II: Southern California Wetlands[1]

The Southern California Bight is a distinct bioregion of California. It extends from Point Conception in Santa Barbara County to Punta Banda, south of Ensenada, in Baja California, Mexico and includes the marine-coastal interface and the coastal wetlands and watersheds. The Bight's embayments, marshes and estuaries are among the most productive and densely populated habitats on the Pacific coast. Within the coastal zone of the Bight, over 60 species of fishes are known to frequent bays and estuaries while no less than 195 species of birds have been identified (Dailey et al. 1993). Coastal wetlands are nursery areas for both commercial and recreational fisheries, such as halibut. They also support many other animals, including the endangered light-footed clapper rail, which nest in marshes, and the California brown pelican, which roosts in lagoons and river mouths. South coast wetlands are also important to migratory birds traveling on the Pacific Flyway. For example, the Arctic Tern travels thousands of miles to nest in the Bolsa Chica wetlands. Rare and colorful songbirds migrate from the south to nesting areas such as Goleta Slough.

The physical features, climate, and hydrology of coastal Southern California have produced an unusual set of conditions and a diversity of plants and animals that sharply distinguish the region from any other in North America. Unlike the broad, gradually sloping coastal plains of the Atlantic and Gulf Coasts, Southern California has steep, coastal mountains that descend sharply to the ocean. Summers are hot and dry in this semi-arid, Mediterranean climate, while winters are cool with rainfall varying in amount and intensity, from droughts to steady rains to torrential downpours. The San Gabriel and San Bernardino Mountains can experience more rain in a twelve-hour period than anywhere else in the continental United States.

This chapter provides an overview of the ecological setting in Southern California including the geomorphology, climate, hydrology, and common wetland types. The chapter also discusses the extent of wetland loss and degradation in the region and the anthropogenic causes of this decline.

Regional Setting

The appearance of wetlands along the Pacific coastline coincided with sea level rise following the last ice age. About 18,000 years ago, sea level was some 400 feet lower than current conditions, and the shoreline lay miles to the west. Over thousands of years, rivers and creeks cut canyons and hollowed wide valleys. These "drowned" valleys became the bays and lagoons of today. Eventually, sea level rise slowed enough to equal the geologic uplift of the continent. The shoreline took on a contour similar to that existing today. Landward, sediment flowing down creeks slowly created mudflats and marsh communities.

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[1] For a general profile and characterization of southern California's wetlands, see: 1) Wayne R. Ferren, Jr. Peggy L. Fiedler, Robert A. Leidy, Kevin D. Lafferty, and Leal A. K. Mertes. "Wetlands of Southern California." *Madroño: The West American Journal of Botany*. 105-233. 2) J.B. Zedler. 1982. *The ecology of southern California coastal salt marshes: a community profile.* US Fish and Wildlife Service. Biological Services Program. Washington, D.C. FWS/OBS-81/54.

Geomorphology

Several topographic and geologic features make the southern California region unique. The shape of California's coastline is a product of tectonic activity and erosion. Coastal mountain ranges include two geomorphic provinces, the Transverse Ranges and the Peninsular Ranges. These ranges form a natural "amphitheater" to the coastline, and provide a unique setting for watersheds and wetlands.

The Transverse Ranges form the northern border of the Los Angeles Basin and include the San Gabriel, San Bernardino, Santa Ynez, and Santa Monica Mountains. The Transverse Ranges are characterized by east-west trending faulting and folding and geomorphic features (mountain ranges and valleys). Tertiary marine and non-marine sedimentary rocks are exposed in the western Transverse Ranges, including the Santa Ynez Mountains. Tertiary volcanic rocks, Mesozoic metamorphic rocks, and Tertiary sedimentary rocks are exposed in the Santa Monica Mountains. Precambrian to Mesozoic age granitic rocks overlain by metamorphic rocks are exposed in the San Gabriel and San Bernardino Mountains of the eastern Transverse Ranges.

The coastal portion of the Peninsular Ranges begin in Orange County and form the northern end of the Baja peninsula. From north to south along the main ridge of the Peninsular Ranges are the San Jacinto Mountains, Santa Rosa Mountains, and Laguna Mountains. The Peninsular Ranges are characterized by northwest-southeast trending faulting and folding and geomorphic features. The granitic rocks of the Southern California Batholith form the core of the Peninsular Ranges and are exposed in the inland areas. Mesozoic and Tertiary sedimentary rocks outcrop along the coastal areas of Los Angeles, Orange, and San Diego Counties.

Rocky headlands and cliffs loom above the shore where the hills and mountain of the Transverse and Peninsular Ranges approach the coastline, and sandy beaches and dune fields extend along the water's edge where valleys or basins, such as the Oxnard Plain and Los Angeles Basin, intersect the coastline. In some areas, marine terraces have been formed by sea cliff erosion. In other areas, including San Onofre, Oceanside, the Palos Verdes Peninsula and the southern flank of the Santa Ynez Mountains, uplift of the shoreline has elevated these wave-cut benches into a series of terraces.

Climate

Southern California is noted for its mild temperatures, short wet winters, and long dry summers, characteristic of a semiarid Mediterranean climate. California has a greater climatic diversity than any other state, and its vegetational diversity is reflective of this varied climate. Although in many regions latitude is a major factor in determining climate, here the major determinant is physical geography – such as proximity to the coast. The region includes various types of both Mediterranean and desert climates. Mean annual air temperatures are similar throughout the region, and generally mild due to the proximity of the Pacific Ocean. The annual average temperature in Los Angeles is 66º F, 59º F in Santa Barbara and 64º F in San Diego (National Climatic Data Center).

Rainfall amounts decrease slightly from the north to south in the region. Rainfall amounts for the southern portion of the region average about 8-10 inches, occurring mostly from November through March. Evaporation exceeds rainfall throughout most of the year in this area. In the central and northern portions of the region, average annual precipitation is from 12 to 14 inches, with slightly higher amounts falling in mountainous and vegetated areas, such as the Santa Monica Mountains. Most precipitation falls during the 6-month period from November to April, and is produced primarily by frontal systems transiting the area.

Weather fluctuations caused by El Niño and La Niña conditions can significantly affect the region's precipitation. El Niño events occur irregularly at intervals of 2-7 years, with an average of about once every 3-4 years, and typically last 12-18 months. El Niño events are characterized by a large scale weakening of the trade winds and warming of the surface layers in the eastern and central equatorial Pacific Ocean. El Niño events produce significantly more rainfall in Southern California – in the 1983 El Niño, rainfall in Los Angeles was 230 percent higher than average. In contrast, La Niña events are characterized by periods of anomalously cold sea surface temperatures in the equatorial Pacific and typically produce less rainfall in a given year.

Hydrology

The annual cycle of wet and dry seasons drives the hydrologic patterns seen in Southern California. Historically, many of the region's streams were intermittent, drying up in the summer. Perennial streams and rivers were fed either by groundwater or snowmelt. Floods and drought cycles occur regularly and are influenced by the cyclical El Niño and La Niña events. Almost all of the significant flood events in Southern California have occurred during El Niño winters.

Wetland Types

Wetlands are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is often covered by shallow water during some parts of the year. In general, wetlands are shaped by the specific climate, geology, topography, and hydrology of a region. Coastal wetlands in Southern California have a unique character due to the distinct setting of this region. The following broad categories cover the four main types of wetlands found in Southern California.

- **Estuarine wetlands** – Most of Southern California's coastal wetlands are estuarine salt marshes with associated tidal channels and mudflats. An estuary is a semi-enclosed body of water that receives both fresh water and seawater. Estuarine wetlands in Southern California include river mouth estuaries, canyon mouth estuaries, bay, lagoons, and structural basin estuaries (Ferren et al. 1995). The size of estuarine wetlands is dependent on a number of factors, including topography, geology, and hydrology. Tidal wetlands are highly impacted by sediment flows because small changes in marsh topography (e.g., 6 inches) can have large impacts on marsh habitats.

- **Riparian wetlands** – Riparian wetlands form as a result of fluvial processes in floodplains and along river and stream corridors. Annual disturbance from flooding is necessary to maintain the health of riverine ecosystem processes. Many riparian plants exhibit physiological and physical adaptations to a flood driven disturbance regime. Floods maintain habitat heterogeneity which in turn, supports a diversity of plants and animals (Ferren et al. 1995).

- **Freshwater marshes (seasonal and perennial)** – Freshwater marshes form in a variety of locations, and are often associated with lakes, ponds, and riparian systems. Freshwater marshes may border inflowing creeks. Along larger streams, freshwater marshes often grade into riparian woodlands; along the coastline, they grade into salt marshes.

- **Vernal pools** – Vernal pools occur in small depressions underlain by dense, impenetrable claypan soils that allow water to accumulate in winter and spring (Ferren et al. 1996). The pools support small, usually annual plants, which flower as the water in the pools begins to evaporate. Vernal pools are less common than other types of wetlands along the Southern California coast, and occur primarily in San Diego and Santa Barbara Counties.

Decline of Southern California Wetlands

Historical Conditions

Prior to the 1800's, southern California contained rivers with wide, unobstructed floodplains that were fed by numerous tributaries and flowed freely to the sea. All of the river systems supported large estuaries at their mouths with a diversity of wetland habitats that transitioned from salt marsh habitat to brackish and freshwater marsh to riparian habitat. Approximately twenty-eight large, distinct estuarine wetlands were found along the south coast in 1850 (Office of Technology Assessment 1982). Riparian vegetation consisting of cottonwood, alder, willow and freshwater marsh species lined most of the coastal rivers and creeks. In addition, vernal pools were found in scattered locations throughout the region. This mosaic of marsh and riparian habitats existed for thousands of years. The coastal wetlands remained in a dynamic equilibrium between terrestrial and marine influences.

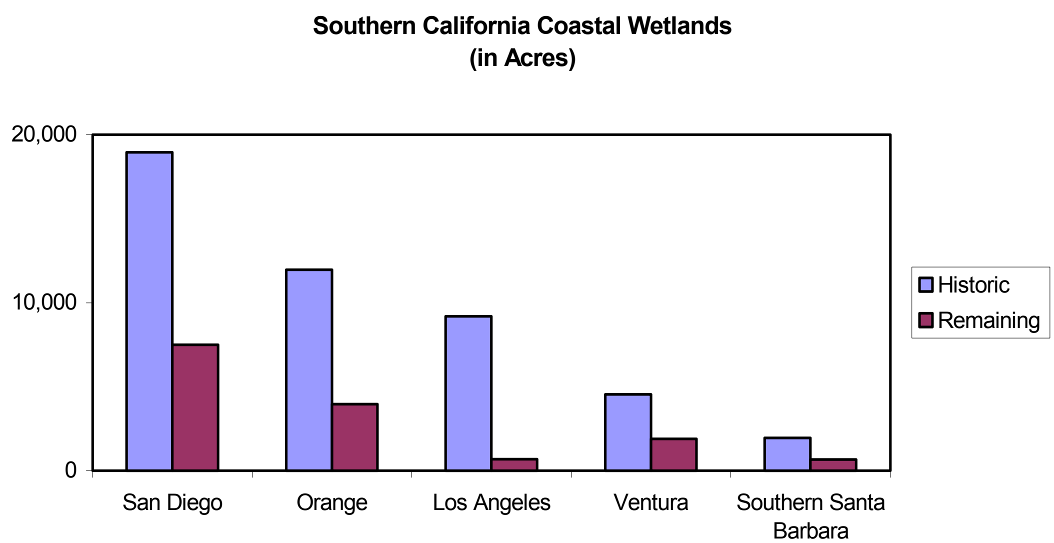
Southern California coastal wetlands and watersheds have been dramatically altered or destroyed by human activities over the past 150 years. Most of the riparian areas of the region's coastal rivers and streams have been lost. Rivers and creeks have been rerouted, dammed, channelized, and paved. Wetlands have been filled. Important freshwater and salt water inputs to coastal wetlands have been altered. Few estuaries are open to the necessary tidal influence. The overall general health and integrity of the region's watersheds and wetland habitats has declined

It is difficult to accurately estimate the historical extent of wetlands and the subsequent loss of wetlands due to the lack of detailed historical data. The Southern California Coastal Wetland Inventory prepared by the Coastal Conservancy estimated the total historic extent of wetlands at 41 key sites in the region to be between 45,000 and 55,000 acres, with a only about 30 percent remaining (see Figure 2.2). The California Department of Parks and Recreation (1988) estimated a 75 percent reduction in coastal wetlands, from approximately 53,000 acres to 13,000 acres. Other estimates of wetland types that have been significantly reduced in southern California include:

- Estuarine wetlands (i.e., salt marshes) as an entire subsystem at 75-90 percent (J. Zedler 1982; California Department of Fish and Game 1983; California Coastal Commission 1989);
- The "riparian community" at 90-95 percent (Faber et al. 1989) including loss of 40 percent of the riparian wetlands in San Diego County during the last decade alone (CDPR 1988);
- Vernal pools at 90 percent (P. Zedler 1987).

The loss and degradation of the region's wetland ecosystems is reflected in the significant decline in the abundance of several species of fishes, shorebirds, seabirds, kelp habitats, and the supply of food observed since 1950 (McGowan et al. 1998). It is estimated that 55 percent of the animals and 25 percent of the plants designated as threatened or endangered by the State depend on wetland habitats. Southern steelhead trout, for example, have been reduced in the past century from tens of thousands in number to approximately 200 to 300 (Pacific Marine Fisheries Council 2000). In the U.S., California ranks second in the number of aquatic species that are endangered (Allendorf 1982).

Figure 2.2 – Estimated Historical and Existing Wetland Acreage by County for at 41 Coastal Wetlands in Southern California.



Estimated from the Southern California Coastal Wetlands Inventory which compiled information on 41 coastal wetlands from Point Conception in Santa Barbara County south to the Mexican Border. Estimates of historic and current wetland acreages were compiled from the literature and U. S. Coast and Geodetic Survey maps created between 1851 to 1893. The types of wetland habitats included in these acreage estimates vary, making it difficult to compare between sites or draw accurate region-wide conclusions. In some cases, the available historic maps did not encompass the entire historical wetland area, and the mapped boundary of the historical wetland was truncated where the available map(s) ended.

Impacts of Regional Development

As Figure 2.2 indicates, Southern California's coastal wetlands and watersheds have been heavily impacted by agricultural and urban development over the past 150 years. Rapid population growth in Santa Barbara, Los Angeles, and Ventura Counties began in the early 1900's, and Orange and San Diego Counties followed in the 1940s and 1950s. Along with this rapid growth came many alterations to the fragile ecological relationships that shape coastal wetland processes, structures and functions. Today, urban and agricultural development continues to significantly fragment the ecological connections between coastal watersheds, wetlands, and the marine system. This section discusses the primary contributors to the regional decline in wetland and riparian ecosystems. These are also summarized in Table 2.1.

Draining, Filling, and Converting Wetlands

As discussed above, at least 75 percent of the coastal wetlands in Southern California have been lost. Large-scale destruction of coastal wetlands began during the second half of the 19th century. At that time, coastal wetland and estuarine habitats were generally seen as breeding grounds for disease-carrying mosquitoes. Many were used as dumps. Federal, State, and local policies encouraged the draining and filling of wetlands and their conversion to agricultural, urban, and military land uses. The direct loss of wetland habitat is probably most striking with the historic wetlands of the Los Angeles River floodplain. The extensive marshes, streams, lakes and seeps associated with the river covered much of present day downtown Los Angeles to San Pedro Bay and eastward to the San Gabriel River. Almost of all of that habitat has been lost.

Hydrologic Modification

Southern California's hydrologic landscape has been massively altered by dams, channelization, groundwater pumping, imported water, and other human activities. These projects have affected the quantity and timing of surface water flows, sediment transport functions, and flood regimes, which in turn have impacted aquatic and riparian habitat, channel geometry, and many other processes. The primary hydrologic modifications seen in the region and their impacts are outlined below.

As discussed in the Regional Setting section, Southern California is characterized by periodic large floods associated with El Niño events. As the region grew, these floods had increasingly devastating impacts on human activities. The most extensive hydromodifications in the region arose from efforts to control flood waters. Rivers and creeks were dammed, redirected, confined within levees, and lined with concrete. These "improvements" allowed urban and agricultural development to encroach further into the floodplains. Today, flood control projects continue to dam and channelize the region's waterways. Dams and diversions have also been constructed in many watersheds to supply water for urban and agricultural uses. In the 24 major drainage systems within the Southern California Bight, 53 percent of the drainage area is controlled by major water retention structures, such as dams and reservoirs (Brownlie and Taylor 1981).

Water supply and flood control projects implemented throughout Southern California have had widespread impacts on the region's wetland and aquatic ecosystems. One of the most significant impacts has been the loss of floodplain and riparian habitat along stream corridors. As discussed above, it is estimated that 90-95 percent of the riparian habitat in the region has been lost. Dams and diversions also change quantity and timing of stream flows and disrupt sediment transport to coastal wetlands and estuaries.

Sprawling urban development throughout Southern California has also changed the region's hydrologic conditions. As an area is developed, roads, sidewalks, driveways, and other impervious surfaces are constructed that reduce infiltration of water into the ground. When it rains, water which previously would have been absorbed into the ground, flows freely into rivers and streams, increasing the volume and rate of storm flows. Urbanization is estimated to increase runoff from an area as much as two to five times the normal flow (Krug and Goddard 1986). The increase in runoff volume and peak flows often destabilizes urban creeks, leading to severe channel and bank erosion and loss of riparian habitat. In Southern California, the common cure for creek destabilization has been concrete; that is, line the channel with concrete so that it will not erode.

Other human activities that have changed both the quantity and timing of surface water flows include irrigation, wastewater discharges, groundwater pumping, and use of imported water. Flows from urban and agricultural runoff and treated wastewater have significantly increased dry season flows so that many previously intermittent streams are now perennial. Use of imported water has increased the overall amount of water available in Southern California. In some areas, extensive groundwater pumping has caused natural springs and seeps to dry up, leading to loss of wetland habitat.

A disturbance in the hydrology can alter the physical, chemical, and biological processes of a coastal wetland. When the hydrology of a wetland changes slightly, the biota may respond with changes in species composition and richness. The primary and secondary levels of ecological productivity are also impacted by hydrological modifications. Excess depths, frequencies, and duration of inundation in wet seasons, or water deficiencies in dry seasons, have the potential to alter the vegetative community and, thus affect the wildlife and aquatic organisms that use the wetland. Too much or too little freshwater can adversely affect fish spawning, shellfish survival, bird nesting, seed propagation, and other seasonal activities of fish and wildlife.

Changes in the availability and timing of freshwater also impact water quality by altering water temperature, salinity, pH, nutrients, oxygen availability, and turbidity, as well as the frequency and extent of tidal mixing and flushing. At lagoons with intermittent tidal influence, barrier beaches may be breached more or less often.

Alterations of Sediment Transport Processes

Transport of sediment is a natural function of a healthy watershed and maintains a delicate balance between erosion and sedimentation. Changes in water level, flow, flood frequency, or groundwater availability will alter erosion and sedimentation balances. In Southern California, sediment transport processes have been altered in many ways, including:

- Dams in the upper watersheds have created physical barriers to sediment transport.
- Dams and water diversions have reduced winter storm flows, thereby reducing downstream scouring of bays and estuaries and sediment delivery to the nearshore waters.
- Ground disturbance associated with urban and agricultural development has caused increased erosion in many watersheds, and frequently has resulted in excess sedimentation of downstream wetlands.
- Increased storm runoff and peak flows have increased bank erosion and channel incision in urban watersheds.
- Levees and canals have altered the geomorphic equilibrium of watersheds, causing destabilization and erosion of natural channels, wetlands, and estuaries.

Conditions in each watershed are unique depending on both the natural environment and human activities. In general, however, three trends are seen in the region: 1) increased sediment flows in coastal streams in urban or developing areas; 2) increased sedimentation in coastal wetlands; and 3) decreased delivery of sediment to the nearshore waters.

Each of southern California's coastal wetlands exists in a delicate sediment balance. Excess sediment delivery can smother riverine, estuarine, and marine habitats, destroy benthic organisms, reduce colonization, interfere with feeding, and reduce the abundance and diversity of plants associated with wetlands. Conversely, insufficient sediment delivery can result in erosion and conversion of wetlands to open water habitat. Sediment flows are also a main transport mechanism for pesticides that adhere to soil particles. The most significant impacts on coastal wetlands of altered sediment transport processes have been caused by accumulated soils washed into surface waters by winter storms and periodic floods.

Degraded Water Quality

Both urban and agricultural development have contributed to a degradation of the region's water quality resulting in increased water temperature, turbidity, and concentrations of nutrients and contaminants (including heavy metals and organic compounds). [2] Impacts to coastal wetlands and estuaries from point and non-point source pollution are diverse and include direct toxicity to biota, eutrophication, oxygen depletion, and sedimentation. Excessive amounts of decaying organic matter, for example, can decrease available oxygen in the water, making habitat unsuitable for fish and other aquatic life.

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2 Sidebar
Golf courses discharge a variety of pollutants, including nutrients, pesticides, herbicides, and organic materials, to the watersheds of coastal wetlands and estuaries. These impacts are most pronounced in golf courses that were constructed decades ago when vegetative buffers were not a requirement for receiving water quality certification from the state. In such older courses, turf grass is commonly manicured and maintained down to the edge of the creeks or rivers, which traverse them. This direct connection between the streams and the manicured turf grass facilitates the transport of fertilizers, pesticides, and grass clippings into the streams and ultimately to coastal wetlands and estuaries. Pollutant releases from golf courses are of particular concern in the reduction of water quality in several areas of the region.

Non-point source (NPS) pollution is the leading cause of water quality impairment to wetlands and estuaries in southern California. Unlike pollution from distinct, identifiable point sources (e.g., a municipal wastewater treatment plant), NPS pollution comes from many sources. NPS pollution is transported by storm and irrigation runoff moving over and through the ground. As the runoff moves, it picks up and carries pollutants, which can be deposited in lakes, rivers, wetlands, and the marine system. Sources of storm water pollution in the watershed are numerous. Copper contamination, for instance, comes from the degradation of automobile and truck brake shoes. NPS pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, metals, and organic chemicals from urban runoff;
- Sediment from improperly managed construction sites, croplands, and eroding stream banks;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;
- Salt from irrigation practices;
- Deposition of air pollutants.

During a rain storm, especially the first of the season, the particles that have fallen to highways, streets, parking lots, and driveways become washed into roadside ditches, which dump into storm drains or creeks, and eventually into coastal watersheds.

Increased loading of nutrients to Southern California's coastal wetlands is of particular concern because it can result in the rapid growth of aquatic plants and plankton, decreasing biological productivity and diversity and leading to depletion of oxygen in coastal wetlands. Major sources of nutrients include runoff fertilizer-laden runoff from agricultural lands and urban landscaping, runoff from livestock areas, wastewater discharge, and sewage spills. Nutrient-laden runoff can be reduced through implementation of management practices such as drip irrigation.

At the Carpinteria Salt Marsh, Page (1999) has linked development of greenhouses in the watershed to elevated levels of nutrients at the marsh. During periods of reduced or no tidal flushing, nitrate enriched runoff results in the rapid growth of macroalgae. Potential impacts of algal blooms include reduction in the abundance and diversity of invertebrates, inhibition of bird feeding behavior, and reduction of oxygen concentration in the water column during algal growth and decay.

Introduction of Exotic Species [3]

Intentional or accidental introduction of invasive non-native species may result in unexpected ecological, economic, and social impacts to wetland ecosystems. Non-native plants often provide little or no habitat value to native fish and wildlife, and introduced animals may threaten native species through predation and competition. Introduced species may have no natural predators in the region. Through predation and competition, introduced species have contributed to the decline of several native populations, fundamentally altering the food web.

Invasive plant species of particular concern in Southern California include Arundo, pampass grass pepperweed, tamarisk, and castor bean. Red fox, feral cats, and off-leash dogs are major introduced predators of wildlife, particularly birds, in coastal wetland ecosystems. In the summer of 2000, *Caulerpa taxifolia*, a highly invasive marine algae, was discovered in two coastal embayments of Southern California. If this algae is not eradicated, it threatens to significantly alter the region's estuarine ecosystems, and could destroy commercial and recreational fisheries.

Resource Extraction

Coastal watershed and wetland systems have also been impacted by resource extraction activities. For instance, salt extraction occurs in south San Diego Bay, aquaculture is conducted in Agua Hedionda Lagoon, and sand and gravel has been mined from many creeks and rivers in the area. In Orange and Los Angeles counties, oil extraction facilities have been located in several coastal wetlands. Impacts to coastal wetlands and streams from resource extraction activities range from disturbance and extraction of wetland species to habitat destruction.

Recreational Use

Southern California is the most highly urbanized region in the state. Open space and opportunities to interact with nature are extremely limited. This situation has created great pressure to provide recreational access to coastal wetlands and stream corridors. Unfortunately, the presence of humans, pets, and motorized vehicles can disturb species that depend on these habitat areas. Off-trail use by hikers, bikers, and equestrian users can trample plants and lead to increased erosion and habitat destruction. Off-leash dogs can disturb wildlife and cause considerable damage to fragile plant species. These impacts are likely to increase as the region's population grows.

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3 Sidebar

Arundo donax is a fast-growing invasive riparian species that propagates vegetatively either from roots or from stems or rhizomes that break off and establish new patches downstream. Having no natural competitors or predators in California, its growth is rapid, allowing it to completely infill stream channels and grow to heights exceeding 25 feet.

The deleterious effects of *Arundo* include the displacement of native riparian vegetation with monocultures of Arundo that have little habitat value for native species. Dislodged *Arundo* plants can choke stream channels and create debris dams that impede fish passage and flood flows. Because *Arundo* is highly flammable, the probability of wildfire increases in infested areas. Its prodigious rate of water consumption can reduce stream flow and groundwater recharge and reduces available water for native species. *Arundo* stalks provide little shade; consequently, exposure to direct sunlight increases water temperatures thereby lowering dissolved oxygen, and promoting algal growth that also alters the pH. These effects all contribute to habitat degradation and loss of life and for many aquatic species.

Climate Change

Climatologists generally expect an anthropogenic global warming that could raise sea level 20-60 inches in the next century and more thereafter. Because coastal wetlands and estuaries are mostly within a few feet of sea level they are particularly vulnerable to rising sea level. If the rise in sea level is not matched by vertical accretion of sediments in wetlands, there will be a gradual conversion of coastal wetlands to open water habitat. Although the inundation of adjacent lands near wetlands would enable new wetlands to form, much of this land is or will soon be developed. If adjacent development is not removed, all coastal wetlands could be squeezed between the rising sea and the dikes or bulkheads used to protect development.

Summary

Southern California's natural landscape has been greatly altered by human activities over the past 150 years, leading to extensive loss and degradation of coastal wetlands and stream corridors. Significant changes in hydrologic patterns and sediment flows, increased inputs of pollutants, channelization of stream corridors, and encroachment of urban development present a complex set of challenges for preserving and restoring the remaining wetlands resources. These challenges increase as population growth and urban development continue throughout the region.

Table 2.1 Anthropogenic Impacts on Wetlands and Stream Corridors

Activity and pathway	Sediment and soil disturbance	Vegetation removal	Hydrologic regime modification	Conversion of wetlands and submerged lands to dry land	Increased sediment delivery	Increased turbidity	Increased runoff volume and flow rate	Increased erosion	Decreased salinity in brackish, estuarine, or saltwater wetlands	Decreased wetland water supply	Increased wetland water salinity	Increased water temperatures	Resuspension of sequestered pollutants	Toxicity to wetland biota	Eutrophication	Introduction of non-native species resulting in reduced native biodiversity	Submerge existing coastal wetlands
Construction, Development, and Urbanization																	
Direct physical modification	X	X	X	X													
Ground disturbance					X	X											
Increased impervious surface area							X	X	X								
Discharges and runoff of imported water and wastewater									X								
Water diversion										X	X						
Removal of riparian canopy												X					
Air and water pollution (polycyclic aromatic hydrocarbons, petroleum products, metals, other toxic substances)														X			
Channelization																	
Direct physical modification	X	X	X	X													
Removal of riparian canopy												X					
Dredging and Filling																	
Direct physical modification	X	X	X	X													
Sediment disturbance						X							X				
Agriculture																	
Direct physical modification	X	X	X	X													
Ground disturbance					X	X											
Agricultural runoff (salt, pesticides, nutrients)											X			X	X		
Animal waste runoff (salt, pathogens, nutrients)											X			X	X		
Pesticides														X			
Animal feed																X	
Nurseries, Landscaping, and Gardening																	
Runoff (salt, pesticides, nutrients)											X			X	X		

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Activity and pathway	Sediment and soil disturbance	Vegetation removal	Hydrologic regime modification	Conversion of wetlands and submerged lands to dry land	Increased sediment delivery	Increased turbidity	Increased runoff volume and flow rate	Increased erosion	Decreased salinity in brackish, estuarine, or saltwater wetlands	Decreased wetland water supply	Increased wetland water salinity	Increased water temperatures	Resuspension of sequestered pollutants	Toxicity to wetland biota	Eutrophication	Introduction of non-native species resulting in reduced native biodiversity	Submerge existing coastal wetlands
Introduction of self-propagating non-native species																X	
Sewage Conveyance, Treatment, and Disposal																	
Runoff, direct discharge, and spills (salt, pathogens, nutrients)											X			X	X		
Discharge of chlorine														X			
Discharges of wastewater									X								
Water Supply and Treatment																	
Chlorine discharge from spills and leaks, pipeline and tank dewatering, and runoff														X			
Pipeline and Tank dewatering					X	X		X									
Direct application of metals (copper sulfate)														X			
Global Climate Change																	
Sea-level rise																	X