


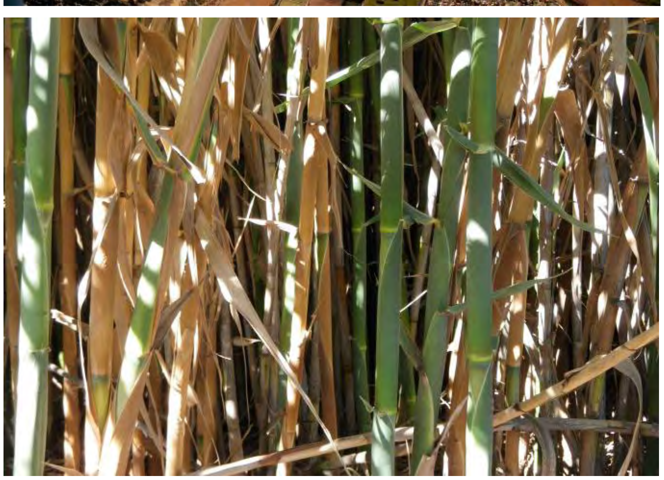

Santa Clara River Parkway

Strategic Plan for Arundo Treatment and Post-treatment Revegetation

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1 INTRODUCTION

1.1 Background

The 116-mile-long Santa Clara River flows from the San Gabriel Mountains in Los Angeles County, through Ventura County, and eventually into the Pacific Ocean near the City of Ventura (Figure 1-1). The river and its floodplain have been significantly altered due to flood protection infrastructure, water diversions and flow regulation, roads, agriculture, aggregate mining, urbanization, and invasion by non-native plants. These impacts have constrained or disrupted natural geomorphic and hydrologic processes, often causing riparian and aquatic habitat loss or degradation. Despite the alterations to the riparian system, the lower Santa Clara River presents a unique opportunity to conserve and restore riparian functions and ecosystems compared with other coastal southern California rivers, most of which are highly degraded. As the watershed is one of the least altered rivers in southern California, it continues to support a variety of natural aquatic and terrestrial communities and native species. It also provides a regionally important north-south corridor between protected terrestrial wildlife areas in the southern California coastal ecoregion, and the river itself provides an important aquatic habitat linkage from the coast and estuary to upstream habitats in the mainstem channel and tributaries.

The Santa Clara River Parkway (Parkway) project, which is lead by the California State Coastal Conservancy (Coastal Conservancy) and The Nature Conservancy (TNC), seeks to ameliorate historical ecological impacts in the lower 33 miles of the river, from the Los Angeles County line to the Pacific Ocean, and conserve existing riparian habitats by acquiring and restoring existing habitat and flood-prone property from willing sellers. The primary goal of the Parkway project is to create, protect and restore 33 miles of continuous river and floodplain corridor from the mouth of the mainstem Santa Clara River to the Ventura/Los Angeles County line. Other goals of the Parkway project are to: 1) conserve and restore aquatic and riparian habitat for native species, 2) provide enhanced flood protection, and 3) provide public access and environmental education within the Parkway. The Parkway is being created through the acquisition of river channel, floodplain, and agricultural lands vulnerable to flooding, and conversion of those lands back to riparian and upland habitats. Land acquisition is being conducted on a willing seller basis and is focused on the lower river, where a number of parcels have already been acquired (Figure 1-2).

The Santa Clara River Parkway Floodplain Restoration Feasibility Study (Stillwater Sciences 2008) was undertaken for the Coastal Conservancy to assist with the acquisition, management, and eventual restoration of lands within the Parkway. The Feasibility Study identified non-native invasive species removal as one of the six primary restoration strategies for the Parkway, and the treatment of arundo (giant reed; *Arundo donax*) in particular. Arundo is a highly aggressive, naturalized landscape plant that is a relative of bamboo and invades riparian zones by establishing dense, monospecific clonal stands (DiTomaso and Healy 2007). It is widely distributed in the watershed, spreads quickly (it establishes by vegetative propagules, most often rhizomes that wash downstream from eroded banks [DiTomaso and Healy 2007]), and severely impacts the ecology of the riparian corridor (Stillwater Sciences and URS 2007).

- Dry and dead arundo stems, or canes, create a thick, dry fuel source and are highly flammable. Arundo has been shown to increase the likelihood and intensity of fire in Southern California riparian corridors, and in the Santa Clara River specifically (Coffman 2007, Coffman et al. 2010, Geissow et al. 2011). In addition, arundo is shade-tolerant and has established under the canopy of native vegetation.

Figure 1-1. The Santa Clara River watershed.

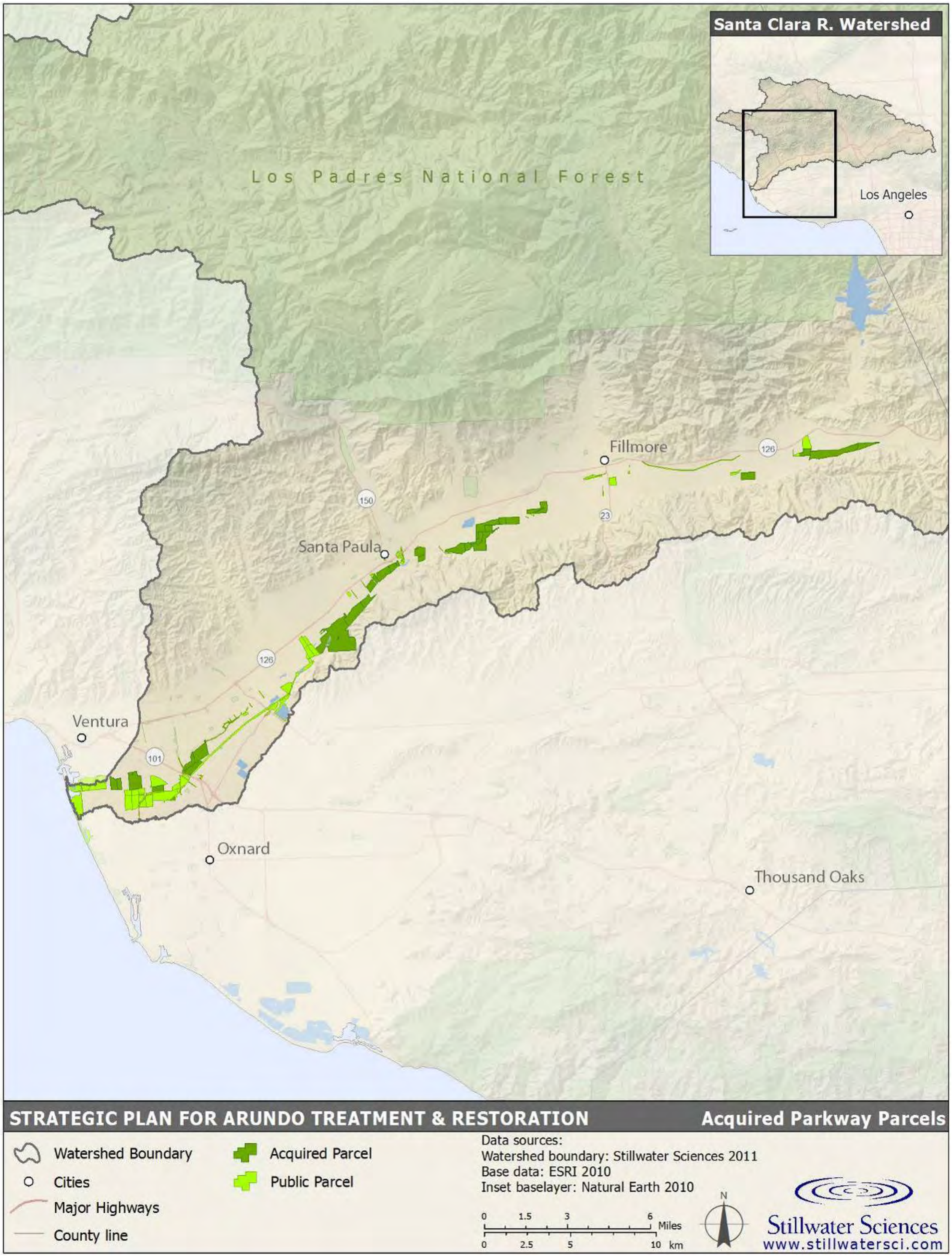

Figure 1-2. Santa Clara River Parkway parcels.

This exposes native riparian trees, which are much less tolerant of fire, to increased fire threat, contributes to the spread of wildfires from and between drier upland vegetation communities, and reduces the function of the riparian corridor as a natural barrier to fire. Arundo also re-sprouts vigorously after fire by quickly exploiting released nutrients, allowing it to outcompete and replace native plant species (Coffman 2007, Coffman et al. 2010). Past and potential future fires along the Santa Clara River, such as the ones that burned approximately 11% of the watershed in 2003, are likely to increase the cover and extent of arundo along the riparian corridor and exacerbate the arundo-fire cycle (Stillwater Sciences 2007b, Lambert et al. 2011).

- Arundo is a hydrophyte and uses a large amount of water to supply its very high rate of growth (Bell 1997, Geissow et al. 2011). A variety of studies in the arid west have demonstrated that, based on its evapotranspiration rate, arundo uses anywhere from three to 110 times more water than native riparian plant species (see Coffman and Ambrose 2011).
- Large stands of arundo obstruct river flow, increase stream roughness, and create debris dams at bridge crossings, thereby increasing the risk of flooding, bank erosion, and damage to infrastructure (DiTomaso 1998, Coffman and Ambrose 2011). In a recent study of several modeled Southern California stream channels, large stands of arundo were found to significantly reduce flood capacity and alter river geomorphology (NHC 2011).
- Arundo is a strong competitor in systems with increased nutrient supply, and heavy fertilizer use may be an important factor aiding its dominance over native riparian plant species in the Santa Clara River watershed (Coffman 2007). It outcompetes native plant species such as willows, mulefat, and cottonwoods, which provide bird nesting habitat for protected least Bell's vireo (*Vireo bellii pusillus*) and southwestern willow flycatcher (*Empidonax traillii eximus*) (Bell 1997, Kisner 2004, Coffman and Ambrose 2011). Silica in arundo leaves and stems reduces herbivory by many native insects and grazers, and its dense growth form can physically restrict wildlife movement through the riparian corridor (Jackson and Nunez 1964 and Kisner 2004, as cited in Coffman and Ambrose 2011).

In the same way that arundo has a multitude of impacts on riparian ecology, treatment of arundo can have a variety of benefits. Reducing the amount of arundo in and adjacent to the riparian corridor can help disrupt the arundo-fire cycle and reduce the risk, extent, and intensity of wildfires. Studies have estimated that treatment of arundo can increase the amount of water available for both ecosystem and human uses, and that the cost of arundo treatment is far outweighed by the benefit in water savings (Seawright et al. 2009, Geissow et al. 2011). Treatment of arundo in the Parkway will provide the opportunity for native vegetation to reestablish and improve the quality of riparian habitat for various wildlife species. At the Hedrick Ranch Nature Area on the lower Santa Clara River, an increase in the abundance and diversity of riparian and special-status bird species has been documented following arundo treatment and riparian restoration activities (WFVZ 2010). This has included numerous pairs of least Bell's vireo and observations of southwestern willow flycatcher and yellow-billed cuckoo (*Coccyzus americanus*).

The Feasibility Study broadly defined the strategy for non-native invasive plant removal and provided guidelines for prioritizing arundo removal projects in the Parkway:

- Projects should generally be conducted from upstream to downstream and in tributaries. These areas have lower risk of reinfestation and reduce the supply of propagules to downstream areas.
- Upland or transition zones between riparian areas and upland areas should be priority areas for removal projects to reduce the supply of propagules to lower areas and to reduce the fire risk to the riparian corridor and adjacent vegetation types.

- Watersheds with low nutrients should be priority areas for removal projects, as these areas would be less likely to favor the reestablishment of arundo over native species.
- Projects should be conducted in the summer following flood event when biomass has already been washed downstream and it is easier to access, cut and treat the plants.
- Projects should be conducted after fires to take advantage of the loss of biomass and to suppress rapid arundo regrowth following fires.
- Projects should be done outside the breeding season (mid-March to late September) of bird species that may use arundo as nesting habitat. In addition, where large tracts of arundo are removed and reduce nesting habitat availability, projects should be quickly followed by revegetation with native riparian species to replace structural habitat for scrub-nesting birds.

While the Feasibility Study broadly defined a strategy for arundo treatment, the lack of a detailed and spatially explicit strategy has made it difficult for the Coastal Conservancy and TNC to know where to start in selecting and acquiring funding for specific treatment projects. The Coastal Conservancy wanted a comprehensive look at the arundo problem in the Parkway, as well as a strategy and a sense of the magnitude of the cost as it pursues funding opportunities. The Coastal Conservancy also recognized that too many arundo removal proposals it receives are piecemeal, uninformed, and would be unsuccessful without a scientifically supported and pragmatic strategy. Fortunately, the Feasibility Study included the development of a number of spatial data sets, including flood frequency mapping, riparian vegetation mapping, and arundo percent cover mapping, which can be used to inform a more detailed and spatially explicit strategy for arundo treatment. Contributing to this difficulty are wide ranging cost estimates for arundo treatment and uncertainty in permitting requirements and costs.

This report summarizes the objectives, methods, and results of a strategic plan for arundo treatment and post-treatment revegetation to restore native riparian habitat for parcels in the Parkway, along with permit and cost information and treatment priorities.

1.2 Goals and Objectives

The primary goal of this strategic arundo plan is to provide the information necessary for the Coastal Conservancy and TNC to select and acquire funding for specific arundo treatment and native riparian habitat revegetation/restoration projects in the Parkway. Specific objectives to support this goal are to:

- Identify effective and appropriate arundo treatment approaches for Parkway lands.
- Identify maintenance requirements, costs, and permits associated with those methods.
- Identify specific areas for the application of treatment methods and priorities for treatment on existing Parkway parcels, using existing spatial data sets (e.g., arundo percent cover, riparian vegetation, and flood frequency) and field reconnaissance.

While the Coastal Conservancy and TNC need cost estimates and specific strategies for the lands that they own or will acquire soon as part of the Parkway, they are also interested in using this strategy and subsequent studies to engage other public agencies that own river lands as well as private landowners as partners in the arundo treatment effort. Hence, while the focus of this study is on current Parkway parcels, cost estimates are provided that include other public and private lands infested with arundo in the lower Santa Clara River.

Subsequent phases of this strategic plan may expand this effort to potential, but not yet acquired Parkway parcels and/or other relevant lands in the Santa Clara River watershed. It is also important to note that areas in the Parkway that do not contain arundo are not addressed in this plan, which is focused on strategies and priorities for arundo treatment and subsequent post-treatment revegetation. Although there are a number of Parkway parcel areas that are suitable for or high priority for revegetation or other restoration strategies (such as removing or setting back levees or developing water quality treatment wetlands), it is recommended that these be addressed at the site-scale (e.g., as parcel-specific restoration plans) or as a separate strategic planning effort.

1.3 Study Area

The Santa Clara River Parkway focuses on the lower 33 miles of the mainstem Santa Clara River, downstream of the Los Angeles/Ventura County Line (Figure 1-1). This strategic arundo plan is specifically for existing parcels in the Parkway, and is organized by the 13 Parkway parcel complexes (i.e., smaller adjacent parcels have been merged into one complex name in some cases): Totlcom, McGrath, Strathmore, Santa Clara Ranch, Hanson-Villanueva, City of Santa Paula, Prairie Pacific, Peto, Hedrick Ranch, Valley View, Aflalo, Lago Marcino, and Vulcan (Figure 1-2).

The Santa Clara River originates on the northern slopes of the San Gabriel Mountains in Los Angeles County (approximately 9,000 ft above mean sea level). It flows through the Santa Clara River Valley and the Oxnard Plain in Ventura County before emptying into the Pacific Ocean near the City of Ventura (Figure 1-1). The river is one of the largest watersheds on the southern California coast, draining an area of approximately 1,600 mi^2. Consistent with other rivers in the region, the Santa Clara River watershed experiences highly variable annual rainfall and peak river flows. During the dry summer season, flows in the mainstem and tributaries are intermittent or non-existent, depending primarily on areas of rising groundwater or inflows from dam releases or other anthropogenic sources, such as irrigation runoff and treated wastewater effluent (Stillwater Sciences 2007a). During winter rainfall events, however, flows can increase, peak, and subside rapidly, with the potential for severe flooding under saturated or near-saturated watershed conditions. In planform, the lower Santa Clara River is characterized by a wide, relatively straight floodway with one or more low-flow channels that are reconfigured after each flood event. The full mainstem channel bed is occupied only during higher magnitude floods, typically larger than a 5-year event. As floods recede, the river becomes more braided in character, with multiple flow courses. There is insufficient perennial flow to retain multiple flowing channels in a majority of the lower Santa Clara River and, in general, a single dominant channel defines the channel thalweg (Stillwater Sciences 2007a).

Arundo is abundant and well distributed throughout the 500-year floodplain of the lower river (Figure 1-3). Arundo-specific vegetation mapping indicates that the species occurs at varying levels of percent cover on 5,242 ac of the lower river corridor (Stillwater Sciences and URS 2007). There are approximately 216 ac with 80–100% arundo cover, where the vegetation generally has a dense, continuous shrub layer completely dominated by arundo (Figure 1-3). Another 1,290 ac have 20–79% arundo cover, where mulefat (*Baccharis salicifolia*) or various willow species (*Salix* spp.) are generally co-dominant species, and another 3,736 ac have 1–19% arundo cover, where arundo is generally a component of the shrub or understory layers of mixed riparian forest and scrub communities (Figure 1-3). Figure 1-3 is based on conditions and arundo levels in 2005 and 2006 and there is the potential that some areas may have been invaded or reinvaded by arundo (particularly riverwash areas that were bare in 2005 as a result of a recent flood). Remapping arundo on Parkway parcels was, however, beyond the scope of this plan. As such, updated mapping of arundo, and tailoring the arundo treatment and post-treatment revegetation types and priorities accordingly, to capture current conditions is likely to be necessary at the site-scale before proceeding with arundo treatment implementation.

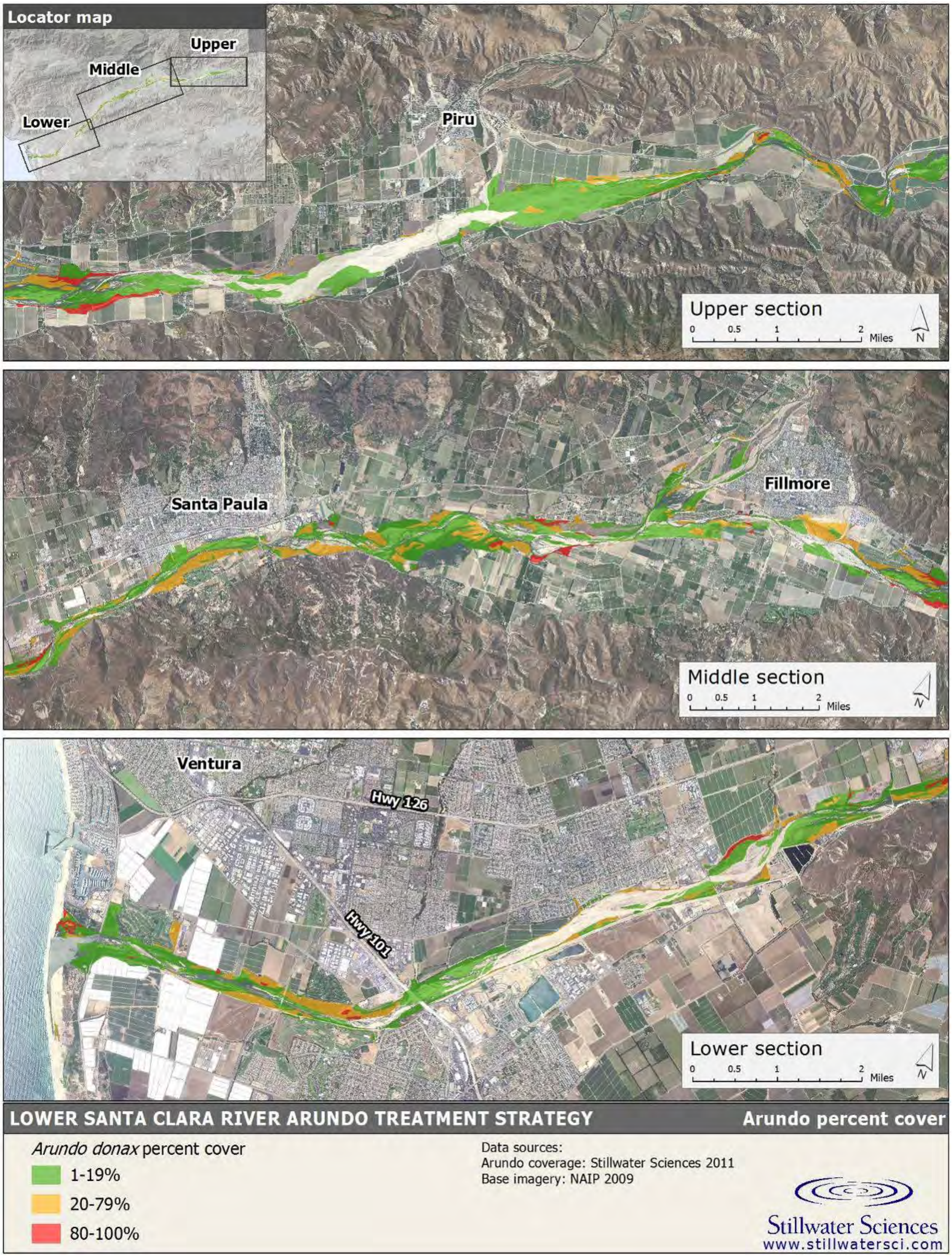

Figure 1-3. Percent cover of arundo in the lower Santa Clara River 500-year floodplain.

2 ARUNDO TREATMENT METHODS AND COSTS

Initial investigations into arundo treatment costs revealed a very wide range of costs/acre, depending on the project region, project size, methods, permitting effort, degree of arundo infestation, and other factors (Appendix A). Several arundo treatment experts with experience in the region were interviewed to identify the most effective treatment methods, the most important determinants for cost, and costs per acre for treatment methods and site conditions that would be characteristic of the lower Santa Clara River. Application of approved herbicides (e.g., imazapyr and glyphosate) and associated adjuvants (materials such as surfactants, dyes, and oils that aid in the application of herbicides), whether on standing arundo, cut arundo stumps, or regrowth after cutting, was unanimously considered the most effective method for treating arundo under the kinds of conditions in the Parkway. The cutting and removal of arundo stems, whether prior to or following herbicide treatment, is the most expensive component of arundo treatment projects. Cutting arundo stems prior to herbicide treatment (also referred to as biomass removal) can be accomplished using mechanical (e.g., mowing and/or mulching) and/or hand techniques, with hand methods being much more time consuming and expensive. Arundo treatment projects may be required to remove or dispose of cut or dead arundo stems from the river or floodplain after herbicide treatments to reduce the perceived risk of fire and/or flooding to adjacent lands and infrastructure and the potential for arundo propagules to be transported downstream. Depending on the disposal method, for example whether stems can be mulched on site or must be disposed of at a landfill, this greatly increases the cost of arundo treatment projects and can easily make many projects financially unfeasible.

The most common methods for arundo treatment in Southern California, and their associated costs, are summarized below and in Table 2-1. Appendix A lists the various cost estimates gathered, considered, and used to develop the estimates provided in Table 2-1.

- **Spray only.** This method has been shown to be effective in Southern California areas where leaving dying and dead arundo stems is appropriate (e.g., in areas with low arundo cover and/or where dead material will not increase fire risks) (Giessow 2010, Neill 2010). Approved herbicides are sprayed directly onto standing arundo stems, either via backpack sprayers or vehicle-mounted spray tanks (Katagi et al. 2002). Because this method does not involve biomass removal it is one of the more cost-effective and straightforward methods to implement (Table 2-1).
- **Contingency.** This method is a variation on spray only. Herbicide is sprayed onto the regrowth of arundo that has recently been scoured by floods or burned by fire. Under these conditions, much of the arundo biomass and surrounding vegetation has been removed, which facilitates access, reduces the amount of regrowth that must be sprayed, and is the cheapest treatment method to implement (Table 2-1).
- **Bend-and-spray.** This method requires minimal crews and equipment and minimizes the risk of herbicide application to non-target vegetation. As such, it is one of the most suitable methods for remotely located, small to moderately sized infestations, with interspersed native vegetation (Newhouser 2008, Coffman and Ambrose 2011). The bend-and-spray method involves at least one worker bending arundo stems away from native vegetation and an herbicide applicator spraying the bent stems with an approved herbicide (Coffman and Ambrose 2011). The hook-and-spray method is a variation of this method that involves only an applicator, who hooks and bends arundo stems with one hand and sprays the bent stems with herbicide with the other (Coffman and Ambrose 2011). These methods are described in more detail by Coffman and Ambrose (2011). If dead arundo stems treated with these methods can be left in place, these methods are similar in cost to spray only, although slightly more expensive due to the increase in

labor hours (to bend or hook the stems) (Table 2-1). If dead arundo stems must be mulched or removed, then the cost is significantly higher (Table 2-1).

- **Cut-and-daub/cut-and-spray.** Depending on the method with which arundo stems are cut, this method can be appropriate in a wide variety of conditions. Both methods include cutting arundo stems at or near the ground surface. Using cut-and-daub, cut arundo stumps are immediately painted with an herbicide (Coffman and Ambrose 2011). Using cut-and-spray, cut stems are allowed to regrow for a season or two and then sprayed with herbicide. In dense arundo infestations that can be accessed by vehicles, arundo stems can be cut with modified mowers and/or mulchers. In less dense infestations or where access is constrained, arundo stems can be cut with a chainsaw or hand tools. Because cut arundo stems can sprout into new arundo plants, it is important that cut stems not be allowed to fall in or near waterways. These methods are described in more detail by Coffman and Ambrose (2011). As with bend-and-spray methods, the cost of this method is significantly less if cut arundo stems can be left in place rather than mulched or removed (Table 2-1).
- **Maintenance/retreatment.** Arundo treatment projects should plan for approximately five years of follow-up treatments or maintenance to ensure that all arundo biomass is killed (Giessow 2010, Neill 2010). Since retreatment is done on previously cut and/or treated arundo, it generally consists solely of herbicide application and is relatively cost effective to conduct (Table 2-1).

The timing of these methods is critical to their success, but is constrained by arundo life history (i.e., when it is growing and would most effectively translocate herbicide into the root system), seasonal climate conditions (when herbicides can be safely and effectively applied), and the bird nesting season (March to September). Late summer through early fall (August to October) is frequently when herbicides are applied to standing arundo stems, or to stems that have been cut the previous winter. This timing avoids the bird nesting season and can maximize the efficacy of glyphosate herbicide, but can also allow for significant arundo regrowth (in which case access is constrained and more herbicide is necessary). Herbicide application to standing or previously cut arundo stems in spring or early summer, when arundo is actively growing, can maximize the translocation of herbicide, particularly imazapyr, into the root system (and more quickly kill the plant) and reduces the potential for significant arundo regrowth, but must be monitored and managed carefully to avoid nesting birds. All methods will most certainly require annual maintenance for several years to ensure that treated arundo is killed. The contingency method is likely to be most appropriate in the summer following a flood or fire, and should not interfere with bird nesting, as the flood or fire will have presumably removed any potential bird nesting habitat in the immediate vicinity.

The costs in Table 2-1 are applied to the acres of arundo both within and outside of existing Parkway parcels to develop total cost estimates for treating arundo in the Parkway and in the entire lower Santa Clara River in Section 4.

Table 2-1. Arundo treatment cost/acre ranges.

Treatment type	Description	Cost/acre range*	Notes
Contingency/ Maintenance/ Retreatment	Herbicide application on scoured, burned, or previously treated regrowth	$1,000-2,000	This includes annual retreatment for all treatment types.
Spray only/bend-and-spray	Foliar herbicide application on standing biomass (i.e., no biomass removal)	$3,000-6,000	Biomass density and protection of native plants increases cost relative to Contingency-level treatment; also more herbicide and labor hours are necessary. Spray only is captured by lower end of cost range, while bend-and-spray is captured by higher end of cost range. This report combines these two treatment types into “spray only”.
Cut-and-daub/cut-and-spray	Herbicide application on cut stumps or regrowth; biomass left on site	$4,000-9,000	Cost depends on biomass removal method (e.g., mechanical, by hand, or a combination). This report refers to these methods as “mechanical”, “hand”, or “mixed”.
Cut-and-spray with disposal	Herbicide application on cut stumps or regrowth; biomass removed from site	$7,000-150,000	Cost depends on biomass removal method (e.g., mechanical, by hand, or a combination). Stem removal is estimated to cost an additional $3,000/acre, if a flail mower is used, to $150,000/acre if hand crews are used to mulch stems (Neill 2010). This report refers to these methods as “mechanical”, “hand”, or “mixed”.

*cost estimates based on treatment of 50-acre site, with gentle gradients, and available site access.

3 ARUNDO TREATMENT PERMITS

A programmatic permitting effort for arundo treatment, such as what is already in place for the upper Santa Clara River watershed (Ventura County Resource Conservation District 2006), is underway for the lower watershed. At this time it is unknown when the programmatic permitting effort will be completed, when the permits will be acquired, and when and under what conditions individual projects may be covered under the programmatic permits. While the programmatic permits will presumably be a great asset to arundo treatment projects throughout the entire lower watershed once they are in place, the Coastal Conservancy sought to better understand individual project permitting requirements in the interim.

Regional permitting guidelines were reviewed, and relevant regulating agencies, as well as individuals experienced in arundo treatment permitting were interviewed to identify the range of potential permit requirements for arundo treatment projects in the Parkway. Table 3-1 summarizes the permits, regulating agencies, and triggers that are most relevant to arundo treatment projects in the Parkway, given the location, likely methods, and incorporated conservation measures. Much more exhaustive descriptions of these and other potential permit requirements are available from Katagi et al. (2002), Ventura County Planning Division (2006), Ventura County Resource Conservation District (2006), and Wildscape Restoration (2010).

Table 3-1. Potential permit requirements for arundo treatment projects.

Regulation	Regulating agency	Trigger for permit	Likely permit type
Clean Water Act Section 404	USACE	Working in floodway and building roads, placing thick mulch, etc	Regional General Permit 41
Endangered Species Act Section 7 or 10	USFWS and/or NOAA Fisheries	Working near federally endangered or threatened species or their critical habitat	No-take-concurrence letter, Biological Opinion, or Safe Harbor Agreement
California Fish and Game Code Section 1600	CDFG	Working in floodway and riparian zone	Streambed Alteration Agreement
Ventura County	Ventura County Watershed Protection District	Working in red-line stream in Ventura County	Encroachment/water course permit

3.1 Clean Water Act Section 404 Regional General Permit

Under Section 404 of the Federal Clean Water Act (CWA), the U.S. Army Corps of Engineers (USACE) has jurisdiction over the area between any levees on the Santa Clara River and the cross-sectional extent of high-flow debris lines, as well as any adjacent wetlands that meet USACE criteria. Projects within this jurisdiction that require the excavation of stumps, building of roads, and potentially the placement of thick mulch in this area would require a Section 404 permit. Many arundo treatment projects in the Parkway are not likely to include actions or be conducted in area that are under the USACE's jurisdiction and, therefore, will not require a Section 404 permit. Those that are determined to be under the USACE's jurisdiction (e.g., when mulch is left in place) should qualify for a Section 404 Regional General Permit (RGP) 41, which covers weed removal in areas with densities greater than 50%. RGP 41 includes CWA Section 401 certification from the Regional Water Quality Control Board, but will trigger the need for

Section 7 consultation with U.S. Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Service (NOAA Fisheries). A Section 404 RGP can take a few months to complete and acquire.

3.2 Endangered Species Act consultation

Whether or not a Section 404 permit is required, federal Endangered Species Act (ESA) consultation (under either Section 7 or 10) with USFWS and/or NMFS is likely to be required given the presence of federally listed species in and around the Parkway. For most treatment projects in the Parkway, No Take Concurrence from USFWS and/or NMFS should suffice, so long as projects incorporate take avoidance measures and are not so large that listed bird species may need to nest elsewhere. No Take Concurrence typically takes approximately 30 days. If these conditions do not apply, then a Biological Opinion (if a Section 404 permit is required) or a Safe Harbor Agreement (if a Section 404 permit is not required) may be necessary. These processes can take several months to a year.

3.3 Fish and Game Code Section 1600 Streambed Alteration Agreement

All arundo treatment projects in the Parkway will likely require a Section 1600 Streambed Alteration Agreement from the California Department of Fish and Game (CDFG). In fact, a Section 1600 permit may be the only permit required for many arundo treatment projects in the Parkway, since many of these projects are unlikely to trigger federal or local permits due to their location and magnitude. The programmatic Section 1600 permit recently acquired by TNC (Notification No.1600-2010-0196-R5) should cover most arundo treatment projects in the Parkway, as additional parcels can be easily added to the TNC permit. There are, however, several requirements of the TNC Section 1600 permit that will affect the cost and schedule of treatment projects, including:

- Pre-project surveys for special-status species must be done three weeks before start of project;
- All project field staff must attend environmental training sessions(s);
- A biological monitor must be on-site during all treatment work; and
- Development and implementation of mitigation and/or restoration plans may be required.

3.4 Ventura County Watershed Protection District Encroachment Permit

An encroachment permit from the Ventura County Watershed Protection District (VCWPD) is required for any project within the 100-year floodplain of the red-line stream. The permit application requires a $215 fee, a $2,000 trust deposit (against which VCWPD permit staff charge their time), and proof of insurance. It may also require a hydraulic assessment report if the project would leave a notable amount of mulch within the stream channel or includes extensive revegetation.

4 ARUNDO TREATMENT AND POST-TREATMENT REVEGETATION TYPES AND PRIORITIES

4.1 Methods

4.1.1 Primary flood reset zone

One of the most important aspects of this study is the identification of the primary flood reset zone. The identification and use of this zone may provide the single biggest cost saving opportunity in planning and implementing arundo treatment projects on the lower Santa Clara River, particularly when compared to conventional site-specific bottom-up arundo removal programs that do not take landscape-scale processes into consideration. The primary flood reset zone was defined to identify areas suitable for arundo treatment projects, the type of arundo treatment methods that will be appropriate, and the level of revegetation that may be necessary. The primary flood reset zone was defined by the combined extents of scoured or partially scoured areas from the 1995 and 2005 floods in GIS (see Stillwater Sciences 2007a), which were 13- and 16-year flood events, respectively. As such, the primary flood reset zone is an estimation of the area that is likely to be reset via scour and/or deposition in the next 10- to 20-year flood event.

The physical removal of arundo biomass greatly increases the cost of arundo treatment projects. Floods, as well as fires, are effective at clearing large swaths of arundo biomass, and present obvious opportunities for cost effective treatment, since treatment would consist only of herbicide application (see Table 2-1). The flood reset zone provides an estimate of the arundo-infested areas that are highly likely to be scoured and have arundo biomass removed naturally during a high-flow event. In addition, arundo treatment in this zone will require only limited herbicide application to treat new growth from those rhizomes that do remain after a high-flow event. The primary flood reset zone is also the area that is most likely to be successfully revegetated through natural recruitment, rather than expensive active planting, which could be scoured away by a subsequent high-flow event. Major arundo treatment or revegetation expenditures in the primary flood reset zone could be undone quickly by the introduction and reinfestation of arundo from upstream sources in the watershed, further limiting the utility of treatment methods that require biomass removal or revegetation that requires active planting.

4.1.2 Arundo treatment types

Outside the primary flood reset zone, arundo percent cover and vegetation composition (Stillwater Sciences and URS 2007) were the primary variables used to identify areas suitable for arundo treatment projects and the treatment approach that may be appropriate on Parkway parcels. In addition, a field reconnaissance was conducted to evaluate opportunities and constraints to various methods of arundo treatment in the Parkway.

Arundo percent cover outside the primary flood reset zone was divided into three categories that, based on our experience mapping arundo in the watershed, we believed would be indicative of the range of site conditions and type of treatment methods that may be appropriate in the Parkway: 1–19%, 20–79%, and 80–100%. Arundo percent cover was overlaid with vegetation mapping of the lower Santa Clara River in GIS to determine the degree and type of native vegetation that may be interspersed with arundo in different areas. Whether or not arundo biomass removal would likely be required was also evaluated to determine appropriate treatment types and associated costs. In some areas, it may be feasible and appropriate to spray arundo biomass directly with herbicide and leave the dead stems standing in place (i.e., spray only). Due to the fire risk associated with dead arundo biomass, however, the spray only treatment type was no considered suitable in areas with very large tracts of arundo or near developed areas. Table 4-1 summarizes the evaluation process used to identify arundo treatment types for Parkway parcels (these treatment types correspond to one or more of the treatment methods described in Section 2). These decision rules were applied in a GIS to identify the arundo treatment types for specific areas of Parkway parcels, and modified as necessary to reflect opportunities and constraints in specific parcel areas.

Table 4-1. Decision rules to identify arundo treatment types.

Decision rule	Treatment type
1. Arundo inside primary flood reset zone	Flood contingent (foliar herbicide application following floods, and potentially fire)
1’ Arundo outside primary flood reset zone	
2. No biomass removal required	Spray only (foliar herbicide application on standing stems)
2’ Biomass removal required	
3. Arundo % cover > 80	Mechanical (mowing as lone or primary biomass removal method prior to foliar herbicide application)
3’ Arundo % cover <80, >20	Mixed (combination of mowing and hand removal of biomass prior to foliar herbicide application)
3’’Arundo % cover <20	Hand (hand removal of biomass prior to foliar herbicide application)

4.1.3 Post-arundo treatment revegetation types

Revegetation of native plants follow arundo treatment can increase the extent and improve the quality of riparian habitat and contribute to ecosystem functioning (Stillwater Sciences 2008). The type of post-treatment revegetation – passive, active, or limited active - appropriate for arundo treatment areas on Parkway parcels was identified based on the selected arundo treatment type, the proximity of the area to native propagule sources, the potential for inundation by high-flows, the elevation and landscape position of the area, and nearby vegetation types. Arundo treatment and revegetation types were then modified as necessary to reflect opportunities and constraints in specific parcel areas. As mentioned previously, it is important to note that there are a number of Parkway parcel areas that are suitable for and/or high priority for revegetation or other types of restoration, but that are not addressed in this plan because they do not contain arundo. These areas will have to be addressed at the site-scale (e.g., as parcel-specific restoration plans) or as a separate strategic planning effort.

In areas where floodplain inundation occurs across a wide area and/or groundwater levels are high, revegetation should rely primarily on natural recruitment, or passive revegetation. These areas are well represented by the primary flood reset zone (Section 4.1.1). Vegetation mapping in 2005 and 2006 and experiments on Hedrick Ranch confirm that natural seed sources are adequate for passive revegetation in many reaches of the lower Santa Clara River (Stillwater Sciences and URS 2007, Coffman and Ambrose 2011). Passive revegetation is generally ill suited where flood flows do not inundate at least once every year or two, or where groundwater levels are documented or suspected of being inadequate to sustain plants during the growing season (Stillwater Sciences 2008). In addition to flood inundation frequency, the extent of arundo treatment (i.e., a relatively small area) and the occurrence of a diverse assemblage and/or large extent of native plants on-site or nearby that could serve as a seed or propagule source was used to determine where passive revegetation will be appropriate and effective on Parkway parcels. These types of areas are generally considered the most appropriate for passive revegetation (Katagi et al.

2002, Coffman and Ambrose 2011).

Where passive revegetation is not expected to achieve restoration goals, perhaps because of a lack of upslope or upstream seed supply, less reliable surface inundation, or shallow groundwater levels, active revegetation should be implemented. Active revegetation consists of planting, and potentially irrigating, native species seedlings, cuttings and/or seeds. Active revegetation in the most active or dynamic portions of the floodway (*i.e.*, those portions of the river that are scoured by floods every one to two years), should generally be avoided. Passive revegetation is likely to occur in these areas without any intervention, and subsequent floods are likely to scour active revegetation efforts. In addition to areas with infrequent flood inundation, active revegetation was recommended for areas on Parkway parcels where:

- a relatively large area of arundo has been treated;
- there is a lack of native plants on-site or nearby that could serve as a seed or propagule source;
- there is a high level of site disturbance by humans or the presence of other site conditions (such as depth to groundwater) that are likely to limit natural revegetation processes; and/or
- accelerated revegetation is necessary (e.g., highly disturbed or former agricultural areas, and to replace the structural habitat needed for least Bell's vireo and southwestern willow flycatcher, both endangered bird species found in the lower Santa Clara River, during breeding season).

Lower cost active revegetation actions (*e.g.*, planting cuttings without irrigation in areas of high groundwater) might also be appropriate in some passive and/or active revegetation areas (e.g., small areas immediately adjacent to the primary flood reset zone). Planting cuttings of willow and cottonwood, which are relatively inexpensive, is more appropriate in areas that receive intermediate levels of scour from flood flows to replace the loss of structure following arundo removal (Stillwater Sciences 2008). This report refers to this as limited active revegetation.

In areas designated as appropriate for active to limited active revegetation following arundo removal, a general vegetation type potentially suitable for active revegetation in the area was recommended. Vegetation types were selected based on the on-site and/or adjacent vegetation type, flood inundation frequency, presumed groundwater levels, and landscape position. For example, willow, cottonwood, and mixed riparian forest and scrub vegetation types are located in areas outside the active floodway (i.e., where significant and frequent scouring would not be expected) and in gaining reaches of the river, where active revegetation is most likely to be successful (Briggs 1996, Stillwater Sciences 2008, Orr et al. 2011). More upland vegetation types, such as oak savanna, giant wildrye, and coastal scrub, were located in areas outside the active floodway and in drier, losing reaches (Stillwater Sciences 2007b, Orr et al. 2011). Guidance for the suite of native species to include in these active revegetation types is provided by Stillwater Sciences (2007b and 2008). Since vegetation type recommendations were based primarily on GIS information, they will need to be evaluated and refined at the site-scale (e.g., as parcel-specific restoration plans) prior to implementation.

While planting just prior to the rainy season can reduce the need for irrigation (although it may increase the chances for scour by winter floods), given the semi-arid climate and lowered groundwater table in some portions of the lower Santa Clara River corridor, irrigation is likely to be necessary for most active revegetation areas (which will not be inundated frequently). In these instances, drip irrigation should be considered as it helps conserve water and limit the establishment of weedy species that can compete with planted seedlings, cuttings, and seeds (Stillwater Sciences 2007b).

4.1.4 Arundo treatment priorities

As discussed previously, the Feasibility Study described a number of general criteria used to prioritize arundo treatment projects. Coffman and Ambrose (2011) also describe criteria for arundo treatment projects, including:

- Remove arundo under mature riparian forests, especially adjacent to fire-prone shrublands;
- Remove the largest arundo propagule sources;
- Control arundo on a watershed scale; and
- Remove arundo immediately after fires or floods.

Several of the Feasibility Study and Coffman and Ambrose (2011) criteria have already been incorporated into this plan, such as the inclusion of a contingency method to treat arundo immediately after fires and floods. While removing arundo on a watershed scale (as recommended by Coffman and Ambrose [2011]) or from upstream to downstream (as recommended in the Feasibility Study) is the ultimate goal of arundo treatment efforts in the Santa Clara River, it is unfeasible, unwise, and unnecessary to wait until arundo is eradicated from the upper watershed before beginning arundo treatment in the lower watershed. It may not be possible to ever eradicate arundo from the upper watershed, and in the meantime arundo would continue to invade and degrade native habitats. In addition, there is a significant amount of arundo in the lower watershed, such as on floodplain terraces and along tributaries, that can be treated and significantly improve habitat conditions with low risk of reinfestation from upstream.

While these general arundo treatment prioritization criteria are useful, additional criteria were necessary to prioritize arundo treatment efforts on specific Parkway parcel areas. Any arundo inside the primary flood reset zone was designated as a low priority, unless a flood or fire that removes arundo biomass from the area occurs. The priority for arundo treatment in these areas, which would be limited to herbicide application, would then be increased to high priority.

To prioritize arundo treatment areas outside the flood contingency zone, the following criteria were considered qualitatively for each Parkway parcel. Responses to these questions were used to rank treatment priorities as high, medium, or low.

- On-site habitat quality – if treated, would the area protect or contribute to any on-site areas of high habitat quality?
- Adjacent habitat quality – if treated, would the area protect or contribute to any adjacent areas of high habitat quality?
- Risk of reinfestation – if treated, could the area become easily or quickly reinfested by arundo?
- Fire risk – if treated, would the area reduce the risk of fire to adjacent infrastructure (e.g., Stillwater Sciences 2008, Coffman and Ambrose 2011)?
- Special features – if treated, would the area protect or contribute to any nodes of high quality habitat or unusual vegetation types?
- Amount of surrounding arundo – if treated, would the area make a significant or strategic reduction in any surrounding arundo (e.g., Coffman and Ambrose 2011)?

4.1.5 Arundo treatment costs

The costs/ac in Table 2-1 were applied to the acres of arundo both within and outside of existing Parkway parcels to develop total cost estimates for treating arundo in the Parkway and in the entire lower Santa Clara River. For Parkway parcels, the treatment methods and acres of individual arundo areas developed in Section 4.1.2 were used to identify and apply the appropriate cost/ac range from Table 2-1 (see Table 4-

2). For example, $1,000–2,000 was used for areas identified for flood contingent arundo treatment; $3,000–6,000/ac was used for areas identified for spray only arundo treatment; and $4,000–9,000/ac was used for areas identified for cut-and-daub/cut-and-spray arundo treatment with hand, mixed, or mechanical biomass removal (see Table 4-2). The lower end of cost ranges from Table 2-1 were used to estimate best-case scenario costs, while the higher end of the ranges were used to estimate worse-case scenario costs, where arundo stem removal and disposal may be required (Table 4-2). A cost estimate for arundo treatment maintenance was also calculated using a cost/acre of $1,500 (Table 4-2).

Table 4-2. Cost/acre estimates for arundo treatment methods on Parkway parcels.

Arundo treatment type	Cost/acre		
	Best-case Scenario	Worse-case Scenario	Maintenance
Flood contingent	$1,000	$2,000	$1,500
Spray only	$3,000	$6,000	
Manual	$9,000	$150,000	
Mixed	$6,500	$78,500	
Mechanical	$4,000	$7,000	

Outside of Parkway parcels, any arundo within the primary flood reset zone was assumed to be treated on a flood contingent basis, with a cost/ac range of $1,500. Outside the primary flood reset zone, arundo percent cover was used to estimate a potentially suitable treatment method and associated cost/ac. Half of areas with 1–19% arundo cover were assumed to require arundo biomass removal by hand prior to herbicide application ($9,000/ac), with the other half assumed to be appropriate for spray only treatment ($3,000/ac). Areas with 20–79% and 800–100% arundo cover were assumed to require arundo biomass removal using mixed and mechanical techniques, respectively, prior to herbicide application ($6,500 and $4,000/ac, respectively).

Due to the assumptions and generalities included in both the cost/acre estimates (Tables 2-1 and 4-2) and the selected treatment methods, these costs should be considered rough estimates only.

4.2 Results and Discussion

4.2.1 Primary flood reset zone

The primary flood reset zone, which was defined by the combined extents of scoured and partially scoured areas from the 1995 and 2005 floods, is depicted in Figure 4-1. Of the 5,242 ac of arundo mapped at varying levels of percent cover in the lower Santa Clara River, 3,093 ac, or 60%, occurs in the primary flood reset zone. Again, arundo treatment, which would be limited to herbicide application, inside this zone would be contingent upon a flood scouring the area and removing arundo biomass naturally. In addition, natural recruitment of native riparian plant species would be the means of revegetating arundo treatment areas inside the flood contingency zone. The primary flood reset zone should be a low priority for arundo treatment, unless a flood or fire that removes arundo biomass from the area occurs, in which case the arundo herbicide treatment should be a high priority.

Again, the primary flood reset zone is only an estimate; there is likely to be scour/reset in areas outside the primary flood reset zone during 10- to 20-year flood events, and most certainly during larger flood events. In addition, floods of these magnitudes will inundate a much larger area that estimated by the primary flood reset zone, but only a portion of the area inundated is likely to be reset by scour and/or deposition.

4.2.2 Arundo treatment and post-treatment revegetation types

Following the decision rules in Table 4-1 and criteria described in Section 4.1.3, five primary arundo treatment types were identified. Table 4-3 summarizes these types and incorporates the cost estimates and permitting requirements from Sections 2 and 3. Figures 4-2 through 4-9 depict the arundo treatment and revegetation types suitable for specific areas on Parkway parcels. Since arundo treatment and revegetation type recommendations were based primarily on GIS information, they will need to be evaluated and refined at the site-scale (e.g., as parcel-specific restoration plans) prior to ultimate implementation.

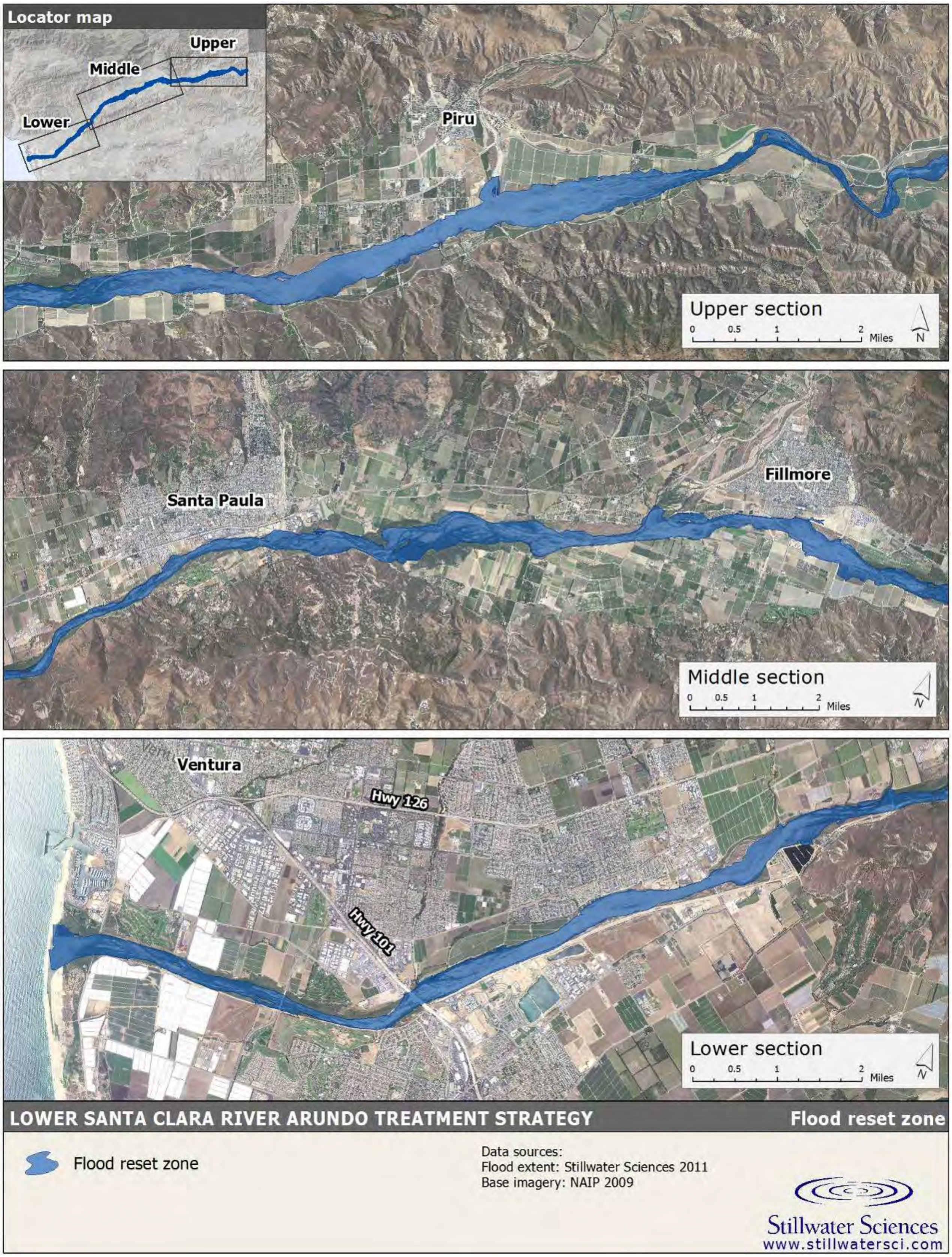

Figure 4-1. Lower Santa Clara River primary flood reset zone.

Table 4-3. Arundo treatment type descriptions.

Decision rule	Treatment type
1. Arundo inside primary flood reset zone	Flood contingent (foliar herbicide application following floods, and potentially fire) • Year 1* price estimate: $1,000–$2,000/acre • Revegetation: passive • Permitting: 1600 & USFWS/NMFS no take concurrence
1′ Arundo outside primary flood reset zone	
2. No biomass removal required	Spray only (foliar herbicide application on standing stems) • Year 1 price estimate: $3,000–$6,000/acre • Revegetation: consider passive if arundo % cover is low, active likely required if arundo % cover is high • Permitting: 1600 & USFWS no take concurrence
2′ Biomass removal required	
3. Arundo % cover > 80	Mechanical (mowing as lone or primary biomass removal method prior to foliar herbicide application)
4. No post-treatment cane removal	• Year 1 price estimate: $4,000–$6,000/acre • Revegetation: active likely required • Permitting: 1600 & USFWS no take concurrence
4′ Post-treatment cane removal required	• Year 1 price estimate: $7,000–$150,000/acre • Revegetation: consider passive • Permitting: 1600, USFWS no take concurrence, and potential USACE RGP
3′ Arundo % cover <80, >20	Mixed (combination of mowing and hand removal of biomass prior to foliar herbicide application)
5. No post-treatment cane removal	• Year 1 price estimate: $7,000–$8,000/acre • Revegetation: active likely required • Permitting: 1600 & USFWS no take concurrence
5′ Post-treatment cane removal required	• Year 1 price estimate: $10,000–$150,000/acre • Revegetation: consider passive • Permitting: 1600, USFWS no take concurrence, and potential USACE RGP
3′′Arundo % cover <20	Hand (hand removal of biomass prior to foliar herbicide application)
6. No post-treatment cane removal	• Year 1 price estimate: $8,000–$9,000/acre • Revegetation: active likely required • Permitting: 1600, USFWS no take concurrence, and unlikely USACE RGP
6′ Post-treatment cane removal required	• Year 1 price estimate: $11,000–$150,000/acre • Revegetation: consider passive • Permitting: 1600, USFWS no take concurrence, and potential USACE RGP

*Subsequent years would presumably be maintenance/retreatment only with an estimated cost of $1,000–$2,000/acre

Several Parkway parcels provide good examples of the decision rules used to identify arundo treatment and revegetation types:

- Santa Clara Ranch (Figure 4-3) is an example of where there is an obvious topographic break, in this case levees, below which active arundo treatment and revegetation is not appropriate. All of the arundo on this parcel is within the primary flood reset zone, and is highly likely to be inundated and scoured by the next high-flow event, which will likely remove arundo biomass, but could also reintroduce arundo from upstream and scour away actively revegetated areas.

- The Strathmore property (Figure 4-2) demonstrates how percent cover of arundo determines appropriate treatment types. There is over 50 acres of arundo with greater than 75% cover. This area will be suitable for mechanical removal of arundo biomass prior to herbicide application, since there are very few interspersed native trees and shrubs that would have to be protected during biomass removal. Following arundo biomass removal and treatment, active revegetation is likely to be necessary to re-establish native vegetation, since mechanical removal would be done over a relatively large area, would leave little to no native trees and shrubs remaining behind, and the area is not likely to be inundated by high flows that would reintroduce native tree and shrub propagules. Given the elevation and position of the Strathmore property and adjacent vegetation types, cottonwood and willow vegetation types are likely the most suitable for revegetation.
- The Peto parcel complex (Figure 4-6) is an example of where spray only arundo treatment methods are likely to be appropriate. In several areas, arundo is at relatively low percent cover, although there are interspersed native species that would need to be avoided. Spray only methods in these areas would no leave behind large, dense stands of dead arundo that could increase fire risk to nearby developed areas. Given the amount of native vegetation that is likely to remain following arundo treatment, passive or only limited active revegetation is likely to be required for post-treatment revegetation.
- The streambank of the McGrath property (Figure 4-2) is as an example of where hand removal of arundo biomass is likely to be required prior to herbicide application. Arundo in this area is located on a steep bank and is interspersed with native riparian trees that would need to be avoided. However, because the native trees will be retained and the area is expected to support relatively high groundwater levels, passive revegetation should be sufficient to restore habitat quality following arundo treatment.

4.2.3 Arundo treatment and post-treatment revegetation priorities

Along with the arundo treatment and revegetation type, Figures 4-2 through 4-9 depict the arundo treatment priorities for Parkway parcels. Table 4-4 summarizes the acreage of different arundo treatment and revegetation types for Parkway parcels, as well as the priority for arundo treatment.

Table 4-4. Arundo treatment and revegetation type acreages and priorities for Santa Clara River Parkway parcels.

Parkway Parcel Complex	Priority	Treatment Type	Revegetation Type	Acres
Aflalo View Complex	Low	Flood contingent	Passive to active (scale broom/alluvial scrub)	27.20
		Manual	Passive to active (scale broom/alluvial scrub)	9.41
		Mixed	Active (cottonwood/mixed riparian forest)	0.42
City of Santa Paula Complex	Low	Flood contingent	Passive	12.86
	Medium	Mixed	Limited to active (mixed willow/cottonwood-willow forest)	30.42
Hanson-Villanueva Complex	Low	Flood contingent	Passive	58.76
	High	Manual	Active (mixed willow scrub/oak savanna)	13.55
		Mechanical	Passive to limited active (mixed willow/cottonwood forest)	14.84
		Mixed	Active (coastal sage scrub/oak savanna)	24.36
			Active (mixed willow forest)	0.89
			Passive to limited active (giant wildrye)	12.01
			Passive to limited active (mixed riparian scrub)	11.32
			Passive to limited active (mixed willow/cottonwood forest)	51.70
		Spray only	Passive	13.79

Parkway Parcel Complex	Priority	Treatment Type	Revegetation Type	Acres
Hedrick Ranch-Valley View Complex	Low	Flood contingent	Passive	210.46
	High	Mixed	Passive	6.99
			Passive to active (mixed willow/cottonwood forest)	53.54
Lago Marcino Complex	Low	Flood contingent	Passive	19.77
		Spray only	Passive	2.77
McGrath	Low	Flood contingent	Passive	1.21
	Medium	Manual	Active (coastal sage scrub)	5.35
			Passive	8.79
		Mixed	Passive to limited active (mixed riparian scrub/cottonwood-willow forest)	22.12
Peto Complex	Low	Flood contingent	Passive	45.02
	High	Manual	Passive to limited active (oak savanna/mixed riparian)	3.33
		Spray only	Passive to limited active (oak savanna)	10.07
Prarie Pacific Complex	Low	Flood contingent	Passive	88.02
	Medium	Mixed	Limited to active (cottonwood-willow forest)	51.79
		Spray only	Passive	0.50
Santa Clara Ranch Complex	Low	Flood contingent	Passive	112.09
		Mixed	Passive	10.97
Strathmore	Low	Flood contingent	Passive	9.78
	Medium	Mechanical	Limited active (cottonwood-willow forest)	6.81
		Mixed	Passive	27.01
Totlcom	Low	Flood contingent	Passive	3.28
Vulcan Complex	Low	Flood contingent	Passive	306.25
		Spray only	Passive	2.36
TOTAL				1,289.83

Several Parkway parcels provide good examples of the criteria used to prioritize arundo treatment areas on Parkway parcels:

- The Hedrick Ranch-Valley View parcel complex (Figure 4-7) is an example of high priority arundo treatment to conserve and restore high on-site habitat quality. Arundo treatment and revegetation in many areas of this parcel complex will expand the extent and increase the habitat value of one of the largest remaining riparian forest complexes on the Santa Clara River.
- The Peto parcel complex (Figure 4-6) is an example of high priority arundo treatment to protect or contribute to adjacent areas of high habitat quality. Arundo treatment and revegetation on this parcel complex will expand the extent of the high-quality habitat on the Hedrick Ranch property, although there are still a number of unprotected parcels between the two.
- The entire primary flood reset zone is a prime example of an area that is low priority for arundo treatment due to the fact that it could become easily or quickly reinfested by arundo. On the other hand, the floodplain terrace on the north bank of the Hanson-Villanueva parcel complex (Figure 4-4) is an example of an area that is high priority for arundo treatment since it is at low risk for flood inundation and arundo reinfestation.
- The southern portions of the Hanson-Villanueva and Prairie Pacific parcel complexes (Figure 4-4 and 4-5) are examples of high priority arundo treatment to reduce the risk of fire. Arundo treatment in these areas could help reduce the risk of fire spreading from more fire-prone upland vegetation types on South Mountain, through the riparian corridor, and toward developed areas on the northern side of the river.

- The Peto parcel (Figure 4-6) is an example of where arundo treatment is of high priority because it would protect or contribute to nodes of unusual vegetation types. This parcels supports vegetation types such as elderberry and live oak savanna and desert riparian scrub that are relatively rare in the lower Santa Clara River and broader region and that could be degraded if arundo is left to invade.
- Due to their large extents, the Hedrick Ranch-Valley View and Hanson-Villanueva parcel complexes (Figures 4-7 and 4-4) are examples of high priority arundo treatment that would make a significant or strategic reduction in surrounding arundo.

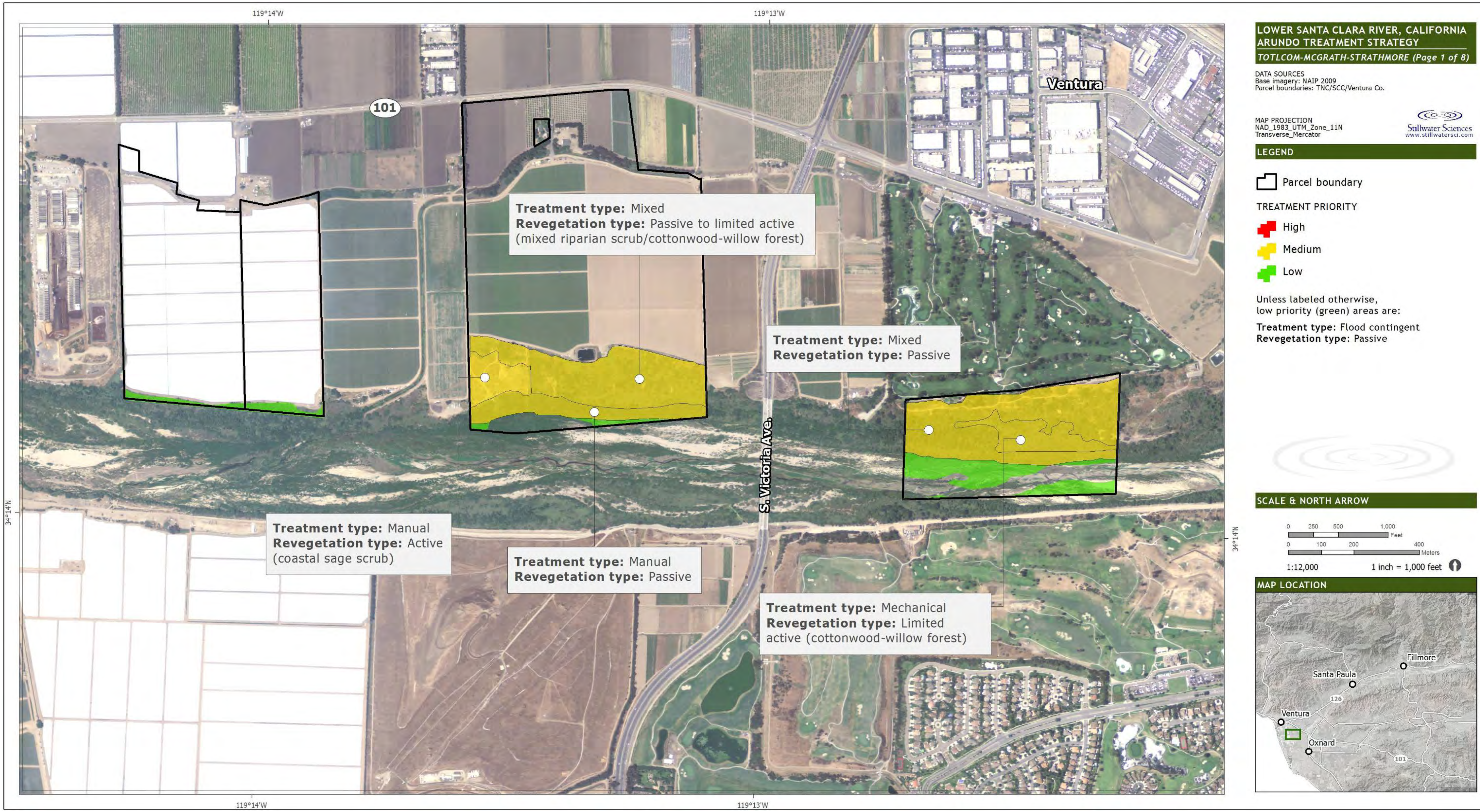

Figure 4-2. Arundo treatment types, revegetation types, and priorities for the Totlcom, McGrath, and Strathmore parcels.

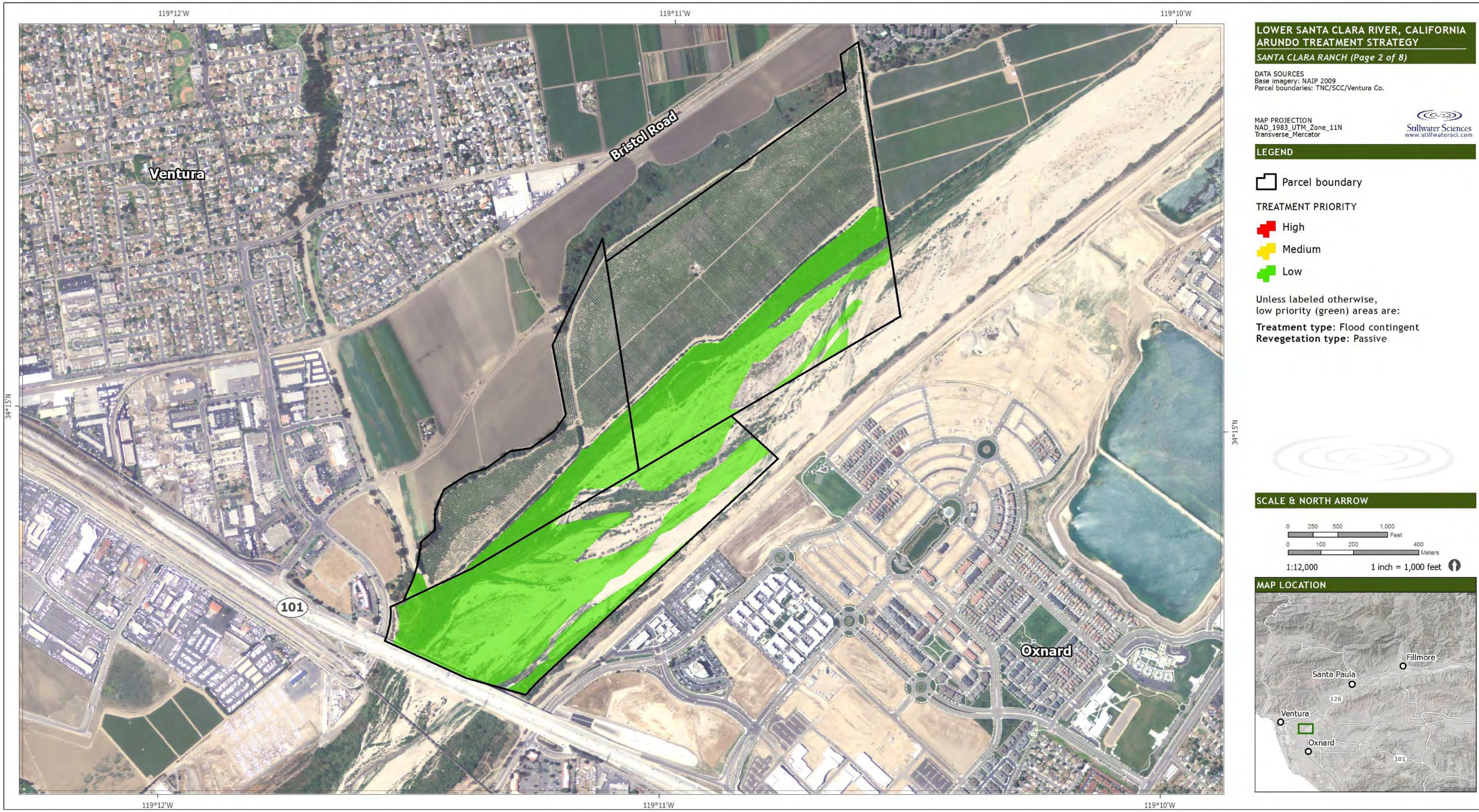

Figure 4-3. Arundo treatment types, revegetation types, and priorities for the Santa Clara Ranch parcels.

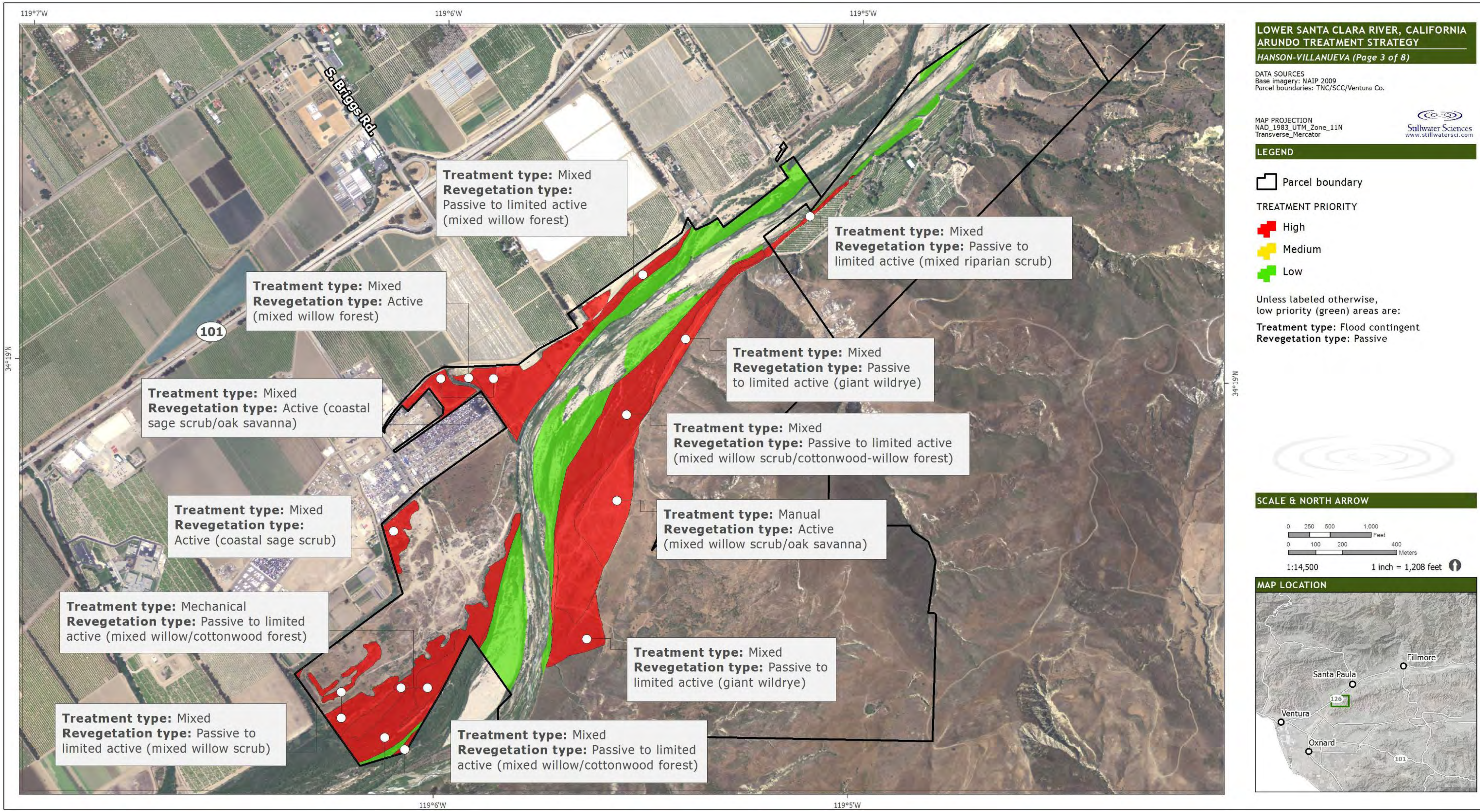

Figure 4-4. Arundo treatment types, revegetation types, and priorities for the Hanson-Villanueva parcels.

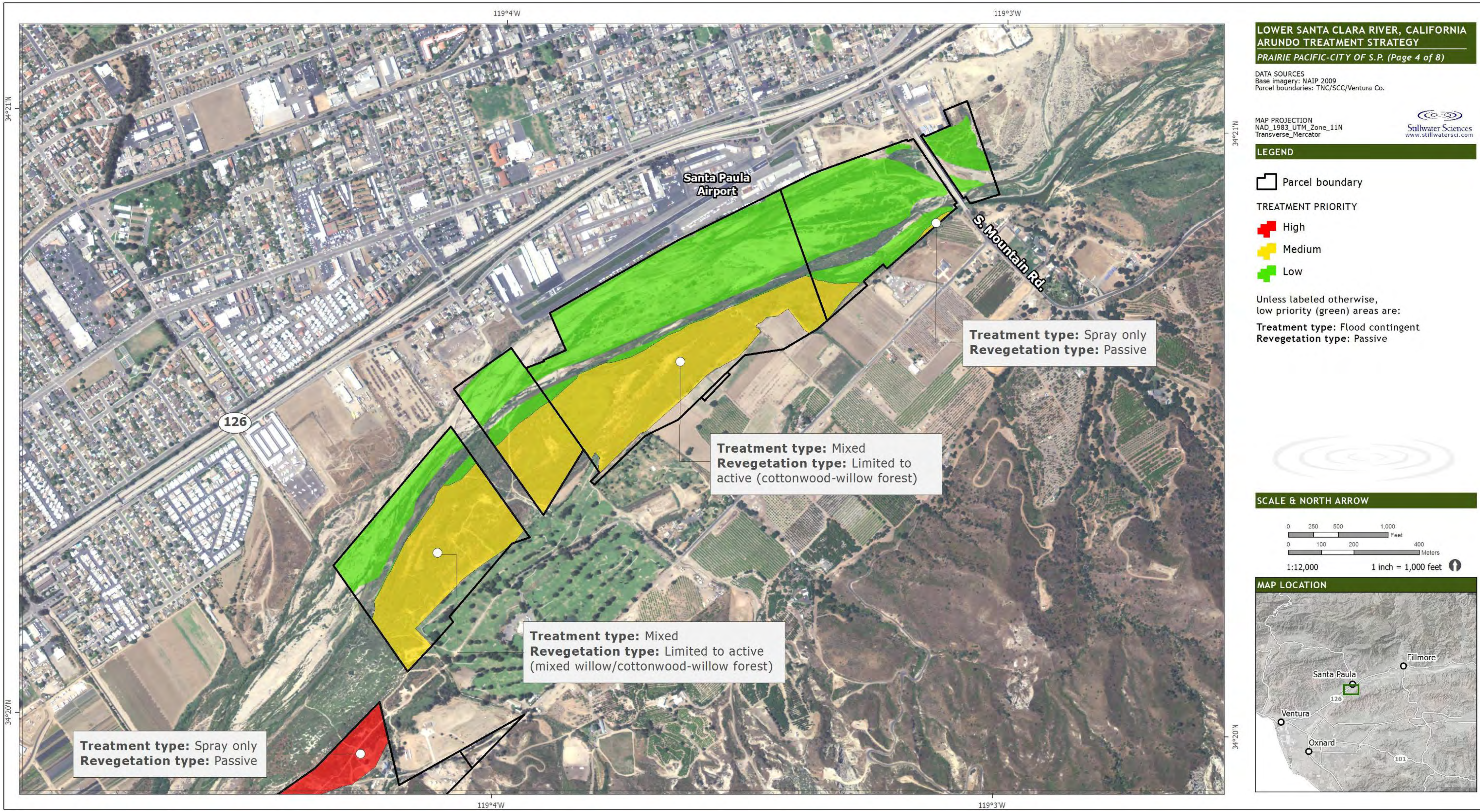

Figure 4-5. Arundo treatment types, revegetation types, and priorities for the Prairie Pacific and City of Santa Paula parcels.

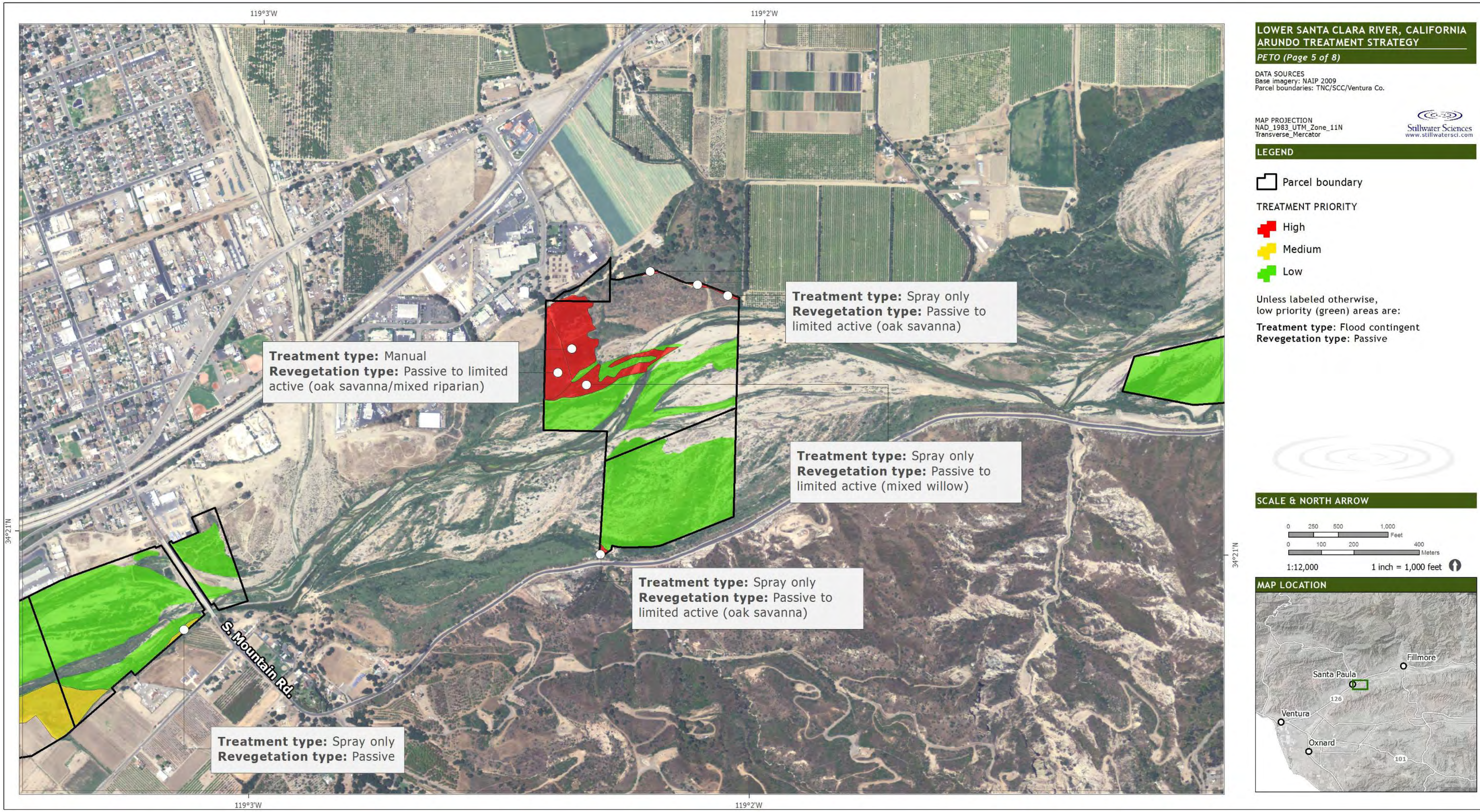

Figure 4-6. Arundo treatment types, revegetation types, and priorities for the Peto parcel.

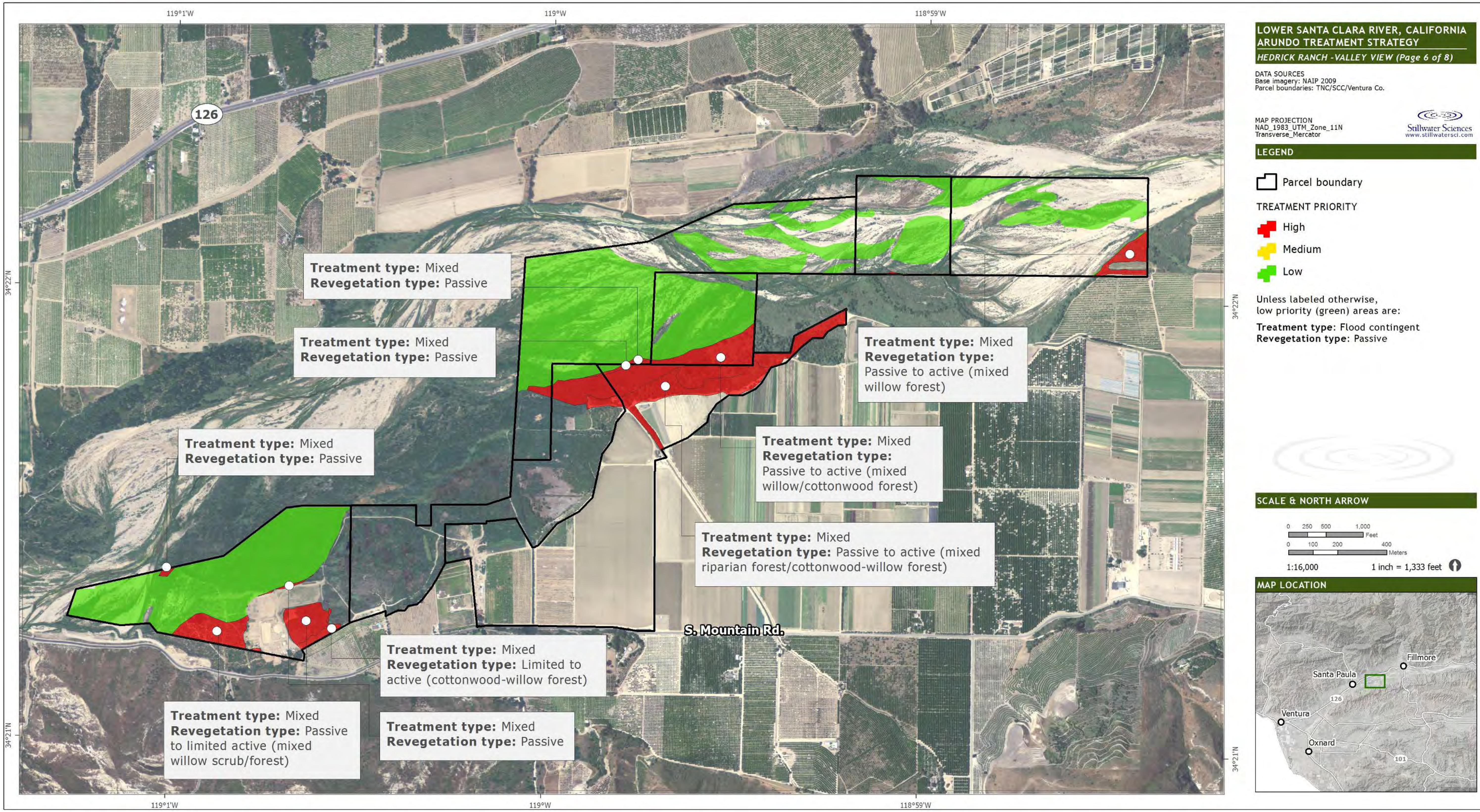

Figure 4-7. Arundo treatment types, revegetation types, and priorities for the Hedrick Ranch and Valley View parcels.

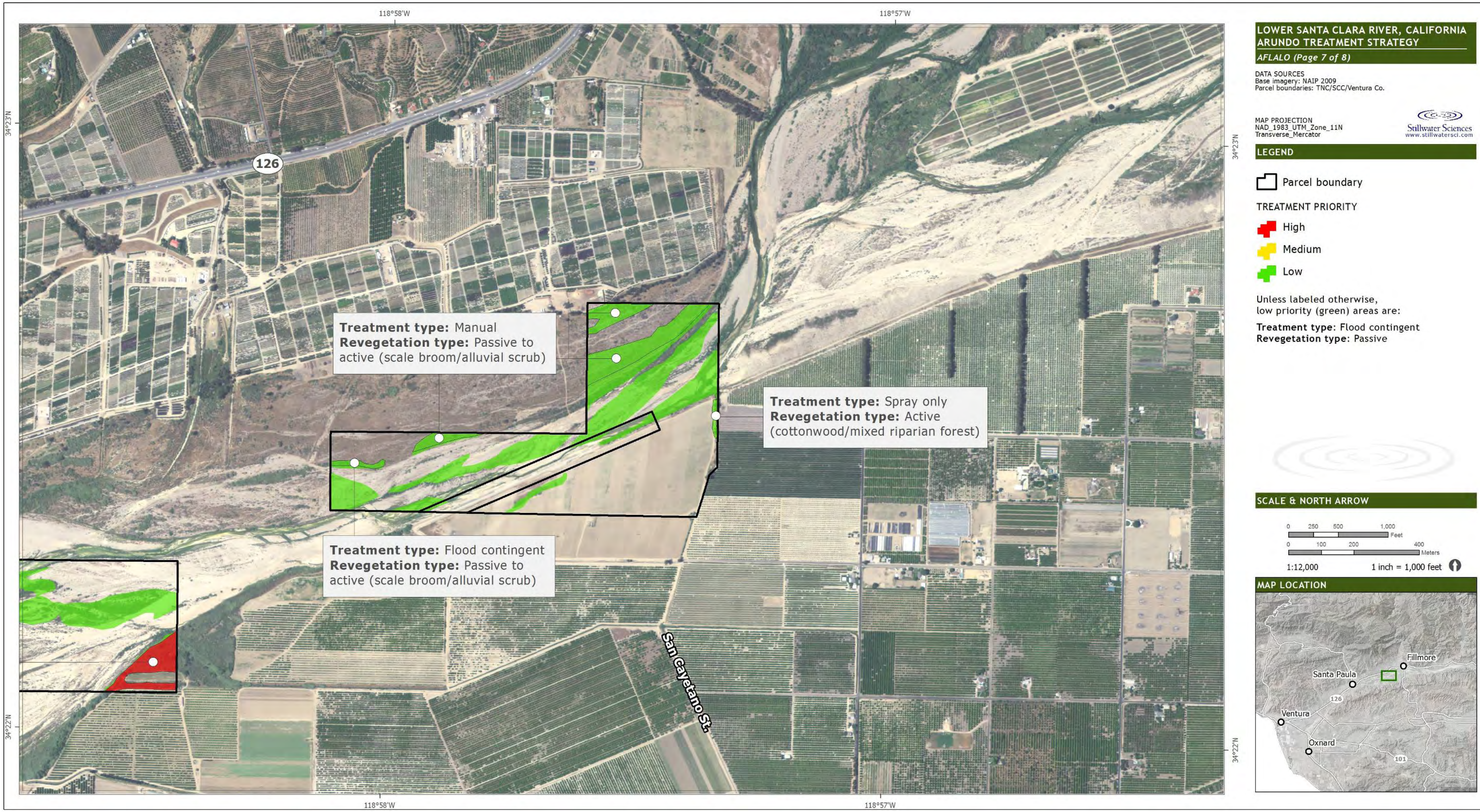

Figure 4-8. Arundo treatment types, revegetation types, and priorities for the Aflalo parcel.

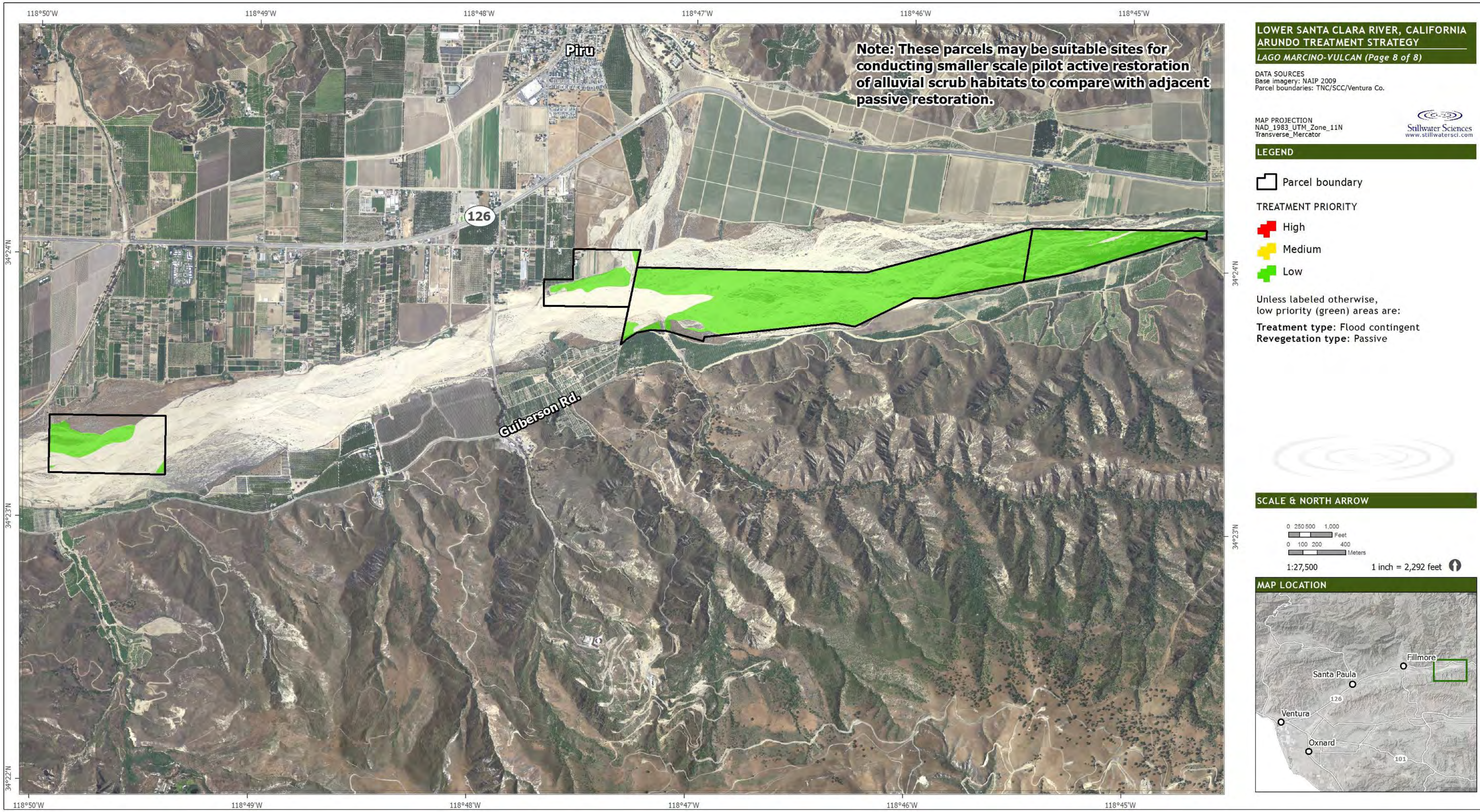

Figure 4-9. Arundo treatment types, revegetation types, and priorities for the Lago Marcino and Vulcan parcels.

4.2.4 Arundo treatment costs

Table 4-5 summarizes the estimated costs for arundo treatment on current Parkway parcels, based on the treatment methods and acres of individual arundo areas in Table 4-4 and costs/ac in Table 4-2. The total cost for arundo treatment on current Parkway parcels, under a best-case scenario, is estimated to be $3.4 million. Under a worse-case scenario, where arundo biomass removal and disposal is required, treatment of arundo on current Parkway parcels is estimated to be $32 million. The cost of arundo treatment maintenance on current Parkway parcels is estimated to be just under $2 million/year, or $9.5 million for five years of maintenance.

Table 4-5. Arundo treatment cost estimates for Santa Clara River Parkway parcels.

Parkway Parcel Complex	Treatment Type	Acres	Best-case Cost	Worse-case Cost	Maintenance Cost
Aflalo View Complex	Flood contingent	27.20	$ 27,200	$ 54,400	$ 40,800
	Manual	9.41	$ 84,700	$ 1,411,800	$ 14,100
	Mixed	0.42	$ 2,700	$ 32,900	$ 600
City of Santa Paula Complex	Flood contingent	12.86	$ 12,900	$ 25,700	$ 19,000
	Mixed	30.42	$ 197,700	$ 2,387,900	$ 45,600
Hanson-Villanueva Complex	Flood contingent	58.76	$ 58,800	$ 117,500	$ 88,100
	Manual	13.55	$ 121,900	$ 2,031,800	$ 20,300
	Mechanical	14.84	$ 59,400	$ 103,900	$ 22,300
	Mixed	100.28	$ 651,800	$ 7,872,300	$ 150,400
	Spray only	13.79	$ 41,400	$ 82,700	$ 20,700
Hedrick Ranch-Valley View Complex	Flood contingent	210.46	$ 210,500	$ 420,900	$ 315,700
	Mixed	60.53	$ 393,400	$ 4,751,600	$ 90,800
Lago Marcino Complex	Flood contingent	19.77	$ 19,800	$ 39,500	$ 29,700
	Spray only	2.77	$ 8,300	$ 16,600	$ 4,200
McGrath	Flood contingent	1.21	$ 1,200	$ 2,400	$ 1,800
	Manual	14.13	$ 127,200	$ 2,120,000	$ 21,200
	Mixed	22.12	$ 143,800	$ 1,736,800	$ 33,200
Peto Complex	Flood contingent	45.02	$ 45,000	$ 90,000	$ 67,500
	Manual	3.33	$ 30,000	$ 499,800	$ 5,000
	Spray only	10.07	$ 30,200	$ 60,400	$ 15,100
Prarie Pacific Complex	Flood contingent	88.02	$ 88,000	$ 176,000	$ 132,000
	Mixed	51.79	$ 336,600	$ 4,065,500	$ 77,700
	Spray only	0.50	$ 1,500	$ 3,000	$ 700
Santa Clara Ranch Complex	Flood contingent	112.09	$ 112,100	$ 224,200	$ 168,100
	Mixed	10.97	$ 71,300	$ 861,000	$ 16,500
Strathmore	Flood contingent	9.78	$ 9,800	$ 19,600	$ 14,700
	Mechanical	6.81	$ 27,300	$ 47,700	$ 10,200
	Mixed	27.01	$ 175,600	$ 2,120,700	$ 40,500
Totlcom	Flood contingent	3.28	$ 3,300	$ 6,600	$ 4,900
Vulcan Complex	Flood contingent	306.25	$ 306,300	$ 612,500	$ 459,400
	Spray only	2.36	$ 7,100	$ 14,200	$ 3,500
TOTAL		1,289.83	$ 3,406,700	$ 32,010,000	$ 1,934,700

Table 4-6 summarizes the estimated costs for arundo treatment outside of current Parkway parcels, based on the primary flood reset zone, arundo percent cover, and the costs/ac described in Section 4.1.5. The total cost for arundo treatment outside current Parkway parcels is roughly estimated to be just under $14 million (Table 4-6). Combining the totals from Table 4-5 and 4-6, the estimated cost for arundo treatment of the entire lower Santa Clara River, under a best-case scenario, is roughly $17 million, while under a worse-case scenario, it is roughly $46 million. Again, due to the assumptions and generalities included in both the cost/acre ranges and the selected treatment methods, these costs should be considered rough estimates only.

Table 4-6. Arundo treatment cost estimates for the lower Santa Clara River outside of Santa Clara River Parkway parcels.

Area	Treatment Type	Acres	Cost
Within Primary Flood Reset Zone	Flood contingent	2209.74	$ 3,314,600
Outside Primary Flood Reset Zone			
1-19% arundo cover	Spray only	460.54	$ 1,381,600
	Hand	460.54	$ 4,144,900
20-79% arundo cover	Mixed	649.43	$ 4,221,300
80-100% arundo cover	Mechanical	170.25	$ 681,000
Grand Total		**3950.50**	**$13,743,400**

5 ARUNDO TREATMENT AND POST-TREATMENT REVEGETATION MONITORING

Long-term monitoring of restoration sites and high-quality reference sites for both aquatic and riparian habitat was recommended in the Feasibility Study to increase the understanding of the lower Santa Clara River system and assist in developing more detailed restoration plans. In particular, monitoring of the effectiveness of different types of restoration and revegetation strategies relative to environmental conditions in the Parkway area (*e.g*., gaining versus losing reaches, time since last disturbance from flood or fire) could help guide and increase the success rate of future restoration efforts.

A selection of the arundo treatment and revegetation projects specified in this plan would make excellent restoration monitoring sites. Coffman and Ambrose (2011) identify a number of appropriate arundo treatment project success criteria, monitoring methods, and statistical analyses for projects on the Santa Clara River. These methods can be easily adapted to individual, select Parkway arundo treatment projects to maximize the contribution of these projects to the collective understanding of the most effective arundo treatment and revegetation methods for the lower Santa Clara River and broader Southern California region, and associated costs.

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Appendix A
Documented arundo treatment project costs

Description	Cost/acre	Notes	Source
Permits	$2,387	For arundo removal and revegetation of an approx. 1-acre site on the beach in Santa Barbara County	Chang 2010
Glyphosate applied to hand-cut stumps	$25,765	Involved approximately 500 man-hours for an approx. 1-acre site in Santa Barbara County	Chang 2010
Biomass disposal	$2,318	21.3 tons of arundo disposed of at Santa Barbara County landfill	Chang 2010
Retreatment	$1,442	Involved approximately 68 man-hours for an approx. 1-acre site in Santa Barbara County	Chang 2010
Low-volume application of imazapyr to small clumps without cutting	$1,000-1,500	Restricted to clumps smaller than 40 ft across, treated by applicators using backpack sprayers; assumes 12 hr labor @ $60/hr for initial treatment and 2-3 follow-up visits over 2 years plus $250 for 3 qt imazapyr herbicide and adjuvant	Neill 2006
High-volume application of glyphosate to large stands without cutting	$3,000-7,000	Suitable for arundo stands as large as 1 acre, treated by 4-man crew using gasoline-powered pump, ladders and long hoses to apply 60-100 gln dilute glyphosate herbicide mixture; high end of price range includes labor to compact arundo and trim native trees where intermixed	Neill 2006
Large flail mower for biomass reduction followed by resprout spraying	$4,000-6,000	Suitable for dense stands larger than 1 acre on relatively open, level terrain; assume $3000-5000/acre for biomass reduction by flail mower and $1000/acre for low volume foliar treatment of resprouts using imazapyr herbicide	Neill 2006
Small flail or rotary mower biomass reduction followed by resprout spraying	$7,000-10,000	Suitable for steep slopes and stands intermixed with trees; assume $6000-$9000/acre for biomass reduction by smaller flail or rotary mower and $1000/acre for low volume foliar treatment of resprouts using imazapyr herbicide	Neill 2006
Chainsaw crew with portable shredder for biomass reduction followed by resprout spraying	$20,000-150,000	Suitable for locations requiring biomass reduction but not accessible to mower tractors; price range depends on stand density, accessibility, amount of dead thatch, etc.	Neill 2006
Herbicide application (single treatment)	$850		Simmons and Berry, no date
Biomass removal and mulching	$3,116		Simmons and Berry, no date
Maintenance	$2,000	Cost per year	Simmons and Berry, no date
None provided	$9,333	Cost per acre for 1,500 acres on the Santa Ana River	Simmons and Berry, no date
None provided	$15,000	Cost per acre for 290 acres on the San Luis Rey	Simmons and Berry, no date

Description	Cost/acre	Notes	Source
None provided	$1,000	Cost per acre for 1,000 acres on the Russian River	Simmons and Berry, no date
None provided	$34,000	Cost per acre for 0.25 acre on the Trabucho Creek	Simmons and Berry, no date
None provided	$20,000-80,000	Includes five-years of retreatments	Russell 2010