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

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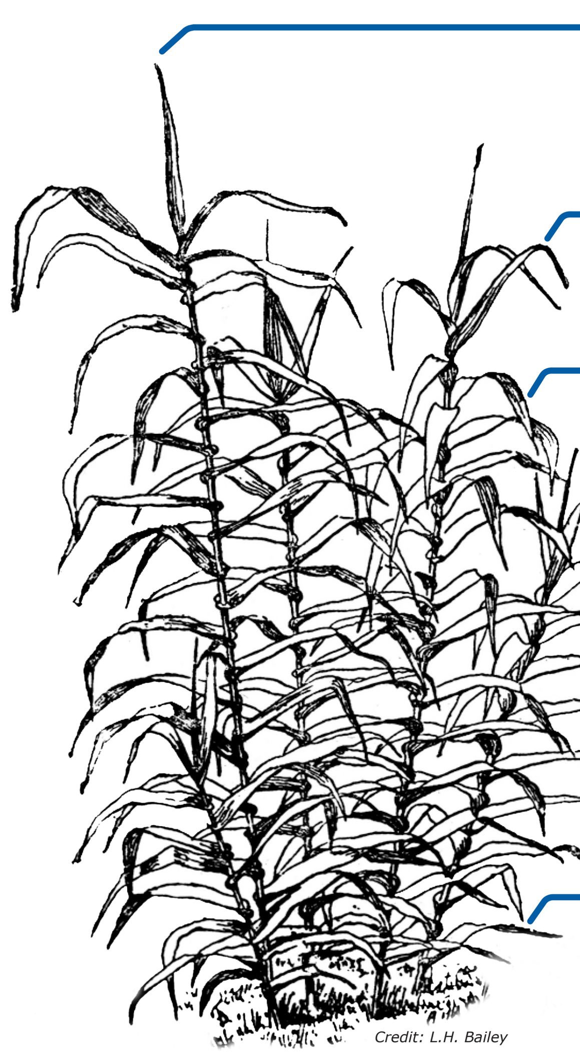
In Southern California, giant reed *(Arundo donax)* is an invasive perennial reed that has infested many riparian habitats, including that along the Santa Clara River (SCR). Current removal programs in the lower SCR are insufficient in addressing the reed's presence within the river corridor. Inadequate funding, paired with high control costs and apprehensive landowners, restricts the ability of restoration managers operating in the lower SCR to coordinate large-scale removal efforts. As such, stakeholders in the lower SCR have expressed a need for more concrete economic evidence to underpin their efforts.



Vegetative structure
Can grow to be over 30 feet tall and can form dense monoculture stands that are able to outcompete native vegetation.

Habitat degradation
Degrades essential habitat for over 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, contributing to more intense and pervasive fires.[3]

Flood impacts
Increases in flood height and extent are caused due to increased frictional resistance of flood waters.[4]

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

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

Water Consumption · Fire Risk · Flood Damage · Removal Costs

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

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* has been replaced with native vegetation. Evapotranspiration data were collected from literature and paired with mapping efforts.

Results | We found that if all *A. donax* mapped is replaced with native vegetation, we would see approximate savings of 11,000 acre feet of water each year, enough to supply 84,000 individuals in Ventura County.

Avoided water consumption = **$900,000/year**

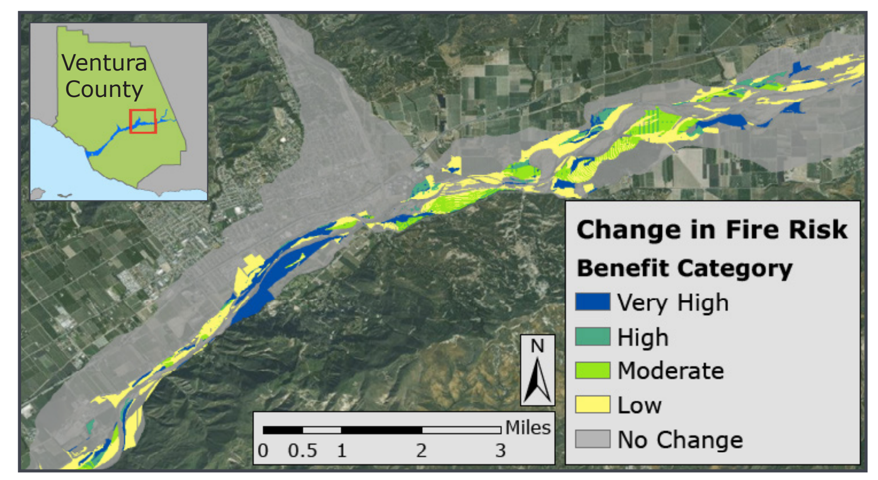
SCR Vegetation: A stand of *A. donax* (left) and mixed native vegetation (right). Replacing 1 acre of *A. donax* with native vegetation saves an average of 11.75 acre-feet of water annually.

Fire Risk

Methods | BehavePlus and ArcGIS were used to develop a multi-criteria analysis that combines 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 acres less burning annually within our area of study when *A. donax* is replaced with native vegetation.

Avoided firefighting costs = **$53,000/year**

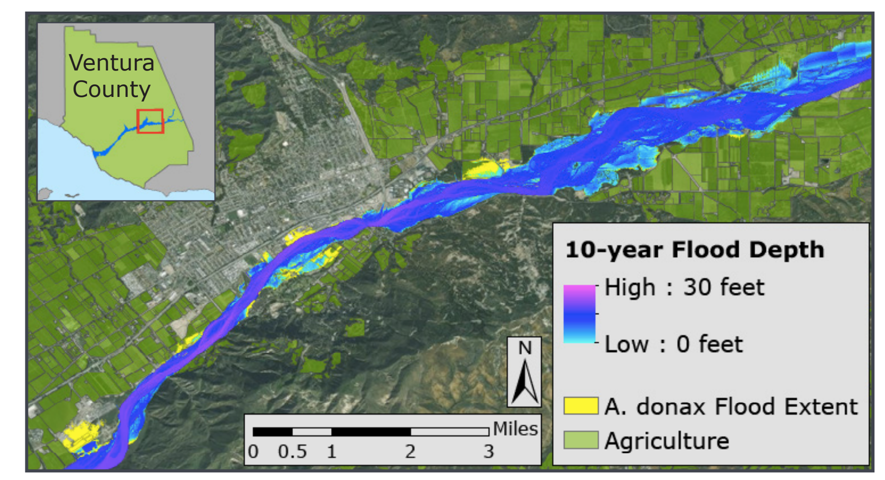


Flood Damage

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 how *A. donax* increases flood impacts 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 approximately 183 acres.

Avoided flood damages to agriculture = **$57,000/year**



Control Costs

Typical *A. donax* removal programs last roughly five years. Costs incurred can be categorized into two removal stages: initial removal (year 1) and maintenance (years 2-5). While maintenance costs are relatively uniform across infestation densities, initial removal costs vary widely and are inversely proportional to the *A. donax* density being treated. The methods for removal and the corresponding cost estimates used for analysis are:

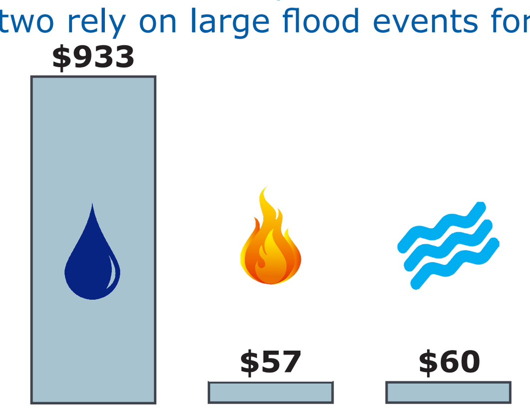
- Low Density – Manual: **$44,250/acre**
- Moderate Density – Mixed: **$24,500/acre**
- High Density – Mechanical: **$5,500/acre**

Manual removal: Cut and daub; handcutting and applying herbicide directly to the stalk.

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 at a discount rate of 3, 5, and 7%. The CBA incorporated a flood simulator that used flood probabilities to generate 1,000 plausible scenarios. This allowed comparison of three different management strategies, of which two rely on large flood events for some level of removal.

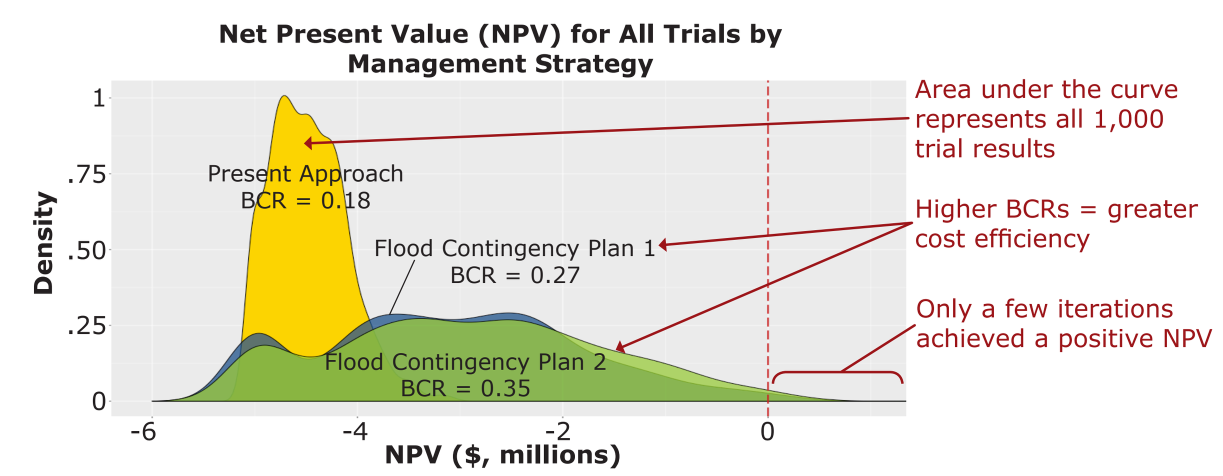


Benefits: Expected annual savings per acre of *A. donax* removed by benefit category.

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

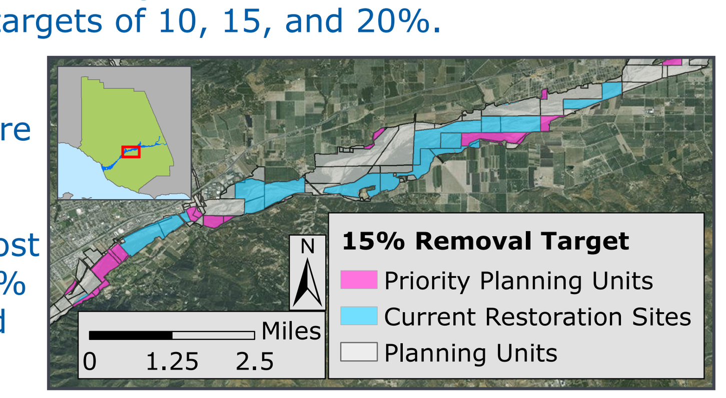
Results | Only the two contingency strategies showed iterations that achieved an NPV greater than zero. Comparing across strategies, the benefit-cost ratios (BCRs) are highest in the contingency approaches, indicating that incorporating a contingency plan into removal efforts would be more cost-effective.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



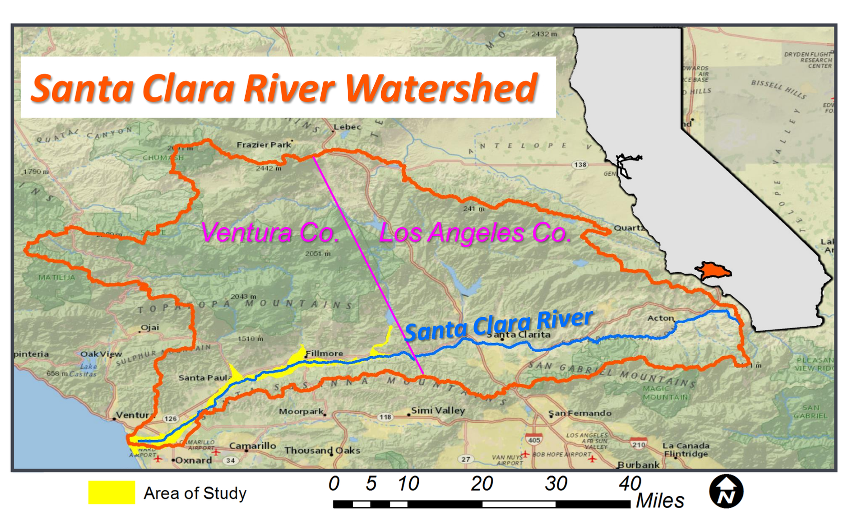
Priority Areas

Methods | We developed an optimization model using Marxan, a conservation planning program that aids in deciding an optimal portfolio of planning units based on costs and specified goals. Here, we optimized for ecological value against 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. Goals reflect specified *A. donax* removal targets of 10, 15, and 20%.

Results | At a 10% removal target, 69 planning units were selected at a cost of $4.2 million. To achieve 15%, 94 parcels were selected at a cost of $8.1 million. Costs for 20% removal are 13.1 million and 105 planning units.



The Santa Clara River Watershed encompasses over 1,600 square miles, spanning across Los Angeles and Ventura Counties.[5] The SCR flows over 83 miles from east to west and is considered one of California's last wild rivers; it still maintains much of its natural hydrology.[6] The river system supports several ecologically diverse communities as well as a rich agricultural industry within the floodplain (concentrated mostly in the lower watershed).



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. By removing all of the reed from the SCR, we would expect approximately 15 acres less to burn each year and 183 acres less to experience flood damage during a 10-year flood event.

Moving forward, capitalizing on natural disturbance events (i.e. scouring floods) will be the most cost-effective strategy in managing *A. donax* in the river system.

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. The development of a watershed-wide contingency strategy will prove most cost-effective. Funding should be identifed and permitting issues should be addressed prior to a large flood event.

Least Bell's vireo: one of several Endangered species found along the Santa Clara River.

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).

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