SYCAMORE ALLUVIAL WOODLAND
Planting Guide

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Prepared for
Loma Prieta Resource Conservation District

Prepared by
San Francisco Estuary Institute
and
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Photo of sycamore leaves (Amy Richey, SFEI, 2017).

INTRODUCTION

This memo builds on recent field-based studies which examined the relative distribution, health, and regeneration patterns of two major stands of sycamore alluvial woodland (SAW) in Santa Clara County. Given that the acquisition, restoration, and improved management of SAW is mandated as part of the Santa Clara Valley Habitat Plan (VHP), it is increasingly critical to understand how, when, and where sycamores establish, which is critical for successful restoration design and planting success. This memo is meant to summarize recent studies on habitat requirements of the SAW habitat type, and present a planting plan and monitoring framework for restoring SAW habitat at two sites in Santa Clara County. As the science and restoration of SAW is an ongoing topic of interest, we also suggest possible subsequent studies needed to further sycamore restoration goals.

California sycamore *(Platanus racemosa)* is an iconic tree species native to California and northern Baja California. It is the defining feature of SAW, a habitat type defined as 'open to moderately closed, winter-deciduous broad-leaved riparian woodland dominated by wellspaced California sycamore' (Holland 1986), and is often associated with intermittent, braided stream reaches with relatively stable groundwater levels and periodic flooding (Keeler-Wolf et al. 1996). Vulnerable wildlife species are often associated with this habitat type, including western pond turtle *(Actinemys marmorata)* and steelhead trout *(Oncorhynchus mykiss)* (Belli 2015, Casagrande 2010). Given their large size and significant accumulation of dead wood and branches, sycamores provide substantial nesting and roosting habitat for a variety of bird species, as well as seed and insect food sources, relative to many other riparian trees (Bock and Bock 1981).

In California, SAW habitat is relatively rare. The distribution and regeneration of SAW has been greatly limited by the loss of such habitat over the past 200 years, largely as a result of changes to flow and sediment dynamics from dams and the removal of floodplains from the influence of regular flooding (Keeler-Wolf et al. 1996). It has been mapped in just 17 occurrences along intermittent streams in California totaling approximately 2,000 acres (Keeler-Wolf et al. 1996). Thus, conservation and restoration of this habitat type is a priority for many regions.

Regionally, the physical processes which create and maintain SAW have largely been interrupted. Natural flood events are critical to deposit fresh alluvial sediment, carry and deposit seeds, and recharge groundwater levels, which then draws down over time (Keeler-Wolf et al. 1996). These conditions are necessary for sycamores to produce and lay a successful seed set for sexual reproduction (Keeler-Wolf et al. 1996). As in most California watersheds, dams have cut off peak flows, thus limiting substantial flood events, coarse sediment deposition, and scour, resulting in altered hydrographs. These dams and other water management practices have often transformed intermittent streams into perennial streams (Kamman Hydrology 2009). Groundwater pumping has altered natural draw-down curves, altering the subsurface conditions to which the sycamore species likely evolved (Gilles 1998, King 2004). Grazing, vegetation management, and other land use changes such as road encroachments and habitat conversion have further altered conditions that support SAW.

If supportive physical conditions can be re-established, SAW might be a cost-effective restoration target ecosystem, given future projections of increased human water demand, increased drought frequency and severity, and sycamores' ability to thrive with limited summer water and intermittent flows (Grossinger et al.

2008). The health and regeneration of existing California sycamore stands has been affected by a wide range of factors, including loss of habitat, hydrologic modifications of creeks, hybridization with the non-native London plane tree *(Platanus × hispanica),* and pathogens such as sycamore anthracnose. While recognizing this range of factors that affect existing SAW habitat, the biotic and abiotic factors influencing sycamore regeneration are, in general, poorly understood. Several studies have been completed or are underway to further understanding of sycamore regeneration.

KEY FINDINGS FROM PREVIOUS AND ONGOING STUDIES

In prior research conducted for the Sycamore Alluvial Woodland Habitat Mapping and Regeneration Study (Beagle et al. 2017), several site characteristics that may be favorable to SAW health and regeneration were identified. The 2017 study focused on two Santa Clara County sites; one along Pacheco Creek, with "reservoir" managed hydrology, and the other along Upper Coyote Creek, with "natural" hydrology. Additional studies at the two sites have included genetic and propagation studies, and seedling mapping.

Description of Pacheco Creek Site Pacheco Creek, which has a watershed area of 435 km^2, is a tributary to the Pajaro River, which flows into the Pacific Ocean near Moss Landing. Historically, the alluvial portion of Pacheco Creek in the study area was a broad, braided, gravel- and cobble-bedded channel with seasonally intermittent flow (Grossinger et al. 2008). It supported substantial stands of sycamore-alluvial woodland on bar and floodplain surfaces slightly elevated above the main channel (Grossinger et al. 2008). However, the construction of Pacheco Reservoir on North Fork Pacheco Creek in 1935 altered the creek's hydrologic regime; late spring/early summer reservoir releases have increased dry-season flows and reportedly converted the creek into a generally perennial system (Gillies 1998, Casagrande 2010). However, in some years, the creek is still dry during much of the summer and fall (Dave Johnston, Pers. Comm.). Land cover in the upper watershed is predominantly grassland and oak woodland (SCVOSA 2014). The study site (~2 km long) is located in an alluvial reach approximately 20 km east of Gilroy (Figure 1). The river corridor is broad and multi-threaded at this location, with sycamores, willows (*Salix spp*.), and mulefat (*Baccharis salicifolia*) dominant in the inner floodplain and pastureland and mature sycamores in the outer floodplain. A tributary to Pacheco Creek, Harper's Creek, also impounded, is located at the western edge of the site. Anthropogenic disturbances to Pacheco Creek, aside from the upstream dam, include bank revetments, road (State Highway 152) encroachment, fire, gravel mining, and livestock grazing.

Description of Upper Coyote Creek Upper Coyote Creek, with a watershed area of 833 km^2, is the headwaters of Coyote Creek, the largest drainage in Santa Clara County, flowing into the San Francisco Bay near Milpitas. The study area is located upstream of two major reservoirs on the creek (Anderson and Coyote Reservoirs) and drains approximately 271 km^2 of steep, rugged terrain. The study area consists of an open floodplain, with intact historical side channels, alluvial braids, natural flows, and mature SAW. The riparian corridor is broad, with intermittent flows that actively re-work well-sorted cobbles and gravels into deep scour pools and gravel bars. It is one of the few areas in the county with relatively unmodified hydrology, and provides a unique opportunity for studying the dynamics of SAW. The study site (~2 km long) is located in an alluvial reach, within Santa Clara Valley Open Space Authority's Palassou Ridge Preserve, approximately 6 km east of Gilroy (Figure 1). The site is subject to periodic grazing and encroachment from an adjacent public road.

Figure 1. (Opposite right) Location of two sites within Santa Clara County.

Anderson Lake

Morgan Hill

Coyote Lake

San Martin

Coyote Creek

101

Pacheco Reservoir

Gilroy

152

Pacheco Creek

San Felipe Lake

SANTA CLARA COUNTY

SAN BENITO COUNTY

Pajaro River

N

4 miles

SAN FRANCISCO BAY

STUDY AREA

California

Hollister

San Juan Bautista

Habitat Mapping Study

The habitat mapping study (Beagle et al. 2017) provided a 'snapshot' of tree distribution, health and regeneration at the two sites. Sycamore distribution followed a predictable pattern at Pacheco Creek, with younger trees closer to the primary channel. Distribution was more variable at Upper Coyote, where there were generally bigger (and presumably, older) trees than at Pacheco, and no clear pattern of size distribution in relation to the primary channel. This may be due to migration of the primary channel at Upper Coyote over time. Trees were evaluated on three measures: their qualitative health and vigor, mortality, and anthracnose incidence (see Beagle et al. 2017 for details). Trees did not differ by site on the health and vigor score. Mortality was higher at Pacheco, with unknown cause. On the anthracnose measure, trees were healthier at Pacheco, with less evidence of anthracnose disease than at Upper Coyote. Regeneration was more evident at Pacheco, where sycamores had more seed set than Upper Coyote sycamores.

Based on observations, a set of conclusions about the site characteristics and conditions necessary to support SAW was developed:

- ***Sycamores appear to do well when they are near an active channel with intermittent flow.*** In general, healthier living trees were located closer to the primary channel than dead or unhealthy trees at both sites.

- ***Flooding is necessary for healthy regeneration, but it is not guaranteed by the presence of a natural hydrologic regime.*** Regeneration was evidenced by the presence of more younger trees at Pacheco, while trees at Upper Coyote experienced less mortality, but little regeneration. At the time of this study, major flooding that would be expected to establish fresh stands had not occurred for at least 65 years; very few seedlings were observed at either site.

- ***Anthracnose may affect sycamore regeneration.*** Anthracnose incidence was high at Upper Coyote and low at Pacheco, and there was low regeneration at Upper Coyote, with higher regeneration at Pacheco. This may indicate that anthracnose inhibits seed set and regeneration. Anthracnose alone rarely causes mortality (Stuart and Sawyer 2001, Crump 2009), but is a regional concern (Shanfield 1984, H. T. Harvey 2014). Incidence varies by local climate conditions, with cool, wet springs possibly promoting anthracnose (Holstein 1981); it may increase in the absence of high, flushing flows (Kamman Hydrology 2009). It is not known to what extent these factors affect sycamores at these sites.

- ***Regeneration may be affected by hybridization with London plane tree.*** Hybridization between California sycamore and London plane tree has been documented in both natural and horticultural settings and may result in the extinction of the native genotype and a loss of habitat values for wildlife (Byington 2016, Johnson et al. 2016). Preliminary results from three stands of sycamore alluvial woodland in Santa Clara County show that hybrid trees were generally young (O'Rourke and Miller 2017).

- ***Grazing and browsing may affect regeneration success.*** Observations of grazing and browsing were not the focus of this study, but may be a key limiting factor for sycamore regeneration (Smith 2016, Sarr 2002). It is possible that the flow requirements are met at Upper Coyote

Creek, but the seedlings and suckers are limited by grazing and browsing pressures and are not surviving. An experiment using exclusion fencing could inform management techniques at Upper Coyote.

In addition to these key findings, the report also suggested specific Santa Clara County locations that were preliminarily recommended as suitable for SAW enhancement. Further investigation of these areas would be required before attempting SAW enhancement at a particular site, including: ownership; hydrology (managed versus natural); range of geomorphic zones; livestock grazing; location relative to the VHP Priority Preserve Areas; and potential for acquisition, restoration, or management. These included: Calero Creek (below dam), Upper Coyote Creek (from Anderson Dam to Hellyer Park), Guadalupe Creek, Hellyer County Park, Coe Park-Hunting Hollow parking lot to approximately 0.5 miles upstream, Llagas Creek (outside existing mitigation area) from Morgan Hill to San Martin, Pacheco Creek (upstream/downstream of Caltrans site), Springbrook mitigation site on Norwood Creek, Upper Penitencia Creek, Uvas Creek. More details can be found in the full report, available at sfei.org.

Genetics and Propagation Studies

Successful establishment of sycamores is a key step in restoring SAW. However, propagating sycamores from cuttings has been generally unsuccessful in the past; and propagating from seed, while often successful, comes with the risk that seeds come from flowers cross-pollinated by London plane trees. To address these concerns, a series of studies are currently underway. H. T. Harvey & Associates (H. T. Harvey) is working with two native plant nurseries (Grassroots Ecology Nursery and The Watershed Nursery) and a genetics lab at UC Davis to study sycamore and London plane tree genetics and cutting propagation techniques. The initial genetics work included processing and extracting DNA from leaves collected from many mature sycamores in wildland settings in Santa Clara County, including trees from the Pacheco and Upper Coyote Creek sites. In addition, leaves were collected from obviously planted London plane trees along city streets in Gilroy and Morgan Hill. Lab data clearly showed a distinction between most of the mature sycamores and the London plane trees, with very little signs of hybridization (O'Rourke and Miller 2017). These results were used to locate genetically pure California sycamores to collect cuttings using various techniques for a nursery propagation study. Data collection for this propagation study is ongoing, but preliminary results show a significant degree of successful rooting, as compared to previous known efforts (Deanna Guiliano and Diana Benner, Pers. Comm).

H. T. Harvey, Grassroots Ecology Nursery and the UC Davis genetics lab are also currently conducting a complementary genetics study. This study includes analyzing additional mature sycamores at varying distances from urban areas where London plane trees are more common. In late spring 2018, leaves were collected from numerous trees and are currently being processed and analyzed by the UC Davis lab. These data, when available, will be combined with the previous database to provide a larger set of known genetically pure California sycamores. These trees will be tracked to determine when mature seed set occurs to allow collection of seeds at various distances from urban areas. The seed will be sown and propagated in the nursery until sufficient leaf material is available for collection, which will then be analyzed by the UC Davis lab to determine the degree of hybridization that may be occurring in relation to distance from higher densities of known London plane trees. Findings from all of these studies will be published to expand upon the existing literature and support planning, design and implementation of future SAW restoration projects.

Seedling Study

Major flooding during water year 2016-2017 provided an exciting opportunity to observe sycamore regeneration at these two study sites. The sites experienced high-magnitude flood events estimated to be between a 10-25 year return interval, with geomorphic changes such as channel scouring, activation of side channels, and scour of floodplains by flood flows. Sycamore regeneration by seed and other regeneration strategies were observed in relation to the geomorphic change at the two study sites.

At both sites, vegetative sprouting from downed trees and limbs was observed. Generally, the downed trees were partially buried with cobble sediment and debris, and had subsequently sent multiple shoots upward from the prone trunks.

Regeneration by seed was not observed at Upper Coyote, but several seedlings were establishing at Pacheco. Geomorphic positions where seedlings occurred included:

1. Freshly sorted point bars that were protected from high velocities at the downstream ends of point bars;
2. New lateral-channel bars in fresh cobble about one foot above the channel thalweg;
3. Side channel, oxbow lake features on bars in protected or lower-velocity areas.

These observations point to a few key unknowns that will need further investigation if general recommendations for sycamore restoration are to be made with greater confidence.

- ***Local access to groundwater may affect capacity for seedling regeneration on freshly sorted bars.*** Though we do not have groundwater elevation data for either study site, we observed flowing water near seedlings at Pacheco, and no water in deep (2+ meters) pool formations at Upper Coyote.
- ***The effect of grazing regime on seedling survival is not known.*** As with the previous study, grazing and browsing are suspected to affect sycamores; evidence of grazing and browsing was observed at both sites, but their effect on seedling survival still remains unknown.
- ***Prolonged drought conditions may affect sycamore seedling survival.*** It is possible that sufficient flows subsequent to high-flow establishment events are necessary to sustain seedlings. For example, releases of water from a dam upstream of the Pacheco site may have provided sufficient water for establishment; this condition does not exist at Upper Coyote.
- ***Patterns of competition with other riparian species is not understood.*** For example, sycamores were observed to be associated with mulefat (*Baccharis salicifolia*) and umbrella sedge (*Cyperus eragrostis*) at both sites, but it is not known whether they compete with them for resources. Alternatively, these species may perform a 'nursery' role by trapping sycamore seeds, and protecting seedlings.
- ***Episodic regeneration patterns are not well understood.*** We observed several 'cohorts' of similar-age sycamores at both Pacheco and Upper Coyote. Next steps for future studies should include investigating additional sites in the region to determine whether this is a regional pattern of regeneration tied to major storm events.

More details on these findings are reported in a memo (SFEI 2018) which describes changes seen and sycamore observations at the two sites between fall 2015 and fall 2017.

CALIFORNIA SYCAMORE REVEGETATION STRATEGIES

Based on previous studies and field observations, this section provides guidelines for promoting active and passive restoration of SAW at the two sites in question, Upper Coyote and Pacheco. Additionally, figures provided as Appendix A show, in plan-view maps and in representative cross sections, information on observed geomorphic conditions and patterns of sycamore growth, as well as recommendations for planting within the geomorphic zones represented in the diagrams. The recommendations provided here, and depicted on the figures in Appendix A, are meant to be applicable across the sites and within similar regional settings.

PLANTING PLAN

The following section is meant to complement the maps and cross-sections included in Appendix A by providing more detailed guidance on determining the types of appropriate plant source materials and planting techniques for SAW restoration across the different geomorphic locations, and associated hydrologic, biotic and abiotic conditions present at the Upper Coyote Creek and Pacheco Creek sites.

Site Assessment

Prior to preparing a site specific planting plan, the existing mapping (Beagle et al. 2017) should be verified through a site assessment to document existing site conditions and determine appropriate planting approaches. This assessment should include observations of the distance from active surface flows, if present; depth to groundwater; soil characteristics; existing plant species; and general health and vigor of existing vegetation and sycamores. Site assessments will help to guide the extent of site preparation that may be necessary and determine the types and quantities of plant source materials needed for restoration.

Plant Source Materials

There are few available plant source material options to consider for native California sycamores, including the following:

Nursery stock: Nursery stock is grown from seed or cuttings and available in varying container sizes. In general, sycamores should be procured in containers, such as Stuewe & Sons, Inc. LP612H or LP512L Treepots, which are structured to allow increased root length development and prevent root spiraling before transplanting. Seed or cuttings used to grow nursery stock should be collected from local, native California sycamores from locations unlikely to be contaminated by London plane tree pollen. All nursery stock should be hardened-off before planting to acclimate to natural conditions and increase resistance to transplanting shock. Seed and/or cuttings need to be collected/harvested at least one year prior to planned planting to allow sufficient time for the nursery to propagate the trees and provide the preferred container size with well developed roots systems.

Seed: Seed is collected from local native California sycamores from locations that are not likely to be contaminated by London plane tree pollen. Seed should be collected when it is mature, which can vary, but is typically between November and February. This requires that close attention be given to the phenology of flowering and seed maturation to ensure that ripe seed is collected at the appropriate time.

Sycamore limbs: Sycamore limbs are large limbs/branches, larger than the smaller "cuttings" used to propagate container stock. The use of sycamore limbs is opportunistic and only implemented when particular conditions allow. Usually sycamore limbs are only available from recently damaged or downed trees. It is not recommended that large limbs be harvested from mature, healthy trees. During site assessments, existing mature sycamores should be evaluated for the potential to provide limb materials, such as branches that may be impacted by other construction activities. If there are limbs identified as suitable for planting (i.e., easily accessible, large limbs from trees that are damaged, and likely to just drop to the ground and decay within 1 year; or limbs from recently downed mature trees), they should be marked in the field for use in planting.

Planting Techniques

1. **Planting Trenches for Nursery Stock.** Planting trenches are a targeted approach to create larger patches of suitable planting conditions on higher-elevation positions where summer groundwater is relatively deep (i.e., greater than 10 feet). Preparing planting trenches requires the use of heavy machinery, so it is essential that prior to planning for this approach, any and all required approvals are confirmed with land owner(s) and regulatory agencies. Actual depths and dimensions of the trenches can vary depending on specific site characteristics but the following assumes an outer floodplain site with coarse alluvial soils and minimal existing, woody vegetation that can easily be avoided.

   Site Preparation and Plant Installation:

   - Excavate a trench to create a planting surface at the bottom that is approximately 5 feet wide by 25 feet long.
   - Side slopes should be gentle enough to allow ingress and egress for plant installation, maintenance and monitoring.
   - Depth of the trench should be no deeper than, and within 5 vertical feet of the approximate elevation of the ordinary high water mark in the adjacent primary stream channel.
   - Trenches should be oriented so that they are parallel to the primary stream channel
   - If the site is large enough to accommodate multiple trenches then trenches should be a minimum of 50 feet apart.
   - Spoils from excavation can typically be spread out across broad floodplain areas at minimal depths or additional site design can incorporate placing spoils at varying depths and add complexity to the floodplains. However, it is essential that any and all landowner and regulatory agency approvals are in place prior to placing spoils on site.
   - Nursery stock is the most appropriate plant source material for trenches
   - Assuming container sizes are Stuewe & Sons, Inc. LP612H or LP512L Treepots, or similar, excavate planting basins that are a minimum of 2 feet deep and 2 feet wide.
   - Install nursery stock so that root crown is slightly above grade with lightly, hand compacted backfill.
   - Nursery stock should be installed on approximately 5-10 foot on-center spacing.
   - Construct a 3 foot diameter irrigation basin around each planting with an approximately 4-inch high by 4-inch wide berm.

- Nursery stock should be planted in late fall/early winter (October - December).
- Irrigate immediately following installation.

2. **Individual Planting Basins for Nursery Stock.** Individual planting basins are a targeted approach for planting areas that are on lower- and middle-elevation positions with summer groundwater less than approximately 10 feet below the soil surface. Preparing planting basins can be accomplished by using heavy machinery or hand excavation. Similar to creating planting trenches, it is essential that any and all required approvals are confirmed with land owner(s) and regulatory agencies. Actual depths and dimensions of planting basins may vary slightly, based on the actual depth to summer groundwater, but in general it is assumed that a typical basin, as described below, with irrigation will be sufficient for most sites on lower- and middle-elevation positions. The following assumes an inner floodplain site with coarse alluvial soils, and minimal existing woody vegetation that can easily be avoided.

   Site Preparation and Plant Installation:

   - Nursery stock is the most appropriate plant source material for individual planting basins
   - Assuming container sizes are Stuewe & Sons, Inc. LP612H or LP512L Treepots, or similar, excavate a planting basin that is a minimum of 2 feet deep and 2 feet wide.
   - Install one nursery stock per planting basin so that the root crown is slightly above grade with lightly, hand compacted backfill.
   - Nursery stock should be installed on at least 15 foot on-center spacing.
   - Construct a 3 foot diameter irrigation basin around each planting with an approximately 4-inch high by 4-inch wide berm.
   - Nursery stock should be planted in late fall/early winter (October - December).
   - Irrigate immediately following installation.

3. **Seeding.** Direct application of seed is a targeted approach for revegetating along the edges of main channels and gravels bars that are regularly inundated during winter flows, where emerging seedlings will have the ability to access shallow groundwater throughout much of the growing season. Seed can be applied in areas that both support some existing riparian vegetation, particularly mulefat, which may serve as a nurse plant, as well as in areas that do not support existing vegetation.

   Site Preparation and Plant Installation:

   - In areas to be seeded first ensure there is bare soil/substrate exposed at the surface. This may require some removal of existing herbaceous vegetation and/or raking the surface of the ground to remove thatch.
   - Broadcast seed at a rate of approximately 10 pounds per acre, if possible. Reduced seeding rates may be required, based on availability of ripe seed in any given year.
   - Seed should be applied following collection to mimic natural dispersal timing, to the degree possible. Ideal timing will follow a dropping hydrograph where recent flows inundate the seeding areas but have subsided back to the primary channel.
   - Following seed application, the areas should be lightly raked to increase seed-soil contact and decrease seed predation.

4. **Planting Trenches for Sycamore Limbs.** As described earlier, use of sycamore limbs is strictly an opportunistic approach to revegetation. Sycamore limbs are a targeted approach for low- to middle-elevation positions where summer groundwater is less than 10 feet. Preparing planting trenches for installing sycamore limbs can be accomplished by using heavy machinery or hand excavation, depending on the depth to groundwater and size of limbs. As with other approaches requiring potential excavation with heavy machinery, it is essential that any and all required approvals are confirmed with land owner(s) and regulatory agencies. Locations for limb installation should be relatively close to the main channel where excavation allows immediate contact with groundwater, at the time of installation. Locations should be in areas that do not support existing woody vegetation or existing woody vegetation can easily be avoided. Depths and dimensions of trenches will vary depending on the depth to groundwater at the time of installation and the size of limbs.

Site Preparation and Limb Installation:

- Excavate trench to depth necessary to expose existing groundwater.
- Width and length of trenches should be just large enough to accommodate placement of limb such that the entire limb fits within the trench.
- Place backfill material, ideally coarse alluvial soil from excavation, on top of placed limb to a depth ranging from 0 - 12 inches. The majority of the limb should have 6-12 inches of backfill to help keep the limb in place. However, it is important to have a good percentage of the limb under only a few inches of coarse alluvial soil or even exposed to allow emerging shoots to have access to air and light.

MAINTENANCE PLAN

A regular maintenance program should be followed for up to 5 years to provide any sycamore revegetation efforts the best possible chance for successful long-term establishment. Maintenance may include irrigation, plant protection, and herbaceous vegetation control, as described below. Special attention should be made during all maintenance activities to protect existing California sycamores and other native riparian vegetation from damage.

Irrigation

Irrigation will be necessary for successful establishment of nursery stock installed in trenches and individual basins until their roots develop to the degree they can access summer groundwater. Plantings installed further from the main channel may require more frequent and longer-term irrigation than plants closer to the channel. Delivery of irrigation water to the plantings may be achieved in a variety of ways such as, a temporary bubbler system or hand watering. The actual approach will need to be determined based on site specific conditions, including accessibility and availability of water sources.

The following is a typical irrigation program that provides general guidelines for establishing nursery stock plantings.

Year 1 - irrigate each planting with 10 gallons, 4 times per month (1X/week) from the end of the rainy season through the onset of the following rainy season (likely April - October).

Year 2 - plan to irrigate each planting with 10 gallons, 2-4 times per month from approximately

April - October. Ideally irrigation frequency should begin to be slowly reduced in Year 2 to encourage development of a deep root system. However, it is more important that irrigation be provided at a frequency such that the plantings do not show signs of significant drought stress, as the plantings at this stage of development are still very susceptible to high rates of mortality if adequate soil moisture levels are not available throughout the majority of the active growing season.

Year 3 - plan to irrigate each planting with 10 gallons, 1-3 times per month from approximately April - October. It is important to reduce irrigation frequency during this time to encourage development of a deep root system which will allow long-term establishment of the plantings. However, it is still important to closely monitor signs of drought stress and increase irrigation frequency on an as-needed basis to limit significant mortality.

Years 4 and 5 - plan to irrigate only on an as-needed basis. At this point it should be relatively clear which plantings are likely adapted to the site conditions and have developed root systems that can access late-season groundwater resources, and which may still require supplemental irrigation. Ongoing monitoring should still closely track any signs of drought stress, particularly in areas that are on higher-elevation positions (e.g. outer floodplain) where plantings may require 1-2 years of additional irrigation to develop sufficient root systems to reach summer groundwater.

Irrigation for sycamore limbs is likely to be required in Years 1-3 to provide adequate soil moisture conditions at or near the surface during the growing season. The irrigation plan for actively growing sycamore limbs in Years 1-3 should include applying sufficient water to the planting area/trench such that the soil profile is fully saturated to a depth of at least 2 feet below the bottom of the limb (i.e., maximum depth of originally excavated trench) to ensure water is available to any developing roots. The actual frequency of irrigation will be contingent on the degree of new shoot emergence/development from the limb and the estimated depth of groundwater throughout the growing season. As the limbs will initially be installed at the interface with groundwater, it is more likely that as roots develop they will have access to relatively shallow groundwater. However, as with all the planting techniques, it is most important that any new growth not show signs of significant drought stress. Ongoing monitoring should closely track the health and vigor of any new growth emerging from the limbs and provide direction for potential irrigation frequency.

Irrigation is not anticipated to be needed for seeded areas due to their proximity to the primary channel. However, a contingency plan of hand watering should be in place to provide supplemental water to establishing seedlings that show significant signs of drought stress. Ongoing monitoring should closely track the health and vigor of any establishing seedlings and provide direction for potential irrigation.

Plant Protection

Damage to any and all establishing sycamores from livestock, deer and small mammals should be controlled, to the degree possible. Full exclusion of all planting areas is likely to be cost prohibitive. Therefore, the following measures should be considered and implemented as site conditions and budgets allow.

Caging. Installation of robust, individual plant protection cages is an expensive option but if installed and properly maintained can provide strong protection against livestock, deer, and small mammal herbivory. This approach is good for planted nursery stock material but could be adapted to create larger enclosures for seeded areas or sycamore limb planting areas. The following are construction materials and installation details for individual planting cages.

Materials and Installation Details

- Cages should be constructed from half-inch, 14 gauge welded wire mesh (i.e., hardware cloth)
- Cages should be approximately 5 feet high and 4 feet in diameter to form a cylinder.
- Overlapping ends should be tightly secured using Zip-ties or wire.
- Bottom of cages should be buried 3-4 inches. If site conditions allow, bottom of cages should also be secured with 6-8 inch landscape staples.
- Cages should be securely fastened to three T-posts with Zip-ties or wire. T-posts should be positioned in a triangular layout to provide a strong structure to attach cages.
- T-posts should be a minimum of 6 feet long and driven into the ground 2 feet, if site conditions allow.
- Cages are best used in locations further from the main channel to limit the likelihood of acting as strainers and catching debris during high flow events.
- Cages should be regularly maintained to ensure they are in good condition and providing the intended function of plant protection.
- Cages should be left in place for 5 years or to the point the sycamore planting is actively growing outside the cage and is likely to be able to withstand limited herbivory.
- At the conclusion of the maintenance period, or when sycamores have exceeded the height of the browse line, cages should be carefully removed so as not to damage stems, branches, and leaves.

Electric fencing. Installation of electric fencing can work well to deter livestock herbivory, but is not typically effective against deer or small mammals. Temporary electric fencing is a browse prevention option to consider for planting trenches with nursery stock, seeded areas, and sycamore limb areas. The fencing can be erected in late spring once the likelihood of large flows has diminished and concentrated on specific areas of higher densities of establishing sycamore plantings. Fencing can be removed annually in the late fall/early winter, prior to the onset of winter rains and large stream flows that can inundate the fenced areas. It is recommended that a contractor with experience using electric fencing for livestock deterrence is consulted prior to implementing this approach.

Browse deterrent. Use of browse deterrents, such as PlantSkydd, can be helpful in limiting deer and small mammal herbivory. Browse deterrents typical come in either a concentrated powder, which is mixed with water and used as a foliar application, or granular form, which is spread on the surface of the soil in the immediate proximity of the plantings. Browse deterrents can be applied annually in the spring and on an as needed basis throughout the growing season. Browse deterrents can be particularly helpful when used in combination with electric fencing to increase the level of protection within fenced areas.

Herbaceous Vegetation Control

Controlling herbaceous vegetation in the immediate vicinity of establishing sycamore plantings throughout the 5-year maintenance program can accomplish multiple objectives, including reduction of competition for limiting resources, and reducing cover for small mammals that can damage young seedlings and saplings.

Any sycamore installed from nursery stock will include a 3-foot diameter irrigation basin. All herbaceous vegetation that establishes within these basins should be carefully removed by hand so that the basins are kept weed-free throughout the growing season. Additionally, an area approximately 10 feet in diameter around each nursery stock planting would benefit from having herbaceous weeds kept to a maximum height of approximately 2 inches throughout the growing season. This can be accomplished by carefully string-trimming or weed-eating 1-2 times per month during the first half of the growing season to control annual grasses and forbs (March - June) and decreasing frequency later in the growing season, once the majority of the annual species have senesced. Weed control activities can be scheduled to coincide with irrigation to increase efficiency with other maintenance activities.

Control of herbaceous vegetation around any establishing new growth from sycamore limbs should be accomplished through hand removal within approximately 2 feet of live growth and carefully string-trimming or weed-eating to create conditions similar to around individual nursery stock plantings.

Control of herbaceous vegetation around sycamores establishing from seed will require a very careful approach in Years 1 and 2, in particular, to ensure the new seedlings are not damaged. During the first 2 years herbaceous vegetation growing in and around establishing sycamore seedlings should be left in place. Removal of the herbaceous vegetation presents a high risk of destabilizing the young root systems of the establishing sycamore seedlings. The only herbaceous vegetation control that should occur in seeded areas in Years 1 and 2 would be in order to reduce competition for light from robust stands of herbaceous vegetation located immediately adjacent to seeded areas, which have a high rate of initial germination. This can be accomplished by carefully string-trimming or weed-eating the vegetation to a height that facilitates improved light exposure for the seedlings. In Years 3-5, removal of herbaceous vegetation around well established saplings should be accomplished through hand removal to create an approximately 3 foot diameter area around saplings that is weed free, similar to weed control by hand in irrigation basins for nursery stock.

MONITORING PLAN

This monitoring plan is designed to track how geomorphic position, planting techniques, and maintenance actions influence California sycamore establishment and inform future California sycamore restoration efforts. While metrics such as vegetation cover can be useful to infer habitat value for wildlife and other ecosystem services, it is recommended that monitoring initially focus on survival for nursery stock, seedling densities for seeded areas, and census counts of numbers of emergent shoots from installed limbs. In addition, simple growth trends, such as height and health and vigor should be noted. It is also important to monitor and track maintenance activities to provide data on the main challenges facing sycamore establishment from the different planting techniques and geomorphic positions. Beyond 5 years, an assessment of vegetation cover provided from planted sycamores installed from the various planting techniques will provide important data regarding long-term establishment trends. Existing California sycamore cover at both the Upper Coyote Creek and Pacheco Creek sites should be assessed through aerial photograph interpretation, before any planting or seeding occurs, to serve as a baseline measure of the extent of existing sycamore dominated habitat at the two sites.

It is essential that a detailed Biological As-built Plan be prepared immediately following planting describing all techniques. This will allow direct comparisons of data collected in the subsequent years. As-built data collection should include, at a minimum:

1. Maps of each planting area overlain on existing geomorphic mapping, designating the planting technique implemented.
2. For nursery stock and sycamore limbs, exact planting locations should be recorded using standard GPS technology.
3. Container sizes and individual heights of planted nursery stock should be recorded at the time of installation.
4. Specific lengths and average diameters should be recorded for any limbs installed.
5. Seed application rates.
6. The source of nursery stock, installed limbs, and applied seed should be documented.
7. Plant protection measures installed.
8. Type of irrigation system installed.
9. Photodocumentation of site conditions following all installation activities from permanent locations.

Monitoring Methods

Survival. Survival of nursery stock plantings should be monitored annually in Years 1-5. Survival counts should include a census of all live nursery stock plantings and comparing that to the number originally installed. Survival monitoring should occur during the peak of the growing season (June - August). Survival of sycamores that establish from seed or limbs and show active growth during the beginning of the second growing season, should also be tracked and recorded.

Seedling Density. Seedling density should be estimated during the first growing season, following seed application. Photographs recording all of the seeded areas taken throughout the growing season should be collected. Depending on the germination rates, estimations of seedling densities can either be done by direct counts in comparison to the area planted or by photographs and visual estimations. The final determination of seedling density should occur at the peak of the growing season (June-August).

Emergent Shoots from Limbs. Locations that have buried limbs installed should be monitored annually in Years 1-5 for evidence of new vegetative shoot development. In any year following installation that a new shoot emerges it should be documented and the exact location recorded with standard GPS technology. Data should be presented as the total number of new emergent shoots in any given year, as buried limbs have the resources to potentially sprout new growth multiple years after installation. The annual count of new emergent shoots should occur during the peak of the growing season (June-August).

Tree Height. The height of nursery stock should be recorded annually in Years 1-5 and compared to previous years' data to show growth trends by geomorphic position and between trenches and individual basins. Heights of any seedlings or limb sprouts should be tracked starting in the second growing season where new

growth is observed. The second season of active growth will serve as the baseline height for comparison to subsequent years of data. If seedling densities are very high, a subset of individual seedlings should be chosen to determine and average height for that cohort of seedlings. Tree height data collection should occur during the peak of the growing season (June-August).

Photodocumentation. Photographs should be recorded from the permanent photodocumentation points established as part of the Biological As-built Plan. Additional photos should be recorded throughout the growing season to document evolving site conditions.

Health and Vigor. Health and vigor ratings for all living nursery stock and limb shoots should be assessed by considering such factors as plant color, bud development, new growth, herbivory, drought stress, fungal/insect infestation, and physical damage. Ratings for seedlings may be made individually or as a cohort, depending on the density at the time of monitoring. Health and vigor ratings should be recorded during the peak of the growing season (June-August) and be based on the following scale:

1 = High

2 = Moderate

3 = Poor

Vegetation Cover. Vegetation cover provided by planted sycamores (installed from all planting techniques) should be assessed every 5 years, beginning in Year-5 following installation. Vegetation cover should be assessed from low altitude aerial imagery collected during the peak of the growing season (June-August). The Year-5 cover will serve as a baseline condition for cover, in addition to the pre-planting cover photographs, for comparison with subsequent sycamore cover monitoring in Years 10, 15, 20, etc.

Geomorphic Monitoring. Geomorphic change should be monitored along with sycamore growth and hydrology at these sites. At a minimum, after major storm events, geomorphic units should be remapped using hand-held GPS units. Ideally, an unmanned aerial vehicle (UAV) would capture a digital surface model of the bare earth before and after storms for a 5-year period in order to understand the changes in geomorphic conditions with the natural recruitment of sycamores.

Surface and Groundwater Monitoring. An array of piezometers should be installed over several dry and wet seasons, along with pressure transducers to measure surface flow. Ideally, groundwater would be monitoring for at least a 5 year period, concurrent with surface hydrology, geomorphology, and vegetation monitoring, so that inferences can be made about the importance of surface and subsurface flows on plant growth.

Maintenance Activities. A detailed maintenance log should be kept to record all activities that occur in any given planting area throughout the 5 year monitoring period. This information will be very important to guide future sycamore restoration efforts and allow focusing the right types of resources in the right locations.

NEXT STEPS AND RECOMMENDED STUDIES

The recommendations presented in this report are based on a current understanding of the causes and conditions necessary for California sycamore regeneration; however, there are still many unknowns. In addition to the experience gained by pursuing restoration efforts as outlined here, specific studies are needed to better understand regeneration and planting survival of California sycamores.

Key unknowns include the role that depth to groundwater plays in regeneration; the regional prevalence of additional stands of 'cohorts' of sycamore trees, if any, and whether this is tied to patterns of flooding; the effects of grazing and browsing on sycamore regeneration; and the commonness of the regeneration patterns observed at the two study sites. A regional study could resolve some of these questions, by examining planting success within different geomorphic units in several regional sites. Such a study should also incorporate the monitoring of site groundwater availability to test lateral variability in groundwater and its relationship to sycamore survival.

Refinement of site-level planting techniques would be possible by implementing a planting study focused on answering questions specifically related to varying success of different plant materials, irrigation regimes, and fencing regimes on establishment of sycamore plantings. In addition to the site monitoring suggested above, such a study would test the effectiveness of fencing of sycamores, planting type, and differing irrigation regimes in sycamore plant establishment.

While many next steps and unknowns exist, sycamore trees and SAW systems in general continue to capture the imagination of land managers, the restoration community, and the public because of their unique character, and their potential resilience to the harsh extremes projected as the climate changes. There is great potential and interest in expanding suitable SAW sites, and integrating SAW into restoration and flood control plans. To do this, pilot projects and continued studies into the genetics, regeneration patterns, habitat quality, health and vigor, and hydrologic conditions (both surface and groundwater) are needed to support self-sustaining SAW systems into the future.

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PRIMARY CHANNEL

Planting Options:
Seeding
- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Maintenance and Management Protocol:
Irrigation: Irrigation is not anticipated. However, hand watering should occur if seedlings show signs of drought stress.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3-5.

Description of Sycamores Found at this Site :
Large and medium-sized sycamores of medium health.

Geomorphic Position and Hydrology:
Intermittent channel characterized by surface water that dries down for much of the year. Deep pool formations. Coarse cobble substrate.

INNER FLOOD PLAIN

Planting Options:
Nursery stock in planting basins
- Space planting basins at least 15 feet apart
- Excavate basins that are a minimum of 2 feet deep and 2 feet wide
- Plant nursery stock in late fall/early winter (October - December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Sycamore limbs
- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October - December)
- Backfill with 0-12 inches of coarse alluvium

Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5. Irrigate limbs on an as-needed basis, based on number and location of emerging live shoots.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional area.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5.

Description of Sycamores Found at this Site : A few, large healthy sycamores present on sparsely vegetated gravels.

Geomorphic Position and Hydrology:
Seasonally activated floodplain with cobbles and gravels, and seasonally scoured vegetation.

SECONDARY CHANNEL

Planting Options:
Seeding
- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

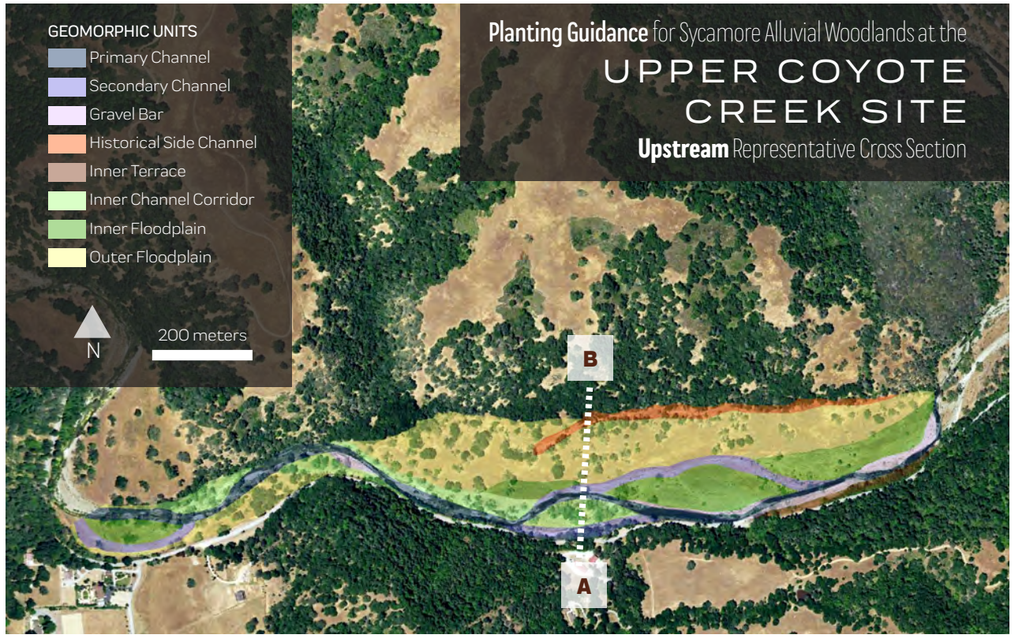
Maintenance and Management Protocol:
Irrigation: Irrigation is not anticipated. However, hand watering should occur if seedlings show signs of drought stress.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3-5.

Description of Sycamores Found at this Site:
A few, large healthy sycamores present.

Geomorphic Position and Hydrology:
Intermittent side channel that can be activated in large (>10 yr) flood events. Cobbles and gravels.



OUTER FLOODPLAIN

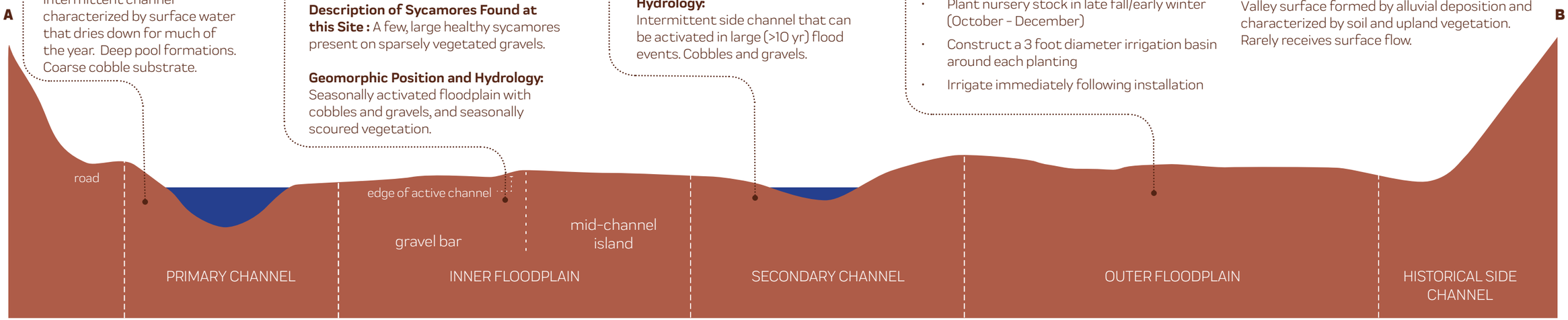
Planting Options:
Nursery stock in planting trenches
- Trenches should be oriented so that they are parallel to the primary channel
- Excavate trench to within 5 vertical feet of the approximate elevation of the ordinary high water mark in the adjacent primary channel
- Create an approximately 5 feet wide by 25 feet long planting surface at the bottom of trench
- Excavate individual planting basins that are a minimum of 2 feet deep and 2 feet wide and approximately 5-10 feet apart
- Plant nursery stock in late fall/early winter (October - December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5.

Geomorphic Position and Hydrology:
Valley surface formed by alluvial deposition and characterized by soil and upland vegetation. Rarely receives surface flow.



SECONDARY CHANNEL

Planting Options:
Seeding
- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Sycamore limbs
- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October – December)
- Backfill with 0-12 inches of coarse alluvium

Maintenance and Management Protocol:
Irrigation: Irrigation is not anticipated for seeded areas but hand watering should occur if seedlings show signs of drought stress. Irrigate limbs on an as needed basis based on number and location of emerging live shoots.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3-5. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional 10 feet to create buffer.

Description of Sycamores Found at this Site :
The secondary channel has fewer trees than the primary channel. Trees are large- and medium-sized, with good health ratings.

Geomorphic Position and Hydrology:
Intermittent side channel that can be activated in large (>10 yr) flood events. Cobbles and gravels.

INNER FLOODPLAIN

Planting Options:
Nursery stock in planting basins
- Space planting basins at least 15 feet apart
- Excavate basins that are a minimum of 2 feet deep and 2 feet wide
- Plant nursery stock in late fall/early winter (October – December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Sycamore limbs
- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October – December)
- Backfill with 0-12 inches of coarse alluvium

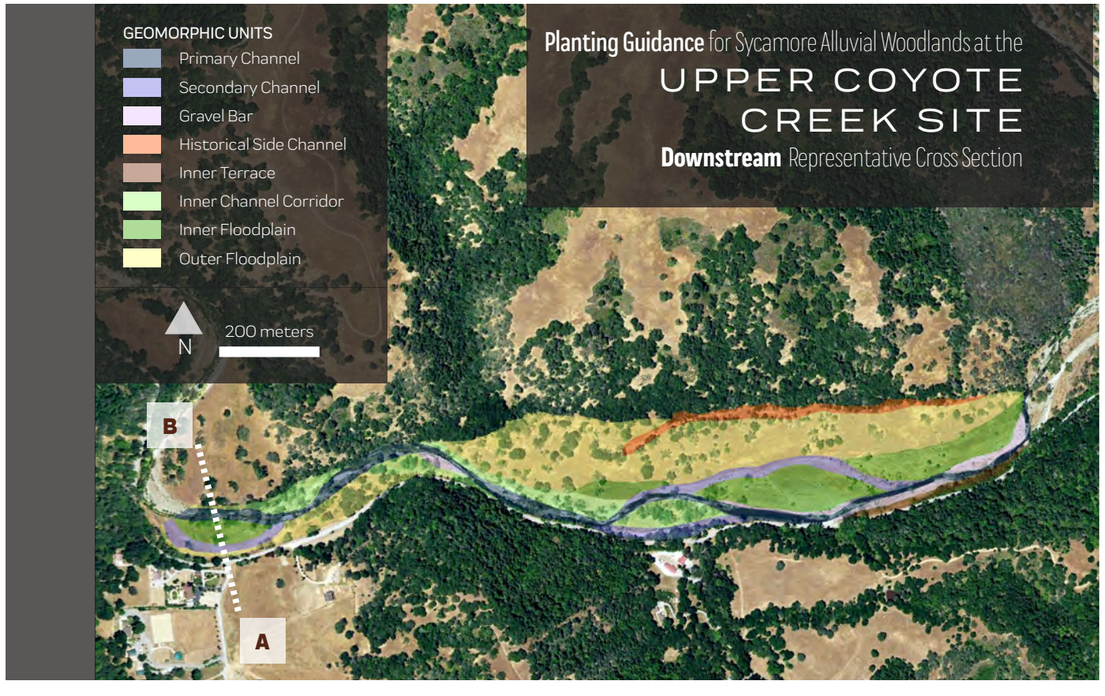
Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5. Irrigate limbs on an as needed basis based on number and location of emerging live shoots.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional 10 feet to create buffer.

Description of Sycamores Found at this Site:
Low-density, large and medium trees with a variety of health ratings.

Geomorphic Position and Hydrology:
Seasonally activated floodplain with cobbles and gravels, and seasonally scoured vegetation.



Planting Guidance for Sycamore Alluvial Woodlands at the
UPPER COYOTE CREEK SITE
Downstream Representative Cross Section

PRIMARY CHANNEL

Planting Options:
Seeding
- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Sycamore limbs
- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October – December)
- Backfill with 0-12 inches of coarse alluvium

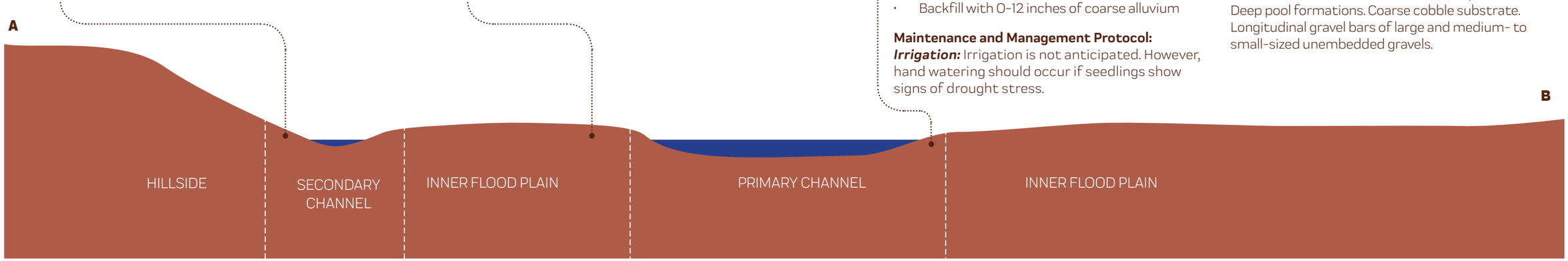
Maintenance and Management Protocol:
Irrigation: Irrigation is not anticipated. However, hand watering should occur if seedlings show signs of drought stress.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as-needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3-5.

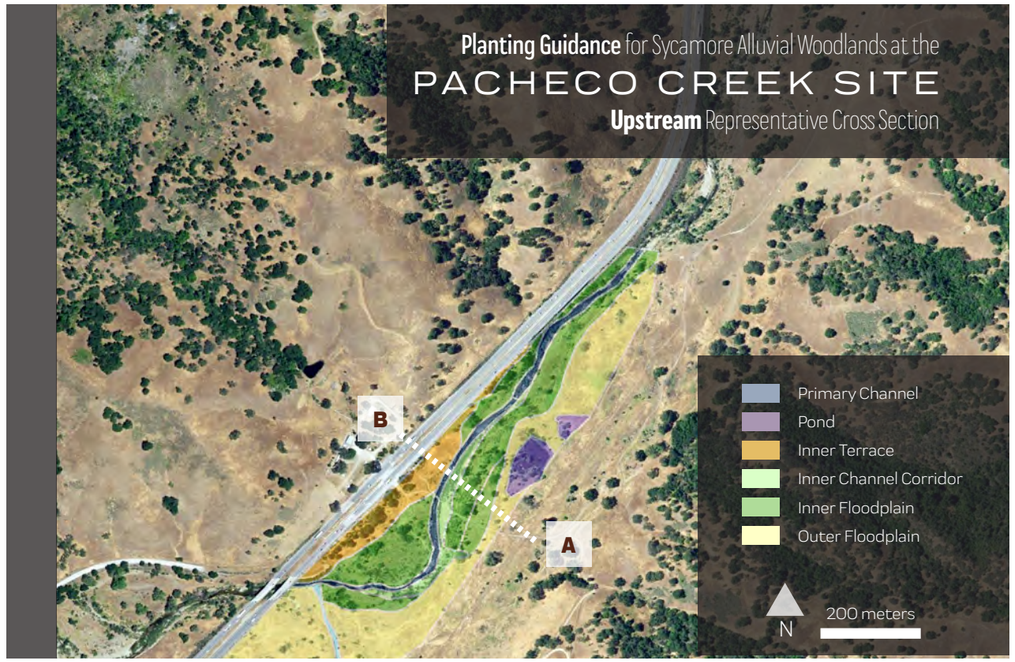
Description of Sycamores Found at this Site:
Healthy sycamore saplings were found on gravel bars near the primary channel. The primary channel has more trees than the other zones.

Geomorphic Position and Hydrology:
Intermittent channel characterized by surface water that dries down for much of the year. Deep pool formations. Coarse cobble substrate. Longitudinal gravel bars of large and medium- to small-sized unembedded gravels.



Planting Guidance for Sycamore Alluvial Woodlands at the PACHECO CREEK SITE

Upstream Representative Cross Section



OUTER FLOOD PLAIN

Planting Options:
Nursery stock in planting trenches

- Trenches should be oriented so that they are parallel to the primary channel
- Excavate trench to within 5 vertical feet of the approximate elevation of the ordinary high water mark in the adjacent primary channel
- Create an approximately 5 feet wide by 25 feet long planting surface at the bottom of trench
- Excavate individual planting basins that are a minimum of 2 feet deep and 2 feet wide and approximately 5-10 feet apart
- Plant nursery stock in late fall/early winter (October - December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5.

Description of Sycamores Found at this Site : Mostly large and medium-sized trees with highest levels of mortality.

Geomorphic Position and Hydrology:
Valley surface formed by alluvial deposition characterized by soil and upland vegetation. Rarely receives surface flow. A thick layer of fine-grained soils is present over cobble substrate.

INNER FLOOD PLAIN

Planting Options:
Nursery stock in planting basins

- Space planting basins at least 15 feet apart
- Excavate basins that are a minimum of 2 feet deep and 2 feet wide
- Plant nursery stock in late fall/early winter (October - December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5.

Description of Sycamores Found at this Site :
Large and medium-sized trees, mostly healthy, with occasional saplings and seedlings present.

Geomorphic Position and Hydrology:
Seasonally activated floodplain with cobbles and gravels, and seasonally scoured vegetation. A layer of fine-grained soils is present over cobble substrate.

INNER CHANNEL CORRIDOR

Planting Options:
Seeding

- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Sycamore limbs

- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October - December)
- Backfill with 0-12 inches of coarse alluvium

Maintenance Management Protocol:
Irrigation: Irrigation is not anticipated for seeded areas but hand watering should occur if seedlings show signs of drought stress. Irrigate limbs on an as needed basis based on number and location of emerging live shoots.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3-5. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional 10 feet to create buffer.

Description of Sycamores Found at this Site: A mix of large, medium, sapling, and seedlings in this area, with mostly healthy trees.

Geomorphic Position and Hydrology:
Medium- to small-sized gravels at a higher elevation than the relatively unvegetated gravels nearer to the wetted channel.

INNER TERRACE

Planting Options:
Nursery stock in planting trenches

- Trenches should be oriented so that they are parallel to the primary channel
- Excavate trench to within 5 vertical feet of the approximate elevation of the ordinary high water mark in the adjacent primary channel
- Create an approximately 5 feet wide by 25 feet long planting surface at the bottom of trench
- Excavate individual planting basins that are a minimum of 2 feet deep and 2 feet wide and approximately 5-10 feet apart
- Plant nursery stock in late fall/early winter (October - December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

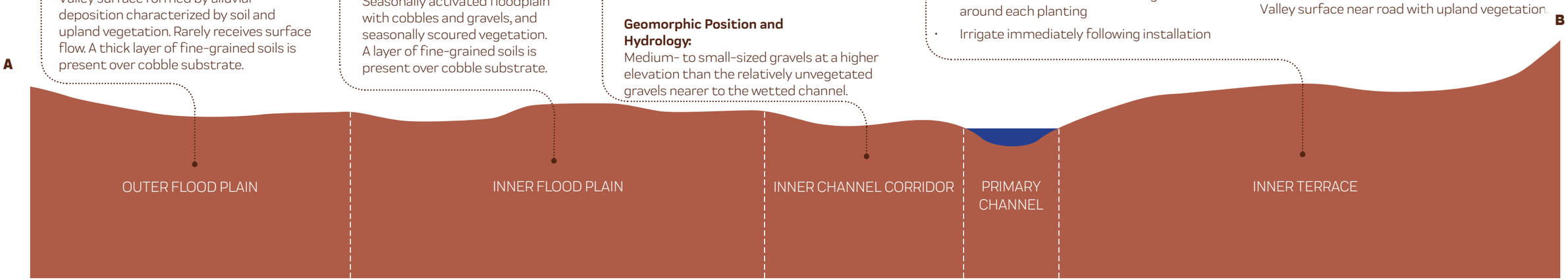
Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April-October) in Year 1. Slowly reduce frequency in Years 2-3. Irrigate on an as-needed basis in Years 4-5.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1-5.

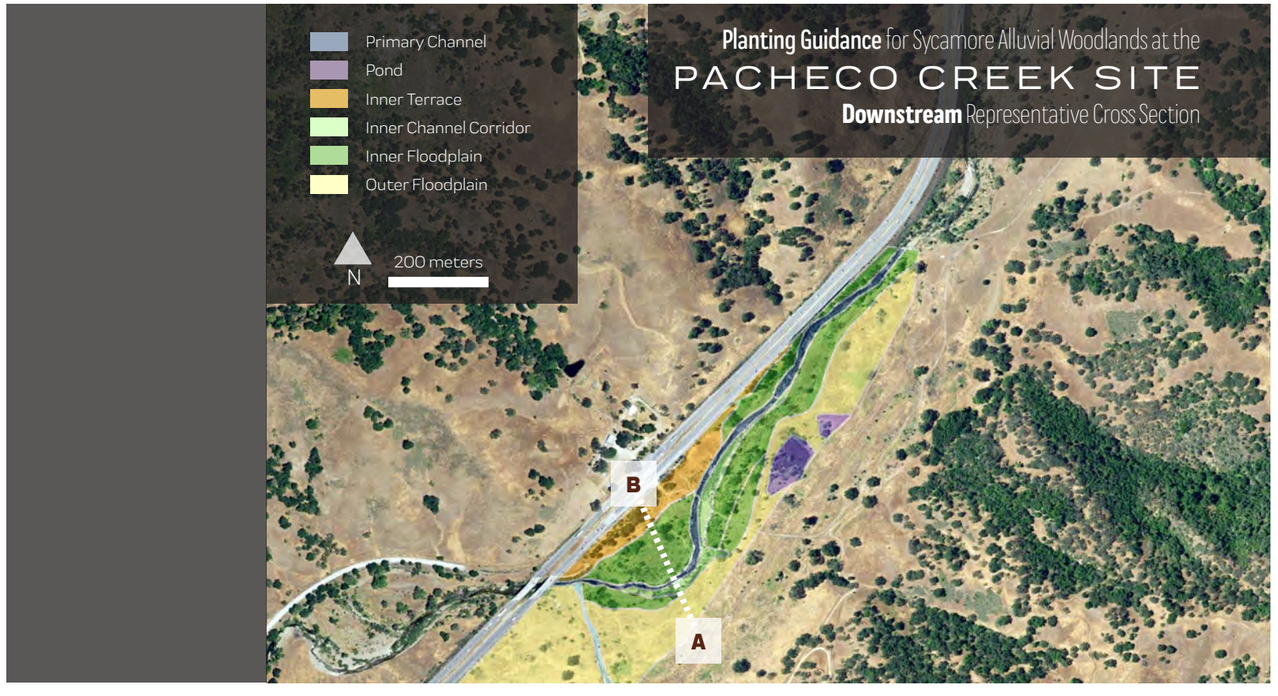
Description of Sycamores Found at this Site:
Few sycamores present, of medium size and health.

Geomorphic Position and Hydrology:
Valley surface near road with upland vegetation.



Planting Guidance for Sycamore Alluvial Woodlands at the PACHECO CREEK SITE

Downstream Representative Cross Section



OUTER FLOOD PLAIN

Planting Options:
Nursery stock in planting basins
Space planting basins at least 15 feet apart

- Excavate basins that are a minimum of 2 feet deep and 2 feet wide
- Plant nursery stock in late fall/early winter (October – December)
- Construct a 3 foot diameter irrigation basin around each planting
- Irrigate immediately following installation

Maintenance and Management Protocol:
Irrigation: Irrigate weekly (April–October) in Year 1. Slowly reduce frequency in Years 2–3. Irrigate on an as-needed basis in Years 4–5.

Plant protection: Cages, seasonal electric fencing and browse deterrents may be used, as appropriate.

Vegetation removal: Hand remove vegetation within 3-foot diameter area and weed-eat to create a 10 foot diameter area around each planting in Years 1–5.

Description of Sycamores Found at this Site:
Large and medium-sized trees, mostly healthy, with occasional saplings present.

Geomorphic Position and Hydrology:
Valley surface formed by alluvial deposition characterized by soil and upland vegetation. Rarely receives surface flow.

INNER FLOODPLAIN: gravel bar

Planting Options:
Seeding

- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Sycamore limbs

- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October – December)
- Backfill with 0–12 inches of coarse alluvium

Maintenance Management Protocol:
Irrigation: Irrigation is not anticipated for seeded areas but hand watering should occur if seedlings show signs of drought stress. Irrigate limbs on an as needed basis based on number and location of emerging live shoots.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3–5. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional 10 feet to create buffer.

Description of Sycamores Found at this Site:
Sycamore seedlings present on freshly sorted gravels near to the channel thalweg.

Geomorphic Position and Hydrology:
Seasonally activated floodplain with cobbles and gravels, and seasonally scoured vegetation. A layer of fine-grained soils is present over cobble substrate.

INNER FLOOD PLAIN: vegetated gravel bar

Planting Options:
Seeding

- Prepare seeding area by removing thatch to create bare surface
- Apply seed soon after collection, ideally on recently inundated surfaces
- Target seed application rate of 10 pounds per acre
- Lightly rake to increase seed-soil contact and decrease seed predation

Sycamore limbs

- Excavate trench to the approximate depth of summer groundwater
- Place limb in the late fall/early winter (October – December)
- Backfill with 0–12 inches of coarse alluvium

Maintenance and Management Protocol:
Irrigation: Irrigation is not anticipated for seeded areas but hand watering should occur if seedlings show signs of drought stress. Irrigate limbs on an as needed basis based on number and location of emerging live shoots.

Plant protection: Seasonal electric fencing and browse deterrents may be implemented on an as-needed basis.

Vegetation removal: Carefully cut dense vegetation around seedlings in Years 1 and 2, if necessary. Hand remove vegetation around well established saplings in Years 3–5. Hand remove vegetation within 2 feet of any live limb shoot and weed eat additional 10 feet to create buffer.

Description of Sycamores Found at this Site:
Several young sycamores growing among mature mulefat (*Baccharis salicifolia*). These potentially established after the same flood event.

Geomorphic Position and Hydrology:
Medium- to small-sized gravels at a higher elevation than the relatively unvegetated gravels nearer to the wetted channel.