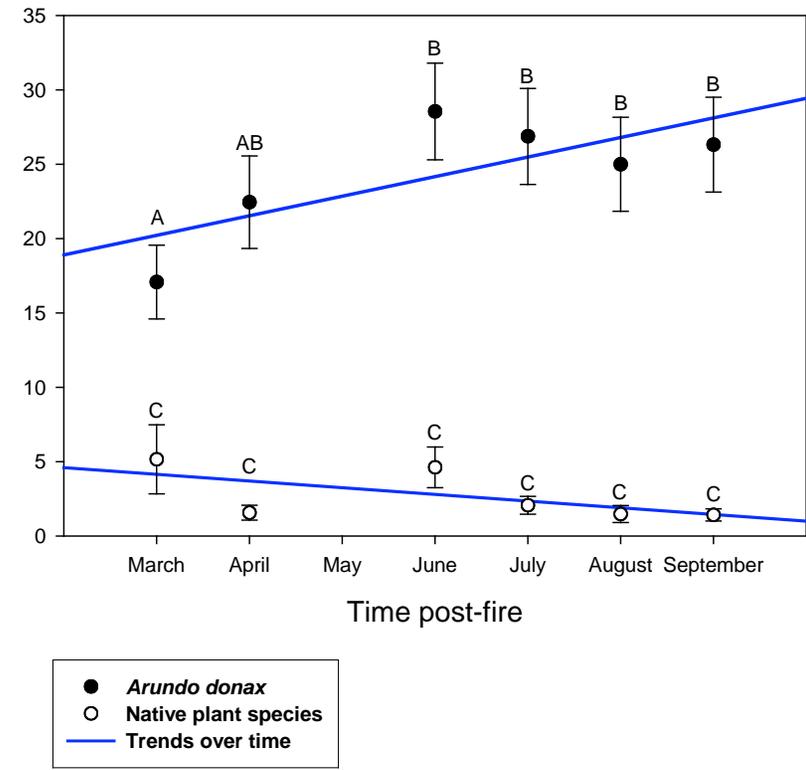
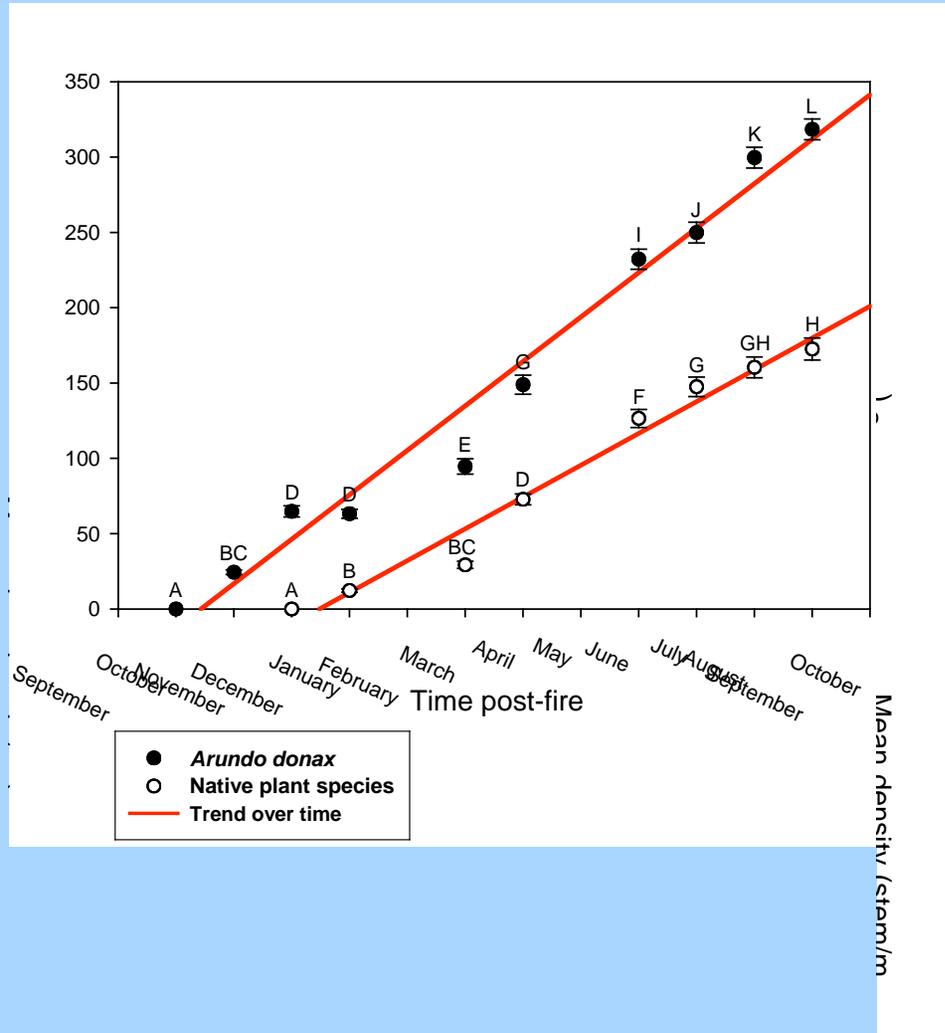
Low Resource Levels

High Resource Levels

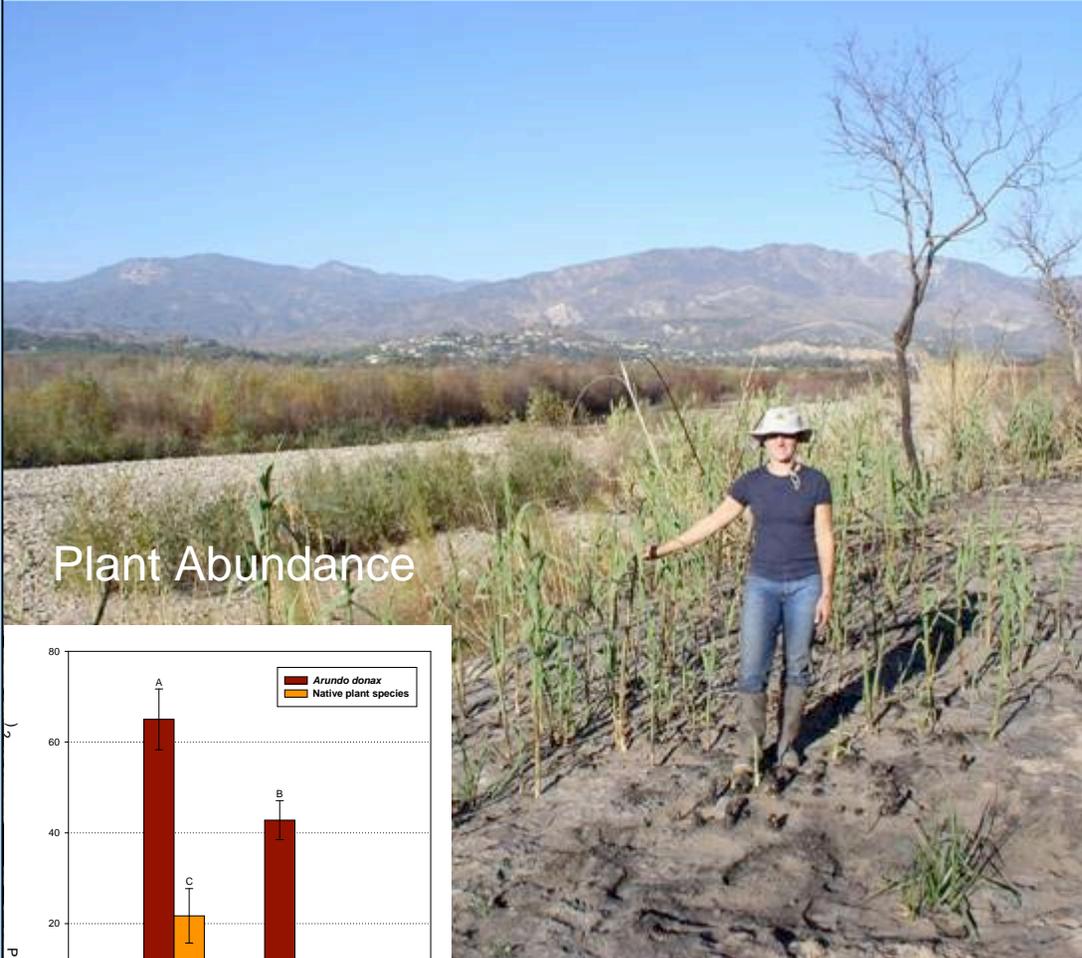




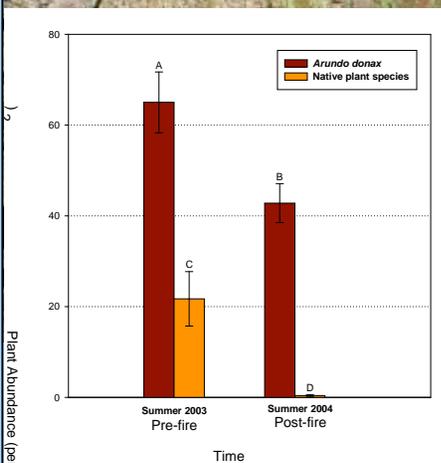
Post-Fire Growth



Rapid *Arundo* growth after fire



Plant Abundance

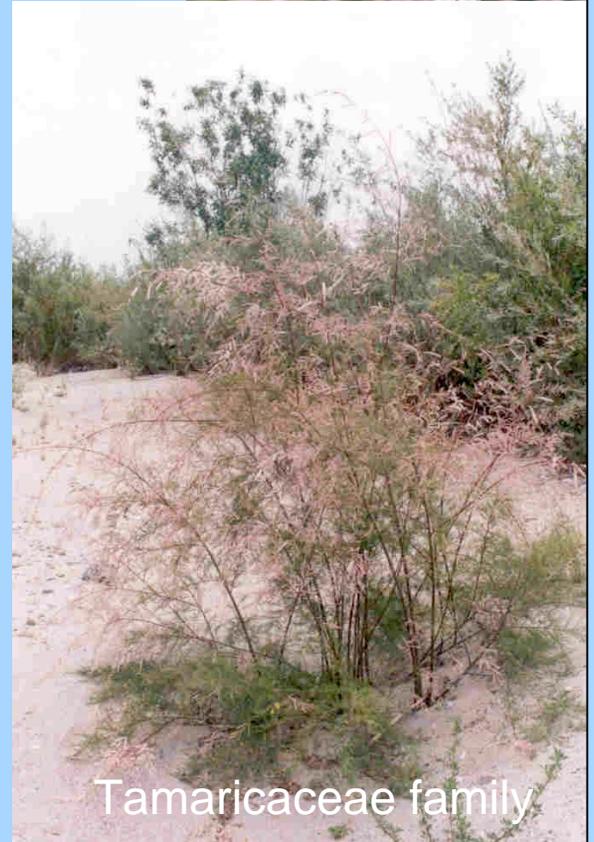


8 weeks

6 months

Salt Cedar (*Tamarix* spp.)

- Small trees or shrubs
- *Tamarix ramosissima*, *T. parviflora*, *T. aphylla*, *T. chinensis* & *T. canariensis*,
- Introduced from Eurasia in mid-1800s in arid and semi-arid Western North America
- Used for windbreaks and to prevent soil erosion
- 1-1.6 million hectares infested currently
- Flooding facilitates establishment



Tamaricaceae family

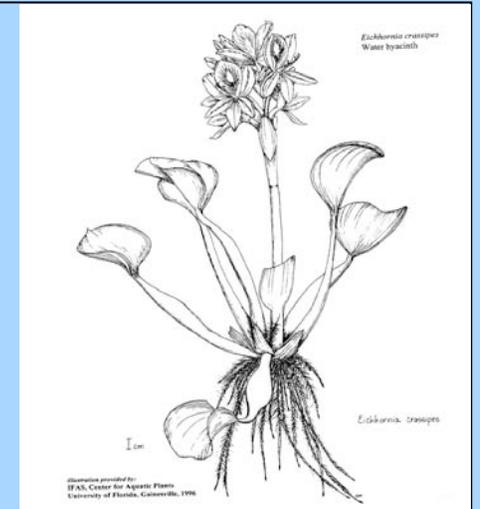
PROBLEM

- Uses greater quantities of water than native riparian species
- Uses deeper and more saline water sources
- Infestations result in decline in flora and faunal diversity
- Accumulated dry biomass effects fire frequency and intensity
- Interferes with land use and access

Water Hyacinth

Eichhornia crassipes

- Floats on the surface of fresh waters or anchored in mud
- 2 in. to 1 meter
- Mats up to 2 m thick
- Native to tropics of South America
- Thrives on every continent except Europe



Pontederiaceae family

PROBLEM

- Rapid growth blocks channels and open waterways
- Highly productive: 1 acre = 200 tons
- Fertilizer and sediments increase growth
- Thick mats reduce light and oxygen, change water chemistry, cause significant increase in water loss due to evapotranspiration
- Threatens biodiversity

REMOVAL AND CONTROL OF INVADERS

General Approach

Remove and control invasives where

- 1) ecological benefit is greatest and
- 2) removal effort lowest



Arundo donax

Removal and control prioritization

1. Mature riparian forests near fire-prone shrublands
2. Low resource levels/high stress conditions
3. Low-nutrient input watersheds
4. Top-down and inside-out approach
5. Largest *Arundo* propagule source
6. Immediately after large flood events

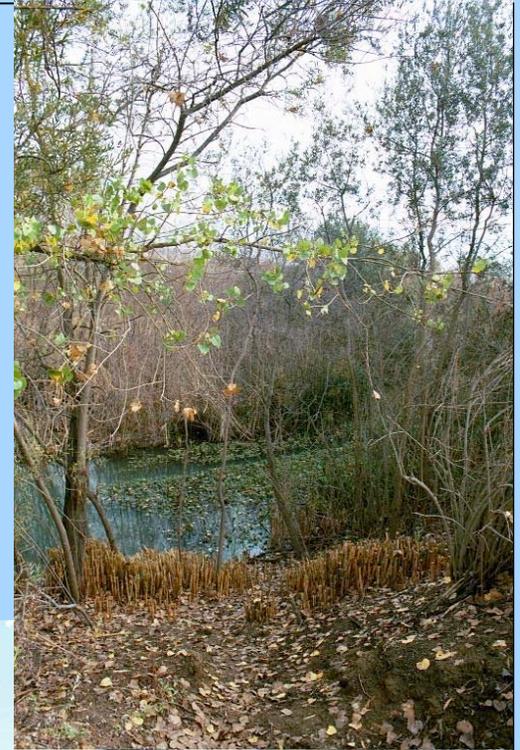
Arundo donax

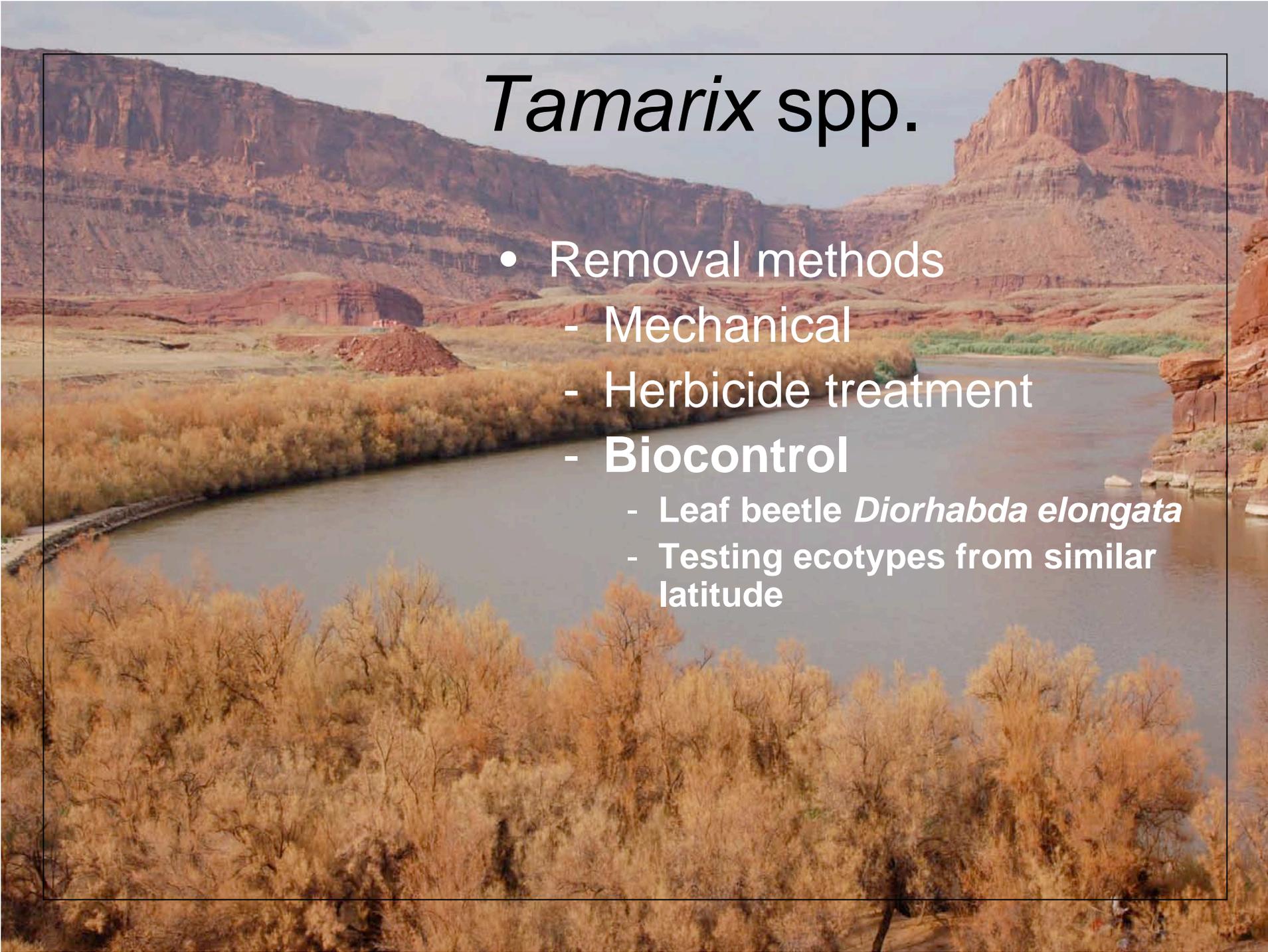
- Removal methods
 - Heavy equipment
 - Hand removal
 - Herbicide treatment - timing is resource level dependent



Arundo donax

- Removal methods
 - Heavy equipment
 - Hand removal
 - Herbicide treatment - timing is resource level dependent



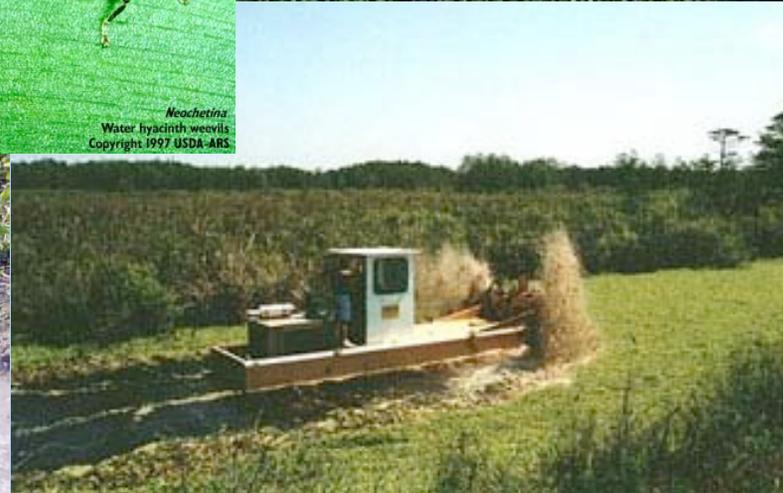


Tamarix spp.

- Removal methods
 - Mechanical
 - Herbicide treatment
 - **Biocontrol**
 - Leaf beetle *Diorhabda elongata*
 - Testing ecotypes from similar latitude

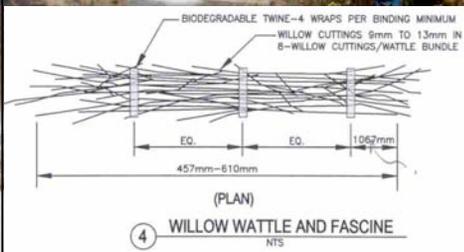
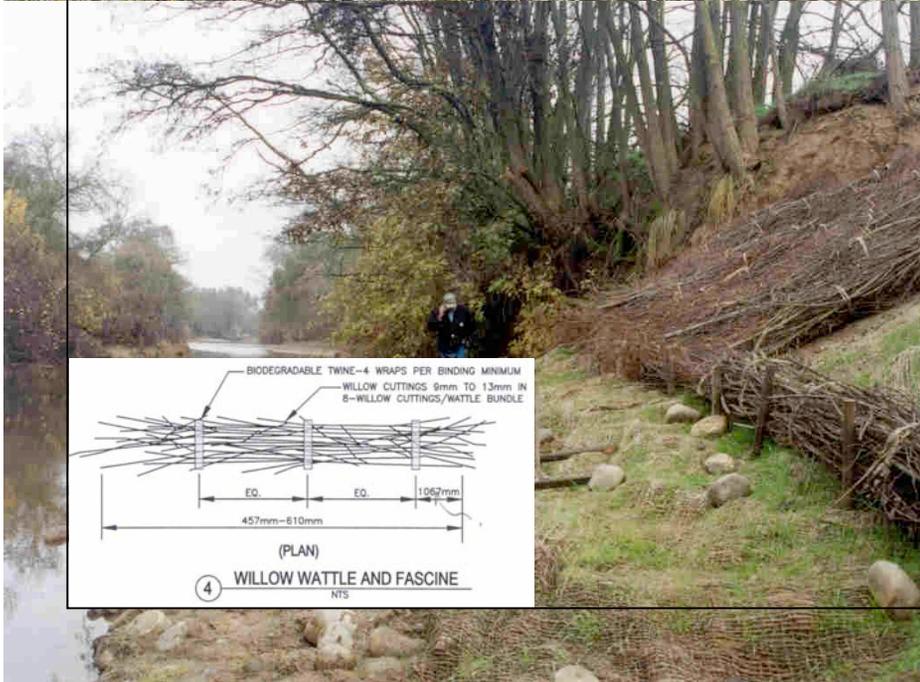
Eichhornia crassipes

- Removal methods
 - Heavy equipment
 - Biocontrol
 - Herbicide treatment



RIPARIAN REVEGETATION

Passive and Active Revegetation





Passive Revegetation

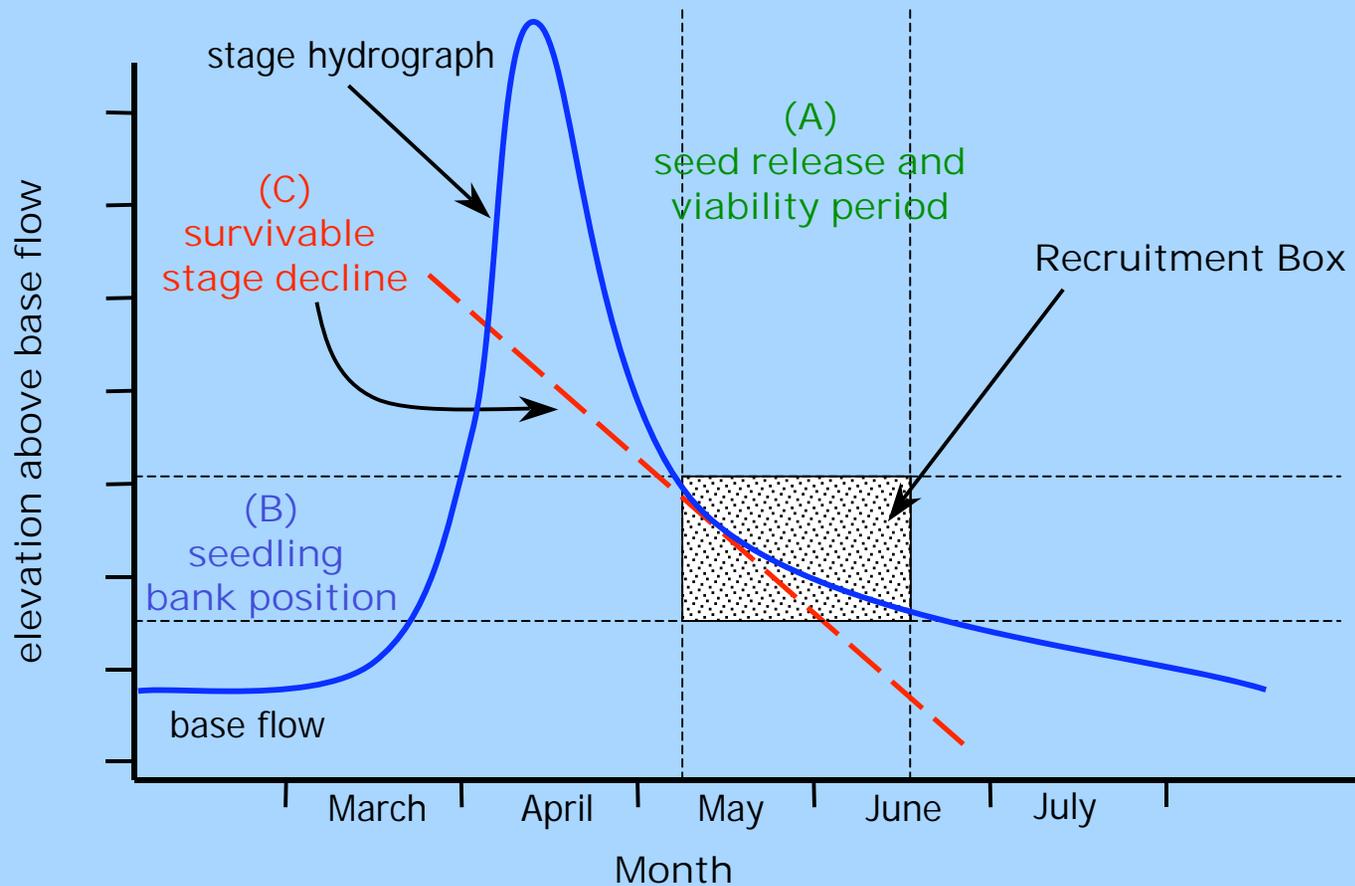
- Benefits and pitfalls
- Environmental flows
 - To promote native revegetation through recruitment
 - To remove invasives
- Examples

Accidental Forest

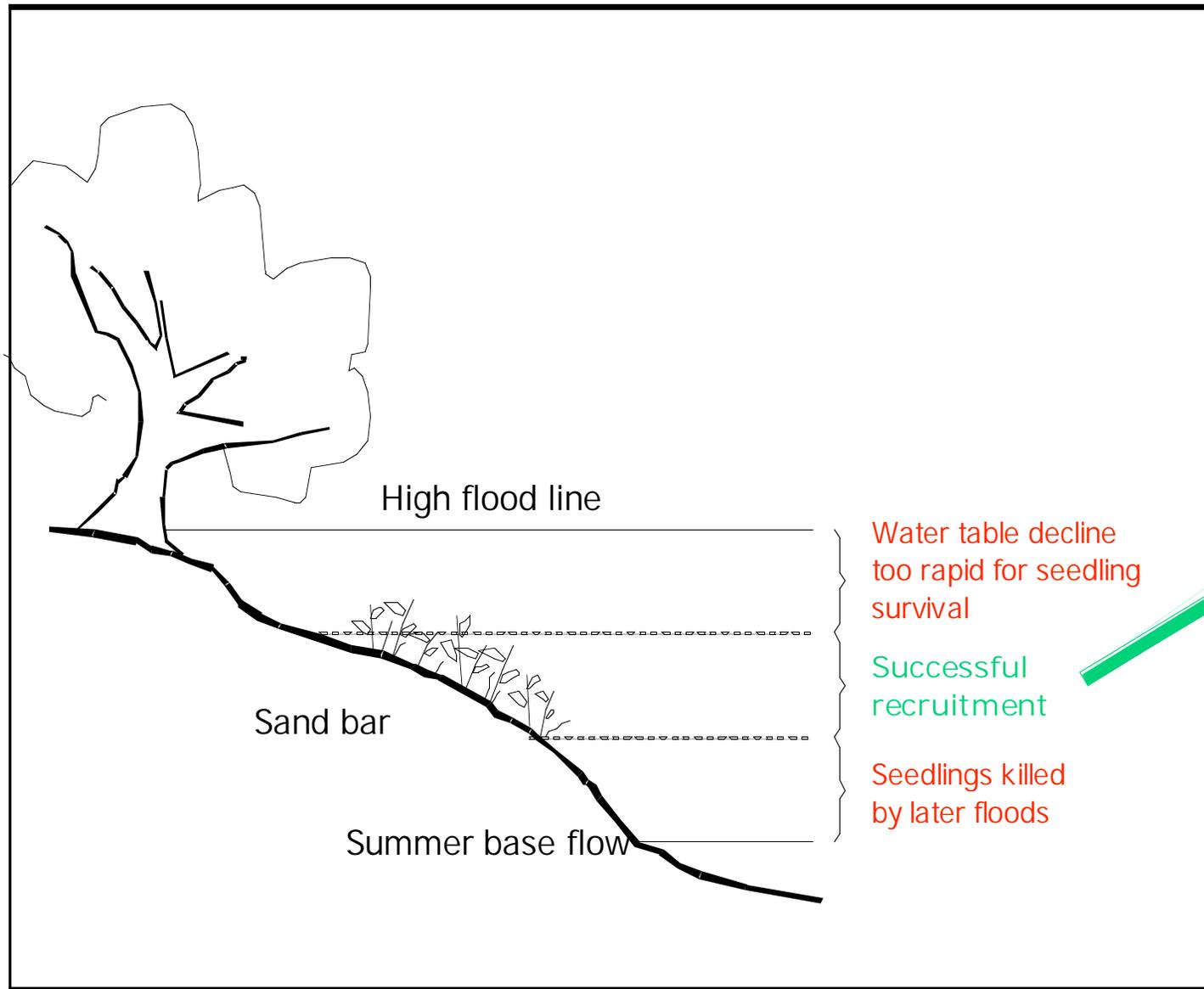
Remnant Riparian
Forest Stand
(Orr Forest)

Intentional Levee Breach

Recruitment Box Concept



Fremont Cottonwood (*Populus fremontii*)



Passive Revegetation

CAUTION!!!

- San Joaquin River –
Spread of Scarlet Wysteria (*Sesbania punicea*) during Pilot Restoration Flows



Passive Revegetation

Santa Clara River

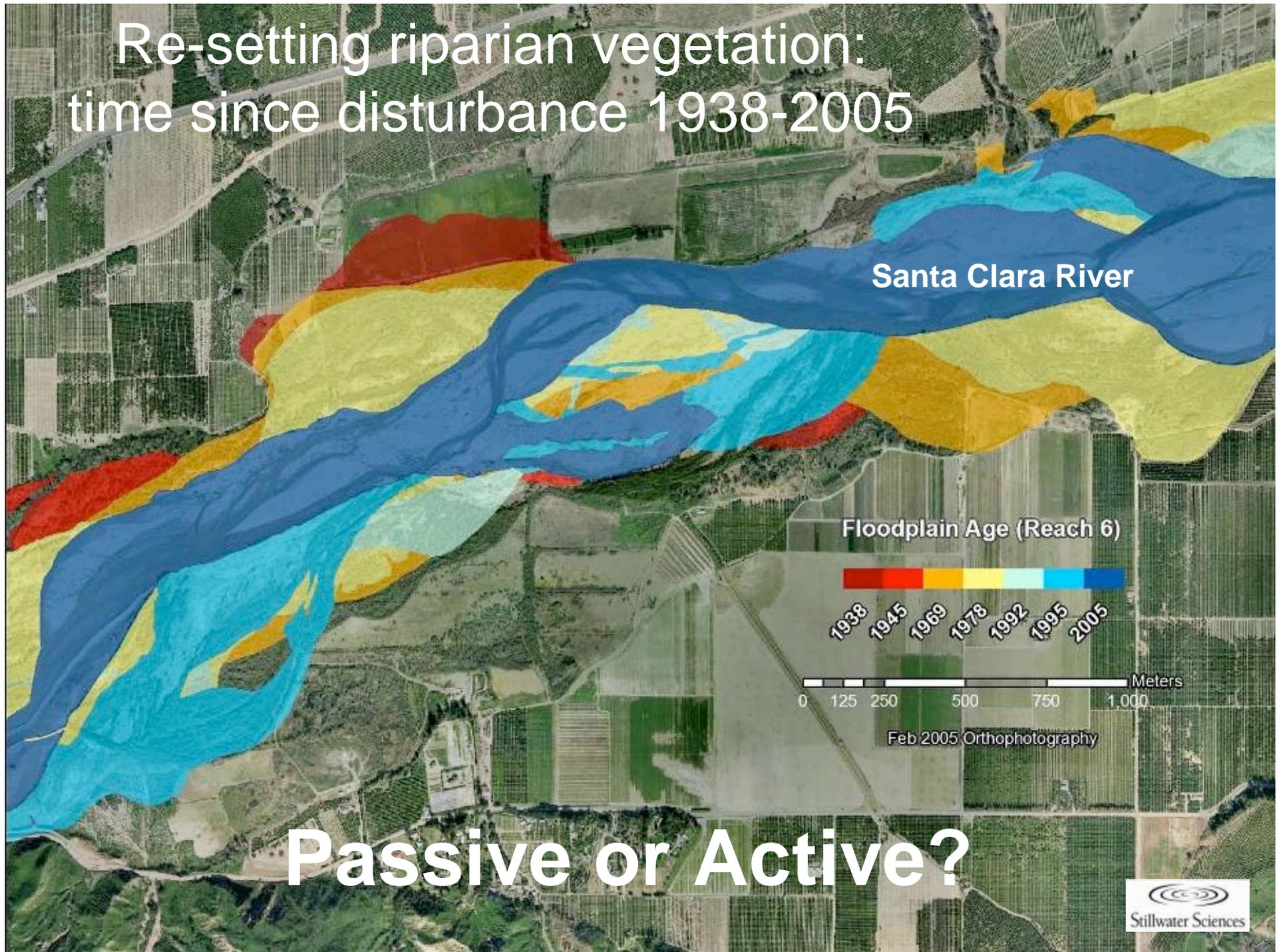
- Removal of Arundo

AND



- Natural Recruitment of Willow Forest

Re-setting riparian vegetation: time since disturbance 1938-2005



Active Revegetation

- Revegetation objectives
 - Replace invasive species removed
 - Create wildlife habitat
 - Increase plant diversity – rare species
 - Stabilize stream banks





Revegetation Approach

- Selection of Plant Species
 - Sample several nearby reference sites
 - Always plant a diversity of NATIVE riparian species
- Planting Design and Specifications
- Collection, Propagation and Growing
 - Collect as close to revegetation site as possible – not outside watershed
- Construct Irrigation System
- Installation of Plants
- Monitoring and Evaluation
- Adaptive Management



Revegetation Design

- Planting design
 - Locate based on knowledge of species
 - Mitigation requirements for planting density
- Specifications

TS-19 PLANTING
TS-19.1 Seed Collection and Plant Procurement
 Riparian and wetland seed collection and plant procurement shall conform to the applicable provisions in Section 20-2.10, "Seed," of the Standard Specifications, and the Plans. All seeds for plant growth and plant plugs shall be collected from within 16.6 kilometers (10 miles) of the project sites along Coyote Creek within the Coyote Creek watershed in Santa Clara County, California.

The contractor shall notify the Engineer in writing 72 hours prior to seed collection and plant procurement.

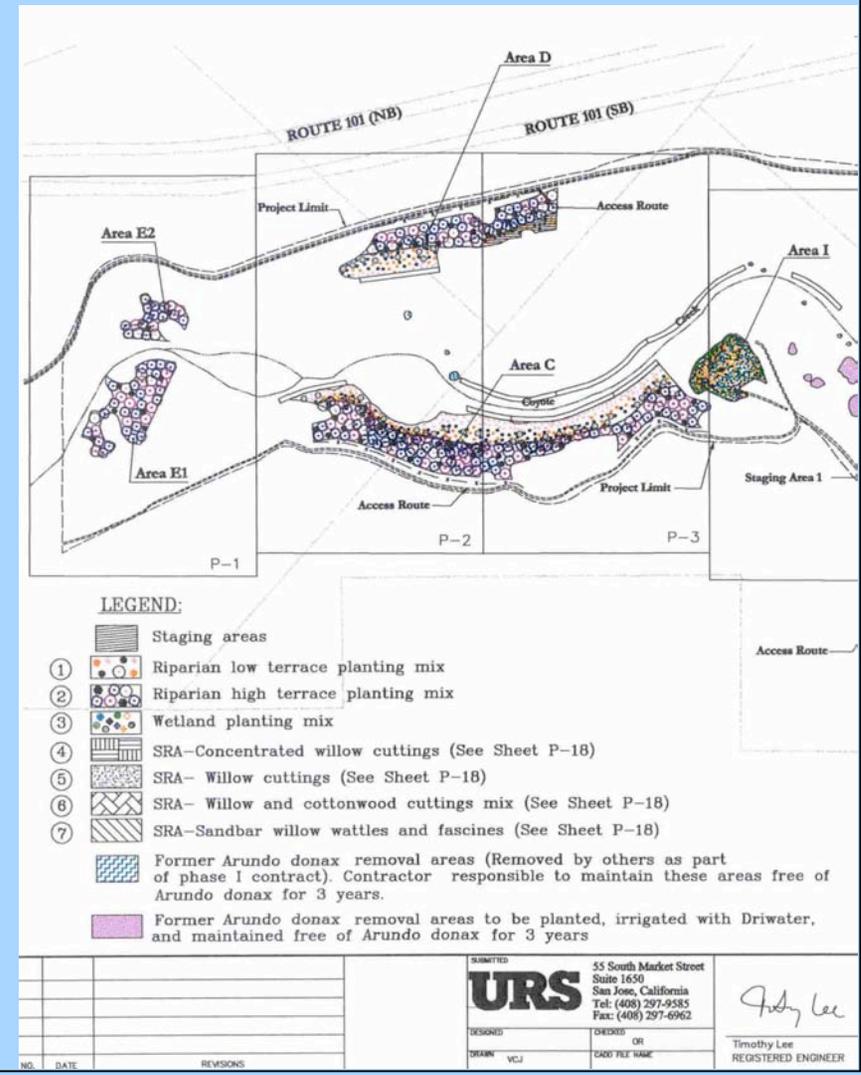
A VTA Biologist shall accompany the Contractor in site selection for seed collection and plant procurement. The Contractor is responsible for obtaining a Santa Clara Valley Water District plant

plans (staging area 1-4). Upon arrival at the site, the Contractor will be responsible for maintaining plants in good condition until installation. Plants shall be watered and placed in a cool area protected from sun and wind.

B. Inspection of all plant material for acceptance shall be made at the project site at time of delivery by the Engineer. Acceptance of the material by the Contractor acknowledges that material is suitable for installation and that the plant warranty will be the sole responsibility of the Contractor from thence forward.

C. Backfill Soil: Contractor shall use only native soil from site to backfill. Riparian tree and shrub backfill shall be native,

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Revegetation Methods

- Types of propagation
 - Pole cuttings of trees and shrubs - easy and cost effective
 - Grow from seeds
 - Divisions of perennial herbs and grasses with rhizomes



Pole cuttings



Seeding stream bank

Revegetation Methods

- Growing riparian plants
 - From cuttings
 - From seed
 - From divisions
- Native Nurseries and Seed Collection
 - Nurseries selling natives throughout CA
 - Establish local nursery for long-term projects
 - Collection of plant material – timing based on phenology of each species
 - Grown in pots or kiddie pools



Native Plant Nurseries

- More than 30 throughout California alone – for contract collection and growing of natives
- Details on Native Nurseries near your project site:

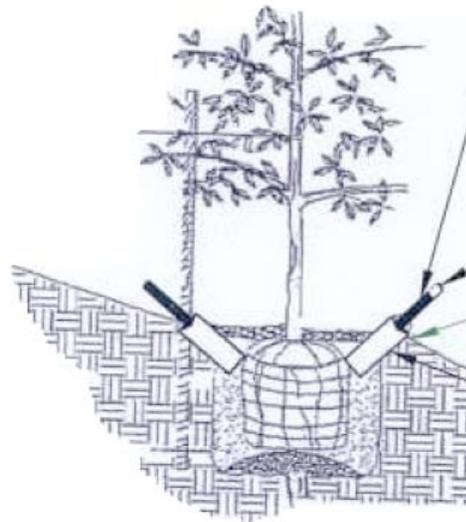
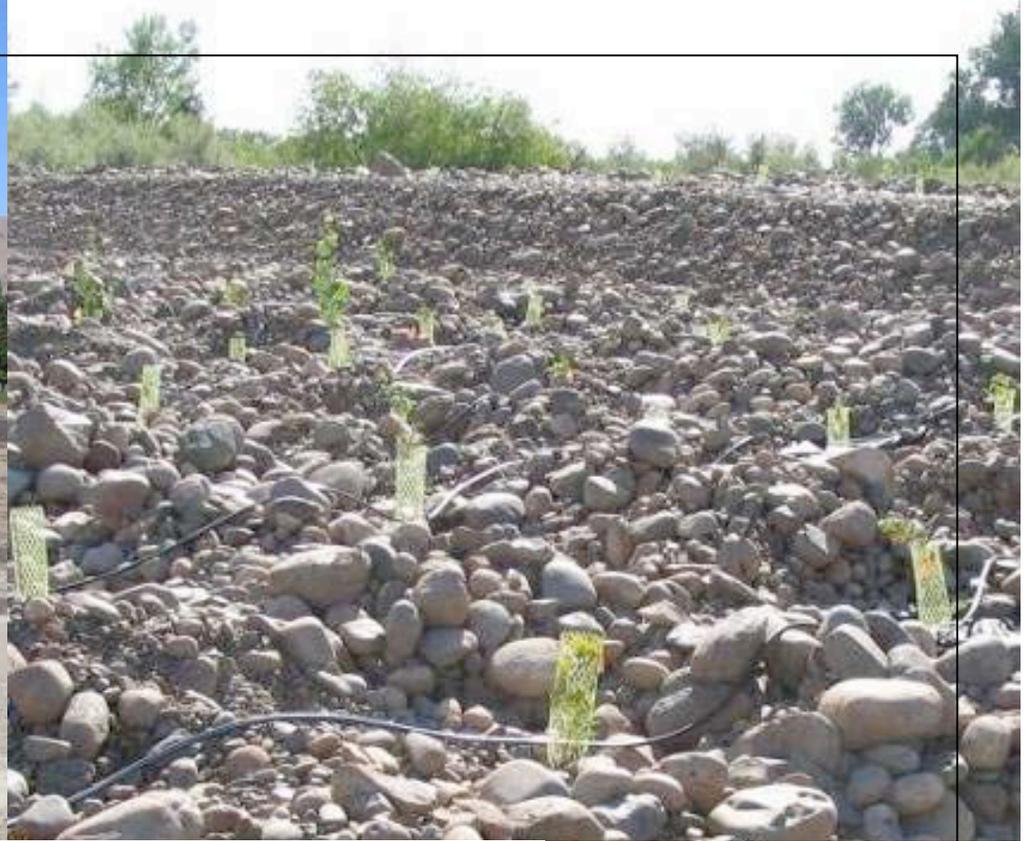
<http://www.wildlifehc.org/managementtools/ba/ckyard-stateresources-state.cfm/?FrontID=733>

<http://www.ecologycenter.org/>



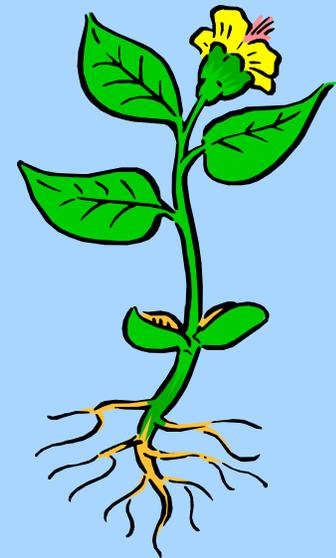
Irrigation

- Drip system
- Water truck
- Driwater



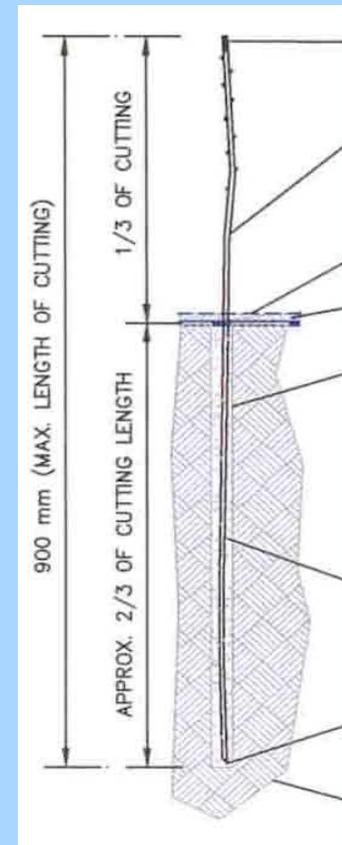
Installation Timing

- Timing of installation crucial to survivorship and establishment success
- Winter is the best time to plant in CA
 - Establish root system first when soil moisture high
 - December to February
 - Assess local soil conditions before planting
 - After a large rain event is ideal



Revegetation Methods

- Pole cutting selection and collection
 - Select only younger branches with buds
 - Cut branches to:
 - Diameter: 0.75 to 1.25 inch
 - Length: 3 feet
- Pole cutting preparation
 - Remove all branches and leaves
 - Remove buds from top 1/3 of cutting (thinner end)
 - Leave buds on thicker 2/3 of cutting (these will turn into roots)



Revegetation Methods

Pole cutting installation

- Push or tap into softer soil
- 2 feet in hole (thick end) and 1 foot out (thin end)
- If soil is too hard
 - Make 2 ft deep hole slightly larger than pole diameter and insert
 - Use t-bar, gas-powered auger or battery operated drill with 1-1.75 inch bit



Gas-powered Auger

Revegetation Monitoring



- Purpose -
 - To evaluate success of revegetation effort
 - To implement adaptive management strategies if necessary
 - To document the most effective methods for future revegetation efforts
- Monitor annually for at least 5-10 years
 - More often in first few years
 - Timing depends on metrics chosen

Development of Revegetation Monitoring Program

- Assess environmental conditions in revegetation area
- Identify plant species requirements
- Plant diversity of species in each habitat based on this information
- Evaluate plant performance
- Implement adaptive management strategies based on plant performance

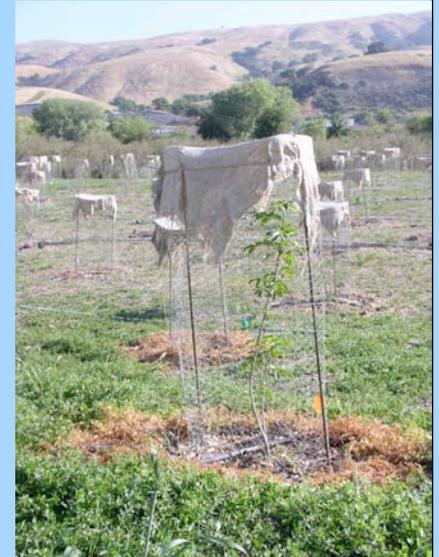
Revegetation Metrics

- Develop Performance Criteria to evaluate success of revegetation effort
- Metrics to measure plant performance:
 - Plant survivorship
 - Stem diameter and density
 - Plant height
 - Percent plant cover
 - Biomass
 - Leaf area index
 - Reproduction



Implementing Adaptive Management Strategies - Example

- Performance criteria
 - Plant survivorship must be $> 80\%$
- Evaluate performance criteria
 - Plant survivorship = 50%
- Adaptive management solution
 - Replace areas of low survivorship with most successful plant species based on local habitat conditions



Revegetation Costs per Acre

- Planting Plan Design = \$ 2 - 5,000
- Plant Material Collection = \$ 500 – 1,000
- Propagation and Growth = \$ 1 – 2,000
- Installation = \$ 2,000
- Annual Maintenance and Monitoring
= \$ 2 – 4,000

Total = \$ 7,500 – 14,000/acre



Revegetation of USACE Levees

- Proposed Policy (April 2007 guidance)
- Effects >1,600 mi of levees in CA
- Technical requirements for landscaping levees
- Vegetation-free zones
- No woody vegetation - grass only
- Vegetation management
- Exceptions

Revegetation of USACE Levees

- For more information on proposed policy:

SAFCA/USACE/DWR Symposium
Sacramento Convention Center
August 28 - 29, 2007

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QUESTIONS?

