Arundo donax
Distribution and Impact Report

March 2011

Agreement No. 06-374-559-0
State Water Resources Control Board

Prepared by: **California Invasive Plant Council**

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This report and spatial data set (GIS geo-database) are available for download at:
http://www.cal-ipc.org/ip/research/arundo/index.php

or

http://www.cal-ipc.org/ip/mapping/arundo/index.php

The spatial data set is also viewable at the DFG BIOS web site:
http://bios.dfg.ca.gov/

BIOS project data sets are named:
Invasive Plants (Species) - Central_So. Cal Coastal Watersheds [ds645]
Invasive Plants (Prct Cover) - Central_So. Cal Coastal Watersheds [ds646]

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Arundo donax (giant reed, giant cane) is a large non-native grass found in many coastal watersheds in central and southern California. It is an extremely problematic invasive plant characterized by extensive infestations and a range of severe impacts to both ecosystem and human infrastructure. Even with a significant increase in research and studies on *Arundo* over the past ten years, no large-scale mapping efforts have been completed and no comprehensive analysis of impacts has occurred. This report set out to accomplish these goals within the study area (Monterey to San Diego), as well as to examine watershed-based capacity to implement control programs. Over $70 million dollars have been spent to date controlling *Arundo* within the study area. It is important to document where this work has occurred and assess the resulting reduction in impacts.

Arundo was mapped at a fine scale using high-resolution aerial imagery and field verification across the study area. *Arundo* acreage prior to the initiation of control programs was 8,907 acres (gross). This is a significant area, but is much less than had been speculated by many in the field. Over 34% of this acreage (>3,000 acres) has been treated to date, with two highly invaded watersheds achieving over 90% control. Many other watersheds have more than 50% control. This indicates that watershed-based control is a realistic objective.

Mapping data show that *Arundo* is most abundant in large low-gradient river areas, where it averages 13% cover. Within specific reaches, there are sections greater than a half-mile in length that have over 40% *Arundo* cover.

This study carried out additional field work to characterize *Arundo* stands and infestations. This work verifies relationships explored by other studies, as well as generating new findings. *Arundo* within the study area was taller (average 6.5 m, maximum 9.9 m) than many previous studies reported. Biomass was confirmed as being extremely high per meter (15.5 kg/m^2). Leaf area was extremely high at 15.8 m^2/m^2 (LAI), which is consistent with other studies in California, but higher than reported in Texas where stands are shorter. Mature stands comprise most of the *Arundo* mapped in the study area. The leaf area of secondary branches is the majority of the leaf area in mature *Arundo* stands, based on leaf area and cane density of new and old canes.

This abundance of growth and cover generates many abiotic and biotic impacts. Mapping *Arundo* at high resolution allows examination and quantification of a number of these specific impacts, including water use, fluvial processes, fire, and listed species.

Spatial data, used in conjunction with stand leaf area measurements and published leaf transpiration rates, generated an *Arundo* stand-based water use value that was extremely high (40 mm/day) compared to most other plants. There are very few studies that have measured *Arundo* water use. Our results agree with one paper (from a study in California, 41.1 mm/day) and are higher than a study in Texas on the Rio Grande (9.1 mm/day). When translated into potential water savings per year from restoration, net savings of 20 ac-ft/yr was estimated. This estimate includes adjustments for replacement vegetation, as well as a reduction of *Arundo* water use to bring it into alignment with other forms of vegetation that consume large amounts of water. This is a large potential water use reduction that could have significant implications for both the ecosystem and human water use.

This study expended significant effort in broadening the understanding of how *Arundo* is impacting geomorphic and fluvial processes. These abiotic processes are particularly significant because they regulate the entire riparian ecosystem. Any changes to fluvial processes have the potential for system-wide ramifications. Large stands of *Arundo* were found to functionally increase bed elevations by five feet (based on field investigation and model re-calibrations following flood events in 1998). In addition to this *Arundo* stand-based modification of elevation, a high roughness coefficient for flows higher than

five feet was supported. This results in a significant reduction in flow capacity and represents an alteration of how *Arundo* stand function is characterized during flow events. New modeling was carried out for this study under four scenarios. Results indicated that *Arundo* stands constrain flows to the low-flow and bar-channel portions of the river profile. Over time this results in a deepening of the channel and a transformation of the system from a braided unstable channel form to a laterally stable single-thread channel form. Mapping of geomorphic forms on the larger systems documented that *Arundo* stands occur predominantly in the floodplain and terrace forms, and are nearly absent from the low-flow and active channel forms. Additional modeling using stream power indicated that over-vegetated floodplains and narrow, stable deep channels result in modifications of sediment transport during flow events. Sediment appears to be lost (removed) in channel areas and gained (aggregated) on floodplains/terraces with *Arundo* stands on them. These impacts to riverine fluvial processes change vegetation succession following flow events, sediment transport budgets, and the geomorphic structure of the habitat, all of which alter the ecosystem in a un-natural way. Such alterations are usually negative for native species that are adapted to pre-invaded ecosystem function. One system has had extensive *Arundo* control since the late 1990's, allowing examination of post-control system response. Active channel areas widened and portions of the floodplain with active flows increased. These are important post-control responses to flood events, indicating a 'normalization' of fluvial processing is occurring.

A historic review of large riparian systems using spatial mapping indicated that floodplain and low terrace forms have become much more vegetated on most systems over the last eighty years. This transformation has been observed in other systems, such as the Rio Grande, and is a result of water importation and a 'compression' of riverine systems. This dense vegetation is both native woody vegetation and *Arundo*. Mature *Arundo* stands, however, have much higher stem density and biomass per unit area, generating the observed flow reduction effects noted above. The historic analysis also showed a significant decline in acreage over time, on most systems, of the active channel area (low-flow and bar-channel areas with little vegetation). Most riverine systems have also become significantly compressed (narrower) over time as terrace and floodplain forms have been permanently separated from the river system by levees that protect both urbanization and agricultural land use. *Arundo* impacts to bridges, levees, and beaches were also described and documented. These impacts are from *Arundo* biomass and reduced flow capacity (*Arundo* stands and sediment trapping).

Impacts associated with fire were thoroughly explored with significant new findings. *Arundo*'s high biomass and stored energy were established based on field and published data. In addition to a high fuel load, *Arundo* stands have a tall, well ventilated fuel structure containing dry fuels throughout the year. This study specifically documented that transient encampments and highway overpasses are key ignition sources for fires that start in *Arundo*. This is a new class of fire events that are fully ascribed to *Arundo*. This study documented that fires are now starting in riparian areas, which did not occurred historically. Fire events were mapped over an eight year period on the San Luis Rey watershed. It was also demonstrated that *Arundo*-initiated fires are occurring on other watersheds. *Arundo*-initiated fires also burn un-invaded riparian habitat and fire suppression impacts were spatially quantified. Over a ten year period *Arundo*-initiated fires were estimated to impact 557 acres of *Arundo* and 732 acres of riparian habitat. Wildfires also burn *Arundo* stands. These fire events burned 544 acres of *Arundo* over a ten year period for the study area. *Arundo* stands that burn during wildfires burn hotter than native vegetation due to the high fuel load, and are very likely conveying fires through riparian corridors. The Simi fire in the Santa Clara watershed was one of the clearest examples of an upland wildfire spreading across a riparian zone dominated by *Arundo*, and then igniting fuels on a separate mountain range. *Arundo*-initiated fires and wildfires together burned 12% of *Arundo* acreage in a ten year period within the study area. The high acreage of burned *Arundo* and native vegetation, as well as suppression impacts, has significant impacts on the ecosystem and listed species.

Impacts to plants and animals were explored by examining 22 federally listed species from five taxonomic groups. Detailed biological assessments examining habitat, life history, distribution and abundance were carried out for these species. Listing documents and spatial occurrence data were used to evaluate *Arundo* impacts on each species. An *Arundo* impact score was calculated for each listed species. An additional metric examining the specific co-occurrence of *Arundo* and each species was derived for each watershed. The impact rank and the co-occurrence rank were then multiplied to generate an overall cumulative impact score. From this analysis, the taxonomic group, individual species, and watersheds were ranked based on scores. Avian and fish species were found to be the most impacted by *Arundo*, with amphibians also ranking high. Plants and mammals ranked very low in cumulative scoring. The two most severely impacted species were least Bell's vireo and the arroyo toad, followed by the southwestern willow flycatcher, southern steelhead, and tidewater goby. Several species that occur in estuary and beach habitat near river mouths also had impacts from *Arundo* identified. The watersheds with highest impacts to federally listed species were the Santa Margarita, Santa Ana, San Luis Rey, and Santa Clara watersheds. Three of the four watersheds have the oldest and most complete *Arundo* control programs in the study area.

A rudimentary cost-to-benefit analysis was also completed using *Arundo* spatial data. Cost of *Arundo* control was determined based on completed control work on numerous watersheds over the past 15 year. The $71 million expended to control 2,862 acres generates a per acre control cost of $25,000. Benefits derived from controlling *Arundo* are based on each impact (water use, sediment trapping, flood damage, fire, habitat, and beach debris). Valuations were conservative and a rationale was given for each impact class. Impacts that were difficult to quantify or value were not included. The benefit to cost ratio for *Arundo* at its pre-control distribution level was 1.94 to 1 ($380,767,747 to $196,481,844). Current *Arundo* distribution (reflecting 3,000 acres of control to date) generates a similar benefit to cost ratio of 1.91 to 1 ($239,461,270 to $124,934,194). A roughly 2:1 return ratio on funds invested is a significant benefit, particularly considering the additional impacts that were not assessed (due to complex valuation), as well as the conservative valuation of factors that were included.

The report concludes with a discussion of treatment priorities that include: continuing treatments of areas that have already been treated (protecting initial investment), controlling *Arundo* on watersheds where it is not abundant but could spread (early control is more cost effective), and prioritization of watersheds with large *Arundo* infestations. Programs are encouraged to use a top-down watershed implementation approach (starting in the upper reaches of the watershed), particularly if the watershed is heavily invaded. The watershed priority rankings are based on four impact classes (water use, geomorphology, fire, and listed species) and two classes of program capacity (experience and regulatory permits). Watershed-based control is most effective when there is a lead organization that can implement comprehensive control, acquire permits, obtain right of entry agreements, and secure funding.