

# **CHAPTER ONE**

## **Introduction**

### **I. Background**

A vast watershed connects the mountain streams surrounding California's Central Valley with San Francisco Bay and the ocean beyond. Long the site of some of the nation's most intensive conflicts over the use of land and water resources, this system is now emerging as the focus of one of the most ambitious ecological restoration efforts ever undertaken in the United States. Millions of years of tectonic forces, erosion and changing sea levels created the basic physical features of this landscape, and the ecological opportunities that eventually resulted in the biologically rich and unique complex of aquatic ecosystems that developed here during the last ten thousand years. Over the course of the last two centuries however, much of the natural productivity, biodiversity and ecological integrity of the watershed has been destroyed as people began to increasingly modify the environment without fully understanding the long-term consequences of their actions. Only recently has it come to be fully appreciated that the resultant habitat loss and degradation have caused losses of native species that may proportionately exceed those occurring in some of the world's tropical rain forests (Moyle and Williams 1990).

An unprecedented opportunity now exists to begin to reverse these negative trends. In 1995, the Federal government and the State of California initiated a three-year program to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system. Recent legislation and agreements, including California's Proposition 204, the Bay-Delta Accord of 1994, and the Central Valley Project Improvement Act of 1992, have authorized the expenditure of over a billion dollars to begin the task of restoring the Bay-Delta-River system. This report is intended to assist those efforts by providing a conceptual overview and framework of natural ecological structure, function and organization of the watershed, and an historical perspective on the way this has changed over the last two centuries.

### **II. General Approach of the Report**

Planning and management efforts directed towards comprehensive restoration and long-term protection of complex ecosystems require a basic understanding of the natural structure, function and organization of the systems addressed, even if these conditions are no longer attainable. Such understanding is an essential prerequisite to assessing and monitoring the ways and degree to which target sites now diverge from a "healthy" or "natural" condition (i.e., one that we know sustainably supported high abundances and diversity of native species). This in turn facilitates (1) identification of restoration actions essential to program success, and (2) measurement of progress towards desired system states after restoration actions have been undertaken.

This effort recognizes that comprehensive restoration in the truest sense of the term - as a return to pre-disturbance conditions - is *not* a realistic goal, or even a possibility, for most of the watershed. Nonetheless, careful consideration of environmental conditions at a time when the system was “healthy” (i.e., in a state we would deem desirable, even if not once again fully attainable) provides a necessary reference baseline from which to develop the conceptual framework and practical tools necessary to effective restoration and management planning at the ecosystem and landscape levels.

To meet the most fundamental information needs of such programs, this report addresses four pivotal questions:

- (1) What is an appropriate and practical **conceptual framework of ecosystem structure and organization** (i.e., ecological typology) for purposes of managing and restoring the system’s natural resources?
- (2) Within that framework, what **essential** structural and functional ecological **attributes** of the system define natural ecological “health” or integrity of the system?
- (3) What types of **human interventions** have substantially modified these identified attributes over the course of the last two centuries, and in what ways, and to what degree, have the attributes been altered?
- (4) How might the answers to the above questions best be **practically applied** to guide restoration planning efforts?

In attempting to answer these questions, this report summarizes and integrates available historic and current geological, hydrological and biological information to describe past and present conditions of this system. Discussion and analysis are focused at the large-scale, ecosystem level of ecological organization because, “*The interconnections among plants, animals, and physical features...are so complex that modification of one component automatically affects all the others to a greater or lesser degree...the only level of ecological theory that will ultimately provide the necessary guidance to management is a theory of ecosystems*” (Cooper 1969, p. 310). Thus, effective long-term species protection mandates “*preventative rather than reactive management, and a focus on landscapes rather than populations.*” (Angermeier and Karr 1994, p. 690).

The term “ecosystem” is used in this report in its modern restoration/management application - as *a defined, ecologically distinctive geographic area occupied by a characteristic biological community*. By definition then, an “*ecosystem level*” approach to restoration/management refers to efforts primarily aimed at identifying and addressing, *in the aggregate*, suites of key attributes (both biological and abiological) of spatially defined areas.

This fundamentally differs from species-level efforts, which instead are based upon attempts to identify and address the “needs” or “limiting factors” of particular species. The geographic scope of such species-focused efforts does not change the underlying basis of the approach - even if spread across extensive portions of a landscape, they should not be confused with or mistaken for ecosystem-level efforts, which fundamentally differ in character and depend upon a quite different information base, as summarily described above.

Ecosystem-level approaches address a number of essential conservation needs that single-species approaches do not; they provide a means to protect species about which little is known, and a means to protect a wide variety of species while they are still common. Nonetheless, it must be emphasized that broad ecosystem-level conservation strategies and restoration programs are not designed to, and should not be expected to, provide a disproportionate advantage or immediate benefit to any particular species. These are meant to complement rather than replace species-level conservation strategies, and most workers would agree that both are necessary to address conservation needs. Thus, more highly-focused, species-oriented efforts must remain a viable option in our species protection strategies. It is our contention, and an underlying organizing principle of this report, that addressing fundamental environmental problems at the ecosystem scale is an absolute prerequisite to the long-term success and ultimate effectiveness of either broadly focused (i.e., long-term biodiversity protection) or narrowly focused (i.e., species recovery, population enhancement) restoration efforts at any and all geographic scales.

The watershed of California’s Central Valley represents a landscape - an ecological unit of considerably greater scale and ecological heterogeneity than that of a single ecosystem as defined above. Rather, it may be considered a mosaic of different “ecosystems” that are functionally and structurally integrated to varying degrees. It is at these larger scales that this effort is focused.

The habitats and species that constitute the watershed’s ecosystems must be considered in the broader context of the underlying geomorphic, hydrologic, and ecological processes that created and maintain them. There is increasing consensus among restoration ecologists and conservation biologists that without adequate support at the ecosystem level (as defined herein), the results of restoration actions at any level are likely to be less sustainable or effective.

Because restoration “*should address the causes and not just the symptoms*” of ecological degradation (NRC 1992), restoration actions are generally more properly focused upon direct manipulation of the underlying abiological (“physical”) factors that are most instrumental in ultimately determining and sustaining the ability of the system to support native species and communities. Restoration actions should be chosen and specifically designed to properly manipulate those factors that, in concert, create the right *conditions*

(ecological opportunities) that will promote biological goals, rather than for the purpose of attempting to directly manipulate biological variables themselves. Once provided, biological processes will naturally proceed to once again translate such opportunities into functional ecosystems that may be reasonably expected to approximate (but never duplicate) past or present expressions of the same ecosystem type. As Berger (1990) pointed out, “*all restorations are exercises in approximation and in the reconstruction of naturalistic rather than natural assemblages of plants and animals with their physical environment.*”

### **III. Methods**

The information base developed and presented here was compiled from a variety of information sources - narrative accounts, drawings, sketches, and maps of early explorers and settlers of the region, historical compilations and analyses performed by other workers, and the results of modern examinations of remaining fragments of natural habitat, surface geology and soils, and paleoecological studies. Several thousand sources of information on the historic and current biology, ecology, history, geomorphology, and hydrology of the watershed were briefly considered, and the most useful of these were more carefully reviewed, and appropriate information extracted and summarized.

The bulk of this report summarizes available information on the natural structure and function of the different kinds of ecosystems that make up the watershed, and the ways in which these systems have been altered by human intervention. What might constitute the most appropriate time frame from which to derive a useful comparison of historical (i.e., natural) versus current system ecology? For most of its geologic history, the watershed was an unusually dynamic environment; thus, probably no single restricted period (e.g., century) might properly be considered “representative” of this complex system as it existed for thousands of years. For several practical reasons, the period around 1850 was chosen as the basis for the characterization developed here of the “natural” or “historic” watershed. Prior to 1850, this landscape was comparatively undisturbed by human activity. That period marks the point in central California’s history just prior to the population explosion and rapid proliferation of environmentally destructive activities that soon followed the discovery of gold in the region. Also, it is the earliest historic period for which we have a sufficient body of recorded information (narratives, maps, drawings, etc.) from which to build an overview description of system structure and function even partially based upon direct observation. Finally, historic accounts provide ample documentation of the healthy, rich, and diverse biological communities occupying the region circa 1850. Therefore, conditions that existed at that time are, from a restoration/management perspective, considered a desirable “target state”.

Several original analyses were performed as part of this effort. These included calculations of habitat area, and a rough water balance for freshwater outflow from the system. The techniques and data sources used in these analyses are briefly described in conjunction with the presentation of their results in Chapters Two and Four. Spatial descriptions of ecosystems and habitat types were mapped in Geographic Information System format to the extent allowed by available data. A brief Appendix describes the relevant technical information associated with this data base.

#### **IV. Report Organization**

The report is organized into five chapters. Following this introduction, Chapter Two provides a broad overview of the natural ecology of each of the watershed's ecosystem types. Discussion of each of the system's component ecosystem types is organized within a framework of structural features (habitats and biological assemblages) and processes (hydrological, geomorphic and ecological). Chapter Three discusses the major kinds of human interventions that have substantially altered the ecology of the watershed during the last two hundred years. Chapter Four describes the major documented ecological changes wrought by the net effects of these interventions on each of the watershed's ecosystem types described in Chapter Two. Chapter Five utilizes the information presented in earlier chapters to outline a recommended strategic approach to restoration in the Bay-Delta-River watershed by integrating modern principles of applied restoration ecology with the findings of this report. This concluding chapter also demonstrates ways in which the information base developed here might be translated into some practical and highly useful restoration/management planning and evaluation tools.