Willow Requirements for Resident Beaver Population

Martinez, CA

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Introduction

Beavers (*Castor canadensis*) are not often thought of as residents of the San Francisco Bay Delta. They have, however, historically inhabited this area, and will persistently return to sites with suitable habitat (Grinnell 1937). Alhambra Creek in Martinez, California is one of those places. The creek channel has been reduced in width, and is bordered by parking lots, buildings, and lawns. It is crossed in multiple places by roads bearing cars, trucks, and trains. While this may seem inhospitable to beavers, there are many resources present which beavers require. The requisite resources for beaver habitat suitability are adequate food, year-round water, gentle stream gradient (of less than 15% slope), and adequate cover (provided by the lodges they build) (Allen 1982). The purpose of this report is to quantify the amount of woody food resources available to the beavers, and to identify if there is a need to add any resources to sustain their presence. It also looks at the nature of willow trees and their use in an urban environment.

Riparian Habitat

Trees of the willow family, Salicaceae, are especially important winter forage for beavers (Muller-Schwarze and Sun 2003; Allen 1982) because they are a food source when herbaceous plants largely die back and are not available forage for beavers (Allen 1982). Species of this family are often used to determine carrying capacity and habitat suitability of a given stream because they constitute the most significant winter forage limitation (Allen 1982). The salicaceous plants present along Alhambra Creek are predominantly willows (*Salix sp.*), and a few cottonwoods (*Populus fremontii*). All the trees are confined to narrow bands along the banks of Alhambra Creek, with the willows stretching from the water's edge to the upland banks, and the cottonwoods inhabiting only the upper banks.

There are two species of willow in the study area, arroyo willow (*Salix lasiolepis*) and shining willow (*Salix lucida* ssp. *lasiandra*). In the more than two years that beavers have inhabited

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the creek, they have had a noticeable effect on the riparian tree populations, using willow as forage and also for dam building. The beavers appear to prefer foraging on arroyo willow to shining willow (Heidi Perryman, Worth A Dam, Personal Communication and Author's research). Noting this, the "Worth A Dam" organization has committed themselves to planting arroyo willow to both replace beaver-felled trees and to increase the overall amount of forage. Condor Country Consulting Inc. was engaged to assess whether the beavers indeed need more willow, and if so, how much.

Characteristics and Ecological Significance of Willows

Beyond providing forage and dam-building materials for beavers, willows serve multiple ecological functions essential to riverine and wetland areas. They host high numbers of invertebrates (450 spp found in British willows) (Kennedy and Southwood 1984) and have dense structural features which provide forage and habitat for many migratory birds. Willow stands host more migrating bird species in stopover sites than any other species of tree (Bates 1951 in Kuzovkina 2004). In the course of this survey many bird species were observed within the riparian zone surrounding Alhambra Creek. (Appendix 1)

Willows have vast networks of fibrous roots (the majority of which are in the upper 40-45 cm of the soil) (Gray and Sotir 1996 in Kzovkina and Quigley 2004) which stabilize banks, reduce soil erosion, and reduce the amount of soil particles suspended in nearby water. Willows can also be used to stabilize slopes uphill from waterways both by providing root structure and by reducing the amount of soil moisture through transpiration (Gray and Leiser 1982 in Kuzovkina and Quigley 2004). The vigorous and exploratory nature of willow roots can present problems in urban areas however. Problems include clogging of drainage lines, and damage to adjacent concrete features i.e.: roads, paths, and foundations (Kuzovkina and Quigley 2004).

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Study Area

The area reviewed for this report lies along Alhambra Creek between Green Street and the Railroad Bridge north of Green Street. While some evidence of beaver activity was detected south of Green Street before the first dams were built (Igor Skaredoff, Friends of Alhambra Creek, Personal Communication), they currently forage exclusively along the banks north of Green Street and south of the Railroad Bridge (Heidi Perryman, Worth A Dam, Personal Communication). They have not, in recent times, built lodges or dams south of Green Street. Beaver are known to forage a maximum of 2624 feet upstream and 984 feet downstream from their lodges in riverine habitats (Boyce 1981 in Allen 1982). If the two beaver lodges located between Escobar and Marina Vista are used as the base point, the upstream and downstream foraging boundaries would be Susana Street Park (Just south of where Susana Street crosses Alhambra Creek) and the Railroad Bridge respectively. (Appendix 2)

Beavers typically forage up to 328 feet on either side of the stream they inhabit (Boyce 1981 in Allen 1984; Hall 1960), with 90% of their tree cutting taking place within 100 feet of their inhabited stream (Hall 1960, Jenkins 1979 in Allen 1984). This poses an interesting problem as Alhambra Creek has been channelized and the lateral foraging distance of beavers is restricted by abrupt landscape changes (i.e. parking lots, parks, streets and buildings adjacent to the creek), the channel wall, and by a 3.5 foot chain-link fence that runs along most of the creek. Most of the favorable beaver forage lies within this fence, but this area is much narrower than the 328 feet in which beavers normally forage, and the entire study area falls short of having a 100 foot wide band on both sides of the creek. Two other factors negatively affect the abundance of beaver forage within the creek corridor. One is the planting and invasion of non-preferred plants (such as those in the genera *Cercis, Arundo,* and *Nicotiana*), the other is that the largest cottonwoods (and a few willows) have been wrapped in chain-link fencing to deter beaver use, but they still actively compete for space and light with the accessible trees. Accordingly, they are not accounted for in the estimates of available forage.


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Beaver prefer herbaceous vegetation to woody vegetation when available (Jenkins 1981 in Brier 1987). They are known to forage on cattail (*Typha sp.*), tule (*Scirpus sp.*), wild rose (*Rosa sp.*), and plants of the genus *Rubus* (blackberries) (Gallant et al 2004), all of which are present within the available foraging area along Alhambra Creek. The area north of the Railroad Bridge is vegetated almost entirely with cattail and tule, and while most of the beavers are not known to forage this far north, the adult male has been seen foraging in that area (Heidi Perryman, Worth A Dam, Personal Communication).

Study Methods

Because of the unique circumstances governing the abundance and distribution of woody beaver forage along Alhambra Creek, and in part due to a lack of literature pertaining directly to beaver foraging preferences in Mediterranean climates, methods were compiled from various papers which allowed biologists to measure and evaluate the abundance of willow, and to evaluate its usefulness as a food source for beavers.

Beaver do not digest the hard woody centers of large trunks, instead they gain nutrients from the bark, small stems, and leaves (Baker and Cade 1995). Therefore the percent usable food in a given stem is inversely related to its diameter. A willow whip contains 93.6% usable forage while a two inch diameter stem contains a mere 12.2 % forage by weight (Baker and Cade 1995).

Baker and Cade (1995) measured the amount of total usable beaver forage in coyote willow (*Salix exigua*) for ten different stem diameters ranging from 1.25mm to 50mm. For the purposes of this study, the data were broken into three diameter class categories: #1-0.05-0.49 inches, #2-0.5-1.08 inches, and #3-1.09-1.97 inches.

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The study area was broken into five zones so that distribution of willow could be evaluated in relation to proximity to beaver habitat, proximity to hydrological features, and relationship to downtown Martinez (Appendix 2). The zones are as follows:

- Zone 1-Between Railroad bridge and Marina Vista Avenue
- Zone 2-Between Marina Vista Ave and Escobar Street
- Zone 3-Between Escobar Street and Main Street
- Zone 4-Between Main Street and Ward Street
- Zone 5-Between Ward Street and Green Street

The amount of usable forage in each zone was determined by site visits where biologists estimated the number of each of the three size classes of branches on every willow tree in the zone. These estimates were done visually from the base of the tree where possible, and occasionally from across the creek in areas where the trees were inaccessible. Since the basal diameters of the trunks were generally larger than the largest size class, most branches were counted from where they branched off the main trunk. To avoid double counting on a given tree, a branch was only counted as falling into a specific size class if it was not subtended by a branch of a larger size class. For example, if a 0.75-inch diameter stem (category 2) was branching off of a 1.5-inch diameter stem (category 3), the 1.5-inch diameter stem would be counted, and the 0.75-inch diameter stem would not be counted because the biomass of the 0.5-inch diameter stem is computed as part of the 1.5-inch diameter stem's total biomass. If the 0.75-inch diameter stem was branching from a 4-inch diameter trunk, then the 0.75-inch diameter stem would be counted because it is directly subtended by a stem that is larger than any size class and therefore unaccounted for.

In this way data were compiled for each zone on the numbers of stems falling within each diameter class category. The number of stems in a given category was multiplied by the estimated amount of usable food (Baker and Cade 1995) in that category to come up with an overall estimate of the amount of usable beaver food in each zone. The data for the size class


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categories were also multiplied by the number given by Baker and Cade (1995:324) for estimating total live biomass, to determine how much total biomass was in the study area.

Each tree was evaluated for beaver "cutting" and "use." Beaver cutting was noted when an entire trunk of a given willow was felled by beaver. Use was defined by any beaver damage to a tree that did not constitute entire trunk cutting (i.e. bark shaving, small branch foraging, moderate gnawing). If a tree was cut it was evaluated for re-growth. Re-growth was quantified when a willow was sprouting back below where a cut had previously been made.

Other field observations included: collecting bird species presence information by auditory and visual detection, identifying key plants based on the Jepson Manual of Higher Plants of California (1993), and observing terrain and vegetation for ideal places to plant willow should that be recommended.

Results

The area between Green Street and the Railroad Bridge had the following numbers of trees: 146 arroyo willows, 26 shining willows, 10 Fremont cottonwoods, and 15 coast live oak (*Quercus agrifolia*).

The total usable willow biomass estimate for the study area is 60,882 grams or about 61 kilograms. This number reflects the total usable beaver forage as estimated by Baker and Cade (1995). It does not include the biomass of the main trunks directly subtending the limbs of the largest size class category, and is therefore an underestimate of edible willow biomass. As stem size increased, percent edible biomass decreases (Baker and Cade 1995). Main trunks are therefore presumed to have a low percentage of usable forage and to be less desirable than smaller limbs (Allen 1982). The estimate for total "live" biomass is 1242 kilograms (Baker and Cade 1995), and reflects the total weight of standing green biomass. It is also an underestimation since it does not include the biomass of trunks or branches over 1.97 inches.

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The biomass estimates for cottonwoods were not estimated because they are almost all fenced off to beavers. The oaks were not estimated because they are not generally eaten by beavers when more preferable food sources are present.

Figure 1: Total edible willow biomass by species.

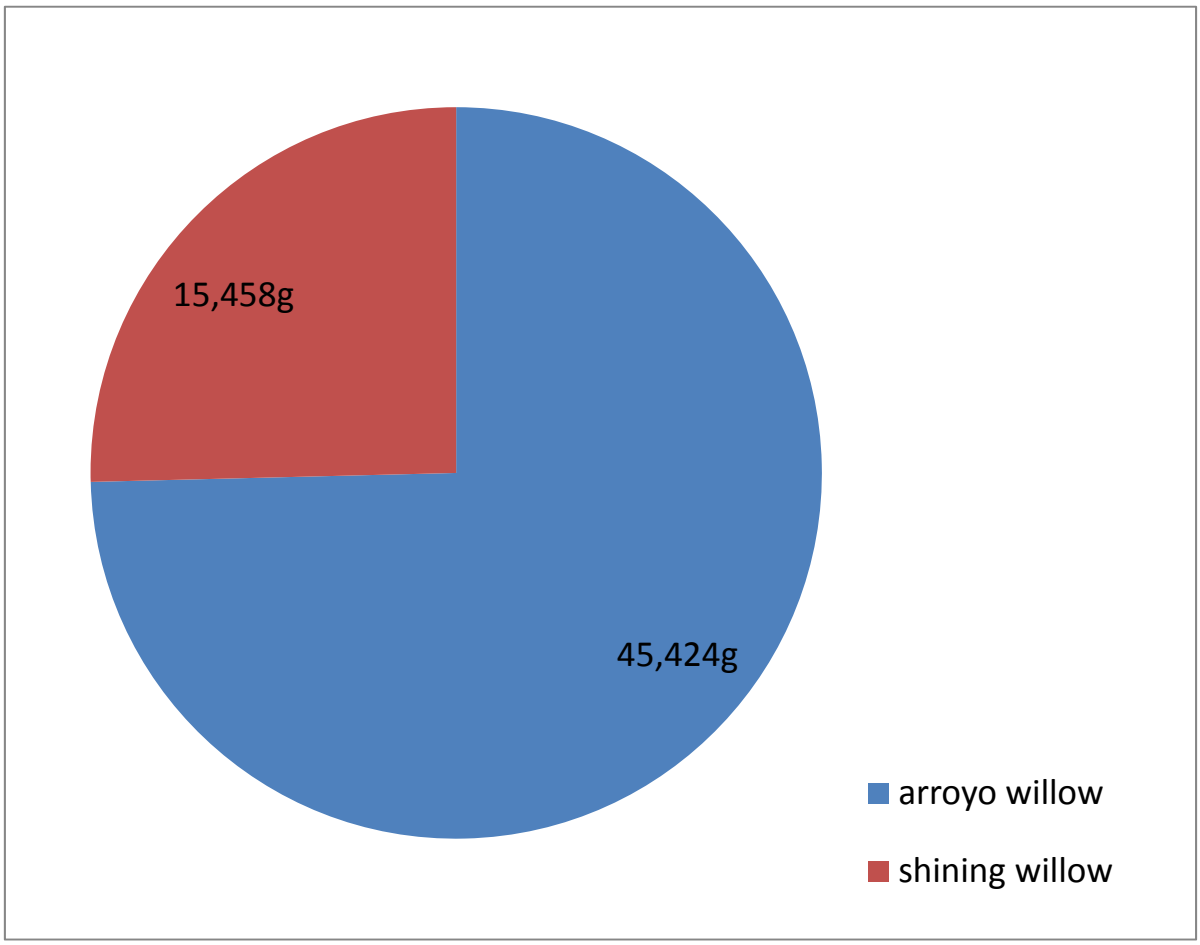
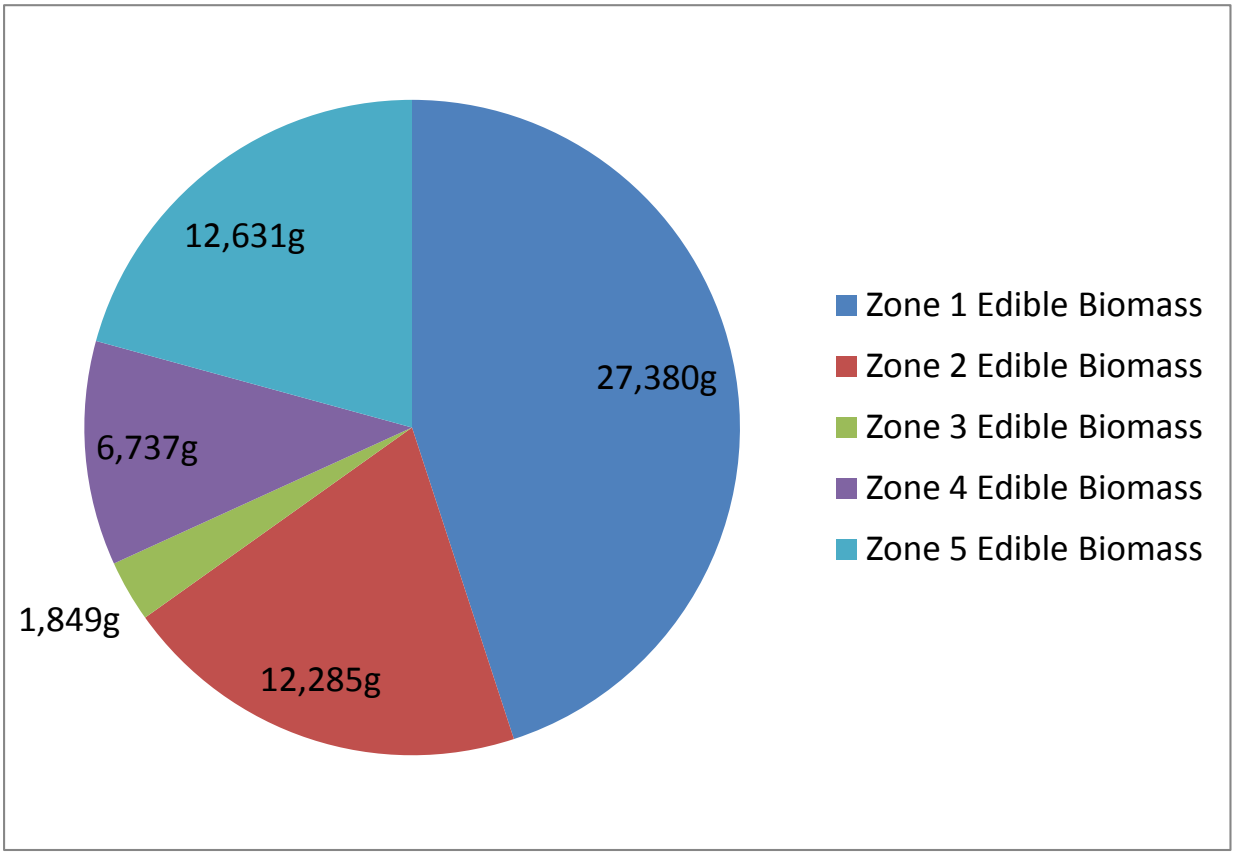


Figure 2: Total edible willow biomass by zone.



The majority of the available edible willow biomass in the study area is comprised of arroyo willow (Figure 1). Of surveyed arroyo willow, 46% showed signs of beaver use, with 33% having at least one trunk entirely cut by beavers. In contrast, only about 26% of shining willow showed signs of use by beaver, with only 8 percent having a fully felled trunk.

Zone 1 had the largest amount of available willow biomass, which correlates to it being not only the longest, but also the widest segment along the creek. Zone 3 has the least biomass, but also has the smallest total area. Arroyo willows were planted on the west bank of Zone 3

in June 2008 (Heidi Perryman, Worth A Dam, Personal Communication), and those that were caged have survived.

Discussion

Estimates of daily willow consumption by beavers range from 551 grams per day in summer months (Belovski 1984 in Baker and Cade 1995) to about 830 grams per day in winter months (Svendsen 1980a). Extrapolating from these estimates we might expect a beaver to consume anywhere from 174-201 kilograms per year (Svendsen 1980a; Belovski 1984 in Baker and Cade 1995).

Beavers live in family groups which average anywhere from 4.09 to 7.59 animals per group depending on whether the yearlings have dispersed and whether the new kits have been born (Novak 1977; Svendsen 1980b). An average of these numbers is 5.84 animals per colony. The Alhambra Creek population currently has two adults, three yearlings, and four kits, born this spring (2009) (Heidi Perryman, Worth A Dam, Personal Communication). Using a family size of six as a conservative estimate for an average long-term beaver population, one could expect an annual consumption of somewhere between 1044 and 1206 kilograms per year. There are currently about 61 kg of woody forage available to the beavers in the area between Green Street and the Railroad Bridge. This represents about 5-6% of the requirement for an average beaver colony of 6. (While it is important for our calculations to use the probable long-term average number of beavers in the Alhambra Creek colony (six), it is also important to acknowledge that there are currently nine beavers in Alhambra Creek. The annual consumption for this year's beaver colony should therefore be 1.5 times the amount needed by a colony of six.)

Having only five to six percent of the total required willow may seem low, but it reflects the accessibility of foragable land. The creek channel between Green Street and Marina Vista Avenue (Zones 2-5) has banks anywhere from 0 to 30 foot wide. Most of the banks are in the

10-20 foot range (Google Earth 2009). This is at most 1/10 of the distance beavers will forage from the creek for woody food, but on average much less. The east side of Zone 1 (between Marina Vista Avenue and the Railroad Bridge) is much wider in contrast, just over one hundred feet in some areas. This area, however, is almost completely barren of willow, having been dredged after flooding in 2005 deposited two to three feet of silt in the area (Tim Tucker, City of Martinez, Personal Communication). It has approximately half the available usable beaver food as the west side, much of which is distributed up to 100 feet from the creek. The trees in this area show almost no sign of beaver use.

Approximate area was estimated for all the zones, from Google Maps, and is as follows: Zone 1=97,669 ft², Zone 2=9,460 ft², Zone 3=6,748 ft², Zone 4=7,723 ft², Zone 5=8,777 ft². This figure includes surface area of the creek, and therefore is an over-estimation of total area, with a proportionally greater error in Zones 2-5 as they are much narrower overall, but have just as wide a stream channel. The total area thus calculated is 130,337 ft², or about three acres.

Other factors limiting the beaver foraging are the 3.5 foot tall fence that runs almost the entire length of the territory, the beavers' apparent disinterest in passing south of Green Street, and the incursion of non-native, non-forage plants into the territory (i.e. *Arundo* in Zone 5, *Nicotiana* in Zones 2 and 3). One can reasonably infer that only approximately five percent of the average beaver foraging range is available to the beavers on Alhambra Creek, and this on a less than average length of creek. Therefore it is a proportionally representative amount of available willow.

The beavers have been in Alhambra Creek now for over two years, and assuming average consumption rates for a colony of six, the amount of willow consumed over the past two years would be 40 times what is currently available. Why have the beavers not cut every single tree and completely deforested the riparian corridor?

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Persistence of willows can partly be explained by willows' ability to re-grow from cutting by beavers. In his four-year study of the growth response of shining willow to beaver herbivory, Kindschy (1985:27) found that even while beavers were harvesting an average of 82% of standing willow, the trees that were being used by beavers "maintained high growth rates and increased in basal diameter similar to the rates of unused trees." He also states that "Natural and prolonged heavy utilization of (shining willow) by beaver did not appear to be responsible for the deterioration, reduction and loss of this riparian species" (Kindschy 1985:27). In his 1989 study simulating beaver herbivory on shining willow, Kindschy determined that height and width of cut trees were only three to five percent less than pre-cut trees after two years of re-growth (Kindschy 1989). While this may be true for shining willow (which comprises only 25% of the available biomass in the study area) other research has pointed to periodic fluctuations in beaver foraging as a critical component in willow's continued vigor. Hall (1960:493) studied the foraging preferences of beavers near Trukee California and noted that "beavers can thrive indefinitely on willow by a form of "block cutting," or shifting their foraging periodically up and down the stream allowing over-browsed sections time to recover."

The other reason there is still willow in Alhambra Creek is probably because there is an abundance of other food sources available, a few of which provide food throughout the winter. Of the plants in the project area, beaver are known to forage heavily on cattail rhizomes, tule root stalks, species of the genus *Rubus*, wild rose, and acorns (Grinnell 1937, Gallant et al 2004). Grinnell (1937:690) suggests that beavers will live in areas dominated by tule, cattails, and aquatic vegetation with little amounts of preferred forage trees, and will focus their chewing on "dry fence posts, bridge timbers, and even oak trees" to keep their teeth sharp and at the right length. Of the non-tree forage plants in the study area, tule, *Rubus sp.*, and wild roses are available in the winter. It could be that the absence of cattail and tule south of Green Street, and the distance from Green Street to large cattail and tule patches are partially responsible for the beavers' reluctance to forage there.


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Recommendations

Two facts have surfaced as a result of this report. First, despite having a forested foraging area and corresponding amount of woody forage approximately 1/10-1/20 of the estimated requirement of a beaver colony of 6, the beavers have persisted on Alhambra Creek for the past two and a half years without completely deforesting the area. Second, there are numerous herbaceous resources along Alhambra Creek which the beavers exploit, and although this may mitigate a lack of woody forage, it does not completely supplant it. The beavers are still taking willow for both forage and dam building, and as those are both ongoing needs, willow will be important in determining the future of the beavers on Alhambra Creek.

With these two facts in mind, and considering that the Alhambra Creek beavers do not currently move up and down stream to allow for over-harvested willow to recover, the recommendation is to plant willows in bare areas that are either neutral to overall stream flow or aid it by stabilizing uphill banks and berms. Since the largest limitation is available space for willows to grow, advantage should be taken of all high quality planting sites to achieve a maximum number of willows. Arroyo willow is harvested by beavers in Alhambra Creek at higher frequencies than shining willow, and therefore is the recommended species to plant.

Plantings should also be used to maximize the beneficial properties of willow trees (i.e. bank stabilization, erosion reduction, and creating migratory bird habitat), and to avoid potential negative side effects (i.e. planting too close to concrete paths and open drains).

The largest amount of available planting area is in Zone 1. The zone extends up to approximately 100 feet from the east edge of the creek, and is therefore perfectly situated within the preferred foraging distance of the beaver. Areas that seem especially beneficial in Zone 1 are:


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- Any open area on the west bank (especially between Marina Vista Avenue and where Alhambra Avenue dead ends);
- The berm that borders the east bank of the Alhambra Creek channel; willows here would help stabilize the berm and maintain the integrity of the creek channel as well;
- The far-east potion of the east bank (adjacent to the Amtrak parking lot) would also be ideal for willow planting; it does not currently show much sign of beaver herbivory, but could become used if the other willow resources are over-harvested;
- Replacement of willows is important in areas where they are not recovering from being cut, but most willows will recover to some degree, and those that don't may be in sites where a sapling willow would have difficulty establishing as well (i.e. shady locations).

Areas in all the zones dominated by non-native, non-preferred plant species could also be cleared and replaced with willow. This is especially true for *Arundo sp*. which spreads readily forming thick stands in riparian areas and potentially could encroach on existing willow, limiting future willow supply. Resources for *Arundo sp*. removal can be found at http://ceres.ca.gov/tadn/

Further Research and Monitoring

Further research is needed on the specific foraging requirements of delta beaver in areas rich in tule and cattail to determine the exact woody forage requirements of these populations. Ongoing monitoring of willow re-growth and replacement as well as overall biomass estimates for the two willow species present in the study area would be useful in determining whether the amount of available forage is increasing, decreasing, or stable.

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Appendix 1: Bird Species observed in or above Alhambra Creek

Common Name	Scientific Name
American Crow	*Corvus brachyrhynchos*
Anna's Hummingbird	*Calypte anna*
Barn Swallow	*Hirundo rustica*
California Towhee	*Pipilo crissalis*
Cedar Waxwing	*Bombycilla cedrorum*
Clark's Grebe	*Aechmophorus clarkii*
Common Yellowthroat	*Geothlypis trichas*
Double-Crested Cormorant	*Palacrocorax auritus*
European Starling	*Sturnus vulgaris*
Gadwall	*Anas stepera*
Green Heron	*Butorides virescens*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Lesser Goldfinch	*Carduelis psaltria*
Mallard	*Anus platyrhynchos*
Northern Mockingbird	*Mimus polyglottos*
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*
Nuttal's Woodpecker	*Picoides nuttallii*


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Orange-Crowned Warbler	*Vermivora celata*
Rock Pigeon (flying over head)	*Columba livia*
Snowy Egret	*Egretta thula*
Song Sparrow	*Melospiza melodia*
Turkey Vulture (flying overhead)	*Cathartes aura*
White-Crowned Sparrow	*Zonotrichia leucophrys*


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Appendix 2: Zone Map

Map Key:
Zone 1-Yellow: Train Tracks to Marina Vista Ave.
Zone 2-Green: Marina Vista Ave to Escobar St.
Zone 3-Blue: Escobar St. to Main St.
Zone 4-Orange: Main St. to Ward St.
Zone 5-Red: Ward St. to Green St.
(Source: Google Earth 2009)

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