APPENDIX F: HABITAT RESTORATION IN THE ARROYO SECO WATERSHED

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Habitat Restoration in the Arroyo Seco Watershed

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Introduction

The Arroyo Seco watershed spans a diversity of habitat types and conditions. Restoration efforts must consider relatively intact, but threatened ecosystems within the Angeles National Forest as well as highly degraded habitats in urban areas.

The major issues of concern with respect to habitat restoration in the Arroyo Seco watershed include:

- Watershed Integrity – and functionality from the perspective of biological diversity
- Habitat Quality & Connectivity– structure and viability for focal wildlife species
- Habitat Connectivity – for wildlife movement needs
- Restoration of Habitat-Shaping Natural Processes – such as fluvial disturbance and corresponding natural succession
- Provision of Adequate Physical Space – to meet habitat requirements of area-sensitive species and to allow for naturally-sculpted habitats, and
- Opportunities for positive relationships between humans and their wild neighbors

These issues are explored throughout the following sections of this document:

I. Habitat Restoration Goals

The overarching goal for habitat restoration across the Arroyo Seco watershed is to restore functional ecosystems. That is, while we must seek understanding of historical conditions and species compositions in order to know what these lands can inherently support, we do not necessarily intend to recreate exact replicas of historical ecosystems, nor could we even if that was our intention. Rather, the goal is to provide for sufficient space, habitat structure, connectivity, and influence of natural processes so that torn ecological relationships may be mended – so that a resilient fabric of the wild may once again stretch from the San Gabriel Mountains through the Los Angeles River to the Santa Monica Mountains and the Pacific Ocean. We acknowledge that the Arroyo Seco watershed cannot stand alone, as its inherent relationships extend beyond the watershed boundaries to these seemingly distant points. Moreover, restoration of these relationships is now dependent on the will of the watershed's human residents to share water and space with their wild neighbors. But we view the watershed as offering promising opportunities to begin the restoration process.

II. Watershed Integrity

Ecologically, the watershed may be broken down into two basic functional units – the upper watershed above Devil's Gate Dam/210 freeway, and the portion of the watershed below that break. In addition to blocking most up- and downstream movements of aquatic species, Devil's Gate Dam also serves as a barrier to terrestrial habitat connectivity in combination with the habitat fragmenting 210 freeway. Since one focus of the overall feasibility study is to evaluate the feasibility of functional connectivity between the San Gabriel and Santa Monica Mountains, this aquatic and terrestrial habitat connectivity break at Devil's Gate Dam must be acknowledged as a formidable barrier. Above the dam, the watershed rising high into the San Gabriel Mountains is clothed with vegetation and habitat types that, superficially at least, retain much of their historic ecological character. One impediment to that character is Brown Canyon Debris Dam, which serves as a second major barrier to aquatic habitat connectivity.

Downstream of Devil's Gate Dam and the 210 freeway, habitat patches are much smaller and fragmented by urban development and infrastructure. Still, these gems of relatively natural historic character call for restorative management and integration into a functional system of wildlife habitats that will synergistically support ecosystem restoration, accessible to urban dwellers. A third major, though natural biogeographical break occurs in the lower watershed – in the vicinity of the Raymond Fault, at the border of Pasadena and Los Angeles. South/ downstream of that point, soils include elevated clay contents similar to those occupying other portions of the Los Angeles Basin. North/ upstream of that point, the substrates tend to be rockier, derived from granitic parent materials. This distribution of basic soil types corresponds to the distribution of walnut woodland south of Pasadena and chaparral types north of there, as well as the distributions of reptiles and presumably many other wildlife species.

While the Arroyo Seco watershed retains a relatively high degree of native biological diversity, it may be thought of as teetering on the brink of ecological destruction, evidenced by a high rate of extirpations of historically present wildlife species and significant degradation of many remaining habitats. But with concerted and timely efforts it appears likely that balance may be tipped in favor of ecological healing and restoration of viable wildlife habitats throughout all segments of the watershed. We trust that such a future will elevate the overall quality of life and spirit of place for the human residents of this truly unique and special watershed.

III. Habitat Descriptions and Restoration Considerations

Riverine & Riparian Habitats

Functional riverine and riparian habitats are necessarily shaped by natural fluvial (flooding) disturbance and renewal. Restoration of dynamic, habitat-shaping flooding processes is essential to the restoration of species dependent on these habitats. This principle is especially critical in habitat restoration for Rainbow Trout/Steelhead, Arroyo Toad and Yellow Warbler, among other potential focal species to be identified in the future.

Riverine habitats are strongly influenced by the structure and health of their associated riparian vegetation. Riparian vegetation shelters and provides the foodweb for riverine ecosystems supporting steelhead and other native fish species. This relationship is sometimes referred to as an "insect rain" on streams from overhanging riparian canopies. Even "fishless headwaters streams are crucial conduits of food for fishes and other aquatic fauna that live downstream." (PNW 2001) Ideal riverine habitats for focal fish species are partially structured by living tree roots that stabilize undercut banks and other niche features. Similarly, dead woody debris is an important component of healthy riverine ecosystems, providing both structural and food web benefits. Likewise, riparian habitats are dependent on the river not only for water, but for the sediments and associated nutrients it brings. The timing, intensities, and sediment loads of flood flows act on local gradients, geology and existing bank structure to shape riparian habitats – scouring away vegetation and soil in some locations, while depositing fresh sediments in others, with each new flood taking a somewhat different pattern across the landscape. Over time and successive floods, a series of different age classes of riparian vegetation may build up across the floodplain, flanked by transitional upland woodlands on former bank terraces, the whole resulting in sometimes complex mosaics of trees and shrubs at varying heights. Such complex mosiacs can provide optimum foraging, as well as nesting habitats for riparian bird species.

The Santa Clara River, vicinity of Interstate 5 crossing has been identified as the nearest reference site for aquatic habitat conditions supporting the entire suite of low elevation fish species that may be hoped for with aquatic habitat restoration on the Arroyo Seco. This area reportedly supports populations of Unarmored Threespine Stickleback, Arroyo Chub and Santa Ana Sucker (Refer to the section Native Fish Focal Species Summaries) and thus offers clues to the quality of habitats to be aspired to in restoration on the Arroyo Seco. Verna Jigour conducted an overview reconnaissance of this area on May 31, 2001. The site supports a broad width of lush riparian vegetation, including cottonwoods (*Populus* sp.) and willows (*Salix* sp.) anchoring the river bottom, which itself is deeply entrenched between steep canyon walls at that point. Among the most noteworthy features of the area is the heterogeneous character of the riparian vegetation, vertically layered by time and past flooding events. At least three to four distinct size/age classes of vegetation were apparent, ranging from shrubby Sandbar Willows (*Salix exigua*) to statuesque Fremont Cottonwoods (*Populus fremontii*). A few stately Valley Oaks (*Quercus lobata*) oversee the river from the upper canyon walls. Interestingly, long stretches of the somewhat braided active channel were fully exposed to the sun and 100˚F+ temperatures that day. However, it appeared that residual pools might be camouflaged under sheltering vegetation. Far from completely pristine, this area is being steadily invaded by the exotic pest giant reed (*Arundo donax*), which has likely impacted the availability of such refuges.

Nevertheless, the site does offer a model of the type of lower elevation riparian habitat to be aspired to on the Arroyo.

While healthy riparian vegetation is critical to riverine ecology, the condition of the watershed may be critical to the health of riverine and riparian habitat ecology. Citing Steedman 1988, *Journal of the North American Benthological Society* 13:605-610, Noss (2001) notes a study illustrating that even intact riparian vegetation may not compensate for the ecological impacts of 55% or more urbanization of watersheds in the Toronto area. Based on that inference, restoration of watershed functions in the urbanized portion of the Arroyo Seco watershed must be among the objectives for recovery of riverine and riparian habitats.

Terrestrial inhabitants of riparian vegetation also depend on the heterogeneous habitat structure wrought by episodic flood disturbance to fulfill the breadth of their ecological needs. Bird species adapted to riparian habitats may use certain parts of the vegetation for nesting and others for foraging. Thus, a mosaic of different plant species, sizes and age classes may be necessary to constitute optimal habitat. The semi-open canopies favored by species such as Yellow Warbler are typically shaped by the combination of flood disturbance and ensuing natural succession by disturbance adapted riparian plant species. Unfortunately, today's riparian habitats are subject to invasion by exotic pest plant species – weeds that are also adapted to flooding and other surface disturbances. These invaders, such as the giant reed, significantly alter the structure of riparian habitats and their food webs. Thus, the process of restoring riparian habitats to the Arroyo must necessarily include a program to control exotic pest plants in the watershed.

Alluvial Fan Sage Scrub

Alluvial fan deposits form in locations where the steeper gradient drainages in the mountains drop onto the valley floors. The abrupt gradient change results in a loss of stream energy, which results in deposition of sediments that may build up over time or suddenly, with discreet flooding events. Flooding deposits sediments in some places and courses through them in others, creating braided stream patterns across the floodplain. The resulting terraces can often be associated with specific major flooding events.Thus, like their riparian counterparts, alluvial fan sage scrub habitats are shaped by natural fluvial disturbance and renewal, perhaps sometimes acting over longer time scales and broader physical expanses than riparian habitats.

The richest alluvial scrub habitats are braided terraces and benches clothed with series of age classes of shrubs and occasional trees, determined by the length of time since flooding disturbance. Flooding scours away existing vegetation, depositing fresh sediments that are relatively sterile and hostile to most plant species. A unique set of native pioneer species colonizes these fresh sands and lays the foundation for a succession of other species to follow. In concert with plant succession, the winds that frequent these canyon environments deposit fines and organic particles that also influence soil development over time. As soils and plant associations mature flooding patterns may course through them, creating mosaics of age classes that enrich overall biodiversity.

Alluvial scrub habitats are commonly characterized by the presence of scalebroom (*Lepidospartum squamatum*), along with a rich array of annuals, perennials, cacti, shrubs and occasional trees such as California Sycamore (*Platanus racemosa*) that tend to stay stunted in these well-drained soils. The distribution of shrubs is relatively open compared with coastal sage scrub, and alluvial scrub habitats appear transitional between coastal and desert environments. Another hallmark of alluvial scrub is cryptobiotic (literally hidden life) soil crusts comprised of mosses, lichens, liverworts and cyanobacteria (a.k.a. bluegreen "algae") that may appear lifeless during the dry seasons, but spring to verdant life during wet weather. These crusts may play a crucial role in rendering the alluvial soils inhabitable for many larger plant species. Other diminutive inhabitants of healthy alluvial scrub habitats are masses of tiny wildflowers that, together with the soil crusts, form a colorful tapestry across the alluvial floor each spring. Healthy alluvial scrub habitats are occupied by various resident burrowing mammals that move and aerate soil and just may play a pivotal role in shaping habitats second only to flooding. The dynamic nature of alluvial scrub

The tiny remnants of alluvial scrub habitat that remain at Hahamongna are fragmented and in some cases isolated from the possibility of fluvial influences. In areas that become inundated for periods of time, clay particles and nutrients build up to render the soils inhospitable for alluvial scrub vegetation. However, the existing remnant alluvial habitats retain significant biological value and offer hope to the worthy goal of restoring alluvial scrub plant and animal associations at Hahamongna. More physical space is needed for natural restoration of alluvial fan sage scrub habitats on the Arroyo, especially if we are to someday recover the Lesser Nighthawk, which demands expansive territories. Removal of the JPL parking lots and the revisioning of water percolation and other water facilities are likely necessary to restore functional alluvial scrub habitats. Along with the Lesser Nighthawk, such measures may have strong implications for restoration of Rainbow Trout/Steelhead and Arroyo Toad.

Coastal Sage Scrub

Coastal sage scrub has often been referred to as "soft chaparral", because the leaves of its dominant species typically lack the hard coatings associated with many chaparral plant species. In contrast, coastal sage scrub is generally characterized by drought-deciduous shrub species that drop their primary leaves during summer drought, replacing them with a lesser number of smaller leaves (O'Leary 1989). Coastal sage scrub is generally shallower-rooted, lower in stature and more open in structure than chaparral. That open structure allows for a greater number of herbaceous annual and perennial species than are able to persist in dense stands of mature chaparral. (ibid.)

Relatively limited extents of coastal sage scrub habitats remain within the watershed, though they once likely covered much of the area now occupied by human land uses. As noted in the focal species discussion, museum specimens of California Gnatcatcher document historic populations of this coastal sage scrub species in Highland Park and Pasadena. Coastal sage scrub occupies lower elevation, rolling and flat lands – the very topography that first attracted agricultural, then residential and urban development in the watershed. While remnants of this plant association still persist in or recolonize small, untended pockets of land distributed throughout the developed areas, such tiny fragments offer limited habitat opportunities for many scrub dependent bird species.

Let this not discourage the native plant enthusiasts who want to restore this plant association to their residential or business landscapes, for they may indeed be delighted by a wealth of native butterflies that somehow make their way across developed areas to find these native plants. Hummingbirds may also be enticed by certain coastal sage scrub plant species. But recovery of a representative diversity of the plant, bird and other animal species that once occupied local coastal sage scrub habitats will likely depend on restoring a functional network of larger habitat patches.

Some of the impacts of habitat fragmentation on diversity of coastal sage scrub animal and plant species have been documented through studies in fragmented coastal sage scrub canyon habitats in San Diego County. These studies offer clues to factors that may be critical to the success of coastal sage scrub habitat restoration in the Arroyo Seco watershed and associated areas. Local extinction vs. persistence of/recolonization by coastal sage scrub bird species has been correlated with the size of fragments, as well as the time since the fragment became isolated from other larger habitat areas (Soulé et al. 1988; Crooks et al. 2001). The species studied included Greater Roadrunner, California Quail, California Gnatcatcher, and Cactus Wren (all identified as focal species in this study), along with California Thrasher *(Toxostoma redivivum*) and three other species. Of 30 habitat fragments studied in 1987 and again in 1997, Greater Roadrunner persisted only in one 72 hectare (178 acre) patch. California Quail and Gnatcatcher also tended to occur only in patches larger than 56 ha. (138 ac.) and 31 ha. (77 ac.) respectively, while the threshold for California Thrasher occurrence was found to be about 10 ha. (25 ac.) (Crooks et al. 2001).

Due to the low stature of the vegetation, the nesting and foraging behavior of resident bird species necessarily occurs relatively close to the ground. This makes them susceptible to mesopredators (secondary carnivores in the food web, or ecological pyramid), including domestic and feral cats, along with Raccoons, Opossums, Striped Skunks and Gray Fox. If their populations are not checked by a primary carnivore, such as Mountain Lion, Bobcat or Coyote, these mesopredators can take a heavy toll on coastal sage scrub bird species (Soulé et al. 1988; Crooks and Soulé 1999). In the fragmented San Diego County coastal sage scrub habitats, Coyote was found to be a Keystone species in ensuring the ecological integrity of those habitat patches (Crooks and Soulé 1999). Thus, habitat connectivity that enables Coyotes to patrol those patches is indicated as critical to their ecological sustainability.

Native plant species richness of fragmented coastal sage scrub patches was also found to decline with the size of the fragment, but this might be expected due to the smaller number of microhabitats in smaller fragments (Alberts et al. 1993). A more telling finding was that native plant species richness declined over time since isolation, while the number of non-native ruderal and horticultural species increased (ibid.). In the Arroyo Seco vicinity, encroachment into scrub habitats has included planting of trees, as well as other horticultural species.

Thus, along with aspiring to restore the greatest feasible expanses of coastal sage scrub, some measure of connectivity of habitat patches should be sought to ensure the ecological restoration and sustainability of these habitats over time. Planning for the restoration of these habitats to the Arroyo Seco watershed should emphasize a system of coastal sage scrub patches, ideally connected to one another, and to patches outside the watershed, through habitat linkages. Since small patches of coastal sage scrub occur in association with other habitat types in the vicinity of the watershed, some of the necessary habitat size and connectivity may be achieved through linkage with native alluvial scrub, chaparral and woodland communities. Of course, the efficacy of any restoration effort will have to be measured through sustained monitoring efforts.

Considerations for restoration or enhancement of coastal sage scrub habitats must include an understanding of the factors that lead to their degradation. In addition to outright removal for land development and agriculture, land management practices have probably lead to the demise of coastal sage scrub from some existing open space areas in the watershed. Past grazing, along with changes in fire regime and fuel modification efforts have likely conspired to result in the conversion of coastal sage scrub to weedy annual (nonnative) grasslands in some locations. The sustainable fire frequency in coastal sage scrub appears to be intermediate between that of grassland and chaparral, with fire return intervals of 5 to 10 years favoring coastal sage scrub, but more frequent fires leading to development of annual grasslands (O'Leary 1989). Increasing urbanization has often resulted in increased fire frequencies, with fires occurring annually in some locations, such as an expansive slope at Debs Park that apparently succumbs to illegal fireworks most years (Cooper pers. com. 2001). Excessive fuel modification efforts can have an effect similar to such frequent fires. As noted in the section Restorative Management of Public Land Habitat Slivers, discing, grubbing or other methods of repeated, complete removal of shrubs and subshrubs favors only annual species, including exotic grasses and mustards (*Brassica* sp.). Conversion to these annual species can, in turn, tip the balance toward more frequent burning simply because of the mass of dead fuel that accumulates each year as the annual species die. Thus, in addition to revegetation efforts, restoration of coastal sage scrub habitats will require development of strategic land management protocols, possibly including prescription burning. Removal of introduced trees (or girdling to create snags) may be appropriate in some locations.

Generally, coastal sage scrub revegetation efforts are only appropriate on disturbed lands, including those dominated by annual grasslands. Among such sites, determination of suitable locations for revegetation of coastal sage scrub versus other habitat types will require evaluation of environmental factors including soil type, slope gradient and slope aspect. As Keeley (1993) noted, coastal sage scrub and chaparral types tend to occur on rockier, more exposed sites, with shallower soils and lower clay content than do native perennial grasslands. Another important revegetation objective is restoration of the soil ecosystems that support the scrub associations. Conversions to nonnative annual grasslands have typically resulted in the loss of soil microorganisms that had enjoyed mutualistic relationships with the native scrub species. Restoration of the full complement of coastal sage scrub plant species to such sites will likely be expedited by some means of inoculation with mycorrhizal fungi, which are thought to function as keystone or catalytic elements in the restoration process. Reintroduction of other microorganisms, such as those involved with formation of cryptobiotic soil crusts, might also prove helpful in some cases.

Careful attention to such details of soil ecology may be among the factors needed to restore habitats for native terrestrial arthropods (soil dwelling insects) important in the structure of local food webs. Monitoring of terrestrial arthropod assemblages at coastal sage restoration sites and comparison sites revealed that the restoration sites lacked native assemblages and hosted significantly more invasive arthropods, including Argentine Ant (*Linepithema humile*), European Earwig (*Forficula auricularia*) and Dooryard Sowbug (*Armadillidium vulgare*) (Longcore 2000). Habitat connectivity for terrestrial arthropods was believed to be a factor in this distribution (ibid.) and should be among the factors addressed in coastal sage scrub revegetation efforts.

The Arroyo Seco watershed lies in an apparent transition zone between two of the six general coastal sage scrub associations identified by Westman (1983). These two general associations, Venturan and Riversidean coastal sage scrubs, are recognized as natural communities in the Holland (1986) classifications used for the California Natural Diversity Database (CNDDB). In the more recent plant associations developed by Sawyer and Keeler-Wolf, the two scrub types are represented in several vegetation series according to dominant species. Determination of appropriate species compositions to use for revegetation should be based on a combination of the presence of any residual native species, historical vegetation data such as the Wieslander Vegetation Type Maps, and identification of comparable reference sites to use as models for restoration objectives. In addition to the obvious shrub species, coastal sage scrub restoration and enhancement efforts should emphasize inclusion of a herbaceous component of both annuals and perennials – the species that proliferate when fires or other disturbances create gaps in the shrub cover. "Inclusion of this component is vital for maintaining diversity, providing a food source for native herbivores, and aiding in the stabilization of postburn nutrient losses (O'Leary 1989).

Chaparral

In contrast to the "soft chaparral" also known as coastal sage scrub, true chaparral associations are characterized by the typically small, thick, stiff, evergreen leaves of its dominant species. This leaf feature is referred to as "schlerophyllous", meaning "hard-leaved" – a moisture-conserving adaptation to the summer droughts characterizing their geographic distributions. As another adaptation, chaparral shrubs employ a dual rooting system, with "an extensive lateral system suited to exploit surficial moisture supplies, and a deeply penetrating system suited to summer drought" (Hanes 1977, citing Cannon 1911). The effectiveness with which these shrubs maintain watershed integrity is evidenced by the dry erosion and mudslides that can follow severe burns in chaparral covered areas. (Please refer to the section, Fire Regime and Watershed Function for a discussion of this relationship).

The quintessential fire-adapted vegetation type in California, typical fire return intervals for chaparral are considered to range from 10 to 40 years (Hanes 1977). Along with an abundance of fire-following annuals and perennials, coastal sage scrub species may serve as early seral (pioneer) colonizers of chaparral sites for a period of years after a burn. If too frequent fires occur – every 5 to 10 years – coastal sage scrub may replace chaparral (O'Leary 1989). In places where the two associations co-occur, coastal sage scrub may dominate on south to west-facing slopes, while the deeper-rooted chaparral species dominate on the more protected north to east-facing slopes.

Likely a few chaparral types exist within the Arroyo Seco watershed, with variations of chamise chaparral occupying lower elevation habitats, and montane chaparral types in the higher elevations. The major conservation concerns for the lower elevation chamise chaparral are habitat fragmentation and type conversion to nonnative annual grasslands through discing or other repeated removal of perennial vegetation. Since chamise chaparral poses high fire risk to nearby structures, regular fuel modification is essential to a harmonious interface with human-occupied areas. But if selective vegetation removal is done carefully, without disturbing soil surfaces, many of the herbaceous annuals and perennials that typically appear only after fires might be encouraged to proliferate in fuel modification zones.

Where the chaparral extends up the slopes of the San Gabriels into the national forest, probably the most critical restoration goal is a return to the mosaic structure of chaparral age classes (since last burning) that apparently existed prior to fire suppression efforts (Minnich 1987). Such structure may be achieved through a program of prescription burning, which will necessarily be a complex undertaking on the part of the national forest, but may prove an important component of the restoration of the Arroyo Seco watershed (Refer to Fire Regime and Watershed Function).

Oak and Walnut Woodlands

The numerous reasons to seek ecological restoration of the Arroyo Seco watershed's woodlands include: 1.) concerns over their long-term sustainability, 2.) their function in providing watershed services, 3.) their aesthetic benefits, and 4.) the array of wildlife species they support.

As human land uses have encroached upon existing California oak woodlands, we have seen numerous examples of the slow but eventual decline of conserved specimen oaks. For example, where a new home site has seemingly coexisted with a mature Coast Live Oak (*Quercus agrifolia*) for a decade or more, the oak will suddenly succumb and die. Excluding unusual disease outbreaks (e.g., the sudden oak death syndrome of the central California coast), such declines are usually the result of subtle, yet cumulatively potent changes in the soil environment supporting the tree's roots – as a result of restructuring to accommodate human needs, often ignorant of the demands of these long-lived residents. Many among us understand the need for careful attention to coexistence with mature oaks, but as land development continues within the watershed, public reminders probably can't be overstated. When large trees do die, especially within woodland settings, the dead snags' value as potential habitat for various species should not be overlooked – it is a value far longer lasting than the temporary comfort afforded by burning them up in a fireplace.

Along with human-caused declines of mature oaks, the often pronounced reductions in natural regeneration of various types of oak woodlands have been of concern throughout California for at least the past two decades. In many cases, especially for Valley Oak (*Quercus lobata*), the woodlands are composed nearly exclusively of mature trees, up to hundreds of years old, with no intermediate or young trees "waiting in the wings" to replace their woodland functions should they succumb. The causes for such regenerative declines are likely complex, but most certainly resulted from human land management impacts, beginning in the late 18th century with the Spanish introduction of cattle ranching, associated changes in fire frequency, and the resulting "type-conversion" of woodland understories to nonnative annual grasses. This understory conversion had perhaps a profound effect on soil moisture relationships of affected oak species (e.g., see Danielsen and Halvorson 1990 with regard to Valley Oak soil moisture relations, comparing native and nonnative grass species understories).

Less concern over regeneration has been focused on the Coast and Canyon Live Oak (*Quercus chrysolepis*) woodlands that occur in the Arroyo Seco watershed. Jigour observed relatively young specimens of both species during the limited field reconnaissance conducted for this study. However, the degree of human interface these woodlands experience suggests that attention to the sustained health of these woodlands is warranted to ensure the resilience of mature trees, as well as the regenerative capability of the woodland. Probably the primary issue of concern in high human use areas is soil compaction, followed by degradation of native oak woodland understories. In the often narrow bands of Canyon Oak woodland that line the upper Arroyo Seco, little native understory exists, while exotic pest plant species form the most common understory. In the Coast Live Oak grove at Hahamongna, understory is typically either absent, due to obvious soil compaction, or composed almost exclusively of naturalized nonnative species.

The concern over oak woodland sustainability and regenerative capacity is necessarily related to concerns about their watershed and wildlife habitat functions, as well as their aesthetic benefits. Soil compaction and understory degradation combine to reduce the ability of these woodlands to store and filter water which, in turn, creates an additional negative feedback loop impacting the health of the woodlands themselves. Unhealthy woodlands are less aesthetically pleasing woodlands and their degradation results in cumulative losses of viable wildlife habitats.

Noteworthy among the fourth category, regarding their wildlife habitat functions, is the relationship of oak woodlands to Arroyo Toad adult foraging areas, which must include some areas of friable (uncompacted) soils (USFWS 1999). Thankfully, this knowledge suggests a clear direction for restorative management of oak woodlands within and near those areas designated as Critical Habitat for Arroyo Southwestern Toad, and that strategy supports management directives needed to address many other wildlife species, as well as the three other general categories of concern. Two other focal species selected to represent other aspects of oak woodland habitat viability, the Oak Titmouse (a perching bird species) and Arboreal Salamander require standing dead and downed, decomposing wood niches, respectively.

For the Canyon Live Oak woodlands along Arroyo Seco Creek upstream of JPL, we recommend evaluation of the degree and nature of: 1.) soil compaction in high human use areas, along with 2.) exotic pest plant encroachment, to determine the need for and feasibility of restorative measures to favor Arroyo Toad adult foraging patterns.

The Coast Live Oak woodland at Hahamongna presents another set of challenges, highlighted by the disc golf course that meanders through its welcoming shade. This highly popular feature has unfortunately taken its toll on the soil ecosystem supporting the oak woodland. Soil compaction is the obvious impact of all the foot traffic, with the most highly used areas having become hardened, lifeless and prone to immediate runoff. The City of Pasadena has made an effort to correct some of the problem by contracting arborist Jan Scow to develop management recommendations for the woodland. Time constraints prevented the team's review of that report, but on her May 2nd visit Verna Jigour observed mounds of mulch deposited in some locations, awaiting spreading to a more uniform cover. Clearly, appropriately implemented mulch applications offer a boon to the health of the oak woodland. However, some additional measures are recommended to ensure that the relationship between humans and this exceptional oak woodland can become mutually beneficial.

Especially in the highest use areas – nearest parking areas and the most intensely used disc golf play routes – mulch applications , reinforced by site shielding techniques, and even temporary closures may be worth exploring. "Site shielding" refers to techniques that would make the site more resilient to ongoing trampling. Temporary closures can also help high use areas recover from trampling effects. Summary discussions of these topics are available in Hammitt and Cole's (1987) Wildland Recreation: Ecology and Management, p. 298-323. A corresponding approach might seek to concentrate use by defining specific traffic/play areas and simultaneously shield them from trampling by, for example, treating high use areas with a layer of wood chips. The decomposing wood chips favor the development of soil macro- and microflora than can help alleviate soil compaction while limiting further compaction impacts. Interpretive education could encourage disc golf players to stay on designated travel areas, leaving other areas to recover with the aid of appropriate mulching.

While the disc golf players are likely the greatest source of compaction problems in this oak grove, they may also prove its greatest stewards if strategic efforts are made to engage and channel their senses of responsibility toward their beloved woodland. As Jigour traveled through the grove in early May around 5 pm, while throngs of disc golfers began to arrive, she encountered one disc golfer near the northern end of the grove pulling masses of wild cucumber (*Marah macrocarpus* var. *macrocarpus*) vines away from a relatively young oak it had been clambering over. Accustomed to seeing volunteer stewards pulling exotic pest vines off the oaks they were smothering, this was the first time Jigour had observed someone targeting the native wild cucumber. Smiling, she asked the volunteer, "'Don't like that plant, eh?" Sweating and winded, he responded, "It kills the oak". Whether or not the native wild cucumber is an appropriate target for oak woodland stewardship, the experience illustrates the sense of stewardship some disc golfers feel toward the sheltering oak grove. With appropriate interpretive and public outreach efforts, it is likely that designated play/no play zones will be respected and that active stewardship initiatives may have a ready supply of volunteers.

A common theme throughout the oak and walnut woodlands of the watershed is the degradation and outright loss of native woodland understory species. The prehistoric composition of walnut woodland understories has apparently never been fully documented. (e.g., Swanson 1967, Leskinen 1972, Keeley 1990 and Quinn 1990). This creates uncertainties for those wishing to faithfully restore native wildlife habitats, although a sizable list of native shrubs and herbs remain associated with walnut woodlands today, partly because their deciduous nature allows light to nurture understories during winter. The specific historic composition of the Canyon Live Oak woodlands lining the upper watershed canyons may not ever have been documented. Where one might speculate a dappled sprinkling of understory species once occupied patches among the leaf litter, exotic pest plants now cover the greatest extent of understory along upper watershed riparian areas. Similarly, the Coast Live Oak grove at Hahamongna is nearly devoid of native understory, except for the steeper slopes. A solitary specimen of Blue Wildrye (*Elymus glaucus*) was the only native understory species Jigour observed on a quick overview reconnaissance of the grove. An array of suitable Coast Live Oak understory species is fairly well documented, although identification of suitable reference sites is likely appropriate for determining an understory restoration program for the Hahmongna grove. While the understories of native Coast Live Oak woodlands may only occupy patchy areas where the canopy gives way, these patches of native shrubs and herbs can provide habitat complexity highly supportive of native wildlife species, including the cover needed by the Arroyo Toad to help avoid predation. The overall soil ecology of the Hahamongna grove appears to have been altered through cumulative human impacts, so strategic efforts to restore understory structure will necessarily require attention to soil ecology, as well as prospective planting programs.

Grasslands

It is likely that significant portions of the lower watershed were once clothed in valley grassland, characterized by Purple Needlegrass [*Nassella* (*Stipa*) *pulchra*], along with other perennial bunchgrasses, native annual grasses and other herbs (e.g., Keeley 1989). The pre-human extent of such grasslands may never be known, as the people living in nearby areas prior to European contact are known to have used burning as a vegetation management tool to encourage the native grasslands that provided them sustenance, among other objectives (Timbrook et al. 1982, see also Lewis 1973). The subsequent European influence brought an influx of Mediterranean herbs and annual grasses better adapted to the introduced cattle and sheep grazing regimes. Today even the most pristine valley grassland relicts always contain a sizable component of nonnative annual grasses, particularly wild oats (*Avena* sp.) and bromes (*Bromus* sp.) (Keeley 1989). An array of colorful native wildflowers may be found in association with native grassland stands.

Within the vicinity of the Arroyo Seco watershed, relict stands of native grasses tend to occur in patches associated with other native plant associations, such as the walnut woodlands at Debs Park and Elyria Canyon. Perennial bunchgrasses are often important recolonizers of coastal sage scrub and chaparral habitats following disturbance by fire or other vegetation disturbance and can often be found colonizing past fire breaks. In addition to helping to stabilize soil surfaces following disturbance, the extensive fibrous rooting systems of native perennial bunchgrasses help to create subsurface soils structures conducive to deep water infiltration.

Opportunities for grassland restoration within the watershed are limited, but restoration of mosaics of native grassland patches with other plant associations is an achievable goal and may serve the habitat needs of the Grasshopper Sparrow, focal species for restoration of grasslands habitats. Among the obvious sites for consideration of grassland restoration are Debs Park and the much smaller area of Rainbow Canyon, but appropriate native grasses should be included in revegetation efforts aimed at most habitat types.

There is often a natural assumption that areas currently occupied by nonnative annual grasslands are suitable sites for restoration of perennial grasslands. However, as mentioned in previous sections, many of these lands were formerly covered with coastal sage scrub and chaparral, and may have soil types unsuited to sustaining bunchgrass stands over time. Keeley (1993) provided clues to site factors conducive to the restoration of native bunchgrasses by analyzing such factors associated with relict stands of the natives, in contrast to annual grasslands with no relict bunchgrasses present. Site factors associated with relict stands included deep soils (50-100 cm), with high clay content and no rocks, and generally north to east-facing slopes. Annual grasslands devoid of native perennials were found most often on rocky, shallower soils (10-30 cm), with little or no clay content, largely on south to west-facing exposures. (ibid.) These site factors should be considered in the design of restoration projects aimed at establishing permanent stands of native bunchgrasses and their associated wildflowers. However, as noted above, the native bunchgrasses are important in the reestablishment of other plant associations and should be included in most revegetation efforts, even if they are not expected to persist as the vegetation matures.

Fire Regime and Watershed Function

Watershed function can benefit from a return to the more natural fire regimes that prevailed prior to the fire suppression efforts that began in the 1890s, with the inception of the U.S. Forest Reserve program. Richard Minnich, in his paper, "Fire behavior in southern California chaparral before fire control: the Mount Wilson burns at the turn of the century" (1987) describes the likely nature of montane fires prior to that time, along with discussion of two burns specifically affecting the Arroyo Seco watershed. Generally, since the inception of fire suppression, the changes in pattern include a shift in the season of burning from summer to fall, as well as increases in the intensity of conflagrations and corresponding increases in area burned, correlating with decreases in the duration and frequency of fires.

Prior to suppression efforts, lightening-ignited fires were more likely to occur during the period "from July to mid-September [when] surges of tropical moisture advect into southern California . . . bringing afternoon thundershowers and lightning" (ibid., citing Hales 1974). Minnich notes accounts by Juan Crespi, of the 1769 Portola expedition, of fires intentionally set by indigenous people to maintain extensive grasslands along the Santa Barbara coastline [see also Timbrook et al. (1982) 1993], along with the Spanish cattle ranchers' burning of chaparral to convert it to rangelands during the early 1800s. Minnich's analysis of a variety of evidence, including newspaper accounts from the 1800s suggests that the majority of fires occurred during the summer, with some extending into the fall. The evidence also points to burns of relatively small areas, patchily distributed across the landscape. The smaller sizes of burn areas were likely due to past burn patterns, resulting in mosaics of chaparral age classes, the youngest being less susceptible to ignition. Citing Mendenhall (1930) Minnich notes that "older settlers stated that 'fires occurred each year . . . and were not extensive due to the fact that they ran into older burns and checked themselves' ".

Minnich observes that "the Mt. Wilson burns . . . were characterized by alternate smoldering and spreading for months through the fire season" and that "such behavior may have been characteristic before fire control. . . . The erratic behavior of the Mt. Wilson fires suggests that active fire spread was possible only during the warmer and drier episodes. Hence, the storage of embers in large fuels was crucial to the persistence of fires." He notes that the relatively small chaparral root crown burls are capable of retaining fires for only a few days and hypothesizes "that long-term fire endurance was encouraged mostly by ember storage in logs and snags in *Pseudotsuga macrocarpa- Quercus chrysolepis* [Big Cone Douglas Fir-Canyon Live Oak] forests". During active fire runs, fire intensities were necessarily high, due to the combustion of entire chaparral canopies required for fire spread, with forty-foot flame heights reported for the 1896 Arroyo Seco fire. But the fastest runs of that fire burned only 3,700 acres (1,500 hectares) in nine days, September 30-October 8 (ibid.). Minnich measured the total extent of that burn as 10,800 acres (4,370 hectares), with the fire's inception in late August to early September and its burning out for lack of fuel on October 16. "Low spread rates during the Mt. Wilson burns were related to marine air penetration characteristic of summer. Fires were active when fanned by afternoon wind; they lulled at night under light air drainage and ground inversions." However, in reviewing the cumulative historic evidence of regional fires, Minnich notes that "the relationship between daily weather and fire behavior was ambiguous. . . . Some periods of active spread were associated with strong marine air penetration. Some hot spells coincided with only smoldering or small runs."

"In 1900, Gifford Pinchot, Chief Forester, visited Pasadena to 'press hard for the employment of 100 rangers [to be] employed seven months/year cutting breaks on the ridges, clearing out undergrowth, and building trails through the mountains so that every section can be reached readily by fire fighters. . . . Immediate suppression of small fires apparently proved to be quite effective." During the period from 1905 to 1919, remarkably little burning occurred in the San Gabriel Mountains. Then, from September 12-26, 1919, two simultaneous conflagrations driven by Santa Ana winds burned 123,500 acres (50,000 hectares) of chaparral, 56,800 acres (23,000 ha) in the East Fork of the San Gabriel, while the 66,700 acre (27,000 ha) Ravenna fire burned from Mt. Gleason to Pacoima. "In 1924, the Monrovia Peak fire spread over 49,400 acre (20,000 ha) from Monrovia to Mt. Waterman. Previous burning spared the Mt. Wilson front country from these conflagrations." The Ravenna fire laid down at the margins of the 1896 Arroyo Seco burn, as well as those of 1908 and 1913 on Mt. Lukens Ridge. "Within five years, almost 65 percent of the chaparral in the San Gabriel Mountains was consumed by only three fires."

Citing a 1908 newspaper article, Minnich notes that icon William Mulholland had "deduced a change in the pattern of fire and took a controversial view against suppression." Mulholland pointed to the watershed benefits of frequent, small fires (ibid.). His views were born out by the fires of 1919 and 1924, which must have had devastating impacts on several tributary watersheds simultaneously, with cumulatively huge impacts on the Los Angeles and San Gabriel River systems. These extensive burns also set the stage for a more homogeneous distribution of chaparral age classes throughout the mountains, relative to the previous mosaics shaped by relatively small burn areas distributed over time. Citing his own 1983 paper, Minnich observes that since the inception of fire suppression, "the greater fire area burned per unit time indicates that recent fires are more intense than were those before fire control and that chaparral is more extensively denuded than before". Thus, fire suppression has apparently lead not only to greater spatial extents, but also to greater magnitudes of watershed impacts per unit area.

The watershed impacts of chaparral fires on steep slopes typically begin before ensuing rains, because the associated soils are noncohesive when dry and subject to dry-creep erosion and/or sliding. Wetting actually makes these soils more cohesive and less erosive. Significant erosion occurs after chaparral wildfires and as much as 90% of that erosion has been documented as occurring during the dry period. (Biswell 1974) The subsequent rain storms simply move the sediments farther down the watershed. During the hottest, most intense fires, successive volatilization and condensation of hydrophobic compounds contained within the chaparral leaf litter can result in the formation of water-repellent layers at varying depths beneath the soil surface. As the wettable soil surface becomes saturated, the sub-surface water-repellent layers act like concrete pavement, causing the saturated soil above to slip. (ibid.) Thus, erosion problems can be exacerbated by the high intensity fires apparently wrought by the cumulative effects of fire suppression.

Indeed, among the most effective strategies to promote restoration of watershed function in the San Gabriel Mountains may be a fire management plan structured to return the forests to pre-suppression fire regimes.

IV. Focal Species Approach to Habitat Restoration Goals

The team has employed a "focal species" approach to defining habitat restoration goals (Lambeck 1997). For expediency and clarification of conservation and restoration goals and objectives, we have begun to describe a suite of focal or "surrogate" species on whose habitat features limited resources may be focused, with corresponding benefits for the ecological integrity of the entire watershed and beyond. Thus, these focal species represent the restoration goals, whose objectives will entail the restoration of habitat structure, connectivity and natural processes supporting those species, many others, and the ecosystem as a whole.

As summarized by Caro and O'Doherty (1999), the surrogate species employed by conservation biologists include the following three general types:

- **Umbrella** species have habitat area and quality requirements that encapsulate the needs of an array of other species.
- **Flagship** species are charismatic species that can attract the attention and imagination of the general public.
- **Indicator** species are broken down into three sub-categories**:**
  Ecosystem Health Indicators are species sensitive to and indicative of anthropogenic (human-caused) disturbances to ecological functions. **Population Health Indicators** are predator species whose own population health provides a measure of the health of their assemblage of prey species and a multitude of associated ecological relationships. Since these predators act as top-down regulators of biological interactions, they often perform a **Keystone** function in the foundation of the ecosystem. Keystone Species exert disproportionately large influences on the ecosystem relative to their abundance and loss of these species can lead to unraveling of the ecological fabric.
  Biodiversity Indicators are not included for Arroyo Seco habitat restoration, as they are typically represented by guilds of species over relatively larger geographic areas (ibid.).

Late in our planning process we received data on species of particular concern from California Natural Diversity Database (CNDDB) and the Angeles National Forest. Further examination of these data may prompt future additions to the list of focal species for restorative measures in the upper Arroyo watershed.

Note: The general scientific custom is to use all lower case letters for species' common names in text, except for proper human or place names that may form parts of common names. However, a comvention among bird enthusiasts especially is to capitalize common names of species in text. We have respected that perspective herein, especially since capitalization of human and place names creates a seemingly inequitable comparison suggesting that plants and animals have lower relative value.

Focal Plant and Animal Species

These species are listed in order of their proximity to the live waters of the Arroyo Seco.

Fish Species

- Steelhead (Wild Rainbow Trout): Flagship/Umbrella – encompasses requirements for Pacific Lamprey, as well as for lower elevation focal fish species (below)
- Unarmored Threespine Stickleback: Umbrella – encompasses requirements for lower elevation Arroyo Chub, Santa Ana Sucker and Santa Ana Speckled Dace

Terrestrial Species

- Arroyo Toad: Ecosystem Health Indicator for "fluctuating hydrological, geological, and ecological processes operating in riparian ecosystems and adjacent uplands" (USFWS 1999)
- Southwestern Pond Turtle: Ecosystem Health Indicator for upper watershed tributaries
- Yellow Warbler: Umbrella species for high quality riparian habitat, shaped by natural fluvial processes
- Arboreal Salamander: Umbrella for high quality oak, walnut and sycamore woodland habitats, including connectivity to riparian areas.
- Oak Titmouse: Umbrella for woodlands that may be somewhat fragmented, but still offer significant habitat value for species less effected by loss of terrestrial connectivity.
- Coast Horned Lizard: Ecosystem Health Indicator for certain aspects of alluvial fan and coastal sage scrubs.
- Lesser Nighthawk: Umbrella for certain aspects of alluvial fan sage scrub, especially area requirements.
- Plummer's Mariposa Lily: Ecosystem Health Indicator and tentative Flagship for alluvial fan sage scrub and chaparral.
- Cactus Wren: Flagship for alluvial fan and coastal sage scrub – stands of *Opuntia* species
- Greater Roadrunner: Flagship for coastal and alluvial fan sage scrub and grassland habitat connectivity
- California Gnatcatcher: Tentative Umbrella for restoration of coastal sage scrub quantity, quality and habitat connectivity
- Grasshopper Sparrow: Umbrella for grassland habitats
- California Quail: Flagship for upland habitat connectivity
- Bobcat: Population Health Indicator for viability of prey species and their ecological relationships; potential Umbrella for landscape-scale connectivity and may serve some of the functions of Mountain Lions, the likely Keystone species, which is essentially excluded from the urbanized portions of the watershed.
- Gray Fox: Possible Population Health Indicator for viability of prey species and their ecological relationships, as well as indicator of habitat connectivity at possibly finer scales than Bobcat.

Native Fish Focal Species Summaries

Historically, the Arroyo Seco and greater Los Angeles River supported a highly diverse assemblage of freshwater fishes. At least seven fish species originally occurred in the inland freshwaters of the Los Angeles River, including five freshwater residents and two migratory sea-run (anadromous) species. Streams to the north and south of the Los Angeles Basin contained only 2-4 species of fish (Swift et al. 1993). This diversity of fish remained in the Arroyo Seco and Los Angeles River until the 1940's when flood control projects led to the extirpation of most of these species (Van Wormer 1991, Swift 1993).

Currently, the rainbow trout may be the only native fish species that still occurs in the Arroyo Seco. The Arroyo Seco has received stocked rainbow trout of different strains and the current population has a questionable genetic make up. Further investigations are needed to determine if any other native species still occur in the Arroyo Seco. Fortunately, all of the native fish species that historically occurred in the Los Angeles River watershed are represented by populations that could be used in reestablishment efforts on the Arroyo Seco.

Coastal Rainbow Trout (*Oncorhynchus mykiss*) /Southern Steelhead (*O. m. irideus*)

Rainbow Trout (*Oncorhynchus mykiss*)
Rainbow trout exist in the upper Arroyo Seco and were observed upstream of the Brown Canyon Debris Dam to the Lower Switzer Campground in the Fall of 2000 (pers. obs. Stoecker). Rainbow trout were also observed in the lowest 200 feet and 50 feet of the Bear Canyon and Little Bear Canyon Creek tributaries respectively (pers. obs. Stoecker 2000). The current genetic makeup of the rainbow trout population in the Arroyo Seco is not well understood, but has certainly been influenced by the planting of rainbow trout strains from different origins. It is not known if any of the native strain rainbow trout still exist in the Arroyo Seco or its tributaries.

Several age classes of rainbow trout, including young-of-the-year, were observed in the upper Arroyo Seco and natural reproduction is occurring. Upstream of the Long Canyon tributary, rainbow trout were observed in moderate to high numbers and appeared in good health with individuals up to 13 inches in length. All rainbow trout observed had adipose fins present (pers. obs. Stoecker 2000). Adipose fins are often removed from hatchery reared/stocked trout, but are present on naturally reared individuals.

<u>Higher elevation species requirements- Focal species: rainbow trout</u>
(Upstream of JPL)

Summer/fall water temperatures- below 75-80F
Summer/fall water column DO levels- over 6.0 mg/l
Winter/spring intragravel DO levels- over 7.2 mg/l
Spawning Gravel Size (inch diameter)- 0.2"- 5.0"
Sand/Silt associated with spawning gravels- optimal below 5%
Suspended sediment concentration- below 3,000 ppm
Food items- Mayfly, Caddisfly, Stonefly, Ants, Beetle, Damselfly, Dragonfly, smaller fish species

Favorable Habitat Conditions- Deep pools, riffles, cool, clean, oxygen-saturated water, instream cover, clean permeable gravel, woody debris, boulders

Steelhead (*O. m. irideus*)
The steelhead is an anadromous form of the rainbow trout and is often taxonomically classified as the subspecies *O. m. irideus*. Steelhead entering streams south of, and including, the Santa Maria River (San Luis Obispo and Santa Barbara Counties) are recognized by the National Marine Fisheries Service (NMFS) as a Evolutionary Significant Unit (ESU) and commonly referred to as southern steelhead. Currently, NMFS does not acknowledge the Los Angeles River and many other southern California streams as part of this designation. The southern steelhead is federally listed as an endangered species and has experienced the most dramatic declines of any ESU in California.

Steelhead historically utilized the Arroyo Seco River and documentation of a 25-inch long adult steelhead caught in the Los Angeles River near Glendale in January 1940 (Leonard G. Hogue) proves their presence in the watershed (Swift et al. 1993) prior to downstream flood control projects and construction of migration barriers. While anadromous steelhead can no longer return to the Arroyo Seco River it has been observed that individuals from the existing rainbow trout population migrate downstream in the Arroyo Seco during typical steelhead outmigration times. It is unknown if any of these individuals ever enter the ocean alive, become steelhead, and/or attempt to return to the Los Angeles River or other coastal streams. Steelhead continue to survive in several streams just to the north, including several drainages of the Santa Monica Mountains and the Santa Clara River. Steelhead are also documented in San Mateo Creek (San Diego County) and likely return to other historically occupied watersheds to the south.

<u>Watershed Connectivity Requirements- Focal subspecies steelhead</u>
(Pacific Ocean upstream to lowest Switzer Falls)

Migration Barrier/Impediment Jump Height- less than 8 feet
Minimum Jump Depth (downstream pool at structure)- 1.25 X Jump Height
Water Velocity (except during peak flows)- below 10-13 cfs
Water Depth During upstream migration- over 7 inches
Streambed- Fairly naturalized, heterogeneous

Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*)
This species was described by Culver and Hubbs (1917) as "one of the most abundant fishes in the lowlands of the Los Angeles Basin (Swift et al. 1993). The stickleback is thought to have been extirpated from the watershed in the 1940's, which coincides with the completion of the large flood control projects in the lowlands (Van Wormer 1991; Swift et al. 1993). Populations of this unique stickleback subspecies currently exist in the upper Santa Clara River and San Antonio Creek to the north. This species is a state and federally listed endangered species. The 1985 USFWS Recovery Plan for the unarmored threespine stickleback calls for reestablishing two viable populations of stickleback in the Los Angeles River Watershed.

Lower Elevation Species Habitat Requirements- Focal species: unarmored threespine stickleback
(Los Angeles River confluence upstream to JPL)

Water Temperature- Below 31 C
Dissolved Oxygen- 7.22 ppm "normal for clean, natural streams in southern California" (Feldman, Baskin) 2.0ppm lowest tolerance limit.
Nesting Sites- Areas of gentle flow and near or within aquatic vegetation (filamentous algae). Nesting velocity 0-.08 m/second
Rearing- Young fish seek cover form predators in aquatic vegetation.
Food items- mayfly nymphs, nematodes, snails, beetles, fly larvae, aphids, leafhoppers, and ostracods
Favorable Habitat Conditions - Mild water velocities, some circulation, and moderate algal cover; Gravel and sand dominated substrate with low amount of cobbles, deposited silt.
Flow- Portions of stream can be dry part of the year

Native Fish Communities and Focal Species

While each native fish species exhibits unique habitat preferences, many of these species co-occur in the same aquatic habitat and have similar requirements. It is well documented on the Santa Clara River to the north that arroyo chub, Santa Ana sucker, and the unarmored threespine stickleback exhibit a sympatric relationship and occur in similar habitat conditions (Baskin 1974). Swift (1993) noted that adequate conditions for unarmored threespine stickleback "would suffice for arroyo chub and Pacific brook lamprey". It has also been noted that the spawning and rearing habitat requirements of the rainbow trout, steelhead, and Pacific lamprey are also similar (Swift et al. 1993). The Santa Ana speckled dace is known to exist in a variety of habitats and has been observed occurring in habitats used by all of these native fish species.

The fish species of the Arroyo Seco can be divided into two groups associated with different habitat types (higher elevation and lower elevation fish communities). Rainbow trout, speckled dace, and the spawning and rearing stages of the steelhead and Pacific lamprey are associated with the more mountainous, higher elevation stream habitat. The unarmored threespine stickleback, arroyo chub, and Pacific brook lamprey favor the slower water found in the lower elevation aquatic habitat. These communities do overlap and the Santa Ana sucker is especially hard to place is one category as this species is often found in both. The transition between these habitats will likely occur near the Jet Propulsion Laboratory, where the Arroyo Seco emerges from a mountainous canyon onto the flatter alluvial fan upstream of Devils Gate Dam.

The rainbow trout and unarmored threespine stickleback were identified as focal species for the higher elevation and lower elevation fish communities respectively. It is believed that focusing restoration-planning efforts on the known habitat requirements of these two focal species will provide the necessary habitat requirements for the other co-occurring species found in (or between) that habitat type(s).

The steelhead was identified as another focal species to help focus efforts on reestablishing a migration corridor in order to achieve the long-term goal of reestablishing connectivity between the Pacific Ocean and the upper tributaries of the Arroyo Seco. The reestablishment of a steelhead population to the Arroyo Seco is highly dependant on improving connectivity along the Los Angeles River downstream of the Arroyo Seco and will require additional effort outside the scope of this study.

Related Fish Species

These fish species will also likely benefit from restoration efforts geared towards the Rainbow Trout, Southern Steelhead, and Unarmored Threespine Stickleback.

Pacific lamprey (Lampetra tridentata)
This species was collected in the Los Angeles River Watershed in 1925 (Swift et al. 1993) but is now extirpated from the watershed due to migration barriers associated with downstream flood control projects. Pacific lamprey utilized the Arroyo Seco to spawn (Swift et al. 1993). This anadromous species continues to run up Malibu Creek and the Santa Clara River to the north.

Pacific brook lamprey (*Lampreta pacifica*)
This species was collected in the Los Angeles River at Griffith Park in 1930 and is now thought to be extirpated (Swift et al. 1993). It is presumed that this species also utilized the Arroyo Seco. The Pacific brook lamprey still occurs in northern California streams and could be successfully reestablished after habitat conditions are improved.

Santa Ana sucker (*Catostomus santaanae*)
This species was described as "common" in the Arroyo Seco (Culver and Hubbs 1917) and was observed as recently as 1992 upstream of Hansen Dam on Big Tujunga Creek (Los Angles River tributary). It is likely that the sucker has been extirpated from the Arroyo Seco and it may have disappearing from the entire Los Angeles River Watershed. Populations of Santa Ana sucker still exist in the San Gabriel and Santa Ana Rivers (Swift et al. 1993). This species is federally listed as a threatened species.

Santa Ana speckled dace (*Rhinichthys osculus*)
This dace was observed in the Big Tujunga Creek tributary of the Los Angeles River until the mid-1980s and has not been observed since (Swift et al. 1993). It is not known if this species currently exists in the Arroyo Seco or greater Los Angeles River. Populations still exist in the San Gabriel and Santa Ana Rivers (Swift et al. 1993).

Arroyo chub (*Gila orcutti*)
In a 1917 survey, the arroyo chub was described as "common in the Arroyo Seco" (Culver and Hubbs 1917; Swift et al. 1993). In 1993, Swift noted that this species still occurs in the Big Tujunga and Pacoima tributaries of the Los Angeles River and the Sepulveda Flood Control Basin. It is not known if this species currently exists in the Arroyo Seco.

Terrestrial Focal Species Summaries

Arroyo (Southwestern) Toad (*Bufo microscaphus californicus*)
The Arroyo Southwestern Toad is listed as a federal Endangered Species under that name. However, Dan Cooper reports that the common name Arroyo Toad may actually be more accurate, as taxonomic changes may be in progress. Critical Habitat for the species was designated in February, 2001, including an area in the central portion of our study area, upstream of Devil's Gate Dam. It is our understanding that surveys for the species within the study area were conducted in 2001, but we have not learned of any results from those surveys to date.

"Arroyo toad breeding habitat is created and maintained by the fluctuating hydrological, geological, and ecological processes operating in riparian ecosystems and adjacent uplands" (USFWS 1999). Such disturbance is primarily responsible for creating the friable, typically sandy soils needed by the species for burrowing, as well as for structuring its riparian and upland vegetative cover. The arroyo toad uses a succession of niches throughout its life cycle, although most current knowledge is confined to its breeding behavior, with little known about its overwintering habitat requirements. In addition to the species' dependence on episodic fluvial renewal of breeding pools and streamside habitats, including willow thickets, the adults rely on upland habitats for foraging, particularly oak woodlands within relatively near proximity to associated stream channels (ibid.). Because of its reliance on this assemblage of habitat features inherent to an intact, dynamic ecosystem, the Arroyo Toad serves as an excellent Ecosystem Health Indicator Species. Restoration of viable habitat for this focal species would signify a profound improvement in the healthy functioning of the Arroyo Seco watershed.

The U. S. Fish and Wildlife Service' Recovery Plan for the Arroyo Southwestern Toad (ibid.) offers a comprehensive understanding of the species' life history, ecology, reasons for its decline, and threats to its persistence and recovery. Along with outright habitat destruction, the document emphasizes the importance of natural fluvial dynamics in structuring the species' range of habitat requirements, and the corresponding impacts caused by diminished, dammed or otherwise altered flows. Roads along stream terraces near Arroyo Toad breeding habitats can have high mortality on the species. Threats from recreation-related activities are numerous throughout the species' range, and suggest direction for mediating potential negative impacts through strategic structuring of recreational uses in the vicinity of the species' critical habitat.

Other threats to the species that are germane to the Arroyo include concerns regarding exotic pest species. Exotic pest plant species can crowd out and severely alter the structure of breeding and foraging habitats, including alteration of natural fire regimes. Several exotic animal species prey on Arroyo Toad, while others degrade its foraging opportunities. Bull Frogs, among the exotic species that prey on Arroyo Toad, are favored by impoundments of water. (ibid.) Thus, such impoundments should be avoided in proximity to Arroyo Toad habitats, and it follows that expansion of spreading basins at Hahamongna may be detrimental to recovery of the Arroyo Toad, due to their potential encouragement of Bull Frogs. We understand that a meandering channel approach to water spreading and infiltration was proposed to the City of Pasadena by hydrological consultants Phillip William Associates, as an alternative to the expansion of spreading basins. We understand that part of the rationale for that proposal is that it would allow some natural fluvial flushing of fine sediments and renewal of surfaces, thus naturally maintaining relatively porous surface conditions better suited for infiltration than settling basins that tend to clog with fines. If carefully evaluated with respect to the habitat needs of Arroyo Toad and discouragement of exotic pest species such as Bull Frogs, such an approach might support the dual objectives of water percolation and restoration of Arroyo Toad ecological needs.

A more subtle, but nonetheless real concern on the Arroyo Seco is the potential invasion of Arroyo Toad habitats by Argentine Ants. It is not known whether these ants pose a direct threat to the Arroyo Toad, but when they colonize areas they displace native ant populations that comprise a significant portion of the Arroyo Toad's diet (ibid.). This effect is also a serious threat to Coast Horned Lizard, discussed in a following section. Argentine ants are favored by irrigated landscapes, including turf, and may be introduced to an area in the soil of landscape plants. (Refer to the discussion of Argentine Ant in the section Exotic Animal Species.) Thus, introduction of nonnative and irrigated landscapes is probably inappropriate in the vicinity of Arroyo Toad habitat.

General Breeding Habitat	Shallow, slow-moving stream & riparian habitats disturbed naturally on a regular basis, primarily through flooding
Pool depth/quality	< 30 cm (12 in) deep/ clear water
Pool depth/ typical breeding	< 5 cm (2 in)
Water velocity	< 5 cm/sec (0.2 ft/sec)
Water temperature – Breeding	14 º C (57º F)
Water temperature – Larval stage:	April-mid-May 12-16º C (54-59º F)
Breeding Substrate	Stream bottoms of sand or well-sorted fine gravel, though a significant component of large gravel or cobble may be present
Foraging Substrate	Uncompacted, with substantial areas of fine sand, into which adults can burrow
Vegetation	Sparsely to heavily vegetated with brush, e.g., mulefat; cottonwoods, CA sycamore, coast live oak and willow; understory may be patchy or nonexistant; vegetative cover can aid the species in avoiding predation; foraging in various upland plant associations, particularly associated with oaks
Juvenile habitat	Sand or gravel bars w/ varying amounts of large gravel or cobble & w/ adjacent stable sandy terraces and oak flats

Southwestern Pond Turtle (*Clemmys marmorata pallida*)
The Southwestern Pond Turtle is listed as a California Species of Special Concern; USDA Forest Service Region 5 Sensitive Species. Because of its historical distribution in the Arroyo Seco watershed, combined with the fact that it apparently prefers stream pools that may be less attractive to rainbow trout/steelhead (and thus its needs may not overlap those of the project's focal fish species), the Southwestern Pond Turtle serves as an intriguing Ecosystem Health Indicator for certain upper watershed tributaries.

Recommended Study: Evaluate potential habitat restoration opportunities for this species along upper watershed tributaries, such as Fern or Millard Canyons.

General habitat	Pools in perennial, slower-moving streams – possibly upper Arroyo tributaries? Some upper watershed tributaries are

	currently choked with exotic pest plants, partly as a result of flow-altering weirs. Such conditions may have choked out former pond turtle habitats.
Water velocity	Relatively slow (velocity TBD)
Vegetation	Emergent & floating vegetation, algae, overhanging branches, basking logs
Substrate	Rocky, gravelly or muddy stream bottoms; emergent basking rocks

Yellow Warbler (*Dedroica petechia*)
In the Arroyo Seco watershed, Yellow Warbler breeds in native deciduous forest with a high, contiguous canopy. These are invariably located along streams, which is why Yellow Warbler has been identified as a good focal species for riparian woodland. They utilize White Alder, Willow sp., and Sycamore for breeding. They are a fairly common summer resident in alder groves in all the major canyons of the San Gabriel Mtns., including the Arroyo Seco above the mouth of the Arroyo at JPL (e.g. Oakwilde, Switzer's Camp), but downstream of here, occur only in the willow forest at Hahamongna (W. Principe, pers. comm.). Elsewhere in the Los Angeles Basin, breeding has been documented from naturally-regenerating willow forests behind Hansen Dam and Santa Fe Dam. Interestingly, they summer in soft-bottomed sections of the Los Angeles River, and have been recorded in June from islands planted with lush riparian forest at Legg Lake in South El Monte (pers. obs.) and are known to breed at Ken Malloy Harbor Regional Park in Wilmington (D. Heindel, pers. comm.). They are extremely sensitive to cowbird parasitism, which is probably a major limitation to breeding throughout the Los Angeles Basin. Cowbird control programs initiated elsewhere in California have resulted in dramatic (100-fold) increases in Yellow Warbler numbers (e.g. Kern River Preserve, Kern Co.).

Optimal habitat structure is comprised of riparian vegetation, vertically and horizontally stratified through fluvial disturbance and subsequent succession over time; with a semi-open canopy. Little habitat remains (CPIF). Because of it's dependence on high quality, naturally structured habitats, Yellow Warbler serves as an Umbrella species for restoration of high quality riparian habitats.

Arboreal Salamander (*Aneides lugubris*)
This species, endemic to the California Floristic Province, makes its home in cavities of broad-leaved trees, including oaks, sycamores, and walnuts. It is known from the Santa Monica and San Gabriel Mtns., and from the eastern San Gabriel Valley, where it is resident in larger habitat patches surrounded by urbanization (e.g., San Jose Hills: vicinity of Cal Poly Pomona; Whittier Hills). It is generally found in association with streams, but doesn't seem to absolutely require them. It does, however, require large trees with abundant cavities, and cool microclimates to stay moist during the summer months. Leaf litter and downed logs are believed important habitat elements for this species (Stephenson and Calcarone 1999). It has not been detected in the oak-walnut woodland at Debs Park (Cooper, unpubl. data), but could occur elsewhere in the drainage (e.g., San Raphael Hills). Focused surveys are needed to document its occurrence in the region. Because of its dependence on mature and naturally cycling woodland elements, as well as the presumed requirement for terrestrial connectivity with nearby riparian areas, the Arboreal Salamander serves as an Umbrella species for high quality oak, walnut and sycamore woodland habitats.

Oak Titmouse (*Baeolophus inornatus*)
A good focal avian species for the lower drainage, Oak Titmouse, as its name suggests, all but requires oak woodlands for most of its ecological needs. It also occurs in mature riparian and even pure walnut woodland (e.g., Puente Hills), but always where dead trees with cavities are abundant. In the foothills, it is decidedly more common (e.g., La Cañada), but becomes highly localized in the southern portion of the drainage. Birds have been recorded in summer, south to near the Pasadena Fwy. overcrossing of the Arroyo, and it is apparently an irregular fall and winter visitor to Debs Park (although it has bred in South Pasadena). It would be encouraged by the maintenance of dead and dying trees in the landscape and the preservation of a dense canopy of living Coast Live Oaks and California Black Walnut where possible. Because it may be less dependent on terrestrial habitat connectivity than the Arboreal Salamander, Oak Titmouse serves as a good Umbrella species for woodlands that may be fragmented, but still offer significant habitat value for species less effected by loss of terrestrial connectivity.

Coast Horned Lizard (*Phrynosoma coronatum blainvillei*)
Coast Horned Lizard requires loose, fine soils with a high sand fraction for burrowing (Stephenson and Calcarone 1999). The species feeds on native ant species, so displacement of natives by Argentine Ants (or Fire Ants), which the lizard does not appear to eat (ibid.) is among the greatest threats to this species, along with habitat destruction. (Refer to the discussion of Argentine Ant in the section Exotic Animal Species.) Because of its specific ecological needs, Coast Horned Lizard serves as an Ecosystem Health Indicator for certain aspects of alluvial fan and coastal sage scrubs.

In our area, Coast Horned Lizard is confined to coastal sage scrub, alluvial fan scrub, and non-grassy chaparral. Many people who have grown up in southern California over the age of 50 remember catching Horned Lizards in larger vacant lots and in washes (unlined with concrete at the time) throughout the Los Angeles Basin (e.g., North Hollywood, Monrovia). However, few sightings of this animal have been made in the San Gabriel Valley since the 1970s, and it is presumed to be widely extirpated. Argentine Ants, relatively recent colonizers, thrive on typical suburban landscaping, particularly the excess water in the system and the year-round greenery associated with residential yards. This has come at the expense of native ants. Investigations at Debs Park (Cooper, unpubl. data) show that Argentine Ants currently outnumber native species by about 100:1. Directed surveys should be done in the Arroyo Seco watershed to determine the current distribution of Coast Horned Lizard.

<u>Threats</u>: The specialized diet and habitat requirements, site fidelity, and cryptic behavior make Coast Horned Lizard highly vulnerable. Commercial collecting, and habitat loss due to agriculture and urbanization are the main reasons cited for the decline of this taxa. Most surviving populations inhabit upland sites with limited optimal habitat. Many of these sites are on marginally suitable Forest Service land (Jennings and Hayes, 1994). However, the most insidious threat to Coast Horned Lizard is the continued elimination of its food base by exotic ants. Argentine ants colonize around disturbed soils associated with building foundations, roads and landfills, and expand into adjacent areas, eliminating native ant colonies (Ward, 1987). Under these conditions Coast Horned Lizard populations have become increasingly fragmented, and have undergone the added stress of a number of other factors, including fire, grazing, off-

road vehicles, domestic cats, and development (Jennings and Hayes, 1994). This taxa is unable to survive habitats altered by development, agriculture, off-road vehicle use, or flood control structures (Goldberg, 1983).

Lesser Nighthawk (*Chordeiles acutipennis*)
Essentially a desert species, on the coastal slope of southern California Lesser Nighthawk is only associated with alluvial fan sage scrub. Grinnell and Miller (1944) write: "For nesting and daytime roosting, gravel-surfaced desert floor or broad, pebbly wash-bottoms with sparse shrubby vegetation such as affords but meager shade." Once probably common throughout much of the Los Angeles Basin (replaced by Common Poorwill in chaparral and woodland), its known breeding is now confined to a handful of natural-bottomed riverbeds. These include the lengths of the Ventura and Santa Clara rivers (Ventura and Los Angeles counties); Big Tujunga Wash upstream of Hansen Dam (Los Angeles Co.); the San Gabriel River upstream of Santa Fe Dam; the Santa Ana River Wash (vic. Redlands and Mentone) and the San Jacinto River (vic. San Jacinto). They have been widely extirpated in coastal Los Angeles and Orange counties, and doubtless occurred along the gravelly wash of the Arroyo Seco and Los Angeles River, as well as the smaller washes in the San Gabriel Valley (e.g., Eaton Wash). Today, much of the lowland portion of these washes has been lost, first to orange groves and then to residential development.

There are no known recent records of Lesser Nighthawk from the Arroyo Seco, and recent (2001) surveys by AMEC for the City of Pasadena have turned up only Common Poorwill within the wash and on surrounding slopes (S. Wilcox, pers. comm.). However, with continued recovery of the alluvial fan scrub within Hahamongna Watershed Reg. Park, this species would be an expected re-colonizer. Since the habitat requirement for one pair of Lesser Nighthawks is many hundred acres, at least (CPIF undated WWW*), Lesser Nighthawk serves as challenging Umbrella species for alluvial fan sage scrub restoration goals.

Species associated with Lesser Nighthawk in our area include: Costa's Hummingbird, Greater Roadrunner, Black-tailed Jackrabbit, Whipple Yucca, Scalebroom.

* CPIF (undated WWW): California Partners in Flight Coastal Shrub-Chaparral Bird Conservation Plan: Species Accounts http://www.prbo.org/CPIF/Scrub/summaries.htm

Plummer's Mariposa Lily (*Calochortis plummerae*)
Plummer's Mariposa Lily is an attractive, naturally rare species that, like many other Mariposa Lilies, may not appear each year if environmental conditions are not suitable. It is listed as federal Species of Special Concern and California Native Plant Society List 1B (Plants rare, threatened or endangered in California or elsewhere) and thus must be dealt with in any CEQA-related documents. Associated with several plant communities, the common factor to each is apparently well-drained, often rocky soils derived from granitic sources. In late May, 2001, Dan Cooper documented Plummer's Mariposa Lily amid the chaparral lining the slopes of Hahamongna Watershed Park. Michael Long also documented the species at Eaton Canyon, the same year, noting that it was the first one he had seen in his twenty years there. Long also reported that regional botanist Gary Wallace notes that this species has only been documented twice in the San Gabriel Range over the past fifty years (pers..com/email 6/4/01). In addition to its apparent patience to wait for suitable environmental conditions, some populations of this

species may go unnoticed by humans simply because they exist in open patches within otherwise relatively impenetrable chaparral cover. This species is also associated with the alluvial fan sage scrub (tentative) vegetation type, where the relative openness of vegetation may make it easier to spot.

Since the species may not appear for years at a time, any future monitoring protocols geared to pick up this species should be correlated with relatively abundant rainy seasons, with rainfall well-distributed throughout the season, such as that of winter/spring 2000-2001. During suitable years, Plummer's Mariposa Lily may serve as an Ecosystem Health Indicator for alluvial fan sage scrub and chaparral, indicating that sufficient extent and quality of habitat exists to support this Species of Special Concern. Quality degradation of these habitats can occur through improper vegetation management that results in proliferation of nonnative annual grasses. (Refer to the related discussion in the section Restorative Management of Public Land Habitat Slivers, following.) Upon consultation with the affected agencies and organizations, this visually appealing species could tentatively serve as a Flagship for chaparral and alluvial fan sage scrub conservation. One possible concern is that attractive wildflowers such as this can readily fall prey to local amateur flower arrangers, potentially threatening their long-term sustainability. Making this a Flagship species would elevate the opportunities for public education about the species and its conservation needs. It would be ideal to cultivate a sense of pride that this rare species can be sustained in the urban/wildland interface with the support of watershed residents.

Behr's Metalmark (*Apodemia mormo virgulti*) &
Square-spotted Blue Butterflies (*Euphilotes battoides*)
These two butterflies have been found in the alluvial fan scrub and extensive coastal sage scrub within the study area. They are conspicuous spring and summer visitors, nectaring on California Buckwheat (*Eriogonum fasciculatum*), as well as certain other buckwheat species. Young caterpillars feed on the leaves of their buckwheat host plants and hibernate inside plant parts such as the dried buckwheat flower heads (USGS NPWRC/WWW).

Based on several days of investigation by Cooper during the summers of 2000 and 2001, both are common at Hahamongna Watershed Reg. Park, but neither has been documented downstream of Devil's Gate Dam, despite the presence of several patches of buckwheat within the lower Arroyo (e.g., Debs Park, Lower Arroyo Park). In these latter areas, "garden" butterflies such as Cabbage White, Common Hairstreak, and Marine Blue dominate the coastal sage scrub patches, may be joined very occasionally by Acmon Blue *(Plebejus acmon)*. The above three common scrub butterflies are also present at Hahamongna, but are far from dominants. Within the lower Arroyo Seco, a good restoration goal would be to increase the presence of wildland-dependent Behr's Metalmark and Square-spotted Blue at the expense of such "weedy" taxa as Cabbage White (*Pieris rapae*). For this reason, these butterflies may serve as Umbrella species for the restoration of smaller patches of alluvial fan and coastal sage scrub. They also may be considered as potential Flagships for restoration of these habitat types in the Lower Arroyo.

Cactus Wren (*Campylorhynchus brunneicapillus* ssp.)
The coastal populations of Cactus Wren have received much attention lately, as they are closely tied to the distribution of coastal sage scrub, a natural community that is rapidly disappearing in

southern California, where it is endemic. On the coastal slope Cactus Wren occurs patchily in a band from the vicinity of Ventura east up the Santa Clara River drainage and along the Simi Hills (vicinity of Conejo Grade). East of here, it is highly-localized, occurring in a handful of small populations, including Big Tujunga Wash, vicinity of Foothill Blvd.; Fish Cyn./San Gabriel River in Azusa and Duarte; and in a band along the southern San Gabriel Mtns. from vicinity of Glendora east toward Claremont. Within the Los Angeles Basin, it remains common in the San Jose Hills (including South Hills Park, Glendora); Puente-Chino Hills; Montebello Hills; and on the Palos Verdes Peninsula. All of these populations involve small groups of birds closely tied to large patches of native cactus (locally *Opuntia littoralis* and *O. parryi*). Using the sharp spines as protection against predation, the Cactus Wren builds its cylindrical, often pendulous nests among the branches or pads of cacti, at an average height of one meter (Solek and Szijj 1999). While these birds are highly sedentary, and almost never appear as vagrants far from their cactus patches, young birds will venture several miles from "home" and attempt to set up territory. This tendency probably evolved in response to living in scattered patches across a landscape.

Historically, Cactus Wren were more common in the Los Angeles area. Writing in 1944, Grinnell and Miller assert "Range on coastal slope of southern California now much restricted as compared with condition in 1880's and 1890's, owing to great reduction of requisite habitat..." They were resident at Eaton Canyon in northeast Pasadena until the early 1980s (M. Long, pers. comm.) until several fires wiped them out. They've never re-colonized, and today the remaining patches of cactus are thoroughly invaded by exotic grasses, which seem to be repellent to this species. Furthermore, Cactus Wren in the San Gabriel Valley have been found to require a continuous cactus height of at least 1 meter for nesting (C. Solek, pers. comm.). An increase in distribution of mature native cactus (taller than one meter) within the coastal and alluvial fan sage scrub associations would be critical for attracting this species back into the study area, but, perhaps as important would be the control of exotic annual grasses.

Cactus wren territory size ranges from 0.5 to 2.8 hectares (1.25 to 7 acres) (Solek and Szijj 1999) Setting viable habitat for this species as a restoration goal suggests provision for larger extents of coastal sage scrub and alluvial fan sage scrub that is subject to natural fluvial flushing and renewal (thus reducing frequency of nonnative annual grasses). Such provision is particularly called for in the Hahamongna area where space may someday be reclaimed for habitat and recreation needs and the inland climate may encourage recruitment of cholla-type cacti (e.g., *Opuntia parryi*) that have a particularly good form for cactus wren nesting, as well as the prickly pear (*Opuntia littoralis*) that has formed apparently incipient stands in the Hahamongna area.

Because their intriguing nest structures capture the human imagination, Cactus Wren may serve as a Flagship for restoration of alluvial fan and coastal sage scrub and their associated cactus stands.

Greater Roadrunner (*Geococcyx californianus*)

Some of the Greater Roadrunner's most noteworthy traits have been popularized in Warner Bros. Cartoons – its distinctive appearance, its preference for walking or running (up to 17 miles per hour), and its general swiftness of action that allows this carnivore to snap up prey species including insects, scorpions, lizards, snakes, rodents and other bird species.

Because of its lightening quickness, the Roadrunner is one of the few animals that preys upon rattlesnakes. Using its wings like a matador's cape, it snaps up a coiled rattlesnake by the tail, cracks it like a whip and repeatedly slams its head against the ground till dead. It then swallows its prey whole, but is often unable to swallow the entire length at one time. This does not stop the Roadrunner from its normal routine. It will continue to meander about with the snake dangling from its mouth, consuming another inch or two as the snake slowly digests. (Desert USA) http://www.desertusa.com/mag98/sep/papr/road.html)While the Greater Roadrunner may fly short distances when sensing danger or moving downhill, it cannot remain in the air for more than a few seconds and is thus confined to a mostly terrestrial existence. It tends to prefer relatively open scrub and grassland habitats, with flat or rolling topography. Trees are no friend to Greater Roadrunners, and they are generally absent from sites with trees or even tall shrubs. The "classic" roadrunner habitat is dry alluvial scrub along a wash, with large patches of gravelly soil interspersed between the shrubs. Due to its terrestrial movement needs and general habitat requirements, combined with its cartoon-elevated mass appeal, the Greater Roadrunner may serve as an attention-getting Flagship species for conservation and restoration of coastal and alluvial fan sage scrub habitat connectivity.

The current status of the Greater Roadrunner within the watershed needs to be studied. Historically, they were commonly observed along the Arroyo Seco south to Highland Park and the Repetto Hills. They probably no longer occur along the lower Arroyo Seco though Los Angeles, although an isolated population was present in the "Monterey Hills" (border of South Pasadena and Los Angeles) until the 1980s (J. Kirchner, pers. comm.). They apparently disappeared following the initiation of regular discing for "brush control" by the City of Los Angeles, since they persisted well after the construction of condominiums along Via Mia/Collis Ave. in that area. They are regularly heard and seen along the southern base of the San Gabriel Mtns. (e.g. Eaton Canyon and Big Tujunga Wash, *fide* M. Long). Field investigations at Hahamongna during Spring and Summer 2001 (D. Cooper, NAS; M. San Miguel, AMEC) did not detect this species. It's status in the San Rafael Hills is not known, but this seems like a likely source population for the lower Arroyo Seco.

Greater Roadrunners have been widely extirpated in the Los Angeles Basin, and no longer occur on the Palos Verdes Peninsula, the Baldwin Hills or (regularly) at Whittier Narrows. Yet, they remain fairly common in the Santa Monica Mtns. (pers. obs.) and in the Whittier Hills (Cooper 2000), both of which are connected to larger wildland areas.

California Gnatcatcher (*Polioptila californica*)
Umbrella for coastal sage scrub quality and habitat connectivity.

The California Gnatcatcher is a small, sedentary songbird confined to lush coastal sage scrub, in our area dominated by California Sagebrush (*Artemisia californica*) and California Encelia (*Encelia californica*). It reaches the northwestern limit of its global range within Los Angeles County, with outposts in the San Jose/Puente Hills, the Montebello Hills and on the Palos Verdes Peninsula. California Gnatcatchers occur with a suite of coastal sage scrub species that includes Cactus Wren, Costa's Hummingbird, Greater Roadrunner, Say's Phoebe and Loggerhead Shrike. On the Palos Verdes Peninsula, only Cactus Wren and shrike remain in the system. Currently, only Say's Phoebe is believed to persist within the Arroyo Seco watershed.

California Gnatcatcher was formerly common throughout the Arroyo Seco drainage (several specimens exist for Highland Park and Pasadena), but with development and tree-planting in former scrub areas, the species has been completely extirpated. The last sightings in the Pasadena area were along the Arroyo in the early 1960s (*fide* M. Long), though an anomalous, one-day-only sighting was made of a dispersing juvenile in a coastal sage scrub restoration area along the Arroyo at the La Loma bridge in Pasadena (June 2001, D. Cooper). Birds have been documented dispersing up to 10 miles through unsuitable habitat, so it is possible that this individual came from the Montebello Hills population, 9 miles to the southeast.

The total Los Angeles County population of California Gnatcatcher is probably only a couple hundred individuals. Since its designation as a Federally Endangered species in the late 1980s, considerable effort has been made to protect and restore the species' habitat in its range in Orange and San Diego Counties, but populations at the edge of its range have received less attention. This species has been shown to be quite responsive to habitat restoration that includes the conversion of ruderal or annual grassland habitat to coastal sage scrub within the species' range. However establishing a new population along the Arroyo will likely require massive habitat restoration (including removal of planted trees, such as Eucalyptus). Thus, restoration of this species to the watershed and its associated open spaces will likely depend on the will of the human residents to restore this dimension of their natural heritage.

Grasshopper Sparrow (*Ammodramus savannarum*)
Umbrella for grassland habitats. The best opportunities for native grassland restoration in the area are Debs Park and the Ascot Hills of El Sereno. In our area, this species actually requires some woody plants interspersed with the grassland, such as occurs in undisturbed patches of coastal sage scrub. In April 2001, several were on territory in pure Black Mustard grassland at Friendship Park, Palos Verdes (D. Heindel, pers. comm.), suggesting that they can tolerate small patches of habitat within urban areas.

California Quail (*Callipepla californica*)
Flagship for upland habitat connectivity, along with keystone population indicators bobcat/gray fox. Occupy woodlands and scrublands, usually near a permanent water source (National Geographic Society)

Within the Arroyo Seco watershed, the California Quail seems to be doing well in the upper portion and very poorly in the lower. It is probably found in maximum numbers within Hahamongna Watershed Regional Park, where large broods of chicks were observed during 2001 (Cooper pers. obs.). It is abundant along the southern base of the San Gabriel Mountains, probably aided by its exceptionally high reproductive rates. It is a consummate habitat generalist, occurring in woodland, scrub and grassland, provided these habitats have an abundance of thick cover near permanent water. These two factors – dense cover and water – seem to be far more important than vegetation type.

Another factor in its persistence seems to be connectivity to larger areas of habitat. Although isolated population remnants may be found at the Huntington Library (San Marino) and in the San Raphael Hills (Pasadena), it has been widely extirpated elsewhere in habitat patches within the watershed (notably absent from 200-acre Debs Park in Highland Park). Quail were found on the Pasadena/Los Angeles border on the west side of the Arroyo (vic. Avenue 64) as recently as the mid-1990s (R. Jillson, pers. comm.), but are now believed to be confined to the hills north of the 134 Fwy./Colorado Blvd. South of here, they are either absent or only rarely encountered. Strangely, this includes the "BFI restoration area" just south of Colorado Blvd., which appears to have excellent habitat. It is possible that high use by people, and especially dogs, discourages their persistence here. Along the main stem of the Arroyo, quail may occur no farther south than Devil's Gate Dam, with occasional birds coming down into the Arroyo, presumably east out of the San Raphael Hills.

Locating remnant populations of California Quail should be a top priority for this study, as they seem to be a good indicator of habitat attributes important to urban conservation projects, including low levels of disturbance from pets, connectivity with larger open space, etc. Natural movement corridors for quail, Mule Deer, and other terrestrial species may include washes, culverts, and utility rights-of-way. These should be located and treated as prime candidates for conservation easements and potential habitat restoration. Examples include Flint Wash, which enters Hahamongna from the San Raphael Hills underneath the 210 Fwy. The search for these features should focus on the interface between the San Raphael Hills and the Arroyo (vicinity of Brookside Golf Course/Rose Bowl). Since so much habitat has been lost or is ecologically isolated within the lower Arroyo Seco, the habitats within the San Raphael Hills should be considered an important link between the upper and lower Arroyo Seco watershed. This is a prime example of why conservation and ecological restoration efforts for the Arroyo must extend beyond the watershed boundaries. Protecting habitat adjacent but outside of those boundaries may prove as important for certain species as restoring habitat within the watershed per se.

Regrettably, the construction of the 210 and 134 freeways cut off movement possibilities for quail into Highland Park and Eagle Rock. However, potential restoration of habitat connectivity for certain species across (over/under) these freeways could occur, especially in the event of potential highway repairs or reconstruction. For example, a combination human/wildlife overpass could serve certain wildlife species, while also serving recreational connectivity. Information about such overpasses is available on the US Department of Transportation's Critter Crossings web page: http://www.fhwa.dot.gov/environment/wildlifecrossings/intro.htm

The area around the Eagle Rock Rec. Center (134 Fwy., Colorado Blvd. and Figueroa Dr., near the actual Eagle Rock") would be a logical spot for such an overpass as a powerline right-of-way crosses there.

Focal Predator Species

The carnivorous Bobcat may be considered a focal predator species that performs regulating services vital to sustaining native ecosystems. Relatedly, it serves as a Population Health Indicator for the viability of its numerous prey species and their ecological relationships, along with serving as an indicator of functional habitat connectivity. We include Gray Fox as another predator of interest that may be served by habitat and connectivity restoration focused on Bobcat. Bobcats function as "top" or primary carnivores on the ecological pyramid, while Gray Fox's role is as a secondary carnivore (mesopredator) in the ecosystem.

In truth, intact Southern California ecosystems include Mountain Lion (*Puma concolor*) as the top carnivore and likely Keystone species, whose loss from the system precipitates cascading impacts down the ecological pyramid. In the Arroyo Seco watershed, Mountain Lion is believed to be generally confined to areas above Devil's Gate Dam. Thus it is hoped that Bobcats, whose habitat requirements are relatively less demanding, may serve some of the ecological functions of Mountain Lions in the more urbanized portions of the watershed. The limits of viability for restored habitats in urbanized areas remain to be revealed, but we may hope that adequate habitat restoration could allow Bobcat, along with Coyote and Gray Fox to adequately patrol much of the ecosystem. Whether they can serve as Keystone species remains to be seen. The apparently increasing presence of Mule Deer in the San Rafael Hills (Cooper pers. com. with Bill Principe Aug. 2001) suggests that an imbalance may eventually occur in the absence of their primary predator Mountain Lions.

Coyote (*Canis latrans*) has been documented as a Keystone species in fragmented San Diego County coastal sage scrub habitats (Crooks and Soulé 1999) and may serve a similar function in Los Angeles County. Because of their apparent ubiquity in the watershed they have not been selected as a focal species for this study to date, but consideration should be given to their possible inclusion in the future.

Bobcat (*Lynx rufus californicus*)
Bobcats are known to inhabit and breed in the San Rafael Hills (Cooper pers. com. with Bill Principe Aug. 2001), and have been seen in the lower Arroyo by several correspondents to the Arroyo Seco News list serve. They favor brushy, rocky slopes for their primarily nocturnal hunting and prefer rock crevices or caves for denning, although they will use hollow logs or dense shrubs if necessary. A typical bobcat diet consists of rabbits, ground squirrels, mice, pocket gophers and wood rats. Quail have been found in their stomach contents, though they reportedly pose no significant threat to native "game" birds. (Desert USA)

> Bobcats occupy areas from 1/4 of a square mile to as much as 25 square miles, depending on the habitat and sex of the Bobcat. Female Bobcats occupy smaller areas than males and normally do not associate with other female bobcats. Males roam wider than females. While they are not particularly tolerant of other males, the home ranges of males will overlap those of both males and females. (ibid.)
> http://www.desertusa.com/april96/du_bcat.html

With these relatively expansive territorial ranges, Bobcat could potentially greatly benefit from restoration of habitat connectivity between the San Gabriel and Santa Monica Mountains, given suitable nodes of functionally restored habitat between.

Gray Fox (*Urocyon cinereoargenteus*)
Gray Fox occupies habitats in chaparral, wooded areas and among boulders on the slopes of rocky ridges in canyons and open desert. The only member of the dog family that can climb trees, they usually do so to seek refuge or roosting prey birds, or sometimes to sun themselves. They can scale just about any kind of fencing, climb trees, telephone poles, etc. They are sometimes seen on rooftops of houses and buildings. Gray Fox are also good swimmers and may frequent riparian habitats. On the ground the species can reach a speed of 28 mph for short distances. In captivity it may live for up to ten years, but its longevity in the wild is limited to to six to eight years, with most individuals dying within the first year from disease, predation, accidents, trapping, and hunting. Although primarily nocturnal, timid and elusive, the Gray Fox may sometimes be seen foraging during the day, seeking primarily small mammals such as rodents, but being an omnivore, it will also eat eggs, insects, birds, fruits, acorns and berries. They reportedly will not harm a domestic adult cat or small dog. They will not attack a human but will fight to protect their young. Foxes' primary enemies are large predators, including eagles, large owls, bobcats, domestic dogs, coyotes, and humans. Gray Fox territories can range from 100 to 2,000 acres, depending on habitat quality, food availability, population density, and competition with other species. (Desert USA: http://www.desertusa.com/nov96/du_gfox.html and WildCare: Terwilliger Nature Education & Wildlife Rehabilitation, San Rafael, CA. http://www.projectwildlife.org/living-fox.htm).

In addition to their presumed occupation of habitats above Devil's Gate Dam, Gray Fox have been observed in the San Rafael Hills and specifically the Flint Wash area (Cooper pers. com. with John Cox and Bill Principe Aug. 2001). Monitoring of this species' movements should provide insights as to its specific habitat requirements and connectivity needs. As a mesopredator, there is potential that unchecked populations of Gray Fox could prove problematic for native bird populations. While movement of Bobcats through a restored Arroyo habitat network may help keep Gray Fox at healthy populations levels, the more human-adapted Coyote may be essential to maintaining ecological balance in the absence of Mountain Lion.

V. Restoration Issues & Opportunities

Renowned conservation biologist Reed Noss has provided succinct summaries of guiding principles related to landscape design for urban ecological integrity and the role of connectivity in urban wildlife conservation in his report prepared for the Los Angeles and San Gabriel Rivers Watershed Council (Noss 2001). These principles summarize the background for our approach to habitat restoration in the Arroyo Seco watershed and are incorporated here by reference.

Restoration of Native Vegetation Types

Restoration of native vegetation types to areas currently dominated by nonnative annual grasses and/or weedy exotic species will likely have measurable positive impacts on watershed function. As stated in a previous section, nonnative annual grasses tend to have significantly shallower rooting systems than their native perennial counterparts. The deep rooting systems of native perennial species can, over time, extend the depth at which soil macro- and micropore formation occurs, thus expanding the volume of water that can be held in a given area of soil. Nonnative annual grasses also tend to consume soil moisture more rapidly, drying it before they expire in late spring. In contrast, native perennial grasses continue to grow and exert biological influences on their soil environments through the summer, thus helping to maintain more even soil moisture throughout the year. For similar reasons, native scrub types are also better suited for maintaining local watershed function than are nonnative grasses and other ruderal vegetation types.

Determination of the appropriate target vegetation types for restoration should incorporate such site factors as soil type, slope angle and slope aspect (solar exposure) (e.g., Keeley 1993). As in any ecological restoration effort, the factors responsible for causing the type conversion to nonnative cover must be ameliorated. Degradation of native vegetation in urban habitat patches often accrues from too-frequent clearing (refer to the previous section, Restorative Management of Public Land Habitat Slivers) or from too frequent fires. An example of the latter case occurs at Debs Park, where fires are sparked annually by urban sources such as fireworks (Cooper pers. com.). Such annual disturbance prevents perennial native species from reaching reproductive maturity, and thus the cover degrades to exotic annual species that are adapted to and facilitate the annual burning, just as introduced annual grass species proved more resilient to introduced stock grazing patterns. In this case, a return to environmental conditions favoring native vegetation types may be dependent on a public awareness effort. It is likely that the frequency of intentionally and unintentionally set fires will continue to increase with increased population densities in the urban portion of the watershed.

Reforestation Concept

An important task for a subsequent phase of the Arroyo Seco Watershed Restoration implementation effort is to evaluate the appropriateness/ feasibility of restoring upper watershed function through reforestation efforts. There is a long-standing misconception that forests previously covered greater extents of the San Gabriel Mountains but were degraded to brushlands through logging, fires set to expand sheep rangelands and other resource extraction activities (Lochman 1981, Burns and Sawyer 1992). Burns and Sauer (1992) reviewed the history of twentieth century efforts to remedy this hypothetical degradation and improve watershed function through reforestation. This paper is a must-read as a preface to evaluation of reforestation as a means of improving watershed function. The reforestation efforts summarized came in two general waves, spanning the period from 1892 through 1910 and again in the 1920s. They included exotic conifer species from around the globe, as well as California natives from other locales. In all cases the efforts proved essentially unsustainable – the introduced native and non-native trees that survived to maturity did not replace themselves after they were lost to the inevitable fires. The authors note that "the failure of any non-native species to naturalize suggests that barriers to dispersal were irrelevant, that diversity of the local conifer flora was ecologically controlled" and that in recent times, "it has been recognized that watershed protection is best left to unmodified natural vegetation". (ibid.)

Rehabilitating Watershed Function: Biofiltration Projects

There are several ways to increase biofiltration within a watershed. We are placing emphasis on the daylighting of creeks.

The unearthing of historic tributary drainages since relegated to storm drain plumbing offers promising opportunities for:

1.) biologically-based filtration of urban runoff,
2.) creation of wildlife habitats,
3.) aesthetic amenities for urban landscapes, and
4.) promoting awareness of people's relationships to the watershed.

Biofiltration features can provide niches for certain aquati c, riparian and other wetland species while improving the quality of water sustaining the existing and restored primary riverine and riparian habitats along the Arroyo. Research on historic place names/stories and/or community envisioning of new names/stories will complement the spirit of place engendered by this approach.

Other methods for enhancing biofiltration include:

- Constructed wetlands
- Best Management Practices, including bioswales and detention basins

Restorative Management of Public Land Habitat Slivers

Especially along the Central Arroyo, slivers of potentially native chaparral, coastal scrub, and in some cases incipient woodland habitats extend for long distances along the slopes bordering public use areas. In some cases these slopes are contiguous with residential land uses. In others, roads intervene between these potential habitats and private residential areas. While sizable expanses of these potential habitat areas lie outside the limits of up to 200 feet of fuel modification required by the Los Angeles County Fire Department, in practice it appears that crews may sometimes be overzealous – extending their "fuel modification" (a.k.a. complete vegetation clearing) across entire slopes of potential habitats for native wildlife, well outside the 200 foot upper limit of fuel modification. In some cases, paved roads intervene between structures and these habitat areas, which could reduce the amount of fuel clearance necessary to less than 200 feet, since the fuel modification zone is determined on a case by case basis. It appears that this annual clearing of native vegetation is effecting type conversions to weedy nonnative grasslands in many areas. While these areas may be but slivers of habitat, they extend along the sides of the Arroyo for great distances, and provide linear habitat connectivity. They offer potential habitats for numerous smaller wildlife species, including various butterflies, hummingbirds, songbirds and reptiles. Furthermore, they just may function as wildlife movement linkages where/when cover is relatively intact.

Some slight management policy changes on the part of the responsible agencies could result in recovery of some portions of these habitat slivers. Limiting fuel modification to the up to 200 foot zone recommended by the County of Los Angeles Fire Department could save some of these habitats. Furthermore, fuel modification does not mean denuding the slopes of all woody vegetation. ***Selective*** clearing, could help maintain some habitat values, while avoiding the weedy results of too frequent removal of woody and other perennial vegetation. In patches where the type conversion to nonnative annual grasslands has already occurred, strategic restorative treatments might include planting of suitable species of native bunchgrasses and smaller shrubs or native herbs, along with inoculation of disturbed soils with leaf litter from nearby intact vegetation.

We recommend that a cooperative initiative be developed to evaluate and provide site-specific recommendations for restorative management of these potentially viable habitat areas.

Restoration of Habitat Connectivity

Restoration of habitat connectivity is important for both aquatic and terrestrial focal species. Species-specific connectivity needs are summarized in the focal species discussions. For several of the terrestrial as well as aquatic focal species, habitat connectivity may be improved by enhancing riparian habitat quality along the Arroyo and connectivity of upland sites with it.

Continuous riparian habitats can provide opportunities for wildlife movement under roads and other infrastructure. An ideal habitat restoration goal for the Arroyo Seco is to restore continuity of riparian and associated upland plant associations along its length, from the San Gabriel Mountains to its confluence with the Los Angeles River. Elements of that vision are in place today and the Arroyo offers greater promise for facilitating wildlife habitat connectivity than other nearby areas.

For example, participants at the statewide Missing Linkages workshop identified South Coast Linkage #28 as a regionally important Missing Link that would ideally connect the Verdugo Mountains with Griffith Park and hence the Santa Monica Mountains (Penrod 2001). However, given the expanse of highly urbanized, and in many cases extremely valuable commercial property between the Verdugos and Griffith Park, a more likely pathway for wildlife movement is from the Verdugos, across Verdugo Wash and the Glendale (2) Freeway, to the San Rafael Hills and then to the Arroyo. In fact, roadkill of mountain lion has occurred along this freeway, just south of its intersection with 210 (Cooper pers. com. with Bill Principe Aug. 2001), suggesting the need to facilitate wildlife passage there. With restoration of continuous wildlife habitats along the length of the Arroyo, wildlife movement opportunities could extend to the confluence, Elysian Park, and up the Los Angeles River to Griffith Park. In his review of linkages pertinent to the Los Angeles and San Gabriel Rivers region, Noss noted that the "Arroyo Seco may offer a superior alternative" to the notion of connecting the Verdugos with Griffith Park directly (Noss 2001). Such regional wildlife connectivity issues exemplify why issues of habitat restoration extend beyond watershed boundaries.

While the Arroyo Seco is itself a tributary of the Los Angeles River, several major tributaries flow into the Arroyo, mainly from the west, providing both surface water as well as movement corridors for terrestrial wildlife in and out of the system. From north to south, these include four that "feed" into the middle Arroyo at the Rose Bowl/Brookside Golf Course; Flint Wash, which enters the Arroyo just upstream of Devil's Gate Dam, and two in the lower Arroyo – Debs Park and "Laguna Canyon". All except for Debs Park and Laguna Cyn. connect relatively intact habitats of the San Raphael Hills with the Arroyo Seco, and should be studied for their contributions linking these two blocks of habitat.

In some locations where freeways and other major roadways intervene, combination human/wildlife overpasses could serve certain wildlife species, such as quail, while also serving recreational connectivity. Information about such overpasses is available on the US Department of Transportation's Critter Crossings web page:
http://www.fhwa.dot.gov/environment/wildlifecrossings/intro.htm

Further investigation of habitat connectivity opportunities will be a major task of future restoration efforts.

Restoration of Native Fisheries

In order to attain adequate habitat conditions to support the fish species native to the Arroyo Seco, a watershed-wide array of restoration projects will be required. Several site-specific restoration projects have been identified below as well as recommendations to conduct studies of areas or structures where more information is needed. Many of these projects are discussed in detail elsewhere by consultants working specifically on that project, but are mentioned here to further reinforce their importance in fisheries restoration on the Arroyo Seco. Additional analysis of many of the mentioned projects will be necessary to provide more detail on exactly how structures should be modified. Identified projects are consistent with the long-term goal of restoring identified focal species and in-turn providing adequate habitat conditions for the entire native assemblage of fish. Several partial and complete fish migration barriers have been identified as project sites to improve watershed connectivity, with particular attention to providing upstream migration for adult steelhead.

Watershed-scale Projects

Fish Migration Barrier Study and Removal/Modification
Further studies are needed to determine the location and severity of all migration barriers to fish within the Arroyo Seco and tributaries.

Naturalizing the Arroyo Seco streambed
Remove portions of the concrete channel from the lower Arroyo Seco and integrate lower elevation fish habitat needs and anadromous fish migration needs into the stream naturalization projects being designed.

Survey Soledad Canyon, Santa Clara River and incorporate attributes into naturalized A. Seco design
Assess habitat conditions where lower elevation species assemblage (unarmored threespine stickleback, arroyo chub, Santa Ana sucker) is present in a fairly naturalized stream just north of the Arroyo Seco. Incorporate physical characteristics and aquatic conditions of this reference site into the streambed naturalization project design on the lower Arroyo Seco to provide adequate/ideal habitat needs for lower elevation fish species.

Water Budget Study and Resource Allocation
Assess historic water flow conditions for Arroyo Seco and tributaries. Determine extent and impact of water extraction and diversions within the system. Determine necessary quantity, quality, and timing of water needed to sustain adequate habitat conditions for aquatic species and obtain this amount of water for aquatic/riparian resources.

Los Angeles River Connectivity Study
Determine how best to provide connectivity between the Arroyo Seco and the Pacific Ocean via the Los Angeles River. Study should identify projects that will provide upstream migration for steelhead and Pacific lamprey as well as adequate habitat conditions for lower elevation fish species and other flora and fauna. Alternatives to be studied should include naturalizing the streambed.

Improve water quality
Implement water quality improvement measures being evaluated (i.e. surface runoff biofiltration, trash catchments, etc.)

Arroyo Seco Fish Study and Management Plan
Determine what fish species (native and exotic) occur in the Arroyo Seco and estimate their distribution and population size. Identify possible measures to eradicate exotic species and develop a management plan to promote native species and minimize or eliminate exotic species. Components of this plan may include: 1) Removing exotic species. 2) Minimizing habitat conducive to exotic species. 3) Identifying measures to prevent inflow of exotic fish from the Los Angeles River and other sources. 4) Reestablishing native species from local populations or allow recolonization to occur with anadromous species (steelhead, Pacific Lamprey) once migratory connectivity is established between the Arroyo Seco and the ocean.

Site Specific Projects

Fish Passage at Devil's Gate Dam
It is likely that several alternatives exist for providing fish passage around Devils Gate Dam, but such a complex project will require an in-depth fish passage feasibility study to determine what engineering and biological constraints exist and what options are available. As part of such a study a broad array of alternatives should be considered including; modifying the existing tunnel underneath the dam for fish passage and complete dam removal. Such a study will likely have to look into the operations of the ground water percolation basins upstream, downstream flooding issues, and adequate flow releases from upstream. Modification/removal of Devil's Gate Dam is essential to the long term goal of reestablishing a steelhead population in the Arroyo Seco.

Dam Removals or Modifications
Remove old dam upstream of JPL Bridge to improve upstream fish migration.

Modify or remove CCC dam (located near the Pasadena filtration plant) to improve/allow upstream fish migration.

Modify Pasadena Diversion Dam to improve/allow upstream fish migration. Install intake screen at Pasadena Diversion Dam to allow downstream migration and to prevent aquatic and terrestrial species from being sucked into the intake and killed.

Install intake screen at Pasadena flow separation dam structure to prevent trapping of downstream migrating fish and to improve upstream fish passage.

Brown Canyon Debris Dam Removal Study
Conduct a dam removal feasibility study to determine how best to remove this obsolete dam and deal with the large amount of sediment deposited behind it. Removing this structure is essential to restoring habitat connectivity in the upper Arroyo Seco and improving habitat and flow conditions. Proper removal would provide upstream passage for aquatic species and eliminate the mortality associated with species washing downstream over this structure.

Creek Restorations
Evaluate habitat conditions and fish migration barriers on Millard Creek.

Remove Fern Canyon debris dam to allow fish migration into this tributary and improve habitat.

Modify USGS gauging structure to improve upstream fish migration.

Future Studies

Issues to be addressed in future studies include the following:

Specific Habitat Restoration Strategies

- Watershed-wide exotic pest plant species management program
- Evaluation and prioritization of exotic pest animal management issues
- Identification, inventory, qualitative description and mapping of potential reference sites to serves as models for habitat restoration objectives
- Understanding of historical ecology throughout the watershed – initiated for the floodplain by Marcus Renner and others
- Prioritization of habitat restoration initiatives relative to focal species goals
- Enumeration of site-specific restoration strategies as may apply to specific restoration programs

Additional Focal Species

- Additional focal species should be considered as appropriate to fully represent the optimal biodiversity of the watershed

Habitat Features in Public Parklands

- Develop strategies for providing more heterogeneous vegetation structure – including shrub and herbaceous understories to increase habitat values
- Investigate design initiatives to provide wildlife viewing opportunities for parkland visitors while affording buffered habitats needed by wildlife

Restorative Management of Private Lands

- What residents can do to provide wildlife habitats and promote watershed restoration on their own properties and neighborhood common areas

Public Outreach Issues

- Investigate existing attitudes related to wildlife, habitat restoration and potential stewardship activities (e.g., through focus groups, surveys, interviews, etc.) to help determine public relations issues and appropriate educational strategies

Adaptive Management and Effectiveness Monitoring

- Because ecological restoration is a relatively young field and includes measures of art, as well as science, any watershed and habitat restoration program must be designed to be adaptive, as insights accrue over time. An adaptive management framework should be developed for the watershed as a whole, as well as for each demonstration project, in the context of the overall framework.

- Effectiveness monitoring is the basis of an adaptive management program. A monitoring program must be developed to test the effectiveness of watershed and habitat restoration efforts. The monitoring program should include protocols addressing the focal species described herein, as well as other species and factors to be determined.

VI. Citations

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