Figure 4.20
Percentage of observed hydric soils outside of stream channel for the three subclasses

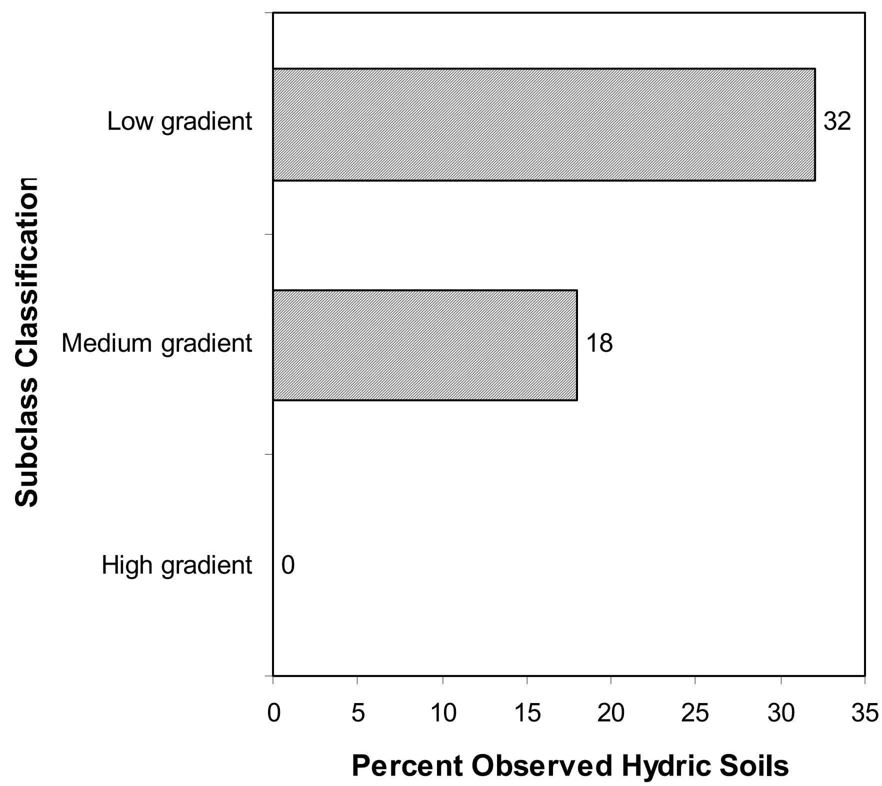
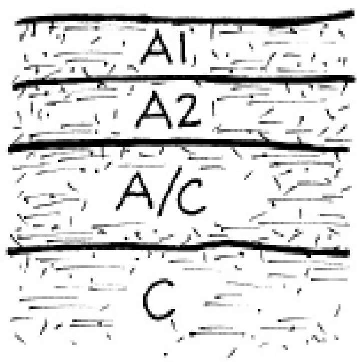


Figure 4.21 Representative soil profiles within the Low gradient subclass

Aqueda Series
Example of well drained soils in valleys

Slope: 0-15%   Elevation: 50-500 feet above mean sea level



PROFILE	TEXTURE	MUNSELL COLOR
A1	silty clay loam	very dark gray, 10YR 3/1
A2	silty clay loam	very dark gray, 10YR 3/1
A/C	silty clay loam	very dark gray, 10YR 3/1 and dark brown, 10YR 3/3
C	clay loam	dark brown, 10YR 3/3

Aquepts Series
Example of newly level soil periodically inundated by tides

Slope: 0-4%   Elevation: tidally influenced

PROFILE	TEXTURE AND COLOR
"Highly stratified thin layers of coarse textured soil material and occasional layers of peat." (Shipman et al., 1981)	Texture and color very variable.

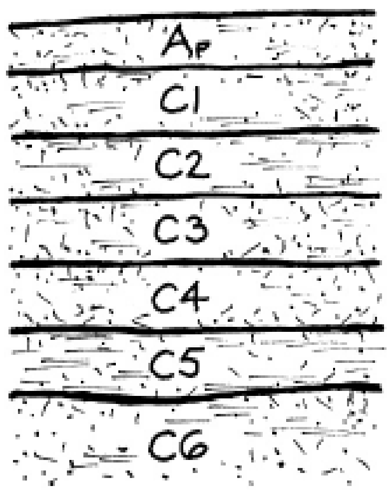
Botella Series
Example of well drained soils on alluvial fans and in small valleys

See **Figure 4.18 Representative soil profiles within the Moderate gradient subclass** for a description.

Figure 4.21
Representative soil profiles within the Low gradient subclass (cont.)

Camarillo Series
Example of poorly drained soils on floodplains

Slope: 0-2%   Elevation: 10-50 feet above mean sea level



PROFILE	TEXTURE	MUNSELL COLOR
Ap	fine sandy loam	brown, 10YR 4/3
C1	fine sandy loam	brown, 10YR 4/3
C2	loam	dark brown, 10YR 3/3
C3	loamy sand	yellowish brown, 10YR 5/4
C4	sandy loam	brown, 10YR 4/3
C5	clay loam	brown, 10YR 4/3
C6	loamy sand	brown, 10YR 4/3

Eldar Series
Example of soils on alluvial fans and narow valleys

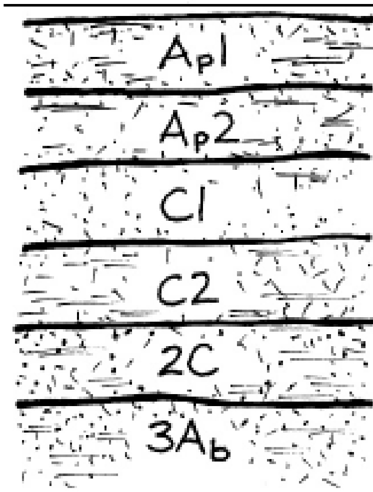
See **Figure 4.18 Representative soil profiles within the Moderate gradient subclass** for a description.

Figure 4.21
Representative soil profiles within the Low gradient subclass (cont.)

Goleta Series
Example of well drained soils on floodplains and alluvial fans

Slope: 0-9% Elevation: 25-500 feet above mean sea level

PROFILE



TEXTURE	MUNSELL COLOR
fine sandy loam	very dark grayish brown, 10YR 3/2
fine sandy loam	very dark grayish brown, 10YR 3/2
mixed fine sandy loam	dark brown, 10YR 4/3
loam	dark brown, 10YR 4/3
loamy sand	yellowish brown, 10YR 5/4
fine sandy loam	dark brown, 10YR 3/3

(NATURALLY BURIED HORIZON)

Fire can affect soil physical and biogeochemical properties by destroying surface vegetation, root biomass, and oxidizing soil organic carbon. Destruction of soil biomass on low gradient surfaces can (1) increase erosion hazard, (2) diminish the moisture holding capacity of the soil, (3) impact infiltration rates, (4) impact soil structure, and (7) increase surface runoff.

Seismic activity can affect soil physical and biogeochemical properties on low gradient surfaces by (1) drastically altering soil drainage patterns, (2) altering stream channel geometry and drainage patterns, and (3) depending upon moisture content and soil texture, drastically altering soil structure and pore size distribution by the process of soil liquification (*i.e.,* causing the soil to behave as a fluid with profound changes in the size, shape, and total volume of soil voids, as well as complete loss of soil structural integrity).

Flooding can affect soil physical and biogeochemical processes differently, dependent upon nature of the surface (*i.e.,* depositional surfaces which receive lower energy water verses erosional surfaces which flood with higher energy water). Flooding of depositional surfaces can affect soil physical and biogeochemical processes by depositing layers of fresh alluvium that can (1) bury surface horizons, (2) alter soil drainage patterns, (3) alter infiltration rates, (4) disturb vegetation communities, (5) alter soil aeration, (6) alter soil moisture holding capacity, (7) input additional nutrients, and (8) alter land use capability classes.

Flooding of erosional surfaces can affect soil physical and biogeochemical processes by creating scour that can (1) remove vegetation, (2) remove soil surface and subsurface horizons, (3) diminish soil organic matter content, (4) alter soil drainage patterns, (5) alter infiltration rates, (6) alter soil aeration, (7) alter soil moisture holding capacity, (8) remove nutrients, and (9) alter land use capability classes.

Anthropogenic perturbations to soil within the Low gradient subclass are primarily clearing and grading operations related to development, the creation of impervious surfaces (engineered hardened surfaces and structures) related to development and flood control, and activities associated with agriculture. Clearing and grading operations can affect soil physical and biogeochemical properties by (1) removing or burying organic rich topsoil, (2) removing or burying surface vegetation, (3) removing nutrients, and (4) causing soil compaction that increases erosion hazard, diminishes infiltration rates, and increases surface runoff due to destruction of soil structure and alteration of the pore size distribution. Activities related to agriculture (tillage and traffic) can affect soil physical and biogeochemical properties within the Low gradient subclass by disturbance and compaction of the soil surface horizon, which results in (1) oxidation and loss of soil organic carbon, (2) diminished soil structure, (3) decreased infiltration rates, (4) increased erosion hazard, (5) decreased soil moisture storage capacity, and (6) decreased soil aeration.

The creation of impervious surfaces related to development and/or flood control can have the most profound effects on soil and riparian physical and biogeochemical processes. Impervious surfaces (and their associated fill materials) can (1) completely disengage the stream from its floodplain, riparian ecosystem, and channel bed, (2) eliminate infiltration, (3) eliminate, or drastically alter, the riparian ecosystem, (4) drastically change sediment delivery and/or retention to floodplain surfaces, (5) irreversibly cover the soil surface thereby eliminating processes and functions related to, and facilitated by, soil moisture, structure, aeration, organic carbon, and microbial and plant communities.

4.9 Vegetation

4.9.1 Introduction

Plant communities along the streams of the central coast of California support a dynamic complement of native trees and other woody species, many of which can and do occur outside the riparian corridor. Perhaps the most conspicuous feature of the mature, native riparian vegetation within the southern portion of California's central coast is the dominance of large Coast live oaks (*Quercus agrifolia*) (Figure 4.22). Stands of live oak range in density from woodland (*i.e.*, individual tree canopies do not interdigitate) to forest (*i.e.*, tree canopies overlap). These stands occur along stream terraces in the upper and middle reaches of the moderately-sized riverine systems. In the less disturbed stream reaches of this geographic region, large oaks are joined by White alder (*Alnus rhombifolia*) and Western sycamore (*Platanus racemosa*) as dominants, particularly immediately adjacent to the stream channel.

In addition to these tree species, the riparian plant communities, *i.e.*, vegetation adjacent to, and influenced by the presence of moving water, a small suite of native shrubs and vines is found in the understory. Poison oak (*Toxicodendron diversiloba*) is ubiquitous, as is California blackberry (*Rubus ursinus*). Less common, but still frequently occurring in the shrub layer, are several species of gooseberry (*Ribes* spp.) and honeysuckle (*Lonicera* spp.). These taxa are critically important food sources for the native fauna, providing a varied and abundant source of berries throughout much of the year.

As is the case throughout much of California, many of the riverine wetland systems of central and southern California, and the reference domain in particular, have been subjected to hydrologic modification. One important consequence of this modification has been the degradation, removal, and replacement of the native riparian plant community. For example, virtually no reference site was free from invasion by non-native species, even reference standard sites (*e.g.*, Site #49, Upper Arroyo Hondo). Further, a significant percentage of the reference sites was dominated by exotic species (42 % [25/60]), and a number of reference sites were completely devoid of native vegetation (*e.g.*, Site #5, San Jose Creek).

4.9.1.a.
General Discussion of the Geologic History of Riparian Forests within California as it Pertains to the Reference Domain

In 1980, Robichaux examined riparian forests in light of three general principles that have emerged from our understanding of the evolution of plant communities in California. In short, he suggested that the state's riparian forests of California illustrate three floristic phenomena:

1. Modern plant communities [in California] . . . are composed of taxa of diverse floristic sources. Two principal floristic elements are a southern "Madro-Tertiary" element that includes species in such genera as *Arbutus, Arctostaphylos, Ceonothus, Cercocarpus, Cupressus, Quercus*, and *Umbellularia*, and a northern "Arcto-Tertiary" element that includes species in such genera as *Acer, Alnus, Castanopsis, Fraxinus, Picea, Quercus*, and *Sequoia*;
2. Modern plant communities [in California] are relatively impoverished representatives of richer, more generalized ancestral communities . . . ; and,
3. Some of the species that are associated within these modern communities have apparently been associated, as ancestral forms in fossil communities, throughout most of California's late Tertiary and Quarternary history, covering a time span of nearly 20 million years (Robichaux 1980:21).

Figure 4.22
Photograph of dominant stand of Coastal live oaks (*Quercus agrifolia*) in Cañada del Coho Creek

With respect to the first principle, and within the context of the reference domain, the tree dominant *Alnus rhombifolia* represents the primary Arcto-Tertiary element of the geological flora, while *Platanus racemosa* and *Salix lasiolepis* represent the southern, Madro-Tertiary element. The species' individual responses to the onset of aridity during the later Tertiary (Axelrod 1968), as discussed by Robichaux (1980), reflect their geographic origins. For example, Western sycamore gradually became restricted from a wider geographic range throughout the western United States, to California and the adjacent regions of Mexico during the late Tertiary. However, both Arroyo willow and White alder apparently were able to adapt *in situ* to the cooler, drier, and less equable climatic regime, and both survived in a rather unmodified form. Interestingly, *Salix lasiolepis* expanded its range into British Columbia. There, its restriction to dry interior regions within the northern portions of its geographic range clearly reflects its southern origins (Robichaux 1980).

With respect to the second principle, fossil evidence from riparian regions throughout the state include modern taxa with late Tertiary fossils found in the western United States. These now "exotic" taxa slowly were eliminated from the region in response to the change in climate as well as a shift in the seasonal distribution of precipitation. Modern taxa from the eastern United States with fossil representatives that likely occupied the riparian and floodplain sites within the reference domain include Silver maple (*Acer saccharinum*), Shagbark hickory (*Carya ovata*), Sweetgum (*Liquidambar styraciflua*), Swamp red bay (*Persea borbonia*), Swamp white oak (*Quercus bicolor*), and Bald cypress (*Taxodium distichum*), among a variety of other taxa.

Finally, with respect to the final third principle, Robichaux argued that by the end of the early Pleistocene, the loss of the "exotic" species was complete, and that for southern California, the riparian woodland was "essentially modern in aspect", including *Acer* (*negundo*), *Cornus* (*californica*), *Platanus* (*racemosa*), *Populus* (*fremontii*), *Salix* (*laevigata*), and *Toxicodendron* (*diversiloba*) (Robichaux 1980: 28). Thus the dominants structuring riparian communities of the study region have been essentially invariant for at least 2.4 million years. Only within the last 300 years have the effects of human settlement drastically altered the composition and structure of the riparian ecosystems of the reference domain, and more broadly, the coastal regions of southern California.

4.9.2 *Classification of Riparian Wetlands Within the Reference Domain*

The classification of vegetation within the state of California has been a controversial endeavor since the first attempts to develop a framework sufficient to capture the rich diversity of vegetation within the Mediterranean regions of the state. As compared to other vegetated communities, waters/wetland systems, particularly those influenced by flowing water, can be particularly difficult to classify. This difficulty is due not only to California's intrinsic dynamics and diversity of vegetation, but also because of the many anthropogenic alterations to waters/wetlands systems throughout the study area (Holland and Keil 1989; Ferren *et al.* 1995, 1996b, c).

Early vegetation classification efforts in the state focused on upland communities (*e.g.*, U.S. Forest Service "Vegetation Type Map Survey of California"). Today this bias toward non-wetland vegetation persists in the description of the state's plant communities, even in the most recent statewide effort (*i.e.*, Sawyer and Keeler-Wolf 1995). As a consequence, few classification systems exist to describe the waters/wetland vegetation within the reference domain, and of these, none are completely appropriate for the scale of the analysis of wetland functions conducted by us for this study. The classification put forth in *The Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995) has been rejected herein because it is based on plant species composition, without consistent regard to hydrology or geomorphic setting. Its antecedent (Holland 1986) includes some categories of relevance, such as Southern Riparian Forests, Riparian Woodlands, and Riparian Scrub, but these categories of waters/wetland types are not of sufficient detail to capture the range of variation and suite of wetland vegetation functions documented throughout the study area. The HGM approach, developed initially by Brinson (1993), is the basis of this document and includes a fundamental classification step. But it is less a classification than it is a protocol for assessing wetland functions. Thus, while the HGM system requires the user to classify wetland ecosystems of interest, only seven, broadly circumscribed, wetland classes – depressional, riverine, mineral flats, peat flats, lacustrine fringe, estuarine fringe, and slope – are recognized. Using the Brinson approach, it is possible to recognize only one wetland class, generally with less than ten subclasses that are defined primarily by stream order and geomorphic surface.

Conversely, the wetland classification system developed by Ferren and his colleagues (1995, 1996a, b, c) is, at its lowest level in the hierarchy, of too great a detail to be congruent with the ecosystem level of assessment of wetland functions and hence, for the HGM models developed herein. Ferren *et al.* developed a classification system for wetlands within the watersheds of central and southern California, based upon a significantly modified version of the U.S. Fish and Wildlife Service's classification of wetlands and deepwater habitats (Cowardin *et al.* 1979). The Ferren *et al.* classification recognizes five major systems of wetlands and deepwater habitats (*i.e.*, marine, estuarine, riverine, lacustrine, and palustrine), and a near infinite number of wetland types thereafter, based upon water regime, water chemistry, geomorphic setting, and plant dominance types. At some intermediate level (*e.g.*, above dominance type but below subsystem), the Ferren system is perhaps most useful to illustrate the range of riverine wetland types (not ecosystem functions) within the SCSBC region.

Despite the lack of consensus on how to classify the vegetation and what types of waters/wetlands are present, riverine waters/wetlands (*sensu* Brinson 1993) are perhaps the most common waters/wetland type in central and southern California. According to the HGM classification, riverine waters/wetlands encompass all waters and wetlands influenced by riverine environment, including wetlands that may occur within the active channel, on the floodplain, and on the adjacent stream terraces that are subject to regular flooding. In contrast, the Ferren *et al.* riverine classification "…includes all wetlands . . . contained within a channel, with two exceptions (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ppt. Figure 4.23 illustrates both the limits and overlap of the HGM and Ferren *et al.* classification systems.

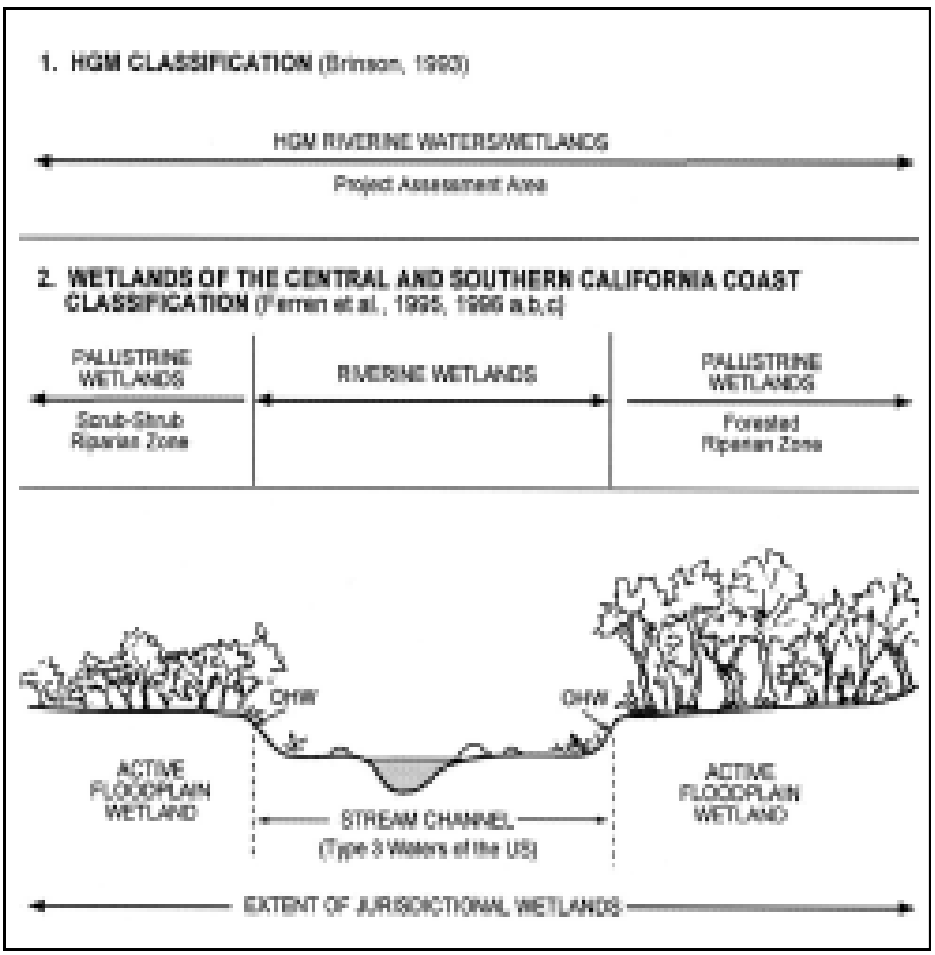


Figure 4.23
Wayne Ferren vs. HGM figure

The conclusion that riverine waters/wetlands are the most common type within the study area is not necessarily in conflict with the work of Ferren and his colleagues, in that the Ferren *et al.* classification for riverine wetlands is much less inclusive than the HGM classification. "Palustrine" wetland systems are the most common wetland type in the region according to Ferren *et al.*, as they are a large and heterogeneous class of wetlands. Palustrine systems (*sensu* Ferren *et al.* 1995, 1996b, c) share the following features (1) they are not influenced by oceanic tides (or if so, the salinity is less than 0.5 ppt), and (2) they are neither lakes nor rivers. Thus palustrine wetlands include wetlands generally known as pools, ponds, basins, and importantly, stream terraces, beaches, banks, and so forth.

Interestingly, natural lakes (lacustrine systems) are extremely scarce within central and southern California. Indeed, there are no natural lakes within the reference domain. Zaca Lake, a flooded caldera and a privately held resort, is the only permanently flooded, natural lake in Southern California. It lies immediately north of the reference domain boundary.

4.9.3 *General Description of the Riparian Communities in the Reference Domain*

As is the case for much of the native vegetation in the state, SCSBC riparian ecosystems have been dramatically degraded, with many of the dominant taxa now replaced by non-native species (*e.g.*, *Myoporum laetum*). Additionally, the lower reaches of many streams are now completely devoid of a native riparian ecosystem (Figure 4.24), consisting instead of a large suite of exotic Eurasian weeds (*e.g., Bromus diandrus, Carduus pycnocephalus*, *Melilotus officinale, Piptatherum miliaceum, Sonchus oleraceus*), ornamental escapes (*e.g., Senecio mikanioides, Tropaeoleum majus, Vinca major*), or a planted riparian corridor of nonnative trees (*e.g., Eucalyptus globulus*). Forty-five percent of the reference sites were dominated by exotic species, many in all strata.

A general descriptor for the reference standard complement of riparian community type for the high and medium gradient riverine classes in this study is "mixed evergreen/deciduous forest." This to say, the dominant tree species are represented by a suite of native tree species, some of which are broadleaf evergreen (*e.g.,* Coast live oak) and some of which are broadleaf deciduous (*e.g.,* Western sycamore). Mixed evergreen/deciduous forests are common throughout California, particularly the Coast Ranges and are found primarily within riparian environments. Upland forests between which the riparian zones interdigitate also are primarily mixed broadleaf evergreen in the coastal regions, and mixed needleleaf evergreen in the Sierra Nevada.

Species Composition

Western sycamore (*Platanus racemosa*; 51.7% frequency of occurrence), Coast live oak (*Quercus agrifolia*; 50.0%), and White alder (*Alnus rhombifolia*; 28.3%) are the three most commonly occurring tree species within the reference domain throughout the High, Medium and Low gradient subclasses. Coast live oak was less common on the low gradient coastal plain, while Western sycamore and White alder were found in consistent proportions throughout the study area. Arroyo willow (*Salix lasiolepis*; 28.3 % shrub form; 25% tree form), Red willow (*Salix laevigata*; 20%), Black cottonwood (*Populus balsamifera* subsp. *trichocarpa*; 20.0 %) and California bay (*Umbellularia californica*; 15%) also were commonly present throughout the High, Medium, and Low gradient subclasses. However, most of the willow species, particularly Arroyo willow and Red willow, were more common at the low gradient reference sites, and in general, replaced the live oaks in the corresponding subclass. These widespread willow species are common throughout much of coastal California, and, while often characteristic of early successional communities, can and will persist even when a later successional tree canopy has been established. Several exceptionally large and presumably old specimens of both Arroyo willow and Red willow were observed at Hollister Ranch. California bay is more often found upslope from the active channel along the steep riparian slopes grading upward toward the "top of bank." Large multi-stemmed bays were particularly common in the High gradient subclass, and rare if not completely absent from the low gradient sites.

The shrub layer in the riparian forests of the SCSBC is characterized by a predictable mix of native and non-native taxa. In order of frequency of occurrence, the most commonly occurring shrubs were castor bean (*Ricinus communis*; 33.3%), Elderberry (*Sambucus mexicana*; 31.7%), and Coyote bush (*Baccharis pilularis*; 30.0%). However, if one also considers suffrutescent taxa (*i.e.*, predominantly herbaceous, but forming a woody rootstock) in this stratum, then the native California mugwort (*Artemisia douglasiana*; 63.3%) is the most commonly occurring shrub.

Woody vines are remarkably common throughout the assessment area. Two very common species, both natives, include Poison oak (*Toxicodendron diversiloba*; 65.0% frequency of occurrence) and California blackberry (*Rubus ursinus*; 58.3%). Virgin's bower (*Clematis ligusticifolia*) is also frequent in occurrence (32.0%). However, quite common is a small complement of non-native vines and scrambling perennials, including Cape ivy (*Senecio mikanioides*; 30.0%), Garden nasturtium (*Tropaeoleum majus*; 23.3%) and Periwinkle (*Vinca major*; 16.6%).

Figure 4.24
Photograph of lower gradient stream devoid of native riparian vegetation - San Ysidro Creek

The herbaceous community throughout the reference domain is characterized by a few very widespread species, accompanied by a very large complement of taxa that occur in moderate frequency. Smilo grass (*Piptatherum miliaceum*), a Eurasian native, was the most commonly occurring species (70% frequency of occurrence) throughout the reference domain. The most commonly occurring native herb was Giant horsetail, *Equisetum telmateia* var. *braunii*, occurring at 52% of the sampling sites. Other commonly occurring to moderately frequently occurring herbaceous species include California mugwort (*Artemisia douglasiana*; 63%), Water bent grass (*Agrostis viridis*) (55.0%), Bristly ox tongue (*Picris echioides*; 51.7%), Common sow-thistle (*Sonchus oleraceus*; 48.3%), Ripgut (*Bromus diandrus*; 43.3%), California figwort (*Scrophularia californica*; 40.0%), Black mustard (*Brassica nigra*; 40.0%), and Cocklebur (*Xanthium strumarium*; 38.3%). Only two, Giant horsetail and California figwort, of the ten most commonly occurring herbs within the study region are native to California. A listing of the one hundred most frequently occurring species is found in Figure 4.25.

Figure 4.25
One hundred most frequently occurring species in reference domain.

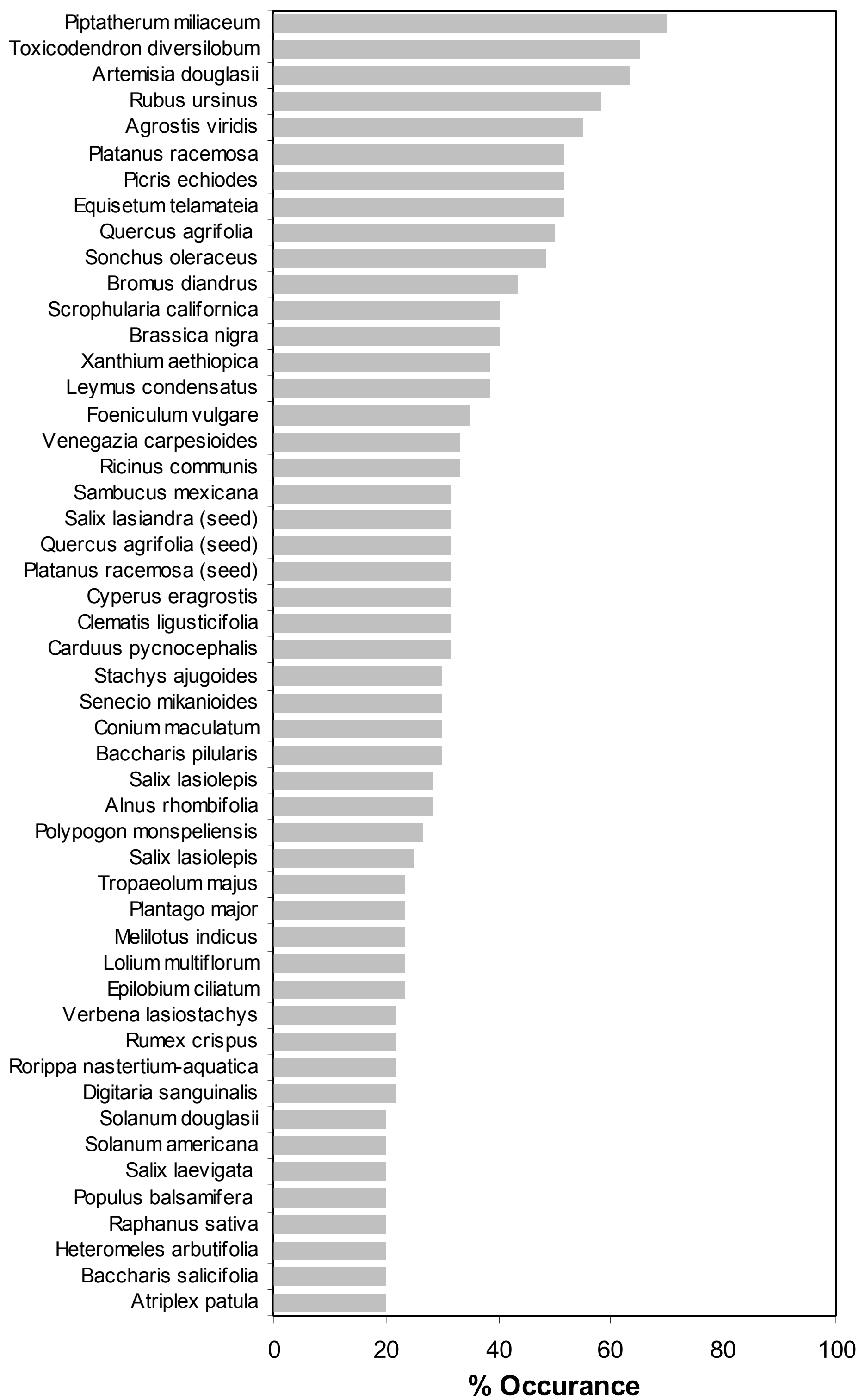
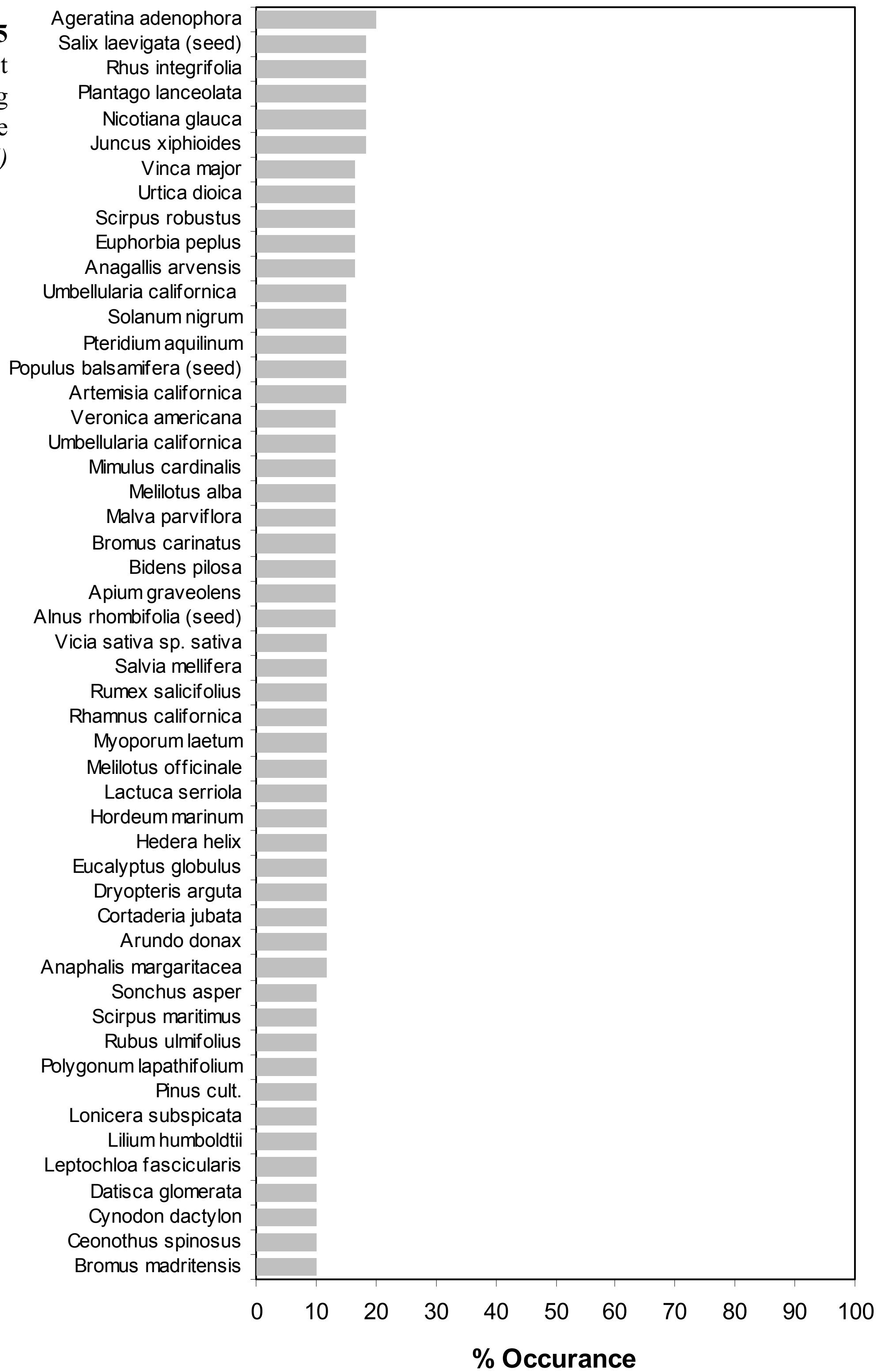


Figure 4.25 One hundred most frequently occurring species in reference domain. (*continued)*



Modes of Reproduction

Virtually all native as well as nonnative tree species encountered in the field reproduce only through sexual means, not having the ability to spread vegetatively. With the exception of the genus *Salix*, this is not usual for the woody riparian flora of California, particularly in the High and Medium gradient subclasses. In the lower reaches (*i.e.,* low gradient coastal plain), the dominant tree species are broadleaf deciduous, and are represented primarily by willows (Red willow [*Salix laevigata*], Arroyo willow [*S. lasiolepis*]). Willows regenerate by seed and by vegetative sprouting from dormant buds.

With respect to the woody plants of the forest and woodland understory, most of the taxa present reproduce sexually, and many of them produce berries, drupes, or aggregate fruit that, in combination with oak mast, are critical food sources for black bear (*Ursus americanus*) as well as the native avifauna. Such species include Poison oak, Gooseberry, California blackberry, and Honeysuckle. The herbaceous taxa within the riparian corridors of the reference domain reproduce both sexually and vegetatively. For example, Smilo grass reproduces by seed, California mugwort by seed and clonal growth from a woody rootstock, and Water bentgrass by seed, clonal growth, and fragmentation of plant parts that are carried down gradient by high stream flows. As a consequence of the multiple means of reproduction these taxa and a large number of other herbaceous species are widespread throughout the reference domain.

Species of Conservation Concern

The riparian communities within the SCSBC reference domain support only a few rare plant species or species of conservation concern. Humbolt lily (*Lilium ocellatum* ssp. *humboltii*) (Figure 4.26) is found occasionally in the High gradient subclass, and occurred in reference standard sites (*e.g.*, Site #49, Upper Arroyo Hondo). This monocot is a "watch species"/ List 4 for the California Native Plant Society's *Inventory* (Skinner and Pavlik 1994). Hoffman's nightshade (*Solanum xantii* var. *hoffmanii*) and Creek dogwood (*Cornus stolonifera* var. *californica*) are local endemics within the reference domain, and Giant vetch (*Vicia gigantea*) reaches its southern limit in the moist canyons at Hollister Ranch (Hendrickson *et al.*1998).

Community Structure

Throughout the reference domain and California in general, riparian habitats in the larger riverine systems are noteworthy for their closed canopy gallery forests and extensive vine (or liana) cover in the understory.

Figure 4.26
A rare Humbolt lily (*Lilium ocellatum ssp. humboltii*) found in the High gradient subclass.

In the High and Medium gradient subclasses within this reference domain, the floodplain and stream terrace geomorphic units are characterized by a woodland or forest of Coast live oak, with Western sycamore and White alder present as single individuals or small stands along the stream channel. Average tree canopy coverage is 45%, with an average basal area of approximately 60-65 ft^2/ac. Reference standard sites exhibit higher tree canopy coverage (63%) and higher basal area (70-100 ft^2/ac). Average tree height is approximately 50 ft (mean of 52.30, s.d. = 17.33; n = 60), with a reference standard average tree height of 68.6 ft (s.d. = 52.92; n = 4).

The vine stratum is the next most conspicuous layer, with an average percent cover of 35.16% (s.d. = 29.6; n = 60). Despite the high variation in the reference data, shrubs are, overall, a less prominent life form than vines in the riparian forests of the reference domain, with an average percent canopy cover of 18.1% (s.d. = 14.7; n = 60). Herbs exhibit the lowest percent canopy coverage (average percent cover of 28.5%, s.d. = 19.78; n = 60) of all life forms. Reference standard sites exhibited exceptionally low canopy coverage for shrubs (3.00, s.d. = 10.5; n = 4), but somewhat higher cover values for herbs (38, s.d. = 10.5; n = 4).

Because of the relative low canopy coverage for shrubs and the highly variable canopy cover for the herbaceous taxa, only two horizontal strata typically are present in the riparian plant communities of the study region. Sampling data indicates an average of 1.74 strata (s.d. = 0.52) for all reference sites, with an average of 2.15 (s.d. = 1.72) strata for reference standard sites. At many sites in the High, Medium and Low gradient subclasses, vines replace the herbaceous forest floor community, blanketing the ground as well as climbing into the tree canopy.

4.9.4 *Vegetation Dynamics*

Landscapes of the study region are dominated by chaparral, the Mediterranean vegetation characteristic of the California Floristic Province, particularly coastal California. The peculiar features of this vegetation (*e.g.*, flammability, allelopathy, "subclimax" successional patterns, complex evolutionary history, and unique species composition) have been studied for many decades (for a review, see Hanes 1988), and it is now reasonably clear that summer drought, fire, and flood cycles alone and in concert are responsible for the major chaparral patterns of vegetation. This is also true for the riparian vegetation embedded within the chaparral landscape. Therefore, to understand the wetland vegetation of the SCSBC, it is necessary to discuss briefly the role of fire in general in the southern California chaparral, and how it resets the vegetation within the large landscape for another cycle of secondary succession.

Patterns of Natural Disturbance – Fire

Much has been written about the ecosystem ecology and natural disturbance cycles in Mediterranean systems (see DiCastri and Mooney 1975, Arroyo *et al.* 1995). The role of fire has been studied most intensively (*e.g.*, DeBano *et al.* 1977, Keeley and Keeley 1986, 1988), but it is still only moderately well understood. The response of chaparral vegetation, specifically "hard" chaparral, to fire depends upon several factors, including, but not limited to, the type of fire (*e.g.*, "hot" or "cool" burn, fuel load, *etc.*), time since fire, rainfall patterns, and so forth. Generally, however, in the first year after a fire there is an explosion of growth from dormant seeds (*e.g.*, *Emmenanthe penduliflora*) and bulbs (*e.g.*, various taxa in *Calochortus, Brodiaea*, *Zigadenus*), as well as a robust growth spurt of long-lived herbaceous perennial taxa, such as larkspurs (*Delphinium* spp.). Also in the first year after fire, shrubs that perennate either by seed ("seeders") or by vegetative reproduction ("sprouters") begin to reestablish. Over a reasonably short period of time (≤10 years), the chaparral changes from a community dominated by fire-stimulated herbaceous species early in the fire cycle to a dense shrub cover. This mid-to-late successional shrub community is characterized by a sparse and species-poor herbaceous understory, persisting until another wildfire starts the vegetation cycle again. When the chaparral is undisturbed by fire for a long period of time, the shrubs eventually become decadent, evidenced by thickets of mostly dead branches and a thin layer of foliage on the shrubs' surface (Dallman 1998). Wildfires are particularly "destructive" when several years of drought follow several wet years in which abundant rainfall has induced the production of a large amount of fuel. An excellent summary of the Mediterranean vegetation found within the reference domain is found in Dallman (1998).

The cyclic nature of wildfires also has been well studied. Prior to human settlement, fires were started primarily by lightning strikes. However, Keeley (1977) has argued that today, fires are more likely to be ignited by human activities than by natural causes. Large, catastrophic wildfires (>24,000 ac) are likely the result of fire suppression policies that result in a large build-up of fuel (Minnich 1983). Length of the fire cycle varies throughout California's coastal regions. In an unpublished study, Greenlee and Langenheim (1980) concluded that the "natural fire cycle" for the inland parts of the Coast Ranges may have ranged up to 100 yrs, and was perhaps even longer for coastal and low elevation sites. Rundel and Vankat (1989) suggested that the natural fire frequency ranges between 30 to 50 years, through perhaps more. Both figures remain controversial.

The effects of fire on the vegetation can be catastrophic when severe floods follow upon a large fire, and a huge mass wasting of soil and boulders flow from the high elevations into the lower reaches of the stream systems. McPhee (1989) has written about the extraordinary drama and loss of property that occurs in this biogeographic region as a consequence of the fire/flood/debris flows. A more detailed discussion of this phenomenon is found elsewhere in this profile (Hydrology and Soils, Sec. 4.7 / Biogeochemistry, Sec. 4.8).

Anthropogenic Forms of Disturbance

In a recent compendium on *Ecosystems of the World* (Vol. 16, *Ecosystems of Disturbed Ground* [Walker 1999]), Rundel (1999) discussed both natural and anthropogenic disturbances in Mediterranean-climate shrublands and woodlands of the world, and argued that urbanization and agriculture (in that order) pose the greatest regional non-natural disturbances to the functioning of California's Mediterranean-type ecosystems, as well represented within the reference domain. For example, ten percent of the land is classified as urban/impervious, based on Landsat imagery within the reference domain. An additional six percent, representing heavily grazed or graded soil, and another eight percent, representing highly irrigated systems such as golf courses and agriculture (discussed in the following section), can be added legitimately to the original ten percent figure of anthropogenic modification. Therefore, a conservative estimate of the two forms of disturbance recognized as primary threats to ecosystem functions in Mediterranean California by Rundel (1999) already occupy nearly one quarter of the land within the reference domain.

Agriculture has, quite obviously, replaced the native ecosystems with highly managed, highly subsidized artificial ones. In the study regions, avocado, citrus and cut flower cultivation are perhaps the most obvious examples. Grazing has facilitated the introduction of an exotic annual grass and forb flora that has transformed the native perennial grasslands into a vegetation type dominated by exotic annuals (Heady 1977). Additionally, it is argued that a major change in the community structure of California's shrubland and woodlands is the change in frequency and intensity of fires due to fire suppression (Minnich 1983), as discussed earlier.

4.9.5
General Description of the Riparian Communities in the Reference Domain by Subclass

Plant communities within the SCSBC reference domain vary from High to Low gradient with respect to most if not all of the standard quantitative descriptors of vegetation structure. However, data were variable, as evidenced by standard deviations that accompany mean values.

Trends in the data from high to low gradient riparian communities suggest that declines in values can be found in (a) tree basal area; (b) coarse woody debris; and (c) number of native species; (d) average width of riparian buffer; and, (e) the ratio of native species to exotic species. Only one measure, maximum percent canopy cover for shrubs, increased from high to low gradient reference sites. Many other measures resulted in similar values for the high and low gradient reference sites, which were different (typically higher) than the value for the same metric at the low gradient reference sites. Such measures include (a) maximum percent canopy cover for trees; (b) maximum percent canopy cover for vines; and, (c) average tree canopy height. Data for which no trends were discernable include (a) maximum percent canopy coverage for forbs; (b) number of non-native species; (c) number of ornamental species; (d) number of cultivated species; (e) seedling density; (f) shrub density; and, (g) average number of strata. A summary of the vegetation statistics is found Appendix C, Vegetation Summary Data.

High Gradient, Santa Ynez Mountain Front Riparian Plant Communities

Tree basal area is highest among the subclasses in the high gradient riparian plant communities. Average basal area for tree is 355.9 sq. ft/acre (s.d. = 143; n = 5). This reasonably high value for basal areas is the result of typically large, old Coast live oaks and Western sycamores that are found throughout the Santa Ynez mountain front riparian zone. Average canopy height of the riparian tree complement is 56.48 (s.d. = 10.6; n = 5).

The percent canopy coverage is similar for trees (x = 44.9; s.d. = 31.97) and vines (x = 41.0; s.d. = 24.65), and these two represent the vegetation strata most likely encountered in this subclass (mean number of strata = 1.74; s.d. = 0.35). Shrubs exhibit relatively low canopy coverage (9.5%; s.d. = 7.2), while forb coverage is significantly greater (29%; s.d. = 12.8).

With respect to the total number of native species found per sampling site, the mean number for the high gradient subclass is 24.4 (s.d. = 4.2; n = 5). This number is notably higher than that for either Medium or Low gradient subclasses, in large part because the High gradient reference sites were on average, less disturbed than those found at the Medium and Low gradient reference sites. Conversely, the mean number of non-native species (exclusive of ornamental and cultivated taxa) (x = 5.6; s.d. = 4.6) is less than that at either the Medium gradient or Low gradient reference sites. The result is that the ratio of native to non-native species in the high gradient subclass is 6.5:1. This ratio reflects the general prevalence of a few widespread non-native taxa (*e.g., Hedera helix*), and the predominance of native taxa in these riparian communities.

Medium Gradient, Alluvial Fan & Debris Flow Riparian Plant Communities

In the medium gradient, alluvial fan and debris flow subclass, tree basal area (x = 257.2 sq. ft/acre; s.d. = 232; n = 34) is intermediate between tree basal area in the High and Low gradient subclasses, although there is considerable variability within all subclasses. This variability likely is the result of several factors, including the (a) inherent variability in this area and community development of the sampling sites; (b) variability of the local site conditions in this subclass (alluvial fan vs. debris flow substrate); and, (c) increased frequency and intensity of perturbation to the riparian communities due to human activities, such as orchards, row crops, *etc*.

Tree canopy coverage is essentially the same in this medium gradient subclass as that in the high gradient subclass (x = 43.8%; s.d. = 28.6; n = 34), as is average canopy height (x = 50.41 ft; s.d. = 22.49). However, the variation is greater, likely the result of a greater diversity of tree species in the riparian zone. Maximum percent canopy cover for vines is similar to trees (x = 41.4%; s.d. = 29.7; n = 34), as in the high gradient subclass, for shrubs, 17.95% (s.d. = 13.1; n = 34), and for forbs, 27.4% (s.d. – 17.5, n = 34). Therefore, shrub canopy coverage is also similar to that found in the high gradient subclass, but forb canopy coverage is considerably greater, likely reflecting the relatively greater site disturbance in this subclass. Average number of strata within this also approximately two (x = 1.9; s.d. = 0.5; n = 34).

The average number of native species found at each reference site also drops from 24 in the high gradient subclass to approximately 19 in the medium gradient subclass. This pattern is accompanied by a concomitant increase in the mean number of non-native species (12.7; s.d. = 7.6) and a decreased ratio of native to all exotic taxa, *i.e.*, 2.5:1.

Low Gradient, Coastal Plain Riparian Plant Communities

Tree basal area in the low gradient, coastal plain riparian communities averages 153 sq. ft., but varies widely (s.d. = 229, n = 19) due to time since disturbance, as well as the extensive alteration and regular manipulation of the coastal plain by humans. In general, tree basal area is substantially lower along the coast than in the Santa Ynez mountain front, as Coast live oak is replaced wholly or in part by Red willow, Arroyo willow, and Black cottonwood.

Not only is the basal area of the tree stratum lowest in this subclass, so is the maximum percent canopy cover for trees (x = 27.0%, s.d. = 30.0; n = 19) and for vines (x = 22.6, s.d. = 25.8, n = 19). However, the maximum percent canopy coverage for forbs (x = 23.9%, s.d. = 14.9; n = 19) and shrubs (x = 19.9%, s.d. = 18.1; n = 19) is higher than in the other two subclasses. This is because the low gradient coastal plain subclass is less steep, more open, and therefore a higher light environment that supports a large complement of herbaceous taxa. The predominance of shrubs and herbs (forbs) in this class also is reflected in the average canopy height (25.85 ft, s.d. = 18.1; n = 19), which is, on average, approximately one half the height of the other two size riverine subclasses. Average number of vegetation strata is less than two (x = 1.4, s.d. = 0.6; n = 19), representing yet another departure from the structure of the riparian communities in the Medium and High gradient subclasses. Another indication of the highly altered nature of the riparian communities in the low gradient coastal plain riparian communities is the average number of native plant species recorded at each reference site. In this subclass, the average number was approximately one-half that recorded in the High gradient subclass (12.2 [s.d. = 8.25, n = 19] vs. 24.4), and two-thirds that recorded in the Medium gradient subclass (12.2. vs. 18.8). Two additional measures parallel this finding. The average number of nonnative species in the low gradient subclass was nearly three times that found in the High gradient subclass (14.9 [s.d. = 9.57, n = 19] vs. 5.6), but equivalent to that found in the Medium gradient subclass (14.9 vs. 12.7). The ratio of native to all exotic taxa (non-native, ornamental, and cultivated taxa declines from 6.5:1 in the High gradient subclass, to 2.5:1 in the Medium gradient subclass, to 0.9:1 in the Low gradient. In short, the Low gradient reference sites are characterized by exotic plant species, and many sites are dominated by their presence.

Reference Standard Sites

Only four reference standard sites were identified during the reference sampling effort. As such, no summary statistics were computed against which to compare summary data from the three subclasses. Values obtained for the reference standard sites vary dramatically for most, if not all of the site characteristics measured. For example, tree basal area ranged from a minimum of 110.1 sq. ft (Site #48) to 476 sq. ft. (Site #49); coarse woody debris ranged from 74.7 volume/acre (Site #48) to 1448.1 (Site #49); and, the number of native species from 19 (Site #34) to 35 (Site #48). It is therefore evident that intrinsic variability exists in the structure and composition of the riparian forests of the SCSBC, even within a comparatively pristine riparian forest. Such is the nature of the Mediterranean climate communities in coastal California.

Summary values calculated for the High gradient Santa Ynez Mountain Front subclass fall within the range of values obtained for the reference standard sites. The few summary values for the High gradient subclass that do not fall within the bounds of the reference sites reflect the reasoning behind their exclusion in the reference standard category. For example, High gradient sites on average support more non-native species than do reference standard sites (5.6 vs. 2-5), and the average ratio of native to non-native species is 6.5:1 for High gradient, in contrast to the 11.5:1 (Site #9) to 7:1 (Site #48) of the reference standard sites.

4.10 Landsat 7 - Enhanced Thematic Mapper (ETM) Data and Analyses

A series of remote sensing and GIS analyses were conducted within the SCSBC reference domain to generate data for the HGM subclass profiles and functional assessment models. A remote sensing and GIS approach was chosen to capture landscape scale/regional data to augment the site-specific reference data collected in the field. A large variety of data sources was included in these analyses (see Appendix D)

4.10.1 *Background and Approach*

Classification of remote sensing imagery, while based upon scientific principles and techniques, is always somewhat subjective by nature. The process and techniques used to classify the data will include a series of "end-user", or project-specified assumptions and requirements that become intrinsically tied to the classification scheme. In this case, the single constraint was to provide a simple, repeatable, and flexible approach to classification of landuse in SCSBC that could generate landscape scale data for HGM subclass profiles and functional assessment model variables.

HGM-based functional assessments are, by design, meant to be rapid and easily repeatable methodologies by end-users with varying backgrounds and expertise. As a result, the remote sensing data and classification approach used for this project by no means represents the most sophisticated nor complex techniques available. Hundreds of remote sensing methods and techniques currently exist, each with their own advantages and disadvantages. In this application, our intent was to provide a flexible methodology that generated output data that could be incorporated easily into the HGM Assessment protocol, offered in the Draft Guidebook. As the goals and requirements of Project Clean Water develop and/or change with time, the methods and techniques presented herein can be used directly, or modified as needed, to provide a basis for future landscape scale analyses throughout the reference domain.

4.10.2 *Landsat 7 - ETM data*

Imagery Characteristics

Landsat 7 ETM data were selected as the basis for a landuse classification of the reference domain. These data were chosen for the analyses because they are used widely for landuse/land change analyses. As such, a robust scientific literature exists regarding the application and interpretation of the imagery (Jensen 1996, Sabins 1997). In addition, Landsat 7 ETM data were selected because they are publicly available, inexpensive, easy to update, and compatible with other ancillary data at similar spatial resolutions (*e.g.,* digital elevation models of the reference domain). Importantly, the Landsat program has been operational since 1972, with a multitude of available data that could be used to document historical, and potentially future land use changes within the reference domain. Spectral characteristics of Landsat imagery allow for analyses in the visible, infrared, and thermal wavelengths, which in turn permit a variety of landscape scale information and data about the reference domain to be derived. An initial classification technique (see Appendix D) was performed on the data set to identify ten land use classes within the reference domain. Comparison of these ten land use classes to aerial photography and our local knowledge indicated an overlap between several of the landuse classes. In order to further differentiate the land use classes, particularly between the multiple vegetation classes, a *Normalized Difference Vegetation Index* (hereafter "NDVI") was calculated from the data for the entire reference domain (Figure 4.27).

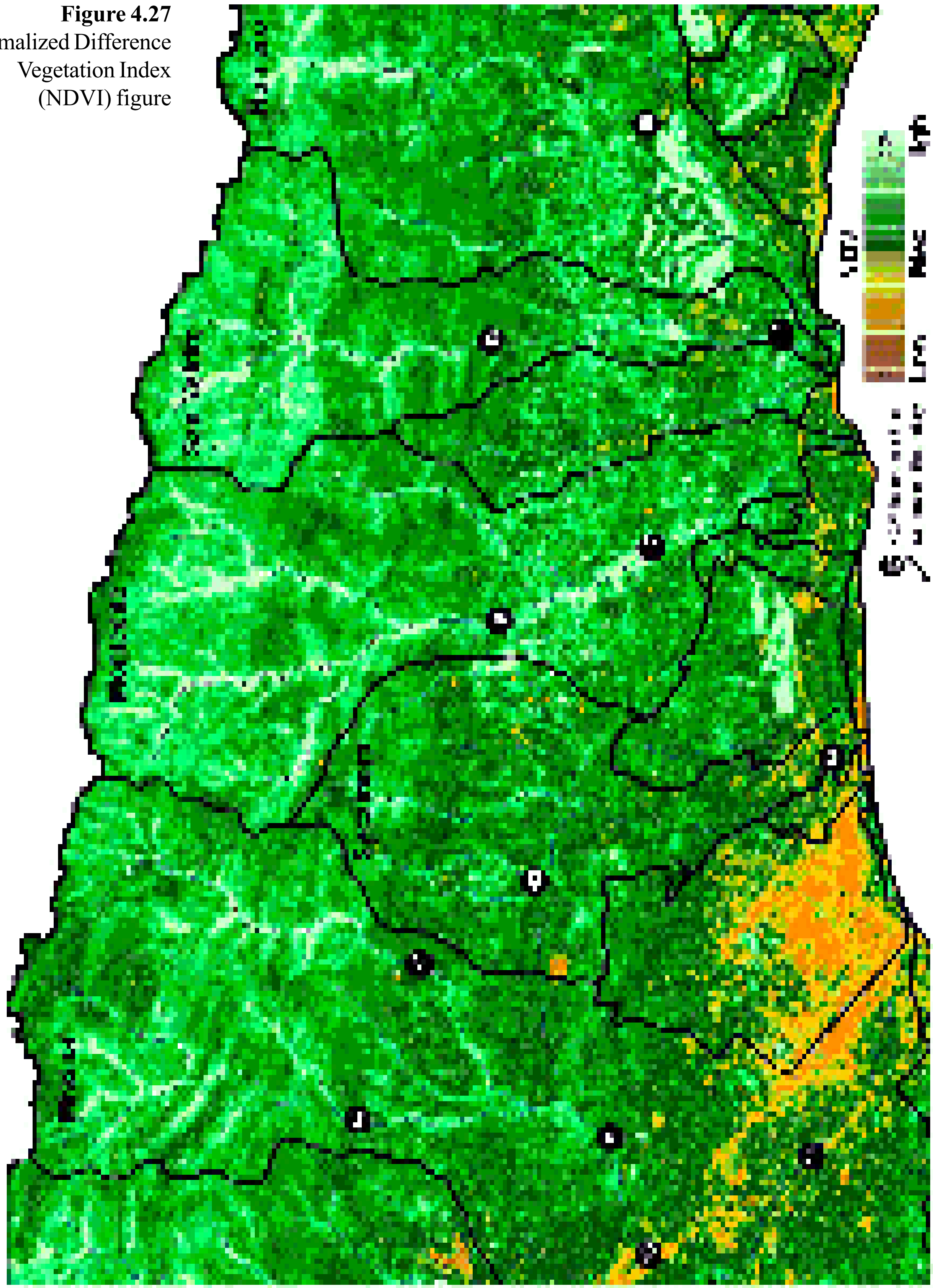
Initial Classification and Normalized Difference Vegetation Index (NDVI)

NDVI is a technique by which multiple bands of image data are reduced down to a single number per pixel. This number predicts or assesses canopy characteristics such as biomass, productivity (phytomass), leaf area index (LAI), amount of photosynthetically active radiation (PAR) consumed, and/or percent vegetative ground cover (Jensen 1996). NDVI is used in a variety of landscapes as a method for detecting seasonal changes/patterns associated with vegetation growth and senescence, as well as various types of agricultural practices and crop rotations (Sabins 1997).

Figure 4.27 illustrates NDVI data for a portion of the reference domain in the vicinity of downtown Santa Barbara. This image includes Mission, Sycamore, Montecito, San Ysidro, and Romero Creek watersheds. These data are non-dimensional (*i.e.*, an index) and have been converted to 8 bits (*i.e.*, values ranging from 0-255) for ease of display. The NDVI values were analyzed, stratified, and compared to vegetation classes on the ETM image. This process reduced the number of ETM landuse classes to eight (see Appendix D).

The index can be used as a surrogate for biomass, LAI, PAR, percent vegetative ground cover, and other measures of vegetation in SCSBC. In addition to facilitating the ETM landuse classification process, the NDVI image/data reveal several interesting points about the distribution of vegetation. First, riparian areas in the upper portions of the watersheds have high NDVI values. These values correspond to riparian vegetation on valley bottoms (*e.g.*, *Alnus rhombifolia, Populus balsamifera* subsp. *trichocarpa*, *Platanus racemosa*, *Quercus agrifolia etc.*), which contrasts sharply in the image with the more xeric to mesic native chaparral vegetation on the hillslopes (*e.g., Adenostema fasciculatum, Arctostaphylos*, spp., *Ceonothus* spp., *Quercus dumosa, Q. berberidifolia*, *etc.*). The contrast of spectral signatures between riparian vegetation and native hillslope chaparral is captured easily in the late summer NDVI image and potentially could be used as a tool for mapping and/or monitoring riparian waters/wetlands within the reference domain.

Figure 4.27
Normalized Difference Vegetation Index (NDVI) figure



Second, golf courses (*e.g.*, southwest of HGM reference site 16 and northeast of site 44 in Figure 4.27) have very high NDVI values. These values result from the active irrigation of the golf course fairways and greens that sustain a high percent cover of grasses that are photosynthetically active despite the region's prolonged summer drought conditions. This fact is illustrated in the NDVI image (near HGM reference site #16) by linear patterns/features that represent the contrast between irrigated fairways and other non-irrigated portions of the golf course between the fairways. In contrast, the urban areas of downtown Santa Barbara (southwest corner of Figure 4.27 have medium to low NDVI values resulting from the high percentage of impervious, non-vegetated surfaces (*e.g.,* roads, buildings, parking lots, *etc.*). The long, narrow, linear feature of low NDVI values to the southwest of downtown (near HGM site #14) is highway 101. Imbedded in the low NDVI signature of urban downtown Santa Barbara are small areas of very high NDVI values which represent public parks with irrigated landscaping (*e.g.,* Ortega and Alameda parks).

Landsat 7- Enhanced Thematic Mapper Landuse Classification Descriptions

Using the techniques described in Appendix D, the following eight land use classes were identified and described within the reference domain:

Class 1 – Ocean & Open Water
ETM Class 1 represents the ocean and other open water bodies such as lakes, ponds, and reservoirs.

Class 2 – Urban (Residential/Commercial) & Impervious Surfaces
ETM Class 2 represents urbanized areas (high- and low-density residential and commercial) and other impervious surfaces such as paved roads and highways. In addition, beach sand shares a similar spectral signature to urban/impervious areas due to its smooth texture and high reflectivity in the visible wavelengths. Beach sand is included in this landuse class, although it represents a very small proportion (< 1%) of the Class 2 landuse within reference domain.

Class 3 – Irrigated Agriculture, Golf Courses, and Residential Lawns
ETM Class 3 represents irrigated areas (*e.g.*, commercial agriculture, irrigated golf courses) within the reference domain. Within the High and Medium gradient subclasses, avocado groves and citrus orchards are the most prevalent type of irrigated agriculture associated with this ETM land use class. Some Class 3 appears in the riparian zones within the High gradient subclass due to the presence of water and/or moist soil conditions.

In portions of the medium gradient and throughout the Low gradient subclass, irrigated golf courses and large (*i.e.*, > 30 m^2 pixel in the Landsat 7 image) residential estate lawns/landscaping (*e.g.*, Hope Ranch and Montecito) are the primary forms of irrigated land use. One exception to this pattern of land use within the Low gradient subclass is the extensive irrigated agriculture (*i.e.*, avocados and citrus) occurring to the east and northwest of downtown Carpinteria.

Class 4 - Shrub/Scrub and Coastal Chaparral
ETM Class 4 consists of a vegetation mosaic dominated by scrub/shrub and coastal chaparral characteristic in SCSBC. These vegetation communities often contain an interspersion of exotic grasses and forbs as well. The scrub/shrub and coastal chaparral community is dominated by a relatively small number of native shrub species, including *Baccharis pilularis, Eriogonum fasciculatum*, and *Artemisia californica*. The mostly exotic grass/forb complement commonly found within this mosaic includes *Avena* spp.*, Brassica nigra, Bromus diandrus, Bromus hordaceus, Hordeum murinum* ssp. *leporinum, Leymus condensatus, Picris echioides,* and *Raphanus sativa.* The distribution of the scrub/shrub and coastal chaparral species is discontinuous or scattered due to anthropogenic disturbance, such as land clearing, light to moderate grazing, and so forth.

Class 5 - Native Chaparral and/or Woodlands (Open Canopy)
ETM Class 5 consists predominantly of a homogeneous cover of 1) native chaparral (*Adenostema fasciculatum, Arctostaphylos*, spp., *Ceonothus* spp., *Quercus dumosa, Q. berberidifolia*, *etc.*, within the High gradient subclass, and 2) native/non-native woodlands (*i.e.*, open canopy structures) in the Medium and Low gradient subclasses (*e.g.*, *Quercus agrifolia, Eucalyptus globulus*, and *Phoenix canariensis*). Within the High gradient subclass, Classes 5 and 6 (see below) are similar with respect to their community composition and structure. The distinction between Classes 5 and 6 is the result of two factors, including shadows in the imagery and variation in hillslope aspect. Shadows are due to steep topography, which results in differing spectral signatures and thus separation into two ETM classes. Variation in hillslope aspect affects the structure/physiology of the vegetation cover.

Within the Medium gradient subclass, Class 5 represents some native chaparral (*i.e.*, in the steeper and undisturbed portions of the Medium gradient subclass) as well as native/non-native woodland communities with open canopy structures. The heterogeneity of Class 5 often is a result of ornamental plantings/landscaping (*e.g.*, eucalyptus, palms, *etc.*) within the urban areas of the reference domain. The variation also may be remnant patches of native woodlands in the non-urbanized portions of the reference domain (*e.g.,* riparian zones in Hollister Ranch).

Within the Low gradient subclass, Class 5 represents native/non-native woodland communities with open canopy structures. Similar to the Medium gradient subclass described previously, the heterogeneity of Class 5 often is a result of ornamental plantings/landscaping within the urban areas of the reference domain, and/or remnant patches of native/non-native woodlands in the non-urbanized portions of the reference domain. Contiguous areas/patches of Class 5 may be located proximate to riparian zones in the medium to Low gradient subclass. These native/non-native woodlands are maintained as a result of Santa Barbara County policy on land use setbacks and buffers.

Class 6 - Native Chaparral and Riparian Forest (Closed Canopy)
ETM Class 6 consists of (1) homogeneous native chaparral communities within the High gradient subclasses (see ETM high gradient Class 5), and (2) native/non-native riparian forest (closed canopy) in the Medium and Low gradient subclasses. Within the High gradient subclass, Classes 5 and 6 are similar with respect to their community composition and structure. The distinction between Classes 5 and 6 is the result of two factors, as discussed previously, that is, shadows in the imagery due to steep topography, and differences in hillslope aspect that affect the structure/physiology of the vegetation cover.

Within the Medium and Low gradient subclasses, Class 6 represents closed canopy forest communities. Contiguous areas/patches of Class 6 often are located in riparian zones in the Medium and Low gradient subclasses, and are maintained through the County's policy on setbacks and buffers. Typical species found in Class 6 include *Alnus rhombifolia, Populus balsamifera* subsp. *trichocarpa*, *Platanus racemosa* and *Quercus agrifolia*, among several others.

Class 7 – Grasslands
ETM Class 7 represents grassland communities dominated by non-native species such as *Avena* spp.*, Brassica nigra, Bromus diandrus, B. hordaceus,* and *Hordeum murianum* subsp. *Leporinum*. In the Medium and Low gradient subclasses, this land use class results from anthropogenic disturbance typically in the form of land clearing activities, or light to moderate grazing of domestic livestock (*e.g.*, cattle grazing on San Marcos foothills East of highway 154). Ground cover of grasses and forbs is continuous with little to no exposed soils. However, as the level of disturbance increases (*e.g.,* moderate to heavy grazing, removal of the grass/forb cover due to mowing/grading, *etc.*), a transition to ETM Class 8 occurs (see below). The presence of Class 7 in the High gradient subclass is a associated generally with the margins of exposed bedrock outcroppings where trees and shrubs are absent.

Class 8 - Heavily Grazed Grasslands, Exposed/Graded Soils, Bedrock
ETM Class 8 represents several land use classes. Within the High gradient subclass, Class 8 represents non-vegetated bedrock outcroppings on the Santa Ynez Mountain front. In the Medium and Low gradient subclasses, Class 8 reflects heavily grazed grasslands where the vegetative cover has been reduced and/or eliminated sufficiently to expose the underlying soils (*e.g.,* portions of Hollister Ranch, San Marcos foothills near highway 154), areas where grasslands are being actively mowed (*e.g.,* taxiways at the airport), or soils that are graded/exposed (*e.g.,* southern slope of Ellings park, Tajiguas landfill, *etc.*).

4.10.3 *Summary of ETM Landuse Classification for the Reference Domain*

The Landsat 7 ETM Landuse Map (Figure 4.28) provides a view of the distribution of landuse classes within the reference domain. Table 4.1 summarizes the relative area and percentage of each landuse class within the reference domain.

Table 4.1 Summary of ETM Landuse Classes Within the Reference Domain

ETM CLASS	LAND USE DESCRIPTION	AREA (ACRES)	PERCENTAGE OF REFERENCE DOMAIN
1	Ocean & Open Water	78	0.04
2	Urban (Residential/Commercial) & Impervious Surfaces	18,998	9.86
3	Irrigated Agriculture, Golf Courses, and Residential Lawns	14,694	7.63
4	Shrub/Scrub and Coastal Chaparral	15,715	8.16
5	Native Chaparral and/or Woodlands (open canopy)	44,262	22.96
6	Native Chaparral & Riparian Forest (closed canopy)	65,281	33.88
7	Grasslands	21,977	11.41
8	Heavily Grazed Grasslands, Exposed/Graded Soils, Bedrock	11,679	6.06
Total		**192,684**	**100.00**

A number of trends in land use within the reference domain can be inferred from these data and the Figure 4.28. For example, approximately 57% of the entire reference domain area is classified as native chaparral, riparian forest, and woodlands (Classes 5 and 6). These landuse classes occur primarily in the High gradient subclass, particularly north of the Los Padres National Forest boundary. As the map illustrates, linear patches of riparian forest and woodland often extend down gradient into the Medium gradient subclass, but become absent in the Low gradient subclass, particularly in the urbanized areas of the reference domain.

Reference standard sites have greater than 90% of their sub-watershed area in ETM landuse Classes 5 and 6, indicating relatively low levels of human disturbance (*i.e.*, grazing, land clearing, *etc.*). As disturbance increases, the average percentage of the sub-watershed area in these two ETM landuse classes drops to approximately 76% in the Medium gradient subclass and 65% in the Low gradient subclass (calculated from all sites in each subclass). The most disturbed sites in the Medium gradient subclass have a range of 10-30% of the sub-watershed in ETM Classes 5 and 6. Low gradient sites have a slightly lower range of 10-20%.

ETM Class 4 (scrub-shrub/coastal chaparral) and Class 7 (grasslands) occur primarily within the medium and low gradient areas, especially in the western portion of the reference domain. These land use classes represent approximately 20% of the entire reference domain area. They are generally associated with anthropogenic disturbance (*e.g.*, grazing, land clearing, mowing, *etc.*) and often transition to ETM Class 8 (heavily grazed grasslands, exposed/graded soils) with increasing levels of disturbance. Reference standard sites have approximately 5% of their sub-watershed area in landuse Classes 4 and 7. The medium and low gradient reference sites average 12% and 15% of their sub-watershed area in Classes 4 and 7, respectively (calculated from all sites in each subclass). Highly disturbed sites in the Medium and Low gradient subclasses have approximately 20% - 25% of the sub-watershed in these two classes.

ETM Class 3 (irrigated agriculture, golf courses, residential lawns) represents approximately 8% of the reference domain area and also exhibits several interesting patterns. First, large areas of irrigated row crops tend to be associated with riparian zones in the Medium and Low gradient subclass. This phenomenon often accounts for the absence of Classes 5 and 6 in these portions of the reference domain, as discussed previously. Ultimately, the need for a local source of water for irrigation (*i.e.*, hyporheic and/or vadose zone pumping) has facilitated the placement of irrigation crops adjacent to, or in place, of

11x17 foldout

the native riparian vegetation. An example of this pattern appears in the Medium gradient subclass north of the airport/Goleta, as well as in the Low gradient subclass east of downtown Carpinteria. Each example is indicated by the dominantly linear patterns of Class 3 (see Figure 28). Another interesting pattern in Class 3 is the widespread and diffuse (*i.e.*, speckled) pattern that appears in the vicinity of Hope Ranch and Montecito. This spectral pattern results from the extensive irrigation of landscaping and residential lawns associated with the large private estates in these neighborhoods. Reference standard sites have < 5% of the sub-watershed in Class 3. The remaining high and medium gradient reference sites average a similar value of approximately 5% of the sub-watershed in Class 3. Low gradient sites have a higher average value of 10% of the sub-watershed in Class 3, with highly disturbed sites averaging 15 - 25% of the sub-watershed in Class 3.

Finally, ETM Class 2 (urban/impervious surfaces) represents approximately 10% of the reference domain. This spectral image/land use is concentrated in three core areas—Santa Barbara, Goleta, and Carpinteria. Urban areas of Santa Barbara and Goleta are essentially interconnected, being separated only by a narrow region of ETM Class 4 and Class 7 in the vicinity of the San Marcos foothills/highway 154. Reference standard sites have less than 0.1% of the sub-watershed in Class 2. Medium and low gradient reference sites have an average of 4% and 13% of their sub-watersheds in Class 2 respectively. Some highly disturbed sites in Medium and Low gradient subclasses have upwards of 30% - 40% of the sub-watershed in Class 2.

4.10.4 *Landsat 7 - ETM Habitat Patch and Contiguity Analyses*

The ETM landuse classification described previously was used as the basis for generating habitat data for the subclass profiles and three variables in the HGM functional assessment protocol, $V_{PATCHNUMBER}$, $V_{PATCHAREA}$, and $V_{PATCHCONTIG}$ (see Appendix B). These variables were developed to assess the effect land use and land cover have on habitat within the High, Medium, and Low gradient subclasses in the reference domain. The ETM landuse classes were reclassified into “high,” “moderate” and “low” habitat structure and functioning based on the landuse type and local knowledge (see Methods, Appendix D). Specifically, measures of the number and relative area of “high” and “moderate” habitat structure and functioning patches were calculated, as was the contiguity of those patches to the existing “core” habitat patch located in the reference domain was calculated.

The “core” habitat patch that currently exists in the reference domain encompasses an extensive region of approximately 98,441 acres (153 $miles^2$) as calculated in the ETM Habitat Patch Analysis. This region consists of native chaparral/riparian forest/woodland with a large portion of the high gradient portions of the watersheds in the SCSBC region (Figure 4.28, Landsat 7 ETM Landuse Classification Map - classes 5 and 6). This “core” habitat patch often extends upgradient to the ridgeline of the Santa Ynez Mountain Range, and continues into much of the upper Santa Ynez River Valley and the Los Padres National Forest. Contiguity of habitat from this “core” habitat patch to riparian ecosystems on the South Coast decreases with increasing human disturbance. This pattern of habitat distribution influences the ability of the native faunal to locate, access, utilize, and disperse through a variety of habitat types.

Habitat Patch Number and Area Analyses

The number and relative area of habitat patches in proximity (as defined by a 1000 ft radius assessment area) to the HGM reference sites was calculated for all reference sites (see Appendix B). Data analyses indicate a trend of an increasing number of habitat patches and decreasing overall habitat size with increasing human disturbance. This pattern holds across High, Medium and Low gradient subclasses except in certain highly disturbed, Low gradient subclass sites where urbanization and/or vegetation clearing results in only “low” habitat structure and functioning within the 1000 ft AA ring (see example ETM habitat patch analysis map in Appendix F).

All reference standard sites and those near to reference standard were located within the “core” habitat patch of homogenous native chaparral/forest or native chaparral/woodland vegetation (habitat classified as “high” habitat structure and functioning in the analysis). In all cases, this one “core” habitat patch covered > 95 % of the 1000 ft AA ring. In three of the four reference standard sites, the number of “moderate” habitat structure and functioning patches was less than 2.

Across all reference sites, Medium gradient subclass sites averaged 3 patches of habitat classified as “high” habitat structure and functioning and 3 as “moderate” habitat structure and functioning per 1000 ft AA ring. Less disturbed sites in the Medium gradient subclass averaged 2 “high” habitat structure and functioning and 3 “moderate” habitat structure and functioning patches covering ≥ 75% of the 1000 ft AA ring, while highly disturbed sites averaged 6 “high” habitat structure and functioning and 3 “moderate” habitat structure and functioning patches covering < 50% of the 1000’ AA ring.

Low gradient subclass sites averaged 3 “high” habitat structure and functioning and 3 “moderate” habitat and functioning patches for all reference sites. Less disturbed low gradient sites averaged 5 “high” habitat structure and functioning and 4 “moderate” habitat structure and functioning patches covering approximately 50% of the 1000 ft AA ring, while highly disturbed sites averaged less than 2 “high” habitat structure and functioning patches and 3 “moderate” habitat structure and functioning patches and < 25% cover in the 1000 ft AA ring. The decrease in patch numbers and relative area in the highly disturbed sites within the Low gradient subclass reflects the high proportion of urban land use and vegetation clearing eliminating “high” and “moderate” habitat structure and functioning and leaving only “low” habitat structure and functioning.

Habitat Patch Contiguity Analysis

The contiguity of “high” habitat structure and functioning and “moderate” habitat structure and functioning patches from HGM reference sites to the “core” habitat patch located in the high gradient portions of the watersheds was assessed. As described in Appendix D of this document, “high” and “moderate” habitat structure and functioning patches were combined and reclassified as “suitable” habitat for the calculation of patch contiguity. In order to facilitate calculation of the data needed to scale the $V_{PATCHCONTIG}$ variable by the end user, the number of breaks or gaps in “suitable” habitat contiguity were calculated and mapped as “unsuitable DLG stream arcs” (see example map ETM Habitat Patch Contiguity Analysis in Appendix F).

These data indicate that reference standard sites and all High gradient subclass sites had no stream arcs classified as “dis-contiguous” between the reference site and the “core” habitat patch. In all cases, these sites had contiguous habitat for the entire length of the stream channel between the assessment area and the “core” habitat patch. Across all medium gradient reference sites there was an average of 2 stream arcs classified as “dis-contiguous” with the more disturbed sites in the Medium gradient subclass averaging 3 “dis-contiguous” stream arcs. Across all low gradient reference sites there was an average of 7 stream arcs classified as “dis-contiguous” with the less disturbed sites averaging 2 and highly disturbed sites averaging 8. It is clear from these data that habitat contiguity decreases from the High gradient subclass to the Low gradient subclass as the level of human disturbance increases.