APPENDICES E

Riparian Vegetation Assessment

SOQUEL CREEK RIPARIAN VEGETATION ASSESSMENT

Prepared for
Santa Cruz County Resource Conservation District
The Coastal Conservancy
California Department of Fish and Game

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EXECUTIVE SUMMARY

The Soquel Creek Riparian Vegetation Assessment was conducted to determine whether the forest along Soquel Creek is in a healthy condition, and to what extent it currently contributes benefits to the instream habitat for fish. The vegetation assessment was performed in conjunction with simultaneous assessments of the hydrology/geomorphology and the salmonid fish of the creek.

The driving force behind the combined assessments was the shrinking populations of special-status fish. Coho salmon have been extirpated from Soquel Creek by a number of habitat changes including warm water temperatures. Steelhead tolerate warmer water than coho, but they too have declined in recent years. The Central California Coast Evolutionarily Significant Unit (ESU) of coho is state-listed as Endangered and federally listed as Threatened, and the Central California Coast ESU of steelhead is federally listed as Threatened.

The purpose of the vegetation assessment was to describe the condition of the riparian corridor as it affects salmonid habitat. The assessment can be used to identify and prioritize sites where planting of trees can provide significant benefit to steelhead or coho, to identify and prioritize sites where the existing conditions provide greatest benefit to the fish habitat, and to function as a baseline for future monitoring of riparian vegetation along Soquel Creek.

Riparian vegetation is defined as the terrestrial component of the stream environment, or as any vegetation that directly influences the stream environment. Riparian vegetation performs several functions that are essential for a healthy fish habitat: it supplies nutrients, cycles nutrients, contributes to spawning and rearing habitat, and provides shade to keep the water cool.

The assessment consisted of a literature review and field work. The literature review covered historical information about Soquel Creek, other riparian assessments, and research papers on the conditions required for natural regeneration of riparian trees. The field work consisted of walking approximately twelve miles of the creek and portions of the tributaries, and establishing transects every 1,000 feet. At each of 60 transects an array of measurements was recorded and a forest inventory was conducted to census trees in a 60’ radius plot. A smaller data set was recorded midway between the transects.

The assessment found that nearly 80% of the sites sampled had less shade than recommended by the California Department of Fish and Game for coho rearing habitat. Although natural events remove some trees, there has been a significant amount of tree removal as the direct and indirect result of human activities. Locations receiving the most solar radiation along the creek were identified, as were well-shaded locations.

The forest inventory found a healthy assortment of native tree species, most of them represented by a full array of size classes. There is a gradual transition from dominance of deciduous trees downstream to dominance of evergreens in the upstream reaches.

Because invasive exotic (non-native) plants cause a gradual deterioration of the forest, they were inventoried at the transects. They were found more in the understory than in the canopy and were generally distributed throughout the length of the creek, though they were somewhat more abundant in developed areas.
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COVER PHOTOGRAPH IS THE VIEW OF SOQUEL CREEK LOOKING UPSTREAM FROM TRANSECT #16, LOCATED 1,000 FEET UPSTREAM OF THE USGS GAGE. SEPTEMBER 20, 2001.
CHAPTER 1: INTRODUCTION

1.1 STATEMENT OF THE PROBLEM / PURPOSE OF THE ASSESSMENT

Populations of steelhead in Soquel Creek have declined in recent years, and coho salmon are now absent. The causes are related to a decline in the quality of the instream habitat. The condition of the riparian vegetation along the creek is one factor that plays a role in determining the quality of the fish habitat.

The purpose of this report is to assess the existing condition of the riparian corridor as it affects salmonid habitat. The focus areas will be a) the factors affecting shading of the low flow stream channel, b) the composition of the riparian vegetation as determined by tree species and size class distribution, and c) the abundance and distribution of invasive exotic plants.

This riparian vegetation assessment was prepared for the Santa Cruz County Resource Conservation District (RCD) in order to develop the Soquel Creek Watershed Enhancement Plan. Funded by the Coastal Conservancy and the California Department of Fish and Game, that plan will be geared toward cooperative and voluntary participation in restoration. It will synthesize the results of the riparian assessment with those of the hydrology, geomorphology, and fisheries assessments, and make recommendations for restoring habitat for steelhead and coho salmon.

1.2 BACKGROUND

1.2.1 Introduction to Riparian Vegetation

The California Department of Fish and Game describes the riparian zone as the terrestrial component of the stream environment (Flosi et al., 1998). Riparian vegetation is defined as “any extra-aquatic vegetation that directly influences the stream environment” (Meehan etal., 1977). The functional roles of riparian zones are shown on the following page as illustrated in the Department of Fish and Game’s Salmonid Habitat Restoration Manual (Flosi et al., 1998).
Riparian zones are typically subject to partial or complete flooding, and riparian vegetation is adapted to constant renewal within a dynamic ecosystem. Storm flows scour existing vegetation and deposit sediment, creating exposed areas of moist substrate and an opportunity for seeds of moisture-adapted species to become established. The recruitment of Cottonwoods is especially dependent on stream migration and overbank flooding (Steen-Adams, 2002).

Riparian tree species are usually identified as the broad-leaved deciduous species that naturally occur only in proximity to water. These species can tolerate anaerobic conditions in their root zone for extended periods of time and are “phreatophytic”, that is capable of taking moisture directly from the water table or from the capillary fringe above the water table. Where proximity to water is limited because the streamside topography slopes steeply upward from the channel, upslope vegetation dominated by conifers and broadleaved evergreens may also functionally be part of the riparian vegetation.

### 1.2.2 Functions Of Riparian Vegetation

**Nutrient Supply.** Leaves falling into the water provide nutrients directly to aquatic organisms, especially invertebrates, and form the basis for the aquatic food chain. Deciduous trees contribute a pulse of food to leaf-mining aquatic insects during the autumn leaf-drop. Riparian vegetation contributes nutrients indirectly by way of insects, moss, lichens, and bird and insect droppings that fall into the water from overhanging branches.
Nutrient Cycling. Riparian vegetation takes up nutrients from the stream and absorbs them into plant tissue. It cycles nutrients back into the forest when leaves, fruits or branches fall to the ground, break down, and become soil amendments that nourish future forest growth.

Wildlife Corridors. Riparian vegetation is dense, diverse, and complex in structure. It provides cover, food, water and travel routes that connect riparian and upland habitats, maintaining a vital web of diverse species.

Spawning Habitat. The roots and foliage of riparian vegetation protect soil particles from detaching from streambanks, reducing inputs of fine sediment that bury spawning gravels. Fallen vegetation on the forest floor of streamside slopes forms a protective blanket that reduces erosion, filters sediment, increases water clarity, and improves spawning habitat. Woody material in the creek captures and immobilizes sediment, further contributing to water clarity.

Rearing Habitat. Large woody material that comes to rest in the stream channel creates pools and escape cover for fish. Overhanging shrubs provide additional escape cover near the banks. The roots of vegetation within and beyond the stream corridor keep the soil porous, increasing infiltration, reducing the flashiness of storm runoff, and increasing base flows during the dry season. Perhaps most importantly, the canopies of trees and shrubs shade the water and keep it cool so that the metabolic rate of salmonids stays within the limits of the available food supply, which consists chiefly of aquatic macroinvertebrates.

1.2.3 Assessment Focus Areas

The Soquel Creek Riparian Vegetation Assessment was the first study along the central California coast to examine riparian vegetation in detail as a component of fisheries habitat (see Literature Review, Appendix V-1). The principal concerns of the vegetation assessment in regard to salmon habitat were 1) the influence of vegetation on water temperature, 2) the collection of information about the makeup of native riparian vegetation, and 3) the status of infestation of native riparian vegetation by invasive exotic (i.e. non-native) plants.

Other consultants assessed the hydrology, geology and fisheries of the Soquel Creek watershed, and there was considerable collaboration among the consultants during preparation of the assessments.

Factors affecting shade. Water temperatures to a significant extent determine the quality of aquatic habitat for steelhead and coho. Because fish are cold-blooded organisms, increased water temperatures increase their metabolic rate. Increased water temperatures may or may not simultaneously increase the food supply at a comparable rate depending on factors which, for steelhead and coho, are discussed in the Fisheries Assessment. If the metabolic requirements of steelhead or coho exceed the rate of food production, the fish starve. Shading by riparian vegetation provides a cooling influence to the creek and buffers it from solar warming. Other cooling influences are contributed where low-temperature groundwater enters the creek below the ground surface, and by the cool waters of tributaries entering as surface flow.
The most direct measure of shade is canopy closure, or the measurement of obstacles -- typically foliage -- blocking the sun’s rays from reaching the stream. Where landforms are steep, the topography itself may contribute to canopy closure, as when the stream flows beside a steep bank or a high bluff. Deciduous trees provide shade for part of the year, evergreen trees provide shade all year round, and topographic shade typically would be permanent even if no vegetation were present. The relative contributions of deciduous, evergreen, and topographic shade were estimated and recorded in this assessment.

Other factors in the creation of shaded riverine aquatic (SRA) habitat include tree height (taller trees cast longer shadows than shorter trees), canopy angle (shadows of tall trees may not shade the creek if the trees are located a distance from the channel, whereas trees of moderate height may provide significant shade if they are located next to the low flow channel; and total width of the channel (portions of a broad channel may be beyond the reach of any shading influence).

Among the elements that contribute to healthy salmonid habitat, shading by riparian vegetation is relatively amenable to human influence, as streamside residents can damage, protect, or enhance riparian vegetation.

Composition – tree species and size class distribution. Tree species contribute in different ways to salmonid habitat. Deciduous trees contribute a pulse of nutrients to the stream during the fall leaf drop, and broad-leaved evergreens (Live Oaks & Tanoaks) contribute a pulse of nutrients during spring when they acquire new leaves and drop the old ones.

Conifers are the tallest trees along Soquel Creek and create the greatest amount of shade. They also attain the largest trunk size, making them valuable as large woody material in the stream, and conifers last longer in the water than hardwoods. In turn, the larger hardwoods (Sycamore) last longer in the water than smaller ones such as Alder and Willow. A detailed survey of large woody material was conducted along Soquel Creek during summer 2002 as part of the Fisheries Assessment. The detailed results are contained in Appendix D of the Fisheries Assessment and are summarized in the body of that Assessment.

Alders occupy a special niche in the riparian forest. Their seedlings readily colonize exposed nutrient-poor bars and bare soil deposited by floods. Their roots fix nitrogen, gradually making infertile ground suitable for other riparian tree species to move in. Sycamores contribute organic matter during the summer and fall, when they shed hairs from the undersides of their leaves and provide exceptionally fine litter to nourish small aquatic invertebrates that form the base of the salmonid food chain.

Tree sizes are most readily determined by measuring the trunk diameter (DBH) at breast height, four feet above the ground. The resulting diameters are usually grouped into artificial size classes in order to analyze the current population and predict the future condition of the forest. If size classes of a given species decline over time, the functions provided by that species (shading, nutrients, escape cover, large wood) are likely to decline thereafter.
Invasive Exotic Plants. A number of detrimental effects are caused by invasive exotic plants in riparian corridors. In terms of vegetation, invasive exotic species typically produce a dense cover, which suppresses recruitment of riparian trees, reduces the species diversity of the native vegetation, and may cause decline of the forest canopy as recruitment declines. Their rapid growth shades slower growing native plants in the understory. In terms of erosion, soil and water losses increase when tap-rooted plants replace fibrous root systems. Several ecosystem effects also are felt when exotic species invade in numbers: 1) invasive species can alter ecosystem processes such as nutrient cycling, intensity and frequency of fire, hydrological cycles, sediment deposition and erosion; 2) some invasive species alter the soil chemistry, altering successional processes or making it difficult for native species to survive and reproduce; 3) in the course of reducing species diversity, they shrink the menu of food available for wildlife, and in the course of reducing structural diversity, they reduce the variety of available cover, thereby degrading habitat for native animals.

Specific problems caused by individual invasive exotic species are shown in Appendix V-3. Only one of the invasive exotic plant species that occur along Soquel Creek is suspected to cause direct harm to fish. The damage caused by invasive exotics consists mostly of a slow and gradual decline in the quality of the native riparian habitat, causing indirect harm to the aquatic portion of the stream ecosystem.

Invasive exotic species were sampled at the principal transect locations in order to determine their relative abundance and distribution. This provides a preliminary basis to prioritize which species are the greatest threats in the understory and in the tree canopy, and to focus eradication efforts.
CHAPTER 2: WATERSHED SETTING

2.1 GENERAL DESCRIPTION OF THE SOQUEL CREEK WATERSHED

Soquel Creek is a coastal stream located in the central part of Santa Cruz County, on the central California coast. It drains an area of 42 square miles from the summit of the Santa Cruz Mountains to the Pacific Ocean. The elevation of Soquel Creek ranges from just above sea level where the creek enters the coastal lagoon to approximately 3,000 feet at the headwaters of the East Branch. The average annual rainfall in the Soquel Creek watershed ranges from 23 inches near the coast at Capitola to over 40 inches at some higher elevations. Rain occurs almost exclusively in the winter, and is usually heaviest in the months of January to March. Fog cools the coastal portion of the watershed during some summer days, usually burning off by late morning.

The topography of the downstream portions of the watershed is gently sloping, and becomes moderately to steeply sloping upstream. At the majority of the locations surveyed, the creek is moderately incised into the surrounding floodplain, with a steep bank on one or both sides. Natural forest is not widespread in the lower elevations, but mixed evergreen and coniferous forests dominate the upper watershed. Urban land uses occupy the lower portion of the watershed, transitioning above the village to orchards, wholesale nurseries, and rural residential use. The majority of the middle and upper watershed is occupied by rural residential use, along with a portion of the Forest of Nisene Marks State Park, a family-owned granite quarry that has operated for many years, and timber production in the Soquel Demonstration State Forest. Logging has been conducted throughout the watershed since the mid-nineteenth century, most extensively in the middle and upper watershed where the heavier timber is located.

Ten special-status species have been reported for areas within the Soquel Creek watershed in the Soquel, Laurel, and Loma Prieta USGS topographic quadrangles (CNDDB, 2001).

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>STATUS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clemmys marmorata pallida</td>
<td>CDFG Species of Special Concern</td>
<td>Occurs east of Conference Grounds and downstream, also in vicinity of quarry, Milpond and Soquel Demonstration Forest</td>
</tr>
<tr>
<td>Southwestern Pond Turtle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danaus plexippus</td>
<td></td>
<td>Winters near Rispin Mansion along the lagoon</td>
</tr>
<tr>
<td>Monarch Butterfly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eucyclogobius newberryi</td>
<td>Federal Endangered</td>
<td>Reported to occur from Highway 1 to Capitola Beach</td>
</tr>
<tr>
<td>Tidewater Goby</td>
<td>CDFG Species of Special Concern</td>
<td></td>
</tr>
<tr>
<td>Holocarpha macradenia</td>
<td>Federal Threatened</td>
<td>Occurs in Coastal Prairie, Valley and Foothill Grassland, not in riparian vegetation</td>
</tr>
<tr>
<td>Santa Cruz Tarplant</td>
<td>State Endangered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CNPS List 1B</td>
<td></td>
</tr>
<tr>
<td>Oncorhynchus kisutch</td>
<td>Federal Threatened</td>
<td>A principal focus of the fisheries</td>
</tr>
</tbody>
</table>

TABLE V-1
SPECIAL-STATUS SPECIES OF THE SOQUEL CREEK WATERSHED
In addition to these species, two individual California Red-legged Frogs (*Rana aurora draytonii*, federally listed as Threatened) have been observed in Soquel Creek above Ashbury Creek during the past decade (T. Sutfin, personal communication).

The two special-status plant species that are known to occur within the Soquel Creek watershed are flowering annuals that occur in open and sunny habitats of Valley and Foothill Grassland and Coastal Prairie rather than in the relatively shaded understory of riparian forest. No additional special-status plants were observed during the autumn 2001 field work for the vegetation assessment.

### 2.2 HISTORICAL RIPARIAN CONDITIONS

Surprisingly, the development of Soquel Village in the mid-1800s did not displace a lush forest that once filled a coastal valley. Rather, like much of the coast of Santa Cruz and San Mateo counties, the area from Soquel to the mouth of the creek consisted of coastal terrace prairie, a natural community dominated by grasses and wildflowers.

The earliest recorded description of the landscape at Soquel dates from the Portolá expedition, which was the first exploration by land along the Pacific coast north of Mexico. On October 9, 1769, the explorers first encountered redwood trees near Watsonville, and named the new species *palo colorado*. Seven days later Fray Juan Crespi, the diarist, recorded that the explorers “stopped at the bank of a small stream, which has about four varas [11 feet across] of deep running water. It has on its banks a good growth of cottonwoods and alders; on account of the depth at which it runs it may be that it cannot be utilized to water some plains through which it runs. It was named El Rosario del Beato Serafin de Asculi” (Bolton, 1927). (“Osocalis” was the name of a local rancheria [Rowland 1940], a name that evolved through many variations to “Soquel.”) The next day’s journey toward the San Lorenzo River crossed “good land well covered with grass”; the intervening three creeks, one of which was dry, were all situated in “plains of good land [with] a heavy growth of cottonwoods and alders in their beds.”

Five years later in 1774, another diarist, Francisco Palou, noted that the small streams east of Santa Cruz all had “plenty of running water and many trees in their beds, such as cottonwoods, alders, willows and some live oaks.” He also recorded that “Above the hills the high range

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
<th>Habitat Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coho Salmon</strong></td>
<td><strong>State Endangered CDFG Species of Special Concern</strong></td>
<td>A principal focus of the fisheries assessment</td>
</tr>
<tr>
<td><strong>Onchorhynchus mykiss</strong> Steelhead</td>
<td><strong>Federal Threatened</strong></td>
<td>Occurs in Coastal Prairie, Valley and Foothill Grassland, not in riparian vegetation</td>
</tr>
<tr>
<td><strong>Plagiobothrys diffusus</strong> San Francisco Popcorn-Flower</td>
<td><strong>State Endangered CNPS List 1B</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rana boylii</strong> Foothill Yellow-legged Frog</td>
<td><strong>CDFG Species of Special Concern</strong></td>
<td>Observed during assessment at numerous locations in Soquel Creek</td>
</tr>
<tr>
<td><strong>Tryonia imitator</strong> California Brackishwater Snail</td>
<td><strong>Extirpated; occurs at coastal lagoons including, formerly, “Soquel Marsh”</strong></td>
<td></td>
</tr>
</tbody>
</table>
continues covered with redwoods” (Bolton, 1926), drawing a distinction between the vegetation at the lower reaches of the streams and the forest on the steeper slopes farther inland.

The Coast Survey of 1853 mapped the coast from the shore to just beyond the coast road, now Soquel Drive (United States Coast and Geodetic Survey, 1853). At Soquel Creek on that map, a narrow band of trees lines the creek from about where Highway 1 is now located, extending to the lagoon on the east bank and to the ocean in the lee of the bluff on the west bank. A broader forest is shown a short distance above the current location of Soquel Elementary School and then the map ends. The entire coastal strip of “Sauquel Cove” is illustrated as mostly grassland and cultivated fields, with trees confined to a narrow band along each stream. The forest has a different character at lower Aptos Creek, which is deep and sheltered by comparison, and occupied by a broader forest. Though no legend is available for this map, the map-maker made a distinction between the tree cover at Soquel and that at Aptos. All the forest at Soquel is designated by rounded shapes (probably broad-leaved species) whereas angular star-shaped symbols (probably conifers) are used for the forest at Aptos.

The first extensive development in the area of Soquel Village took place in the 1840s and 1850s, after the breakup of the Soquel Rancho and Soquel Augmentacion. John Hames and John Daubenbiss built a sawmill in 1845 on the east bank near the present school, and after it washed out in 1846 a new one was built a short distance upstream on the west bank. In 1853 two Porter cousins established a tannery at Porter Gulch and a brother opened a store along Soquel Creek, in which the first post office was opened in 1884 (Rowland 1940).

Early industry must not have removed significant large trees, because large stumps (or clumps of resprouts) are not visible in the earliest photographs. An 1880 panorama (private collection of Richard Nutter, copy on display at the Porter Memorial Library) shows the budding village set in a mostly treeless valley flanked by largely treeless hills. A pattern of treeless lower hills with conifers on the mountains in the background may also be seen in many of the photographs of coastal towns in Santa Cruz County in the 1880s (Koch, 1973). The earliest agricultural uses of the land away from Soquel Creek was for potatoes in the 1850s, then wheat (Soquel Pioneer & Historical Association, 2002), a pattern more consistent with development of pre-existing grassland than with conversion from forest. There was little motivation and less technology available in the 19th century to remove large stumps, and with modern heavy equipment it is still difficult today to remove the stump of a large redwood. In a short number of years, a cut redwood produces a conspicuous clump of young sprouts. The locations of such clumps, both in the 1880s and now, give a good indication of where redwoods historically occurred.

Although they occupy the coastal fog belt, redwoods are damaged by salt spray, which can dehydrate and kill the tree’s foliage. As a result redwoods are usually absent from the immediate shore (Evarts and Popper, 2001). Along the lagoon, a few individual clumps and stumps are found in the shelter of the bluff at the Rispin Mansion (Alley, personal communication, 2002) and across from Nob Hill. There is a group of flat-topped old-growth redwoods in Noble Gulch (Lydon, 2002; Perry, 2002). A large group of second- or third-growth redwoods is located on the east bank a short distance downstream from the mouth of Bates Creek. Opposite the mouth of Bates Creek, in the cemetery, there are stumps of several large Douglas-firs; it is not known whether these occurred naturally or were planted. On Bates Creek redwoods are a dominant
creekside tree upstream of the Main Street bridge. There were sawmills in Bates Creek and Grover Gulch.

The current occurrences of large redwoods gradually increase midway up the main stem, backing up the evidence from old photographs. The vicinity of Allred Road contains occasional large redwood stumps. In the West Branch and the tributaries, redwoods are consistently a significant component of the riparian forest. Tall conifers occur naturally throughout the watershed in varying degrees, being sparser downstream and denser upstream.

Native Americans burned the coastal prairies for perhaps thousands of years. It is more probable that the purpose was to manage and rejuvenate the grasslands than to convert extensive forest to grassland.

The historical makeup of the riparian forest does not limit the future potential for enhancement of the stream habitat. Planted tall trees and buildings have altered the landscape such that locations formerly unsuitable for redwoods can now support them in locations where they would be valuable to provide long shadows cooling the creek. Redwoods and Douglas-firs are not only respectively the tallest and second-tallest trees of the Soquel Creek riparian corridor, but are also relatively fast-growing.
CHAPTER 3: ASSESSMENT METHODOLOGY

The riparian vegetation assessment was conducted by reviewing riparian literature and collecting data during a field survey.

3.1 LITERATURE REVIEW

The literature review for the vegetation examined the earliest historical descriptions of Soquel Creek; other river and stream assessments (see Appendix V-1); reports from the California Natural Diversity Data Base for the Soquel, Laurel and Loma Prieta quadrangles; research papers on the hydrological requirements for recruitment of riparian vegetation; and all the relevant aerial photographs available in the Map Room of the University of California at Santa Cruz. See also References.

3.2 FIELD SURVEY

The field survey was conducted on fifteen days from September 11 to October 17, 2001, when the water level was approximately at minimum for the season.

3.2.1 Geographical Scope and Transect Delineation

The survey consisted of walking Soquel Creek from its downstream end where it enters the lagoon, up the main stem, the east branch to the weir above Olive Springs Quarry, a portion of the lower west branch, and lower sections of Amaya Creek, Hinckley Creek, Hester Creek, and Bates Creek.

At every 1,000 feet, measured with a hip chain, a 50-foot wide transect belt was established. It extended from the outer edge of the riparian vegetation on one bank to the outer edge of the riparian vegetation on the opposite bank, or 60 feet beyond the toe of each bank, whichever was greater. At each of these locations, an array of information was recorded as described in Appendix V-2. If an obstacle interfered with data collection at the 1,000 foot mark (e.g. a bridge creating artificial shade, a low-flow channel too deep to collect measurements, a logjam or manmade stream alteration), the sampling point was moved 200 feet farther upstream. The next transect was then located 1,000 feet upstream from the “stretched” transect. On the main stem and branches, four transects (#2, 25, 41 and 46) were located 1,200 feet upstream from the previous one rather than 1,000 feet apart.

Five hundred feet upstream from each 1,000 (or 1,200) foot point, a smaller data set (described in Appendix V-2) was recorded. There were 60 full data sets and 75 small ones.

Amaya Creek was sampled from 500 to 2,500 feet above its mouth, with one full data set and four smaller data sets. Hinckley Creek was sampled from 500 to 3,000 feet above its mouth, with two full data sets and four smaller ones. Hester Creek was sampled from 500 to 2,900 feet upstream of the Young residence at 123 Hoover Road; here logjams necessitated stretching the
location of one of the four small data sets as well as the location of the main transect. Bates Creek was sampled from 500 to 2,500 feet above the Main Street bridge, with four small data sets and one full one.

The transect locations are summarized on the following table and are illustrated on Figure V-2 on the following page.

| Transects 1-4 | Reach 1 | Lagoon to Soquel Drive |
| Transects 5-7 | Reach 2 | Soquel Drive to below Bates Creek |
| Transects 8-12 | Reach 3 | Bates Creek to upstream (u/s) end of Whiteheads’ property |
| Transects 13-16 | Reach 4 | Whiteheads’ to near Conference Ground (end of Cherry vale Avenue, 1,004’ upstream from stream gage) |
| Transects 17-18 | Reach 5 | near Conference Ground to downstream (d/s) from prominent left bend |
| Transects 19-24 | Reach 6 | 375’ u/s from prominent left bend, to Moore’s Gulch |
| Transects 25-29 | Reach 7 | Moore’s Gulch to Purling Brook |
| Transects 30-34 | Reach 8 | Purling Brook to confluence of East and West Branches |
| Transects 35-45 | Reach 9 | East Branch from West Branch to Hinckley Creek |
| Transects 46-51 | Reach 10 | East Branch from Hinckley Creek to District Weir |
| Transects 52-55 | Reach 13 | lower West Branch |
| Transect 56 | lower Amaya Creek |
| Transects 57-58 | lower Hinckley Creek |
| Transect 59 | lower Hester Creek |
| Transect 60 | Bates Creek u/s from bridge at Main Street |

NOTE: Reach designations are those of D. W. ALLEY & Associates.

Notes and photographs were made of features (e.g., significant erosion areas, presence of Redwood stumps in the downstream reaches) on and between the transects. Each transect was mapped on the USGS topographic quadrangle, and an identifying flag was tied at the transect location.

It should be noted that the scope of the field work consisted of sampling 135 sites, rather than a continuous survey. Though observations and some measurements were recorded between transects, the focus of consistent data collection was at the transect locations.

Additional details regarding the data collected are described in Appendix V-2.
Soquel Creek Watershed
Vegetation Transect Locations

Figure V-1: Soquel Creek Watershed, Santa Cruz County, California. Vegetation transect locations are noted and numbered in most instances with transect numbering corresponding to that discussed in the text.

Prepared for Greening Associates by Balance Hydrologics, Inc.
Soquel Creek Watershed Vegetation Assessment, 2003.
3.2.2 Focus Area Methodologies

Factors Affecting Shade. What we think of as “shade” is measured in terms of canopy closure over the stream, i.e. a measurement of how dense or sparse the shade is at a certain location, taking into account the number and size of the openings in the canopy. One hundred percent canopy closure (a rarity) would represent a canopy that is entirely shaded, with no holes for the sun to shine through. Fifty percent canopy closure represents a canopy in which half of the canopy consists of openings where the sky shows through. Canopy closure was measured with a concave spherical densiometer (Robert E. Lemmon, sold through Forestry Suppliers, Inc.).

Canopy angle was measured with a Brunton Clino-Master clinometer from the low-flow channel, with 90° being the maximum for canopy directly overhead. The clinometer was also used to calculate the height of the dominant vegetation on each bank using a standard formula: (% angle to top of tree minus % angle to base of tree) X horizontal distance to tree = tree height.

Topography was recorded by sketching a cross-section of the channel and by recording a brief verbal description of each bank (gentle slope, moderate slope, steep slope, bluff, terrace etc.). Where topography contributed to the canopy closure, its estimated relative percentage was recorded.

Forest Composition – Tree Species and Size Classes. A forest inventory was performed at each transect to determine species composition and size class distribution. A 60-foot-radius circular plot was laid out with half of the plot on each bank, using a tape measure and a Bushnell Ranging Rangefinder to determine which trees were within the circular plot. Every tree greater than 6” in diameter at breast height (DBH) was inventoried as to size and species. Sizes were identified using a combination of a Biltmore stick and ocular estimation. Trees on the left and right banks (facing downstream) were recorded separately.

Trees in the inventory were recorded by transect and actual measurement, but were also grouped into four size classes: 6-9 inches DBH, 10-19 inches DBH, 20-29 inches DBH, and >29 inches DBH.

Invasive Exotic Plant Survey. At each transect, the kinds and amounts of any invasive exotic (i.e. non-native) plants present were recorded. For each invasive species present, abundance was categorized as absent, sparse, common, abundant, or dominant. For graphing purposes, these categories were given values of zero through four, respectively.

Invasive exotics were recorded separately for the canopy and the understory, and for each bank. To show the general distribution of invasive exotic species throughout the survey area, the four subsets were tallied together for each transect, with multiple species within any subset increasing the abundance value.
CHAPTER 4: RESULTS

4.1 FACTORS AFFECTING SHADE

4.1.1 Canopy Closure Over the Low-Flow Channel

Canopy closure gradually increased with distance upstream. It was highest in the west branch and the tributaries. Canopy closure was uneven in the main stem and east branch, with by far the lowest values being in the vicinity of the riprap along the east branch. Figure V-3 on the following page shows that only 27 sites, or 20.6% of the total, achieved the minimum canopy closure recommended by the California Department of Fish and Game for coho (Flosi et al., 1998).

The low-flow channel was frequently located adjacent to one bank or the other. It was therefore nearer to trees and in greater shade than if it were located at mid-channel.

Topographic shade increased with distance upstream, as did the amount of shade provided by evergreen trees. Of all (100%) of the available shade, the proportions provided by topography, evergreen trees and deciduous trees are shown on Figure V-4.

4.1.2 Tree Height

The taller trees, eighty feet and taller, were charted on Figure V-5. Redwood and Douglas-fir were respectively the tallest trees along Soquel Creek. Redwood was observed to be the dominant tall tree species at more locations (14 of 120, left and right bank recorded separately for the 60 transects), than was Douglas-fir at 5 locations. Cottonwood was the third tallest dominant species, at 10 locations, followed by the fourth tallest, Alder, dominant at 15 locations.

Sycamore and Big-leaf Maple are two tree species that provide shade and nutrients by leaning out over the creek. Sycamore was the dominant tree species above 80 feet at only one site. It tends not to occur in dense colonies as some of the other species do. Big-leaf Maple met or exceeded a height of 80 feet at 10 locations, though it never exceeded 90 feet.

Live Oak occasionally grew tall, between 80 and 100 feet at two locations. Eighty feet seemed to be an upper limit for Bay, Willow and Tanoak, which reached just over 80 feet tall at a few locations.

Figure V-6 charts the heights of dominant trees, irrespective of species, at each transect. It illustrates that there was a general trend toward taller trees with progression upstream, except along the stretch of riprap that extends from 135’ above Transect 47 to just downstream of Transect 49. The low tree stature continued into adjacent transects both up- and downstream.
There is a data gap at Transect 29.
FIGURE V-4

CATEGORIES OF AVAILABLE SHADE
SOQUEL CREEK

Note: Absent bars are data gaps.
FIGURE V-5

HEIGHTS OF DOMINANT TREES 80+ FEET TALL, BY SPECIES
SOQUEL CREEK

NOTES:
Left and right bank were recorded separately.
Ten additional occurrences of dominant trees 80' or taller were recorded in transects 1-20, species not noted.
Only one occurrence of dominant trees 80' or taller was downstream from Transect 13, Redwoods on right bank at Transect 1.

FIGURE V-6
HEIGHT OF DOMINANT TREES
SOQUEL CREEK

Main Stem

East Branch

W. Br.

Tribs.

Feet

Transect I.D.

0

20

40

60

80

100

120

140

160

1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
59

Left Bank (facing downstream)
Right Bank
FIGURE V-7

ANGLE OF CANOPY ABOVE LOW-FLOW CHANNEL
SOQUEL CREEK

LEFT BANK

RIGHT BANK

Greening Associates

March 2003
FIGURE V-8

DECIDUOUS AND EVERGREEN TREES
SOQUEL CREEK

LEFT BANK

RIGHT BANK

Transect I.D.

# of Trees

Total Deciduous Trees

Total Evergreen Trees
4.1.3 Canopy Angle

Canopy angle was another factor producing shade over the creek. High canopy angles may be more important than height of trees at locations where the stream channel is narrow. In the tributaries, canopy angle tended to be high on both banks. In the vicinity of the rip-rap on the East Branch, the canopy angle was low on both banks. In most locations, low canopy angle on one bank tended to be compensated by high canopy angle on the opposite bank. This reflected the fact that the low-flow channel location was frequently adjacent to one bank or the other.

4.1.4 Topography

In general, where Soquel Creek flows through a relatively broad valley, the amount of shade contributed by topography was minor, except beside the high bluff at Transect 7, a short distance downstream of the cemetery. Topographic shade was a component of the total shade in the upper main stem, where steep slopes were encountered on one or both banks of eleven transects in a row. Topographic shade was a significant component in the West Branch where the creek flows through a steep canyon.

The topography of the east branch steepens above the quarry, where the stream flows through a relatively narrow canyon and the canopy closure increased, partly as a result of increased topographic shade. At this part of the east branch the Fisheries Assessment found that water temperature was relatively low.

The vegetation assessment addressed the lower segments of Amaya, Hinckley, Hester and Bates creeks. The tributaries flow through relatively steep topography and there are no broad sunny areas; but for the most part neither are they deeply engraved into the landforms, and topographic shade was a factor only beside the high bluff on Hinckley Creek just downstream of Olive Springs. Informal measurements found that water temperatures in the tributaries were cool.

4.2 FOREST COMPOSITION – TREE SPECIES AND SIZE CLASSES

Tree size classes and the species composition at each transect are contained in Appendices V-4 and V-5. While an in-depth analysis of the forest inventory was outside the scope of the vegetation assessment, the 60 forest plots provided pertinent information that relates to instream conditions for salmonid fish.

Deciduous trees decreased gradually and evergreen trees increased gradually with distance upstream, with the pattern of distribution of evergreen and deciduous trees tending to be similar on the two banks at most transects (Figure V-8 on the preceding page). A recording error (recording the left bank data and then continuing to record right bank trees in the same data row) was sometimes noted and corrected in the field; if at other times it went undetected, it could account for the apparently higher numbers of trees on the left bank. It would not affect the full-plot data shown in Appendices V-3 and V-4.

Alders and Cottonwoods were abundant in the main stem. Alders were most strongly represented in the 10-19 inch and 6-9 inch size classes. Cottonwoods were also strongly
represented in the 10-19 inch size class, but all size classes of this species were represented on the main stem. There were few Maples below Moore’s Gulch; above Moore’s Gulch most were less than 20 inches in diameter. Like the Maples, Tanoaks were recorded only above Moore’s Gulch, occurring mostly in the two smaller size classes.

Only eleven Sycamores occurred within the 60 plots, and this species seldom occurs in dense stands. An individual Sycamore can become massive; the biggest one seen, on Transect 6 near the gaging station, was ten feet in diameter. Two other large ones, possibly 36” DBH (one of them measured at 117’ height), were noted within 200 feet of Transect 18 on the right bank. No Sycamores were tallied in the 6-9 inch DBH size class.

Most willows big enough to tally occurred in the lower portion of the main stem; nearly all were in the two smaller size classes. Live Oaks also were recorded mostly in the two smaller size classes, and occurred more in the upper portion of the main stem than elsewhere. Bays were scattered lightly everywhere above Bates Creek and were present in all size classes.

Douglas-firs were found in all sections of the creek and were represented by all size classes. Redwoods were lightly distributed along the main stem, where only one was >29 inches DBH; all size classes occurred more frequently in the portion of the east branch below the riprap, and good-sized Redwoods were dominant along the West Branch and tributaries. The biggest Redwoods were removed for timber in the late 1800s.

Though Box Elders are commonly found along Santa Cruz County streams, none occurred in the forest inventory plots along Soquel Creek.

4.3 **INVASIVE EXOTIC PLANTS**

In late summer 2001, invasive exotic (i.e. non-native) plants were present at most locations along Soquel Creek but had not taken over as heavily as they have in stream corridors in more urbanized areas. The abundance of invasive exotics by transect is shown on Figure V-9. For graphing purposes, abundance was assigned values of “absent” (0), “sparse” (1 point), “common” (2 points), “abundant” (3 points) or “dominant” (4 points); if multiple invasive species were present their respective values were added together.

Where sun-loving invasive species decreased, the shade-loving invasive species generally increased, such that the total presence of invasive exotic species was fairly consistent from the lagoon to the upstream reaches, decreasing only along the west branch and tributaries.

Most invasive plant species were located in the understory. The principal invasive species in the understory were Periwinkle (*Vinca major*) in shady locations, French Broom (*Genista monspessulana*) in sunny locations, Cape Ivy (*Delairea odorata*), and English Ivy (*Hedera helix*), in that order.

The principal invasive species in the canopy were English Ivy, Acacia (*Acacia spp.*), Tree of Heaven (*Ailanthus altissima*), and Blue Gum (*Eucalyptus globulus*), in that order.
Abundance by individual species is shown on Figures V-11 and V-12, where units of abundance are the number of sites where a given species occurred, with left and right banks of the 60 main transects considered separately for a total of 120 sites.

Eupatory (*Eupatorium adenophora*) and Bergamot mint (*Mentha citrata*) were present in all reaches. Pampas Grass (*Cortaderia jubata*) was found at some locations. Wandering Jew (*Tradescantia fluminensis*) was found only near houses. Surprisingly, the berries along the creek were mostly the native blackberry and raspberry (*Rubus ursinus* and *R. leucodermis*). Himalayan Blackberry (*Rubus discolor*), which is weedy at many other locations, was found at only 3 of the 120 sites (60 transects x 2 banks) along Soquel Creek.

Giant Reed (*Arundo donax*) was present at six locations, two of them planted. The Santa Cruz County Resource Conservation District is planning to remove them.
INVASIVE EXOTIC PLANTS BY LOCATION, LATE SUMMER 2001
SOQUEL CREEK

NOTE: Absence of bar indicates zero value, no invasive exotic plants present on transect.
FIGURE V-10

**ABUNDANCE OF INVASIVE SPECIES IN CANOPY, BY SPECIES**

60 transects x 2 banks

- **ACDE** = Green Wattle (*Acacia dealbata*)
- **AIAL** = Tree of Heaven (*Ailanthus altissima*)
- **ARDO** = Giant Reed (*Arundo donax*)
- **COJU** = Pampas Grass (*Cortaderia jubata*)
- **EUGL** = Blue Gum (*Eucalyptus globulus*)
- **HEHE** = English Ivy (*Hedera helix*)

Occurrences per species
FIGURE V-11

ABUNDANCE OF INVASIVE SPECIES IN UNDERSTORY, BY SPECIES

60 transects X 2 banks

 occurrences per species

AIAL = Tree of Heaven (Ailanthus altissimus)
ARDO = Giant Reed (Arundo donax)
COJU = Pampas Grass (Cortaderia jubata)
DEOD = Cape Ivy (Delairea odorata)
EUAD = Eupatorium adenophorum – under-represented
GEMO = French Broom (Genista monspessulana)
HEHE = English Ivy (Hedera helix)
IPTR = Morning Glory (Ipomoea tricolor)
LALA = Wild Sweet Pea (Lathyrus latifolius)
LOJA = Honeysuckle (Lonicera japonica)
MECI = Bergamot Mint (Mentha citrata)
MEOF = Lemon Balm (Melissa officinalis)
MYLA = Forget-me-not (Myosotis latifolia) – under-represented
PECL = Kikuyu Grass (Pennisetum clandestinum)
PYRA = Pyracantha sp.
RUDI = Himalayan Blackberry (Rubus discolor)
TRFL = Wandering Jew (Tradescantia fluminensis)
TRMA = Nasturtium (Tropaeolum majus)
VIMA = Periwinkle (Vinca major)
FIGURE V-12

TRANSECTS FREE OF INVASIVE EXOTIC PLANTS
OF 60 TRANSECTS TOTAL

TRANSECTS WHERE CANOPY ON BOTH BANKS WAS FREE OF INVASIVES:
6, 9, 10, 11, 13, 15, 16, 18-32, 34, 37-41, 43, 44, 45 (no canopy present on left bank), 47-51, 53-59
4.4 OTHER RESULTS AND OBSERVATIONS

While the scope of the assessment did not include land use, several observations were noted.

There are numerous locations where people have removed the riparian vegetation to the water’s edge, some locations where structures have been built on the stream banks, and others where grading operations have been conducted in or adjacent to the channel.

From the ocean to Soquel Village, commercial and residential land uses place consistently narrow limits on the width of the riparian forest, which seldom extends beyond the top of the bank. Upstream from the village, rural-residential and agricultural land uses limit the extent of the riparian forest at a number of locations, with scattered but significant portions of the riparian vegetation being relatively intact.

Within the area of the East Branch that was surveyed (from the confluence with the West Branch to the Soquel Creek Water District weir), rural-residential and equestrian land uses have altered the riparian vegetation at a notable number of locations. In this reach, a granite quarry is located upslope from the right bank (looking downstream); across from the quarry, an extensive flood plain has been cut off from the creek by a treeless bank of white dolomite riprap, approximately 1,800 feet long, that forces the creek toward the quarry and causes erosion. This stream alteration was apparently performed at a date later than the 1989 aerial photographs. Downstream from both of these locations, a former lumber operation removed vegetation from the right bank at what is now the Millpond events center.

Rural-residential land uses have altered the riparian vegetation at a few locations on the portion of the lower West Branch that was surveyed.

All of the tributaries have been disturbed by human activities: logging throughout the watershed, rural residential use along Hinckley Creek, rural residential use and dumping of trash from Old San Jose Road along Hester Creek (which is prone to landslides), and urban use along Bates Creek. Nonetheless, the tributaries are relatively shady and cool.
CHAPTER 5: DISCUSSION

Taken as a whole, the riparian vegetation along Soquel Creek is in a moderately healthy condition. In some of the less-urbanized locations, the streamside forest may currently be as wide as it was before 1840. Tree cutting is localized on numerous properties, and channel alteration has been performed adjacent to some, but there are few long stretches where the streamside forest has been removed by land use activities (see Section 4.4). Shorter stretches of bank where vegetation has been cleared are located on a significant number of small and medium-sized parcels. Continuous measurements were beyond the scope of this assessment; cumulatively, however, these smaller-scale clearings may equal or exceed the extent of the larger clearance areas. Most of the longer treeless banks appear to be the result of natural forces combined with poor management of streamside vegetation. There is a clear opportunity to improve the riparian vegetation along Soquel Creek, and the need is greater at some locations than at others.

5.1 SHADE

The chart of percent canopy closure (Figure V-3, Section 4.1.1) shows individual locations, and groups of locations, where canopy closure was relatively low in late summer of 2001. The chart of channel width where a canopy cover of trees or shrubs was lacking (Figure V-13, next page) shows locations where the width of channel exposed to the sun was wide, both in feet and in percent of the total channel width from toe of bank to toe of bank. From these charts, a table of the most “unshaded locations” was developed. These relatively unshaded locations are high priority sites where active planting of riparian vegetation may be considered, because they were the most exposed to solar heating during the day. However, any site with less than 75% canopy closure could potentially be enhanced with plantings.
FIGURE V-13

WIDTH OF CHANNEL NOT COVERED BY TREE OR SHRUB CANOPY
TOE OF BANK TO TOE OF BANK
SOQUEL CREEK

Transect I.D.

Main Stem

East Branch

W. Br. Tributaries

Width of channel lacking canopy cover, in feet
Channel width, in feet
Percent of channel lacking canopy

Greening Associates  March 2003
### TABLE V-3
**UNSHADED LOCATIONS ON SOQUEL CREEK, LATE SUMMER 2001**

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>TRANSECTS #1-10</th>
<th>TRANSECTS #11-20</th>
<th>TRANSECTS #21-30</th>
<th>TRANSECTS #31-40</th>
<th>TRANSECTS #41-50</th>
<th>TRANSECTS #51-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>An individual transect where canopy closure was less than 20%</td>
<td>4a, 9a</td>
<td>19a</td>
<td>21a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 out of 3 adjacent transects having less than 30% canopy closure</td>
<td></td>
<td>21a to 22a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 out of 6 adjacent transects having less than 50% canopy closure</td>
<td>1 to 3a</td>
<td></td>
<td></td>
<td>39a to (41)</td>
<td>(39a to) 41, 46a</td>
<td></td>
</tr>
<tr>
<td>More than 60' of channel width (toe of bank to toe of bank) lacking canopy</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>More than 50% of channel width (toe of bank to toe of bank) lacking canopy</td>
<td>2, 4, 5, 7, 9</td>
<td>11, 15, 17, 18</td>
<td>21, 22</td>
<td>33, 35, 37-39</td>
<td>45, 47, 48,50</td>
<td>51, 58</td>
</tr>
<tr>
<td>Channel width (toe of bank to toe of bank) &lt;30' and &gt;40% lacking canopy</td>
<td>5</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td>56, 58</td>
</tr>
</tbody>
</table>

**NOTES**
1. Data for the non-canopied channel widths were recorded every 1,000 feet (numbers only) and canopy closure was recorded every 500 feet (numbers with an “a” after them); thus the apparent discrepancy in the transect identifications (“#” vs. “#a”).
2. The narrower (<30’) channel locations with >40% lacking canopy were not necessarily unshaded locations, but may offer significant opportunities for cooling the water in the creek.
3. Refer to Figure V-2 for site locations.

### TABLE V-4
**WELL-SHADED LOCATIONS ON SOQUEL CREEK, LATE SUMMER 2001**

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>TRANSECTS #1-10</th>
<th>TRANSECTS #11-20</th>
<th>TRANSECTS #21-30</th>
<th>TRANSECTS #31-40</th>
<th>TRANSECTS #41-50</th>
<th>TRANSECTS #51-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 out of ten transects having 80% canopy closure</td>
<td></td>
<td>13 to 20a</td>
<td></td>
<td></td>
<td></td>
<td>52a to 55, 58</td>
</tr>
<tr>
<td>5 out of ten transects having 20 channel width lacking canopy</td>
<td></td>
<td>13, 14, 16, 19</td>
<td>24, 27</td>
<td>31, 32, 36</td>
<td>41</td>
<td>52, 53, 54, 55,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57, 59, 60</td>
</tr>
</tbody>
</table>

**NOTE**
1. Data for the well-shaded channel widths were recorded every 1,000 feet (numbers only) and canopy closure was recorded every 500 feet (numbers with an “a” after them; thus the apparent discrepancy in the transect identifications (“#” vs. “#a”).
Locations where multiple “unshaded” criteria overlapped or adjoined in clusters (bold) are highest priority sites to consider for planting. They should be field-checked to verify their present state of natural regeneration, habitat value, logistical and access considerations, and potential for voluntary participation by landowners to water plants if needed.

Locations where multiple “shaded” criteria overlapped or adjoined (bold) are highest priority sites to consider for preservation in their current state. They should be field-checked to verify whether the conditions within the transect locations are representative of their surroundings.

All shaded locations merit protection because of their existing positive influence on the fisheries habitat.
5.2 FOREST COMPOSITION – TREE SPECIES AND SIZE CLASSES

In general, the forest inventory reveals a healthy array of tree species and size classes. From the information available (see Section 2.2 above), the riparian forest of Soquel Creek today accords somewhat with its condition two centuries ago. There are some exceptions. The width of the riparian forest has been generally reduced to the area between the tops of the banks in the urbanized areas, and also occasionally upstream at agricultural, rural residential and equestrian sites. At some locations the riparian vegetation has been cleared entirely from the bank. The largest (and most commercially valuable) Redwoods were removed throughout the watershed during the late 1800s, after the technology for cutting the larger trees was developed. There are some immense Redwood stumps along the creek whose roots are still holding the banks a century or more after their tops were removed.

Since there have been no previous studies of the composition of the forest for the length of the creek, it is not possible to discern population trends for the riparian forest; however, this current assessment can provide a baseline against which to evaluate future trends.

5.2.1 Roles of Tree Species along Soquel Creek

The several groups of tree species that play distinct roles in contributing to healthy salmonid habitat are all well represented along Soquel Creek. The deciduous trees that provide nutrients when their leaves drop in the fall are most heavily located in the main stem – where water temperatures are warmest (see Fisheries Assessment) and salmonids require a greater food supply – but are widely distributed throughout the areas surveyed. Cottonwoods were an exception among the deciduous trees, as they occurred in the forest inventory plots only on the main stem and east branch, and not on the tributaries or west branch, which flow through relatively narrow canyons.

Deciduous trees also provide an indirect benefit to the instream habitat: spurts of fish growth in spring and again in late fall coincide with periods prior to leafing out and after leaf drop when water temperatures are cool (see Fisheries Assessment).

The broadleaved Live Oaks and Tanoaks provide nutrients in spring when their new leaves develop and the old ones drop. Live Oaks and Tanoaks are found in the middle reaches, while Tanoaks also occur along the west branch and tributaries. Redwoods, which increase upstream, shed needles and branchlets from late summer through winter.

Conifers contribute the longest-lasting large wood to the instream fish habitat. Though conifers are present along the length of Soquel Creek, the survey of large wood (or large woody debris, LWD) that is contained in the Fisheries Assessment found there was a remarkably small amount of large wood present in the active channel, nearly all of it old Redwood.

Several species were noted to provide bank stabilization. Shrubby willows and the densely spreading root systems of Alders were frequently observed to bind the soil of the streambanks. Less commonly, Cottonwoods send up a widespread thicket of short sprouts from shallow roots and this thicket protects the bank during high flows. Creek Dogwoods knit the bank with their
fibrous roots, and were observed to create a broad (to 10’) overhang over the low flow channel, creating escape cover for fish. The flexible branches of this shrub bend down during high flows and can contribute supplemental erosion protection for the surface of the banks while they are temporarily inundated. Though data were not collected on the shrub species, Creek Dogwood seems to be under-represented in its occurrences along Soquel Creek compared to other central coast creeks. It appears to prefer less-shaded locations, and may offer potential for “soft” bank protection at erosion sites.

Field studies are increasingly revealing the importance of biological diversity. Ecosystem interactions among plant species, microbes, invertebrates, and vertebrates can fall apart when any one species, even one that might appear to be insignificant, drops out of the system. Along Soquel Creek, the vegetative ingredients of ecosystem diversity are substantially in place and functioning now, and they can be restored in those patches where they have been removed.

5.2.2 Potential for Natural Regeneration

Where riparian vegetation is removed by streamside residents, it usually is not allowed to regenerate. However, at locations where natural processes remove riparian vegetation, natural regeneration tends to replace the riparian vegetation, and this process is taking place in the riparian forest along Soquel Creek. Planting projects need be considered only where they would supplement or replace natural recruitment.

The forest inventory excluded all trees that were six inches or less in DBH, and these were numerous enough to indicate that recruitment is actively occurring. Natural regeneration is a self-sustaining, cost-free and maintenance-free process that should be encouraged to take place, as should natural maturity and senescence of the trees. Trees that fall into the creek may be dead plants but they become part of the living habitat for salmonids.

Nearly all of the tree species are represented by a full array of size classes, which indicates that younger trees are coming in to take the place of older ones as they die off. However, as noted in Section 4.2 above, one species that is not represented in the smallest size class is Sycamore. It is not a dominant species because it tends to occur singly. It prefers open locations and sandy or gravelly soil. It warrants inclusion in any contemplated plantings where the conditions of soil, water, and landowner cooperation may support it. The relatively low numbers of Cottonwoods in the smallest size class could also be supplemented by planting.

In any situations where planting is contemplated, certain considerations need to be taken into account, based on past research on the establishment of riparian vegetation.

Past research at other riparian locations. There is a modest body of research data that addresses the hydrological requirements for natural recruitment of riparian trees along stream and river corridors. The past research has largely focused on Cottonwoods (*Populus* spp.). Cottonwoods are considered an indicator of ecosystem integrity because they contribute large wood that creates aquatic habitat, increase the accumulation of finer sediments, and make fluvial landforms more resistant to erosion; also because they contribute substantial organic
matter to newly deposited and nutrient-poor primary substrate through annual inputs of leaf litter (Dykaar and Wigington, 2000).

Some of the past studies have been performed in arid or summer-dry climates, mostly on Fremont Cottonwood (*P. fremontii*). A small portion in turn has focused on either the Black Cottonwood species that occurs along Soquel Creek (*Populus balsamifera ssp. trichocarpa*) or on species previously identified as possible synonyms, *Populus balsamifera* or *P. trichocarpa*. A significant portion of past studies has related to managed water flows released from dams. However, recruitment processes on free-flowing river systems remain incompletely understood for even the most studied species (Cooper *et al.*, 1999).

Successful establishment of riparian trees occurs in channel positions that are moist, bare, and protected from removal by subsequent disturbance (Scott *et al.*, 1996). These locations develop during three different processes. One is narrowing of the stream channel, which creates recruitment opportunities at elevations within the channel bed during one to several years of flow below that which is necessary to rework the channel bed. A second is meandering, which establishes riparian trees near the bankful elevation on point bars during periods of frequent moderate flows. And the third process is flood deposition, which establishes riparian trees well above the channel bed elevation during periods of infrequent high flows.

All three of these establishment processes depend upon viable seed being available during the time period when the bare substrate is moist. Riparian trees produce copious quantities of seed that is capable of being dispersed by wind and/or by water. The seed of Douglas-firs is dispersed by wind in the fall, while that of Redwoods is dispersed by water during the winter. Seed of Sycamore (wind-dispersed) and White Alder (water-dispersed) both ripen in winter. The seed of these four species retains viability for several months. Seeds of Cottonwoods and Willows (both wind-dispersed) ripen during early spring and are viable for only a few days. Storms in late winter distribute seed, provide rainfall for germination, and sustain a high enough water table to potentially sustain root growth through the dry summer.

The survival rate for riparian tree seedlings is strongly dependent on substrate texture since fine-textured alluvium that is saturated during late winter flooding provides the flood-derived soil moisture normally necessary for late-summer seedling survival (Cooper *et al.*, 1999; McBride and Strahan, 1984) and this determines the rate of water infiltration and drainage from the riparian zone (Kranjcec *et al.*, 1998). The texture of the substrate varies from one location to another within a stream corridor, because particles of varying sizes are sorted and laid down by variations in the stream flow. Cooper *et al.* (1999) identified minimum conditions for survival of Fremont Cottonwood to the first autumn as at least 1.25 m. above the base flow stage, and where at least 10 cm. of the upper 45 cm. of the alluvium was fine-textured, i.e. either sandy loam, loam, or silt loam. They also discovered that seedlings in the most favorable locations for establishment at their study site on the Yampah River in northwestern Colorado did not become phreatophytic (capable of tapping into the water table or the capillary fringe) until their third or fourth growing season.

Black Cottonwood saplings are considered more tolerant of water table declines than other species because this species occurs in areas where streams rise and fall rapidly (Kranjcec *et al.*, 1998).
Maximum survivable rates of water table decline for Fremont Cottonwood have been defined as >4-6 mm/day (Cooper et al., 1999) and for Cottonwoods generally as 2.5 cm/day (Mahoney and Rood, 1998).

For Cottonwood establishment, maximum elevations above the late summer stream stage have been variously identified as about 0.6 to 2m. in elevation using a model developed in Alberta, Canada (Mahoney and Rood, 1998); or 1.25-2.5 m. on the Green and Yampa Rivers near the Utah-Colorado border (Cooper et al., 1999). Along an intermittent stream in Sonoma County, California, 93% of Fremont Cottonwood seedlings growing within 20 cm. of the water table survived the first summer compared to 0% where the water table was more than 1 m. below the ground surface; survival of Sandbar Willow (*Salix hindsiana*) in the same situations was 24% vs. 0% and survival of Red Willow (*S. laevigata*) was 63% vs. 0% (McBride and Strahan, 1984).

Researchers point out that the relation between stream flow and tree establishment varies among species (Kranjec et al, 1998), from site to site (Scott et al., 1996), and even from reach to reach within the same stream (Shafroth et al., 1998).

**Implications for Soquel Creek.** Seedling establishment of riparian trees is defined as survival through three growing seasons (Cooper et al., 1999). This suggests that where bars within Soquel Creek currently support three-year-old trees that have recruited voluntarily since the last high flow, the vegetation is now in a condition to shape the creek during moderate flows. For instance, at Mountain School and the Whitehead property, where broad expanses of channel were exposed in historical floods and more recently in 1997-98 (El Niño) and 1999-2000 (La Niña), the developing vegetated bars may influence the future alignment of the creek during moderate flows. Bars tend to promote meandering and increase the channel capacity to carry higher flows. At these two locations trees are regenerating vigorously on their own and active tree planting on the bar and at the toe of the bank is not needed, although planting of shrubs could increase the stability of the banks. These are locations that will always be vulnerable to channel migration. However, stability can be improved by moving land uses back from the creek and restoring the riparian forest on the terrace. Heavy floods may remove portions of restored riparian vegetation on terraces, but re-establishing riparian forest at these locations will nonetheless reduce erosion and siltation during future moderate flows, improving the instream habitat for steelhead and coho during most years. The tallest and fastest growing tree species should be included in any planting in order to provide the earliest possible shading to the creek.

The success of any contemplated planting will depend upon the substrate being fine-textured and the location being within close range of surface water or the water table. Alternatively, plantings that are set back from the bank may be successful if there is a realistic commitment by the property owner to irrigate deeply for the first three summers.

The dead and dying trees on the right-bank terrace in the vicinity of Transect 50 bear investigation. The creek reportedly shifted its course in the not-distant past, and apparently also downcut substantially in its new location (Nelson, 2001). It may be possible to identify the date and cause (possibly fault-related) for this dramatic change. In any case, the drop in water table was deep enough and rapid enough to stress mature riparian trees, and some valuable information could be gained from understanding what occurred there.
5.3 REVEGETATION CONSIDERATIONS

The tallest deciduous riparian trees, the Sycamores and Cottonwoods, are generally located on terraces well above the bed of the creek where they became established following heavy flow events. For the most part, the high terraces are not suitable for active planting of these species, unless deep irrigation can be supplied for a three-year establishment period, because during most years the depth to the water table is too great for roots of young trees to reach the moisture of either the saturated soil or the capillary fringe needed to sustain phreatophytic species. Redwoods and Douglas-firs are less dependent on water, and if irrigation is available during an initial establishment period they could be suitable species for terrace plantings.

Before any tree-planting is planned, there should be a field reconnaissance of the sites receiving the greatest solar radiation (Section 5.1) to verify their present state of natural regeneration, habitat value, logistical and access considerations, appropriate species, and potential for voluntary participation by landowners to water plants if needed; also to assess whether non-vegetative bank stabilization is needed. Sites selected for planting should be located where they are not vulnerable to being scoured by moderate flows. At locations above the bankful channel, Redwood and Douglas-fir are the most suitable species because they are tall and fast-growing, and because after they are established they will be more drought-tolerant than other species. Tree-planting may be especially valuable along the south side of the creek. If Cottonwoods or willows are planted from vegetative propagules, the majority should be from female plants in order to promote future recruitment.

When identifying opportunities for planting riparian trees to improve shading and lower the water temperatures in Soquel Creek, “site-specific” should be the rule of the day. Where on-site drilling can identify soil texture and the depth to the water table, planting may be undertaken if the soil is sandy loam, loam, or silt loam and the depth to the water table is a meter or less. Otherwise, planting of riparian trees should be undertaken only where the planting location in late summer is, in elevation, within 1 meter above the visible low-flow surface of the water; or is adjacent to surface water; or where voluntary agreements can be obtained to deeply irrigate planted trees every two weeks during the first summer and monthly during the second and third summers after planting.

At locations where tree planting appears to be unsuitable and the existing banks are vulnerable to erosion during moderate flows, planting rooted cuttings or container-grown plants of Creek Dogwood (Cornus sericea ssp. occidentalis) could benefit the creek. They should be planted at water level during May or June when the water table is declining and the roots may be drawn downward, to establish biological “soft” armoring of the banks and protect the banks from erosion during moderate-flow years.
5.4 INVASIVE EXOTIC PLANTS

Invasive exotic (i.e. non-native) plants are found in all reaches of the creek, with no particular location containing significantly more or less than others with the exception that invasive exotic plants are more abundant in the understory than in the canopy. Overall, Soquel Creek is less heavily invaded than more urbanized creeks elsewhere in central California, and Himalayan Blackberry (*Rubus discolor*) in particular is less abundant than it is elsewhere.

Cape Ivy is the only invasive exotic species present that is suspected to have a direct deleterious effect on fish. The harm done by invasive exotic species consists of simplifying the diversity of the riparian forest and suppressing the recruitment of seedlings of the native riparian trees. A decline in the health of the riparian forest causes indirect harm to the salmonid habitat because it removes food sources upon which the aquatic invertebrates rely, removes sources of large wood, and alters the shade regime.

English Ivy (*Hedera helix*) is a threat to riparian trees when it climbs into their crowns, because it weakens them by shading their foliage and its weight pulls them over. Ivy in the treetops can be controlled simply by cutting away a band of the roots surrounding the tree. An illustration of this technique is included in Appendix V-7. Removing Ivy from the canopy produces a dual benefit, because Ivy produces seed only in its climbing portions, and not when it grows as a groundcover. Once the climbing portions are killed, there is no longer seed available from that plant to be spread by birds eating the berries.

Periwinkle, Ivy and French Broom appear to be the invasive species that most actively displace native vegetation along the banks of Soquel Creek. For this reason, they are high priorities for eradication. All three can be controlled manually. The pamphlet “A Plague of Plants”, available online at [www.wildwork.org](http://www.wildwork.org), describes control methods for the principal invasive exotic plants of Santa Cruz County.

Periwinkle is difficult to remove completely because even a small piece of root left in the ground will produce a new stand. Herbicide is usually used as a supplemental tool to eliminate it. It does not produce a seed bank in the soil, and once removed it does not come back. Ivy can similarly grow back from a missed piece left in the ground, but it is easier to remove all the pieces. French Broom is shallow-rooted and easy to pull, but the seed bank that remains in the soil requires follow-up work sessions for several years to remove new seedlings.

Giant Reed (*Arundo donax*) spreads rapidly to clog waterways, and twenty-five million dollars have been spent in Southern California to remove it. Currently it only occurs at six locations along Soquel Creek, so there is an opportunity to eradicate it while it is most cost effective.

The highest priorities for invasive exotics removal are two: 1) removal of the six stands of Giant Reed (*Arundo donax*), and 2) killing or removing English Ivy (*Hedera helix*) where it is in the canopies of trees. These two control efforts will be effective, relatively simple to execute, and dramatic in terms of stewardship learned.

The next highest priorities for invasive exotics removal efforts are, in the understory, sequentially: Cape Ivy (*Delairea odorata*) before it gets into the canopy at the small number of...
locations where it currently occurs, Periwinkle (*Vinca major*), French Broom (*Genista monspessulana*) and English Ivy (*Hedera helix*). In the canopy, Green Wattle Acacia (*Acacia decurrens*) and then Blue Gum (*Eucalyptus globulus*) are the next priorities for removal after English Ivy.

Invasive exotic plants are a very real problem in California and along the Soquel Creek corridor, but less so than in other parts of the world where non-indigenous human colonists moved in several hundred years ago, bringing their weeds with them, and where there has been a much longer opportunity for the weeds to spread. In South Africa, for instance, the book that catalogs “problem plants” weighs five pounds or more. Along Soquel Creek, invasions by the most harmful species can still be controlled by human efforts. A dedicated property owner who chooses to can eliminate all detrimental species along her or his streamside through sustained periodic work over a period of several years, during which the level of effort entailed shrinks significantly each year.

Unlike tree planting, which may take two decades before any benefit accrues to the creek, removal of invasive exotic plants creates an immediate improvement of the riparian habitat.

### 5.5 MONITORING PLAN

The general monitoring plan described in the Geomorphology and Hydrology Assessment can be applied to vegetation and used for future monitoring of the enhancement plan. Future monitoring of the vegetation should repeat the methods used in this assessment in order to facilitate comparisons over time. At a minimum, future monitoring should address canopy closure, the composition of the riparian forest, and the status of invasive exotic plants.
CHAPTER 6: CONCLUSION

The principal goals of any future efforts to enhance salmonid habitat in Soquel Creek in terms of its vegetation should be twofold. The first is to increase the amount of shade along the main stem and east branch, especially at meander bends and locations with wide cobble bars. This will require that naturally regenerating riparian trees be retained throughout their full life cycle (after which they should be allowed to fall into the creek to improve instream salmonid habitat), that existing well-shaded sites be protected, and that tree planting be undertaken where the forest is absent but the sites are suitable for establishing riparian trees.

The second goal is to maintain a fully diverse array of native riparian species in an actively regenerating condition. This will require all of the measures needed to improve canopy closure. In addition it will require that removal of the native streamside vegetation become a less prevalent activity. It will also require that invasive non-native plants be controlled so that the native species important to salmonid survival can continue to be self-sustaining.

Except for localized sites, there are no striking contrasts that can be drawn between one section of the creek and another. There is, however, a graduated spectrum of overall condition, with healthier riparian vegetation located in the upstream reaches and greater negative impact downstream in the more urbanized areas. Where human populations cause a problem, they can also bring about the remedy; there are opportunities to improve human stewardship of the living creek. Though it takes time for a tree planted today to benefit the fish, it may still be possible to learn and implement practices that will improve the health of the riparian forest within the time frame required to maintain the viability of steelhead – and conceivably even to bring back coho salmon.
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PAST RIPARIAN ASSESSMENTS

A selection of prior riparian assessments performed on Soquel Creek and comparable California coastal streams was reviewed to provide context for this assessment. It revealed that this is the first assessment along the central California coast to examine riparian vegetation in detail as a component of fisheries habitat.

After the flooding of January, 1982, and additional high flows in 1983, Steven Singer and Mitchell Swanson prepared a Soquel Creek Storm Damage Recovery Plan for the U.S. Soil Conservation Service. The purpose of their stream survey was fourfold:

- To identify present and potential sources of large woody debris and sediment;
- To map areas where significant bank erosion, landslides and log jams occurred during the high flows of 1982/1983;
- To record evidence of flood flow stream behavior; and
- To assess overall stream conditions including the impact of human activities on stream behavior.

The Singer and Swanson survey covered much the same stream reaches as the current vegetation study. It did not specifically assess the condition of the riparian vegetation; however, the survey found that the presence of riparian vegetation (Alders, Willows, Cottonwoods, etc.) on stream banks and meander points does not increase the risk of log jam formation. On the contrary, it acts to reduce the number of floating logs in two ways: 1) by filtering out logs when high flows cut across vegetated meander points, and 2) by protecting banks from erosion (p. 35). Singer and Swanson described an important distinction between logs as hazards and logs as habitat, and recommended that stream clearance work be coordinated with fish habitat improvement work.

In 1999, Northwest Hydraulic Consultants, Inc. prepared a Soquel Creek Stream Analysis for Soquel Drive Bridge. Its focus was the analysis of bridge replacement alternatives within the context of geomorphological and hydraulic conditions in the vicinity of Soquel Village. While it noted the importance of vegetation in protecting banks from erosion, it did not assess vegetation per se.

In 2000, Jones & Stokes prepared the Santa Ynez River Vegetation Monitoring Study, Santa Barbara County, California for a consortium of local, state and federal agencies. The purpose of this study was to determine whether the operation of the Cachuma Project, completed in 1956, had affected the extent and condition of riparian vegetation along 50 miles of river between Bradbury Dam and the Pacific Ocean, focusing in particular on the effects of operations related to releases for downstream water rights during the low-flow season. The study method consisted of analysis of pre- and post-project aerial photos, combined with ground-truthing along selected transects to determine mapping accuracy, identify vegetation types with questionable photographic signatures, and modify the mapped polygons as necessary. The area of increase or decrease in each vegetation type was then calculated. In most areas riparian vegetation
increased, possibly as a result of fish flow releases, although it decreased in some locations. Decreases immediately downstream of the dam were related to the presence of the dam; other decreases were attributed to instream aggregate mining and drought.

For the Santa Ynez River study, a riparian habitat classification system was developed to facilitate analysis of the vegetation using aerial photos. This classification system was not available at the beginning of the Soquel Creek field work, and few of the riparian habitats are common to both streams; however, the concept of this approach could be useful for future monitoring as the quality of available aerial photos continues to improve. While two-dimensional map analysis cannot take the place of on-the-ground data collection in three dimensions, it may help target where to focus the field work.

In 2002, Balance Hydrologics, Inc., in association with D.W. Alley and Associates, Coastal Watershed Council and Toni Danzig, prepared the Arana Gulch Watershed Enhancement Plan Phase 1: Steelhead and Sediment Assessment, Santa Cruz County, California. As its title implies, this study focused on instream features of steelhead habitat. The vegetation of the stream corridor was not targeted for specific study because the canopy was relatively continuous over a narrow stream corridor, and shade was not a limiting factor for steelhead.

Also in 2002, Alley, Dvorsky and Smith prepared the Draft Fisheries Enhancement Strategy for the San Lorenzo River, for Santa Cruz County’s Planning and Environmental Health Departments. While it did not study the vegetative cover in detail, it identified segments of the San Lorenzo River system where there were significant gaps in the riparian canopy, totaling 4.8% of the length of the river and its tributaries.

HISTORICAL DESCRIPTIONS OF SOQUEL CREEK

The earliest written descriptions of Soquel Creek were reviewed, along with early photographs, a map from 1853, historical anthologies, and a video of 150 years of Soquel history (Lydon, 2002). Additional information was obtained through conversations with local historians Geoffrey Dunn, Sandy Lydon, Frank Perry, and Richard Nutter. Relevant portions of the resulting information are contained in Section 2.2 of the assessment text.

HYDROLOGICAL REQUIREMENTS FOR ESTABLISHMENT OF RIPARIAN TREES

Approximately twenty recent papers publishing the results of research on the subject of the hydrological requirements for establishment of riparian trees were reviewed. Those that contained pertinent information are cited in Section 5.2.2 of the text.
INFORMATION RECORDED IN EACH OF THE 60 FULL DATA SETS

At each of the 60 transects, general data were recorded as follows:

- Date
- Time
- Transect number
- Reach, using the reach designations from Don Alley’s prior fisheries work
- General location
- GPS coordinates, from Magellan GPS Blazer 12 Satellite Navigator. Few of these aligned with the location of the creek on the USGS 1994 (Soquel) and 1996 (Laurel) topographic quadrangles.
- Stream order, determined from the USGS topographic maps per the California Department of Fish and Game’s California Salmonid Stream Habitat Restoration Manual
- Weather conditions
- Initials of data collectors: SES = Suzanne Schettler, JC = Josh Cohen
- Compass direction of the stream flow
- Compass direction of major canopy gaps
- Wetted channel width
- Wetted channel depth, both average and maximum
- Dominant height of trees in the band extending 25’ upstream to 25’ downstream from the 1,000 foot mark along each bank, with dominant species noted
- Width of the riparian canopy on each bank, consisting of species identified in the Santa Cruz County Riparian Corridor Protection Ordinance: Cottonwoods, Alders, Sycamores, Box Elders, Creek Dogwoods and Willows

The cross-section was sketched (not to scale) and each bank was given a brief verbal description (gentle slope, steep slope, terrace, bluff).

Notes and photographs were made of significant features (e.g., significant erosion areas, presence of Redwood stumps in the downstream reaches) on or between the transects. Each transect was mapped on the USGS topographic quadrangle, and labeled flagging tape was tied at the transect location.

Certain environmental parameters were assigned a numerical score or rank, in some cases converting qualitative information to quantitative values, to facilitate comparisons from site to site. The scoring system is shown on the following page.
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SCORE AND CRITERION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of channel (toe of bank to toe of bank)</td>
<td>4 POINTS 3 POINTS 2 POINTS 1 POINT 0</td>
</tr>
<tr>
<td>&lt;20 feet</td>
<td>20-29 feet</td>
</tr>
<tr>
<td>20-29 feet</td>
<td>30-39 feet</td>
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<tr>
<td>30-39 feet</td>
<td>40-49 feet</td>
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<tr>
<td>40-49 feet</td>
<td>50+ feet</td>
</tr>
<tr>
<td>Width of channel (toe to toe) not covered by tree/shrub canopy</td>
<td>&lt;20% of total width 20-39% 40-59% 60-79% &gt;80%</td>
</tr>
<tr>
<td>Canopy closure at center of low-flow channel (average of u/s, d/s, left bank)</td>
<td>80+% 60-79% 40-59% 20-39% &lt;20%</td>
</tr>
<tr>
<td>Angle of typical canopy, 25’ u/s to 25’ d/s from 1,000-foot point, viewed from low-flow channel</td>
<td>80° 60-79° 40-59° 20-39° &lt;20°</td>
</tr>
<tr>
<td>Dominant vegetation on left bank</td>
<td>shrubs trees grass/forbs bedrock &lt;50% of streambank is vegetated &amp; dominant material is soil or anthropogenic materials</td>
</tr>
<tr>
<td>Dominant vegetation on right bank</td>
<td>shrubs trees grass/forbs bedrock &lt;50% of streambank is vegetated &amp; dominant material is soil or anthropogenic materials</td>
</tr>
<tr>
<td>Invasive species in canopy, left bank</td>
<td>absent sparse common abundant dominant</td>
</tr>
<tr>
<td>Invasive species in canopy, right bank</td>
<td>absent sparse common abundant dominant</td>
</tr>
<tr>
<td>Invasive species in understory, left bank</td>
<td>absent sparse common abundant dominant</td>
</tr>
<tr>
<td>Invasive species in understory, right bank</td>
<td>absent sparse common abundant dominant</td>
</tr>
<tr>
<td>Disturbance</td>
<td>none evident &amp; invasive spp. absent none evident &amp; invasive spp. present light moderate heavy</td>
</tr>
<tr>
<td>Water temperature</td>
<td>&lt;62°F 62-64°F 65-67°F 68-70°F &gt;70°F</td>
</tr>
</tbody>
</table>

At the recommendation of the Technical Advisory Team, water temperature was deleted from the scoring system, because the temperatures were recorded at different times and locations.
The fisheries assessment independently analyzed water temperature data collected by ten continuous temperature recorders from late May to early October, 2001; those data are referred to in the text of this assessment.

Scores were recorded for each parameter by placing the actual measurement or word in the appropriate column, rather than a check mark or “X”. Scores were summed for each column and then for the transect. A hypothetical perfect score would have all 13 entries in the four-point column, for a total of 52 points.

Although a chart of the composite scores confirmed a general trend of improved habitat quality with progression upstream, at the request of the funders the scores were not included in the assessment report.

A forest inventory was conducted at each transect. A 60-foot-radius circular plot was laid out with half of the plot on each bank, using a tape measure and a Bushnell Ranging Rangefinder to determine which trees were within the circular plot. Every tree greater than 6” in diameter at breast height (DBH) was inventoried as to size and species. Sizes were identified using a combination of a Biltmore stick and ocular estimation. Trees on the left and right banks (facing downstream) were recorded separately.

**INFORMATION RECORDED IN EACH OF THE 75 SMALLER DATA SETS**

A smaller data set was recorded midway between the transects, plus four on each of the sampled tributaries. This data set included:

- Water temperature
- Air temperature
- Time
- Estimated riparian canopy width on each bank
- Canopy closure measured in the low-flow channel, averaged upstream and downstream
- Wetted channel width, dry channel width and total

The data forms were reviewed by the fisheries and geomorphic consultants before the field work began, and some of the data were collected to supplement their work.

Copies of the data sheets and the topographic maps showing the locations of the transects are housed at the Monterey office of the California Department of Fish and Game.
<table>
<thead>
<tr>
<th>NAME</th>
<th>VEGETATIVE PROBLEMS</th>
<th>CHEMISTRY</th>
<th>HABITAT PROBLEMS</th>
<th>EROSION</th>
<th>HYDROLOGY</th>
<th>ECOSYSTEM PROBLEMS</th>
<th>HAZARDS TO HUMANS</th>
<th>AESTHETIK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periwinkle (Vinca major)</td>
<td>Dense cover prevents establishment and growth of other plant species. Lowers species diversity and disrupts native plant communities</td>
<td>Contains alkaloids that may be harmful to wildlife</td>
<td>Can suppress natural erosional processes in a creek, promoting deepening and scouring of the creek bed and altering local hydrology and vegetation</td>
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<td>Sources: Bossard, 2000; Taylor and Farnsworth, 1973</td>
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<td>French Broom (Genista monspessulana)</td>
<td>Displaces native plant and forage species. Can form monospecific stands, displacing whole natural communities. Grows more rapidly than most trees used in forestry, and shades out tree seedlings in revegetation areas.</td>
<td>Foliage and seeds contain a variety of quinolizidine alkaloids. Can cause digestive disorders and paralysis in livestock.</td>
<td>Degrades wildlife value by displacing native forage species and changing microclimate conditions at soil levels. French Broom is believed to be responsible for reducing arthropod populations by one-third in Golden Gate National Recreation Area.</td>
<td>Burns readily and carries fire to the tree canopy, increasing the frequency and intensity of fires. Fixes nitrogen and alters nutrient cycling.</td>
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<td>Source: Bossard, 2000</td>
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<tr>
<td>Cape Ivy (Delairea odorata)</td>
<td>Climbs over other vegetation and shades it out. Its heavy weight sometimes causes trees to fall. Species richness of native plants decreases</td>
<td>Contains pyrrolizidine alkaloids and xanthones that make it unsuitable forage for most fauna. Preliminary research has</td>
<td>By reducing plant species diversity and altering vegetation structure, it may reduce normal rates of riparian nutrient cycling. When</td>
<td>Shallow root system can contribute to soil erosion problems.</td>
<td></td>
<td>Cape Ivy is associated with significant reduction in abundance of two insect orders (Coleoptera [beetles], and Diptera [flies], and</td>
<td>Causes more diverse and interesting flora to disappear. Its odor is offensive to some people</td>
<td></td>
</tr>
<tr>
<td>Source: Alvarez, 1997; Bossard, 2000, Chipping, 2002</td>
<td>50 to 95% in areas containing Cape Ivy; impact is greatest on annual species.</td>
<td>shown Cape Ivy floating on water surface can be lethal to fish. Pyrrolizidine alkaloids from a related species (<em>Senecio jacobea</em>) resulted in growth depression, mortality, and liver damage to rainbow trout.</td>
<td>monospecific, renders habitat worthless for plants and animals.</td>
<td>gnats and midges) which could affect other species dependent on these insects, including fish.</td>
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<tr>
<td>English Ivy (<em>Hedera helix</em>)</td>
<td>Outcompetes other vegetation, forming &quot;ivy deserts&quot;. Inhibits regeneration of understory plants, including forest wildflowers and new trees; may jeopardize long-term persistence of the forest. Kills trees in understory and overstory by shading them out. Preferentially climbs toward the sun in deciduous trees during winter while they are leafless, then shades out foliage in summer and weakens the tree that supports it.</td>
<td>May replace species used by native wildlife. Its leaf litter adds nitrogen to the soil, possibly a disadvantage to native species that thrive under low nutrient levels.</td>
<td>Causes more diverse and interesting flora to disappear.</td>
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<td>Source: Bossard, 2000</td>
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<tr>
<td>Giant Reed (<em>Arundo donax</em>)</td>
<td>Massive stands displace native plants and associated wildlife</td>
<td>Reduces habitat and food supply, particularly insect populations.</td>
<td>Can promote bank erosion because its shallow root Giant Reed is suspected of altering hydrological Dense growth significantly increases the available fuel for Giant Reed is highly flammable, and fire renews its</td>
<td>Causes more diverse and interesting flora to disappear.</td>
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<tr>
<td>Species</td>
<td>Effects</td>
<td>Source</td>
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<tr>
<td>Green Wattle Acacia (Acacia dealbata)</td>
<td>Provides little shading to in-stream habitat, leading to increased water temperatures and reduced habitat quality for aquatic wildlife.</td>
<td>Bossard, 2000</td>
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<td>Musts out smaller and/or slower-growing plants. Fallen pod and leaf mulch smothers less aggressive vegetation.</td>
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<td>Reduces menu of available forage for wildlife. Seldom exceeds 30-40 feet in height, therefore provides limited amount of shade over the water.</td>
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<td></td>
<td>Greedy root system robs soil moisture.</td>
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<td>By fixing nitrogen, Acacias create a disadvantage for native species that thrive on low nutrient levels.</td>
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<td>Acacias are weak-wooded trees that often fall over.</td>
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<td>Uprooted plants create hazards when trapped behind bridges and other structures.</td>
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<td>Blue Gum (Eucalyptus globulus)</td>
<td>Displaces native vegetation by producing abundant root sprouts which form thickets of considerable area. A high degree of shade tolerance gives Tree of Heaven a competitive edge over other plant species.</td>
<td>Bossard, 2000</td>
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<td>Produces allelopathic chemicals that may contribute to displacement of native vegetation.</td>
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<td>In California its most significant displacement of native vegetation is in riparian zones.</td>
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<td>Toxic phenolic compounds and terpenes inhibit growth of most other species.</td>
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<td>Inhibits the coexistence of most other plant species and the life forms which depend on</td>
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<td>Its large amounts of litter and volatile oils make it one of the most flammable forest.</td>
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<td>Stringy bark is carried away while burning, making eucalyptus.</td>
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<td>Its stature and growth form are distinct and unlike native trees.</td>
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<td>Sources: Bossard, 2000; Greening Associates, 1995; Wildlands Restoration Team, 1998</td>
<td>native species for water. The high volumes of forest debris consisting of bark strips, limbs and branches form a physical barrier that inhibits establishment of other plants.</td>
<td>them.</td>
<td>fuels.</td>
<td>forests the worst in the world for spreading spot fires. Eucalyptus can drop large limbs without warning.</td>
<td>species, which compromises the visual quality of natural landscapes.</td>
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<td>Pampas Grass / Jubata Grass <em>(Cortaderia jubata)</em></td>
<td>Reproduces aggressively to produce large stands; each plume can produce hundreds of thousands of seeds. Reduces native plant diversity. Suppresses re-establishment of seedling conifers.</td>
<td>Reduces habitat value and forage for wildlife.</td>
<td>Creates fire hazard with excessive build-up of dry leaves, leaf bases, and flowering stalks.</td>
<td>The sawtoothed leaves can cause injury to humans. Large clumps can complicate fire management activities by blocking vehicle and human access.</td>
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</table>
APPENDIX V-4

TREE SIZE CLASSES BY TRANSECT

IN ALPHABETICAL ORDER BY COMMON NAME: DECIDUOUS SPECIES THEN EVERGREENS
Alder Size Classes
East Branch, West Branch and Tributaries
Soquel Creek

<table>
<thead>
<tr>
<th>Transect I.D.</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 - 36</td>
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<td>37 - 38</td>
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<td>39 - 40</td>
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<td>41 - 42</td>
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<td>55 - 56</td>
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</tr>
</tbody>
</table>

- 6 - 9 inches DBH
- 10 - 19 inches DBH
- 20 - 29 inches DBH
- >29 inches DBH
COTTONWOOD SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.

Abundance

6 - 9 inches DBH  10 - 19 inches DBH  20 - 29 inches DBH  >29 inches

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
6 - 9 inches DBH
MAPLE SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.

Abundance

6 - 9 inches DBH
10 - 19 inches DBH
20 - 29 inches DBH
MAPLE SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Abundance

Transect I.D.

☐ 6 - 9 inches DBH  ☐ 10 - 19 inches DBH  ☐ 20 - 29 inches DBH
PLUM SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Abundance

6 - 9 inches DBH
SYCAMORE SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.

Abundance

10 - 19 inches DBH
20 - 29 inches DBH
>29 inches DBH
SYCAMORE SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Abundance

-10 - 19 inches DBH
TREE OF HEAVEN SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Abundance

6 - 9 inches DBH
WALNUT SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.

Abundance

☐ 6 - 9 inches DBH  ☐ 10 - 19 inches DBH  ☐ >29 inches DBH
BAY SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.  

Abundance

6 - 9 inches DBH  
10 - 19 inches DBH  
20 - 29 inches DBH  
>29 inches

Transect I.D.
BAY SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Transect I.D.

Abundance

6 - 9 inches DBH  10 - 19 inches DBH  20 - 29 inches DBH  >29 inches
DOUGLAS-FIR SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Transect I.D. vs. Abundance

- 6 - 9 inches DBH
- 10 - 19 inches DBH
- 20 - 29 inches DBH
- >29 inches DBH
EUCALYPTUS SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Abundance

10 - 19 inches DBH
EUCALYPTUS SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

![Graph showing Eucalyptus size classes with Transect I.D. on the x-axis and Abundance on the y-axis. The graph indicates the abundance of trees with 20-29 inches DBH.]
LIVE OAK SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Transect I.D.

Abundance

6 - 9 inches DBH  10 - 19 inches DBH  20 - 29 inches DBH  >29 inches
Privet Size Classes
Main Stem
Soquel Creek

Abundance

10 - 19 inches DBH
REDWOOD SIZE CLASSES
MAIN STEM
SOQUEL CREEK

Abundance

 Transect I.D.

6 - 9 inches DBH  10 - 19 inches DBH  20 - 29 inches DBH  >29 inches DBH
REDWOOD SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Abundance

Transect I.D.

6 - 9 inches DBH
10 - 19 inches DBH
20 - 29 inches DBH
>29 inches DBH
TAN OAK SIZE CLASSES
EAST BRANCH, WEST BRANCH AND TRIBUTARIES
SOQUEL CREEK

Transect I.D.

Abundance

6 - 9 inches DBH
10 - 19 inches DBH
20 - 29 inches DBH
TREE SPECIES COMPOSITION

TRANSECT NO. 9

TRANSECT NO. 10

TRANSECT NO. 11

TRANSECT NO. 12

60' RADIUS SPILL PLAT: LEFT AND RIGHT BANK
TREE SPECIES COMPOSITION
60' RADIUS SPLIT PLOT, LEFT AND RIGHT BANK
TREE SPECIES COMPOSITION

60' RADIUS SPLIT PLOT, LEFT AND RIGHT BANK

TRANSECT NO. 24

TRANSECT NO. 23

TRANSECT NO. 22

TRANSECT NO. 21

TRANSECT NO. 20

TRANSECT NO. 19
TREE SPECIES COMPOSITION

60' RADIUS SPLITT PLOT, LEFT AND RIGHT BANK

TRANSECT NO. 36

TRANSECT NO. 35

TRANSECT NO. 34

TRANSECT NO. 33

TRANSECT NO. 32

TRANSECT NO. 31
TREE SPECIES COMPOSITION

60' Radius Split Plot, Left and Right Bank

TRANSECT NO. 42

TRANSECT NO. 41

TRANSECT NO. 40

TRANSECT NO. 39

TRANSECT NO. 38

TRANSECT NO. 37
TREE SPECIES COMPOSITION

60' RADIALS SPILL PLOT, LEFT AND RIGHT BANK

TRANSECT NO. 48

TRANSECT NO. 47

TRANSECT NO. 46

TRANSECT NO. 45

TRANSECT NO. 44

TRANSECT NO. 43
TREE SPECIES COMPOSITION
60' RADIUS SPLIT PLOT, LEFT AND RIGHT BANK

TRANSECT NO. 55

TRANSECT NO. 56

TRANSECT NO. 57

TRANSECT NO. 58

TRANSECT NO. 59

TRANSECT NO. 60
## NATIVE PLANT SPECIES DISCUSSED IN TEXT

### TREES

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>BOTANICAL NAME</th>
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<tbody>
<tr>
<td>Big-leaf Maple</td>
<td><em>Acer macrophyllum</em></td>
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<tr>
<td>Box Elder</td>
<td><em>Acer negundo</em></td>
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<tr>
<td>Alder (White Alder)</td>
<td><em>Alnus rhombifolia</em></td>
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<tr>
<td>Tanoak</td>
<td><em>Lithocarpus densiflora</em></td>
</tr>
<tr>
<td>Sycamore (California Sycamore)</td>
<td><em>Platanus racemosa</em></td>
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<tr>
<td>Cottonwood (Black Cottonwood)</td>
<td><em>Populus balsamifera ssp. trichocarpa</em></td>
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<tr>
<td>Douglas-fir</td>
<td><em>Pseudotsuga menziesii</em></td>
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<tr>
<td>Live Oak</td>
<td><em>Quercus agrifolia, Q. wislizenii and hybrids</em></td>
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<tr>
<td>Willows</td>
<td><em>Salix spp.</em></td>
</tr>
<tr>
<td>Redwood (Coast Redwood)</td>
<td><em>Sequoia sempervirens</em></td>
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<tr>
<td>Bay</td>
<td><em>Umbellularia californica</em></td>
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### SHRUBS

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>BOTANICAL NAME</th>
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<tbody>
<tr>
<td>Creek Dogwood</td>
<td><em>Cornus sericea ssp. occidentalis</em></td>
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<tr>
<td>Willows</td>
<td><em>Salix spp.</em></td>
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<tr>
<td>California Raspberry</td>
<td><em>Rubus leucodermis</em></td>
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<tr>
<td>California Blackberry</td>
<td><em>Rubus ursinus</em></td>
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</table>

PHOTO 1. Bend shown in Figure G-15 of Geomorphology Report, at vegetation transect 11, looking downstream. March 6, 2000.

PHOTO 2. Same location, viewed a few yards downstream from Transect 11 on September 19, 2001. During two growing seasons, Willows and Alders have rapidly colonized the mid-channel bar and the toe of the bank on the outside bend.
PHOTO 3. A closer view of the outside bend shown in Photos 1 and 2, looking upstream. The larger two clumps of Alders are the ones in the center of Photo 2, and willows are colonizing the toe of the bank and the bar. September 19, 2001.
PHOTOS 4 (ABOVE) AND 5 (BELOW). Two views of the straightaway downstream of the bend illustrated in Photos 1-3. Both are looking downstream, and Photo 5 is the farther downstream. Both illustrate that natural regeneration is actively occurring after only two growing seasons and that the left bank is quite steep, with few mature trees on the terrace. September 19, 2001.
PHOTO 6. Giant Reed (*Arundo donax*) forms impenetrable thickets that are difficult to photograph.

PHOTO 7. Every node along a branch of Giant Reed can produce new plants that break away during storm flows to establish new colonies.
PHOTO 8. The weight of English Ivy (*Hedera helix*) can be relieved from the canopy of a tree by simply cutting away a band of its climbing root, and the Ivy top then withers. Care must be taken not to damage the bark of the tree. Since fruits of Ivy are produced only in its aerial portions, this procedure has the added benefit of removing a source of seed that would produce future Ivy plants. The non-fruiting groundcover portion must still be dealt with because it smothers seedlings of riparian forest species.