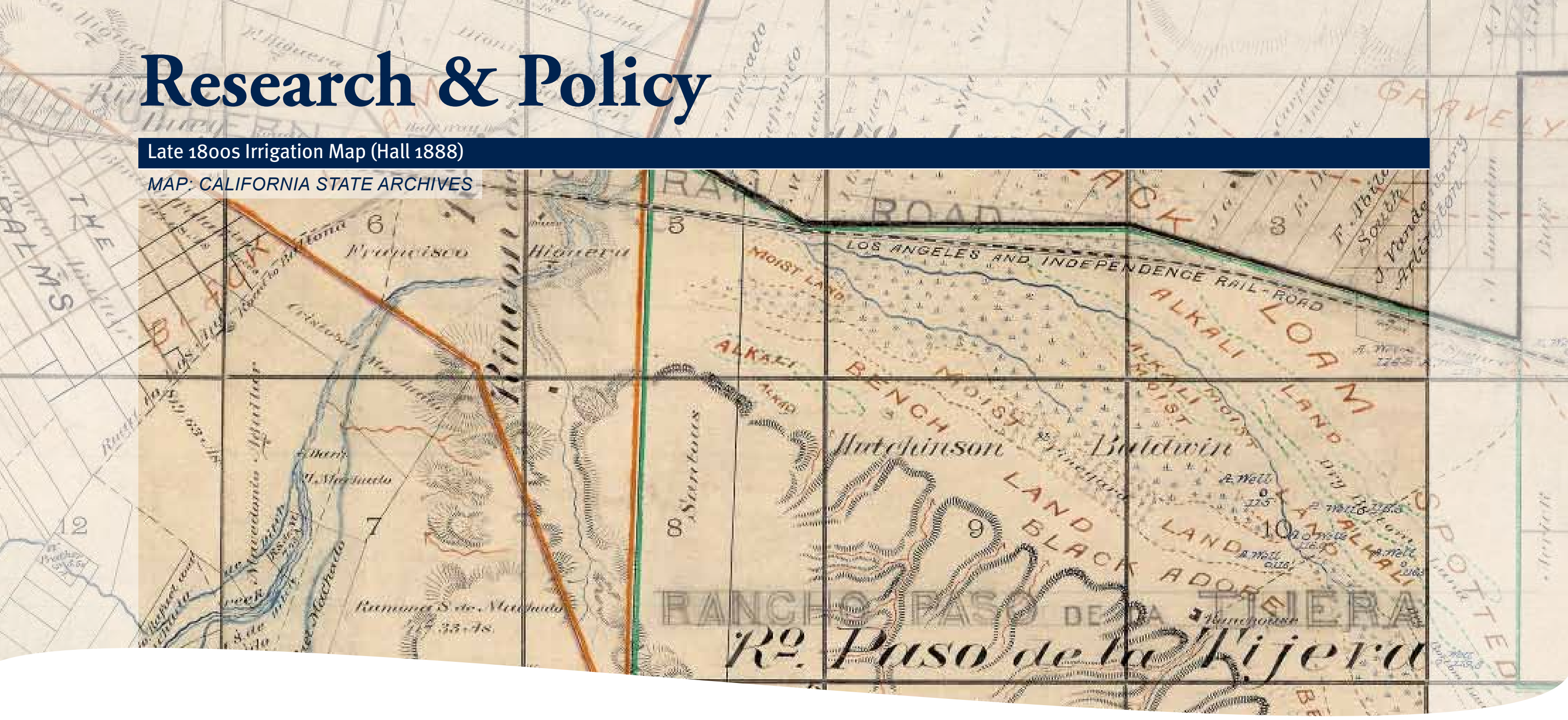


Late 1800s Irrigation Map (Hall 1888)

MAP: CALIFORNIA STATE ARCHIVES

Historical Ecology as a Living Resource for Informing Urban Wetland Restoration

SHAWNA DARK, ERIC D. STEIN, DANIELLE BRAM, & JOEL OSUNA

Abstract

In the urban environments of California, much of the academic understanding of wetland and riparian ecology is derived from systems highly modified by human activities. Therefore, identifying appropriate un-impacted reference conditions or distinguishing natural processes from anthropogenic effects can be difficult. Research in historical ecology provides valuable insight into historical reference conditions and the driving forces of ecosystem change. New tools and technology allow scientific components of historical ecology to evolve such that standardized approaches to hypothesis testing are now available. The technical rigor imparted by these tools makes historical analysis more valuable for understanding ecosystem function and for developing sound restoration planning.

Introduction

The urban watersheds of the California coast provide a unique opportunity to explore the value of historical ecology research for developing contemporary wetland and riparian restoration plans. Studies have demonstrated that restoration and mitigation planning would be greatly improved if done within the context of ecosystem function (Kentula 1997, 2007; Kershner 1997; National Research Council [NRC] 2001; White and Fennessy 2005). Unfortunately, in the urban environments of California, much of the current understanding of wetland and riparian ecology is derived from systems highly modified by human activities. Thus, identifying appropriate functional reference conditions or distinguishing natural processes from anthropogenic effects can be difficult. Recent historical ecology studies in California have provided new and surprising evidence of wetland resources previously not recognized, particularly in Southern California where evidence suggests wetland ecosystems were larger and more diverse than previously thought (Stein et al. 2010; Grossinger et al. 2011; San Dieguito River Park 2010). This suggests that historical ecology not only provides important information about functional reference conditions but also sheds light on previous misconceptions about the historical environment.

The value of historical ecology has been questioned in the urban coastal regions of Southern California where natural hydrologic processes are unlikely to be fully recoverable. Arguably, historical ecology may provide confusion in the face of a systematic incapability to return wetland ecosystems to their pre-development condition, often due to the permanent loss of natural hydrodynamic processes that were present prior to human contact. Understanding the historical template is as important as understanding the contemporary condition. Knowledge of historical ecosystem components is key to creating management and restoration plans that make sense relative to the contemporary landscape. The historical perspective provides an understanding of the relationship between physical settings that support natural wetland functions, the driving forces behind ecosystem degradation, and, perhaps most importantly, the value of wetland ecosystems that remain intact (Stein et al. 2010). Considerable evidence supporting the importance of historical ecology in contemporary wetland management, even in highly urbanized areas, now exists (Kentula 1997; White & Fennessy 2005; Stein et al. 2010). In addition, new technical tools provide shared access to data collected for historical ecology projects creating an opportunity for cross-disciplinary collaboration and ongoing discovery of historical reference conditions beyond traditional reports.

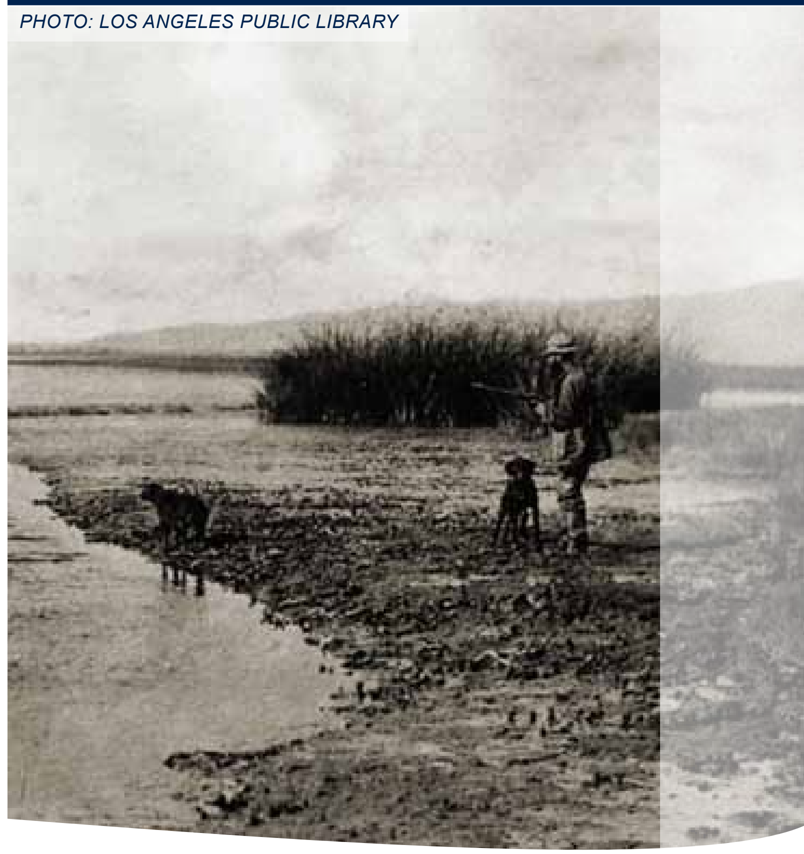
Defining Historical Ecology

Historical ecology seeks to identify the complex history of interactions between human groups and their environment with an emphasis on how humans have reshaped the biophysical environment (Ballee 2006; Rhmetulla and Mladneoff 2007). A key component of historical ecology is that it is an interdisciplinary approach that synthesizes information from different disciplines, data sources, and scientific perspectives (Swetnam, Allen, and Betancourt 1999). The application of this knowledge in turn provides a foundation for understanding ecosystem function, human modification, and management of ecosystems. Land managers should understand that historical ecology is not meant to provide a blueprint for the future, but rather, is meant to provide a foundation of understanding in light of contemporary landscapes where reference conditions do not exist (Stein et al. 2010). Historical ecology also provides several ancillary benefits, including the availability of "living" tools that allow for access to data collected during historical research. These tools are considered "living" because they can continually be updated with new data and therefore represent a dynamic document. They also allow for the sharing and ongoing use of historical data, promoting cross-disciplinary collaboration by scientists and land managers.

Like any scientific endeavor, historical ecological research should be designed to test hypotheses, challenge existing theories, and create new questions about the context of the contemporary environment. For historical ecologists to contribute to the scientific understanding of urban coastal systems, the researchers' findings must be validated with multiple data sources as well as repeated and compared with studies across similar systems (Swetnam et al. 1999; Grossinger et al. 2007). Traditional researchers would not draw conclusions based on a single data point, nor should historical ecologists. The continual process of validating and refining conclusions should be viewed as iterative, ongoing, and subject to change, as new evidence about historical reference conditions surfaces.

Duck Hunting Scene

PHOTO: LOS ANGELES PUBLIC LIBRARY



Surprisingly, this synthetic nature of applied historical ecology often serves as a focal point in the criticism of its application (Swetnam et al. 1999). Historical ecology can be subject to a lack of precise information, fragmentary evidence, and ambiguous interpretations, largely because historical data sources were originally developed for purposes other than wetland mapping or assessment. However, using traditional strategies for increasing objectivity and confidence in historical interpretations provides a strong scientific foundation for this research. For example, a repeatable and transparent analytical process results from a combination of comparative analyses, testing with multiple, independent data sources, and drawing conclusions from converging lines of evidence (Swetnam et al. 1999). Grossinger et al. (2007) take this a step further and provide a framework for quantifying converging lines of evidence through a systematic classification of certainty associated with the interpretation of each historical wetland mapped. This quantification of uncertainty provides a programmatic framework for assessing the value of historical interpretations and serves as an opportunity to create methodological standardization across historical ecology research projects.

Figure 1. Sample Portion of Online Metadata Catalog

CREDIT: CALIFORNIA STATE UNIVERSITY, NORTHRIDGE (CSUN)

Subset Records by Reference Type: All
Subset by Primary Source:
Subset by Collector:

	Reference Type	Author	Journal / Publisher	Found (Y/N)	Acquired (Y/N)	Useful (Y/N)	Original Scan Aquired (Y/N)	Title	Year	Primary Source	Call #	Secondary Source	Call #	Tertiary Source	Call #	Geographic Area	Watershed	Scale	Description	Keywords	Collector
Select	Text	Mesmer, L.		Yes	Yes	Yes		Soil Survey of the Los An ...	1904	Google Book Search						Los Angeles County			Soil survey for Los Angel ...	soils, hydric soils	S. Dark
Select	Map	Unknown		Yes	Yes	Yes	Yes	Map Showing Part of the R ...	1887	LA County Department of Public Works	MR022-020					Rancho Rincon de los Buey ...			Plat map scanned by LA Co ...	sycamore, valley floor habitats	S. Dark
Select	Map	Mesmer, L.		Yes	Yes	Yes	Yes	Soil Map: Los Angeles She ...	1903	University of Alabama, Department of Geography						Los Angeles County		1:62,500	Great soils map, really g ...	soils, hydric soils, cienegas	S.Dark
Select	Text	Salvator, Ludwig		Yes	No	Yes		Los Angeles in the Sunny ...	1929	First-person Narratives of California's Early Years	F869.L8 L94					General Study Area			Very general description ...	Springs, rivers	S. Dark
Select	Map	Jonas, C		Yes	Yes	Yes	Yes	Index map to county surve ...	1950	Library of Congress Map Collections	G1528.L6 R3 1950					LA Basin		1:24000	General index map for sur ...	Surveyor index	S.Dark
Select	Text	Davidson, A.		Yes	Yes	Yes		Catalog of the Plants of ...	1896	Archive.org	None					Los Angeles County			Key to plants in Los Ange ...	plants	S. Dark
Select	Text	Grinnell, J.		Yes	Yes	Yes		Birds of the Pacific Slop ...	1898	Archive.org	None					Los Angeles County			Birds of LA County. Usefu ...	Birds	S. Dark
Select	Map	Solano, A.		Yes	Yes	Yes	Yes	Map of Those Parts of the ...	1868	LA County Department of Public Works	3204					Rancho La Ballona			Plat map scanned by LA Co ...	lagoon	S. Dark
Select	Map	Thompson, G		Yes	Yes	Yes	Yes	Plat of the Rancho San An ...	1868	Los Angeles County Building and Safety	1-169					Rancho San Antonio			Plat map of Rancho San An ...	creek	S. Dark

Methods in Historical Ecology

Historical ecology methodology can be divided into three broad categories: data collection, data compilation, and synthesis/interpretation. To date, historical ecological research has relied on maps, textual data, and photographs. All three categories of data are of equal importance and are used collectively to support historical findings at any given location. Systematic and consistent cataloging and attributing of this data are essential for ensuring all appropriate data are included in the interpretation process and for retrieving the data efficiently. Ongoing historical analysis of wetland conditions, for example, involves research by numerous agencies and individuals over time. Being able to share data dynamically is a critical function to reduce repetition of effort, to allow for collaborative viewing of data, and to facilitate regional synthesis and ongoing investigations. To support the ongoing collaborative nature of this research, an online metadata catalog was created. The catalog provides the means to organize and query historical documentation by spatial location, wetland descriptions, time period, and source. The metadata catalog also allows for data to be uploaded to a website via ftp so current and future team members are able to download and access the data dynamically (Figure 1). Bibliographic tables and information about source institutions may also be downloaded from this online database, creating a secondary product for stakeholder use. This type of database creates a living tool for discovering new information and allows different hypothetical questions to be created that can be explored by future researchers.

Maps

Maps usually serve as a primary source for historical ecology projects and are easily assimilated and processed in Geographical Information Systems (GISs). Historical ecology projects often deal with a tremendous volume of maps that are scanned and georeferenced using a GIS. Common map sources used on recent projects include historical topographic maps, General Land Office plat maps, and historical soil survey maps (Figure 2a–c). These maps are routinely collected for wetland historical ecology projects and often serve as a starting point for preliminary interpretation and mapping. In addition to these common map sources, regional collections provide another source of historical maps specific to the project area. In some cases, these maps are more useful than standard maps, providing more detail of the study area. In the Los Angeles County–Ballona Historical Ecology project, the early Los Angeles County Solano Reeves Collection at the Huntington Library and draft W. H. Hall Irrigation maps from the California State Archives (Figure 3) became extremely valuable sources for interpreting historical wetland patterns due to the maps' high level of detail and focus on water resources.

Textual Data

Textual data include, but are not limited to, historical newspaper articles, written histories and accounts by indigenous peoples, and land survey notes. Textual data sources provide critical support to historical mapping efforts and therefore are an essential component of the metadata catalog, where they can be queried as necessary. The following are examples from a recent project on the Ballona watershed by Stein et al. (forthcoming):

> *In the medium part of this southwest course [Ballona Creek] is bordered on either side by a rich plain of several thousand acres in area, and which, to some extent, it has served in irrigation for a long number of years. The lands irrigated are all within the rancho La Ballona[,] and the waters have for many years been considered as appurtenant thereto. –Hall (1888)*

> *Coldwater Canyon Creek; Ballona Creek basin; Los Angeles County; an intermittent stream, 3 or 4 miles long, draining a small area in the Santa Monica Mountains, and flowing southward and southeastward into Rodeo de las Aguas Rancho. Near the mouth of its canyon it receives streams draining from Franklin and Higgins canyons. –Lee (1912)*

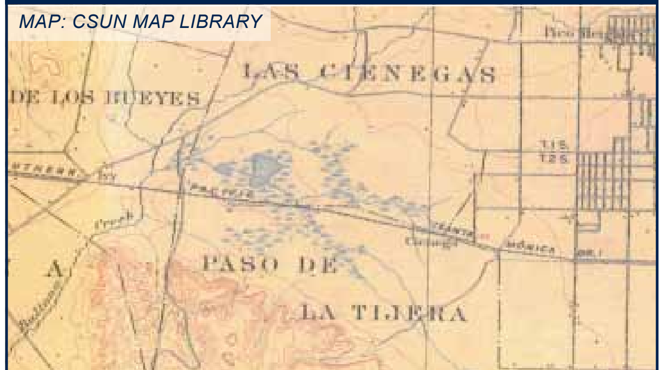
Textual data help to elucidate historical conditions and explain details on maps that are not self-evident. Therefore, textual data should be viewed as being as important as map data. This importance imparts a need for appropriate cataloging and attributing of the data in the metadata catalog.

Photographs

Photographs provide explicit confirmation about the attributes of a mapped feature such as the presence of a river mouth or depressional wetlands. In addition, some photographs, which are not necessarily focused on ecology, often provide significant insight. Most of these photographs depict enough of the landscape to allow supporting evidence to be derived. For example, the Ballona Historical Ecology project used a set of

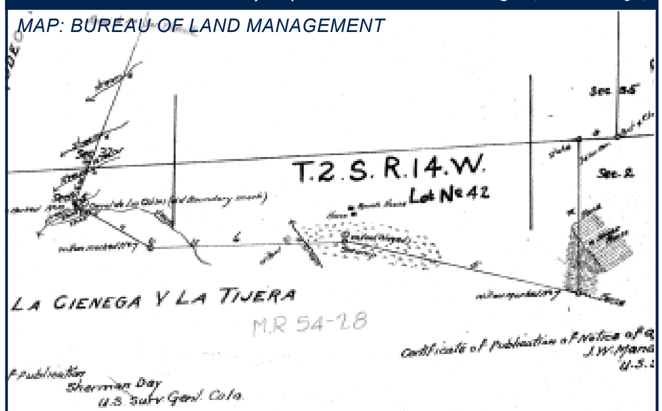
Figure 2. Historical Maps of What Is Now Culver City at the Base of Baldwin Hills

2 a. Historical Topographic Map, Santa Monica Quad (Giffin 1902)



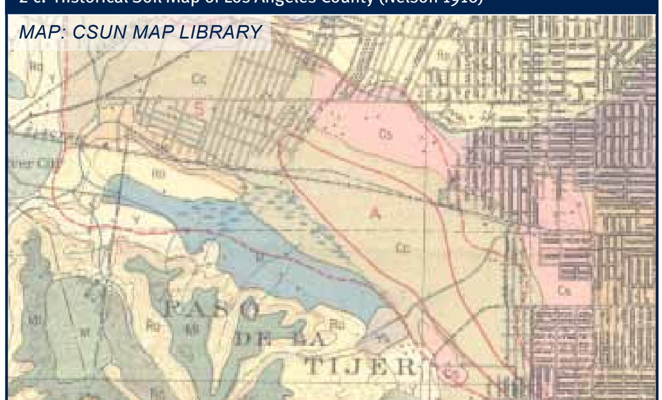
MAP: CSUN MAP LIBRARY

2 b. General Land Office Survey Map, Plat of Rancho Las Cienegas (Hancock 1858)



MAP: BUREAU OF LAND MANAGEMENT

2 c. Historical Soil Map of Los Angeles County (Nelson 1916)



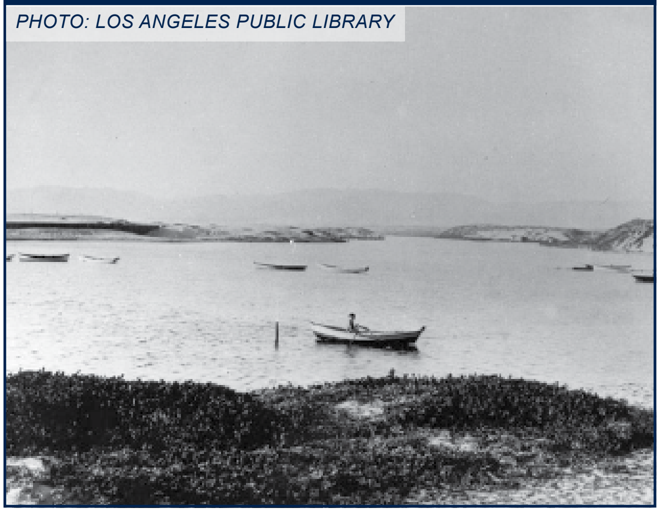
MAP: CSUN MAP LIBRARY

Figure 3. Draft Irrigation Map (Hall 1888)

MAP: CALIFORNIA STATE ARCHIVES

Figure 4. Photograph of Ballona Lake, Circa 1910

PHOTO: LOS ANGELES PUBLIC LIBRARY



photographs depicting recreational use of Ballona Lake (Figure 4). Photographs such as this were likely intended to focus on boating, hunting, and other activities around the water body. However, these photographs also provide significant ecological information such as depicting an outlet to the ocean and possible dredging activity that may have modified the hydrological features in the area.

Compilation and Synthesis

Synthesis and interpretation of what are often hundreds of data sources is the heart of historical ecological research. Compilation should follow general rules of geospatial analysis, and confidence in the final mapped polygons should be assigned using the structured system described above. However, because each specific historical ecology project is driven by its own unique set of data, the precise approach leading to the ultimate map varies by project, based on the different data sources available. Synthesizing a map or model of historical ecological features usually begins with interpreting and analyzing data sources that are the most reliable for the mapping period. Often, primary sources, mainly maps, are used to draw initial wetland polygons on a feature-by-feature basis. This mapping is often followed by crosschecking with all other sources, such as textual data and photographs, which may refer to or depict the feature in question. If corroboration exists, the other sources contribute to defining the feature's attributes as supporting sources in addition to the initial digitizing source. However, if the feature is depicted differently in terms of size, shape, or identification, further analysis is required. Surrounding features that may have a link or relate to the feature in question are also considered. The initially drawn features are iteratively refined using additional data sources. As data sources are overlaid, each is attributed (Grossinger et al. 2007). The attribution of these sources is based on information queried from the metadata catalog, thereby providing a spatially explicit connection between the various datasets used for synthesis. Once the "final" form of a feature is mapped, a historical wetland classification is assigned and compared to a contemporary classification.

Quantifying Certainty

Measuring and quantifying certainty is critical to the final interpretation and usefulness of historical ecology data. According to Grossinger (2005), feature attributes are developed to capture the estimated certainty of a mapped feature's interpretation, size, and location. Each feature is assigned these attributes to provide a concise assessment indicating the confidence in a feature's presence and habitat classification as well as how spatially accurate the feature is (Grossinger and Askevold 2005). Certainty levels are based primarily on the number, type (e.g., General Land Office and historical topographic maps), and quality (e.g., degree of detail and/or spatial accuracy) of the data sources (Table 1). For example, a wet meadow feature supported by numerous and highly detailed independent data sources would be assigned a "high" value for interpretation certainty. However, a wet meadow referenced in only one or two more-contemporary historical documents may receive a lower value. Estimation of certainty is critical to the scientific credibility of any study and reinforces why conclusions about historical conditions must be based on corroboration of multiple lines of independent evidence. Ultimately, land managers and other stakeholders can use these objective classifications of certainty to guide the decision-making process and help determine how extensively results are applied to various land management and restoration activities.

Table 1. Sample of Certainty Levels for Interpretation, Size, and Location (Grossinger et al. 2007)

Certainty Level	Interpretation	Size	Location
High/"Definite"	Feature definitely present before European American modification	Mapped feature expected to be 90%–110% of acutal feature size	Expected maximum horizontal displacement < 50 meters (150 feet)
Medium/"Probable"	Feature probably present before European American modification	Mapped feature expected to be 50%–200% of actual feature size	Expected maximum horizontal displacement < 150 meters (500 feet)
Low/"Possible"	Feature possibly present before European American	Mapped feature expected to be 25%–400% of actual feature size	Expected maximum horizontal displacement < 500 meters (1,600 feet)

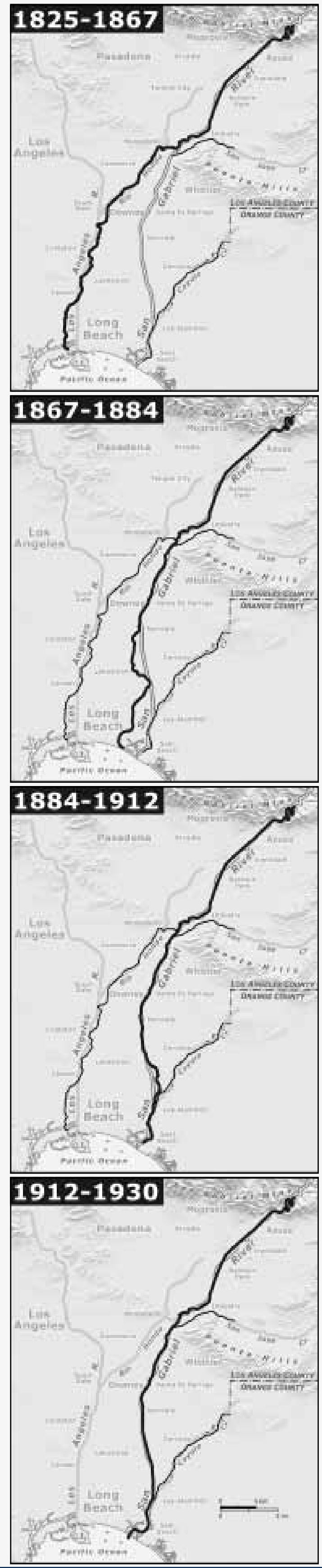
Valuing Historical Ecology

Historical ecological studies have and will continue to challenge the contemporary understanding of historical reference conditions throughout the urban coast of California. For example, a recent study suggested that the estuaries along the south coast were closed much more than previously expected (Jacobs, Stein, and Longcore 2010). Studies have also suggested that wetlands were larger, more diverse, and more dynamic than the current theoretical understanding of urban wetlands have suggested (Stein et al. 2010; Grossinger 2011). Historical ecology, therefore, plays a relevant and important role identifying critical components of the theoretical understanding that may indeed be faulty or poorly supported. In addition, as with traditional science, almost every historical ecology study generates new hypotheses for further testing, creating a rich and diversified knowledge base for wetland reference conditions.

From an applied perspective, the challenge is to bridge this evolving knowledge to contemporary landscape management plans. The knowledge of reference conditions often creates considerable debate about what should be restored, how, and where. This debate is an extremely valuable process that leads to the development of management plans that are more successful and sustainable. In most urban environments, the expectation that systems can be restored to their natural hydrodynamics is unrealistic. For example, results from the San Gabriel River Historical Ecology project showed that there were vast alkali meadow complexes along the transition zone from the estuary to inland freshwater systems (Stein at al. 2010). These areas are now completely urbanized, and the hydrological conditions that supported such wetlands no longer exist. Likewise, historical ecology produces results that should be viewed as a snapshot in time, and a snapshot may not always be comprehensive enough to be the basis for exact management plans.

Other impacts on the application of historical ecology include climate change issues, development impacts, and major shifts in the natural environment due to natural events such as earthquakes, flooding, and fire. For example, the San Gabriel River in Los Angeles County had many courses over a 100-year period and supported a variety of different wetland ecosystems in different locations as the river changed course (Figure 5). Thus, the findings from historical ecological research should not be viewed as the detailed prototype for restoration and management (Swetnam et al., 1999). Applicability largely depends on the extent of human modification, the confidence of historical interpretations, and the intended purpose of restoration. Historical ecological studies also do not dictate one specific endpoint, but may support numerous alternatives for a particular project. In fact, the ensuing debates about restoration and the iterative process by which further understanding is developed are valuable outcomes of historical ecological research.

Figure 5. Map Demonstrating the Various Courses of the San Gabriel River over the Past 100 Years (Stein et al. 2007)



New technologies, such as online geodatabases, metadata catalogs, and web-based mapping applications, will continue to contribute living tools that provide knowledge about historical reference conditions. These living tools support a more collaborative process in the application of historical ecology by providing detailed and multiple lines of evidence supporting a particular interpretation. Historical ecology products are unique compared to traditional reports, but are extremely important in that they provide delivery systems that better convey the inherent dynamism of the coastal wetland ecosystems of California. New technologies produce historical ecology products in a more accessible format for conveying information and are thus likely to be more useful to stakeholders as well as scientists. Therefore, the further development of technological tools should be prioritized on historical ecology projects.

The urban coast of California will continue to be a place of dynamic wetland conditions and debate about how to restore these systems. The regulatory and ecological impetuses for restoration have created an opportunity for serious debate about how the future of wetland ecosystems will unfold. Historical ecology provides the foundation for this debate and creates a process whereby stakeholders, scientists, and policymakers may work collaboratively to better understand the multitude of options for the future.

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