RELATIONSHIPS AMONG SOME WETLAND AND MOIST-SITE HABITAT CLASSIFICATIONS USED IN CALIFORNIA

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Between 1780 and 1980, California lost 91 percent of its wetlands (Dahl 1990). Katibah (1984) estimated losses at 89 percent of the state's riparian areas, while much of the remaining is degraded. These losses and the present demand for water for many environmental and human purposes make effective wetland management critical. For example, much of California's endemic fish fauna is declining because of competition for use of water (Moyle and Williams 1990, Meng, Moyle, and Herbold 1994). The Central Valley Habitat Joint Venture is part of the North American Waterfowl Management Plan, a treaty involving Canada, the United States, and Mexico. The goal of the Joint Venture is increasing wetland area in the Central Valley by 120,000 acres, and improving habitat on another 290,000 acres (Agriculture/Wildlife Enhancement Committee, unpublished). The number of wetland or aquatic species listed as endangered or threatened is increasing. Management of water for listed salmonid species in the Sacramento River competes with water goals of the Joint Venture. Other examples could be given to show that water and wetlands are important in California.

The intensity of wetlands management will necessarily increase. To be successful, managers need predictive tools to evaluate proposed habitat changes. The Wildlife Habitat Relationships System (WHR) (Airola 1988, Mayer and Laudenslayer 1988) for California was designed to be such a tool, but at a general, area-wide level of resolution. However, most wetland management involves site-specific evaluations. The WHR oversight committee is planning for new formats and greater degrees of resolution.

In thinking about developing new WHR models of habitat relationships for wetland species the senior author began to question the adequacy of the underlying plant community classification in WHR. Improvement in the classification would seem beneficial because WHR includes only three herbaceous-dominated wetland habitats. Related habitats include valley foothill riparian, wet meadow, and four aquatic types. We believe two emergent wetland types and one wet meadow type for the state were insufficient for current needs, either for impact analysis or for management. Other classifications exist or are being developed. Before recommending changes to WHR, we decided to assess existing schemes and fully consider the complexity of WHR. Our purpose was to review and compare the major wetland classification schemes (Table 1) and array their units to enlighten us to potential improvements for WHR. We also wanted to enable other workers to more easily relate habitat information among different habitat classification systems.

We made no attempt to adhere to the U.S. Army Corps of Engineers (Anon. 1987) legal definition of "wetland." Most of the schemes we examined predated the existence of the definition, and thus are more or less inclusive than the legal definition. To be of maximum use to researchers and managers, we extended our consideration of communities beyond the bounds of the legal definition of wetlands. We included other moist sites and those influenced by the physical forces of surface water during floods.

Philosophies and Goals of Classifications

The authors of the various schemes constructed them in different ways and for different purposes. Some schemes contained highly refined units while others were general with modifiers to refine the categories. Some were hierarchical, some were ordered, and some were *ad hoc* lists of types with no intent to standardize levels or to be complete (Table 1). Some schemes used physical and chemical factors primarily, while others used vegetation or fish because they integrate ecosystem forces.

DESCRIPTIONS OF THE CLASSIFICATIONS EXAMINED

Some key information about the classification systems we examined is summarized in Table 1, and presented in more detail below.

Table 5. Types, stages, zones, and substrates for herbaceous and aquatic habitats, California's Wildlife Habitat Relationships System.

Aquatic Habitats (<2% canopy of vegetation)
- Marine
  - Zone:
    - Pelagic
    - Subtidal
    - Intertidal
    - Shore
  - Substrate for each zone:
    - Organic
    - Mud
    - Sand
    - Gravel/Cobble
    - Rubble/Boulders
    - Bedrock
- Estuarine
  - Zones & Substrates same as for Marine

Herbaceous Habitats:
- Saline Emergent Wetland
  - Height Classes:
    - Short Herb
    - Tall Herb
  - Canopy Closure for each height class:
    - Sparse Cover
    - Open Cover
    - Moderate Cover
    - Dense Cover

Table 6. An example of the WHR hierarchy, including modifiers.

Herbaceous
- Fresh Emergent Wetland
  - Tall Herb (>12")
  - Moderate cover (49-59%)
    - Elements (incomplete list):
      - Water/agriculture edge
      - Riparian inclusion
      - Soil:organic
      - Water
      - Pond
      - Mudflat
      - Algae
      - Graminoids
      - Forbs
      - Seeds
      - Invertebrates
      - Nest platform
    - Geographical Location
      - Solano County

Table 7. An example of the Moyle and Ellison (1991) hierarchy.

C0000 Great Basin Province
C1000 Standing Waters
- C1300 Permanent Waters w/Fish
  - C1340 Desert Springs
    - C1341 Lahonton Desert Spring

Parker and Matyas (1979).
This hierarchical classification is based on visual (height) dominance at broad levels, and compositional dominance by layers at specific levels (Table 8). The series level (defined by using overstory dominance by composition) is the most refined level, but the classification allows for more refinement following data collection and analysis of associations and phases. CALVEG starts with 8 ecological provinces within California. These are divided into 8 physiognomic types, and then into series and associations.

Table 8. An example of the CALVEG hierarchy.

Central Valley Ecological Province
- Herbaceous Physiognomic Type
  - Cattail-Sedge Series
    - Association – user defined

Proctor et al. (1980).
This 5-volume work hierarchically classifies ecosystems of the coastal zone from northern California northward (Table 9). It includes human-impacted areas and describes biotic and abiotic ecosystem functions. Volume 1 crosswalks to 14 other classifications, 3 of which we include herein. The classification was developed iteratively in conjunction with data collection. It is organized into phyto-geographical zones, within which are habitats (e.g., pilings habitat in the intertidal estuarine zone).

Sawyer (in prep.).
This latest revision of Cheatham and Haller (1975) is much more inclusive. There is an underlying hierarchy, but the draft we used was a simple list of "series," "stands," and "habitats," identified by dominant

Table 9. An example of the Proctor et al. (1980) hierarchy.

Redwood Coast Watershed Unit
1.0 Inland Zones
    1.2 Slopes and Lowlands
        1.2.3 Mixed Evergreen Zone
            B. Palustrine

vegetation. Several keys to the series were provided. The descriptions of series refer to similar types of other authors and to data-based plant association descriptions. It lists 41 herbaceous and shrub-dominated wetland series. Many of its tree-dominated series also included riparian or wetland components.

Shaw and Fredine (1956).

A committee of wetland ecologists, led by Alexander Martin (Martin et al. 1953), classified 20 broad wetland types for the United States. These were listed and inventoried by Shaw and Fredine (1956). The list is hardly hierarchical, with the 20 types grouped under four categories; inland fresh and saline, and coastal fresh and saline.

Thorne (1976).

Thorne (1976) listed 78 communities and subcommunities, placed in 21 groups such as "freshwater aquatic" or "vernal pool ephemeral". He briefly described each community and the identified equivalents to his types from Munz and Keck (1973).

METHODS

We listed all the units of Cowardin et al. (1979), including appropriate modifiers subordinate to each final unit, in the first column of a spreadsheet (Table 10). We then aligned other schemes with Cowardin's, each in its own column (Table 11).

Several of the classification systems (Table 1) included aquatic or terrestrial units in addition to wetlands. Therefore, we had to establish arbitrary boundaries beyond which we would not consider types for inclusion in the crosswalk. We began with open water, omitting only the pelagic marine types. We extended into dry land types as long as surface or subsurface water provided an important physical or growth-determining influence in the plant community. We did not include redwood stands on well-drained alluvial soils, nor dry desert washes, except where an author used those types in a broad sense that included communities more influenced by water. We included riparian communities on other intermittent streams where the physical impact of flooding determined the makeup of the community.

Table 10. A portion of the first column of our crosswalk, illustrating the level of detail.

Palustrine
    Emergent Wetland
        Persistent
            Nontidal
                Permanently Flooded
                    Mineral[1]
                        Acid
                            Hypersaline
                            Eusaline
                            Mixosaline
                            Fresh
                        Circumneutral
                            Hypersaline
                            Eusaline
                            Mixosaline
                            Fresh
                        Alkaline
                            etc.
                    Organic
                        Acid
                            etc.

[1] All combinations of soil, pH, and salinity may not exist. The full range is presented to allow comparison with any situation found in other classifications or in the field.

Each investigator had different goals, used different methods and definitions, and thus created units with different degrees of resolution. To solve the problems caused by the resulting variation among systems, we repeated habitats wherever they overlapped with another investigator's type. For clarity, we also occasionally repeated part of each system's hierarchy (Table 11) to show where in the scheme a particular type belonged. As a result, types were repeated frequently in the columns to the right of the Cowardin array.

Among systems, some types overlapped or were more restricted than other similar types. We aligned type names whenever there was some overlap in definitions. We did not define degrees of overlap, so the crosswalk can convey mistaken impressions about equivalency unless the user determines the degree of overlap for the types of interest. We recommend that users should always refer to the original author's definition to accurately identify a type. We hoped this procedure would maintain the identity of each author's

The Sawyer (in prep) system is likely to be adopted by the California Natural Diversity Database. A closer link between the CNDDB and WHR would increase use of both systems. A common hierarchy for plant community descriptions would facilitate sharing of data and linking the two databases.

Adequacy of Other Classifications

Some schemes, such as Munz and Keck (1973) are too general to be useful for wildlife habitat relationships or for plant ecology, except at the largest scales. Others are quite detailed in some aspects, and lacking in others. But none adequately and regionally include the factors that influence wildlife across the entire spectrum of the state, and in all natural situations.

CONCLUSIONS

At present, no classification system adequately describes wildlife habitats provided by wetlands and moist sites. Two actions are needed to improve the wetlands part of the WHR system. First, a wetland classification suitable for wildlife relationships analysis needs to be designed. Perhaps the strong aspects of several of the existing schemes (and other regional ones) can be melded without re-inventing types and creating more work. This job will require several years, at least. Secondly, in the interim, persons who determine wildlife relationships for different habitats need to choose from the most appropriate of the existing classifications we reviewed, or others. We recommend that the California Interagency Wildlife Classification Task Group (CIWTG) examine our crosswalk and adopt an interim system to guide researchers who want to work on habitat relationships in wetlands. Our recommendation is founded in the need to maintain correspondence with other information storage systems. We suggest that a CIWTG committee begin with the Cowardin et al. (1979) classification scheme, and append to it appropriate series from Sawyer (in prep). Some new intermediate group levels may be necessary and appropriate to WHR needs. New WHR models can then be built upon this framework and will be adaptable to joint use with the CNDDB. Because the Sawyer (in prep) system is so detailed, most types within the other classification systems can be equated to Sawyer's types. Correspondence of WHR results to Sawyer's will facilitate linking WHR to other systems.

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