An economic assessment of invasive giant reed (*Arundo donax*) control for the lower Santa Clara River

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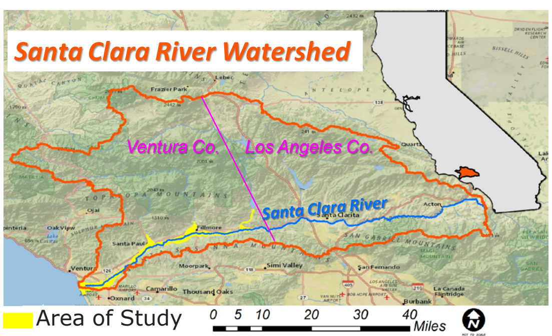
Introduction

Giant reed (*Arundo donax*) has invaded extensive portions of riparian habitat in Southern California. Its invasion in the Santa Clara River (SCR) watershed has degraded habitat that hosts Endangered species and provides many ecosystem services to communities in Ventura and LA Counties, such as water for a profitable agriculture industry.

To better support *A. donax* removal efforts, the full benefits that the people and environment could receive from watershed-scale restoration need to be quantified.



Project Objectives

1) Conduct a cost-benefit analysis of *A. donax* removal in the lower Santa Clara River with regard to the following benefits/costs:

Benefits

Vs.

Costs

2) Identify priority areas for *A. donax* removal that maximize ecological value and minimize costs.

Vegetative structure
Can grow 30 ft. tall and form monocutures that outcompete native plants

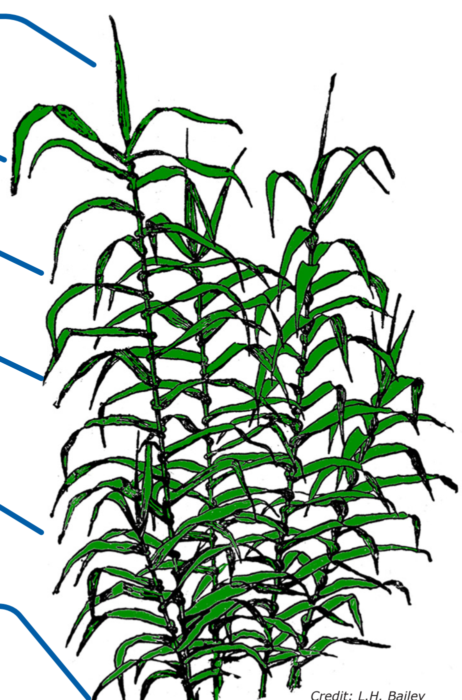
Habitat degradation
Degrades habitat for >15 Threatened and Endangered species in the SCR[1]

Water consumption
Evapotranspiration rates are higher than native species due to high leaf area[2]

Fire impacts
High standing biomass increases fuel loads, creating more intense and pervasive fires[3]

Flood impacts
Increases frictional resistance of flood waters, increasing flood height & exent[4]

Dispersal mechanism
Movement of rhizomes allow the reed to propogate new areas, typically downstream during large flood events



Credit: L.H. Bailey

Key Findings

- Reduced water consumption provides the greatest monetary saving of *A. donax* removal.
- *A. donax* removal can reduce localized flood damage and fire risk.
- Capitalizing on scouring floods and fires is the most cost-effective removal strategy.

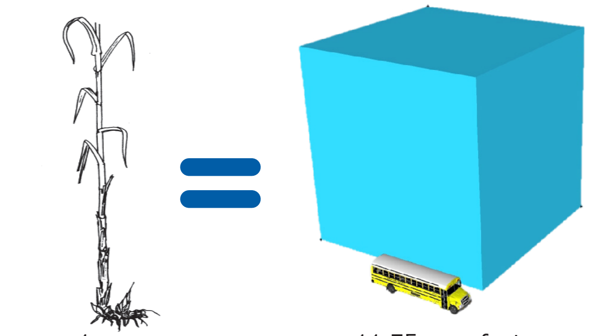
Water Consumption

Methods | The difference in water consumption across our study area was calculated using the current distribution of *A. donax* and a scenario in which all *A. donax* had been replaced with native vegetation. Evapotranspiration data were collected from literature and paired with mapping efforts.

Results | We found that if all *A. donax* is replaced with native vegetation, we would see approximate savings of 11,000 acre feet of water each year.

Avoided water consumption=

$900,000/year



1 acre
A. donax removed

11.75 acre-feet
water saved annually

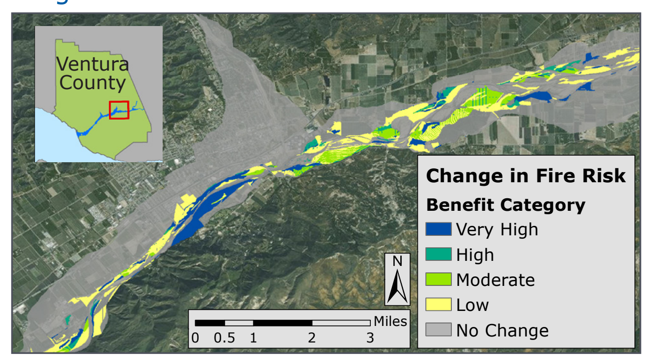
Fire Risk

Methods | BehavePlus and ArcGIS were used to develop a multi-criteria analysis that combined environmental (aspect, slope, and elevation) and vegetation (fuel load) characteristics. Fire rate of spread and flame length were used to map fire risk with and without *A. donax*; fire risk reduction is the difference between the two.

Results | Overall, there was a reduction in fire risk equal to 15 fewer acres burning annually within our area of study when *A. donax* was replaced with native vegetation.

Avoided firefighting costs=

$53,000/year



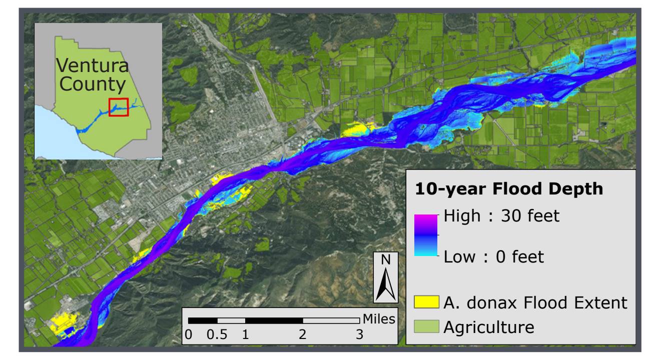
Flood Damage

Methods | A HEC-RAS model was used to simulate the height and extent of 1-, 5-, and 10-year flood events within our area of study both with *A. donax* and with the reed replaced by native vegetation. Model results were coupled with agricultural data to understand the additional impact *A. donax* has on the industry.

Results | We found that removing all *A. donax* from the area of study reduces the agricultural land flooded during a 10-year flood by 183 acres.

Avoided flood damages to agriculture=

$57,000/year

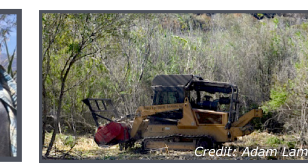


Control Costs

Typical *A. donax* removal programs last roughly five years. Costs incurred during this period can be categorized into two removal stages: initial removal (year 1) and maintanance (years 2-5). While maintenance costs are relatively uniform across infestation densities, initial removal costs vary across a wide range and are inversely proportional to the *A. donax* density being treated. The methods for removal employed at different densities are:

$44,250/acre **$24,500/acre** **$5,500/acre**

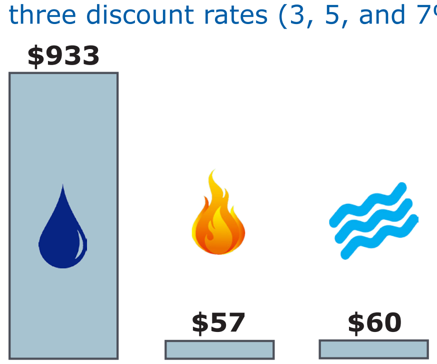
Manual removal: Cut and daub; handcutting and applying herbicide.



Mechanical removal: The use of large machinery to mow large stands of *A. donax*.

Cost-Benefit Analysis

Methods | A cost-benefit analysis (CBA) was done comparing the costs of removal to the modeled benefits that could be received over a 20-year time frame. The CBA incorporated a flood simulator to allow for comparison of of three different management strategies, of which two rely on large flood events for some level of removal. A sensitivity analysis was performed using three discount rates (3, 5, and 7%).



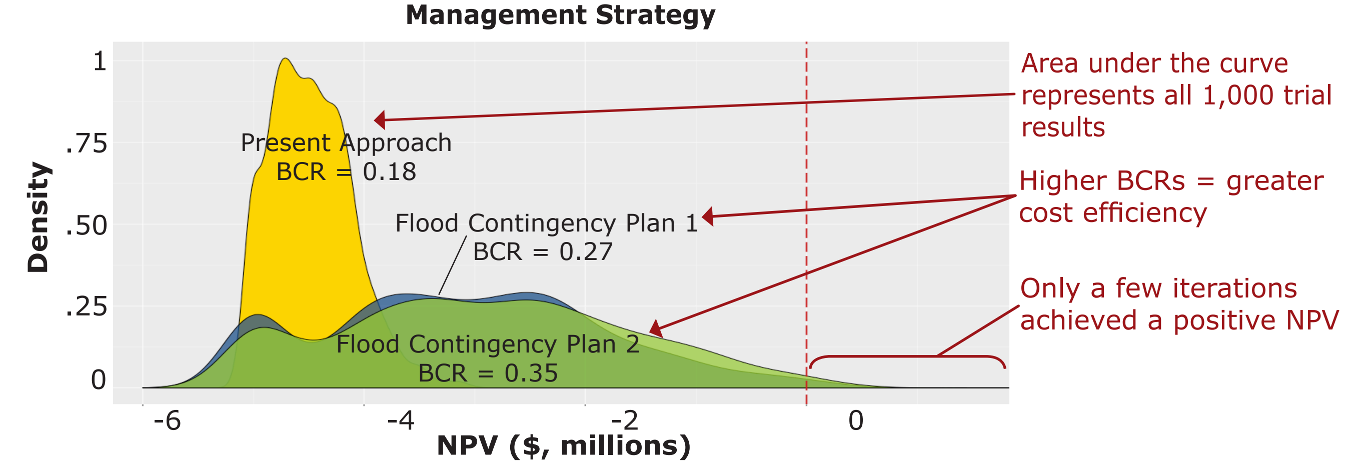
Benefits: Expected annual savings per acre of *A. donax* removed by benefit category.

Management Strategies

1. Present Approach
   15 acres removed annually
2. Flood Contingency Plan 1
   15 acres removed annually
   + 25 acres treated after a flood
3. Flood Contingency Plan 2
   15 acres removed annually
   + 50 acres treated after a flood

Results | Only the two contingency strategies showed iterations that achieved an NPV greater than zero. Comparing across strategies, the benefit-cost ratios (BCRs) are highest in the contingency approaches, indicating that incorporating a contingency plan into removal efforts would be more cost-effective. Finally, the discount rate had little impact on the NPV and BCR in all instances.

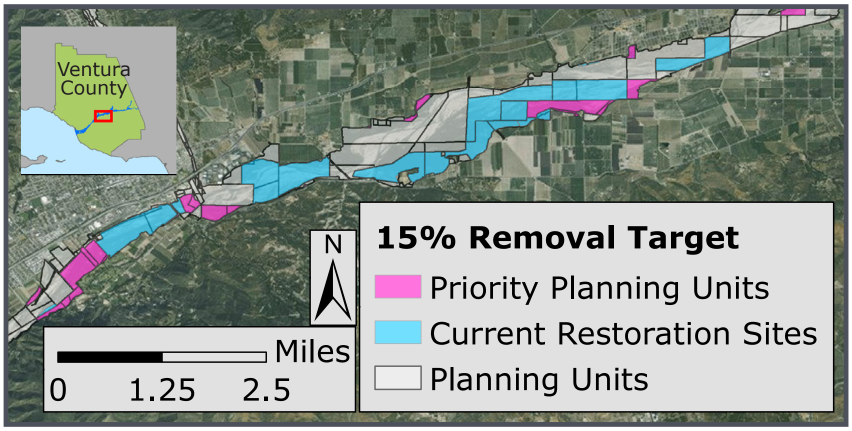
Net Present Value (NPV) for All Trials by Management Strategy



Priority Areas

We developed an optimization model using Marxan to identify areas with high ecological value and low removal costs. Ecological value was determined using habitat type as a proxy for several Endangered avian species. Data on steelhead trout oversummering habitat were also included. Current restoration sites were added in an effort to develop a conservation network along the river corridor.

The results of each Marxan trial indicate which parcels would be best suited for removal to achieve the greatest ecological gain at least cost. For example, at a 10% removal target, 69 planning units were selected at a cost of $4.2 million. To achieve a 15% removal target, 94 parcels were selected at a cost of $8.1 million. Costs for 20% removal are $13.1 million and 105 planning units.



Conclusions

Reduction in water consumption from the removal and replacement of *A. donax* within our area of study provides the greatest monetary savings at approximately 15 times the benefits received from the reduction in fire risk and the reduction in flood damages.

A. donax removal reduces fire risk and flood damage within the floodplain. Approximately 15 fewer acres are expected to burn each year while damages from flooding are reduced in approximately 183 acres of agriculture in the case of a 10-year flood event.

Capitalizing on natural disturbance events (i.e., scouring floods) to remove *A. donax* biomass will be the most cost-effective strategy when moving forward in managing *A. donax* within the river.

A strategic and opportunistic approach to *A. donax* control should also focus efforts on high priority areas that maximize ecological benefits while minimizing the costs of removal.

Recommendations

1. Future analysis must look into the monetization of other benefits such as the impact on habitat quality and Endangered species.

2. Benefits should be highlighted to garner buy-in for local, state, and federal collaboration.

3. Establishing funding and permitting to carry out a flood contingency plan in the event of a large flood will be the most cost-effective management strategy.

Major floods in winter of 2005 scoured much of the vegetation within the river channel, including *A. donax*.

Acknowledgements | This project would not have been possible without the support of many individuals. Special thanks to our faculty advisor, Dr. Derek Booth, and our clients, Dr. Adam Lambert and Dr. Tom Dudley of the Riparian InVasion Research Laboratory (RIVRLab).

References | [1] Court et al. (2000) Prioritizing Sites along the Santa Clara River for Conservation of Threatened and Endangered Species (Master's Thesis). University of California, Santa Barbara.
[2] Watts et al. (2011) Water-use dynamics of an invasive reed, Arundo donax, from leaf to stand. Wetlands, 31, 725–734.
[3] Hobbs (2000) Invasive Species in a Changing World. Island Press.
[4] Spencer et al. (2013) An evaluation of flooding risks associated with giant reed (Arundo donax). Journal of Freshwater Ecology, 28(3), 397–409.