Biological control of *Arundo donax*; an invasive weed of the Rio Grande Basin

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Research Team

- **John Goolsby, Don Thomas**, USDA-ARS, Edinburg, TX, Project coordination, host range testing, biology of agents, field evaluation of agent, interaction with cattle fever ticks

- **Beto Perez de Leon, Felix Guerrero**, USDA-ARS, Kerrville, TX, Ant impacts, decomposition of dead biomass

- **Patrick Moran**, USDA-ARS, Albany, CA, evaluation of agents in CA.

- **Alan Kirk, Marie Claude, Javid Kashefi**, USDA-ARS, EBCL, Montpellier, France, Foreign exploration for biological control agents in Europe, ID of leafminer endophytes

- **Massimo Cristofaro**, BBCA, Foreign exploration in Italy

- **John Gaskin**, USDA-ARS, Sidney, MT, Genetic characterization of biological control agents

- **Matt Ciomperlik, Aaron Carlson**, USDA-APHIS, Edinburg, TX, Aerial release of agents, implementation program

- **Alex Racelis**, UT-RGV, Edinburg, TX, Water use of Arundo

- **Maricela Martinez Jimenez** – Instituto Mexicano de Tecnologia del Aguas, Cuernavaca, Mexico, Evaluation of biological control agents in Mexico

- **Eduardo Galante, Maria Angeles Marcos, Elena Cortez Mendoza** – Universidad de Alicante, Spain, Biology of the arundo scale in Spain

- **Mike Grusak**, USDA-ARS, Houston, TX, Plant nutrient effects on agents

- **Ron Lacewell** – Texas A&M Agrilife, College Station, Economic impact of *Arundo donax* in the Rio Grande Basin

- **Jim Manhart, Alan Pepper, Daniel Tarin** – Texas A&M, College Station, Molecular genetics of Arundo and biological control agents

- **Chenghai Yang** – USDA-ARS, College Station, TX, Remote sensing
Research Funding

• Dept. of Homeland Security, Customs and Border Protection
• U.S. Dept. of Agriculture
Arundo donax L.

- **Common names:** giant reed, carrizo cane
- **An invasive weed in riparian habitats**
- **Clonal** – spreads by movement of rhizomes
- **Declared noxious weed** – 45 States, listed by Cal EPPC, SE EPPC
- **Also invasive in** Mexico, Argentina, Australia & South Africa

2009

Rio Grande River
Presentation

• Impacts of Arundo in Rio Grande Basin
• Comparison to native range in Europe
• Biological control program in TX & Mexico
• **Immediate Results:** New Mechanical Topping + Biological Program to achieve immediate visibility of river
• Summary of accomplishments
Impacts of Arundo in the RGB

- Water Availability
- Environmental
- National Security
- Livestock Health
Water is the limiting resource
How do we conserve water in Rio Grande Basin

- Reduce urban landscape water use
- Industrial water recycling
- Reduce irrigation losses – line canals
- Control invasive water-using weeds
Control of invasive weeds – increased water conservation
Size of Arundo infestation in RGB
Satellite Image of Arundo donax

Rio Grande River near Eagle Pass, Texas

17 km (10.6 mi)
Tasked February 2007
Subset1
Estimated Area of Arundo in RGB

- 70,000 – 100,000 acres in the Rio Grande Basin
- This is along the main rivers and tributaries
- Does not include infestations along creeks, ditches, canals
  - Could be as much as 100,000 additional acres

Everitt and Yang, USDA-ARS, Weslaco, Texas
Expected Benefit-Cost Implications and Economic Cost of Water Saved for the *Arundo donax* Biological Control Program between San Ignacio and Del Rio, on the Rio Grande River.\(^a\)

<table>
<thead>
<tr>
<th>Result Item</th>
<th>Low Value of Water(^b)</th>
<th>High Value of Water(^c)</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Present Value</td>
<td>$72,400,000</td>
<td>$145,700,000</td>
<td>$16,700,000</td>
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<tr>
<td>Annualized Benefits</td>
<td>$4,700,000</td>
<td>$9,400,000</td>
<td>---</td>
</tr>
<tr>
<td>Benefit to Cost Ratio</td>
<td>4.35 : 1</td>
<td>$8.74 : 1</td>
<td>---</td>
</tr>
</tbody>
</table>

Annuity Equivalent--Economic Cost of Water Saved ($/acre-foot) $44.42

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\(^a\) Source: Seawright, Emily. Masters of Science Thesis, Department of Agricultural Economics, Texas A&M University

\(^b\) Low Value of Water refers to the low marginal returns for water calculated using the composite acre for low value crops (i.e., corn, cotton, sorghum), a value of $139.22 per acre-foot. The values calculated with the low value of water represent the lower bound of the social benefits to be realized over the 50-year planning horizon.

\(^c\) High Value of Water refers to the high marginal returns for water calculated using the composite acre for high value crops (i.e., fruits, vegetables, sugar cane, corn, cotton, sorghum), a value of $279.99 per acre-foot. The values calculated with the high value of water represent the upper bound of the social benefits to be realized over the 50-year planning horizon.

Impacts of *Arundo donax*

- Water Availability
- Environmental
- National Security
- Animal Health
Environmental

Rio Nadadores, Coahuila, México
Extinction of endemic fish species
U.S. National Security
Livestock Health

1. Arundo enhances survival of tick
2. Transition back to native vegetation--better biological barrier to ticks

High Infestation Areas
Invasive Monoculture

Down river from Big Bend
Invasive Monoculture

Rio Conchos, Chihuahua, Mexico
Amistad Dam, Del Rio, Texas

Invasive
Monoculture
Invasive Monoculture

South of Del Rio
Invasive Monoculture

South of Eagle Pass, Texas
Invasive Monoculture

Laredo, Texas
Invasive Monoculture

Irrigation canal, Weslaco
Comparison of *Arundo donax* in its native range in Mediterranean Europe
Rio Guadiana, Portugal

Native Biodiverse Ecosystem
Mediterranean coast of Spain near Malaga
El Saler (Valencia), Spain

Native Biodiverse Ecosystem
Native Biodiversity Ecosystem

Ebro River, Tortosa, Spain
Native Biodiverse Ecosystem

Rivesaltes, France
There are over 230 types of *A. donax* in Spain. Through our research we found that only 1 type from Mediterranean Spain was brought over to Mexico in the 16th century and spread across the Americas.

This was fortuitous as we could concentrate our research on the single set of type-specific biological agents for controlling the dominant type in the Rio Grande Basin.

Biological Control of *Arundo donax*

- Long-term, sustainable
- Low cost
- Environmentally friendly
- Bi-national agreement

Seville, Spain
Biological Control Agents

**Arundo wasp**
- *Tetramesa romana*
- Hymenoptera: Eurytomidae
- Larvae feed on stems & side shoots (adult stingless)
- Released April 29, 2009

**Arundo scale**
- *Rhizaspidiotus donacis*
- Homoptera: Diaspididae
- Scale insects feed on roots and side shoots
- Released Dec 17, 2010

**Arundo leafminer**
- *Lasioptera donacis*
- Diptera: Ceccidomyiidae
- Larvae are leaf sheath miners causing defoliation
- Released Dec. 2016

**Arundo fly**
- *Cryptonevra spp.*
- Diptera: Chloropidae
- Fly larvae feed on new stem shoots
- Testing in Europe
Biocontrol agents transferred to Mexico
U.S.-Mexico binational program
Testing of Biocontrol Agents
**Tetramesa romana** (Hymenoptera: Eurytomidae)

- Adult females live 4-5 days and reproduce via parthenogenesis.
- One female produces an avg. of 26 new adults; max of 66.
- Larvae develop inside cane (endophagy) in 30-35 days.
- Almost all (90%) of egg-laying and feeding occur at shoot tip.
- Growth of plant stunted by gall.
- Host specific to *Arundo donax*.


Wasp Impacts on Growth

Side shoot galls, ideal for arundo scale
Mass-rearing of *T. romana*
Arundo wasp damage LRGV
Aerial release of arundo wasps

300,000+ Arundo wasps aerial released since Jan 2010, wasp now widely established & self sustaining

+ Cuernavaca, Morelos, Mexico
+ Nuevo Laredo, N.L., Mexico
+ Matamoros, Tamps, Mexico
Rhizaspidiotus donacis, Arundo scale

- Feeds on roots and stems, host specific to *Arundo*
- Adult female survival (on plant until reproductive maturity): 203 days
- Average crawler production by individual female: 85 to 300, 50-80% of females are reproductive
- Highly significant impact on *A. donax*

Arundo scale damage – Del Rio, TX
October 2012

Arundo stand in plot is thinning. 24% of stems dead

High densities of large, robust, mature F2 females

Many new buds are dead from scale feeding

Mature rhizomes infested with scale at each node and bud
22% reduction in *A. donax* biomass between Del Rio and Brownsville
• 2.5 million tons of *A. donax* removed
• 6000 acre ft of irrigation water conserved per year
• Visibility into stands from 6 to 27 ft.
• Ecological transition back to native vegetation beginning

Biocontrol of Arundo promotes conservation of water quantity and quality

Maverick Irrigation District Facility

Water use of Arundo reduced in 2015

2014-2015 Monthly Evapotranspiration In Eagle Pass, Texas

- April: 0
- March: 100
- May: 150
- June: 120
- July: 180
- August: 160
- September: 100
- October: 90
Biocontrol insects reduce water use of Arundo

- 26% decrease in water use during 2015 not due to differences in temperature or precipitation
- ~75% increase of wasps in summer 2015

![Graph showing mean number of arundo wasps per trap from January 2014 to February 2015](image)
2016 Recovery of Native Riparian Vegetation on Rio Grande

- Further 28% reduction in biomass
- Biocontrol agent densities correlated with recovery of native plant species
- 44 plant species were encountered in plots, 86% native
Lasioptera donacis, Arundo leafminer

- Leafminer larvae feeds on leafsheath
- Causes rapid leaf death and defoliation
- 1 month life cycle
- Host specific to *A. donax*
- *Newest agent released*
Presentation

• Impacts of Arundo in Rio Grande Basin
• Comparison to native range in Europe
• Biological control program in TX & Mexico
• **Immediate Results:** New Mechanical Topping + Biological Program to achieve immediate visibility of river
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Control of Carrizo Cane Topping + Biological Control Insects

Advantages:

• Topping provides immediate visibility of river for law enforcement.
• After topping biocontrol insects suppress regrowth of carrizo cane for 1 year.
• No environmental issues.
• Biocontrol process is gradual, which keeps river bank stable and prevents erosion.
• Ready acceptance by landowners.
• Mexico supports biocontrol program and is also releasing insects.
• The native trees, shrubs, and grasses re-grow to fill the void, which leads to significant water conservation.
• Biocontrol is permanent, no need for re-release of insects.
• All Federal permits (NEPA) in place for immediate action.

Contact: John A. Goolsby, USDA-ARS 956-373-3223 john.goolsby@ars.usda.gov Edinburg, TX (Moore Airbase)
La Azteca Island, Laredo, TX
La Azteca, Laredo, TX

Before

After

Visibility on Day 1 and stays for 1 year, no standing dead cane, no fire hazard
300 Yard Visibility

USDA employee at far end
How long does topping + bio keep carrizo cane stunted?

11 months after topping – Brownsville, TX
Conclusions

• *Arundo donax* is extremely invasive with multiple social, political, agricultural and environmental impacts in the riparian habitats of the Southwestern U.S. watersheds.

• Significant economic benefits from control of *A. donax*

• Biological control best adapted strategy for long-term basin-wide control

• Biological control program has released 3 agents from Spain, gall-forming wasp, armored scale, & leafminer

• Significant benefits to Rio Grande Basin.

• >7000 acre feet of water conserved per year

• Texas Agrilife model – $5 million in benefits per year
Summary

• *Arundo donax*, carrizo cane is declining along Rio Grande from Del Rio to Brownsville due to attack by biocontrol insects

• New topping techniques synergizes with biocontrol to provide immediate visibility and is a scalable technology for Rio Grande

• 3rd agent the arundo leafminer will further accelerate decline
Arundo donax is an exotic and invasive weed of riparian habitats in the southwestern U.S. and northern Mexico. Arundo dominates these habitats, which leads to: loss of biodiversity; stream bank erosion; increased costs for chemical or mechanical control along irrigation canals and transportation corridors; reduction of access and visibility of the international border for law enforcement personnel; increased risk of cattle fever tick incursion; and this weed competes for water resources in an arid region where these resources are critical to the environment, agriculture and urban users. Biological control using insect agents from the native range of A. donax in Europe may be the best option for long-term and widespread management. Two biological control agents have been released and established in the U.S. and Mexico. A detailed economic analysis of the biological control program indicates that for each research dollar spent, society benefits between $4 and $8 in return.

Research Objectives:
1. Evaluate field impacts and dispersal of established biological agents on A. donax, and monitor transition of riparian zone to native vegetation, changes in water use, visibility of border, and interactions with cattle fever ticks.
2. Evaluate additional biological control agents from the native range that target different life stages of A. donax.
3. Develop mass rearing and aerial fleet release methods for the agents for control of A. donax in the remote areas of the Rio Grande.
4. Develop methods to integrate mechanical and biological controls to meet needs for immediate control and visibility.
5. Use aerial remote sensing techniques to measure changes in A. donax density and distribution, which can be used in the economic model to quantify benefits of the biological control program.

Impact of Agents on Biomass

Integration with Mechanical Topping

Topping creates immediate river visibility for law enforcement agencies. Topping promotes short bushy side shoots with max plant height = 3-5 feet. Mass release of biocontrol insects further suppresses Arundo canes which stay stunted allowing desirable native vegetation to return.

Impact of Agents on Biomass

Fig. 1. Arundo biomass on the Rio Grande (558 river miles) has been reduced by 32% from 2007 to 2016 due to widespread arundo wasp damage. This reduction equals 2.5 million tons of cane removed, conserving 6000 acre ft. of water per year valued at $4.4 million. Additional control expected from the Arundo scale and leafminer.

Eddy covariance equipment is being used to measure water use of arundo before and after release of the agents. With more than 30,000 ha. of arundo in the RGB, there is significant potential for water conservation.

Law enforcement officials in the U.S. and Mexico have reduced visibility and access to the international border. Biological control has bi-national support as a solution.

The arundo wasp reached outbreak levels on the Rio Grande during 2013 which has thinned cane stands. While boards are used to measure changes in with-in stand visibility caused by the agents.

The arundo scale is established in several remote areas of the Rio Grande. Topping creates immediate river visibility for law enforcement agencies. Topping promotes short bushy side shoots with max plant height = 3-5 feet. Mass release of biocontrol insects further suppresses Arundo canes which stay stunted allowing desirable native vegetation to return.

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The field released April 2009 Arundo wasp (Tetramesa romana) is an invader of Nelumbo, which is native to India.

Field Results

Field released April 2009

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