WETLANDS OF CALIFORNIA, PART I: HISTORY OF WETLAND HABITAT CLASSIFICATION

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ABSTRACT

A review of the history of vegetation classification in California reveals a serious underestimation of the diversity, extent, and functions of the state's wetlands and consequently, a misrepresentation of the perceived paucity of wetlands in California and the arid West. We review the classification systems of California's wetlands, beginning with early efforts in vegetation typing by the U.S. Forest Service, and illustrate that a detailed comprehensive methodology for the classification and description of wetlands and deepwater habitats is required before they can be protected and managed adequately.

Wetlands can be classified within a system of categories distinguished by origin, structure, flooding frequency, water chemistry, dominant organisms, or some other combination of physical and/or biological attributes. A hierarchical classification of wetlands is a system of classification where wetlands are ranked in categories one above another. Cowardin et al. (1979) produced a hierarchical classification of wetlands for the U.S. Fish and Wildlife Service that incorporated a ranking of systems, subsystems, classes, and subclasses. We have adopted this classification (Ferren et al. 1995) as a starting point and have modified and expanded it formally to include water regimes, water chemistry, hydrogeomorphic units, and substrate and dominance-type categories (see Part II, Ferren et al. 1996a; and Part III, Ferren et al. 1996b). Although Cowardin et al. (1979) provided modifiers for the classification in the form of categories for water regimes, chemistry, and dominance types, these

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were never formally incorporated into the classification, and in addition, no landform/habitat information was provided. Thus, it was not possible in their classification to distinguish a wetland based upon its ecosystem context, such as a structural basin estuary, montane alkali lake, or coastal plain stream.

California has a complex interface of environmental factors; therefore it is necessary to employ a classification of wetlands that portrays adequately the richness of wetland types resulting from this complexity. A classification methodology demonstrating differences among wetlands is essential if conservation efforts are to preserve at least some representation of the state's natural wetland heritage. Largely because of the rapid urbanization of California, it will be difficult to conserve wetland resources that are not identified as distinct or sufficiently described. Classifying and describing different wetland types will help establish a link, for example, between a specific wetland habitat and any existing or potentially significant or unique ecosystem function (e.g., endangered species habitat) or socioeconomic value (e.g., wetlands as nurseries for economically important fish such as halibut). To date, no previous attempts at classifying California wetlands have approached the level of detail that is required to articulate the richness of the state's wetlands. In this paper we provide a history of the classification of wetlands in California to demonstrate the various weaknesses in previous classification efforts. We then propose a classification methodology in Part II (Ferren et al. 1996a) and a key to and catalogue of example types in Part III (Ferren et al. 1996b) as contributions toward the wetland conservation effort and an improvement in documentation techniques.

Environmental Setting

California is climatically, topographically, and geologically diverse, which contributes to its great habitat richness (Barbour and Major 1988). Factors that influence the formation and differentiation of wetlands can include, elevation, exposure, landform, bedrock, soil, rates of erosion or sedimentation, temperature, rainfall, accumulation of salts, distance from the ocean, tidal regimes, energy of water flow, and artificial disturbances. Wetlands of the state extend topographically from marine wetlands exposed irregularly at extreme low tide, to glacial ponds and alpine habitats. The great richness of habitat types and environmental parameters, including potentially large seasonal variation in local weather patterns, has undoubtedly contributed to the evolution of equally rich and often unique biological resources. Biological endemism is a particular characteristic of wetlands with special hydrogeochemical features, such as alkali meadows, serpentine and tar seeps, vernal pools, and salt marshes.

Wetlands in central and southern California occur in various ecosystem contexts and have origins related to several major physical processes. Wetlands that develop as a result of fluvial processes occur in riparian corridors along streams and rivers, such as the Santa Margarita and San Luis Rey rivers in San Diego County. Riverine and palustrine wetlands also may occur in proximity to estuarine and marine wetlands where a river reaches the coast and sea water mixes with fresh water of continental origin, such as at the mouths of the Santa Ynez, Ventura, and Santa Clara rivers. Elsewhere, structural basins with high or perched water tables may serve as sediment sinks and support the development of alkali flats, as in the Temescal Wash and Lake Elsinore area along the eastern margin of the Santa Ana Mountains in Riverside County. Other basinal hydrogeomorphic units and their associated wetlands can develop as a result of: (1) eolian processes that form dune swale wetlands, such as at the San Antonio Terrace Dunes on Vandenberg Air Force Base in Santa Barbara County; (2) earthquake faults along which can form "sag-ponds", such as Lost Lake in San Bernardino County; (3) historic glaciation that has produced ponds impounded by moraines, such as Dollar Lake in the San Gorgonio Wilderness; (4) volcanism that can create calderas, such as Zaca Lake in Santa Barbara County; or (5) artificial creation of basins including the impoundment of lacustrine reservoirs, such as Big Bear Lake in San Bernardino County, Cachuma Lake in Santa Barbara County, Lake Casitas in Ventura County, and Twitchell Reservoir in San Luis Obispo County.

In addition to the creation of wetlands and deepwater habitat wetlands associated with artificial structures such as reservoirs, various impacts to ecosystems also can result in the conversion of wetlands from one type to another, further compounding the process of classification. For example, at Ballona Wetlands (Playa Vista) in Los Angeles County, natural estuarine wetlands were converted to nontidal, impounded, palustrine wetlands when berms and tide gates were installed. These artificial palustrine wetlands were used temporarily for agricultural purposes. The resulting degraded wetlands support a mixture of native hydrophytes and exotic weedy species in a soil topography typical of tilled areas. A large-scale restoration project has been approved for portions of the Ballona Wetlands (National Audubon Society 1986), which will return tidal circulation to previously estuarine habitats and also introduce the process of wetland restoration to the classification and description of the site's habitats.

Superimposed on the origin (e.g., fluvial, structural, eolian, glacial, volcanic), ecosystem context (e.g., estuaries, streambeds, lake margins), and disturbance history (natural or artificial) of wetlands are the influential attributes of strongly seasonal, wet and dry periods, and a wide range of edaphic differences among sites. The combination of these environmental features results in the formation of a truly vast number of hydrogeomorphic units (i.e., wetland habitats such as bars, banks, channels, pools, and seeps) and their corresponding wetland types. This is the origin of the rich wetland heritage of California.

Scarcity and losses. Because of the generally dry climate of the ecoregions of southern California, dogma apparently has developed in many professional and lay circles that wetlands of the region are uncommon and by inference are limited in type, numbers, and importance. Generalizations abound. For example, ". . . marshes and swamps are scarce throughout the [Californian estuary] province" (Cowardin et al. 1979, p. 28). Recent evidence, such as that presented herein (Part II, Ferren et al. 1996a), demonstrates that wetlands of the California province are very diverse. Some wetlands such as those associated with riparian corridors are more common, whereas others are rare and even unique, such as natural lacustrine lakes (e.g., Baldwin Lake in San Bernardino County, Cuyamacha Lake in San Diego County, and Mystic Lake in Riverside County) of coastal southern California, each of which is represented by only one example. The incomplete and largely superficial approach to classification, description, and inventory of wetlands in California has led to many difficulties in the protection and management of these wetlands, as well as in the simplification and generalization of important ecosystem functions. In direct terms, the recognition of fewer wetland types and fewer examples of these types has translated to less protection for the unrecognized natural diversity and for the extent of this diversity.

As might be expected, we have found that many wetlands have been destroyed before they were identified, studied, and protected. In the United States during the past 200 years, the lower 48 states have lost an estimated 53% of the original 221 million acres of wetlands; 22 of these states have lost 50% or more of their original wetland acreage (Dennis and Marcus 1984; Dahl 1990). Dennis and Marcus (1984) estimated nearly a decade ago that approximately 9% (ca. 450,000 acres) of the wetland resources remain as compared to when California became a state in 1850 (ca. 5 million acres). This translates to a loss of 91% of the state's wetlands, and a reduction of total surface of the state in wetlands from approximately 5% of the land to less than one-half of one percent of the land (Dahl 1990).

The California Department of Parks and Recreation (CDPR 1988) reports that at the state-wide level, California has lost approximately 80% of the coastal salt marshes, 95% of the riparian wetlands, 90%

of freshwater marshes, and 90% of the vernal pools. Along the southern coast of California, CDPR (1988) estimates there has been a 75% reduction in wetlands, from approximately 53,000 acres to 13,000 acres. In southern California, notable examples of wetland categories for which losses have been extensive include: (1) estuarine wetlands (i.e., salt marshes) as an entire subsystem at 75–90% (Zedler 1982; California Department of Fish and Game 1983; California Coastal Commission 1989); (2) "the riparian community" at 90–95% (Faber et al. 1989) including loss of 40% of the riparian wetlands in San Diego County during the last decade alone (CDPR 1988); and (3) vernal pools at 90% (Zedler 1987). These losses have contributed directly to the endangerment of the biological resources of California, as evidenced by estimates that 55% of the animals and 25% of the plants designated as threatened or endangered by the State depend on wetland habitats for their survival.

It is with general interest in our California wetland heritage and with concern for the rate and extent of habitat loss that we have integrated a compilation of information into a hierarchical classification (see Part II, Ferren et al. 1996a) based on a modified version of Cowardin et al. (1979). The scope of this classification includes all wetlands from the five wetland systems identified for North America (i.e., marine, estuarine, riverine, lacustrine, palustrine), each of which occurs in California. Only through detailed analysis can we appreciate fully the richness of wetland habitats and biota in California, and can we hope to protect and manage those wetlands that remain.

Classification of California Wetlands

Early efforts. From 1927 to 1941, the U.S. Forest Service conducted the Vegetation Type Map Survey of California, which was based largely on upland types of vegetation cover (e.g., chaparral). It included only a few broad categories of wetlands (e.g., coastal marshes) and several aquatic features (e.g., large bodies of water). The great majority of wetland types, however, were not identified and most of the vegetation maps were never published. In addition to this generalized federal effort, individual researchers published detailed floras and technical papers on particular sites or habitats such as vernal pools in San Diego County (Purer 1939) and marshlands at Newport Bay (Stevenson and Emery 1958). Munz (1959, 1968) typically has been cited as the reference for vegetation classification provided in the statewide floristic treatment, *A Flora of California.* However, he treated vegetated wetlands in only several broad categories (e.g., coastal salt marshes, freshwater marshes, and alkali sink). More typically, Munz referred to the habitat in which particular wetland species occurred (e.g., "along streams", "rather deep water", "shallow ponds", "vernal pools", "muddy places"); or he provided an indication that the wetland community was within a larger context such as "Foothill Woodland", "Chaparral", or "many Plant Communities". No clear explanation of palustrine scrub-shrub or forested wetlands occurred in this classification. The importance and impact of the publication of Munz (1959), however, cannot be minimized in the treatment of the state's flora or its vegetation. His tendency to overlook the richness of wetland types has had a profound effect to the present (e.g., Holland 1986; Sawyer and Keeler-Wolf 1995).

Perhaps the most important publication on the flora of California wetlands was authored by Mason (1957) two years before the issue of Munz (1959). In *A Flora of the Marshes of California,* Mason compiled a compendium on the wetland flora and included much information on wetland habitats, although he proposed no formal classification of types of wetlands or wetland vegetation. He included many insightful comments for the time, including:

> *Generalizations regarding the floristic organization of the marsh and wetland habitats are difficult, because such organization centers around the intergrading environmental variables that not only account for different combinations of habitat conditions, but, through natural selection, permit a high degree of overlapping of species between habitats. Communities of plants therefore are rarely definitive in relation to what may appear to be distinctive habitat. The three most important sets of environmental variables are:*
>
> 1. *The relative permanence of water, or the character of the intermittence of water in the habitat*
> 2. *The relative salinity and the hydrogen-ion concentration of the soil solution*
> 3. *The habitat variables related to seasonal temperature and length of the growing period*
>
> *Some aspects of each of these three sets of variables are evident in every marsh or wetland habitat. They combine in various ways to produce exceedingly complex habitat diversity . . . (Mason 1957, p. 7)*

Many of the observations made by Mason for the state, especially his extensive research in central California wetlands (Mason n.d.) nearly forty years ago, are true today but have been overlooked during recent efforts to classify wetlands.

Improvements and additions. The first major effort to provide a statewide, hierarchical classification of habitats was provided by

Cheatham and Haller (1975) as an unpublished manuscript, which originally was intended for inclusion in Barbour and Major (1977). Cheatham and Haller (1975, p. 2) defined habitat type or one of its subdivisions as: "an assemblage of natural features of the landscape that lead us to the subjective conclusion that one area is sufficiently different from another to warrant separate description." They described their "Major Categories" as approximating "Vegetation Types" in Munz (1959), and their "Habitat Types" as approximating "Plant Communities" in Munz. They also added "Major" and "Minor Subdivisions" of the Habitat Types. In their work for the University of California's Natural Reserve System, Cheatham and Haller (1975, p. 2) found that ". . . it was obvious we were working with habitat types that fell between [Munz's] categories." They subsequently stated that their document ". . . goes into a more detailed level and attempts to pick up where [Munz] leaves off" (Cheatham and Haller 1975, p. 2). Several major subsequent works on the classification of California vegetation (e.g., Holland 1986; Sawyer and Keeler-Wolf 1995) elaborate upon the effort set forth by Cheatham and Haller. Relevant examples of the Cheatham and Haller categories with selected subcategories are presented in Table 1.

At about the same time that Cheatham and Haller (1975) was in preparation, the California Native Plant Society held a symposium entitled *Plant Communities of Southern California* (Latting 1976), during which Thorne (1976) provided another classification of vascular plant communities of California. This classification also was described as a replacement for Munz (1959):

> *The [Munz] classification of plant communities has served a most useful purpose in the past but it omits numerous recognizable plant communities or combines several under one overly broad heading. Most neglected are the aquatic communities with surfweed, marine meadow, vernal pool ephemeral, bog, and riparian communities largely ignored and freshwater marsh and stream, lake, pond, and reservoir aquatic communities combined under freshwater marsh (Thorne 1976, p. 5).*

Table 2 includes the aquatic communities presented in numerical order by Thorne (1976).

Both classifications by Cheatham and Haller (1975) and Thorne (1976) made important contributions to classify the vegetated and nonvegetated wetland resources in California. However, neither provided a methodology that was sufficiently detailed for the identification, classification, and nomenclature of the great richness of wetland types that occur in California. In 1980, The Nature Conservancy and the California Natural Diversity Data Base (Holstein 1980) at the California Department of Fish and Game released a

TABLE 1. EXAMPLES CALIFORNIA HABITAT "CATEGORIES" WITH SELECTED "SUBCATEGORIES" THAT INCLUDE WETLANDS AS PORTRAYED BY CHEATHAM AND HALLER (1975).

- 1.0 COASTAL AND SHORELINE HABITATS
  - 1.1 Open Water
    - 1.11 Bays and Harbors
    - 1.12 Coastal Esteros
  - 1.2 Coastal Wetlands
    - 1.21 Tidal Flats
    - 1.22 Salt Marshes
  - 1.3 Exposed Open Coast
    - 1.31 Exposed Sandy Beach
    - 1.32 Exposed Cobble Beach
    - 1.33 Exposed Mixed Beach
    - 1.34 Exposed Rocky Shore
  - 1.4 Protected Open Coast
- 3.0 SCRUB AND CHAPARRAL
  - 3.6 Alkali Scrub
    - 3.62 Alkali Sink Scrub
      - 3.621 Intermittently Moist Alkali Sink
      - 3.622 Permanently Moist Alkali Sink
    - 3.63 Alkali Seep
- 4.0 GRASSLANDS, VERNAL POOLS, AND MEADOWS
  - 4.4 Vernal Pools
    - 4.41 Great Valley Vernal Pools
      - 4.411 Sacramento Valley Vernal Pools
      - 4.412 San Joaquin Valley Vernal Pools
    - 4.42 Coast Range Vernal Pools
    - 4.43 Southern California Vernal Pools
      - 4.431 Interior Cismontane Vernal Pools
      - 4.432 San Diego Mesa Vernal Pools
  - 4.5 Meadows and Seeps
    - 4.51 Montane Meadow
    - 4.52 High Elevation Meadows
    - 4.54 Alkali Meadows
    - 4.55 Alkali Seep
    - 4.56 Freshwater Seep
- 5.0 BOGS AND MARSHES
  - 5.1 Bogs and Fens
  - 5.2 Marshes and Swamps
    - 5.21 Coastal Salt Marshes
    - 5.22 Coastal Brackish Marshes
    - 5.23 Alkali Marshes
- 6.0 RIPARIAN HABITATS
  - 6.1 Bottomland Woodlands and Forests
  - 6.2 Streambank Woodlands and Forests
  - 6.3 Alluvial Woodlands and Forests
  - 6.3 Palm Oasis Woodland
- 7.0 WOODLANDS
  - 7.4 Alluvial Woodlands (see 6.3)
- 10.0 AQUATIC HABITATS
  - 10.1 Springs
  - 10.2 Streams
    - 10.21 Mountain Streams
    - 10.22 Foothill and Valley Streams
    - 10.23 Coastal Streams
  - 10.3 Rivers
  - 10.4 Lakes and Streams
  - 10.5 Cave Aquatic Habitats

TABLE 2. A CLASSIFICATION HIERARCHY THAT INCLUDES THE "AQUATIC COMMUNITIES" OF CALIFORNIA PRESENTED BY THORNE (1976).

1. MARINE AQUATIC
   a. Surfweed
   b. Marine Meadow
3. COASTAL SALT MARSH
   a. Tidal marsh
   b. Salt-flat succulent
4. FRESHWATER AQUATIC
   a. Freshwater marsh
   b. Lake, pond, and quiet stream aquatic
   c. Reservoir semiaquatic
5. VERNAL POOL EPHEMERAL
6. SPHAGNUM BOG
   a. Floating bog
   b. Darlingtonia bog
   c. High nutrient bog
7. RIPARIAN WOODLAND
10. PACIFIC CONIFEROUS FOREST
   d. Redwood forest (in part)
16. MOUNTAIN MEADOW
   a. Montane Meadow
   b. Subalpine Meadow
   c. Alpine Meadow
20. DESERT SCRUB AND WOODLAND
   h. Desert oasis woodland
   i. Desert riparian woodland
21. ALKALINE SCRUB
   b. Alkali sink scrub
   c. Alkali meadow and aquatic

draft version of the *California Vegetation Cover Types,* which included a hierarchical list of types based on vegetation cover and arranged in systems, cover classes, cover types, and community types. The list provided no information on locations or habitats and did not separate wetland from upland types. As with many efforts, Holstein (1980) excluded habitats lacking vegetation cover, but he did include systems for bryophytes, lichens, and algae.

Agency efforts. State and federal agencies also have developed classifications of vegetation. The U.S. Fish and Wildlife Service developed a comprehensive classification methodology to inventory and map the nation's wetlands as part of the National Wetland Inventory (NWI) Program. This classification, entitled *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979), has provided the definition of wetlands accepted in our classification (see Part II and III, Ferren et al. 1996a&b), emphasizing the presence of wetland hydrology, hydrophytic vegetation, or hydric soils. Under a more recent interpretation of the U.S. Fish and Wildlife Service definition, however, a wetland must be periodically saturated or covered by shallow water during a portion of the growing season, regardless of the presence of hydrophytes or hydric soils (Tiner 1989). National Wetland Inventory (NWI) maps, based on high altitude aerial photography and plotted on 7.5″ U.S.G.S. quadrangle maps, exist for most of California; however, they often are incomplete and general in the categorization of wetland types. As in our previous comments, this classification provided the primary structure for the higher levels of our hierarchical classification, but it is insufficient to portray accurately the richness of wetland types because it lacks most elements of hydrogeomorphology that are essential in the differentiation of types.

In a series of publications (Payson et al. 1980, 1982; Hunter and Payson 1986), the U.S. Forest Service offered a hierarchical classification and guides for the state. One such publication, *A Vegetation Classification System Applied to Southern California* (Payson et al. 1980), included the following hierarchical elements based on plant structure (i.e., physiognomy) and cover: Formations (e.g., Herbaceous), Subformations (e.g., Aquatic), Series (e.g. Pondweed Series), Associations (i.e., a plant community or the basic unit of the classification), and Phases (i.e., local variants). The authors state that:

> *The Vegetation Classification System for Southern California is compatible at all levels with a national land classification system being proposed by the Forest Service and which incorporates the international system for classifying vegetation. . . . The system is based upon a hierarchical stratification of plant cover. . . . The nomenclature for Association reflects the dominant overstory species, and the most prevalent (or distinguishing) associated species. . . . The Associations have not yet been developed. They can be identified on the ground on a project basis of identified uniformity for the entire southern California area after adequate field samples are taken (Payson et al. 1980, p. 2).*

This classification system is open ended in that the Associations and Phases are generally left undescribed. As with most other efforts, nonvegetated areas are not included, and only physiognomy and vegetation cover are used to classify the upland and wetland vegetation. In a related effort, the U.S. Forest Service has undertaken an ecosystem-type classification for its lands, including reconnaissance and intensive sampling and ecological type description (Allen 1987). The "Ecological Type" is the basic unit of the classification model and ". . . is defined as a classified category of land with a unique plant association and physical site characteristics, differing from other categories of land in its ability to produce vegetation and respond to management" (Allen 1987, p. 2). This classification apparently is meant largely for upland ecological types, and would include only vegetated wetlands on Forest Service lands.

In 1990, the U.S. Environmental Protection Agency (EPA), Region IX, prepared a draft, *List of Priority Wetland and Aquatic Habitats of California* (Leidy 1990). As stated in the document, "The . . . list represents the initial efforts to identify priority wetland and aquatic habitats within California. This list identifies particularly important and vulnerable wetland and aquatic habitats in order that these areas can receive improved levels of protection by EPA under its various review and regulatory authorities" (Leidy 1990, p. 1). The extensive, annotated list includes by region, the name, location, habitat types, function, categorized socio-economic value, threat, and status of the wetlands and aquatic habitats. The following "habitat types" are used: (1) estuarine; (2) lagoon/bay, open ocean; (3) riverine [perennial stream, intermittent stream, pool/riffle sequence]; (4) lacustrine; (5) mud flat; (6) vegetated shallows; (7) emergent wetland [salt marsh, brackish marsh, freshwater marsh]; (8) riparian woodland/wetland; (9) farmed wetland; (10) vernal pool; and (11) other. In a recent effort, EPA IX funded a study of the assessment of ecosystem functions of the waters of the United States, including wetlands, in the Santa Margarita Watershed (L. C. Lee & Associates, Inc. 1994). Wetland nomenclature for the inventory of types followed an earlier draft version of our modified Cowardin et al. approach.

State agencies also have undertaken efforts to classify California's vegetation, habitats, and ecosystems. The California Department of Parks and Recreation (CDPR) initiated a project in 1979 to conduct an inventory of "terrestrial and semiterrestrial vegetation" included on their lands (Jensen 1983). Most state efforts are agency specific, however, and do not consider lands outside the jurisdiction of a specific agency. The CDPR vegetation classification is part of a multi-hierarchical classification system of ecosystem, biotic communities, and habitats. The Natural Diversity Data Base of the California Department of Fish and Game has made several efforts at conducting inventories and assessments and at improving the classification of vegetation. Jensen (1983) conducted an inventory using Cheatham and Haller's classification and produced a document on their occurrences for The Nature Conservancy entitled *The Status of California's Natural Communities: Their Representation on Managed Areas.*

Perhaps the most important and widely-used addition to classification efforts has been contributed by the Department of Fish and Game, *Preliminary Descriptions of the Terrestrial Natural Communities of California* (Holland 1986). Holland's treatment is based on a thorough reorganization of Cheatham and Haller, resulting in a hierarchical, numerical classification with element codes, names, descriptions, and characteristic species presented for each community. Approximately 68 wetland community types are identified in this statewide effort. Although this document and classification has been the most useful to date, many wetland types were omitted or grouped with other types. For example, no clear separation of wetland and upland riparian was established. Certain relevant portions of the Holland classification are found in Table 3.

Currently the California Department of Fish and Game, in con-

TABLE 3. PORTIONS OF THE HOLLAND (1986) "TERRESTRIAL COMMUNITY" CLASSIFICATION FOR CALIFORNIA, INCLUDING APPARENT WETLAND "ELEMENT CODES AND NAMES."

40000	GRASSLANDS, VERNAL POOLS, MEADOWS, OTHER HERB COMMUNITIES			
	44000	Vernal Pool		
		44100	Northern Vernal Pool	
			44110	Northern Hardpan Vernal Pool
			44120	Northern Claypan Vernal Pool
			44130	Northern Volcanic Vernal Pool
		44300	Southern Vernal Pool	
			44310	Southern Interior Basalt Flow Vernal Pool
			44320	San Diego Mesa Vernal Pool
	45000	Meadow and Seep		
		45100	Montane Meadow	
			45110	Montane Wet Meadow
			45120	Montane Dry Meadow
		45200	Subalpine Meadow	
		45300	Alkali Meadows and Seep	
		45400	Freshwater Seep	
	46000	Alkali Playa Community		
50000	BOG AND MARSH			
	51000	Bog and Fen		
	52000	Marsh and Swamp		
		52100	Coastal Salt Marsh	
		52200	Coastal Brackish Marsh	
		52300	Alkali Marsh	
		52400	Freshwater Marsh	
		52500	Vernal Marsh	
		52600	Freshwater Swamp	
60000	RIPARIAN AND BOTTOMLAND HABITAT			
	61000	Riparian Forests		
		61100	North Coast Riparian Forests	
		61200	Central Coast Riparian Forest	
		61300	Southern Riparian Forests	
		61400	Great Valley Riparian Forests	
		61500	Montane Riparian Forests	
		61600	Modoc-Great Basin Riparian Forests	
		61700	Mojave Riparian Forests	
		61800	Colorado Riparian Forests	
	62000	Riparian Woodlands		
	63000	Riparian Scrubs		
90000	ALPINE HABITATS			
	91000	Alpine Boulder and Rock Field		
		91200	Alpine Talus and Scree Slope	
			91210	Wet Alpine Talus and Scree Slope

junction with the California Native Plant Society Plant Communities Committee, has undertaken the task of producing a new classification to supersede Holland (1986). The final document (Sawyer and Keeler-Wolf 1995) is entitled *A Manual of California Vegetation.* We have worked with the Committee in an attempt to coordinate our efforts so that the two classifications have some compatibility. Information provided in Ferren (1989), "A Preliminary and Partial Classification of Wetlands in Southern and Central California with Emphasis on the Santa Barbara Region," provided a vehicle to discuss some level of coordination. One result of the interest in wetlands was the organization of the information in Holland into a "*Preliminary Key to California Wetland Vegetation*" (Keeler-Wolf 1992). The coordination also has been useful in that Sawyer and Keeler-Wolf (1995) incorporated some aspects of the Cowardin et al. (1979) classification. However, inclusion or exclusion of a series as wetland or upland is based upon Reed (1988), *National List of Plant Species That Occur in Wetlands: California (Region 0).* Unfortunately, many plants that characterize wetlands in California are not included, or are incorrectly categorized on this list, and therefore, wetlands dominated or characterized by them are not included as wetlands in Sawyer and Keeler-Wolf (1995). Table 4 includes the proposed list of series that contain wetland examples.

The Sawyer and Keeler-Wolf list represents the first time there has been an effort to provide a statewide listing of vegetated wetland dominance types or series. However, the scope of the classification (1) does not include wetlands not dominated by vascular plants; (2) does not include hydrogeomorphic units or classes; and (3) generally does not adequately separate wetland and upland types when they occur in the same series. Throughout the volume there is an uneven application of the water regimes. Nonetheless, Sawyer and Keeler-Wolf (1995) attempt to bridge the gap between the traditional superficial treatment of wetlands in California and the nationwide effort to classify wetlands differently than uplands, such as has been spearheaded by Cowardin et al. (1979).

Additional classification efforts. Other attempts that have contributed toward a better understanding and classification of wetlands in North America and particularly the American West include a variety of classifications. Most notable is a classification system recently developed by Moyle and Eliason (1991), which is a hierarchical system for inland waters of California, based largely on patterns of fish distribution, and including fishless habitats. Although this classification is useful for describing general patterns of fish distribution, it does not reflect adequately the great diversity of hydrogeomorphic units and riverine wetland types within the study region, especially those that are fishless or do not support other well known aquatic organisms.

Another system of vegetation classification in California currently under development by the National Biological Service, is the Gap Analysis Project of the actual vegetation of California (Davis et al. 1995). Its purpose is to assess the protection status of plant com-

TABLE 4. CALIFORNIA WETLAND VEGETATION "SERIES" PROPOSED IN SAWYER AND KEELER-WOLF (1995). Additional series were included in an earlier key to wetland series (Keller-Wolf 1992); however, all series characterized by plants not included on the *National List of Plant Species That Occur in Wetlands* (Reed 1988) were excluded from a wetland affiliation in the latter work whether or not wetland examples are found in California.

WETLAND SERIES DOMINATED BY HERBACEOUS PLANTS

- Alkali sacaton series
- Kentucky bluegrass series
- One-sided bluegrass series
- Cordgrass series
- Ashy ryegrass series
- Creeping ryegrass series
- Saltgrass series
- Sedge series
- Spikerush series
- Bulrush-cattail series
- Bulrush series
- Cattail series
- Darlingtonia series
- Pickleweed series
- Duckweed series
- Mosquito fern series
- Bur-reed series
- Pondweed with floating leaves series
- Pondweed with submerged leaves series
- Yellow pond-lily series
- Ditch-grass series
- Quillwort series
- Beaked sedge series
- California oatgrass series
- Common reed series
- Giant reed series
- Introduced perennial grassland series
- Nebraska sedge series
- Pacific reedgrass series
- Rocky Mountain sedge series
- Tufted hairgrass series

WETLAND SERIES DOMINATED BY SHRUBS

- Mountain alder series
- Sitka alder series
- Arrow weed series
- Buttonbush series
- Mexican elderberry series
- Mountain heather-bilberry series
- Mule fat series
- Narrowleaf willow series
- Sandbar willow series
- Bush seepweed series
- Greasewood series
- Iodine bush series
- Spine scale series
- Tamarisk series
- Winter fat series

WETLAND SERIES DOMINATED BY TREES

[One Dominant Conifer Species]

- Alaska yellow-cedar stands
- Engelmann spruce stands
- Sitka spruce stands
- Beach pine series
- Lodgepole pine series

[One Dominant Non-conifer species]

- Aspen series
- Black cottonwood series
- Freemont cottonwood series
- California sycamore series
- Hinds walnut series
- Arroyo willow series
- Black willow series
- Hooker willow series
- Pacific willow series
- Red willow series
- Sitka willow series
- Mixed willow series
- California bay series
- Fan palm series
- Foothill pine series
- Mesquite series
- Mixed oak series
- Red alder series
- Subalpine fir series
- Water birch series
- White alder series

[Forests Where More than One Species Important]

- Black cottonwood series
- Fremont cottonwood series
- Valley oak series
- California walnut series
- Blue palo verde-ironwood-smoke tree series
- Mixed willow series
- Enriched stands in the Klamath Mountains

HABITAT SERIES

- Alpine habitat
- Mountain meadow habitat
- Montane wetland shrub habitat
- Fen habitat
- Subalpine meadow habitat
- Subalpine wetland scrub habitat

munities, animal species, and vertebrate species richness in the state. In the first of a series of publications by Davis and his colleagues (Davis et al. 1995), plant communities and plant species distributions are described at a rather large scale of resolution (e.g., one hectare). Davis et al. suggest that their methodology necessarily neglects small vegetational units, many of which are wetlands. One of their important conclusions, however, is that many of the threatened or endangered plant communities in southwestern California are wetlands (e.g., "San Diego Mesa Hardpan Vernal Pool", "Southern Willow Scrub", etc.).

Another recent classification developed by Rosgen (1994) is a hierarchical, semiquantitative stream classification that employs indices of channel morphology. The system was developed for application at the river reach scale and is a helpful tool for viewing riverine wetlands within a watershed context. However, our methodology has been developed to describe riverine wetlands below the level of the reach, at the level of hydrogeomorphic unit as defined in our classification. Other classifications relevant to our study include those of: (1) aquatic plant life forms (Schuyler 1984); (2) the "riparian system" (Johnson et al. 1987); (3) California vegetation (Barry 1982; Holland and Keil 1989); (4) marine and estuarine natural communities of Washington (Dethier 1992); (5) meandering glide and spring streams in Idaho (Rabe et al. 1994); (6) aquatic and semiaquatic wetland natural areas in Idaho and western Montana (Rabe and Chadde 1994); (7) the flora of California (Hickman 1993); (8) meadows of the Sierra Nevada (Ratcliffe 1985); (9) subalpine meadows of the Sierra Nevada (Benedict and Major 1982); (10) montane meadows of the southern Sierra Nevada (Halpern 1986); (11) alluvial scrub vegetation of the San Gabriel River floodplain (Smith 1980); (12) old growth coastal redwood vegetation (Lenihan 1990); (13) California bioregions (Welsh 1994); and (14) riparian forest and scrublands of Arizona and New Mexico (Szaro 1989).

Conclusions

Although we began our endeavor with a thorough but relatively simple classification in mind, and with what seemed at the time an extensive preliminary list of wetland types, in our journey through a large part of California and through the process of a three-year study, we have arrived at one indisputable conclusion: an accurate representation of the State's wetland resources cannot be prepared without a classification that includes sufficient detail to capture the range of ecological attributes necessary to differentiate the many wetland types. In spite of all past efforts at simplicity, California's great wetland diversity requires a classification methodology that portrays this diversity. Thus, conservation of California's wetland heritage may depend on our ability to articulate the habitat and biotic richness, both past and present.

The many efforts to provide a framework within which to organize a classification of the State's wetlands have failed to include enough information to distinguish differences among the many types. The result has been a serious under-representation of wetland resources. Much detail has been given to upland vegetation throughout the state, with many classifications of the types of grasslands, chaparral, coastal sage scrub, oak woodlands, and coniferous forests (Barbour and Major 1977, 1988; Sawyer and Keeler-Wolf 1995). At the same time, wetlands have been grouped largely into a few broad categories: "freshwater", "salt water", and "alkali" marshes; "riparian" systems; and "vernal pools". California continues to lose its natural wetland heritage, perhaps in part because we have seriously underestimated the richness of wetland types and their associated ecosystem functions and socio-economic values.

To help compensate for this underestimation of richness and to assist with the conservation of California's wetland heritage, we propose an alternative to the various classification schemes and methodologies that have been proposed to date. Our hierarchical, numerical approach, which was developed through the support of the U.S. Environmental Protection Agency, Region IX, is an extensive modification of Cowardin et al. (1979). It is presented in Part II (Ferren et al. 1996a) and Part III (Ferren et al. 1996b), as applied to the coast and coastal watersheds of central and southern California.

We are concerned for the future of California's wetlands, and in particular for those along the coast and in the coastal watersheds of Central and Southern California. The inevitable rapid urbanization of this region will necessitate continued fragmentation, isolation, and even loss of wetlands in spite of the various federal, state, and local legislation and policies to protect them. One important tool to assist in the conservation of the region's wetlands is the development of a wide base of knowledge on the diversity and importance (e.g., ecosystem functions and socio-economic values) of wetlands at all levels. Such knowledge will give us the ability to articulate accurately the need to protect, and when possible, to restore or recreate them. Recent endeavors to study, restore, purchase, or protect wetlands have contributed toward a new public interest in the importance of wetlands and the need to work actively for their conservation, including efforts by: (1) federal regulatory and resource agencies such as the U.S. Environmental Protection Agency, Fish and Wildlife Service, Army Corps of Engineers, and Forest Service; (2) California state agencies and institutions such as the State Coastal Conservancy, California Coastal Commission, State Lands Commission, Department of Fish and Game, Department of Parks and Recreation, and University of California; (3) cities such as Carpinteria in Santa Barbara County; (4) organizations including the National Audubon Society, The Nature Conservancy, Campaign to Save California Wetlands, Surf Riders Association, and Urban Creeks Council; and (5) numerous local interest groups such as Friends of the Ventura River, Santa Margarita River Foundation, Land Trust for Santa Barbara County, and the Goleta Slough Management Committee.

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Literature Cited

Allen, B. H. 1987. Ecological type classification for California: The Forest Service approach. U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley. CA. General Technical Report PSW-98.

Barbour, M. G. and J. Major, eds. 1977. Terrestrial vegetation of California. John Wiley & Sons, New York.

Barbour, M. G. and J. Major, eds. 1988. Terrestrial vegetation of California. California Native Plant Society Special Publication Number 9, Sacramento, CA.

Barry, W. J. 1982. Preliminary guidelines for the classifying, inventorying, evaluating, and monitoring of terrestrial and semiterrestrial vegetation. California Department of Parks and Recreation, Sacramento, California.

Benedict, N. B. and J. Major. 1982. A physiographic classification of subalpine meadows of the Sierra Nevada, California. Madroño 29:1–12.

California Coastal Commission. 1989. California coastal act of 1976 as amended January 1989. California Coastal Commission, San Francisco, CA.

California Department of Fish and Game. 1983. A proposal to inventory California's wetlands. California Department of Fish and Game, Sacramento, CA.

California Department of Parks and Recreation. 1988. California wetlands, an element of the California outdoor recreation planning program. California Department of Parks and Recreation, Sacramento, CA.

Cheatham, N. H. and J. R. Haller. 1975. An annotated list of California habitat types. University of California Land and Water Reserves System. Unpublished ms.

Cowardin, L. M., V. Carter, F. Golet, and E. T. Laroe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, U.S. Fish and Wildlife Service. FWS/OBS-79-31.

DAHL, T. E. 1990. Wetland losses in the United States 1780's to 1980's. U.S. Fish and Wildlife Service, Washington D.C.

DAVIS, F. W., P. A. STINE, D. M. STOMS, M. J. BORCHERT, and A. D. HOLLANDER. 1995. Gap analysis of the actual vegetation of California 1. The southwestern region. Madroño 42:40–78.

DENNIS, N. B. and M. L. MARCUS. 1984. Status and trends of California wetlands. California Assembly Resources Subcommittee on Status and Trends.

DETHIER, M. N. 1992. Classifying marine and estuarine natural communities: an alternative to the Cowardin system. Natural Areas Journal 12:90–99.

FABER, P. A., E. KELLER, A. SANDS, and B. M. MASSEY. 1989. The ecology of riparian habitats of the southern California coastal region: a community profile. U.S. Fish and Wildlife Service, Biological Report 85(7.27), Washington, D.C.

FERREN, W. R., JR. 1989. A preliminary and partial classification of wetlands in southern and central California with emphasis on the Santa Barbara region. Unpublished ms.

FERREN, W. R., JR., P. L. FIEDLER, and R. A. LEIDY. 1995. Wetlands of the central and southern California coast and coastal watersheds. A methodology for the classification and description. Report prepared for the U.S. Environmental Protection Agency, Region IX, San Francisco, CA. February 6, 1995.

FERREN, W. R., JR., P. L. FIEDLER, R. A. LEIDY, K. D. LAFFERTY, and L. A. K. MERTES. 1996a. Wetlands of California, Part II. Description and classification of wetlands of the central and southern California coast and coastal watersheds. Madroño 43(Supplement):125–182.

FERREN, W. R., JR., P. L. FIEDLER, R. A. LEIDY, K. D. LAFFERTY, and L. A. K. MERTES. 1996b. Wetlands of California, Part III. Key to and partial catalogue of wetlands of the central and southern California coast and coastal watersheds. Madroño 43(Supplement):183–243.

HALPERN, C. B. 1986. Montane meadow plant associations of Sequoia National Park, California. Madroño 33:1–23.

HICKMAN, J., ed. 1993. The Jepson manual. Higher plants of California. University of California Press, Berkeley.

HOLLAND, R. F. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game, Sacramento, CA.

HOLLAND, V. T. and D. H. KIEL. 1989. California vegetation. California Polytechnic State University, San Luis Obispo, CA.

HOLSTEIN, G. 1988. California vegetation cover types. California Natural Diversity Database, Sacramento California. Unpublished Report.

HUNTER, S. C. and T. E. PAYSEN. 1986. Vegetation classification system for California: user's guide. U.S. Forest Service Pacific Southwest Forest and Range Experiment Station, 1986. General Technical Report PSW-94.

JENSEN, D. B. 1983. The status of California's natural communities: their representation on managed areas. California Department of Fish and Game for The Nature Conservancy. Unpublished report.

JOHNSON, R. R., C. D. ZIEBELL, D. R. PATTON, P. F. FOLLIOTT, and R. H. HAMRE. 1987. Riparian ecosystems and their management: reconciling conflicting uses. First North American riparian conference, April 16–18, 1985. Tucson, Arizona. U.S. Forest Service Rocky Mountain Forest and Range Experiment Station General Technical Report RM-120.

KEELER-WOLF, T. 1992. Preliminary key to California wetland vegetation based on Holland (1986). California Department of Fish and Game. Unpublished ms.

LATTING, J., ed. 1976. Plant communities of southern California. California Native Plant Society Special Publication No. 2. California Native Plant Society, Berkeley, CA.

L. C. LEE & ASSOCIATES, INC. 1994. Advanced identification and functional assessment of waters of the U.S., including wetlands in the Santa Margarita watershed, California. Prepared for the U.S. Environmental Protection Agency, Region IX.

LEIDY, R. A. 1990. List of priority wetlands and aquatic habitats. Draft prepared for the U.S. Environmental Protection Agency, Wetlands, Oceans, and Estuaries Branch, Region IX, San Francisco.

LENIHAN, J. M. 1990. Forest associations of Little Lost Man Creek, Humbolt County, California: reference-level in the hierarchical structure of old-growth coastal redwood vegetation. Madroño 37:69–87.

MASON, H. L. No date. Floristics of the Sacramento-San Joaquin Delta and Suisun Marsh (approximate title). Unpublished ms. on file in the Sacramento Office of the U.S. Army Corps of Engineers and in the Menlo Park Library of the U.S. Geological Survey.

MASON, H. L. 1957. A flora of the marshes of California. University of California Press, Berkeley.

MOYLE, P. B. and J. P. ELIASON. 1991. A conservation-oriented classification system for the inland waters of California. California Department of Fish and Game 77(4):161–180.

MUNZ, P. 1959. A California flora. University of California Press, Berkeley.

MUNZ, P. 1968. A California flora, with supplement. University of California Press, Berkeley.

NATIONAL AUDUBON SOCIETY. 1986. Ballona wetland habitat management plan. National Audubon Society, Western Regional Office, Sacramento, CA.

PAYSEN, T. E., J. A. DERBY, H. BLACK, JR., V. C. BLEICH, and J. W. MINKS. 1980. A vegetation classification system applied to southern California. U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. General Technical Report PSW-45.

PURER, E. 1939. Ecological study of vernal pools, San Diego County. Ecology 20: 217–229.

RABE, F. W. and S. W. CHADDE. 1994. Classification of aquatic and semiaquatic wetland natural areas in Idaho and western Montana. Natural Areas Journal 14: 175–187.

RABE, F. W., C. ELZINA, and R. BRECKENRIDGE. 1994. Classification of meandering glide and spring stream natural areas in Idaho. Natural Areas Journal 14:188–202.

RATCLIFF, R. D. 1985. Meadows in the Sierra Nevada of California: state of knowledge. U.S. Forest Service Pacific Southwest Forest and Range Experiment Station, General Technical Report PSW-84, Berkeley, CA.

REED, R. B. 1988. National list of plant species that occur in wetlands: California (Region 0). Biological Report 88(26.10). USDI, Fish and Wildlife Service, Washington, D.C.

ROSGEN, D. 1994. A classification of natural rivers. Catena 22:169–199.

SAWYER, J. T. and T. KEELER-WOLF. 1995. Manual of California vegetation. California Native Plant Society.

SCHUYLER, A. E. 1984. Classification of life forms and growth forms of aquatic macrophytes. Bartonia 50:8–11.

SMITH, R. L. 1980. Alluvial scrub vegetation of the San Gabriel River floodplain, California. Madroño 27:126–138.

SZARO, R. C. 1989. Riparian forest and scrubland community types of Arizona and New Mexico. Desert Plants 9(3–4). Special Issue.

STEVENSON, R. E. and K. O. EMERY. 1958. Marshlands at Newport Bay, California. Allan Hancock Foundation Publications Number 20. University of Southern California Press, Los Angeles.

THORNE, R. 1976. The vascular plant communities of California. Pp. 1–31 in, J. Latting, ed. Plant communities of southern California. California Native Plant Society Special Publication No. 2. California Native Plant Society, Berkeley, CA.

TINER, R. W. 1989. A clarification of the U.S. Fish and Wildlife Service's wetland definition. Natl. Wetlands Newsletter 11(3):6–7.

WELSH, H. H., JR. 1994. Bioregions: an ecological and evolutionary perspective and a proposal for California. California Fish and Game 80:97–124.

ZEDLER, J. B. 1982. The ecology of southern California coastal salt marshes: a community profile. U.S. Fish and Wildlife Service Biology Report 81-54, Washington, D.C.

ZEDLER, P. H. 1987. The ecology of southern California vernal pools: a community profile. U.S. Fish and Wildlife Service Biology Report 85(7.11), Washington, D.C.

ANNOUNCEMENT

WETLANDS OF CALIFORNIA, PARTS I, II, AND III

The "Supplement" to Madrono 43(1) containing *Wetlands of California, Parts I, II, and III,* is available in limited numbers from author Robert Leidy at the U. S. Environmental Protection Agency. additional copies of the "Supplement" are available from authors Wayne Ferren and Peggy Fiedler @ $5.00/ copy. Individual reprints of Parts I, II, and III are not available.

ANNOUNCEMENT

WWW ADDRESS FOR FERREN, FIEDLER, AND LEIDY (1995)

Wetlands of the Central and Southern California Coast and Coastal Watersheds: A Methodology for their Classification and Description, Report to the U. S. Environmental Protection Agency, Region IX, San Francisco, CA (Ferren, Fiedler, and Leidy 1995) is available on the World Wide Web at the following address:

http://ucjeps.herb.berkeley.edu/wetlands/

This report is the original document from which the "Supplement" to Madroño 43(1), including *Wetlands of California, Parts I, II, and III,* has been condensed and revised. Included in this report and not available in the Supplement to Madroño 43(1) are chapters specifically dedicated to particular wetland systems, including: marine (Lafferty et al.), estuarine (Ferren et al.), riverine (Leidy et al.), lacustrine (Fiedler et al.), and palustrine (Ferren et al.) types. Also included in the report is a chapter (Mertes et al.) dedicated to the classification of wetlands and an assessment of their functions and values in the Ventura River Watershed. The electronic version of Ferren, Fiedler, and Leidy (1995) is a joint project among the UC Santa Barbara Museum of Systematics and Ecology, the SMASCH Project of the University and Jepson Herbaria, and the Museum Informatics Project at UC Berkeley.