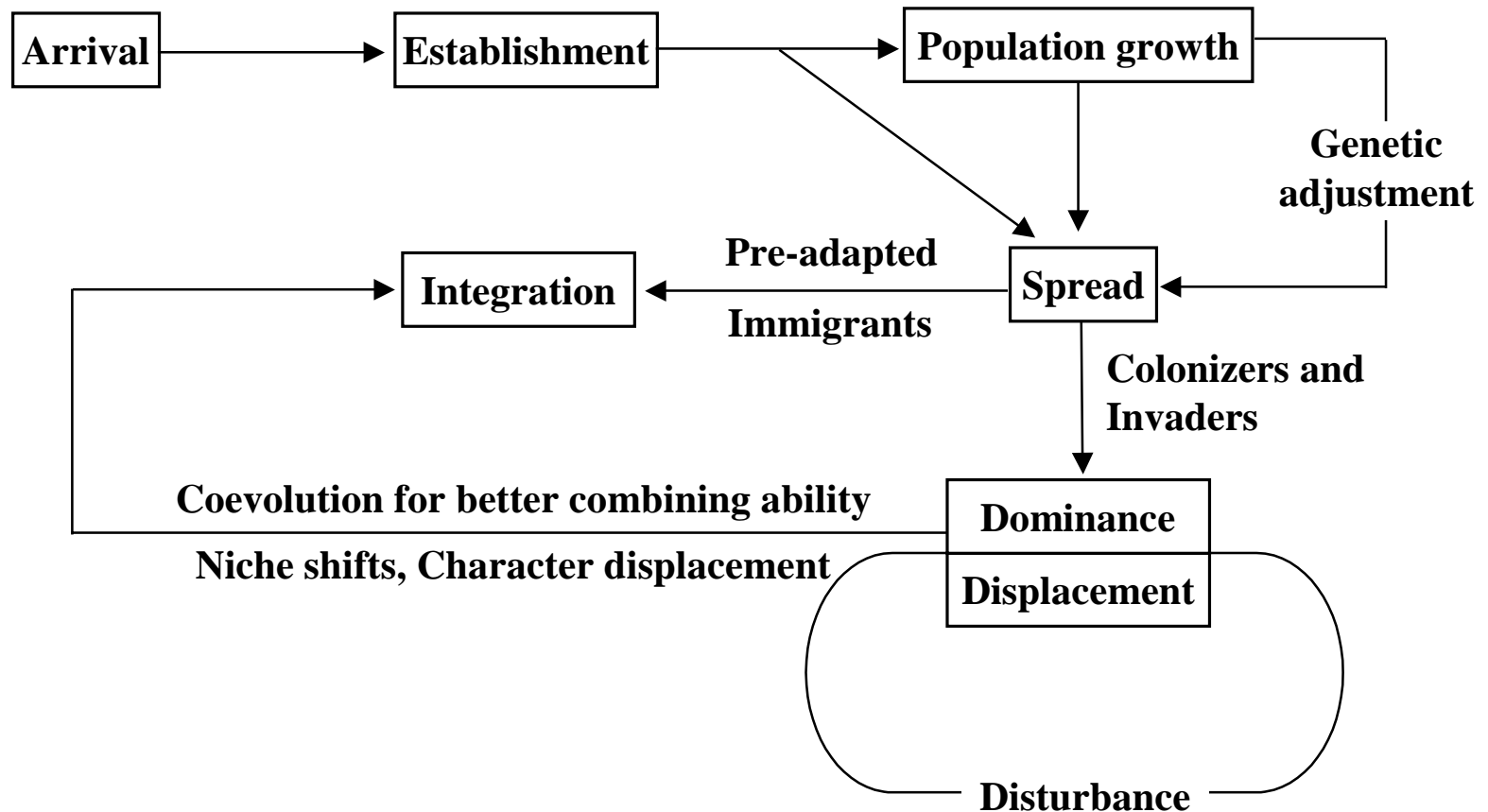


**Invasion of *Arundo donax* in River  
Ecosystems of Mediterranean-type  
Climates: Impacts, Causes, and  
Management Strategies**

**Gretchen Coffman  
Richard F. Ambrose  
Phil W. Rundel**

**UCLA**

# Invasion Process

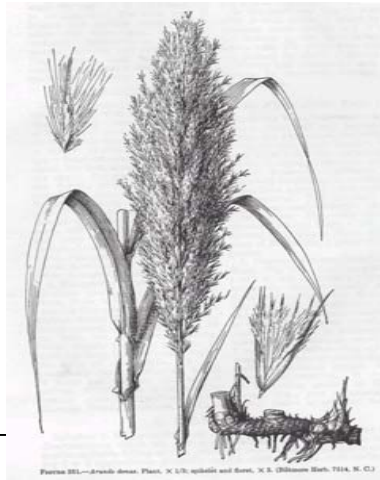


SANTA CLARA RIVER



# Arundo (*Arundo donax*)

- Indigenous to northern India and southern Nepal
- Bamboo-like member of Grass family
- 8-10 meters tall
- Spreads via massive rhizomes



# Invasion of *Arundo donax*

- Introduced to Mediterranean-type climate regions for use in erosion control, ceilings, roofs, fences and baskets
- Successful invader in Southern CA in past 30 years
- Major invasive species of riparian habitats, forms extensive monoculture stands

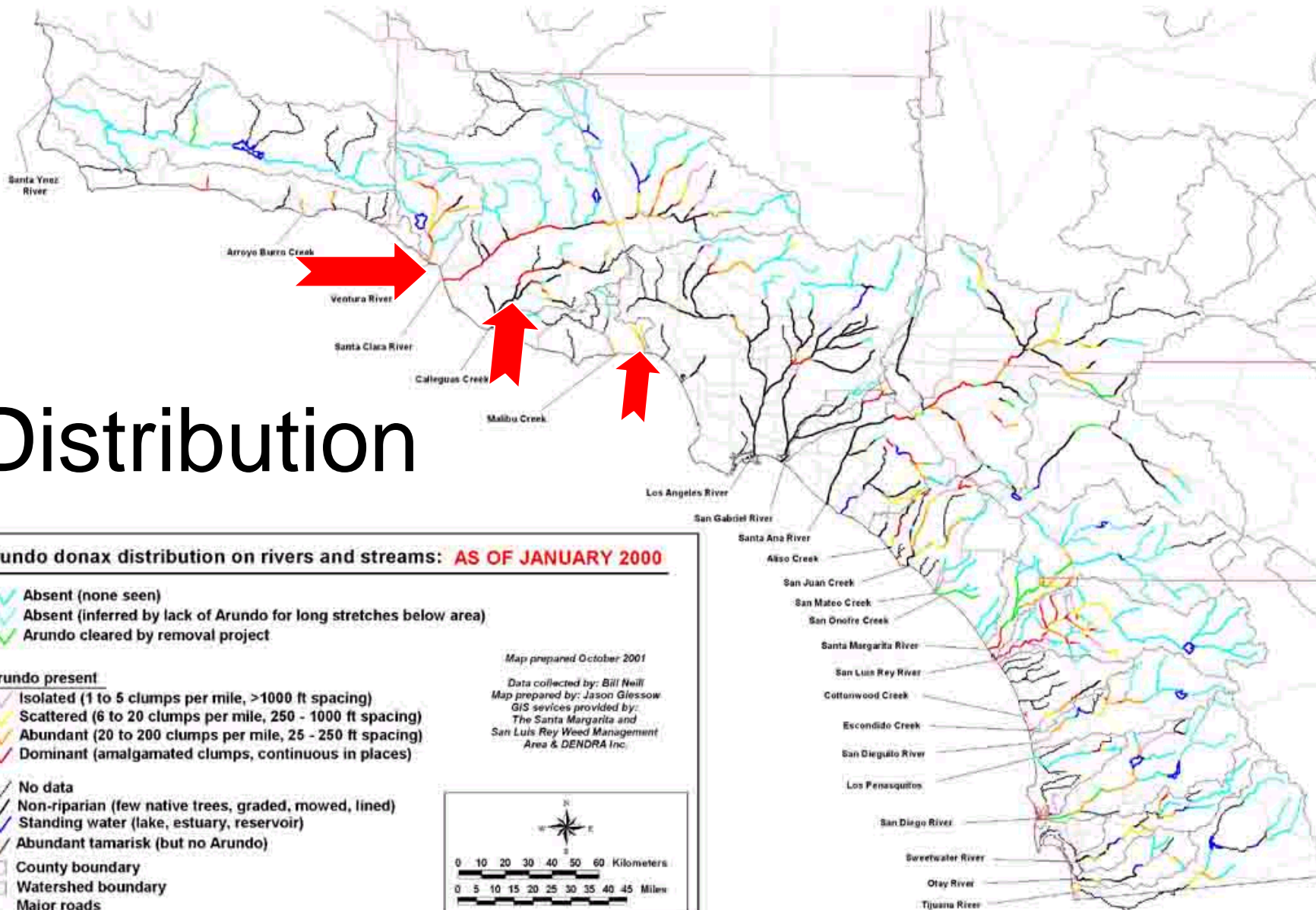


# DISTRIBUTION OF ARUNDO DONAX IN COASTAL WATERSHEDS OF SOUTHERN CALIFORNIA: AS OF JANUARY 2000

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

Bill Neill  
Riparian Repairs  
4900 Glenview Ave. Anaheim CA 92807  
phone: 714-779-2099  
email: bgnill@earthlink.net

Jason Glessow  
Santa Margarita and San Luis Rey Weed Management Area & DENDRA Inc.  
phone: 760-943-8924  
email: wera@smslrwma.org or jglessow@home.com



## Distribution

### Arundo donax distribution on rivers and streams: AS OF JANUARY 2000

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

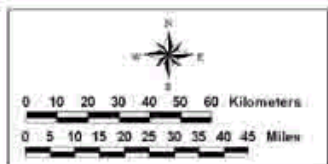
#### Arundo present

- 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 October 2001

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.

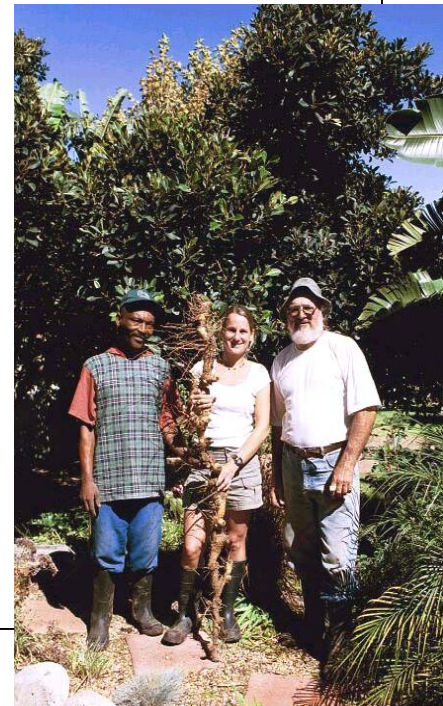


# Impacts

- Economically costly
  - Enhances fire susceptibility
  - Spreads fire
  - Enhances flooding risk
- Ecologically damaging
  - Higher water requirements and transpiration rates than native riparian species
  - Displaces native plant communities
  - Poor habitat value for animals

# Why is Arundo So Successful?

- Adapted to Mediterranean-type climate
  - fast growing (up to 7 cm per day)
  - reaches >8 m in height after only a few months
  - grows 3-4 times faster than native plants
- Outcompetes indigenous plant species for resources
- Recovers quickly from disturbance
- Easily dispersed via rhizomes





# Why has Arundo only expanded in last 30 years?

- Nobody knows.... but:
  - Arundo thrives in disturbed systems
  - Disturbance in southern California watersheds started >100 years ago – cattle, agriculture, urban development, flood control, etc...
  - One possible trigger: increased nutrient and water inputs from modern agriculture and wastewater discharges associated with increased population growth

# Hypothesis - Causes

Increased nutrients, water, and light in riparian ecosystems have made a significant contribution to the successful invasion of *Arundo* (*Arundo donax*) throughout river systems in Mediterranean-type climates

# Factors Thought to Contribute to Invasion

- Nutrients
- Water
- Light
- Fire



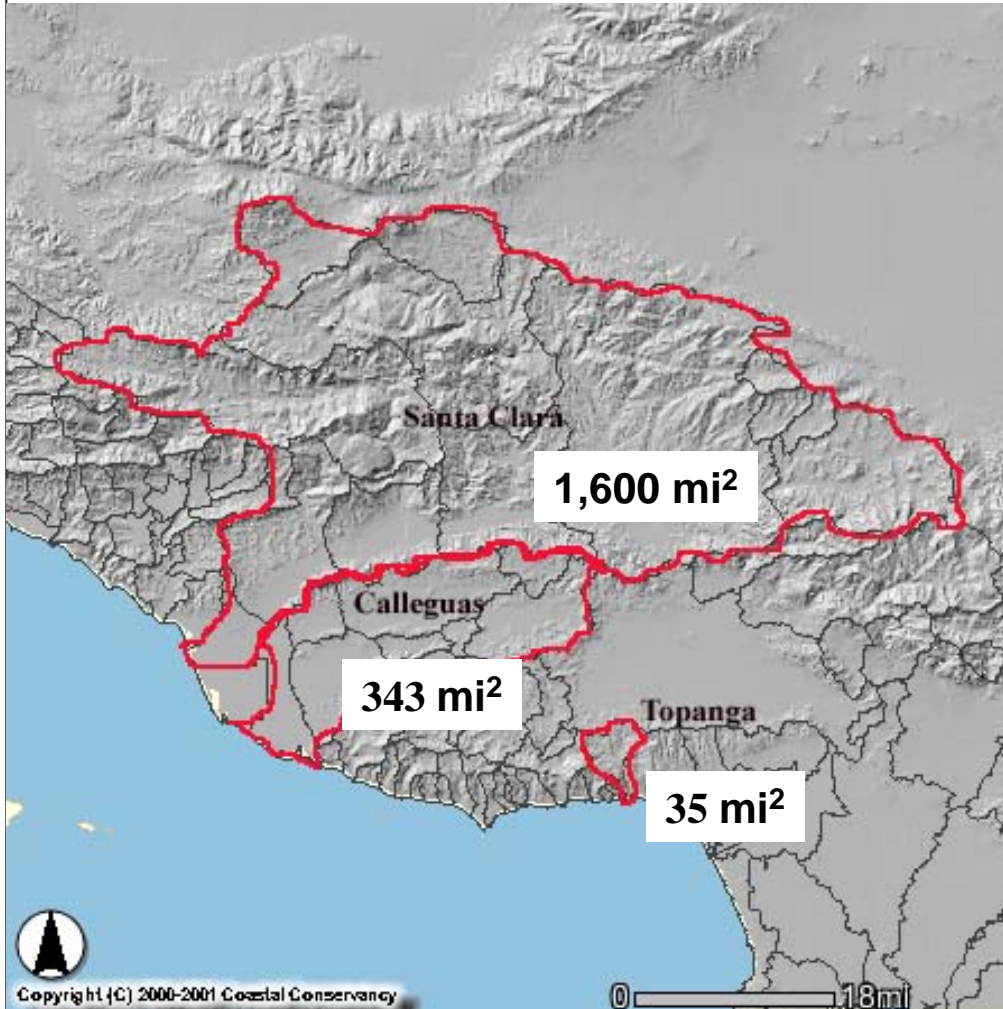
# Study Approaches

- Correlational field studies
  - Southern California
  - Western Cape, South Africa
  - Opportunistic fire study
- Experimental study
  - large-scale field experiment

# NUTRIENTS



# Southern California Study Watersheds



- Three watersheds
- 188 study sites
- Relate nutrient levels to
  - Arundo infestation size/density
  - land use types (agriculture, residential and open space)
  - Floodplain vs. terrace



# Measurements

- Nutrient analyses
  - Soil, shallow groundwater, plant material (leaves)
  - Nitrogen (nitrate, nitrite, ammonia) and phosphorus
- Arundo infestation size/density
- Adjacent land use

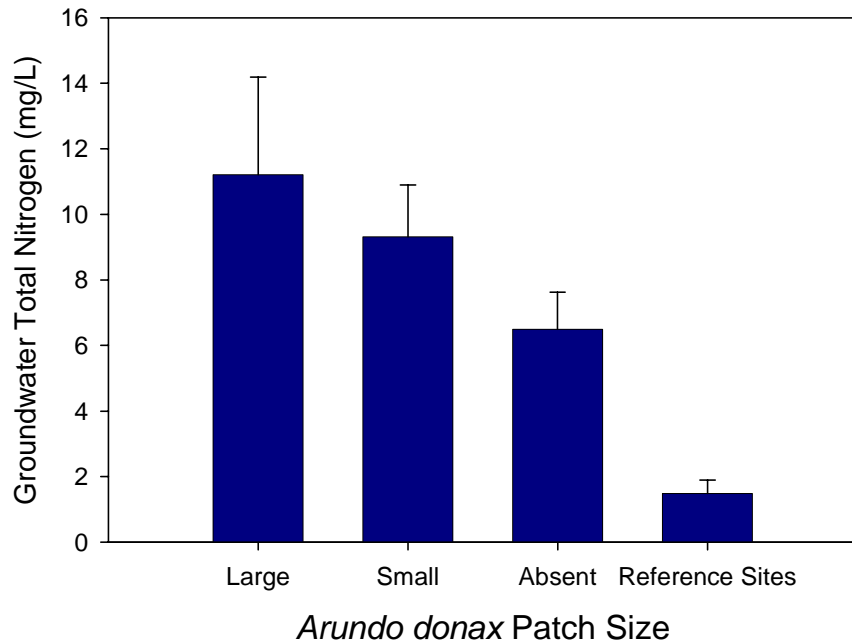


# Results



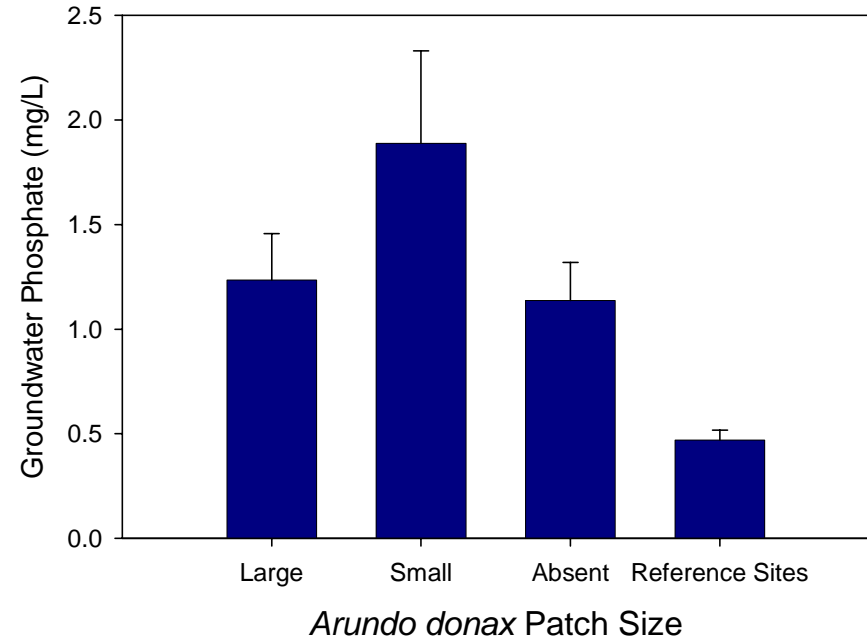
# Nutrients in Groundwater by Infestation Size

Total Nitrogen in Groundwater by Patch Size



**N**

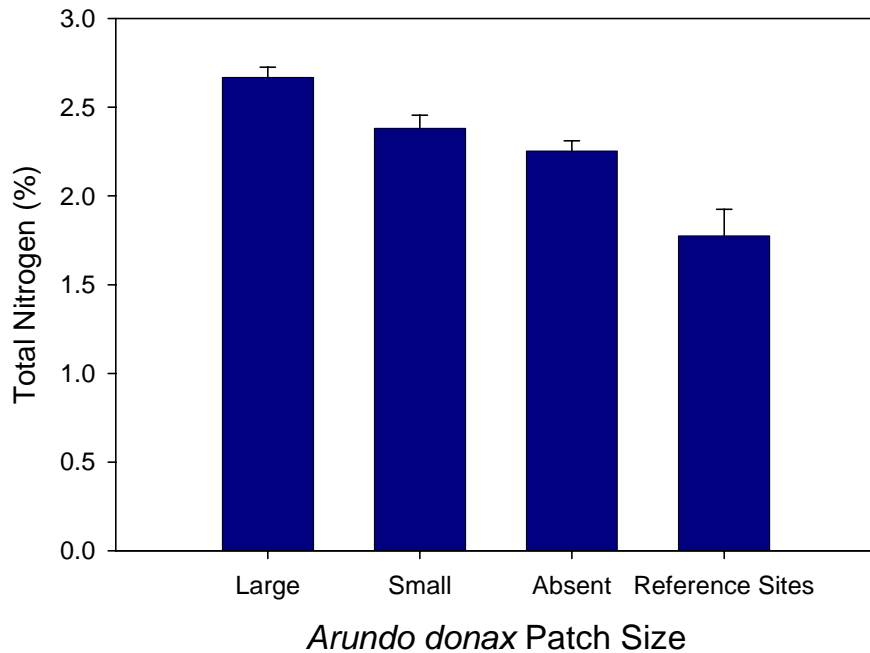
Phosphate in Groundwater by Patch Size



**P**

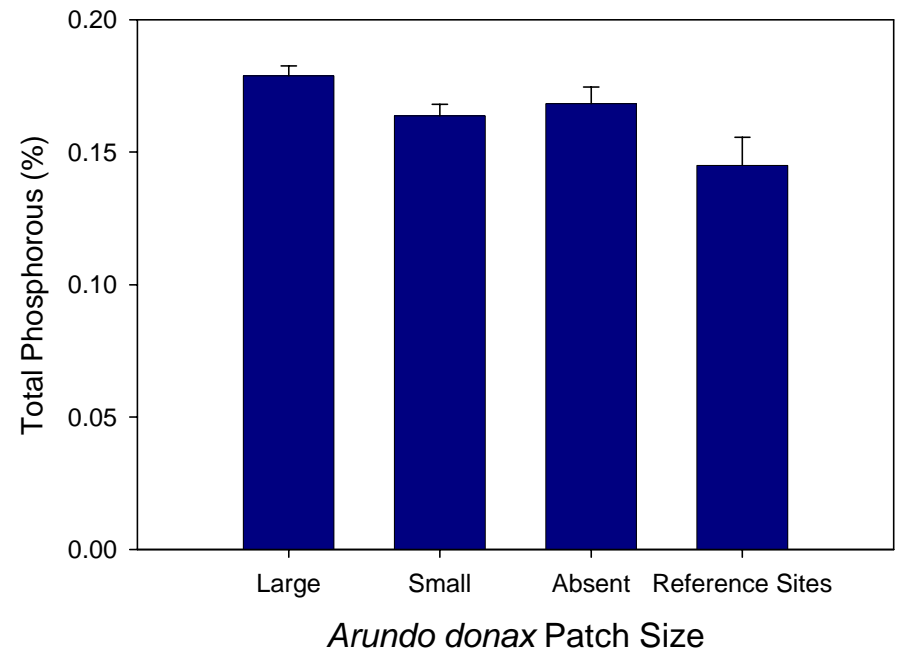
# Nutrients in Plants by Infestation Size

Percent Total Nitrogen of Plant Tissue by Patch Size



**N**

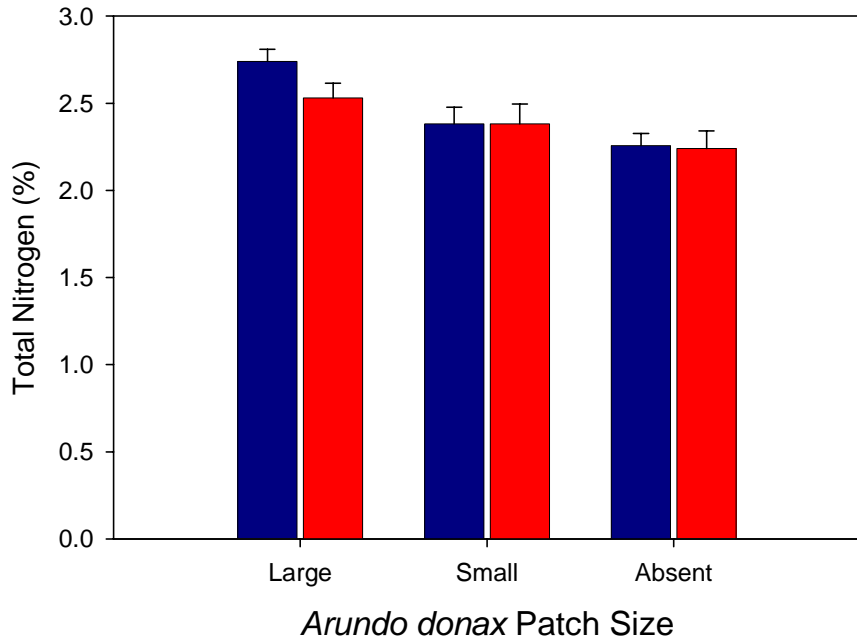
Percent Total Phosphorous of Plant Tissue by Patch Size



**P**

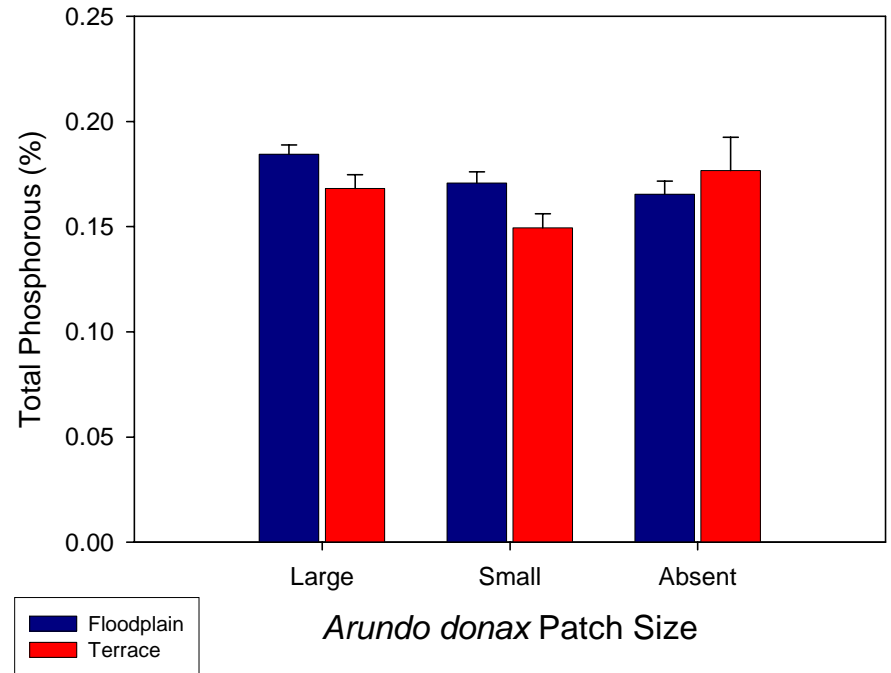
# Nutrients in Plants Floodplain vs. Terrace

Percent Total Nitrogen in Plant Tissue by Patch Size



**N**

Percent Total Phosphorous in Plant Tissue by Patch Size

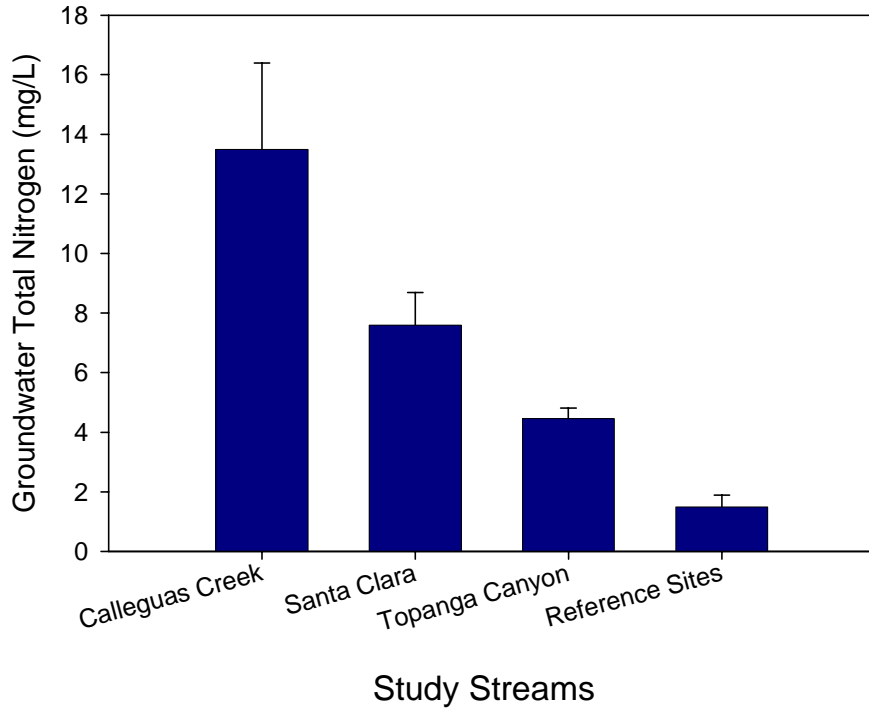


**P**

Note: no groundwater samples from terraces, plant N used as a proxy for groundwater N

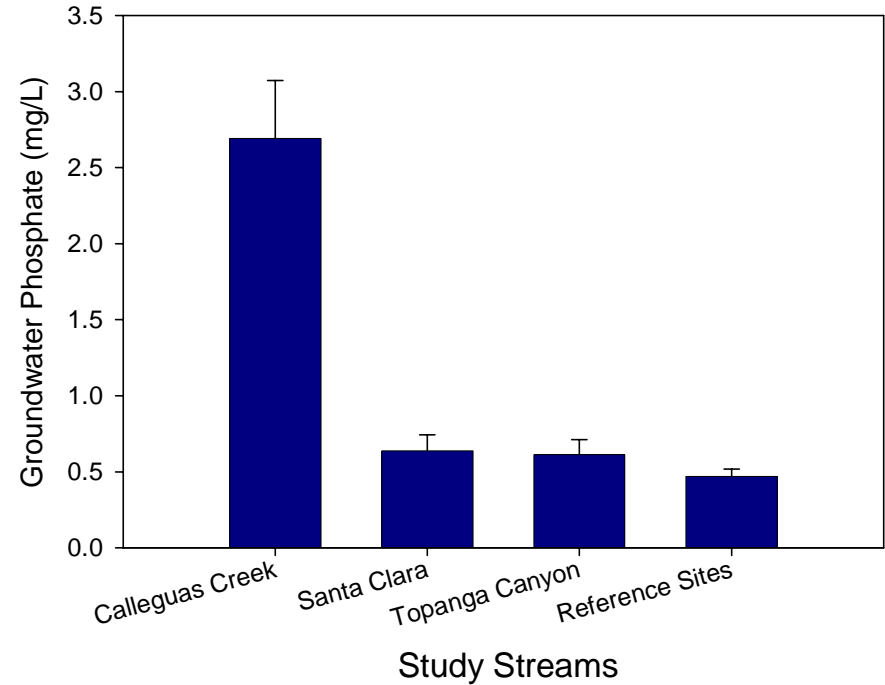
# Nutrients in Groundwater by Watershed

Total Nitrogen in Groundwater by watershed



**N**

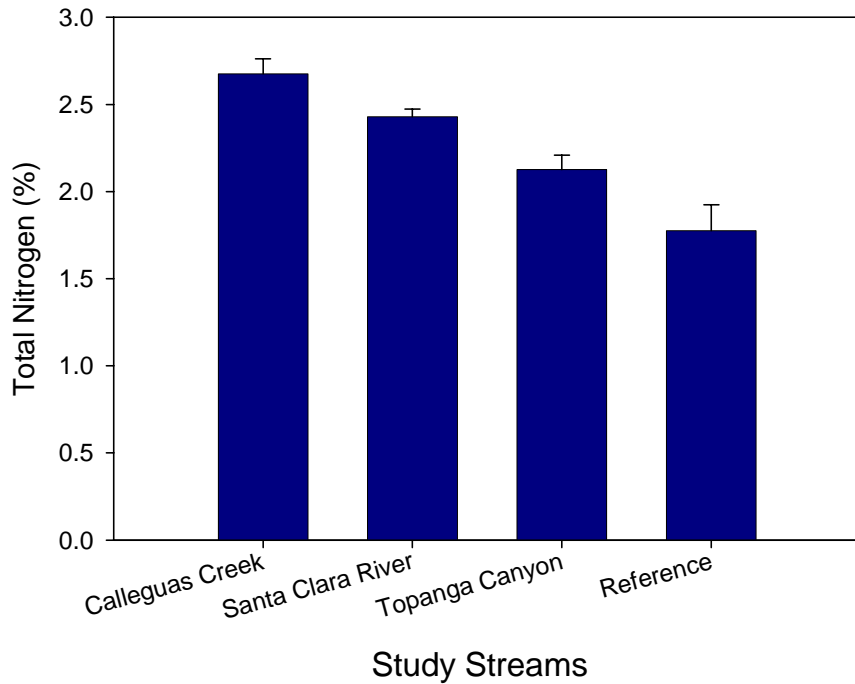
Phosphate in Groundwater by watershed



**P**

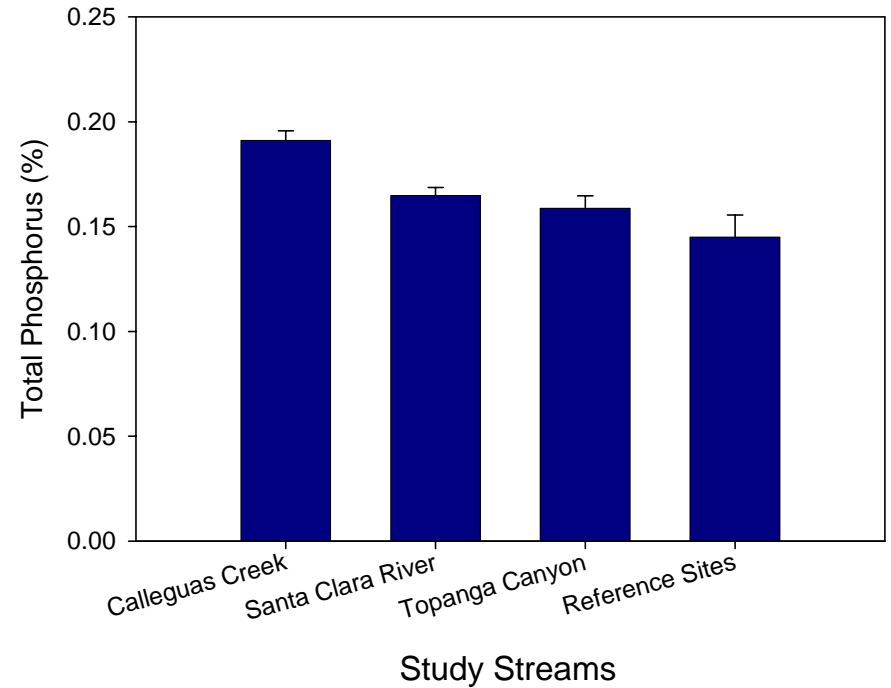
# Nutrients in Plants by Watershed

Percent Total Nitrogen of Plant Tissue by Stream



**N**

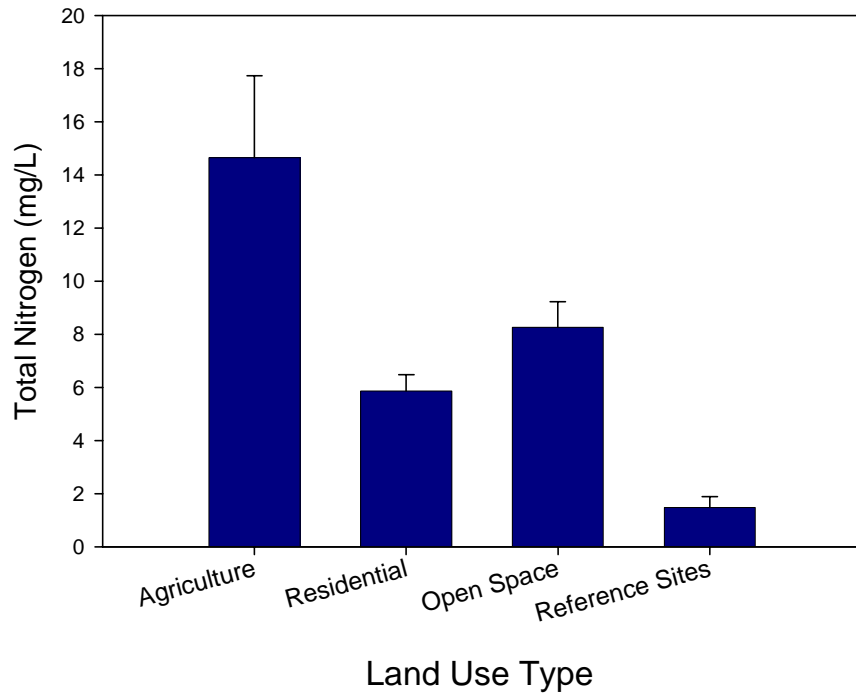
Percent Total Phosphorus of Plant Tissue by Stream



**P**

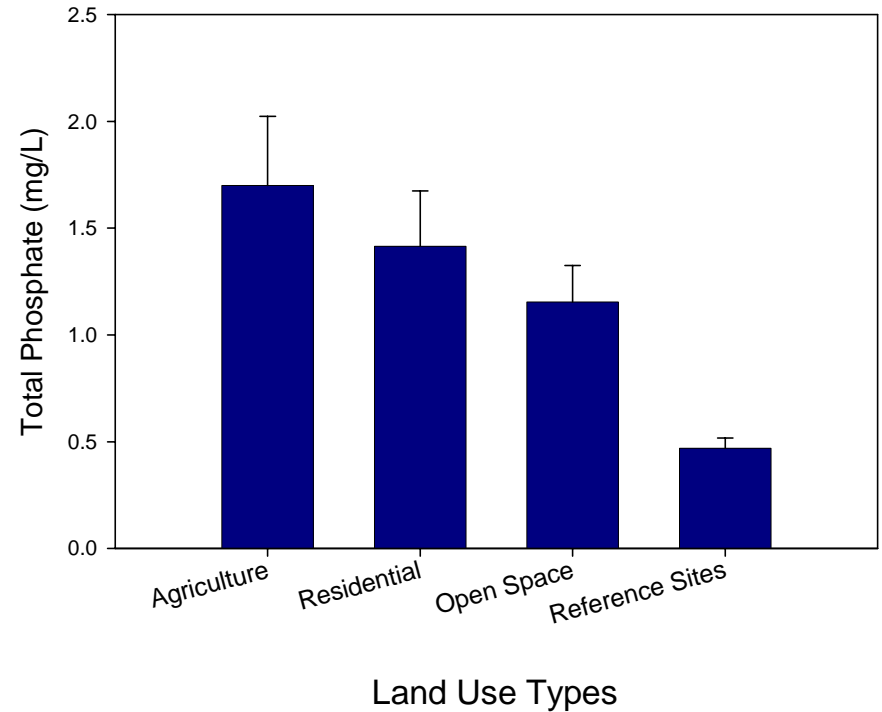
# Nutrients in Groundwater by Land Use

Total Nitrogen in Groundwater by Land Use



**N**

Total Phosphate in Groundwater by Land Use



**P**

# Summary - Nutrients

- In floodplains:
  - Arundo occurs where groundwater nutrients are high
  - Nutrients levels in groundwater and plants differ by watershed and are correlated with higher percent of more intense land uses
- On terraces:
  - Large infestations of Arundo occur where N is higher
- Agriculture has the highest groundwater nutrients
  - Large infestations next to agriculture have highest nutrient levels of all
- Similar patterns where found in South African study



FIRE

October 2003

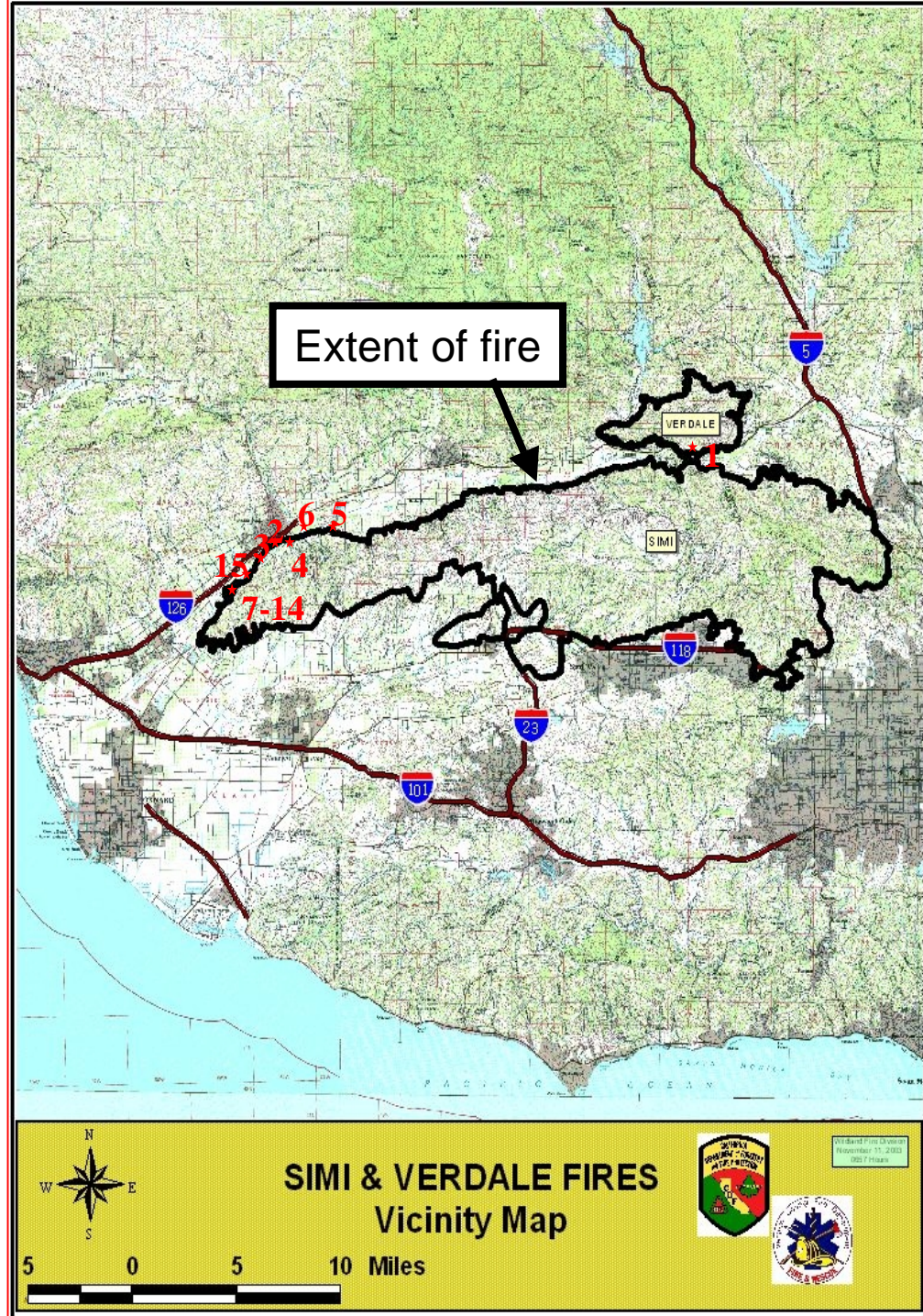


# Arundo and Fire

- Arundo is thought to influence fire dynamics of riparian habitats, but no actual studies
  - Drier than native riparian plants during fire season - late summer through fall
  - More flammable than native riparian plants
- Many study sites along Santa Clara River containing Arundo were burned in the October 2003 wildfires
- Opportunity to study
  - invasion process adjacent to shrubland ecosystems
  - post-fire vegetation dynamics

# Study Design

- 15 sites
  - differ in amount of water, light, fire intensity, competition with native species
- Document spread of fire through Arundo
- Measure growth after fire



# Rapid *Arundo* growth after fire



8 weeks



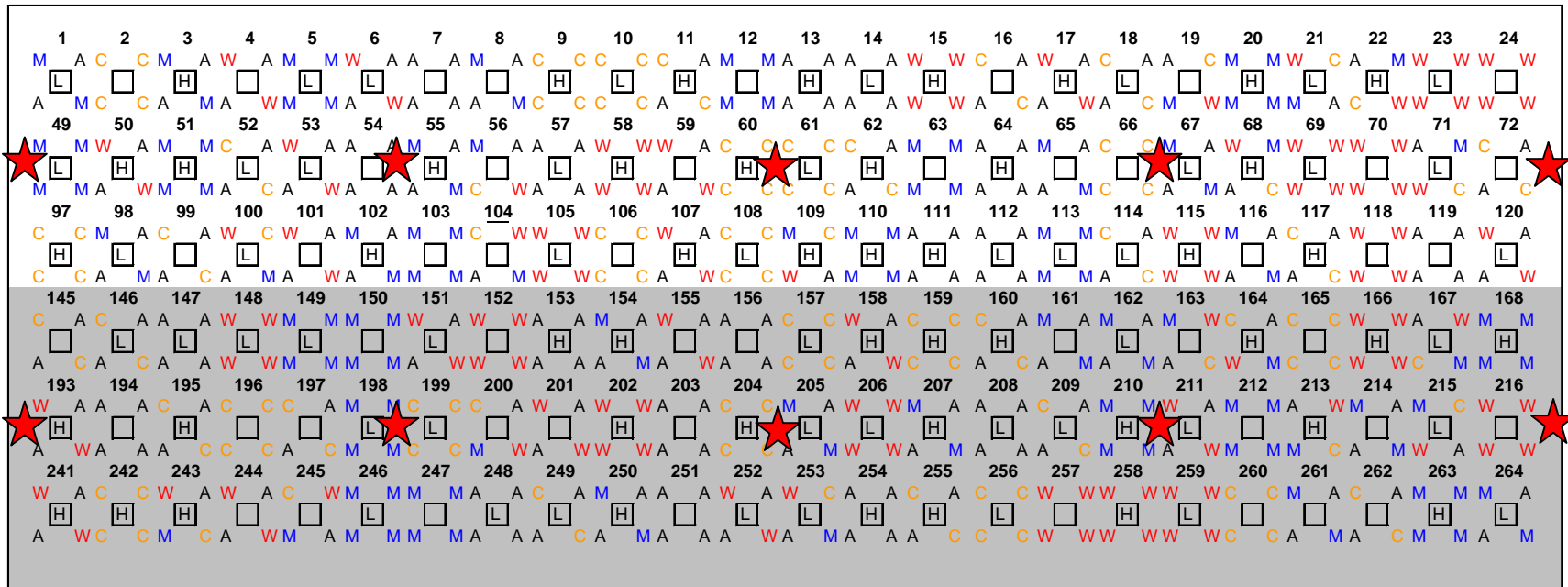
6 months

**COMING  
SOON....**

# Riparian Field Experiment




- Large-scale field experiment (0.4 ha)
  - 1,152 plants
  - 8 competition treatments (4 species)
  - 3 nutrient treatments
  - 2 water treatments
  - 2 light treatments

# Study Design



LEGEND:

- A = *Arundo donax* (Giant Reed)
- C = Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa*)
- M = Mule Fat (*Baccharis salicifolia*)
- W = Red Willow (*Salix laevigata*)
- H = High N fertilizer treatment
- L = Low N fertilizer treatment

-  = Open treatment
-  = Shade treatment (80%)
- 11 = Plant grouping number
-  = Plant grouping

★ Groundwater wells  
and soil moisture sensors

# Management Strategies

- Remove *Arundo* from:
  - terraces adjacent to shrubland
  - terraces next to agricultural land use
  - other terrace areas
- **PLANT NATIVE RIPARIAN SPECIES!**
- Remove *Arundo* along floodplains from top of watershed downward only
- Use chemical herbicide only at end of growing season

# Acknowledgements

- Funding:
  - UC Water Resources Center
  - State Coastal Conservancy
  - Santa Clara River Trustee Council
  - The Nature Conservancy
  - University Research Expedition Program
  - Rico International
- Thanks to my many field assistants and volunteers in the Western Cape, South Africa and Southern California who made this research possible!



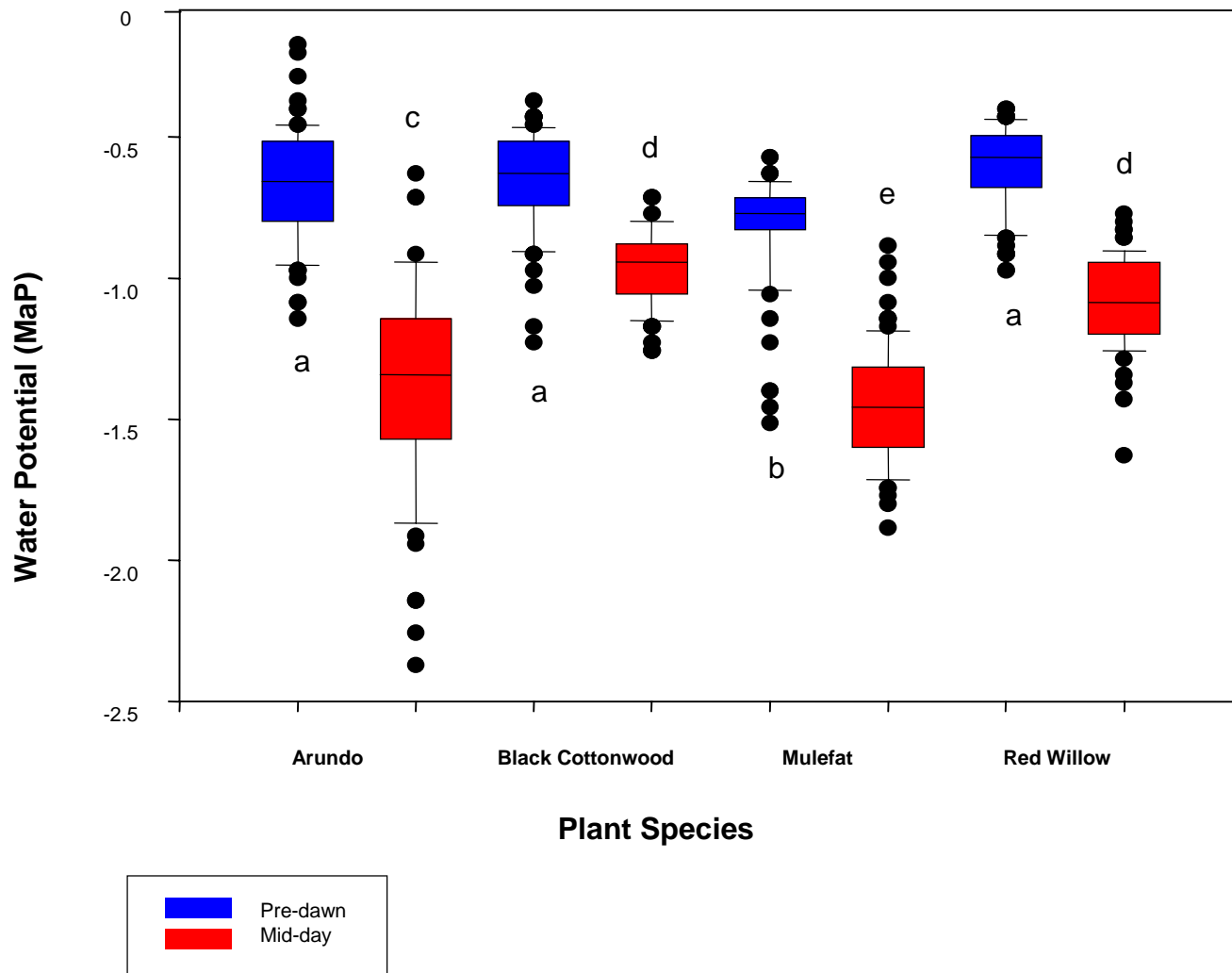


# WATER



# Riparian Plant Water Relations

## Spring 2004



# Summary - Water and Fire

- Increased water availability
  - Arundo uses more water than other indigenous riparian species
- Effects of fire
  - Helped spread wildfire through a riparian ecosystem to shrubland
  - Grows 3-4 times faster and more dense than indigenous plant species after fire

# Plant Introductions - Rivers

