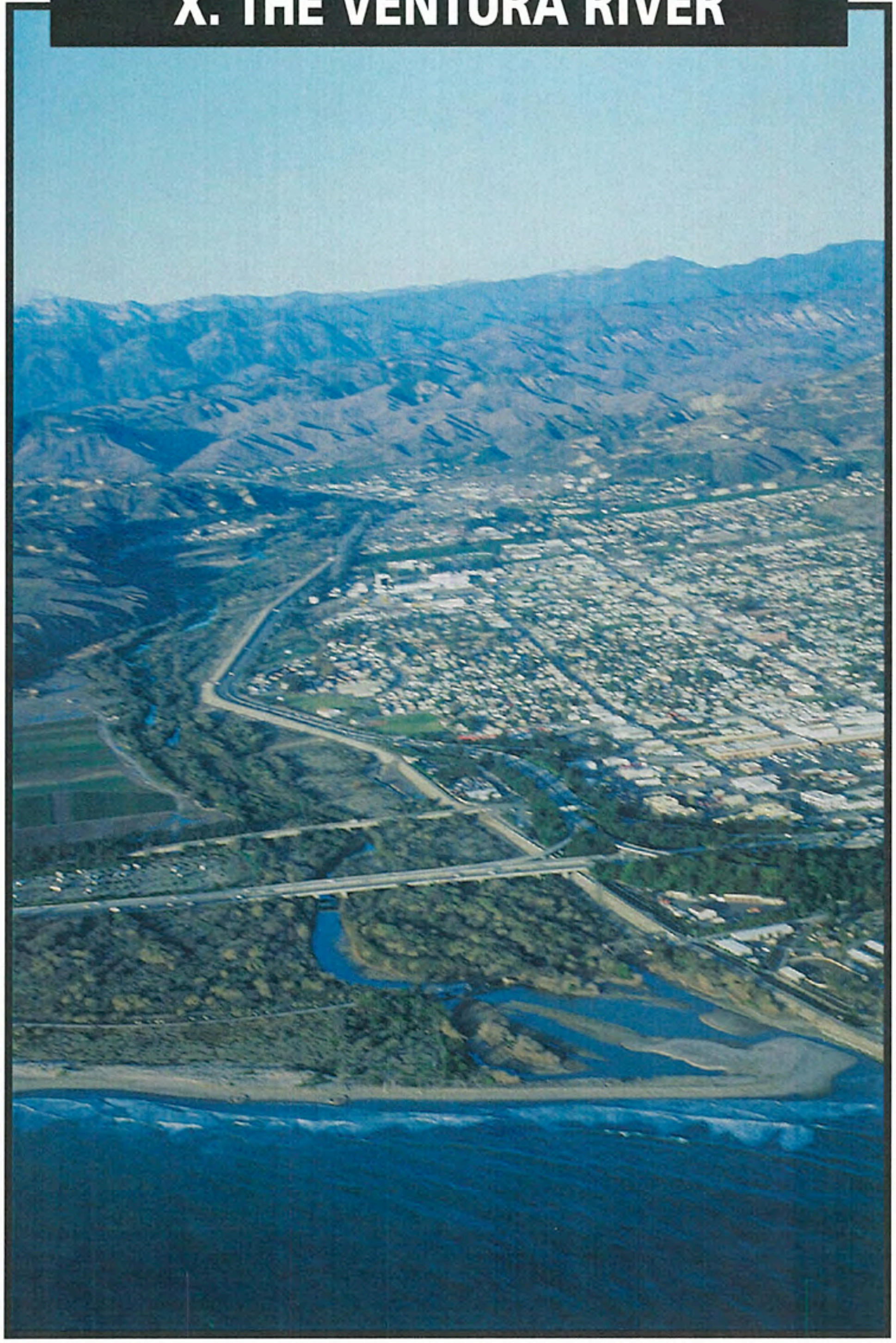
X. THE VENTURA RIVER



California, Ventura County: Ventura River Watershed

HYDROGEOMORPHIC CLASSIFICATION AND ASSESSMENT OF FUNCTIONS AND VALUES OF THE WETLANDS OF THE VENTURA RIVER WATERSHED

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INTRODUCTION

The topography, geology, hydrology, and substrate texture and composition that differentiate wetland templates typically can be characterized in the framework of the hydrogeomorphology influencing the development and maintenance of the site. Once characterized in this framework, it is anticipated that natural wetland grouping will become apparent and often will support similar flora, fauna, and function. Based on this hypothesis, our study of the physical characteristics of the Ventura River Basin, related to wetland construction and maintenance, is based on stratifying the basin into structural elements and sub-watersheds that show similar characteristics. Standard hydrologic and geomorphic data provide the physical basis for comparing the characteristics and functionality among wetland types. The emphases of this watershed analysis for distribution of wetlands are to (1) demonstrate use of the new classification scheme described in this document; (2) characterize the variability of wetlands in the Ventura River Watershed; and, (3) determine the relationship between the hydrogeomorphic habitats and wetland functions based on methodologies described by Brinson (1993; et al. 1993) and Sullivan and Richardson (1993).

The Ventura River Watershed was selected for this study for several reasons. It is of intermediate size within the larger study area, a significant literature is available, much of the land is readily accessible, and a wide variety of pristine and modified wetland habitats are present representing all five systems described herein and by Cowardin et al. (1979). In particular, the Ventura River maintains a perennial flow to its delta, where both estuarine and marine wetlands exist; and two reservoirs exist that support lacustrine wetlands. Twelve reference wetland sites, each comprising a mosaic of hydrogeomorphic habitats, have been chosen from the basin to represent a selected variety of wetland types, function, and values in this watershed.

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Background

Standard hydrologic and geomorphic techniques can be combined to provide data that express the physical basis for comparing and correlating characteristics and functionality among wetland types (Mitsch and Gosselink 1986, 1993). For riverine and riverine-associated palustrine wetlands, many studies have shown the relationships among hydroperiod (i.e., duration of inundation), plant communities and growth patterns (e.g., Bedinger 1971; Leitman et al. 1984; Worbes 1985; Keeland and Sharitz 1992), biogeochemistry (e.g., Devol et al. 1990; Maltby et al. 1992), and average sedimentation rates (Hupp and Morris 1990; Kleiss 1992; Mertes 1994). Vegetation successional patterns associated with differently aged geomorphic surfaces (e.g., Sigafoos 1961; Hupp and Osterkamp 1985; Salo et al. 1986) illustrate the dynamic nature of riverine wetland templates. Mitsch and Gosselink (1986; 1993) and Vernberg (1988), among many, have reviewed the hydrogeomorphic character and functions of estuarine, marine, and lacustrine wetlands.

Brinson et al. (1993) and Brinson (1993) described in detail the use of reference wetland types as the basis for assessing wetland function according to hydrogeomorphic character. Their premise is that several gradients exist across wetland landscapes and throughout watersheds. Primarily these gradients are a result of geologic, geomorphic, and hydrologic variability. By selecting reference wetlands along these environmental gradients it is possible to establish the degree to which each type performs ecosystem functions of interest. Reference sites should include both pristine and modified wetlands, which will likely show a gradient in their functionality. In describing this hydrogeomorphic functional assessment along environmental gradients, Brinson (1993) concluded that the critical gradients for a watershed include the upstream to downstream variation in riverine wetlands, the terrestrial to aquatic transition across each wetland, regional climatic variability, and regional patterns of sediment and nutrient availability.

THE VENTURA RIVER WATERSHED

Physical Characteristics

The Ventura River Watershed is a fan-shaped basin that extends 36 km north from the Pacific Ocean into the interior portions of the western Tranverse Ranges (Fig. X-1). The drainage area covers 585 km^2 (U.S. Army Corps of Engineers 1971) with its headwaters rising approximately 1830 m to the crest of the Santa Ynez Mountains of the western Transverse Ranges. The hypsometric properties of the basin, based on a digital elevation model (Fig. 2), show that 50% lies below 500 m elevation, 25% lies between 500 and 1000 m elevation, and 25% lies between 1000 and 1800 m elevation. This coincides with the broad classification of 15% valley, 40% foothill, and 45% mountain categories reported by the U.S. Bureau of Reclamation (1954). The basin attains high elevations rapidly and the rugged topography consists of steep slopes and narrow canyons.

Major subwatersheds clockwise from north to south (Fig. X-1) include Matilija Creek, San Antonio Creek in the Ojai Valley, Cañada Larga, and Coyote and Santa Ana Creeks. The main trunk of the Ventura River extends south from the confluence with Matilija Creek and the North Fork Ventura River and flows about 26 km to the Pacific Ocean. The maximum width of the floodplain of the Ventura River is nearly 2 km and the narrowest segment is slightly less than 200 m. The average gradient of the Ventura River is 15 m/km.

Based on USGS 7.5' topographic sheets, the drainage network of the basin is comprised of approximately 400 first-order streams, 100 second-order streams, 25 third-order streams, 7 fourth-order streams, and one fifth-order stream, the Ventura River. Typical stream lengths are 1.1 km for first order, 2.3 km for second order, variable lengths totalling 94 km for third and fourth order, and 22 km total length for the main Ventura channel. Based on the average basin bifurcation ratio (number of streams in one order divided by number in next highest order, Chorley et al. 1984) of 4.6, there are approximately 1800 streams, gullies, and bedrock channels in the headwaters of the basin. Most of these headwater waterways are less than 500 m in length, yielding approximately 600 km of waterways in the highest and steepest parts of the basin.

The rugged topography of the Ventura River Watershed is the result of tectonic activity in the Transverse Ranges that are an anomalous "east west trending topographic and structural zone superposed on the otherwise northwest-trending structural grain of California" (Rockwell et al. 1984:1466). Rates of uplift of less than 1 mm/yr to over 1 cm/yr have been reported by Rockwell et al. (1988), Keller et al. (1982), Yeats (1983), Scott and Williams (1978), and Rockwell et al. (1984). Since the Pasadenan orogeny in the middle Pleistocene (Norris and Webb 1976), several major geologic structures have continued to transform the most recent deposits and provide the structural framework controlling the general flow patterns and landscape development of the basin (Fig. 3). This active deformation of Pleistocene and Holocene deposits is relatively unique in North America (Scott and Williams 1978). The Ventura River itself appears to be antecedent (i.e. formed prior to the deformation) to the rise of the northwestern portion of the basin where the river crosses the grain of the range and enters the Matilija Gorge.

An area of particular interest to this study is the group of faults known collectively as the Oak View fault zone (Fig. X-3). As reported by Rockwell et al. (1984), these faults are flexural-slip faults that have a vertical displacement producing surfaces tilted to the southeast away from the main river valley. Several sites adjacent and between these faults have a depressional structure relative to the surrounding terrain.

The lithology of the basin is comprised primarily of Cretaceous to Holocene sedimentary rocks that are largely tilted, overturned, or otherwise deformed (Scott and Williams 1978; Putnam 1942). The basin is famous for its extremely thick sequence of largely marine sedimentary rocks (Norris and Webb 1976; Ferren et al. 1990), which exceeds 18,000 m and comprises a nearly complete record of the history of coastal southern California since the beginning of the Cenozoic (Putnam 1942). Alternating sequences of more resistant sandstone and less resistant shales have resulted in alternating steep and less steep terrain throughout the basin. The valley bottoms tend to be filled with alluvium except in the highest parts of the drainages where the bedrock is typically scraped clean.

The Ventura River Basin is characterized by a Mediterranean climate with mild, moist winters and moderately warm, generally rainless summers (Fig. 4). Average monthly temperatures near the river mouth range from 10° C (50° F) in January to 18° C (65° F) in August (Ferren et al. 1990). Higher temperatures prevail in the summer months in the interior, often exceeding 38° C (100° F). The presence of coastal fog is primarily responsible for the narrow seasonal range in temperature. Typically the coastline of southern California is subjected to an inversion layer that traps cool, moist air at low elevations, producing fog or low clouds during the night and early morning hours. Through the day the inversion layer rises and the fog evaporates. As the land is warmed seasonally the fog moves inland, up the river valley, keeping temperatures moderate for several kilometers into the basin. As the summer progresses and the temperature difference between the land and ocean decreases, the occurrence of fog also decreases (Ferren et al. 1990).

Rates of precipitation are highest at the highest elevations in the northwestern corner of the watershed where 18 cm (7 in) may fall in the average winter month (Fig. X-4). Less than 13 cm (5 in) of precipitation per winter month occurs in the areas at lower elevations. Annually, nearly 102 cm (40 in) may fall at the higher elevations, whereas only 38 cm (15 in) may fall near the river mouth.

The overall hydrologic regime in this basin is considered "flashy" because over 80% of the precipitation falls in the winter months, often the result of intense storms. Seventy-five percent of the runoff occurs from January through April (U.S. Army Corps of Engineers 1971). Typically there is a very short time lag from rainfall to runoff due to the steep terrain, intensity of the rainfall, and thin soil cover throughout the basin (Fig. X-4). Flood discharges since 1938 on the Ventura River, 2 km upstream from its confluence with Cañada Larga, have ranged from 765 to 1801 m^3/s, with the 5-year flood estimated to be 504 m^3/s and the 100-year flood estimated to be 2129 m^3/s (Keller and Capelli 1992). A low flow is always maintained in the main Ventura River channel, partially the result of outflow from reservoirs and sewage treatment plants.

The combination of rapidly rising rugged topography, fractured sedimentary rocks, and a flashy, often intense, precipitation regime yields sediment transport processes dominated by debris flows, mudflows, and other mass movements (Scott and Williams 1978). A typical sediment transport pattern for channels is continuous filling with sediment during drier periods, and scouring during floods (Scott and Williams 1978; Keller and Capelli 1992). Reporting on the flood history of the Ventura River, Keller and Capelli (1992) concluded that the discharge of a 20-year flood, e.g., the flood of February 12, 1992, is capable of tremendous scour compared to the same scale flood on a less flashy river. Florsheim et al. (1991) concluded that chaparral wildfires with a recurrence interval of 30 to 65 years, contributed to sediment yield and redistribution primarily by causing an increase in the rate of sediment delivery to channels by dry ravelling. They concluded that fires do not always result in large debris flows, because these types of flows require the coincidence of intense rainfall and recent burns. Time of recurrence of large debris flows in the basin appears to be an order of magnitude greater than for fires, based on radiocarbon dates of debris flow deposits (Florsheim et al. 1991).

Milliman and Syvitski (1992) included the Ventura River in their list of relatively small mountainous rivers that contribute inordinately large sediment loads to the ocean due to their rugged terrain and proximity to the coast. In their study of erosion rates in the Transverse Ranges, Scott and Williams (1978) concluded that the watersheds of the Ventura River Basin have the highest rates of erosion per unit area in these mountains and that over 80% of the sediment is transported by 1% of the flows. Taylor (1983) estimated that under natural conditions, with no artificial structures, upland sediment delivery totalled nearly 450,000 m^3 of sediment annually, whereas nearly 900,000 m3 of sediment was delivered annually to the coast. Over the long term, this discrepancy would result in continued incision and erosion with limited floodplain deposition. These rates of sediment delivery yield a denudation rate across the entire basin on the order of a few millimeters per year, which is somewhat less than the uplift rates (Taylor 1983; Scott and Williams 1978).

Estuarine Characteristics

As summarized by Ferren et al. (1990), for general reference, salinity of sea water for the region is about 33 o/oo (parts per thousand), salinity for estuarine water is greater than 0.5 o/oo and may be hypersaline exceeding 33 o/oo, and that of river water is generally less than 0.5 o/oo of ocean-derived salts (Cowardin et al. 1979).

The Ventura River Estuary is characterized by (1) short periods of tidal flushing when the mouth is open and longer periods of ponding and lagoon formation when the mouth is closed by a sandbar; and, (2) a year-round inflow of freshwater that is the result of upstream surface flows, rising groundwater, and the discharge of effluent from the Ojai Valley Sanitary District. Because there is perennial freshwater runoff into the estuary, hypersaline conditions apparently are not reached at the surface of the estuary. The estuary is tidally flooded by brackish water when the mouth is open, and is flooded by slightly brackish or fresh surface water when the mouth is closed. Freshwater inflow also determines the depth of the estuary, the extent of areas flooded during ponding, and pattern of salinity and temperature stratification (J.J. Smith 1987).

Evidence for alternating salinity conditions in the estuary is provided by salinity recorded occasionally between April 1988 and April 1989. When the sandbar blocking the mouth is removed by winter storm runoff, the estuary can remain open for extended periods through spring. Water at mean high tide (ca. 1.2 m above mean sea level) near the landward side of the estuary had a surface salinity ranging 13-17 o/oo and bottom salinities approximating 20 o/oo. During conditions that approximated low tide in April, Ferren et al. (1990) observed surface salinities ranging from about 10 o/oo in a pool behind a cobble berm partially closing the mouth, to 7 o/oo, and then to 2 o/oo moving landward in the estuary. Salinities in the vicinity of the riffle marking the transition between riverine and estuarine conditions ranged from 1-2 o/oo at low tide conditions and were not distinguishable from riverine salinities just upstream of the transition. Further upstream, near the San Antonio Creek confluence, the Casitas Municipal Water District recorded (Ternes 1989) June salinities ranging from 0.3-0.8 o/oo. These values exceeded the 0.5 o/oo level for ocean-derived salinity used to distinguish freshwater riverine from estuarine conditions, and suggest that natural runoff from the watershed may be slightly saline or that effluent discharged to the river might be saline.

Under summer and fall conditions of reduced runoff, a sandbar usually closes the mouth and tides are prevented from flushing the estuary. Perennial low-flow runoff, however, fills the estuary temporarily creating a nontidal estuary with surface water elevations that extend to about 1.8 m above mean sea level and generally exceed water levels reached at high tide, creating a seaward hydraulic head. During July and August stratification of lagoon may occur with less than 10 o/oo at the surface and as high as 31 o/oo on the bottom. Occasionally the mouth opens during the summer. If it does not open, then by the fall, salinities in the lagoon may be as low as 0 o/oo.

In addition to the main estuary, the Ventura River has second mouth to the west which is flushed by runoff typically only during large flood events. This second mouth can also receive marine water when storm waves top the cobble and sand berm that blocks the mouth. Under these conditions, the second mouth is not a typical estuary. Surface salinities in April range from 9 o/oo at the seaward end to 13 o/oo at the landward end. Salinities measured in October ranged from 13-14 o/oo at the southern end to 15-16 at the northern end. Occasionally pools become isolated from flushing flows and can have higher salinities. The hydrology of the second mouth estuary and associated lagoons and isolated pools appears to be closely linked to the rise and fall of the water table in the delta. The primary influence on this rise and fall is whether mouth of the main estuary is closed and the system is experiencing lagoonal conditions. The higher the lagoon, the more hydrologically connected the entire system becomes.

Marine Characteristics

The delta of the Ventura River consists sand and cobbles which serves as an aquifer that holds large amounts of fresh and brackish water, especially when the mouth of the estuary is blocked and the water table is high. Because of the porous nature of most of the deltaic sediments, water continually flows from the seaward margins of the delta into the marine environment. At low tide, water can be observed to seep from the sand and cobble berm along the shoreline. Salinities reveal that this seep water is brackish water from the estuary and water table that flows through the substrate. A gradient in salinity from the berm seaward ranged from 5-10 o/oo to 25 o/oo.

History of Land and Water Development

Both Ferren et al. (1990) and Keller and Capelli (1992) provided descriptions of the development of the watershed, and their conclusions are summarized in this section. The Ventura River basin has been occupied by humans for at least the past 6000 years (Rogers 1929; Landberg 1965; Greenwood 1976). However, the vegetation in general had not be altered substantially until the last 150 years as the result of agricultural development and during the last 75 years with urban development. Before 1542 A.D., the primary occupants of the region were the Chumash who resided predominately in the coastal regions of the basin (Heizer and Elasser 1980). Most evidence suggests that these Native Americans significantly altered the native vegetation only in the vicinity of their dwellings.

The river basin was first visited by Europeans in 1542, but the first settlers did not begin to colonize the coastal regions of California until the mid-1700's. The site for the San Buenaventura Mission was selected in 1769, but the Mission was not founded until 1782. The founding of the Mission brought with it the first substantial impacts to native ecology with the clearing of extensive agricultural fields (Englehardt 1930). Cattle also were introduced at this time and probably resulted in the introduction of non-native species such as Field Mustard (*Brassica rapa*).

Development and use of the basin intensified after the California Gold Rush in 1849. In 1850, California became a state and at this time the transfer of land under Mexican deeds to U.S. owners was begun. Lands not confirmed to owners were opened for claims by Americans, and the remaining land was open to homesteading under the National Homestead Act of 1862. During this period the entire basin began to experience considerable expansion of agriculture and cattle and sheep ranching. The period from 1849 to 1870 was the period of the California Ranchos when large herds of cattle were grazed on open, unfenced fields and undeveloped lands (Cleland 1969). Adding to the fragmentation by agriculture was the addition of several new transportation routes including the Southern Pacific Railroad line, which cut across the Ventura River Delta and Estuary in 1887. Significant wetland loss and modification occurred in the vicinity of the new railroad line.

Impacts from agriculture, grazing, and transportation corridors have increased steadily since the early 1900's . Added to these three were increased urbanization in both the coastal and interior regions and the discovery of oil in the 1920's in the main Ventura River Valley and several of its subwatersheds. Impacts from the oil industry include the discharge of oilfield wastes, such as drilling muds and brines, into the Ventura River. As recently as the 1960's, a new impact on the system began with the onset of the Southern Pacific Milling sand and gravel operation, which was established on the floodplain of the main river, just a few kilometers upstream from the mouth. Removal of gravel from river systems can degrade floodplains and fish habitat, as well as invoke river incision (Collins and Dunne 1989).

While the landscape became more fragmented in the Ventura Basin over the past 150 years, the diversion of water for agricultural, industrial, sewage, and recreational uses also has occurred. The first diversion of the Ventura River began in the time period when the Mission was founded (Browne 1974). The Matilija Dam was completed in 1948 on Matilija Creek (Fig. 1). The reservoir was designed with an original storage capacity of 8.6 million m^3 (7000 acre-feet), but has since been reduced to approximately 1.4 million m^3 (1100 acre-feet) as a result of siltation and lowering the dam. In 1958, the Casitas Dam (with storage capacity of 313 million m^3 or 254,000 acre-feet) was constructed on Coyote Creek (Fig. 1) along with the Robles Diversion (with a diversion capacity of 14 m^3/s or 500 cfs) on the main branch of the Ventura River. Both of these projects altered the flow regime of the lower Ventura River, although they have not eliminated catastrophic floods (U.S. Army Corps of

Engineers 1971).

Since 1958, the Casitas Municipal Water District has by-passed the first 20 cfs of low flow at the Robles Diversion. This by-pass helps to sustain a surface flow in the lower river down to the estuary, and supports a remnant Steelhead Trout rearing habitat approximately 11 km upstream from the delta. Reduced flows can change the character of the riverbed by (1) not allowing scouring, (2) altering water quality, and (3) affecting the distribution of wetland environments. A conjunctive use agreement between the Casitas Municipal Water District and the City of San Buenaventura would have allowed the District to divert the entire low flow of the upper Ventura River into the Casitas Reservoir for storage and later use by the city. In 1988, an Appellate Court decision (subsequently sustained by the California Supreme Court) on a lawsuit filed by the Friends of Ventura River set aside the proposed conjunctive use agreement because the anticipated significant adverse effects on the Steelhead had not been adequately mitigated (California Court of Appeal 1988; California Supreme Court 1988). Such an agreement would have had significant adverse effects on the biology of especially the estuary. Although this decision prevented additional major impacts to the Ventura River, the effects of depressed base flows and water pollution in the form of turbidity, nutrients, and various other contaminants continue to threaten the viability of the ecosystem. A recent study (J. Montgomery 1990) concluded that the high nutrient discharge water from the Oak View Wastewater Treatment Plant has caused an increase in plant growth, which in turn has resulted in a decrease in dissolved oxygen in river water where there is excessive plant growth.

METHODS

Data Collection

Primary data for our study of wetlands of the Ventura River Watershed were collected during field visits to over 100 sites throughout the basin between April, 1993 and July, 1994 (Fig. X-5). To organize the field mapping we stratified the basin into two geologic categories, structural and non-structural regions, and into several subwatersheds. Initially we investigated sites along the major structural elements and faults to determine the extent and variety of wetlands associated with structural depressions or fault gouge zones. In these areas groundwater and surface water pathways are often altered. After completing the survey of wetlands associated with structural elements we systematically sampled our four major subwatersheds along the riparian corridors from the headwaters down to the Ventura River. In addition to the main trunk of the Ventura River, the subwatersheds included San Antonio Creek, Coyote and Santa Ana Creeks, Matilija Creek, and Cañada Larga Creek. It was often difficult to investigate our ideal sites because of private land ownership, which exceeds 90% in many parts of the basin. Private landowners typically were unwilling to allow the wetlands on their properties to be mapped. To overcome this difficulty, several sites, especially in the Coyote and Santa Ana drainages, were evaluated based on wetland signatures on fine resolution aerial photographs (these interpreted sites are shown with asterisks in Fig. X-5). The general types of wetlands interpreted to be at these sites that we could not visit in the field were all visited elsewhere in the watershed. However, we could not document in detail the mosaic of hydrogeomorphic types at the photo-interpreted sites.

Field data collected for each site included system, subsystem, class, and subclass classification. Information on water regime (potential flooding frequency and vigor) and water chemistry (broad categories such as fresh, saline, or petroleum impacted) also was noted. Dominance types were listed along with characteristic and associated species. Geomorphic data collected for each site where applicable included slope, width, elevation relative to water surface, length, substrate character and texture, aspect, and landform type (hydrogeomorphic unit). Other geomorphic parameters were noted to specifically help generate a measure of hydrologic function included degree of channel confinement, including channel width and depth ratio, and position of wetland relative to local drainage and geologic structure.

Lacustrine wetlands were investigated by boat in the summer of 1993 at Casitas Reservoir. Field sheets were developed as described above.

For the marine, estuarine, riverine, and palustrine wetlands mosaic at the river delta and estuary we relied on extensive data reported by Ferren et al. (1990). In their study, analysis of the wetlands distribution was in part based on twelve field trips conducted by Ferren and colleagues between June 1987 and August 1989. Fifteen reconnaissance trips by Capelli and colleagues from April 1987 to October 1989, during low-tide periods completed the mapping of the marine and estuarine wetlands. Combining aerial photographic interpretation and field work, eight detailed transects were established for surveying the vegetation and topography. Both line-intercept transect and relèvè plot methods of sampling (Barbour et al. 1980) were used to estimate the field cover of species. Data from these surveys reported by Ferren et al. (1990) provide much greater detail than is characteristic of the nearly 150 sites visited elsewhere in the watershed. The detailed information for these deltaic sites allowed them to be readily classified into the new classification hierarchy described in this volume.

Digital data used in this study included digitized versions of the hydrography of the basin in the form of an EPA - Reach 3 file, a mosaic of nine digitized 7.5' USGS quadrangles for hypsometric and slope analysis, and Landsat MSS and TM data for regional views of watershed characteristics and wetlands distribution. A digitized version of the National Wetlands Inventory (NWI) for the Ventura quadrangle was also used to compare NWI data to field data. However, the level of detail available from the NWI data was insufficient for a complete comparison to the wetlands classification employed in this study. At the system and subsystem level the classifications generally matched. However, most of our field sites represent a mosaic of sites at a spatial resolution much finer than can be derived from aerial photographic analysis, which is the primary technique for development of the NWI maps.

Data Analysis

The emphasis of this watershed analysis for wetlands' distribution is to characterize the variability of the wetlands and then to determine the relationship between wetland type and function.

When considering wetland type in the context of its physical characteristics, it is often possible to show systematic relationships between fundamental hydrologic and geomorphic conditions and wetland types. In the most common analysis, hydroperiod is examined as having a causal relationship to the distribution of plant species. In riverine and riparian corridors, adding an analysis of stream power to hydroperiod allows one to separate upper, mid, and lower perennial regimes and to begin to consider the stability of the landforms upon which the wetlands exist. In a study of Rattlesnake Creek, which is a perennial creek that is 40 km north of the Ventura River Watershed and shares many characteristics of Ventura River Basin streams, Best and Keller (1986) determined that several common types of landforms exist in the riparian corridor of these steep mountain drainages, ranging from active floodplain to relatively stable debris-flow terrace deposits. From their analysis of tree ages and a few ^{14}C dates from buried fragments in debris flow deposits, they concluded that the least stable channel deposits were scoured out every few years (Keller and Capelli 1992), while the most stable deposits were several hundreds of years old. Hence, by combining information on the hydrologic and geomorphic processes active in the watershed, it is possible to determine the type, longevity, and morphology of the template upon which the wetlands exist.

After establishing the overall patterns of hydrologic and geomorphic processes in the watershed, the next step in this analytical process is to determine whether there is a systematic association among wetland types, biologic communities, and these physical characteristics. In our study, we have chosen correspondence techniques for this analysis. Detrended correspondence analysis is an indirect gradient technique, or ordination technique, that uses an iterative algorithm to force complete independence of axes representing species and samples based on eigenvector scores (DECORANA software - see Hill 1973; Hill and Gauch 1979a; Gauch 1982 for a detailed description). This technique is preferable to principal components analysis for biological community applications, because it does not require a strongly homogeneous or linear dataset (Gauch 1982). Once the species and samples have been processed to obtain stable and independent axes of variation, the environmental variables can be applied to determine the degree to which the environmental parameters determine the total variability of the modelled data. Environmental variables analyzed for the entire watershed included elevation, slope, slope-elevation, aspect, and hydrologic regime. Ferren et al. (1990) reported ordination analyses for the deltaic region based on environmental variables that included flooding regime, elevation above mean sea level, salinity, and distance from the ocean.

Assessment of Functions and Values

For the assessment functions and values of wetlands in the Ventura River Basin, twelve reference sites were chosen that represent the environmental gradients present in the basin, including upstream to downstream variations in riverine and riparian corridors, terrestrial to aquatic transitions, climate variability, sediment and nutrient availability, tidal range, salinity gradients, and degree of human impact. Each of the twelve reference sites is a mosaic of wetland types that spans several of these environmental gradients, yet represents for each area of the watershed a typical community with multiple wetland types at the finer spatial resolution of a few meters to tens of meters. The functions that were assessed were grouped into three major categories. For hydrology function, the subcategories of flood control, groundwater discharge, groundwater recharge, and shoreline protection/sediment stabilization were assessed. For biogeochemistry/water quality function, the subcategories of wastewater treatment, removal of toxic substances, and removal of nutrients were assessed. For foodchain support/nutrient cycling, the subcategories of primary production, decomposition, nutrient export, and nutrient utilization were assessed. For socio-economic values, two subcategories were recognized. Non-consumptive uses such as recreation, research, and natural heritage were assessed and consumptive uses such as gravel extraction, fisheries, and crops were also assessed. A fourth ecosystem function, abitat function was assessed for the five wetlands systems, rather than for the twelve reference sites. The habitat function was based on sensitive species for the Ventura River Watershed, because we assumed that presence of sensitive species represents the highest level of function for any wetland type.

For most of the basin, the wetlands tend to be nearly pristine to moderately impacted. Therefore, to express the range of functionality in the watershed, two case studies are presented that represent the extremes of human modification of the wetlands of the watershed. In the first case, Mirror Lake is a palustrine vernal lake that has been heavily impacted and is unlikely to ever return to its natural condition. In the second case, a gravel extraction site has been revegetated and rare species have been seen in the recovering wetlands.

DESCRIPTION OF WETLAND TYPES AND DISTRIBUTION

To describe adequately the distribution of wetlands in a watershed as large as the Ventura River Watershed it is critical to determine the level of detail required. In our analysis, we emphasized characterizing the variety of wetlands present and the range and types of their functionality. Typically, different wetland types could be distinguished at spatial scales of meters, and it was rare that any field site showed the presence of just one wetland type. The most important parameters for distinguishing the wetlands at the finest spatial resolution are the hydrogeomorphic unit and dominance type. The flexibility of the classification hierarchy is that it allows for this fine spatial classification and also provides a means for a broader classification of wetland ecosystems. In the following five subsections, the general characteristics of wetlands in each of the five systems are described and important wetlands in each system are highlighted. After these descriptive sections, the wetland characteristics for the entire watershed are quantified, summarized, and analyzed with respect to the regional physical characteristics. Appendix XV-2 contains a complete catalogue of the wetland types identified during our surveys and those of Ferren et al. (1990). The numbered sites are located on the map in Figure X-5.

Marine System

The description and classification of the marine wetlands are based on material presented by Ferren et al. (1990). The wetland site number for all of the marine wetlands is 201. The marine wetlands of the Ventura River Watershed are an extension of the Ventura River Delta. This delta consists of rock and cobble deposited by the Ventura River and sorted by ocean waves, tides, and currents. The cobble material ranges in size from 10-92 cm in diameter and is composed primarily of various types of sandstones from the marine formations in the basin. Approximately 2.2 km of cobble habitat exist along the Ventura River Delta (Fig. X-6a). Large and small boulders are also scattered in this area.

Thirteen different wetland types were classified, primarily distinguished on the basis of dominance type and degree of flooding by tides. Only one hydrogeomorphic habitat was classified (delta). The habitats can generally be divided into high, mid, and low intertidal in terms of the community grouping. The rocky shore at the upper margins of the shoreline is 0.8 to 0.3 m above Mean Lower Low Water (MLLW). This area is flooded and exposed by tides diurnally. The upper tidal areas are dominated by a variety of algae, including *Enteromorpha* spp., *Ulva* spp., and *Chaetomorpha linum*. There are also areas where Bryopsis corticulans is relatively common. A number of red algae such *Porphyra* spp. and *Grateloupia doryphora* can also be seasonally abundant as an over story.

In the mid reaches of the shoreline (0.3 to -0.2 m MLLW), the aquatic bed is flooded and exposed during most diurnal tidal cycles. The mid-tidal area is dominated by a combination of green and red algae. Dominant species include *Gigartina* spp., *Porphyra* spp., *Ulva* spp., and *Polysiphonia* spp.

At the lowest margins of the shoreline (-0.2 to 0.4 m MLLW) the area is almost continuously flooded, with exposure occurring only during minus tides. The lower tidal area contains the richest composition of species, with representatives from all major algal groups. Dominant algae species include *Gigartina* spp., *Ulva* spp., and *Gracilaria* spp. Additionally, the lower margins are dominated by dense beds of the marine angiosperms *Phyllospadix* spp.

Estuarine System

The description and classification of the estuarine wetlands are based on material presented by Ferren et al. (1990). The wetland site number for the estuarine wetlands is 201 (see catalogue). The estuarine wetlands form a transitional zone between the marine wetlands and a variety of riverine and palustrine wetlands (Fig. X-6b). Mud, sand, and cobbles comprise the substrate for the estuarine wetlands.

Twenty-six different wetland types were distinguished in this estuarine intertidal environment. The primary distinguishing characteristics include hydrogeomorphic habitats (8), dominance type, salinity, and degree of flooding. The persistent emergent vegetation is dominated by perennial herbaceous species that usually have aboveground parts that persist from year to year or that produce enough biomass that the standing dead, aboveground parts affect the nature of the habitats. Among the hydrogeomorphic habitats with persistent emergent vegetation is the low-intertidal-brackish-marsh unit that occurs on the margins of the estuary near the highwater elevation of flooded lagoonal conditions. The characteristic species are Narrowleaf Cattail (*Typha domingensis*) and California Bulrush (*Scirpus californicus*). Similar vegetation occurs in and on the margins of a permanently flooded basin near the second mouth of the river. In this area, Alkali or Prairie Bulrush

(*Scirpus maritimus*) and *Scirpus californicus* are dominant. Also in the area of the second mouth are saline soils in irregularly and seasonally flooded salt marsh habitats that support characteristic species such as Alkali Heath (*Frankenia salina*), Jaumea (*Jaumea carnosa*), Pickleweed (*Salicornia virginica*), and Coastal Saltgrass (*Distichlis spicata*). These wetlands could be listed in the Palustrine System because during dry seasons and drought they are infrequently flooded by marine or riverine water, and typically are wetted by precipitation or high water table conditions. However, there hydrologic character is dynamic and depending on the year could easily be primarily a function of estuarine hydrology.

The emergent-nonpersistent vegetation generally lacks aboveground persistent parts and is frequently composed of annual plants that colonize seasonally or regularly exposed habitats. In the estuary, emergent-nonpersistent vegetation occurs in intertidal wetlands consisting of exposed lagoonal bars, benches, and shallow channel beds (Fig. X-6b). Vegetated wetlands of this type are uncommon in southern California and may be characteristic of or even restricted to lagoonal estuaries that occur at the mouths of rivers. Because brackish rather than saline or hypersaline conditions prevail and because habitats are often exposed for weeks, annual plants can colonize habitats that do not exist or are infrequent in estuaries with a greater marine influence. The characteristic emergent-nonpersistent vegetation is characterized by the native species Spear-leaved Saltbush (*Atriplex patula*), Coast Goosefoot (*Chenopodium macrospermum*), and Salt Marsh Sand Spurrey (*Spergularia marina*). Introduced species include Brass Buttons (*Cotula coronopifolia*) and Rabbitsfoot Grass (*Polypogon monspeliensis*).

The nonpersistent emergent wetland communities of the Ventura River Estuary are quite different from those of estuaries in southern California with euryhaline marshes. Annual plants in the latter type grow when precipitation during the winter leaches salts from upper marsh and transitional margins of deltas (Ferren 1985; Ferren et al. 1987; Calloway et al. 1990). These annuals die when a return to drought conditions in spring produces hypersaline soils. *Spergularia marina* apparently is the only dominant species that occurs in both euryhaline and brackish nonpersistent emergent wetlands.

Scrub/shrub wetland is characterized by low-growing, woody species that may be shrubs or juvenile/stunted trees. In the delta region the scrub/shrub wetlands are largely transitional to Palustrine scrub/shrub wetlands. On the margins of the Ventura River Estuary, they occur near the limit of high water during lagoonal conditions and are characterized by narrow bands of Mule Fat (*Baccharis salicifolia*), Arroyo Willow (*Salix lasiolepis*), and Sandbar Willow *(Salix exigua)* that develop between the estuarine emergent wetlands and palustrine forested wetlands. In the vicinity of the second mouth, scrub/shrub wetlands are found on the margins of the salt marsh hydrogeomorphic unit supporting emergent wetland types. The primary shrub on the saline soils is Brewer's Saltbush (*Atriplex lentiformis*), which is generally mixed with herbaceous species such as Pickleweed *(Salicornia virginica)* and Western Goldenrod (*Euthamia occidentalis*). The proximity of this wetland to the estuary and association with salt marsh species distinguishes it from the palustrine wetlands. Other woody species that are minor elements of the vegetation include *Baccharis salicifolia*, *Salix lasiolepis*, and the invasive Salt Cedar (*Tamarix ramosissima*).

In the deepest parts of the estuary aquatic bed vegetation of both the submerged, rooted vascular and the floating type have been observed. The rooted vascular type can grow in subtidal habitats and intertidal flats or channels. Fragments of Spiral Ditchgrass (*Ruppia cirrhosa*) have been found floating in the lagoon and probably were uprooted from the subtidal habitats in the estuary. It has been observed to grow in the permanently flooded estuarine habitats near the second mouth, where salinities range from 10-16 o/oo. Floating aquatic bed vegetation occurs in the estuary under lagoonal conditions when the surface salinity approximates 0.5-2 o/oo. During these times *Lemna minor*, *Azolla filiculoides*, and often *Entermorpha intestinalis* are found in floating masses on the margins of the lagoon. The freshwater species of Duckweed and Duckweed Fern probably were washed down the river into the estuary, where they can persist as long as the conditions are only slightly brackish.

Lacustrine System

Lake Casitas supports wetlands around much of its perimeter. On field visits to numerous sites in the summer of 1993, many wetland types were observed, most of which are present along the northwest shore near site 155 (Figs. X-5 and X-7). Matilija Reservoir also supports lacustrine wetlands, but these were not documented in detail for this study and generally appear to be duplicated in type by the wetlands observed at Lake Casitas. Lake Casitas is a artificial canyon reservoir that drowns the lower reaches of several streams, including Coyote and Santa Ana Creeks. The shoreline is a mix of bedrock, mixed-coarse sediment, and mud, with the mix depending on the proximity of the site to debris and sediment input from one of the drowned tributaries.

Eleven lacustrine wetland types were observed at site 155, mostly distinguished on the basis of flooding duration, dominance type, and hydrogeomorphic unit (2). Shores of bare rock, and unconsolidated cobbles and mud are common as the water level of the reservoir seasonally falls and rises. These wetland areas tend to support a minimal vegetation cover and likely vary in extent depending on climatic conditions and dam management. The littoral bed supports aquatic-bed rooted-vascular species dominated by Burhead (*Echinodorus berteroi*) under intermittently exposed conditions. Associated rooted-aquatic-bed plants include *Najas marina* and *Zannichellia palustris*. Emergent nonpersistent vegetation that is typically seasonally flooded includes Bermuda Grass (*Cynodon dactylon*), *Ammania coccinea*, Sedges (*Cyperus* spp.), and Docks (*Rumex* spp.). *Echinodorus berteroi* also was observed on semi-permanently flooded beds as emergent nonpersistent vegetation.

Riverine System

Riverine wetlands are characterized by nonpersistent vegetation that reflects the unstable and stressful physical characteristics of the environment (Fig. X-8). In the Ventura River Watershed the water regimes cover the full range from ephemeral to intermittent to perennial streams and rivers, thus providing representatives of six out of the eight riverine subsystems, including upper, mid, and lower intermittent and perennial. Among the 126 individual riverine wetlands documented in the basin, there were 85 distinct types, including 7, 13, 3, 16, 22, and 24 types in upper, mid, and lower intermittent and perennial, respectively. Although dominance type was important in distinguishing these riverine wetlands, the most important parameters for differentiating these wetlands were hydrogeomorphic unit (23 different types) and flood regime.

Substrate in the channel centers changes broadly from bedrock and boulders in the upper reaches, to mixed cobbles and gravel in the middle reaches, to patchy boulder, cobbles, gravel, mud, and sand in the downstream reaches. Stream margins are variable from boulders to mud with inconsistent relationships to elevation, in part due to lithology changes in the underlying rocks. The slopes in the upper intermittent and upper perennial reaches are similar and vary from 5 to 45% . The mid-intermittent reaches have slopes between 4 and 35%, whereas the mid-perennial reaches have much lower slopes of 1 to 3%. The lower intermittent reaches have slopes from 4 to 18%, whereas the lower perennial reaches have slopes less than 1%. The hydrogeomorphic character of the riverine system ranges from spring-fed, nearly vertical falls on bedrock that are permanently flooded (Site 10) to intermittent streams that are temporarily flooded for perhaps just hours after a storm (Site 39), to perennial flow in the lower reaches (Site 201) supported by dam and effluent ouflow.

Intermittent rivers and streams typically support annuals (*Mimulus cardinalis*) on the seasonally exposed stream margins and occasionally on the streambed and aquatic-bed vegetation dominated by Green algae spp. (Chlorophyta). Not until the mid-perennial reaches of the river system does it support a substantial variety of emergent persistent and nonpersistent dominants in the riverine wetlands. In the middle reaches of the perennial streams emergent persistent dominants observed included *Agrostis viridis* and Water cress (*Rorippa nasturtium-aquaticum*). Furthest downstream at sites 141 and 201 a wide array of associations exists. On the stream margins of the river channel various annuals thrive including naturalized species such as *Conyza canadensis* and *Gnaphalium luteoalbum*. In more frequently flooded areas, lower on the channel margin, often next to permanently flooded areas, dense mixtures of native and naturalized species exist. Typical species include Dotted Water Smartweed (*Polygonum punctata*), Northern Willow-Herb (*Epilobium ciliatum*), and Water-parsnip (*Berula erecta*). Common naturalized species include Brass Buttons, Water Primrose (*Ludwigia hexapetela*), *Rorippa nasturtium-aquaticum*, and Water Speedwell (*Veronica anagallis-aquatica*).

Aquatic bed vegetation in the lower reaches occurs both as a submerged, rooted-vascular type and a floating type on the Ventura River. The shallow, perennial nature of the lower river provides potential habitat for numerous species, but few have been collected. Leafy Pondweed (*Potamogeton foliosus*), Fennel Pondweed (*Potomogeton pectinatus*), and Horned Pondweed (*Zannichellia palustris*) were collected and described by Smith (1976). The apparent lack of native submerged rooted-vascular species could be the result of a combination of water pollution and invasion by exotic species such as Watercress. Floating aquatic-bed vegetation like Duckweed (*Lemna minor*) and Duckweed Fern (*Azolla filiculoides*) appears to thrive in isolated mats at channel margins, in backwater pools, and seasonally-flooded/dessicated beds and benches.

Palustrine System

The palustrine wetlands system includes the bulk of the wetland types documented by our surveys of the Ventura River Watershed. From the total of 562 wetland sites and 400 wetland types, 390 are palustrine wetlands divided into 265 types. For the sake of discussion, the palustrine types will be divided into wetlands associated with the riparian corridor, vernal wetlands, and others.

Riparian Corridor Wetlands. For the riparian corridor palustrine wetlands the environmental gradients most critical to determining their distribution throughout the watershed are topographic, hydrologic, degree and frequency of disturbance, and somewhat less, variation in the local substrate. In addition, like the riverine wetlands, the stability of the landform forming the wetland template to some degree determines the age and structure of the community residing on the landform. Travelling from the upstream end to the mouth of the river, it is possible to describe a fairly regular sequence of communities that create the mosaic of wetland types associated with the riparian corridor. In many instances this mosaic consists of aquatic vegetation, emergent annuals, scrub/shrub, and then forest sequentially at increasingly higher elevations and greater distances from the water source.

In the headwaters of the watershed, streams are frequently intermittent and therefore support wetland vegetation on temporarily flooded surfaces or through groundwater flow. One example of a wetland community in these high elevation, steep reaches is site 67 (in the north central part of the watershed) which supports the emergent persistent species *Artemisia douglasiana* on a temporarily flooded floodplain, whereas California Bay (*Umbellularia californica*) is supported as a phreatophytic species on the stream terrace, which is ten's of centimeters above the floodplain surface. An additional, characteristic upstream site is site 31 (in the headwaters of the San Antonio Creek subwatershed) where White Alder *(Alnus rhombifolia)* is a dominant in a forested broadleaved deciduous floodplain (see other example from Matilija Creek in Fig. X-9) that also has a thick cover of *Rubus ursinus* in a scrub/shrub type. White Alder requires at least temporary flooding, in contrast to the phreatophytic mixed deciduous and evergreen forest with *Platanus racemosa* and *Umbellularia californica* as dominants on the slightly higher stream terrace. The presence of an *Alnus rhombifolia* and *Platanus racemosa* forested-mosaic is common on many of these upstream floodplains. On thirteen stream terraces at sites throughout the upper parts of the watershed, *Platanus racemosa* was found as a dominant. Frequently present as emergent persistent vegetation in the temporarily-flooded to permanently-saturated areas is *Mimulus cardinalis*, whereas Green Algae spp., *Adiantum capillus-veneris*, and *Lobelia dunnii* are most frequently found in the seasonally-flooded to permanently-saturated regions. In some areas, such as site 103 (also in the San Antonio Creek headwaters), the driest parts of the stream banks, in transition to upland conditions, support phreatophytic oak species such as *Quercus agrifolia* and scrub/shrub evergreen species such as *Ceanothus spinosus*. The slightly wetter floodplain surfaces tend to support *Baccharis salicifolia* as a dominant in scrub/shrub communities.

In the middle reaches of the watershed, where floodplains tend to be more extensive, reworking of the floodplain and terraces takes a longer time, and flows are more long-lived, the mosaic of floodplain types associated with the riparian corridor expands. Across the transition from wettest to driest using sites 83, 84, 85, 87, and 88 on San Antonio Creek for examples, it can be concluded that the wettest part of the temporarily-flooded streambed supports emergent persistent species such as *Cyperus eragrostis* and the invasive weed, *Arundo donax*, whereas the floodplain supports a scrub/shrub community with occurrences of *Salix lasiolepis*, *Salix laevigata*, and *Baccharis salicifolia*. The stream terraces tend to support phreatophytic broadleaved-deciduous species like *Platanus racemosa* and *Quercus lobata*, frequently with *Toxicodendron diversilobum* and *Rubus ursinus* as an understory. At site 88, the furthest downstream sample, Black Cottonwood *(Populus balsamifera,* ssp. *trichocarpa)* is a dominant on the temporarily-flooded floodplain whereas the understory is a mix with the annualCocklebur (*Xanthium strumarium*) as a dominant.

Entering the mainstem of the Ventura River near its confluence with San Antonio Creek, sites 121 and 130 are characteristic of the rich mix of wetland communities in the riparian corridor. Figure X-8 shows a palustrine forested wetland with *Populus balsamifera,* ssp. *trichocarpa* as a dominant on low terraces. The terraces also support scrub/shrub species including and *Malosma laurina*, the invasive exotic Spanish Broom (*Spartium junceum*), and exotic weed Fennel (*Foeniculum vulgare*). Moving closer to the channel and water table, the forest transitions to a mixed willow forest supporting *Salix laevigata* and *Salix lasiolepis*, which in this area are actually situated in an seasonally saturated, artificial drainage swale resulting from construction of a levee and bike path near the river. The scrub/shrub community is dominated by Mule Fat and Coyote Brush.

In the reaches of the Ventura River upstream of Casitas Springs, the river and floodplain widen to an average of 600 m. Through this braided stretch of the river, channel alteration is frequent and thorough, leaving behind a landscape in a perpetual state of disturbance that is frequently dry. This reach of the river supports predominantly scrub/shrub wetlands with a mix of *Baccharis* spp. and *Eriogonum fasciculatum*.

Downstream of Casitas Springs an impermeable sediment layer forces a continual flow of spring water into the channel. Here, the river channel pattern and floodplain character changes dramatically in part due to levees and other flood control structures that have been in place since the late 1890's. Although not as extensively braided as in the reach upstream of Casitas, the channel in this reach is still remarkably active, albeit over a smaller area (average alluvial width is only 300 m). Keller and Capelli (1992) and Hunt (1992) reported that the entire riverbed was essentially scoured out and replaced during the storms of 1991 and 1992. Extensive floodplain deposition and erosion also occurred.

Persistent emergent vegetation along the channel margins in this reach, which are seasonally or permanently flooded, is characterized by *Typha* spp., bulrushes such as California Bulrush (*Scirpus californicus*), *Ludwigia hexapetala*, and rushes such as Iris-leaved Rush (*Juncus xiphiodes*) (Ferren et al. 1990). The area is frequently invaded by exotic species like Fennel, Cocklebur, and Giant Reed, because of the high level of substrate disturbance.

The mixed scrub/shrub vegetation in this reach typically establishes itself soon after storms have reworked the substrate. The moisture regime may be quite variability, depending on the width of the floodplain, types of soil, and relative location of river water and ground water. The dominant species include Fennel, Mule Fat, Scale-broom (*Lepidospartum squamatum*) and immature Arroyo Willow. The higher elevations support vegetation transitional to upland communities and may include the hydrophytes Mule Fat and Arroyo Willow and facultative species such as *Artemisia californica* and *Ceanothus oliganthus*.

The forested wetlands in this region (sites 141 and 201) are a rich mosaic of broad-leaved deciduous types, whose variability is primarily determined by topography, water availability, and disturbance history. The richest mix of tree species occurs near the channel, along the seasonally flooded channel margins. It typically includes a mixed stand of White Alder, Arroyo Willow, Red Willow, and Yellow Willow (*Salix lasiandra*). In some locations Arroyo Willow completely dominates the forest. Higher up on drier, floodplain soils, more mature forests have developed, in part because of their hydrogeomorphic unit is more stable. In these drier areas Arroyo Willow may dominate, but often there is a mix of Black Cottonwood *(Populus balsamifera*, ssp. *trichocarpa*), Arroyo Willow, California Walnut *(Juglans californica*), Blue Elderberry (*Sambucus mexicana*), and Castor Bean (*Ricinus communis*). Lianas grow rampant in these moist forests including Poison Oak, Virgin's Bower (*Clematis ligusticifolia*), California Blackberry, and Wild Cucumber (*Marah fabaceus*). Native shrubs frequently found include California Hedge Nettle (*Stachys bullata*), Few-Seeded Bittercress (*Cardamine oligosperma*), Common Eucrypta (*Eucrypta chrysanthemifolia*), and California Figwort (*Scrophularia californica*).

Vernal Wetlands. Vernal wetlands are included in the Palustrine System, and three distinct types exist in the watershed. The most frequently occurring vernal wetland is the vernal freshwater marsh. A type example, can be found at site 211 near the Coyote and Santa Ana drainages. This relatively flat, somewhat depressional area appears to lie along the Arroyo Parida Fault and may be depressional due to activity along the fault. Site 211 comprises two hydrogeomorphic units, including a vernal drainage channel and the vernal freshwater marsh. The species dominance is different in the two habitats, with the naturalized weedy species *Lolium multiflorum* and *Briza minor* and emergent persistent *Eleocharis macrostachya* dominants in the drainage channel. Several emergent persistent species are present in the vernal marsh, including *Ambrosia psilostachya*, *Lotus scoparius*, *Lythrum hyssopifolia*, and *Rumex crispus*. Vernal freshwater marshes of a similar configuration and supporting a similar community are located at several locations between the Arroyo Parida, Oak View, and Lion Fault Zones. These faults tend to tilt valley floors and constrict the drainage through the faulted valleys, hence, creating ideal conditions for the temporary saturation associated with vernal habitats.

One of the most unusual examples of a vernal habitat in this faulted region occurs near the east side of the drainage along Lion Fault. Site 162 (Fig. X-10) represents one of only two vernal plains observed in the southern California coastal drainages. At nearly 100 acres (40 hectares) it is the largest expanse of a vernal hydrogeomorphic habitat found in the Ventura River Watershed. The species are dominated by nonpersistent types, most prominently naturalized *Polypogon monspeliensis* (Rabbitsfoot - see Fig. X-10b). Additional species include the naturalized weedy species *Anthemis cotula* and the emergent nonpersistent *Juncus bufonius*. The hydrogeomorphic setting for this particular vernal plain habitat is that it lies between Lion Creek to the north and Lion Fault to the south. Sources of water could include the alluvial fans upslope and to the east of the vernal plain. Additionally, springs coming out of the faulted terrain along Lion Fault may contribute flow. All of this flow causes seasonal flooding that is sufficient to support a vernal wetland. The direction of flow is west and downstream towards Lion where the vernal plain abruptly drops off into the creek.

One of the most significant vernal habitats associated with the Oak View Fault Zone is Mirror Lake (site 205 - Figs. X-5 and X-11). It is a wetland that is formed in a structural basin likely along one limb of the flexural slip faults of the Oak View Fault Zone (Rockwell et al. 1984). Before extensive impacts reduced its size and changed its hydrology, Mirror Lake was a natural palustrine-vernal-lake of which there are few in southern California. In the sequence of open water bodies that includes pools, ponds, palustrine lakes and lacustrine lakes, Mirror Lake was larger than pools and ponds, but smaller than lacustrine lakes that are generally at least 20 acres in size and have wave-formed shorelines and limnetic zones. The flooding regime was seasonal but the duration was sufficiently long to support species that characterize pools, ponds, and lakes. Vernal pool and related indicator species include, for example, *Pilularia americana*, *Marsilea vestita*, *Isoetes howellii*, *Eleocharis acicularis*, *Crassula aquatica*, *Callitriche marginata*, and *Elatine brachysperma*. Vernal pond and lake species included *Alisma plantago-aquatica* and *Ammannia coccinea*. Freshwater marsh and aquatic bed species included *Scirpus californicus*, *Typha latifolia*, *Eleocharis macrostachya*, and *Potamogeton* spp. It was unique in southern California, because it is the only site where the endangered species *Sagittaria sanfordii* occurred until ca. 1980. Impacts such as the construction of roads, homes, a care facility, and drains have contributed to the reduction in size and loss of flooding. In spite of these impacts, it still supports *Alisma* and *Eleocharis* spp. and various native and introduced hydrophyte species typical of freshwater marsh habitats. Although many of the indicator species apparently have been eliminated, Mirror Lake remains unique in Ventura County and southern California.

Wetlands Associated With Seeps and Falls. The Palustrine System also includes seeps, falls, and springs, which may or may not flow into a channel system. Most of the seeps and falls in the Ventura River Watershed maintain extensive, saturated wetland areas for a good part of the year, if not all of the year. Many of these seeps and falls are located along structural elements, such as faults, or at lithologic boundaries where the flow of water may be prevented by the presence of an impermeable formation. These waterways tend to support lush, emergent persistent vegetation almost always with *Lobelia dunnii*, *Adiantum capillus-veneris*, Green algae spp., and *Mimulus cardinalis*. Although there may be sufficient water, slopes in these seep areas are on average too steep to support wetlands dominated by heavier vegetation such as shrubs and trees.

Some of the differing water properties of the seeps and falls found in the Ventura River Watershed include sulfur-affected cold springs and petroleum-affected springs. For example, the sulfur-affected cold spring at site 23 (in the Matilija subwatershed) supports Green Algae spp. on a semi-permanently flooded aquatic bed, and *Leptochloa uninverva* and *Salix lasiolepis* on permanently saturated muddy surfaces. An extensive wetland community is supported at site 73 (in the San Antonio subwatershed) by a petroleum-affected spring and adjacent stream. In the marsh area a community of emergent nonpersistent species including *Polypogon monspeliensis* and *Xanthium strumarium*, and persistent species, *Agrostis viridis*, *Juncus mexicana*, and *Typha latifolia*, are supported by nearly permanent flooding on landforms nearly entirely constructed of tar. There is sufficient water along the spring margins to support *Juglans californica* with scrub/shrub areas dominated by *Salix lasiolepis*, *Baccharis salicifolia*, and *Clematis ligusticifolia*. It is not unusual to find petroleum-affected streams and springs in this oil-rich watershed, although they do not always support unusual species.

Watershed Distribution

The catalogue for wetlands for the Ventura River Watershed cumulatively lists 562 different wetlands (Appendix XV-2). Of these 562 different wetlands, there are 400 types divided amongst 70 hydrogeomorphic units (Table X-1) and 147 different dominants, including 141 plant species and 6 cover types (Table X-2). Each of the wetlands systems is represented with the total number of types in each equal to 13 for Marine, 26 for Estuarine, 11 for Lacustrine, 85 for Riverine, and 265 for Palustrine. As expected the largest number of wetland types is in the Palustrine System, which includes wetlands associated with all of the different hydrologic environments in the system. The individual types of wetland also are distributed into many of the Subsystems, including one Marine Subsystem (Intertidal), one Estuarine Subsystem (Intertidal), and six of the eight Riverine Subsystems (Upper, Mid, and Lower for both Intermittent and Perennial). Based on its climate, rugged terrain, proximity to the ocean, and presence of reservoirs, the watershed was expected to represent fully the range of waterbody types likely to exist in southern California watersheds. Because of these factors, especially the interaction between the regional precipitation and topography, the wetlands in the watershed thrive across the continua of flooding regimes. This conclusion can be seen in the fact that the water regimes from irregularly-exposed to seasonally-flooded in the tidal water-regime and from permanently-flooded to phreatophytic in the nontidal water-regimes are documented for the watershed based on our survey. The only nontidal water-regime not included in our catalogue is the intermittently-exposed regime. The absence of intermittently-exposed sites may be an artifact of the timing of our field visits. Full seasonal investigations of individual sites would be required to determine with absolute certainty the flood conditions of each site.

The diversity of types in the watershed is not surprising given the wide array of physical conditions present in the basin. In performing a watershed analysis of the distribution and function of wetlands, it is necessary to determine what are the systematic relationships among physical parameters and wetland types. This information is necessary in order to be able to predict the potential for wetlands to exist in sites where field visits and more detailed investigations were not possible.

In the case of the Ventura River Watershed our data on wetland types come from two main sources: (1) an earlier study on the deltaic region (Ferren et al. 1990) and (2) our more recent survey of over 100 sites between the summers of 1993 and 1994. With regard to the watershed analysis and determining the extent of the Marine and Estuarine Systems and associated Palustrine wetlands, we have sufficient data to determine the general relations between the physical conditions and wetland types and to determine the areal extent of the different wetland types in the deltaic region.

Ordination Analyses. Ferren et al. (1990) reported ordination analyses for 49 relèvè plots that showed fairly consistent patterns among vegetation communities and species groupings. Twelve main species groups were identified by examining the three most abundant species in each plot, and these communities were then related to the elevation/flooding potential for the sites. The species groups grade from beach and persistent estuarine through nonpersistent estuarine, coastal scrub, riverine, and woodland communities. The salinity gradient was difficult to determine in detail from their analyses, because it was not clearly separate from the moisture and tidal flooding gradient from the ocean towards land. In addition, the salinity conditions in both the marine and estuarine environment depend on whether the mouth of the estuary is closed, and, therefore, are seasonally inconsistent. They concluded that a complex of inter-related environmental factors such as elevation, flooding, salinity, and distance from the ocean contribute to the variability in the communities.

To investigate whether there is a systematic variation in the distribution of wetland types and species dominance throughout the watershed in the Riverine and Palustrine Systems we performed gradient analyses on species and environmental data (Fig. X-12). Our canonical correspondences was based on classifying moisture gradients on a scale of 1 through 9, with permanently flooded assigned 1 and phreatophytic assigned 9. Elevations from USGS 7.5' topographic sheets and slope measured with a clinometer in the field or from the topographic sheets were combined to yield an elevation-slope gradient. The results shown in Figure X-12 are based on data from 488 samples taken at 130 sites, where there were 92 dominant species.

Canonical correspondence analysis showed a very high correlation between canonical axis 1 (cc1 - Fig. X-12) and regime (-0.8453) and was also correlated with slope (0.2185). This axis accounted for 49.4% of the canonical variance. Axis 2 (cc2 - Fig. X-12) had a high correlation with slope (.6024) and elevation (.4413). This axis accounted for 30% of the canonical variance. The first axis (regime) was found to be significant at the 1% level.

The slope-elevation gradient provides an explanation of the greatest amount of variability of wetland type, whereas the regime gradients were most strongly correlated with vegetation type. Much of the variability due to slope-elevation is expressed by the extreme values given to *Adiantum capillus-veneria* and *Lobelia dunnii* (Fig. X-12), which occur on nearly every waterfall in the Ventura Basin. In addition, *Arundo donax* is found only at the lower elevations, possibly due to the fact that it was initially planted in these areas and has not yet dispersed to higher elevations. Regime was also important to species variation, with algae clearly the wettest dominance type in the basin, followed by marsh species such as *Typha* spp. and *Juncus* spp., and waterfall species such as *Adiantum capillus-veneria* and *Lobelia dunnii.* Tree species that are frequently phreatophytic, such as Western Sycamore (*Platanus racemosa*), Southern California Walnut (*Juglans californica)*, Broad-leaved Maple (*Acer macrophyllum)*, and California Bay (*Umbellularia californica)*, fall at the other end of the spectrum.

The ordination techniques indicate that in all of the systems there is a strong relationship between water regime and wetland type as represented by species dominance. In addition to water regime, the wetland type also varies as a function of the hydrogeomorphic unit. In the riparian corridor, this variation with respect to hydrogeomorphic unit can be expressed with respect to individual river-floodplain-terrace cross section or as a upstream to downstream trend in landform type and extent. To estimate the potential areal coverage of wetlands along the riparian corridors, it is necessary to estimate the areal cover of landforms upon which the wetland types exist.

Estimate of Areal Distribution. Basic drainage basin geomorphology suggests that there is a systematic variation in the landforms that exist along streams and rivers as the order of the stream increases (Chorley et al. 1984). In the steepest headwaters of the Ventura, the riparian corridor averages 3 m wide and is a mix of bare bedrock and occasional bar deposits that are unstable. Further downstream, in slightly less steep terrain, the channels widen to an average of 5 m and sufficient alluvial deposits exist to support some scrub/shrub vegetation. In the second and third order streams, the corridor widens to 15 to 25 m. The landforms are more diverse and include channel bed and bars, debris flow deposits (Best and Keller 1992), and occasional floodplain and terrace deposits in the wider valleys. Along the main fourth-order streams of the basin (e.g., San Antonio Creek) in their lowermost sections, the alluvial cross section varies between 25 and 100 m on average and includes multiple configurations of channel landforms (including back-bar channels), bar forms, debris deposits, floodplain landforms, and terraces. Along the fifth-order channel of the Ventura River the alluvial cross section averages 600 m in the braided reach and 300 m elsewhere.

This consistent downstream increase in the wetland area along riparian corridors in the basin is complicated by the influence of tectonic activity in the basin. Rockwell et al. (1984) described in detail the development of terraces in response to uplift and tilting in the Oak View Fault Zone. Terraces abound where the river crosses the Ventura anticline near its mouth. Additionally, we observed that when a fault crossed a stream channel, frequently the channel pattern changed abruptly by carving nearly 180° bends around the faulted zone. Apparently as a result of this channel change the floodplain upstream of the fault crossing tended to be wider. Hence, the interaction of streams and faults in many places in the basin results in wider floodplains, thus providing potentially more wetland area.

As described earlier, the geology and tectonic structure also impacts the distribution of the vernal wetlands in the basin. They typically are aligned with faults in depressional zones and their hydrology typically is the result of drainage derangement along the fault gouge zones. Falls and seeps also are closely associated with fault zones.

In conclusion, the distribution of wetlands in the Ventura River Watershed is a function of the proximity to the ocean and the interaction of the rugged topography and climate (Fig. X-2). Imprinted on these topographic and climatic gradients is the structural character of the basin, which influences the placement of many wetland types and impacts channel-floodplain development.

Having shown that the distribution of the wetlands in the basin is somewhat predictable, based on the gradients in physical characteristics, it is now possible to estimate the areal cover of wetlands in the entire basin, as summarized in Table X-3. For the Marine and Estuarine systems, we relied on areal estimates reported by Ferren et al. (1990). These estimates show that 0.01 km^2 of the deltaic wetlands are in the Marine System. The Estuarine System covers 0.11 km of the deltaic region, including areas near the second mouth of the river. For the Lacustrine System we assumed that on average the wetlands covered 50 m around the circumference of Lake Casitas and Matilija Reservoir. Lake Casitas is about 25 km around and Matilija Reservoir is about 3 km around. This yields 1.4 km^2 of lacustrine wetlands. The areal cover of vernal wetlands was separately calculated to be approximately 1.0 km^2, including Mirror Lake at 0.5 km^2, the vernal plain at 0.4 km^2, and vernal marshes totalling 0.1 km^2 (Table X-3).

To estimate the Riverine and Palustrine wetlands associated with riparian corridors we made the following calculations. There are 600 km of channels in the headwater region, with potential wetland areas averaging 2 m wide, yielding 1.2 km^2. First-order streams total 390 km in length with wetland areas averaging 3 to 5 m wide, yielding 1.7 km^2 of potential wetland area. The second and third order streams total 90 km in length with wetland areas averaging 15 to 25 m, yielding 1.7 km^2 of potential wetland area. For the fourth order streams of all of the subwatersheds, the streams total 94 km in length with floodplains varying between 25 and 100 m wide, yielding potential wetland area on the order of 5.2 km^2. The potential wetland area is greatest along the mainstem of the Ventura River, where the measured total is 9.5 km^2, including 0.1 km^2 from the Matilija Creek confluence to the braided reach, 6 km^2 in the braided reach, 3 km^2 in the reach from the San Antonio Creek confluence to the estuary, and 0.4 km^2 at the mouth (Table X-3).

The estimated total wetland area for the Ventura River Watershed is 22 km^2, with the bulk occurring along the riparian corridors of the Ventura River and its major tributaries. This areal estimate comprises only 3.8% of the entire basin. From this regional perspective, clearly there is much more in this basin that is not wetland!

ASSESSMENT OF FUNCTIONS AND VALUES

When performing a watershed analysis for the distribution of wetlands, one turns from detailed site analyses to viewing the basin from a regional perspective. When visiting field sites, one is typically immersed in nature of the community structure and its relation to the local physical conditions. Most striking in these investigations are the tight links between the health of the wetland community and the degree of human impact on and interference with the physical characteristics contributing to the construction and maintenance of the wetland. It is possible to combine the regional and local perspectives on the health of wetland communities throughout a basin by selecting reference sites that represent the continuum of wetland types in the basin. Assuming a relationship between wetland type and wetland function, it is then possible to consider the functions of wetlands at the watershed scale.

For our analysis we selected 12 reference sites. The locations of the reference sites are shown with letters A through L on Figure X-5. The field site associated with each reference wetland (see catalogue in Appendix XV-2) is: A-121, 153 (Fig. X-8), B-155 (Fig. X-7), C-205 (Fig. X-11), D-201 (Fig. X-6), E-151 (Fig. X-9), F-162 (Fig. X-10), G-67, H-176, I-211, J-73, K-75, and L-141. These sites were selected to represent the usual and unusual wetland mosaics in the basin.

The functional assessment for these sites is summarized in Tables X-4 and X-5. Hydrology, water quality, and foodchain support ecosystem functions, and socio-economic values are listed in Table X-4 for all reference sites. The reference sites were recombined back to their respective wetland systems in order to perform the habitat functional assessment. Only the habitat functional assessment is based on sensitive species and we assume that they are good indicators for the health of each of the wetland systems in the basin. In the following discussion of the assessment, the reference sites will be described in the context of the ecosystem functions and socioeconomic values that they best support. After this discussion, habitats of the sensitive species as they relate to wetlands in the basin will be described and evaluated. In conclusion, management issues related to the overall health of the watershed will be discussed.

The ecosystems functions considered for this assessment are very general and broadly cover the range of important attributes associated with wetland environments. Most of these functions and their relations to wetlands have been treated exhaustively in the literature and will not be covered here. Excellent reference texts for function analysis include (Mitsch and Gosselink 1993; Brinson et al. 1993; Sullivan and Richardson 1993).

River Mouth Ecosystem. Reference Site D represents the mosaic of wetland habitats that exists at the mouth of the river. This deltaic environment is a rich association of wetlands from 4 of the 5 systems and is one of the last remaining, nearly natural river mouth ecosystems in southern California. As can be seen in Table X-4, this deltaic association of wetlands essentially supports all of the wetland functions and socioeconomic values listed except for gravel extraction and crops. Crops could even be included as there are several small subsistence gardens on the landward areas of the delta. The most important functions associated with this environment are related to the fact that it continues to be an estuarine system connected to its riparian corridor and therefore provides habitat for a number of sensitive species (Table X-4). This area provides foraging for the California Least Tern and habitat for the Tidewater Goby (Table X-5). The River Mouth Ecosystem, as represented by Reference Site D, is also extremely important ss an entry point for anadromous fish species like Steelhead Trout. The area as a whole is stable in the sense that it is not consistently gaining or losing wetland area, although it was highly altered during storms in 1992 (Keller and Capelli 1992).

The greatest impacts on this section have been the reduced water quality due to inputs from upstream sewage treatment plants and a changed hydrologic regime due to upstream flood control. However, because the dams do not control for catastrophic floods, the area is frequently reworked by storms, thus providing essential new surfaces for development of new wetland communities. Another concern in this region is the invasion of exotic plants. Many species have been identified that are presently or that could be potentially threatening to native plants, including Giant Reed, Kikuyu Grass, and Fennel. Future impacts include increased recreational use as the urban corridor expands, potentially resulting in critical damage to relatively rare and sensitive communities in especially the marine and estuarine areas. These impact themes of reduced water quality, flood control, urban expansion, and exotic species recur throughout the basin.

Lake Ecosystems. The Lacustrine System is represented by Reference Site B, associated with field sites around Lake Casitas. The wetlands along this lake are the result of the relatively recent impoundment of water (26 years ago) behind Lake Casitas Dam and include both Lacustrine and Palustrine types. The wetlands themselves provide functions associated especially with shoreline stabilization and groundwater recharge (Table X-4). Probably the most important socioeconomic values of the lake environment and associated wetlands are recreation and fisheries, as boating and fishing are extremely popular on Lake Casitas. Habitat for the Tricolored Blackbird has also increased in this area as tules of California Bulrush (*Scirpus californicus*) have developed in the vicinity of the lake (Table X-5).

Vernal Wetland Ecosystems. The most unusual wetlands in the Ventura River Watershed are the Palustrine vernal wetlands. Vernal wetlands are represented byReference Sites C (Mirror Lake), F (vernal plain), and I (vernal freshwater marsh). These are described in detail in the Palustrine System section of this chapter and represent a range of hydrologic conditions from a seasonal pond environment to a relatively dry marsh environment. As shown in Table X-4, the vernal wetlands are most important for accepting and subsequently releasing groundwater and spring discharge. During this process, if nutrients or toxic chemicals are present, they will likely be removed or utilized as the water passes through the environment. The degree to which nutrients in these systems are utilized or exported requires further research. Vernal sites are becoming more rare and, therefore, the few remaining sites are critical for research regarding California native communities and as representatives of California's natural heritage values.

The primary pressures on vernal wetlands in the Ventura River Watershed are related to agricultural activities and urban expansion. Most of the vernal marshes and the vernal plain are in pasture or crop lands and are subjected to regular ploughing and grazing. The fact that these sites continue to show vernal characteristics speaks strongly of the resiliency of these ecosystems and the potential for their full recovery if left in a natural state. For example, the pressures of urban expansion critically altered the hydrologic conditions, water quality, and extent of the Mirror Lake vernal wetlands, and resulted in the extirpation *Sagittaria sanfordii*, a Candidate 2 species (see Table X-5).

Chemically-Affected Wetland Ecosystems. Wetlands influencec by water chemistry are common throughout the Ventura River Watershed. Sulfur-affected and petroleum-affected streams and springs appear to support wetlands communities similar to those with freshwater inputs. Reference Site J is representative of these chemically-affected wetlands. As described in the Palustrine

System section (field site 73), Reference Site J is a mosaic of wetlands associated with a petroleum seep and a nearby stream. This particular site provides some area for reduction in flood flows, receives groundwater discharge from the petroleum seeps, and removes toxic substances, as evidenced by the accumulation of tar (Table X-4). Because of its water chemistry this wetland area is less likely to be used for crops or grazing. It is not clear however, what the effect of the chemistry would be on the instream fauna.

Riparian Corridor Ecosystems. The upstream-to-downstream variation in wetland function along the riparian corridors of the watershed is represented by Reference Sites E and H for upstream seeps/springs, E and G for upstream channels, H for intermediate channels, and A and K for downstream channels. Site E (field site 151 - Fig. X-9) is a mosaic of wetland types including a perennial canyon seep that seasonally floods a steep rock wall and subsequently a stream terrace and bank. This seep/spring supports the emergent persistent species *Adiantum capillus-veneris* and *Boykinia rotundifolia*, as well as the broadleaved evergreen species *Umbellularia californica*. Site H on Coyote Creek (field site 176) has a canyon-spring wetland supporting a variety of emergent-persistent and scrub-shrub species including *Apocynum cannabinum* and *Rubus ursinus*. The importance of the seeps and springs is not only that they support wetlands, but that they enhance the richness of the mosaic of wetlands at any site where they occur.

The upstream riparian corridor wetlands exist primarily in narrow strips near the channel, occur around substrate that is usually bedrock or boulders, and thrive in spite of the steep slopes and occasional instability of the substrate. Because water moves through these areas quickly, there is little retention of flood flows, which in turn leaves little time for nutrient and toxic substance removal (Table X-4). However, these areas likely provide nutrients in the form of plant materials and soil that is washed through by storm flows. If the river-continuum concept (Vannote et al. 1980) applies in semi-arid stream corridors, then it would be expected that nutrient export would be high in these areas. The socioeconomic value of recreational use of these areas is high, although the ecosystem functions of habitat support are limited due to dams and flow reductions downstream (Table X-5). In many parts of the Ventura River Watershed the upstream riparian corridor is little affected by development, with the exception of grazing. It is not known if grazing has resulted in increased sediment transport off hillslopes and into stream channels.

The middle reach corridors, as represented by Reference Site H on Coyote Creek, have been impacted by a variety of activities. Specifically, the Coyote Creek and Santa Ana drainages have been inundated by Lake Casitas. This change resulted in an increase in lacustrine wetlands, loss of extensive riparian wetlands, and alteration of the wetlands of the drainages adjacent to the lake. However, throughout most of the basin these areas remain relatively intact and support a variety of functions. Because water passes through these areas more slowly due to less steep slopes and wider floodplains, there is a greater opportunity for the wetlands to reduce flood flows, exchange nutrients, and in some cases stabilize sediment (Table X-4). Several sensitive species are found in these regions including Least Bell's Vireo, Southwestern Pond Turtle, and California Red-legged Frog (Table X-5). The primary impacts are grazing and groundwater pumping reducing year-round flows and the loss of anadromous fisheries due to dams downstream.

Downstream reaches of the Ventura River, as represented by Reference Sites A and K, essentially support all of the functions listed in Table X-4 to some degree. (1) Floods can still access the valley bottom, although it is somewhat restricted by levees and roadways. (2) Groundwater is discharged and recharged in alternating sections. (3) Fisheries are supported by primary production in the river channel, which is enhanced by excessive nutrients in waters from the sewage treatment plants. (4) Several sensitive species, such as the Least Bell's Vireo, reside in this downstream riparian habitat.

However, several impacts have been significant and may yet result in long term deterioration of this functioning riparian corridor. First and foremost, the alteration of the flood regime due to upstream flood control, effluent output, and groundwater pumping results in perennial, nutrient-rich flows supporting growth of non-native species which threaten the native communities. In addition, rejuvenation of the riparian substrate through reworking by flood flows is restricted to catastrophic flows and may have the long term effect of reducing diversity. Urban encroachment also threatens several sections of the river where relatively pristine riparian environments have survived because access has been limited.

Restored Wetland Ecosystem. The wetlands of the Ventura River Watershed function at a relatively high level and appear to have the resiliency to resist or recover from ongoing impacts. Site K represents an example of a revegetation project on the lower part of the river that has resulted in the apparent return of the endangered Least Bell's Vireo to nesting sites in the restored area (Table X-5). The area around Site K was associated with gravel extraction by the Southern Pacific Milling Company for 25 years (Hunt 1992). Mining activities ceased in 1992, with no plans for future activity. Since that time several acres on the site have been planted with native plant species. The species' mixtures were based on associations between hydrology, soil, and distance to the river. Plantings include Quailbush (*Atriplex lentiformis*), California Sagebrush (*Artemisia californicus*), Scalebroom (*Lepidospartum*), Lemonade Berry (*Rhus integrifolia*), Laurel Sumac (*Malosma laurina*), and Elderberry (*Sambucus mexicana*). Tree species include Western Sycamore (*Platanus racemosa*) and Black Cottonwood *(Populus balsamifera,* ssp. *trichocarpa)* (Hunt 1992).

In summary, the assessment of functions and values of wetlands of the Ventura River Watershed demonstrates that the basin surprisingly is still only moderately impacted. Many sensitive species are supported and various properties of the river and deltaic system are presently being exploited without completely destroying the health of the ecosystem. However, there are many management concerns for the watershed in order to prevent continued loss of wetland habitat. Management options that could significantly improve the quality of the wetlands and the degree to which they support functions and socioecomonic values include: (1) plant native vegetation, (2) remove exotics, (3) acquire land and allow for natural recovery, (4) control non-point source pollution, (5) adjust flood control to more natural conditions, and (6) control public access to sensitive areas.

TABLE X-1 . **HYDROGEOMORPHIC UNITS REPRESENTED IN VENTURA RIVER WATERSHED SURVEY.** The numbers are listed sequentially for all systems and Marine-Estuarine hydrogeomorphic units are distinguished by (M-E).

HGM #	Name	HGM #	Name
113	Main Channel Pool	453	Valley Streambed
131	Cold Spring	455	Canyon Streambed
133 (M-E)	Rivermouth Estuary	463	Valley River Bed
146	Palustrine Vernal Lake	464	Coastal Plain Riverbed
211	Montane Stream Channel	471	Montane Stream Channel Bar
212	Foothill Stream Channel	472	Terrace Stream Channel Bar
213	Valley Stream Channel	473	Valley Stream Channel Bar
216	Canyon Stream Channel	475	Canyon Stream Channel Bar
223	Valley River Channel	483	Valley River Channel Bar
231	Stream Backbar Channel	521 (M-E)	Delta
232	River Backbar Channel	522	Montane Valley Vernal Plain
241	Vernal Drainage Channel	551	Stream Floodplain
261 (M-E)	Montane Stream Falls	552	River Floodplain
280	Artificial Ditch	553	Canyon Floodplain
313 (M-E)	Estuary Shore	554	Montane Floodplain
336	Canyon Reservoir Shore	561	River Terrace
341	Montane Stream Shore	562	Stream Terrace
342	Foothill Stream Shore	622	Canyon Bluff
343	Valley Stream Shore	632	Canyon Slope
343 (M-E)	Bench	712	Bluff Seep
350	River Shore	713	Canyon Seep
353	Valley River Shore	714	Stream Bank Seep
354	Coastal Plain River Shore	718	Valley/Plain Seep
371	Montane Stream Bank	722	Bluff Spring
372	Foothill/Terrace Stream Bank	723	Canyon Spring
373	Valley Stream Bank	800	Palustrine Basin
375	Canyon Stream Bank	810 (M-E)	Salt Marsh
383	Valley River Bank	812 (M-E)	Middle Intertidal Salt Marsh
391	Stream Margin	813 (M-E)	High Intertidal Salt Marsh
392	River Margin	821 (M-E)	Low Intertidal Salt Marsh
398	Spring Margin	840	Marsh
422 (M-E)	Shallow Bar	841	Vernal Freshwater Marsh
446	Canyon Reservoir Bed	850	Swale
451	Montane Streambed	853	Dune/Beach Swale
		855	Artificial Drainage Swale
		913	Levee

TABLE X-2. **DOMINANT SPECIES AND SUBSTRATE COVER REPRESENTED IN VENTURA RIVER WATERSHED SURVEY.** Species name or substrate name followed by number of occurrences.

Acer macrophyllum 6
Adiantum capillus-veneris 14
Agrostis viridis 4
Alisma plantago-aquatica 1
Alnus rhombifolia 23
Ambrosia psilostachya 1
Ammania coccinea 2
Andropogon virginica 1
Anthemis cotula 1
Apium graveolens 1
Apocynum cannabinum 1
Artemisia biennis 2
Artemisia californica 1
Artemisia douglasiana 7
Arundo donax 5
Atriplex californica 3
Atriplex patula 2
Atriplex semibaccata 1
Azolla filiculoides 2
Baccharis pilularis 6
Baccharis salicifolia 48
Baccharis salicifolia / Clematis ligusticifolia 1
Bedrock 1
Berula erecta 1
Bossiella 1
Boulder 10
Boykinia rotundifolia 1
Brickellia californica 5
Briza minor 1
Carex senta 2
Ceanothus oliganthus 2
Ceanothus spinosus 1
Chenopodium macrospermum 2
Cladophora 1
Clematis ligusticifolia 3
Cobble 7
Conyza canadensis 1
Conyza coulterii 1
Corallina 1
Cornus sericea 1
Cotula coronopifolia 3
Crypsis vaginiflora 1
Cynodon dactylon 1
Cyperus 1
Cyperus eragrostis 3
Datisca glomerata 3
Distichlis spicata 4
Echinodorus berteroi 2
Eclipta alba 1
Egregia 1
Eleocharis acicularis 1
Eleocharis macrostachya 3
Enteromorpha 1
Epilobium ciliatum 1
Equisetum laevigatum 1
Equisetum telmetea 1
Eriogonum fasciculatum 1
Euthamia occidentalis 2
Foeniculum vulgare 2
Frankenia salina 1
Gelidium 1
Gigartina 1
Gnaphalium luteo-album 1
Gracilaria 1
Grateloupia 1
Green-Algae 39
Helenium puberulum 1
Heliotropium curassavicum 1
Hoita machrostachya 1
Isocoma menziesii 2
Isoetes howellii 1
Jaumea carnosa 2
Juglans californica 9
Juncus acutus 1
Juncus bufonius 3
Juncus mexicanus 1
Juncus patens 1
Juncus xiphioides 2
Kochia scoparia 1
Lemna minor 1
Lepidospartum squamatum 1
Leptachloa uninerva 1
Leymus condensatus 1
Leymus triticoides 3
Lobelia dunnii 8
Lolium multiflorum 2
Lotus scoparius 1
Ludwigia hexapetala 2
Lythrum hyssopifolia 3
Malacothamnus fasciculatus 1
Malosma laurina 8
Marsilea vestita 1
Mimulus cardinalis 8
Mimulus guttatus 1
Mixed-Coarse 32
Mud 7
Muhlenbergia rigens 1
Najas marina 1
Nicotiana glauca 3
Pennisetum clandestinum 1
Phyllospadix scouleri 1
Piptatherum milaceum 1
Platanus racemosa 29
Platanus racemosa / Umbellularia californica 1
Polygonum spp 1
Polypogon monspeliensis 4
Populus balsamifera 9
Porphyra 1
Potamogeton foliosa 1
Potamogeton pectinatus 1
Potentilla anserina 1
Pteridium aquilinum 2
Quercus agrifolia 8
Quercus lobata 1
Rhamnus californica 1
Rorippa nasturtium-aquaticum 3
Rosa californica 2
Rubus ursinus 11
Rubus ursinusMalosma lau. 1
Rumex 1
Rumex crispus 5
Ruppia cirrhosa 1
Salicornia virginica 4
Salix exigua 1
Salix laevigata 7
Salix lasiolepis 31
Salix lucida 1
Salvia mellifera 4
Sambucus mexicana 2
Sand 7
Scirpus americanus 1
Scirpus californicus 6
Scirpus maritimus 1
Spartium junceum 3
Spergularia marina 2
Tetragonia tetragonioides 1
Toxicodendron diversilobum 3
Typha domingensis 1
Typha latifolia 3
Ulva 1
Umbellularia californica 11
Umbellularia californica / Acer macrophyllum 1
Umbellularia californica /
Urtica dioica 1
Veronica anagallis-aquatica 1
Woodwardia fimbriata 1
Xanthium strumarium 5
Zannichellia palustris 1

TABLE X-3 . **ESTIMATES OF AREAL COVER OF WETLANDS THE VENTURA RIVER WATERSHED.** Estimates of area covered by wetlands in different systems. Areal estimates for Marine and Estuarine Systems based on Ferren et al. (1990). All other estimates based on field data, aerial photographic interpretation, and watershed analysis for distribution of streams of different orders throughout the watershed. See text for a more detailed description of watershed analysis for the area of wetlands along the riparian corridor.

System	Area (km^2)	Source
Marine	0.01	Ferren et al. (1990)
Estuarine	0.11	Ferren et al. (1990)
Lacustrine	1.4	this report
Palustrine - Vernal	1.0	this report
Riverine & Palustrine		
Riparian Corridor		
zero order streams	1.2	this report
1st order streams	1.7	this report
2nd order streams	0.9	this report
3rd order streams	0.8	this report
4th order streams	5.2	this report
5th order stream	9.5	this report and Ferren et al. (1990)
Total Wetland Area	**22**	

TABLE X-4. **ASSESSMENT OF FUNCTIONS AND VALUES FOR REFERENCE SITES.** An x means the value or function is supported by wetlands at the reference site. A dash or question mark indicates that the function/value is not supported or is not known.

	REFERENCE SITES											
Assessment	A	B	C	D	E	F	G	H	I	J	K	L
Ecosytem Function												
Hydrology												
Flood control	x	x	-	x	-	-	-	x	-	x	x	x
Groundwater discharge	x	-	x	x	x	x	x	x	x	x	x	x
Groundwater recharge	x	x	x	x	-	x	-	x	x	-	x	x
Shoreline protection/ sediment stabilization	x	x	-	x	x	-	x	x	-	-	x	x
Biogeochemistry/Water quality												
Wastewater treatment	x	-	x	x	-	-	-	x	-	-	x	x
Removal of toxic substances	x	x	x	x	-	x	-	x	x	x	x	x
Removal of nutrients	x	x	x	x	-	x	-	x	x	x	x	x
Foodchain support/ Nutrient cycling												
Primary production	x	x	x	x	x	x	x	x	x	x	x	x
Decomposition	x	x	x	x	x	x	x	x	x	x	x	x
Nutrient export	?	?	?	x	?	?	x	?	?	?	?	?
Nutrient utilization	?	x	?	x	?	?	?	?	?	?	?	?
Socio-economic Value												
Nonconsumptive												
Recreation	x	x	x	x	x	-	x	x	-	-	x	x
Research	x	x	x	x	x	x	x	x	x	x	x	x
Natural heritage	x	-	x	x	x	x	x	x	x	x	x	x
Consumptive												
Gravel extraction	x	-	-	-	-	-	-	-	-	-	x	x
Fisheries	x	x	-	x	x	-	x	x	-	-	x	x
Crops	x	-	-	-	-	x	-	x	x	-	x	x
Grazing	x	x	x	x	-	x	-	x	x	-	x	x

TABLE X-5. **HABITAT FUNCTION FOR SENSITIVE SPECIES IN WETLANDS OF VENTURA RIVER WATERSHED**

			WETLAND SYSTEM			
Species	**Status**	**MARINE**	**ESTUAR.**	**RIVER.**	**LACUST.**	**PALUS.**
Plants						
Juncus acutus	CNPS List 4		x			
Sagittaria sanfordii	FC2					x (vernal)
Juglans californica var. californica	CNPS List 4					x
Animals						
Invertebrates						
Monarch Butterfly *Danaus plexippus*						x
Vertebrates						
Amphibians and Reptiles						
Calif. Red-legged Frog *Rana aurora draytonii*	Proposed FE		x	x		
Southwestern Pond Turtle *Clemmys marmorata*	FC2		x	x		
Two-striped Garter Snake *Thamnophis hammondii*	FC2		x	x		
Fish						
Tidewater Goby *Eucyclogobius newberryi*	FE		x			
Steelhead Trout *Oncorhynchus mykiss*	Petitioned FE		x	x		
Arroyo Chub (introduced) *Gila orcutti*	CSC			x		
Mammals						
San Diego Desert Wood Rat *Neotoma lepida*	FC2					x
Pallid Bat *Antrozous pallidus*	CSC					x
Greater Western Mastiff Bat *Eumops perotis*	FC2, CSC					x
Pacific Western Big-eared Bat *Plecotus townsendi*	FC1					x
American Badger *Taxidea taxus*	CSC					x
Harbor Seal *Phoca vitulina*	Mar. Mammal Act	x				

TABLE X-5 (cont.). **HABITAT FUNCTION FOR SENSITIVE SPECIES IN WETLANDS OF VENTURA RIVER WATERSHED**

		SYSTEM				
Species	**Status**	**MARINE**	**ESTUAR.**	**RIVER.**	**LACUST.**	**PALUS.**
Birds						
Brown Pelican *Pelecanus occidentalis*	FT, SE	x	x			
Bald Eagle *Haliaeetus leucocephalus*	FT, CSC			x		
Peregrine Falcon *Falco peregrinus*	FE, SE			x		
Osprey *Pandion haliaetus*	CSC		x	x		
Cooper's Hawk *Accipiter cooperii*	CSC					x
Snowy Plover *Charadrius alexandrinus*	FT	x	x			
Calif. Least Tern *Sterna antillarum browni*	FE, SE	x	x			
White-faced Ibis *Plegadis chihi*	FC2, CSC		x			
Least Bell's Vireo *Vireo bellii pusillus*	FE, SE			x		x
Yellow Warbler *Dendroica petechia*	CSC			x		x
Yellow-breasted Chat *Icteria virens*	CSC			x		x
Blue Grosbeak *Guiraca caerulea*	CSC			x		
Belding's Savannah Sparrow *Passerculus sandwichensis beldingi*	FC2, SE		x			
Tricolored Blackbird *Agelaius tricolor*	CSC			x	x	x
Historically Present Species *						
1929 - SW Willow Flycatcher *Empidonax traillii extimus*	Proposed FE, SE			x		x
1933 - Swainson's Thrush *Catharus ustulatus*	CSC			x		x

Status Codes as of August 30, 1994:

S=State of California	F=Federal
E=Endangered	T=Threatened

*=Historically Present Species - Specimens in the Western Foundation of Vertebrate Zoology in Camarillo.

CSC=California Department of Fish & Game, Species of Special Concern

C1=Candidate 1 species, taxa for which sufficient biological information exist to support a proposal to list as Endangered or Threatened.

C2=Candidate 2 species, taxa for which existing information indicates may warrant listing, but for which substantial biological information to support a proposed rule is lacking (California Department of Fish and Game 1988).

CNPS List 4=California Native Plant Society Sensitive Species List 4

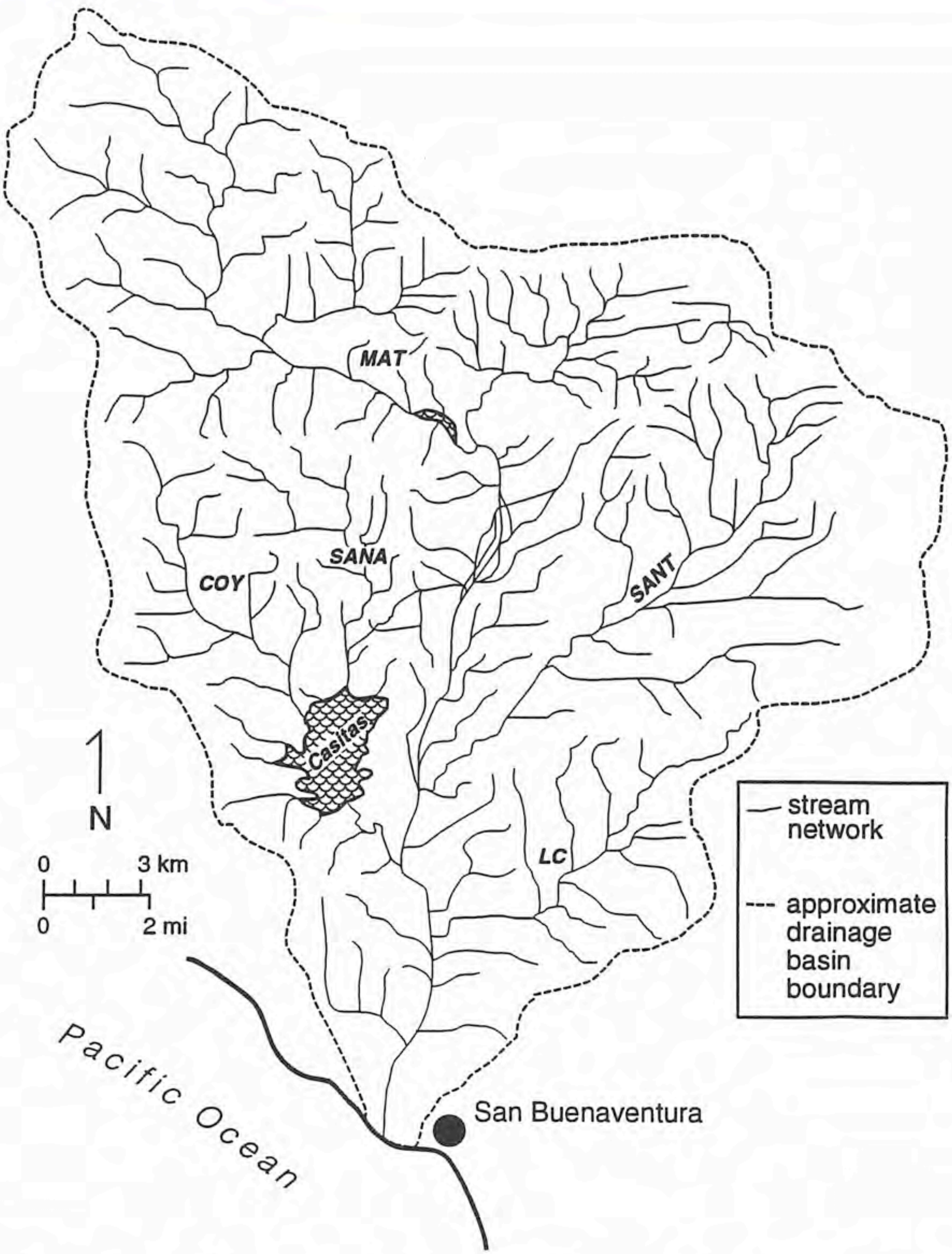

FIG. X-1. LOCATION MAP WITH VENTURA RIVER WATERSHED DRAINAGE NETWORK. Map view of the Ventura River with drainage network as mapped on USGS 7.5' quadrangles and digitized in EPA Reach 3 file. Lowest order streams in headwater regions not shown. Subwatersheds include: MAT = Matilija Creek Drainage; SANT = San Antonio Creek Drainage; LC = Cañada Larga Drainage; COY = Coyote Creek Drainage; SANA = Santa Ana Creek Drainage.

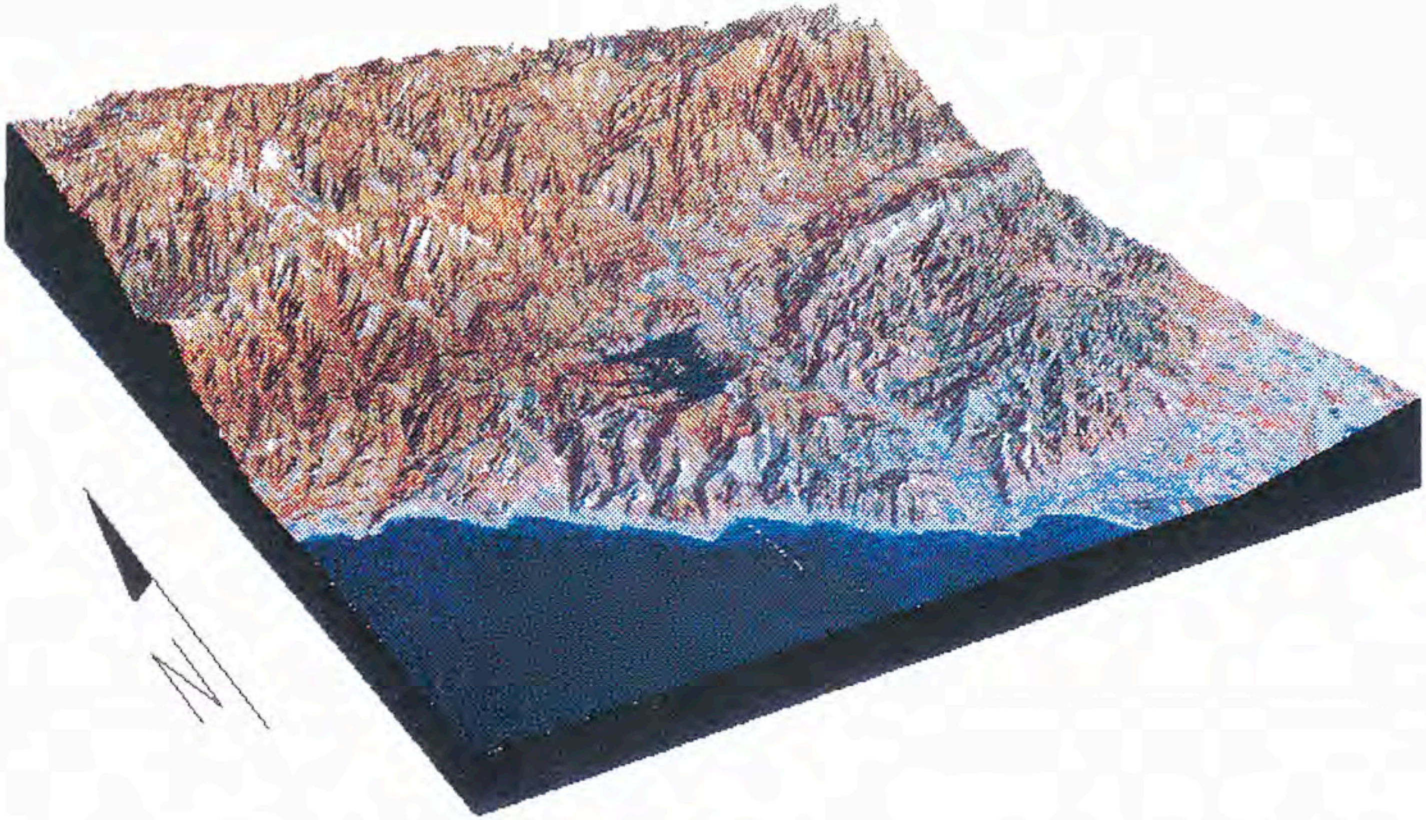

Fig. X-2. VENTURA RIVER WATERSHED THREE-DIMENSIONAL RELIEF MAP. View from the Pacific Ocean northward into Ventura River system. Processed image is a false-color-infrared composite (Landsat MSS Bands 7,5, and 4 rendered as red, green, and blue, respectively) for December 17, 1982. The Landsat image has been draped over a digital elevation model for the basin. Exaggerated vertical elevation emphasizes the rapid rise of the terrain from sea level to over 1800 m. The relatively flat area in the east-central part of the basin is the Ojai Valley.

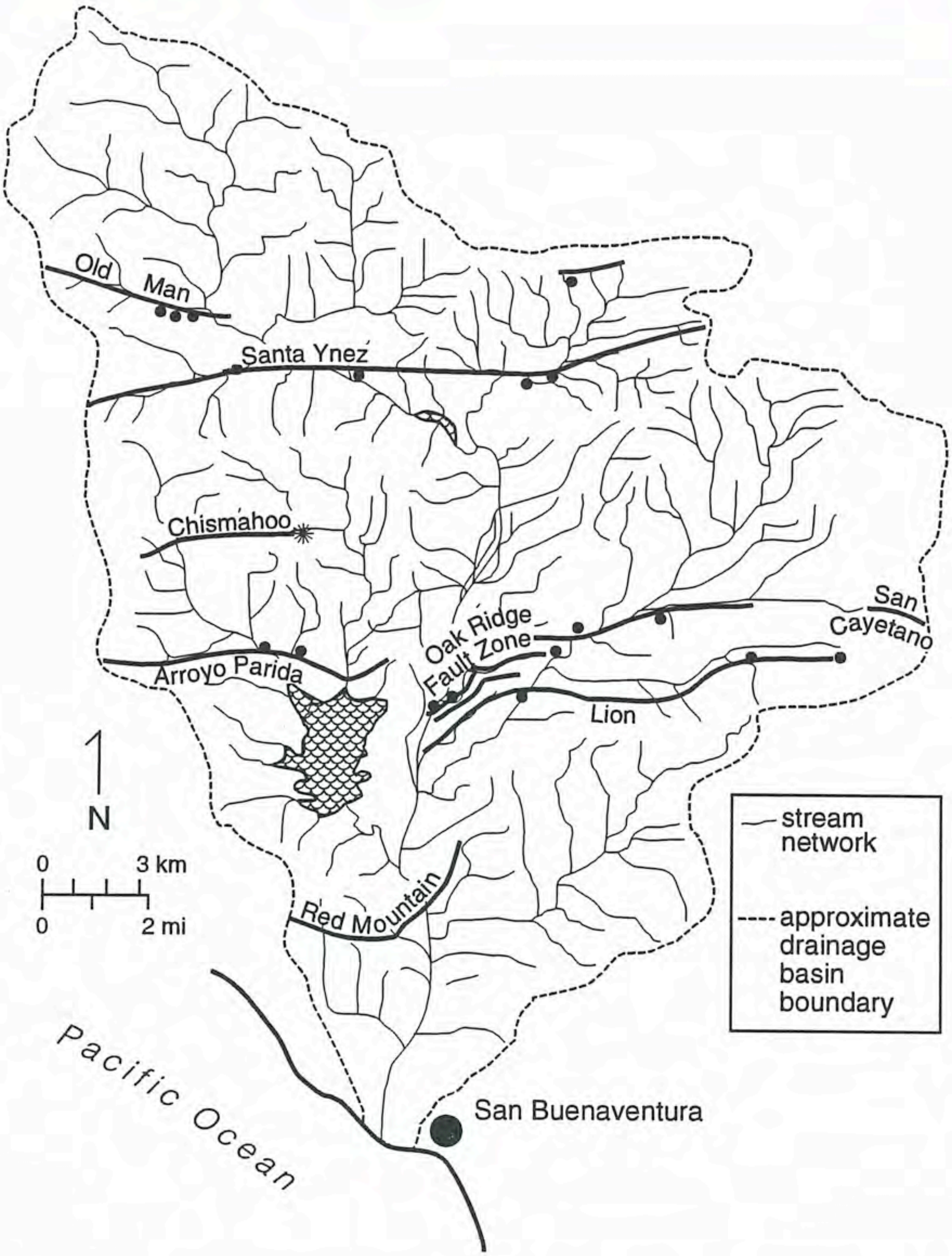

FIG. X-3. **REGIONAL FAULTS IN VENTURA RIVER WATERSHED.** Generalized map of major fault systems in the Ventura River Watershed (after Rockwell et al. 1984). Dots show locations of documented wetlands in those areas impacted by basin structure. See Figure X-5 for site numbers for wetlands. The Oak Ridge (Oak View) Fault Zone is a series of associated flexural-slip faults that break up the landscape (Rockwell et al. 1984).

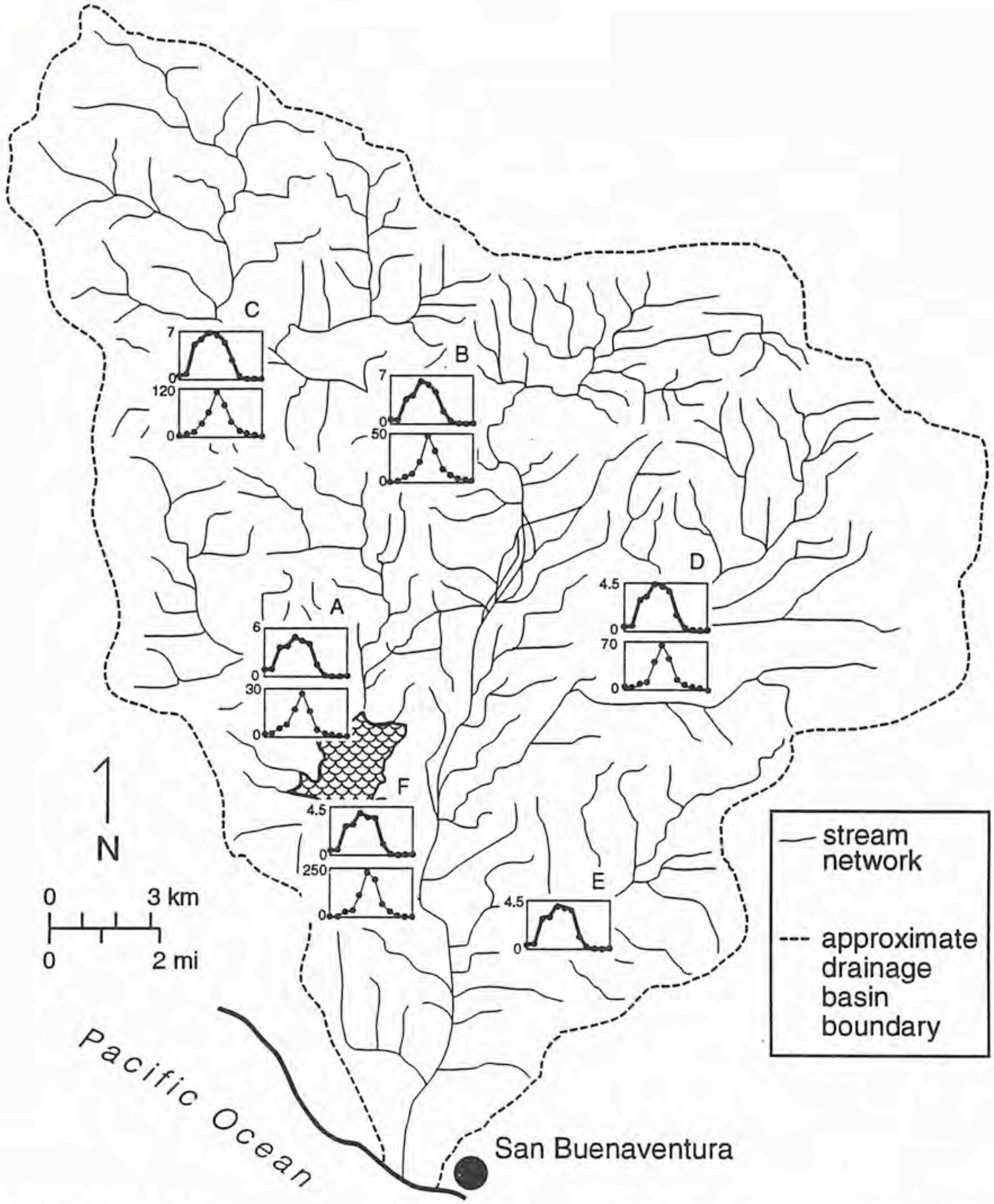

FIG. X-4. **RAINFALL AND RUNOFF IN VENTURA RIVER WATERSHED.** Precipitation in inches (upper graph with thick line) and water discharge in cubic feet per second (lower graph with thin line) shown for the water year (September 1 through August 31) as average monthly values based on 20 or 25 years of data provided by the Ventura County Flood Control District. Location A shows Santa Ana Valley rainfall (1964-1989) and Santa Ana Creek water discharge (1969-1989). Location B shows Matilija Dam rainfall (1964-1989) and North Fork Matilija Creek water discharge (1964-1989). Location C shows Matilija Canyon precipitation (1964-1989) and Matilija Creek water discharge (1964-1989). Location D shows Ojai Valley (FS) precipitation (1964-1989) and San Antonio Creek discharge (1964-1989). Location E shows Cañada Larga precipitation (1964-1989). Location F shows Kingston Reservoir precipitation (1964-1989) and Ventura River water discharge at Foster Park (1964-1989).

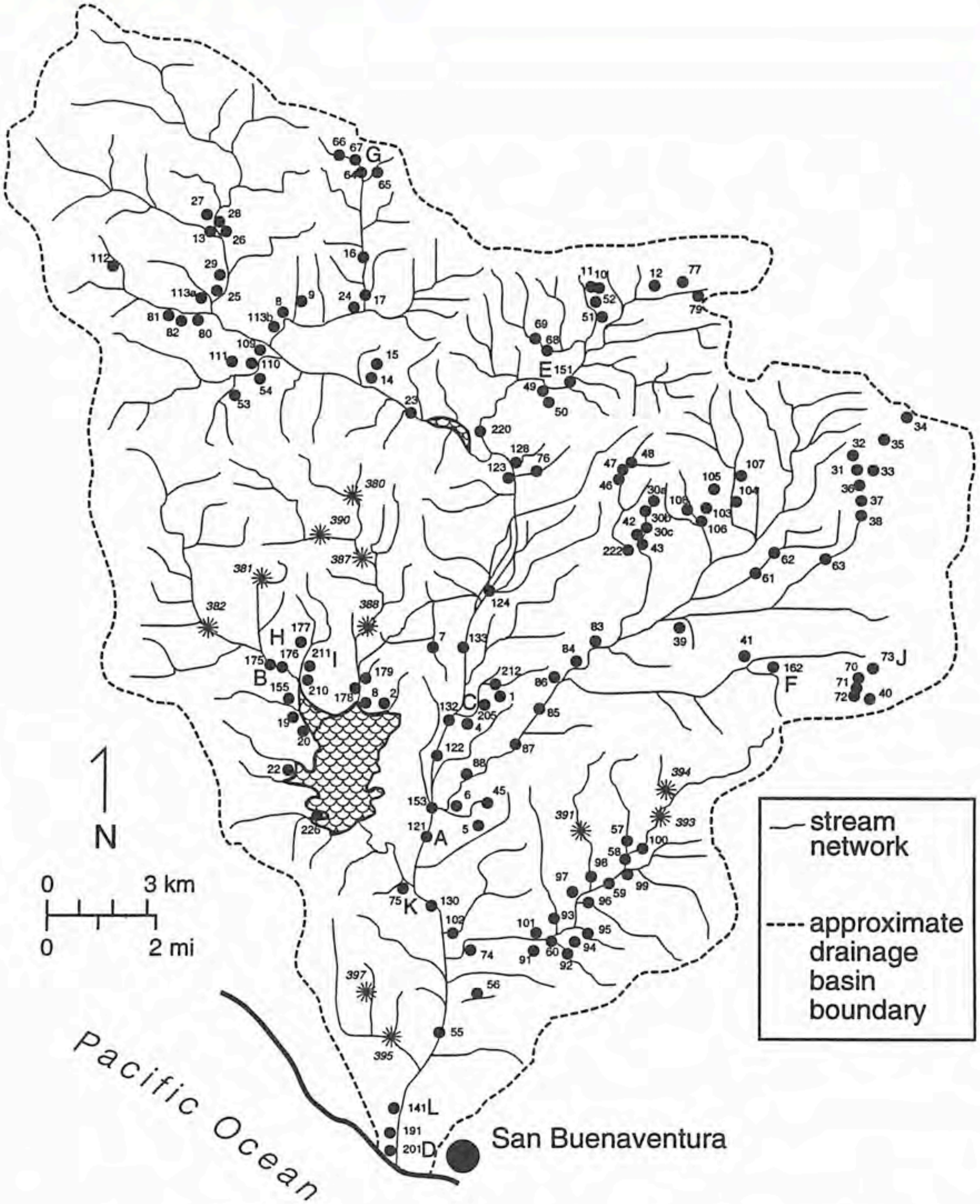

FIG. X-5. **LOCATION MAP FOR FIELD SITES AND REFERENCE SITES FOR ASSESSMENT OF FUNCTIONS AND VALUES.** Filled circles and their corresponding numbers show where data were collected for this study. The field site number corresponds to the site number listed in the catalogue of wetland types for the Ventura River in Appendix 2 of Chapter XV. The sites marked with asterisks were evaluated solely based on aerial photographic interpretation and had wetland types that were duplicated elsewhere in the basin. These sites are not included in the catalogue, because the dominance or substarte could not be accurately determined from the aerial photographs. The letters A through L indicate the locations of the reference sites for the assessment of functions and values. Typically they characterize an ecosystem that is represented by a mosaic of wetland types which are individually listed in the catalogue. See text for further details.

FIG. X-6a. **VENTURA SITE D: VENTURA RIVER MOUTH AREA**. View westward across marine wetlands at low tide along delta of the Ventura River.

FIG. X-6b. **VENTURA SITE D: VENTURA RIVER MOUTH AREA**. View of the Ventura River Estuary, northwestward from mouth of river-estuary toward railroad bridge.

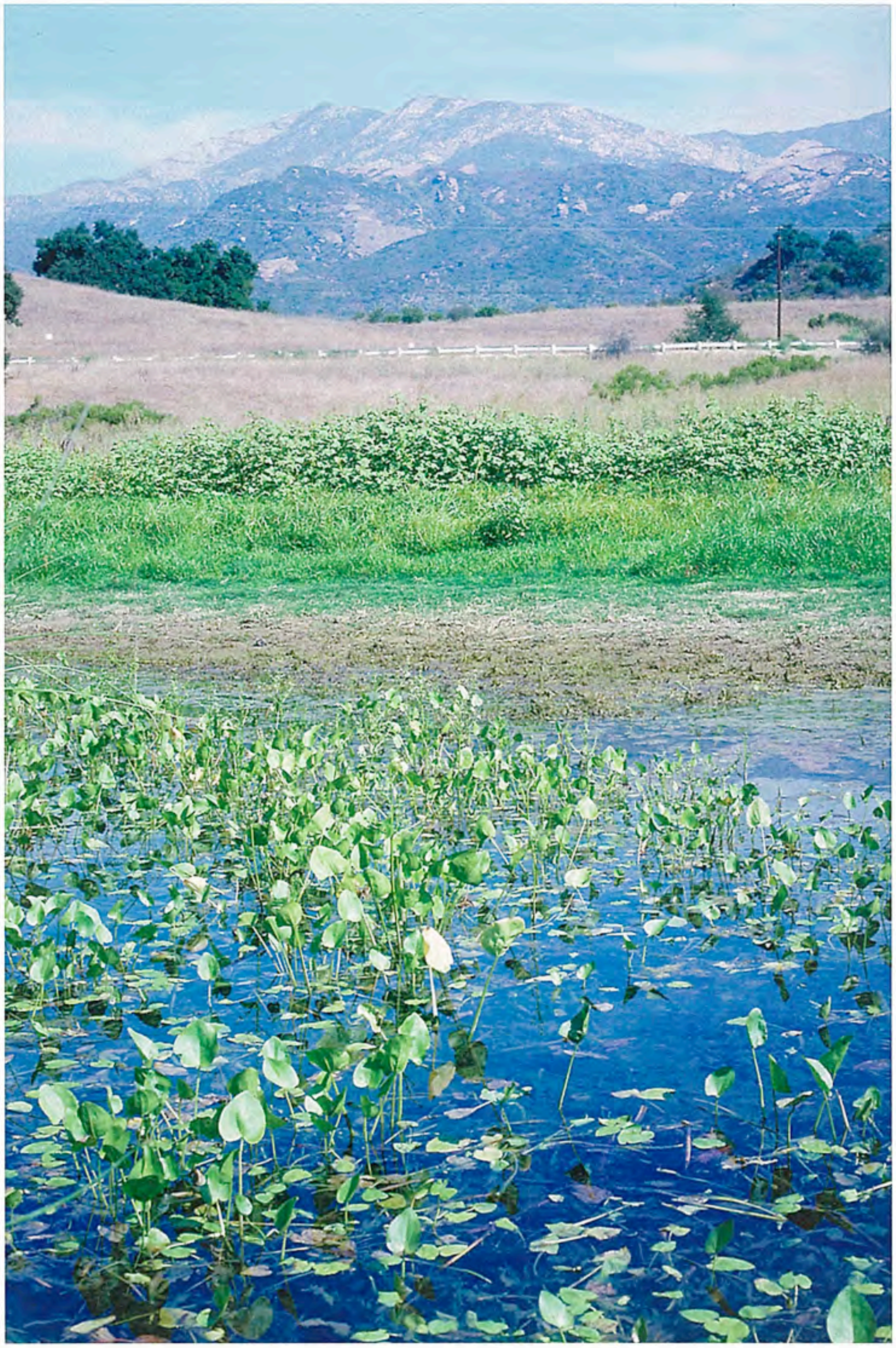

FIG. X-7 . **VENTURA SITE B: LAKE CASITAS, NORTHWEST SHORE**. View northward across lacustrine emergent wetlands dominated by *Echinodorus berteroi* (Burhead) toward lacustrine unconsolidated-shore wetlands.

FIG. X- 8 . **VENTURA SITE A: SAN ANTONIO CREEK, CASITAS SPRINGS AREA**. View northwestward across riverine wetlands toward palustrine forested wetland dominated by *Populus balsamifera* ssp. *trichocarpa* (Black Cottonwood).

FIG. X- 9. **VENTURA SITE E: MATILIJA CREEK, WHEELER GORGE**. View upstream along Matilija Creek. Palustrine forested wetland as illustrated is dominated by the broadleaved-deciduous tree *Alnus rhombifolia* (White Alder).

FIG. X-10a **VENTURA SITE F: UPPER OJAI VALLEY, VERNAL PLAIN**. View from lower end of the montane valley, eastward along the long-axis of the vernal wetland plain.

FIG. X-10b. **VENTURA SITE F: UPPER OJAI VALLEY, VERNAL PLAIN**. View southward across narrow-axis of vernal wetland plain, toward Sulphur Mountain. Palustrine emergent wetland is dominated by nonpersistent species such as *Polypogon monspeliensis* (Annual Beard Grass).

FIG. X- 11a. **VENTURA SITE C: OJAI VALLEY, MIRROR LAKE**. View northward across remnant of a palustrine vernal lake in a desiccated state.

FIG. X- 11b. **VENTURA SITE C: OJAI VALLEY, MIRROR LAKE**. View of vernal lake vegetation including *Alisma plantago-aquatica* (Water Plantain, center) and *Eleocharis macrostachya* (Spike Rush, left center).

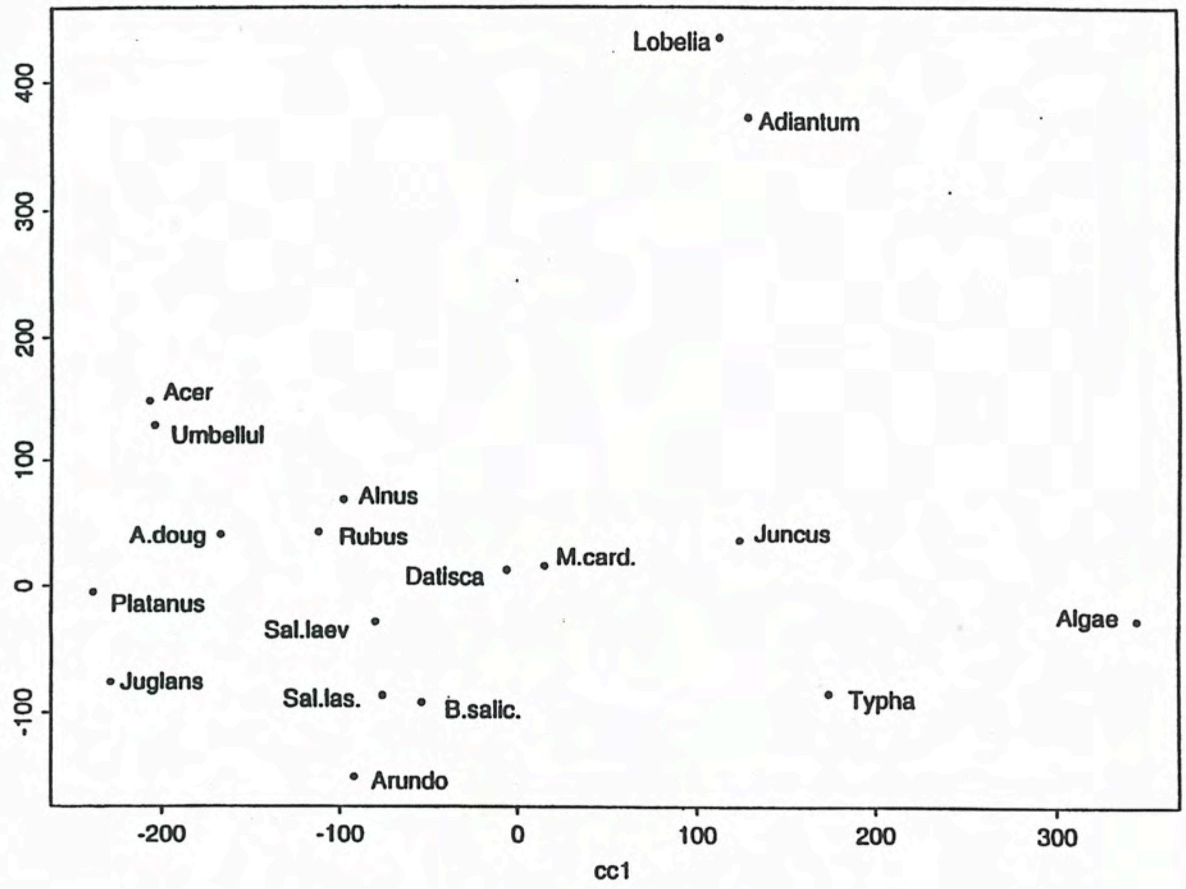

FIG. X-12. **CANONICAL CORRESPONDENCES FOR CHARACTERISTIC VEGETATION TYPES OF THE VENTURA RIVER WATERSHED.** Dry conditions are indcated by low abscissa (cc1) values. Ordinate values (cc2) are directly related to slope and elevation. Marine and Estuarine species were not included in this analysis.