INTERPRETING HISTORICAL MAPS TO RECONSTRUCT PAST LANDSCAPES IN THE SANTA CLARA VALLEY

A thesis submitted to the faculty of
San Francisco State University
In partial fulfillment of
The requirements for
The Degree

Master of Arts
In
Geography

by

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San Francisco, California

December, 2005

CERTIFICATION OF APPROVAL

I certify that I have read *Interpreting Historical Maps to Reconstruct Past Landscapes in the Santa Clara Valley* by Ruth Askevold, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirements for the degree: Master of Arts in Geography at San Francisco State University.

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Interpreting Historical Maps to Reconstruct Past Landscapes

in the Santa Clara Valley

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ABSTRACT

Historical maps are a rich source of environmental data for science-based historical ecology, but are unlike other scientific data, and therefore may be misinterpreted or not used. This study is a research-based analysis and interpretation of data, using a critical framework established by geographer J.B. Harley to place maps in social and technical context. The paper applies an existing theoretical body of work to a new domain by contextualizing historical maps for use in historical ecology studies. It bridges the gap between historical sources and their use in science-based studies, providing a framework that increases the usability of archival map sources.

I certify that the Abstract is a correct representation of the content of this thesis.

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ACKNOWLEDGMENTS

Thanks to Nancy Wilkinson who gave me the map, put the compass in my hand, and pulled me along the path, and kept believing in me longer than I had any right to hope for; to Jerry Davis, who showed me what GIS could do; to Jean Vance, who somehow wouldn't be at all surprised to see this; and to the many professors of geography that have guided me over the years. Thanks to all staff at the San Francisco Estuary Institute, who provided a remarkably supportive and scientifically stimulating environment; but especially to Robin Grossinger, who embodies the spirit of detailed surveying performed by David Kerr of the U.S. Coast Survey in the 1850s; and to my friends and colleagues Kristen Larned and Cristina Grosso (both SFSU geographers), who were steady sources of sustenance. To my great-grandfather Anders Askevold, a cartographer in the 1870s who may have worked side by side with some of the map makers described in these pages; to my parents, Annette and Robert Askevold, who live on in my heart and mind; to my brother, Robert, a geographer disguised as a railroad historian; and to Gene Case who travelled many roads with me. And most thanks to Mary Phillips, a geographer extraordinaire, who always shows me which way is up.

My map absorbs me with what it does not reveal.

– Fra Mauro, *A Mapmaker's Dream* (Cowan 1996)

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1. INTRODUCTION: PURPOSE AND SIGNIFICANCE

This paper seeks to understand the use of historical maps to reconstruct past landscapes in historical ecology studies. The use of archival cartographic material in historical ecology studies provides a rich source of spatial data (Figure 1.1.), but properly integrating historical maps into a science-based study can be difficult (Grossinger and Askevold 2005a). Maps, while often appearing to be scientifically objective, carry with them many hidden and not readily answered questions (Harley 1989a).

For example, who commissioned the map and how did that affect the contents? What do the symbols on the map mean (as many have no explicit legend)? How 'accurate' is an 19th century map? Why was this particular area depicted and not the land two miles away? What world and local events influenced the contents of the map? What features are shown, and conversely, what features are left out? Can the scale of the map provide an accurate reflection of 'reality'? Does the technology of the time—affecting how the map was created and how it was produced and distributed—affect the contents?

I suggest that by placing the map in context, the map becomes more useful in a science-based study. Understanding the context of a map may seem a logical step before including these sources in historical science studies. However, most scientists have little experience in the historical and social science concerns related to establishing the context of historical sources, and instead attempt to establish usefulness solely through quantitative measures if at all (Harley 1989b).

This study is a research-based analysis and interpretation of data, using a critical framework established by geographer J.B. Harley (see 1968, 1982, 1988a, 1988b, 1989a, 1989b, 1990) to place maps in social and technical context. The paper applies an existing theoretical body of work to a new domain by contextualizing historical maps for use in historical ecology studies. It attempts to bridge the gap between historical sources and their use in science-based studies, providing a framework that increases the usability of archival map sources.

Concerns about how best to use maps often result in a study not fully utilizing the archival evidence, as unanswered questions about the maps force the study to use maps as hidden background information not held to a critical light the way other physical and written evidence is. Because maps are often considered mirrors of reality rather than texts that need deciphering (Harley 1989b), they are taken at face value when much of their worth may come from exploring below the surface. By placing a historical map in context and teasing out the underlying meanings, the map provides a greater wealth of information than if regarded simply as an accurate or inaccurate reflections of reality.

Contributing to the theoretical and applied knowledge of integrating maps into historical ecology is important for several reasons. Historical maps represent an enormous amount of information potentially useful in recreating past landscapes (Swetnam *et al.* 1999). Historical maps are increasingly available in digital format, making archival maps a readily available resource for research (Rumsey and Punt 2004). The potential information and increased availability of historical maps is coupled with an expanded interest in historical ecology for use in restoration and understanding past ecosystems (Egan and Howell 2001). Because maps are often difficult to integrate—especially for scientists accustomed to dealing with the collection of data through direct observation—historical maps are often misused or underutilized (Grossinger and Askevold 2005a). Misuse can come from integrating historical maps into geographic information systems, which can obscure some of the challenges of integration by making the maps look objective and scientific (Harley 1991).

The critical framework established by J.B. Harley is examined in Chapter 2. Harley's premise was that we should regard all maps—including modern maps recreated from historical data—as subjective (Harley 1989b). He argued that the objectivity of the map is largely unchallenged, and he suggested that those using maps identify the cartographic discourse and rhetoric behind the map and see the maps as text or language (Harley 1990, 35). The discussion of Harley's framework is followed by an update on how his work has been carried forward by a number of geographers, including Matthew Edney (1996), David Turnbull (1996), Catherine Delano Smith (1996), Christian Jacob (1996), and Susan Schulten (2001). Harley addressed his comments to cartographers, map historians, and historical geographers, and the remainder of the chapter looks at how these groups have viewed and used historical maps, and if they applied any of Harley's framework in the course of their work.

Historical ecology—and how maps are integrated into historical ecology studies—is considered in Chapter 3. This section describes how geographers contribute to historical ecology studies; provides examples of previous studies, and how each used historical maps; and notes the challenges historical ecologists face when incorporating maps and related written materials into environmental studies.

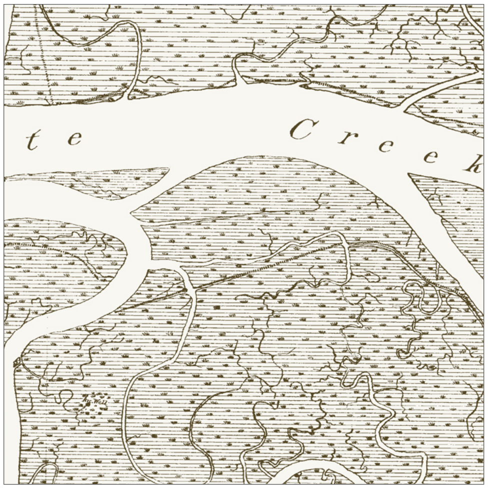
The methodology used in writing this paper is described in Chapter 4. I discuss how the extent of the study area was determined; how historical maps were selected and acquired for the study area; what I was looking for when researching each map; and how maps were compared to other historical graphics. Chapter 5 describes the study area in the northern portion of the Santa Clara Valley. The study area encompasses the land between Coyote Creek and the Guadalupe River, extending north into the tidal areas of San Francisco Bay and south to the city of San José. Included in this chapter is a brief discussion of the successive waves of immigrants affecting land use in the area.

I used archival maps and images from the Historical Ecology Program at the San Francisco Estuary Institute (SFEI), and selected three of the earliest maps of the area to review in detail. The first is a *circa* 1838 Mexican land-grant map *(diseño)*, used to establish ownership in Mexico and later to determine property rights after the area became part of the United States; the second is a topographic map of tidal marshlands and other shoreline features, published by the U.S. Coast Survey (USCS) in 1857; and the third is from a county atlas produced by Thompson and West in 1876. In Chapters 6, 7, and 8, drawing upon the framework suggested by Harley and others, I provide an in-depth discussion of the each map's provenance by exploring the context of the person or entity responsible for creating the map; the societal context of the time and place in which it was created; and the implications of the techniques and methods used to create and reproduce the map.

Following this, in Chapter 9, I compare the *diseño,* the U.S. Coast Survey map, and the Thompson and West atlas to other maps of the same era (time); to maps of the same subject matter (theme); and to maps of the same area (space). These include comparisons with a later Coast Survey map from the same area; with a 16th century map from Mexico; with two U.S. Surveyor General maps from 1859 and 1862 confirming the boundary of the *diseño;* with a portion of the 1899 U.S. Geological Survey San José quadrangle; with a photograph of Coyote Creek from 1905 by Alice Iola Hare, a photographer who actively captured images of the Santa Clara Valley at the turn of the century; and with an aerial photograph from 1939, commissioned by the U.S. Department of Agriculture, depicting orchards and other farm-related land use.

The results from this research—and how they apply to historical ecology studies—are described in Chapter 10. The value of placing maps in context is assessed through the development of several tables that can be used as templates for other studies incorporating historical maps. This includes a "certainty level" table, made possible from research into the map's context; a table comparing the map's original purpose with possible uses in historical ecology, and the implications from using a map for different purposes than what it was intended for; and "usability" table, resulting in categories indicating the possible appropriate use of a map. These tools represent an integrated approach for the applied use of historical maps in a science-based study.

In the conclusion section of Chapter 10, I suggest further avenues for research and assess the following questions. Does Harley's approach provide a useful framework for using maps in historical ecology? Does understanding the context of a historical map improve its usability in reconstructing a past landscape? Does this awareness allow for better integration into the historical ecology study? Or conversely, can historical maps be successfully used *without* placing them in context?



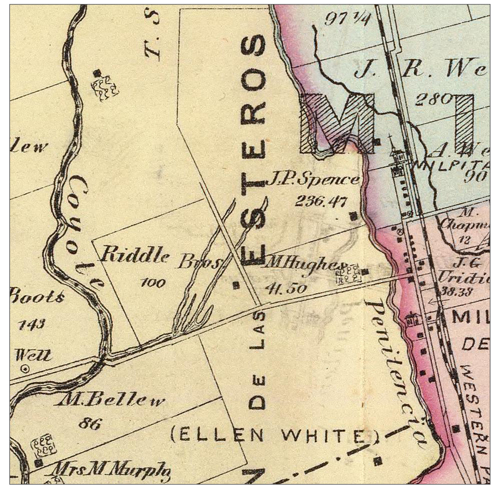


Figure 2.1-A and 2.1-B. Detail from Coast Survey T-sheet , 1897 and Thompson and West Map Sheet 2, 1876. Left, detail from U.S. Coast Survey T-sheet 2313, shows a small section of tidal marshland around Coyote Creek and just north of Alviso, the map details the waterways but also shows a new cultural artifact—levees indicated by hashed lines just north and south of the creek (Westdahl 1897a). This contrasts with the detail, right, from a Thompson and West 1876 atlas, which emphasizes cultural features. Milpitas is on the east in the center of the map; the lower reach of Coyote Creek is on the west, paralleled on the east by the Western Pacific Railroad and Penitencia Creek. The names of individual land owners populate the landscape (Thompson and West 1876).

2. PLACING MAPS IN CONTEXT : THE CRITICAL FRAMEWORK

Maps exist in an overlapping realm between science and art (Thrower 1999). The science of cartography dictates a map's projection, geometry, datum, construction, and methodology, while the art of map-making grapples with color, graphics, symbols, and balance. The construction of a map is dictated not only by scientific limitations and artistic conventions but by external political, social, and economic forces. For example, the U.S. Coast Survey (USCS) produced a multitude of beautifully rendered and highly accurate maps depicting coastal and navigational features, but the impetus for these charts was to further the United States' economic interests through safe navigation (see Figure 2.1-A). Thompson and West, publishers of several county atlases in California, show streets, railroads, schools, farms, orchards, and creeks and ditches against a brightly colored background, designed to make the area appear prosperous and attractive to both existing residents and newcomers, and to sell more atlases (see Figure 2.1-B). The very different appearance and content of the two sets of maps is a reflection of the differing social, economic, and political forces driving each map.

Use of historical maps falls into two broad categories of usage, and this study is concerned with both. In the first category, a reproduction of the archival map is simply used to illustrate a point (see Figure 2.2). The second category of usage—called historical cartography (not to be confused with the study of historical maps or the history of cartography)—is the *reconstruction* of past landscapes from historical sources (Skelton 1972, 62). In this category, new maps are created from historical data sources. Non-spatial archival documents—such as narrative explorer journals or census data—can be used to make new maps (see Figure 2.3); or the new map may illustrate a change in the landscape over time, often combining several sets of historical maps (see Figure 2.4). Creating a new map from historical maps using a geographic information system (GIS) to combine and synthesize several historical maps into a new map is increasingly used as a technique in historical research (Knowles 2000, 2002). Historical maps are also scanned and georeferenced for display purposes or compilation (Rumsey and Punt 2004).

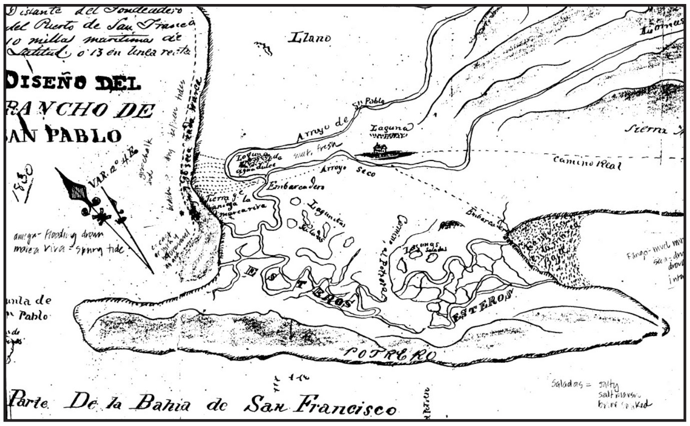


Figure 2.2. Example of an archival map used directly in a paper; an 1830 land grant map depicting land use and physical features of Wildcat Creek in Contra Costa County (Forbes and U.S. District Court *circa* 1840; used in SFEI 2001).

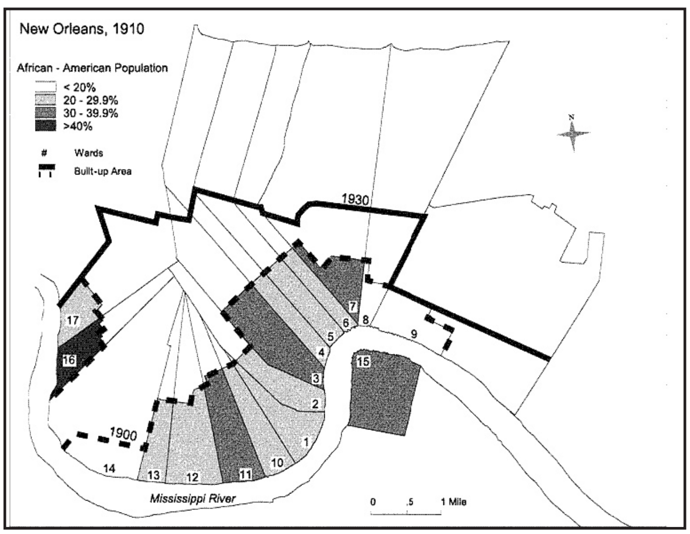


Figure 2.3. Example of historical cartography—a map created from historical sources, using census data to illustrate the percentage of African American population in various wards of New Orleans, 1900 (Colton 2002, 247).

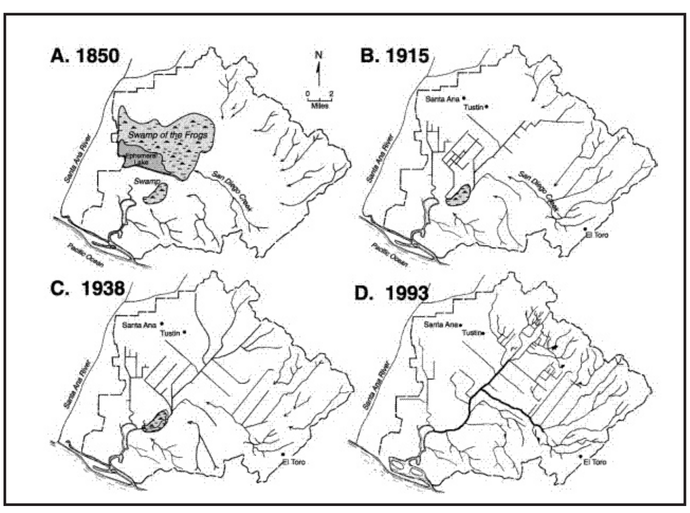


Figure 2.4. Example of maps created from a series of historical map sources to show changes in hydrography over time (Trimble 2003, 426).

A theoretical framework provides a systematic structure in which to understand maps, making explicit our cultural beliefs concerning the nature of maps and framing new research objectives and questions. The following sections discuss J.B. Harley's theoretical framework, which is used in this paper, for analyzing maps; criticism of Harley's theories; and how cartographic theory has advanced since Harley's death. The final section of the chapter considers how Harley's primary audience—cartographers, map historians, and historical geographers—have regarded maps.

HARLEY'S THEORETICAL FRAMEWORK

This section discusses the work of British historical geographer J. B. Harley (see 1968, 1982, 1988a, 1988b, 1989a, 1989b, 1990). Harley (1932-1991) received his Ph.D. in geography from the University of Birmingham and taught historical geography at the University of London. He became an expert in eighteenth and nineteenth-century geography and cartography, an avenue of research that grew into his interest in the social implications of historical maps in general (Woodward 1992). In the late 1970s he started to edit a six-volume *History of Cartography* with David Woodward of the University of Wisconsin (Harley and Woodward 1987), and in 1987 he accepted an academic position at the University of Wisconsin. Harley's writing provides several related but varying frameworks for assessing the social and political implications of historical maps. Though he spent the last decade of his career writing about the subject, the evolution of his theoretical framework was cut short by his death in 1991 (Lawton 1992).

Harley's premise was that we should regard all maps—including modern maps recreated from historical data—as subjective. He argues that the objectivity of the map is largely unchallenged, and the perceived role of the map is to "present a factual statement about geographical reality" (Harley 1990, 35). Harley proposed that when using maps, we drop the pretense of scientific neutrality and instead embrace the notion that "cartography is politicized and it always has been", (Harley 1991, 206) and move away from the traditional cartographic concerns of true and false, or accurate and inaccurate (Harley 1988a, 53).

Early hints of this later framework can be found in a methodology paper Harley wrote in 1968 for *Imago Mundi,* suggesting a set of procedures to evaluate early maps. Writing for an audience of map historians, Harley suggested performing various physical tests on the map material to determine dates; study of handwriting to reveal the identity of the cartographer and revisions; and using features on the map to place the map in time (1968, 63-64). He proceeds with mathematical tests to determine scale, projection, degree of distortion, and the accuracy of the location of features (1968, 64-65). While these are all elements in a thorough cartobibliography, Harley also suggests exploring the map in new ways, and in the final section of his paper on comparative cartography, he urges the map historian to consider the map in context. "Maps, like other sources for study of the past, need to be considered in a wide spectrum of external evidence" (1968, 67) and he suggests searching in newspaper advertisements for printers and cartographers, map-sellers' catalogs, surveyors' manuscripts, and even in the work of novelists at the time the map was made. "The study of maps," he concludes, "cannot be imbued too deeply with the place and period of his subject" (1968, 67).

Harley borrowed from several closely related theoretical frameworks, including art history, critical theory, the philosophy of history, and deconstruction (Andrews 2001, 2) and adapted a broad range of postmodernist concepts to critical map study. These can be broken into three general themes that recurred in Harley's essays. First, maps are texts that can be decoded, deciphered, and read by using a linguistic model of analysis on each phase of communication. Second, maps are social constructs that have a relationship to power and usually represent the nation-state. In this line of inquiry, understanding the context in which a map was made in is key to understanding the map, as maps are products of a political, social, and economic milieu that affects how the map is constructed and what is depicted. Third, Harley suggested that accepting the assumption that maps have become more accurate, correct, and reliable over time leads to erroneous assumptions, as maps—regardless of their scientific construction and apparent objectivity—are still selective representations dependent on their context. Closely related to this is the loss of a richer meaning that can "help us experience the human struggles of the past "when maps are studied using scientific positivism as a framework (Harley 1989b, 87).

Maps as Text. Harley often applied the postmodern theory of deconstruction—a critical literary theory developed in Paris in the 1960s by French philosopher Jacques Derrida—to map analysis. When used in literary criticism, deconstruction aims to undermine the claims of truth in written text (Johnston *et al.* 2001, 155). Harley suggested using ideas based on deconstruction for analyzing maps to develop "an alternative epistemology, rooted in social theory rather than in scientific positivism" (Harley 1989a, 152). To do this, he asks us to identify the cartographic discourse and rhetoric behind the map and see the maps as text or language.

By looking at maps as text, Harley suggests we can decipher maps using a linguistic model of communication. He notes that even something as innocuous appearing as a state highway map contains text that can be read and recommends we construct meaning by looking at separate events in the process of communication. A message is communicated by an addresser to an addressee. This requires *contact* through the delivery of the message as oral, written, or visual, and a *code,* or the form of the message as speech, numbers, writing, or visual expression. He cites a North Carolina state highway map, suggesting it constructs a "mythic geography [of] the hierarchy of towns and the visually dominating highways" and a landscape filled with state-selected points of interest (Harley 1989a, 161). The message requires a context understood by both the addresser and addressee to make sense (Harley 1982, 266-267)—i.e. conventions of mapping must be mastered and are not the same across all cultures (Jacob 1996, 193). In the example of the highway map, the various symbols used to represent road hierarchy—width, color, line type—are understood only because of a shared social knowledge of a certain type of map (Harley 1989a).

Maps and power. Another perspective advocated by Harley is to analyze the map for its connection to power. In this broad category, Harley describes several types of relationships maps have with power, including the links between maps and empire, in which maps are used by the colonial power as part of an imperialist conquest; the ties between cartography and the rise of the nation-state; the cartographic conventions used that can create what Harley calls "subliminal geometry", such as the selection of an ethnocentric projection, or the placement of a country as the center of the universe; and the relationship between what is shown and the silences or omissions on the map (Harley 1988a, 59). He suggests by assessing the sociology of knowledge and power contained within the map, we will better understand "the extent to which political, religious, or social power produce the context of cartography" (Harley 1988a, 53-56). In the case of the road map, Harley suggests the map has become "an instrument of State policy" and "an affirmation of [the state's] dominion over its territory" (Harley 1989a, 161).

Maps and science. Harley objected to the notion that maps have moved along a progressive trajectory that makes them increasingly accurate and truthful representations of reality (Harley 1989a, 154). By incorporating scientific positivism into mapmaking—through standardized, repeatable methods based on empirical observations—the discourse in map theory has centered around accuracy rather than social constructions. Map makers have dictated the discourse in map theory, and present the map as a "transparent window on the world" (Harley 1992, 523). In an essay observing the 500th anniversary of Columbus' first voyage, Harley suggests that by critiquing the "standard scientific knowledge and cognition of cartography", the European conquest can be better understood. Innovations in cartography empowered the Europeans, Harley asserts, and "offered opportunities for the visualization of the land not only in an intellectual sense but also for its conquest, appropriation, subdivision, commodification, and surveillance" (Harley 1992, 524).

CRITICISM OF HARLEY'S THEORIES

Harley's theoretical framework is not without detractors, and Harley himself notes that cartographers "will probably shudder at the mention of deconstruction" (Harley

1989a, 154). Five decades earlier, Wright dismissed the idea of a map being read like a text, noting that "a map is not like a printed text, in which statements can be qualified with fine shades of meaning" (Wright 1942, 529). Though Wright was speaking literally about cartographic practice and application, Harley would no doubt argue cartographic statements can be dissected using literary theory. Hamshere argues the textual framework proposed by Harley is considered by many geographers as an abrupt departure from the traditional concerns of historical geography and therefore not readily adopted, though Hamshere notes the communication model Harley proposes is useful to outline the highly complex nature of source materials available to the historical geographer (Hamshere 1987, 48-49).

A selection of Harley's essays, published posthumously in 2001, is introduced by Irish geographer J. H. Andrews. Andrews is critical of Harley's work, calling Harley's judgements "gnomic and idiosyncratically expressed" (Andrews 2001, 3). Harley's notion that all maps contain rhetorical elements is especially criticized by Andrews, who suggests the philosophy only works for a specific set of maps such as Tudor maps of England, and that Harley's insistence that all maps can be deciphered in this fashion lessens his overall argument (Andrews 2001, 10). The editor of the collection notes that "some may find Andrews simply out of tune with the postmodern temperament and an uncomfortable intrusion" (Laxton 2001, x).

Shortly after Harley's death, *Cartographica* published a critical assessment of Harley's deconstruction of maps by Barbara Belyea, an English professor at the University of Calgary. She suggests Harley simply borrowed the idea of deconstruction without really understanding Derrida and Foucault, and that he failed to "push the cartographic application of Derrida's and Foucault's arguments to their logical, radical conclusions" (Belyea 1992, 1) because Harley believed in the "generally accepted definition of maps as representations of the world" (Belyea 1992, 4). Belyea argues that by simply putting the gloss of social theory on cartographic history, Harley missed the point.

These criticisms are worth keeping in mind when evaluating historical cartography using the theoretical framework suggested by Harley. How would Harley's framework change the inquiries of historical research? Can all historical maps be studied to reveal their rhetoric and underlying meaning, or does that method work well with only certain maps? And if Harley missed the true meaning of Derrida's deconstruction, do his arguments have validity?

CARTOGRAPHIC THEORY SINCE HARLEY'S DEATH

It should be noted that since Harley's death in 1991, thinking on the objectivity of maps has shifted, at least within the field of geography. Johnston *et al.* note that a trend in the last decade is to broaden the definition of the map beyond Euro-American terms and at the same time to think of maps as "socially constructed representations" (Johnston *et al.* 2000, 66). While it has been widely accepted that maps have grown continually more precise in terms of locational accuracy, geographers also regard the map as having many functions not just associated with planimetry (Johnston *et al.* 2000, 66). The broader acceptance of postmodern concepts provides opportunities for the deeper analysis Harley hoped for, though it is not clear if this type of analysis occurs in studies incorporating historical maps.

This section describes how his work has been carried on by a number of geographers, including Matthew Edney (1996), David Turnbull (1996), Catherine Delano Smith (1996), Christian Jacob (1996), and Susan Schulten (1998, 2001).

The evolution of Harley's theories—which he hoped to develop into a more cohesive framework for a book (Woodward 1992, 123)—was cut short by his death in 1991. However, others who agreed or disagreed with his body of work have continued to develop new avenues of thought using Harley's theories. It is difficult to find a paper or book on the nature of maps that does not reference Harley, even in popular works (see, for example, Turchi 2004; Lippard 1997).

The 16th International Conference on Historical Cartography, held in Vienna in 1995, convened a session on the theoretical aspects of the history of cartography (Dahl 1996). Matthew Edney, Jacob Christian, and Catherine Delano Smith presented papers referencing Harley and suggesting refined avenues of theoretical research. Rather than developing a radically new approach, the three presenters suggested modifications to his framework and further avenues for research based on Harley's previous work. Their work was directed at map historians—traditionally a rather conservative group (Harley 1989a, 150).

Edney notes that map historians have largely taken an empirical rather than theoretical approach, and have regarded the nature of maps as self-evident, in that they are assumed to be natural objects that are easily understood, rather than as social constructs (Edney 1996, 187). He suggests that just because map historians do not acknowledge theory in the study of maps does not mean that theories are not in operation. He reiterates Harley's approach, suggesting the audience acknowledge the subjectivity of the map and merge the study of the map with a variety of historical disciplines: science, cultural and social history, and intellectual and economic history (Edney 1996, 188).

This sounds much like Harley's approach, but Edney differentiates his strategy by injecting a more flexible theoretical structure. Empirical evidence "must always correct the theory" (1996, 189), and universal generalizations should be avoided (1996, 189). Edney's theoretical approach employs a more pragmatic framework less invested in sweeping postmodern explanations. Not only was Harley's polemical manner resented by map historians, Edney notes, but he presented his theories as universal in scope. This left Harley open to criticism when examples contradicting his generalizations about power in the modern state and imperialism were identified (Edney 1996, 187).

Both Smith and Jacob take up several recurring themes of Harley's work. Jacob suggests map historians move from viewing historical maps as representations of reality to perceiving them as visual and material artifacts that can be explored in terms of the culture that created them (Jacob 1996, 193). Smith refers less directly to Harley but borrows heavily from his body of work. Much like Harley, Smith suggests the philosophy of critical theory philosophy invented by Michel Foucault and Jaques Derrida (see Johnston *et al.* 2000, 129-133) has much to offer the study of maps. When considering the context of the author (cartographer), Smith asks us to consider our own biases. She cites Harlan, who when writing about theoretical framework for history, notes that we cannot approach documents with open minds. Instead, we are “loaded with all presuppositions, assumptions, and prejudices” and the original author is effectively replaced by our own bias, and the text (map) “begins to suggest possibilities its author may never have imagined” (Smith 1996, citing Harlan 1989). While the ultimate extension of this theory would be that the only valid experience is by the reader, Smith asks us instead to take Carr’s advise that “the historian who is most conscious of his own situation is also more capable of transcending it” (Smith 1996, 200, citing Carr 1961).

The conference included a discussion following the presentation of these papers that is revealing. Tony Campbell—at the time, editor of *Imago Mundi*—questions that these theories can be applied to all maps. “Where, for instance,” he asks, “is the hand of ‘big brother’ in a map that was unambiguously made, bought and used for a simple, straightforward function such as way-finding?” (Campbell *et al.* 1996, 203-204), which brings to mind Harley’s discussion of the North Carolina road map being a device of the state (Harley 1989a). David Fletcher warns about what he calls the two extremes—the person for whom “theory is a self-serving and possibly self-indulgent preoccupation” and the “map hunter who is deeply suspicious or even phobic about theory” and suggests we take a middle ground appealing to map collectors and map historians (Campbell *et al.* 1996, 204).

Schulten addressed the same session two years later at the 17th International Conference on Historical Cartography in 1998; the paper was later incorporated into her full-length book on the geographic imagination in the United States (2001). Schulten discusses Harley’s theory of maps as “arbiters of power” without apology in her treatise exploring how academic geography and mass-market cartography shaped the world view of Americans (2001, 5).

Harley has become synonymous with critical theory of the history of cartography. Most contemporary books on the nature of maps refer to Harley. While Harley was still alive, Turnbull created a workbook to lead the reader to the conclusion that maps are not objective but value-laden constructions of cartographic conventions dependent on context for understanding (Turnbull 1989) and used Harley's arguments in a later article discrediting the idea that "the history of cartography was of maps becoming increasingly scientific and ever more accurate mirrors of nature" (Turnbull 1996, 6). Denis Wood's 1992 book is somewhat a tribute to Harley, with chapter titles such as "Maps Work by Serving Interests"; "Maps are Embedded in a History They Helped Construct"; "Every Map Shows This...But Not That", etc. (Wood 1992).

HARLEY'S PRIMARY AUDIENCE AND THEIR USE OF MAPS

Harley's essays appeared in journals such as *Imago Mundi, Cartographica, American Cartographer,* and the *Journal of Historical Geography* (see a compiled list of work by Harley in Edney 2001, 281-296), and he addressed an audience of map historians, cartographers (including those using geographic information systems), and historical geographers. These groups view and use historical maps in a variety of different ways, with varying degrees of awareness and acceptance of an over-arching theoretical framework. Some of these aspects are explored below.

Map historians. Harley was a map historian and wrote frequently for *Imago Mundi,* a journal concerned with the history of cartography. Harley chided historical cartographers for lacking a useful theoretical framework. "It would appear that we are still working largely in either a 'premodern' or a 'modern' rather than a 'postmodern' line of thought," he complained in 1989, suggesting that map historians are too reliant on what "cartographers tell us maps are supposed to be" instead of starting with the premise that "cartography is seldom what cartographers say it is" (Harley 1989a, 151).

Imago Mundi is filled with articles on the minutia of cartographic history, rather than cartographic theory. Cartobibliographies—details about the changing editions of a specific map, establishing each edition's date, edition, physical size, title, author, and description or changes—play a predominant role in the magazine's pages. Tony Campbell was editor of the magazine when he asked—as noted earlier—"where…is the hand of 'big brother' in a map that was unambiguously made, bought and used for a simple, straightforward function such as way-finding?" (Campbell *et al.* 1996, 203-204), though under his editorial guidance, Harley published three articles on theory in the 10 years prior to his death (see Edney 2001, 281-296).

Maps as social constructs have been considered in several books on cartographic history. In a collection of essays on historical maps of the southwest (Reinhartz and Colley 1987), David Buisseret compares Spanish and French mapping in the Gulf of Mexico in the sixteenth and seventeenth centuries (Buisseret 1987). Buisseret places early Gulf cartography in historical context and identifies five key types of map making. To do this, he devised a method for comparing each of the maps, one on top of the other. Buisseret—who later edited a collection of essays introduced by Harley on using historical maps (Buisseret 1990)—provided the historical context for the map recommended by Harley, as Buisseret explores the relationship of a given map to others in the same cartographic genre, geographic place, and historical time. Too many historical geographers fail to do that, notes Harley, who asks that historical maps “be returned to the past and situated squarely in their proper place and period” (Harley 1990, 35).

In another article in the same collection, Judith Tyner analyzes how the Southwest is presented in nineteenth century American atlases. She suggests 19th century atlases depicting the American Southwest (from the Gulf of Mexico westward to the Pacific) shaped and were shaped by their audiences—largely well-educated individuals with access to atlases (1987, 58). The atlases of the time were compiled by cartographers and explorers reconstructing details from memory and a variety of written and graphic sources, and the resulting maps were creative but inconsistent even within a given atlas (Tyner 1987, 58). Blank spaces were “intolerable to the geographic imagination” and were filled in regardless of available knowledge (Tyner 1987, 59). Hence an area of Texas once represented in 1834 as part of a ‘Great American Desert’ became labelled as ‘excellent land’ or ‘rolling and fertile’ on maps in 1844 (Tyner 1987, 70). Though Tyner only attributes the new designations to a change in geographic knowledge, Harley would no doubt comment on the social and political forces driving the designations. In both these articles it becomes clear that cartographic historians are comfortable in describing the context in which the maps were created, though perhaps not using Harley’s specific social theory of knowledge and power.

Other collections on the history of cartography are not as postmodern in their approach. For example, in *The Mapping of America* (Schwartz and Ehrenberg 2001; published first in 1980 but updated for a 2001 edition), Harley notes that the authors have disregarded any input Native Americans had on mapping America in the period immediately after 1492 (Harley 1992, 524).

Cartographers and theory. Cartographers consider several theoretical aspects of map-making, especially of the perceived objectivity of maps (see Robinson and Petchenik 1976). The view that maps are subjective is not a new one to geographers, though cartographers have tended to point to extreme examples of propaganda and marketing rather than to characterize maps in general as subjective (Schulten 2001, 5). In an rather widely quoted essay written during World War II, Wright discusses some of the obvious geopolitical propaganda maps of the time, but also criticizes the notion that the cartographer is objective, noting that "map makers are human" (Wright 1942). Despite the "trim, precise, and clean-cut appearance that a well-drawn map presents [which] lends it an air of scientific authority" (Wright 1942, 528), maps are subjective, Wright argues, but can be made as "truthful" as possible through a commitment to "scientific integrity" (Wright 1942, 529).

This idea—that the 'problem' of subjectivity can be solved by training and scientific methods—is considered by a number of cartographers after Wright. In a book written for non-professional map makers, Greenhood suggests that maps can "put up an argument" and warns that the power of maps could be used by "wily demagogues" for propaganda purposes" (Greenhood 1964, xi). He discourages those uses and instead urges map makers to seek "the beauty of truth" (Greenhood 1964, xiii). In a textbook for training cartographers widely used until recently, Robinson describes map making as "a meeting place of science and art" in which the map maker must apply logic to the technical problems of scale and projection (Robinson 1969, 17-18); implicit in his discussion is that technical expertise and a bit of design skill on the cartographer's part will result in an objective map that "employs the scientific method in the form of reason and logic in constructing its products" (Robinson 1969, 17).

More recently, Monmonier takes a different approach, telling us that maps by definition are untruthful, since to portray a three-dimensional shape on a flat piece of paper requires tremendous distortion (Monmonier 1991, 1), but he also returns to the theme of proper training. Monmonier attributes much of "cartographic mischief" to errors in map making by the "cartographically ignorant" (Monmonier 1991, 2). He cautions the map user to be "a skeptic, ever wary of confusing or misleading distortions conceived by ignorant or diabolical map authors" (Monmonier 1991, 156). Dobson echoes the sentiment of the danger of the ignorant cartographer, noting that "in my opinion...most of the substandard cartographic products are the result of individuals who have not been properly trained" (McHaffie *et al.* 1990, cited in Harley 1991, 200). These statements place the burden of objectivity on the cartographer rather than considering whether or not the process of map-making is inherently subjective.

Historical geographers and historical maps before Harley. These widely held views on the perceived objectivity of maps spill from cartography over into historical geography, where historical maps have been used widely. The following section examines how historical geographers—writing before Harley started publishing his essays on map theory—integrated historical maps into their studies, beginning with the work of Clifford Darby, J.B. Mitchell, W. G. East, Carl Sauer, and the views of a group of British historical geographers in the 1960s.

In general, early historical geographers did not place the historical sources they were using in context. Hamshere notes that "historical geographers were generally concerned with the manipulation of the [source] material...rather than an analysis of the source itself" (Hamshere 1987, 48). Until the mid-twentieth century, historical geographers relied on extensive fieldwork to reconstruct landscape evolution, but more recent interest in social historical constructs has led to the extensive use of archives (Hamshere 1987, 47).

This trend was pioneered by historical geographer Clifford Darby (1909-1992). Even though Darby used historical data to reconstruct maps rather than using historical maps directly, Darby's long career span, the nature of his work, and his thoughtful analysis of the methods of historical geography make him an important figure to assess. Darby spent much of his career as a historical geographer constructing maps of the medieval British landscape using the Domesday Book (see Figure 2.5), a survey ordered by William the Conqueror in 1085 for the purpose of taxation. The survey recorded information about the country's farms and manors, including how many men (free, tenant, or slave) lived at a particular manor; the name of the manor and the owner; how much of the land was in wood, meadow, or pasture; and how many mills and fishponds were on the land (Darby 1950). From these records, Darby and others working with him painstakingly assembled the aggregate data required to produce over 800 maps in five volumes (Butlin 1993, 89).

Baker notes Darby's effort is significant to historical geography in that it influenced several generations of historical geographers (particularly in Britain) and set the standard for use of historical data in map construction (Baker *et al.*

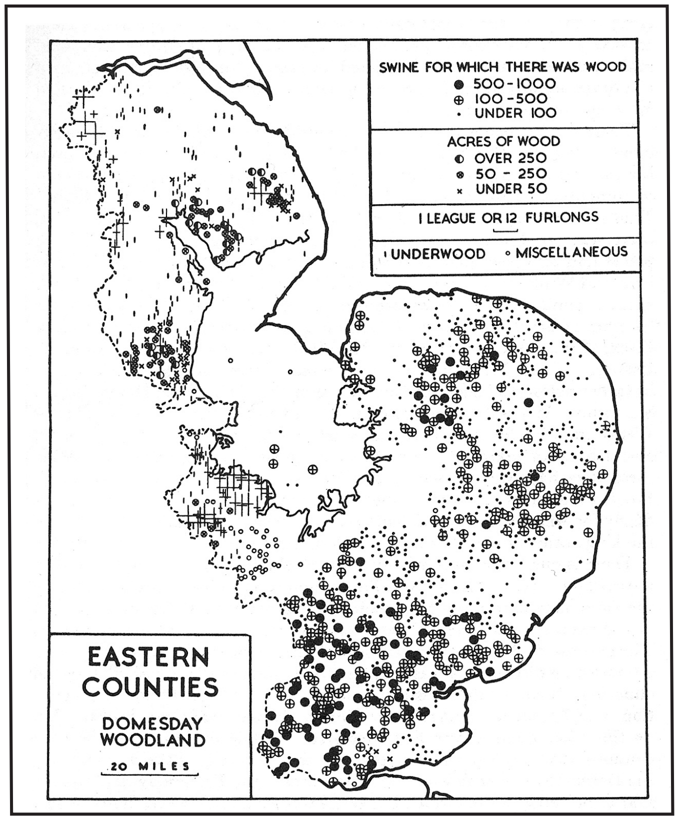


Figure 2.5. Map depicting compiled Domesday data. This map illustrates the difficulty of incorporating diverse data (Darby 1950, 49).

1970). Several geographers have discussed the difficulty of aggregating such diverse material to create the Domesday maps, as Darby was required to resolve changed boundaries, ambiguous units of measurement such as "cartload" and "basket", and uncertain time spans in accounting (Baker *et al.* 1970 17). Baker points out that Darby, like all historical geographers, could not "approach historical source material *de novo* and immediately extract data to be mapped and analyzed" but instead had to create a cohesive whole of historical data despite inherent "quantitative variety and imprecision" (Baker *et al.* 1970, 17).

Darby's maps appear to simply present the data he coaxed from the Domesday Book, but Harley observes that the process of selecting material for inclusion on maps is always subjective (Harley 1989b, 80). Darby himself questioned the objectivity of maps in a 1962 Presidential Address to the Institute of British Geographers, noting that "a possible answer to a plea for 'scientific objectivity' would be to present the geography of an area in terms of…maps, but I am far from sure about the objectivity of these" (Darby 1962, cited in Harley 1989b, 80). Butlin notes that while Darby's maps give the appearance of objectivity they contain the bias inherent in selecting certain features to map over others (1993 50).

Harley uses Darby's work on the Domesday Books as an example of how historical geography might use his map-as-text framework (Harley 1982, 266-272). As discussed earlier, Harley would have us examine the historical data within the Domesday Book as a text, in which the data is a message which can be deciphered by uncovering the code and placed in historical context to reveal its full historical meaning. Darby has done much to provide a meaningful translation of the message through the construction of maps depicting the landscape at that point in time, Harley argues, and many others have revealed the code and context of the sources, but Harley suggests the full meaning has never been uncovered because we have not drawn out the connections between the message, the code, and the context. He asks us to answer questions such as—what effect did the Domesday Book have upon eleventh-century England? Were the documents simply made and lost in amid bureaucratic red-tape or did they impact the English society by exerting social control and changing land distribution? Were specific groups not allowed to understand the message since the code (in terms of literacy or access) was not available to them?

Answering these questions, Harley asserts, "could breathe new life into the study of evidence" (Harley 1982, 267).

British historical geographer J. B. Mitchell, writing on the practice of historical geography in 1954, urged the geographer to scrutinize map for clues to where archaeological artifacts are located, though he does warn that the historical geographer must "decide how far the differences between two maps lie in differences in the skill of the cartographers...rather than in changes in the place between the dates at which the maps were made" (Mitchell 1954, 37). This view was shared by W. G. East, an historical geographer and contemporary of Mitchell's, who assigns value of an historical map based on "how much they depict and on how accurately they do this" and warns about reliance on them since cartography as an exact science was not born until the 18th century (East 1950, 16).

Carl Sauer's views toward creating historical maps are not as explicit. He wrote widely on subjects of interest to him in Mexico and made extensive use of archives in Mexico for source material (West 1979, 16-21). He comments that "the reconstruction of past cultures is a slow task of detective work" and advocates developing the skills to see the land through the eyes of the former inhabitants (Sauer 1941, 361-362). In a postmodern critique of Sauer, Guelke complains that Sauer approached geography with an "ecological orientation" that "owed more to natural science than it did to history" and concludes that Sauer has a poorly developed theoretical concept of history (Guelke 1982, 8). In a similar critique, McDowell suggests that Sauer largely ignores the element of human decision makers when explaining the landscape (McDowell 1994, 148).

In a volume of articles by historical geographers collected from the 1950s and 1960s, geographers are in many ways less concerned with the political and social framework, and more concerned with how a quantitative approach might be applied to historical geography (Baker *et al.* 1970). In the introduction, Baker *et al.* lament that gaps in available historical data make it impossible to construct statistical and theoretical models such as "central place systems, technological diffusions patterns, urban and formal functional structures, agrarian systems, or the geometry and impact of successive transportation networks" with data missing, "however beguiling the prospect" (Baker *et al.* 1970, 20). These papers illustrate the emphasis on quantitative methods of the time, and as such are filled with tables, scattergrams, and bar charts.

Contemporary historical geographers and historical maps. How do contemporary historical geographies—those published since Harley began publishing essays on map theory—use historical maps to create new maps? Recreating past geographies by drafting new maps from historical data is still a favored method of geographical representation for historical geographers, as demonstrated in a number of articles published in the last several years of the *Journal of Historical Geography.* This preference is hardly new—Harley points out that in *Geographical Interpretations of Historical Sources* (Baker *et al.* 1970), each article used an average of six reconstructed maps (Harley 1989b, 81). Hamshere analyzed articles in the *Journal of Historical Geography* in the mid-eighties and noted a similar preference toward the creation of new maps to illustrate historical data, averaging four maps per article (Hamshere 1987, 62).

In the following section, I discuss some of the particular issues of using historical data in the context of contemporary work by several historical geographers. I attempt to assess the methods they used to combine historical data sources, the degree of awareness they demonstrate about placing historical maps in context, and whether they consider Harley's theoretical framework within their papers.

A survey of the last several years of the *Journal of Historical Geography* reveals that most historical geographers have not taken up Harley's theoretical framework of historical maps as rhetorical text. Though the articles apply postmodern concepts to historical subjects, little information is given within the articles regarding the sources or the construction of new maps and even less on the direct social and political implications of the historical data sources. Hamshere concluded in 1987 that "virtually no attention has been given to the mapping of historical data" despite this being a highly used method for visualizing the past (Hamshere 1987, 63), and this still seems to hold true today.

For example, an article on industry in the San Francisco Bay Area from 1850-1940 (Walker 2001) includes a reconstructed map of industrial zones of San Francisco from 1880-1900 (Figure 2.6). The techniques for creating the map, which depicts clusters of industry around the city's edges, are not discussed, though the sources, which include historical city directories and maps as well as contemporary dissertations and books about San Francisco, are mentioned in the notes section (Walker 2001). Because space is limited in published articles, a lengthy discussion of cartographic techniques would not be appropriate, but more information about the historical sources used to create the map would possibly reveal new insights. A similar treatment of historical sources and map construction is found in Craig Colton's article on environmental inequality in New Orleans (Figure 2.6), where details are relegated to a short note section at the end of the article (Colton 2002). While making references to the information depicted on the maps throughout the article, Colton barely footnotes the map sources, adds little information about how he used historical data to draw his conclusions, and provides no information about how he created his maps.

Just as Harley suggested a new set of questions for Darby and his work with the Domesday Books—such as, what effect did the historical documents have on the

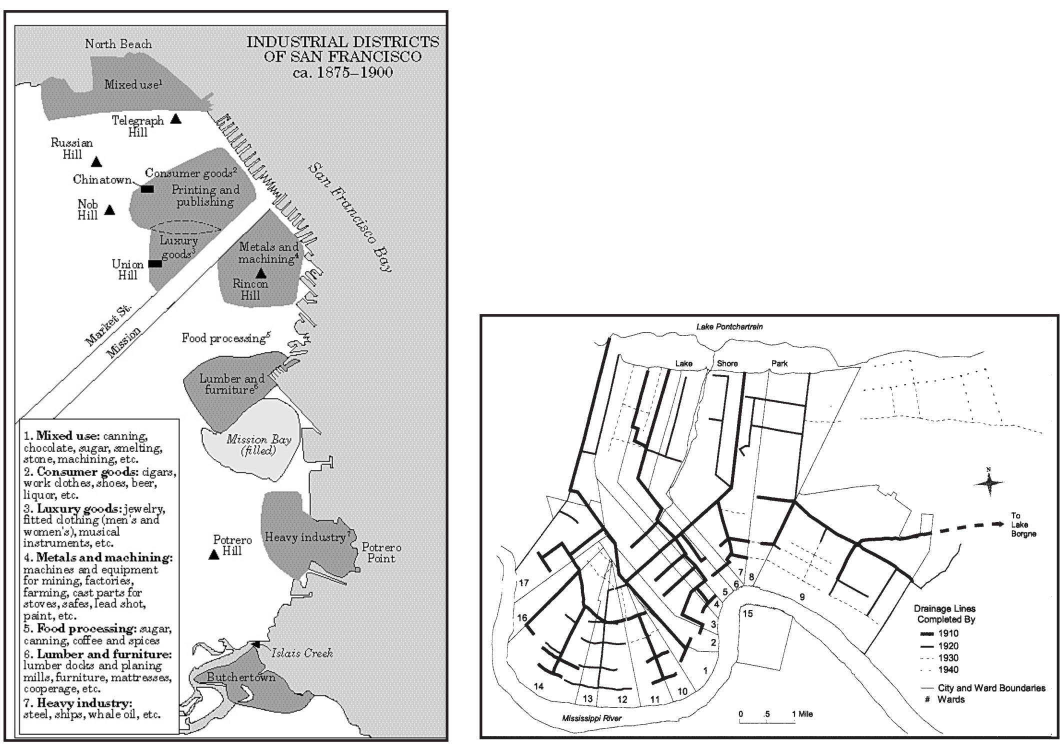


Figure 2.6. Two examples of maps drafted from historical information. Left, clusters of industry around the edge of San Francisco (Walker 2001, 39); and right, the chronology of New Orleans' drainage lines (Colton 2002, 244).

social structure of the era and were the documents simply made and lost amid bureaucratic red-tape or did they impact society by exerting social control and changing land distribution?—it would be useful to develop similar questions for contemporary work in historical geography journals. However, asking these questions would change the direction of each of these papers. The historical sources would no longer be relegated to the background, but instead would shape the questions asked. Hamshere notes that a new methodology such as what Harley suggests "affects not only the questions asked of the sources, but also the sources themselves" (Hamshere 1987, 51), and these articles might be shaped differently if the papers were written with Harley's deconstructionist framework.

Historical cartography and GIS. A geographical information system (GIS) seem like a logical tool for historical cartography, though Harley raised concerns about the objective appearance of GIS-generated maps, suggesting that the scientific veneer of a GIS contributes to the impression that the final map is objective and masks the underlying subjective source material (Harley 1991, 202).

Despite his concerns, the capabilities of a GIS certainly seem to provide a potentially invigorating method for examining the past. A recent issue of *Social Science History* is devoted to exploring the use of a GIS in historical research, and geographer Anne Knowles writes in the introduction that "people love new tools that enable them to do what they have dreamed of doing" (Knowles 2000, 451). Knowles acknowledges historical geography's rather late entry into the GIS field (Knowles 2000, 456) but points to three compelling reasons for using a GIS in historical studies. One, it forces users to develop accurate spatial boundaries so meaningful comparisons of change over time can be made; two, it allows historical geographers to better understand the spatial aspects of human history; and three, using a GIS will reveal dimensions of change otherwise difficult to envision (Knowles 2000, 452-453).

Early indications are that use of a GIS is bringing a new sensitivity to combining the myriad data sources available to historical geographers. "GIS is a superb tool for compiling data and bringing different sources of information into registration," writes Knowles (2000, 458). Siebert suggests that using a GIS "forces the researcher to be more systematic" and "resolve conflicts between sources and investigate gaps in the record" (Siebert, cited by Knowles 2000, 459). Siebert notes the difficulty of integrating the diverse sources available to historians (including maps, urban plans, photographs, and census, economic, institutional and voting records) without a GIS (Siebert 2000, 538).

Harley's concerns are not unwarranted. Using a GIS may in historical geography may be seen by many as a return to quantitative and positivist methods (Pickles 1995), without awareness of the social and political implications of the source material. Harley suggested that use of computerized mapping methods would only lead to more strident "scientific rhetoric" by map makers (Harley 1989a, 151). Taylor and Johnston complain that available data rather than the question lead a GIS project (Taylor and Johnston 1995, 56), though that is probably true for any project in historical geography. Other criticisms of use of a GIS that parallel criticisms of quantitative methods are that a GIS handle qualitative data poorly; that a GIS requires data be generalized and reduced; that a GIS separates the data from the social forces that created it (Knowles

2000, 464). While it is true that a GIS allows for a more quantitative approach, Knowles sees this as a positive outcome, and she suggests that a GIS may provide geographers with the means to do the "spatial analysis of social phenomena to which geography's spatial analysts aspired in the 1960s" (Knowles 2000, 462). She argues that the collected essays she is introducing reflect a very creative line of inquiry that involves social and historical factors as well (Knowles 2000, 464).

Referring to another collection of historical GIS papers—also edited by Knowles—historical geographer Deryck Holdsworth is enthusiastic about the convergence of geography and history through use of a GIS. He admits that the most striking essays are by historians, though he notes that "historical geographers contribute two solid chapters" (Holdsworth 2003, 486-487). Indeed, while geographers Ian Gregory and Humphrey Southall carry on the tradition of Clifford Darby in mapping British population history (Gregory and Southall 2002) by analyzing historical census data within historical boundaries, it is the work of historian Geoff Cunfer that appears more compelling. Cunfer uses a GIS to show that the Dust Bowl may well have been caused by cyclical rainfall and temperature fluctuations, rather than land use practices, as usually assumed (Cunfer 2002).

A GIS has the capability of bringing new insights to studies incorporating historical maps, and early research is promising—perhaps not providing the analysis Harley would hope for—but certainly there appears to be a trend to discuss source material, how the sources are combined, and to bring a sensitivity to the resulting maps through the use of detailed metadata, that answers Harley's concern about strident rhetoric.

David Rumsey—a private collector of over 150,000 historical maps—uses both GIS and the web to show the relationship between the past and present in maps (Rumsey 2005). Rumsey creates hybrid maps of historic and current cartography. While the map sources and methods for combining them are carefully described, Holdsworth notes that Rumsey's work does little to bring voice to "the many silences that Brian Harley and others have so clearly analyzed" (Holdsworth 2003, 487). Rumsey's work instead seems to suggest techniques for overlaying maps that could be used in the pursuit of such analysis.

HARLEY'S LEGACY

Map historians, cartographers, and historical geographers create and publish reconstructed maps, but for the most part, the source material for these maps remains unexplored, though that may change with the use of GIS, and source material may be discussed more rigorously. Harley suggests that map historians, cartographers, and historical geographers have mistakenly tried to fit their work into the framework of academic cartographers, using the rigid conventions of a discipline that strives to become more precise—which just renders the work lifeless. Instead, Harley writes, "a radical critique of academic cartography as it bears on historical geography is overdue", and that historical geographers should instead develop methods that will "help us experience the human struggles of the past" (Harley 1989b, 87).

One criticism leveled at Harley is that he did not fully understand Derrida's theory of deconstruction, and that he simply applied the gloss of social theory to cartographic history (Belyea 1992, 4). I argue that while it may be true that

Harley incorrectly identified his theories as being aligned rather than derived from Derrida and Foucault, it does not invalidate what Harley was suggesting. If geographers were to follow Belyea's directions and "push the cartographic application of Derrida's and Foucault's arguments to their logical, radical conclusions" (Belyea 1992, 1) geographers would have to discard the "generally accepted definition of maps as representations of the world" (Belyea 1992, 4), which would leave out much of the discipline of geography. Instead, Harley suggested an examination of the subjectivity inherent in the maps as representations of the world, something that seems entirely suitable for geographers.

Harley was suggesting less reliance on the "statistical graphics of academic cartography" and the development of a "new cartography" that would "help us experience the human struggles of the past" (Harley 1989b, 87). Almost fifteen years later, Holdsworth lists some of the "new ways of imaging and seeing the past" which include new forms of cartography such as GIS in research, historical atlases using photographs and other archival material, and digital text and images online (Holdsworth 2003, 486).

Indeed, it appears that Harley's concern for the illusion of objectivity in computerized mapping was misplaced, and the most innovative work in historical geography is being accomplished with geographical information systems. While much room for abuse abounds (Pickles 1995), early work using GIS in historical geography shows GIS as a useful method for examining the past. In both collections of papers by Knowles (2000, 2002) there appears to be a trend to discuss source material, how the sources are combined, and to bring a sensitivity to the resulting maps that answers Harley's concern about strident rhetoric. As long as the research considers the subjectivity of the source material, historical geographers should "be open to the dazzling array of new ways of seeing, and imaging, the past" (Holdsworth 2003, 491).

Figure 3.1. Detail from oblique low altitude aerial photograph of South Bay by George Russell, *circa* 1920. Photographs such as this are used by historical ecologists to reconstruct the past (Russell *circa* 1920).

3. HISTORICAL ECOLOGY AND THE USE OF ARCHIVAL MATERIALS

Historical ecology is variously described as the "interface between ecology and historical geography" in studies of past ecosystems (Egan and Howell 2001, 2); or as the interplay between human culture and the environment "made manifest in the landscape" (Crumley 1994). Ecologists may use historical ecology research to understand long-term climatic and vegetation changes independent of human influence (Swetnam *et al.* 1999, Turner 1990, Swetnam *et al.* 1999), while others seek to discover the past interplay between the physical environment and human interactions that result in an altered landscape (Russell 1997).

Historical ecology reconstructs a past landscape from physical and written historical artifacts, and evidence of the past used in this process may include many diverse sources (Figure 3.1). Physical artifacts are remnants of earth-system processes extracted directly from the landscape; examples include tree rings, pollen spores, phytoliths, plant microfossils, packrat middens, and ice cores. Written historical artifacts are written, photographic, or cartographic documents, including manuscripts, diaries and narratives from explorers, oral histories, weather observations, photographs, land surveys, maps, and drawings (Swetnam *et al.* 1999, 1190-1191). This study is concerned primarily with the incorporation of maps, as written artifacts, into historical ecology studies.

Using historical written data is challenging to scientists accustomed to incorporating data prepared specifically for a study and presented with a description of methods of development and limitations of use. While conventional scientific data is gathered from the landscape directly, historical documents were not designed to support modern scientific questions and require developing an understanding of how the data were gathered, assembled, and presented (Grossinger and Askevold 2005a, 3). Written materials created for one purpose—for example a land survey developed to aid in the sale of property—are preserved for other purposes (Ham 1993, 95) and the historical ecologist needs to understand the source before mining it for other reasons such as the location of a channel or other natural features (Grossinger and Askevold 2005a).

The importance of historical archival information—including maps—to ecological restoration has grown as scientists have recognized its value for establishing a reference point for these efforts (National Research Council 1992, Swetnam *et al.* 1999, Egan and Howell 2001). Carefully synthesized maps can support a range of interrelated science and management objectives, including documenting reference or baseline conditions to set appropriate restoration goals (Goals Project 1999), understanding the physical and cultural processes controlling habitat formation and maintenance (e.g. Leopold and Collins 1993, Collins and Montgomery 2002), and providing detailed, project-level specifications for restoration and enhancement efforts (e.g. Hood and Hinton 2003). By documenting landscape characteristics both before and as a result of colonization and/or industrialization, historical maps—combined with other written and physical historical evidence—can identify the sequential changes and likely causes of landscape change (Knox 1987, Magilligan and Stamp 1997; Kondolf *et al.* 2001).

The following section describes how geographers contribute to historical ecology studies; provides examples of previous historical ecology studies, and how each used archival maps; and discusses the challenges historical ecologists face when incorporating maps and related written materials into environmental studies.

GEOGRAPHERS, HISTORICAL GEOGRAPHY, AND HISTORICAL ECOLOGY

Because historical ecology requires analysis of diverse physical and cultural artifacts, historical ecology studies are considered multi-disciplinary efforts, best undertaken by collaboration between historians, ecologists, foresters, anthropologists, biologists, and geographers, among others (Crumley 1998, Egan and Howell 2001). Geographers seem particularly well-suited as team partners, bringing to bear a wide array of cultural, spatial, and analytical skills. Geographers already have a critical analytical framework developed for using historical maps (Harley 1989a and 1989b, Thrower 1999) and more recently have incorporated the use of archival photography and other imagery (see Ryan 1997, Schwartz and Ryan 2002).

The field of historical ecology is closely aligned with early to mid 20th century historical geography and is influenced by the sequent occupancy studies of Derwent Whittlesey (1929), by the regional reconstruction of Jan Broek (1932), and by the cultural geography of Carl Sauer (1941). Sauer's historical geography and Broek's regional study of Santa Clara Valley—both drawing from natural and cultural histories—have much in common with historical ecology.

Historical geography was largely overshadowed by the quantitative paradigm, which was adopted by geographers in the 1950s and 1960s. Because it had always relied on qualitative descriptions and narratives, the subfield was relatively late in adopting the quantitative paradigm. This had the effect of pushing historical geography towards the "margins of the discipline", forcing many historical geographers to adopt quantitative methods (Johnston *et al.* 2000, 337). They soon became dissatisfied with the use of an inductive methodology that relied on natural sciences as a model, swung away from the quantitative paradigm, and turned instead to theoretical writings. Historical geographers began using philosophers such as Marx and Foucault, and studying labor, socioeconomics, feminism, and the environment in a postmodern framework (Butlin 1993, 62; Miller 1995, 128). Over the last three decades, historical geography has been largely concerned with postmodern theoretical writings rather than quantitative methods (Butlin 1993, 62).

The focus on these concerns led geographer and environmental historian Michael

Williams to suggest that the emphasis on Marxist perspectives and issues of class, gender, imperialism, etc., has resulted in an abdication of the physical world and that these new paradigms have "diverted energies and interest away from the basic question of human in nature" (Williams 1994, 9). However, these paradigms have had the effect of invigorating the field, broadening the areas of inquiry, and blurring the boundaries between historical geography and other related disciplines. This has led to the current eclectic and multidisciplinary approach in historical geography (Johnston *et al.* 2000, 338) that incorporates new techniques, including the application of geographic information systems to historical geography studies (Holdsworth 2002, 672).

Geographers often do not even identify themselves historical geographers. Agnew proclaimed "we are all historical geographers now" (Agnew cited in Entrikin 1998, 94), in reference to the number of mainstream geographers that have an interest in historical geography. Certainly Sauer, Whittlesey, and Darby shared the sensibility that historical geography is perhaps best considered an essential part of geography as a whole and not as a subfield (Leighly 1963 , Darby 1950). Wilbur Zelinsky, in a deliberately playful essay, declared "there is, alas, no logical basis for the existence of any field of study that could be honestly labeled 'historical geography'" (Zelinsky 1973, 188), arguing that the subject matter and general techniques are no different that in any other geographic research and that all geographic research needs to consider the past. Entrikin echoes this, noting that the "historical is inseparable from the geographical" (Entrikin 1998, 97).

How does contemporary historical geography differ from the type of studies that can be categorized as historical ecology? Based on the types of articles published in *The Journal of Historical Geography* (see previous chapter), geographers who identify themselves as historical geographers seem largely concerned with postmodern issues that are at odds with the positivism and deductive reasoning of science-based historical ecology studies. It may be that geographers most suited to collaborative efforts on historical ecology studies will not identify themselves as historical geographers *per se* but instead use terms such as "new regional geographer or landscape geographer" (Entrikin 1998, 94), and will include geographers specializing in biogeography, geographic information systems, and the history of cartography. Geographers with the ability to place maps in historical context, understand the technical constraints of map construction, and provide guidelines for using maps to create a synthesis would be positive additions to any historical ecology study.

EXAMPLES OF PREVIOUS STUDIES

Developing historical knowledge to understand and manage ecosystems is becoming increasingly important, and historical ecology can provide the framework for gathering and analyzing the data required. Historical archival information is used to determine the range of variability or reference conditions of an ecosystem during a time when it was less affected by humans (Swetnam *et al.* 1999, 1189). Four studies using historical documents are described below to exemplify the challenges the scientists faced when incorporating archival maps. Studies differing in purpose and methods have been described to show the wide embrace of historical ecology.

Mitchell *et al.* developed an interdisciplinary team to reconstruct the vegetation and land cover immediately after the initial arrival of Europeans in the Upper Chesapeake Watershed (2001). Travelers' journals and accounts were extensively cross-referenced to build a general land cover image of the area. Survey maps with recording markers (called witness trees) containing species-specific information were utilized (Mitchell *et al.* 2001, 176-177). The team incorporated information from 1,000 surveys recorded between 1730 and 1780 to create a database on 7,802 witness markers. From this data, they traced a decline in white oak, hickory, red oak, and black oak, and an increase in pine species (2001, 179). Difficulties encountered including sorting out vernacular tree names of the time from common 20th century nomenclature. For example, the 18th century surveyors referred to a 'spruce pine', which is probably what we call 'hemlock' when referring to *Tsuga canadensis* (2001, 181). The team constructed a table to cross-reference common names used by the surveyors with modern scientific and common names (2001, 181). The team also faced the difficulty of sorting out the surveyor bias to reference specific trees from actual changes in the composition of the forest (2001, 183).

Trimble took a historical ecology approach in demonstrating how an effort to eradicate the build-up of sediment in Newport Bay in the 1970s did more harm than good, as the effort was based on an incorrect understanding of the historical conditions of the watershed (Trimble 2003). Trimble, a geomorphologist, used accounts from early Spanish explorers and American settlers; a *diseño* (Mexican land grant map) from 1842; a study of the harbor by the U.S. Army Corps of Engineers in 1888; a soil survey from 1901; and U.S. Coast and Geodetic Survey maps from 1912 to 1980 to build a portrait of stream channels near Newport Bay (Trimble 2003, 442-

444). He created a series of maps showing changes in hydrography over time (see Figure 2.4) based on historical sources. Trimble used historical maps and sources that varied in level of detail, scale, datum, and construction, but he gives little indication of how these differences were assessed and handled in developing his conclusions.

Bahre used written and physical evidence to show that vegetation change in southeastern Arizona stemmed from human disturbance and not from long-term climatic change (1991). He used explorer's journals, maps, newspapers, photographs and rephotographs, along with field work in his study. Bahre's secondary premise was that physical scientists have underestimated if not completely disregarded the effect humans have on the environment, thereby missing the cause of change. When using land general land office surveyor's maps and notes, he faced a similar difficulty as did Mitchell *et al.*, in that he was required to understand the limitations and biases of the surveyors. Bahre described the surveyors' descriptions of vegetation cover as "vague, incomplete, and often contradictory" and noted that they were useful only when used in conjunction with repeat ground photography, repeat aerial photography, climate data, newspaper accounts, etc. (Bahre 1991, 60).

Dedrick (1985) used historical 19th century U.S. Coast Survey maps to compare historical tidal systems to their still functioning counterparts in San Mateo County near Bair Island and Foster City. Dedrick created basemaps; projected 35-mm slides taken at low altitudes and known tidal levels onto a wall and transferred the contemporary tidal system onto sheets of mylar; and compiled maps of the historical and contemporary systems to show accretion and erosion over time. He discusses at length other efforts to create similar comparisons, and provides a detailed description of the U.S. Coast Survey, indicating an understanding of the level of detail the Coast Survey maps could provide. The basis of Dedrick's work—comparing the historical tidal systems to their contemporary counterparts—is being completed for a larger scale using reliably using a geographic information system (see Collins and Grossinger, 2004; Grossinger and Askevold 2005a).

INCORPORATING HISTORICAL MAPS INTO ENVIRONMENTAL STUDIES

Archival maps represent a vast repository of underutilized data. As described above, maps can inform a reconstruction of the past in a number of ways. Natural systems—including the distribution of tree species, vegetation composition, stream channel and pond morphology, tidal slough and channel density—can be reconstructed from historical maps.

Several challenges face historical ecologists using historical maps. These are similar to broader issues to be considered when using any archival sources, including assessing the reliability of the archival source, the ability of the researcher to correctly interpret the material, and the need to study not just isolated pieces but the whole record in context. Harris asks about archives, "What to accept, what to reject?" and asserts that no set of specific methods will compete with "years of study and creative intelligence" (Harris 1978, 287 and 297). Two categories of challenges—that maps are fragmentary and incomplete records of the past that are easily misinterpreted, and that properly incorporating a map may require a theoretical framework that runs contrary to scientists' reliance on empirical knowledge and deductive reasoning—are discussed below.

Maps are fragmentary and incomplete records of the past. Historical maps are available through libraries, archives, historical societies, public agencies, or private collections, and increasingly on-line in digital format (see Ehrenberg 1996). Historical maps available to researchers are simply the maps that survived over time and were not discarded, a process described by archivists as Darwinian 'natural selection' of historical documents (Ham 1993, 12). Maps disappear from the historical record because they are not considered significant enough to save—in this regard, one-of-a-kind maps that were not printed as multiple copies are more susceptible to discard (Andrew and Larsgaard 1999). For example, many copies of historical U.S. Geological Survey quadrangles remain, because many copies of the map were printed on a press. However, there may be only one copy of a railroad's map of a proposed bridge over a stream channel, and if someone decided the map had no value and disposed of it, the map is gone forever. Additionally, the map that depicts the area or features of interest may have never been created at all.

Swetnam *et al.* notes that historical documents are affected by "a kind of 'cultural' filtering that affects their availability, completeness, and reliability" (1999, 1192). Maps may be selected simply because they provide continuous coverage across the study area, even though they may not be the earliest source. For example, U.S. Geological Survey surveyed the southern San Francisco Bay by 1900, but other sources such as the land grant *diseños,* U.S. Surveyor General confirmation maps of the Mexican land grants, and U. S. Coast Survey maps, all pre-date the U.S. Geological Survey maps. Hence, while it is tempting and sometimes necessary to use the U.S. Geological Survey maps because of their consistency and continuity, earlier maps that show varying level of detail and emphasize alternate features should be used in any synthesis (Grossinger and Askevold 2005a, 38).

Archivists consider historical documents to have two purposes: their original and primary purpose, being the administrative, legal, or fiscal reasons the document was created; and a secondary purpose, when they are used for research purposes other than those for which the document was originally created (Hunter 1997, 49). Understanding the primary purpose of a historical map is critical to evaluating appropriate secondary uses. Maps are usually drafted for a specific purpose, but through survival in an archive or library, may be used for entirely other reasons. For example, a city surveyor's map of property boundaries originally created to facilitate the sale and taxation of land may be used later by a researcher to document the width of a stream channel depicted on the map. Historical maps are often separated from written reports or narrative descriptions (Harley 1989b). Metadata contained within a digital map created by a geographic information system describes the map's origin, purpose, level of accuracy, scale, and projection, but historical maps are often lacking such information (Kandoian 1999).

Inductive versus deductive reasoning. Scientists are accustomed to using inductive logic, based on direct observations, while historians tend to use deductive reasoning, in which events of the past can be used to deduce broader patterns (Johnston *et al.* 2000). Swetnam *et al.* acknowledges the difficulty this can cause environmental scientists accustomed to using data collected from the landscape specifically for the project at hand, with a relatively thorough understanding of the methods, limitations, and potential errors resulting from the data collection methods, while "...the interpretation of gathered historical facts can be highly subjective" (1999, 1192). Historical maps represent data sources over which the scientist has no control. He or she was not there at the time of data collection and cannot easily understand how human techniques, decisions, and skills affected data collection, and must rely on deductive methods rather than direct observations.

Integrating historical data brings a set of challenges distinct from those associated with other types of data commonly used by environmental scientists. The collection of historical data was not designed to support modern environmental science questions (Figure 3.2). Furthermore, because historical data were generally

Figure 3.2. Using historical documents. Unlike data collected directly from the field, historical maps and documents were created for prior purposes and require an extra step—the interpretation and understanding of the map—before they can be utilized in a science-based study (from Grossinger and Askevold 2005a, 4).

produced outside of the scientific community—in which shared education, training, and lexicon provide a measure of consistent context—more attention must be paid to the wide social and cultural context within which historical documents were produced. Interpreting the origins and characteristics of historical documents has a well-established methodology in the field of history and geography, but scientists may less knowledgeable (and less comfortable) about incorporating such sources.

Hypotheses relating to events in the past are not easily tested, and because of this, historical data is often regarded as subjective and unscientific (Arens 2002, 206). Cleland suggests that inductive science starts with one hypothesis and subsequent experiments prove or deny the hypothesis, while those working with history develop many working hypotheses, which are confirmed or not through 'traces' or clues in the historical evidence (Cleland 2001, 987; Arens 2002, 206). Thus, though the method of inquiry used by "experimental scientists and historical scientists" differs, Cleland asserts that neither method has greater ability to test hypotheses (2001, 987). Furthering this avenue of thought may create a bridge between environmental scientists and social scientists by developing more useful ways to incorporate historical documents.

The next chapter discusses the methodology used in the remainder of this paper, and considers how Harley's theories—updated with a more flexible and pragmatic framework—can be applied to understanding and incorporating historical maps into science-based historical ecology studies.

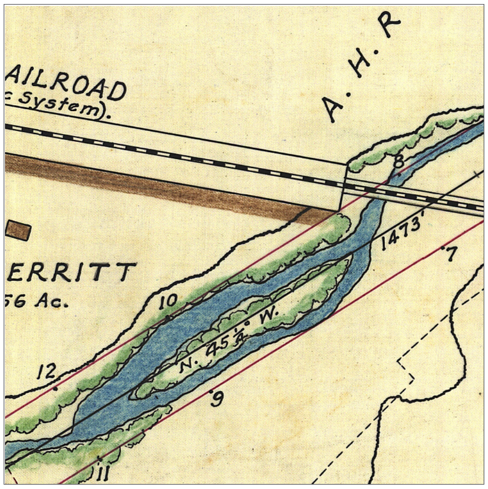


Figure 4.1. Detail from Coyote Creek survey by A.T. Herrmann, 1874. After repeated flooding, the county commissioned Herrmann to prepare detailed surveys of the active channel and high flow channels (Herrmann 1874).

4. METHODS AND MATERIALS

The method used to develop this paper can be broken down into the following steps. The study area was determined and defined; historical maps and other archival graphics were acquired for the study area and specific maps and materials were selected for inclusion in the study; information relating to the making of individual maps was researched and this information was used to place the map in context; the maps were compared to other maps and graphical material; and the results were synthesized. Each of these steps is explored more fully in the remainder of the chapter.

STUDY AREA

The San Francisco Estuary Institute (SFEI)—where I have been employed in the Historical Ecology Program since early 2004—has successfully contributed to the understanding of the San Francisco Bay through a number of historical ecology studies (see, for example, Collins and Grossinger 2004, Grossinger *et al.* 2004, Goals Project). Current work at SFEI in historical ecology includes a comprehensive reconstruction of the landscape of the South San Francisco Bay and Santa Clara Valley various local agencies (Grossinger 2004, personal communication). This on-going study provided access to a comprehensive body of archival research material, the extent of which would have been difficult to obtain as an individual. In short, it presented a unique opportunity to combine work and personal interest.

I selected an area in the Santa Clara Valley that falls between the lower reaches of the Coyote Creek and Guadalupe River, and includes both tidal marshlands now managed as salt ponds and urbanized areas along the rivers. (This area is described in detail in Chapter 5.) This area was selected because several early maps of interest to SFEI studies cover this area; the region has seen tremendous land use change; and those changes are documented in explorer journals, newspapers, local histories, land grant case transcripts, landscape paintings and photography, and a wide variety of cartographic products (for example, see Figure 4.1). The changes to the natural features of the area—two major rivers and associated tributaries, and the former tidal marshes, including a network of sloughs, channels, and many tidal marsh pannes—make the area suitable for a historical ecology study, though no comprehensive effort exists to date.

ACQUISITION OF MAPS AND GRAPHIC MATERIALS

Historical maps and other graphical material—landscape photographs and paintings—for the area are available through a wide variety of institutes, and increasingly, material is available digitally from web sites (Grossinger and Askevold 2005a, 6). A summary of the primary graphic sources used for the project is provided in Table 4.1. Most material was acquired from the various institutions digitally, which provided several advantages. The material could be plotted or printed at various sizes quite easily; the digital files could be easily shared among team members; the images could be used in reports and posters; and the maps could then be georeferenced using geographic information system (GIS) software. While web sites often provide a downloadable image, these are usually low resolution, and SFEI contacted each institution to acquire a high resolution file and arrange for permission rights to use the image.

The resolution at which an image is scanned affects the ability to examine the image in detail, or the size the image can be printed at (see Figure 4.2). Resolution—the number of pixels per inch (ppi)—also depends on the size of the image. For example, 35 millimeter slides only measure 1.35 inches wide by .9 inches high, so they need to be scanned at a very high resolution (1200 or higher) to yield enough resolution to be printed at a reasonable size. Large graphics, such as maps, have the opposite problem—scanning them at high resolution results in a massive file size of hundreds of megabytes, though various compression software (such as jpeg format and LizardTech's Mr. Sid compression algorithm) can reduce the file size.

SFEI requested images from institutes at relatively high resolution. Though the resulting file sizes were quite large, this allowed us to view on screen details of the

Table 4.1. Summary of primary graphic sources. 'Title' refers to map or graphic name; 'Created by' lists the entity responsible for creating the image; 'Type' classifies graphic into categories of map, photograph, or painting; 'Year' is date map or graphic was published; 'Institutional Source' refers to the entity the archival material was acquired from; 'Digital' indicates if the map or graphic was provided by the institutional source in digital format (though graphics only available in hard-copy were scanned at SFEI); and 'Resolution' describes the original size of the graphic in pixels per inch.

[1] All California land grant maps are available on-line for viewing and downloading at the Online Archive of California (www.oac.cdlib.org/)[2] Also available at the Online Archive of California (www.oac.cdlib.org) and the Library of Congress (www.loc.gov).

Title of map	Created by	Type	Year	Institutional Source	Digital	Resolution
United States Coast Survey T-sheet	United States Coast Survey	map	1857	National Ocean Service, NOAA	yes	600 ppi
Diseño of *Rincon de los Esteros* (diseño or land grant map)	land grant owner	map	c. 1838	The Bancroft Library, University of California, Berkeley*	yes	400 ppi
Wallace confirmation survey	commissioned by land grant owner; surveyed under instructions by the U.S. Surveyor General	survey	1859	The Bancroft Library, University of California, Berkeley*	yes	400 ppi
Reed confirmation survey	commissioned by land grant owner; surveyed under instructions by the U.S. Surveyor General	survey	1862	The Bancroft Library, University of California, Berkeley[1]	yes	400 ppi
Thompson and West, Santa Clara County Map Atlas (Map Sheet Number Two)	Thompson and West	maps	1876	primary maps available through David Rumsey website (www.davidrumsey.com/)	yes	600 ppi +
Bird's Eye View of the City of San José Cal.	W. Vallance Gray & CB Gifford (design and lithography); and Geo. H. Hare (publisher)	bird's eye drawing	1869	Library of Congress: American Memory collection (www.loc.gov)	yes	600 ppi +
Coyote Creek image by Alice Iola Hare	Alice Iola Hare	photograph	c. 1905	The Bancroft Library, University of California, Berkeley[2]	yes	400 ppi
Herrmann Coyote Creek survey	County of Santa Clara	map	1874	County of Santa Clara	yes	300 ppi
AAA aerial photographs	Agricultural Adjustment Administration (USDA)	photograph (aerial)	1939	Santa Clara Valley Water District (copy of negative acquired by the district and loaned to SFEI)	no / SFEI scanned 9 x 9 in neg.	600 ppi
U.S. Geological Survey Palo Alto quadrangle	U.S. Geological Survey	map	1899	U.C. Berkeley Earth Sciences Library	yes	300 ppi +

map otherwise impossible. David Rumsey's team describes this phenomenon:

> Magnified on screen, [Rumsey] began to see things that he never had seen before. The images were of such high resolution that one could make out individual fibers in the paper. The digital version of the maps were in some way more useful for study than the paper originals (Rumsey and Punt 2004, 126).

Though the effect is more dramatic when viewed on the computer screen, the resolution affects the ability to discern detail through prints as well.

It should be noted that while SFEI sought a wide range of archival material—and endeavored to acquire all early maps of the area—the assembled material only represents what survived. For example, spatial representations from the Ohlone tribes of the area have not survived, probably due to the ephemeral nature of

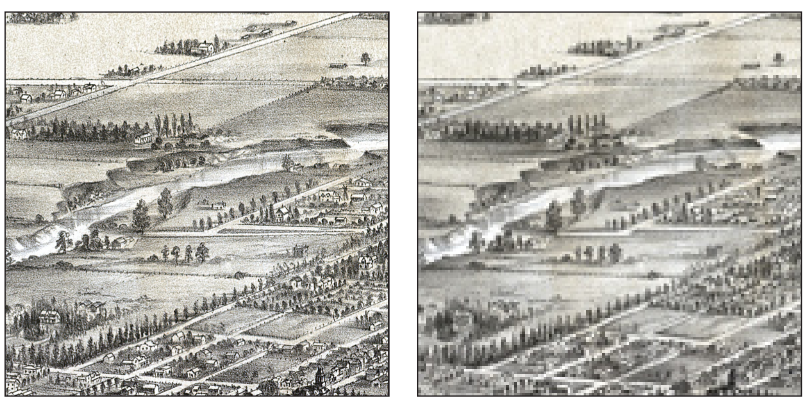


Figure 4.2. Example of scanned images at varying resolutions. Both images are of detail from a bird's eye view of San José, printed by lithography in 1869 (Gray and Gifford 1869). Both details are shown in a 2 by 2 inch frame; the image on the left has 300 ppi resolution, while the image on the right has only 72 ppi. The higher resolution allows the user to see additional detail not visible in the lower resolution image.

the information. Lewis notes that native maps were "born of experience and oral tradition, not an inscribed archival history in the Western sense" (Lewis 1998, 52). Thus, while the Ohlone probably contributed to the spatial understanding of the Spanish Mission and pueblo populations, the evidence of this has vanished (see Harley 1992). Other maps, photographs, and paintings may have been discarded and not entered the archival record, or never found, leaving gaps.

In many ways, the selection of maps used for the project could have been random. Answering the question—can historical maps be successfully used *without* placing them in context—can be asked and answered using any set of maps. The maps used in this report—a *diseño* from *circa* 1838; a U.S. Coast Survey T-sheet map from 1857; and a map from the Thompson and West atlas of 1876—were selected from the available set for several reasons. One, they represent some of the earliest cartographic efforts in the area, and as such, present views of the landscape during early eras of change. Two, the maps were created for very different purposes and for different audiences, which presents interesting possibilities for comparison. Three, each of the maps was created and produced with very different technology, again providing opportunities for contrast and comparison. Four, each of the maps presents some tantalizing spatial information useful in reconstructing natural features for a historical ecology project. Finally, the level of information available—about the agencies and individuals that made the maps as well as the methods and technologies used—varies considerably , and I again thought the different levels of available knowledge could create an interesting contrast in later chapters.

RESEARCH OF MAPS AND GRAPHICS FOR CONTEXT

In an introduction to a book of essays on historical interpretation using maps, Harley suggests a method for applying his map theory (Harley 1990) that I have adapted for use in this paper. He proposed examining the agency or entity responsible for the creating the map, and if possible, the individual cartographer(s) within the agency who made the map; exploring the social, political, and economic context of the time in which the maps were made; reviewing the cartographic techniques and printing methods used to create the map; and comparing the map to other maps of the same era (time); to maps of the same subject matter (theme); and to maps of the same area (space). This outline provides a method for applying Harley's complex theories and a structure in which to analyze different layers of meaning. Using this structure, Harley suggests, allows us to understand how each map is a highly selective construction, move the map from a technical and mechanical problem to an object of discourse, and, through the use of narrative, explain the map's connections with other historical data sources (Harley 1989b, 84-85).

My strategy in research was to find material that would allow me to examine these factors. Research involved a wide range of primary sources, including federal census records, U.S. Coast Survey reports, land grant case court transcripts, newspaper and journal accounts, as well as a numerous secondary sources. Topics of research included political, economic and social history, land use patterns, printing techniques, cartographic and surveying methods, and history of individual cartographers and agencies.

Much more material was available for the U.S. Coast Survey than for either the *diseños* or the Thompson and West atlas maps. Hence, the chapter discussing the Coast Survey is more substantial than the other two chapters; the implications of that are discussed in the results section.

This research provided the basis for applying Harley's theoretical framework to historical map study. However, it became clear that parts of Harley's framework—with sweeping generalizations, rather strident postmodern overtones, and a general condemnation of the power associated with mapmaking—could be adjusted to better serve the purpose at hand. Harley's interest in critical map theory came at the height of postmodern fervor in deconstruction and critical theory, and his approach might have mellowed and become more flexible and pragmatic, as many of his followers have suggested (see Edney 1996; Jacob 1996).

Refining Harley's theory is appropriate given that many of the postmodern concepts have softened and become an accepted view of the world. Other parts of postmodernism have been discarded or have been reworked. Dissatisfaction with postmodern tenets has led to an exploration of the theory's flaws. While deconstruction has had a positive effect by recognizing that knowing the position of an author, in terms of class, culture, race, and gender, encourages alternative readings and writings of texts, deconstruction can be carried to an extreme as it "knows few limits" (Johnston et al 2000, 621). Deconstructing the deconstruction leaves the observer on "uncertain ground", in which the ability "to provide an adequate understanding of other people and places must be slender indeed" (Johnston *et al.* 2000, 621). A modified form of postmodernism has found favor, in a return to hermeneutics.

> For while hermeneutics acknowledges the collision between the author and the data as an inescapable element in the production of knowledge, it is a realization that generates not paralysis but a series of best practices to limit and contain authorial distortions (Johnston *et al.* 622).

Historical ecology may not benefit from all facets of Harley's theories and his approach is used here only as a basic framework to provide context to the map. Assigning imperialist motives to Thompson and West's 1896 atlas may not be as successful as when analyzing the maps of the Colombian Encounter. Still, if maps are to be integrated into scientific studies they must be understood—deconstructed—to gain authority and complete usefulness. This assumes, of course, that maps are not objective but rather are shaped by a number of factors including the time in which they were made, the purpose they were made for, the entity that commissioned them, and the technology used to create them, i.e. their context. I suggest that without this understanding, the scientist cannot really put them to good use.

Mindful of suggestions to understand my own perspective, it's important to disclose the biases I bring to the work. As a GIS professional, I often assess maps for their potential to be incorporated into a GIS. The surveyed lines of a confirmation map, created for the U.S. courts to establish the boundaries of a land grant, appeal to me on some level more than the individualized *diseños,* which provide intriguing historical clues but present awkward spatial relationships, at least when incorporating into a GIS. As a cartographer and graphic designer, maps that are aesthetically appealing may impress me more than maps that are less visually compelling. As a self-identified environmentalist living in the U.S. in the 21st century, I am looking for maps that will help us understand past ecosystems for use in habitat restoration—as such, I am not interested in finding maps to aid with exploration, real estate transactions, subdivision development, military installations.

COMPARISONS: MAP TO MAP AND MAP TO GRAPHIC

Much can be learned by comparing one map to another. A comparison provides insight into what a map has in common with other maps; how it presents the same information differently; what it includes and excludes based on other maps. Harley suggests we compare a map to other maps of the same era (time); to maps of the same subject matter (theme); and to maps of the same area (space). "Sooner or later early map interpretation becomes an exercise in comparative cartography", notes Harley (1990, 42). Probably drawing on his experience in detailed cartobibliographies, he suggests several strategies for making comparisons. Linear topographic features—such as coastlines, rivers, roads, sloughs—can be compared, though Harley suggests caution in attributing what might be cartographic license to actual change (1990, 43). Another avenue of exploration in map-to-map comparison is place name study to establish and understand interrelationships between groups of people. Harley also suggests assessing different editions of a map over time, and by cataloging the revisions, building a record of change over time (1990, 44).

I compare each of the maps discussed in the following three chapters—the *diseño,* Coast Survey T-sheet, and Thompson and West atlas map—to other maps, finding maps that correspond to the same era, have a similar subject matter, or are of the same geographic area. When comparing each of the maps to other maps, I found it necessary to investigate each of those maps or graphics in a similar way—i.e. understand their historical context—to engender meaningful comparisons. For the most part, the maps covering the same geographic area have been incorporated into a GIS at SFEI, through the use of georeferencing and georectifying software tools, so that features can be compared and the maps visually studied at the same scale. The maps used in the comparisons are presented on a page with a summary of the results of each comparison.

SYNTHESIS OF RESULTS

While it is difficult to answer these questions quantitatively, the value of placing maps in context can be assessed through application of several tables that can be used as templates for other studies incorporating historical maps. To do this, I create a table analyzing the map's strengths and weaknesses; a table comparing the map's original purpose with possible uses in historical ecology, and the implications from using a map for different purposes than what it was intended for; a "certainty level" table, made possible from research into the map's context that assesses each map's locational accuracy; and a table of usability, summarizing the scores of the maps on the previous criteria. These tools represent an integrated approach for the applied use of historical maps in a science-based study.

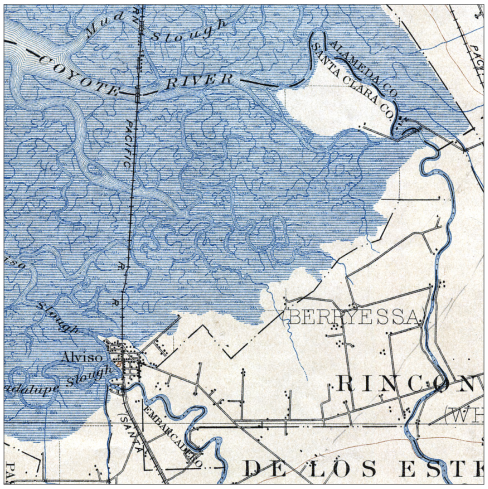


Figure 5.1. Detail from the U.S. Geological Survey 15-minute San Jose quadrangle, 1899. This detail shows the north end of the Santa Clara Valley, where Coyote Creek and Guadalupe River meet the tidal marsh of San Francisco Bay (U.S. Geological Survey 1899 [1895]).

5. THE STUDY AREA: COYOTE CREEK, SANTA CLARA VALLEY

The Mexican land grant *diseño,* the 19th century U.S. Coast Survey map, and the Thompson and West atlas sheet described in this paper depict an area in the Santa Clara Valley between the lower reaches of Coyote Creek and the Guadalupe River, including tidal marshlands now primarily managed as salt ponds, a sewage treatment plant, and urbanized areas along the rivers (Figure 5.1). Two of the maps were triggered by new governments: the *diseño* was part of the land grant process after Mexico took over the territory from Spain, and the U.S. Coast Survey map allowed for navigation of the southern portion of the San Francisco Bay after the United States took control from Mexico. Written histories of the area are similarly divided into sections describing each successive wave of colonization—the Spanish, then Mexican, and then American conquest of the area, after beginning with a description of the native Ohlone populations (for example, see Broek 1932; Friedly 2000; Payne 1987; Pitt 1966; Pitti 2003; and Sawyer 1922).

Santa Clara Valley is situated at the shallow southern end of the San Francisco Bay, bounded on the east by the Hamilton Range and on the west by the Santa Cruz coastal mountains. The valley itself is divided into a northern and southern plain, separated in the middle by the Coyote Narrows, where the Santa Teresa Hills to the west and the foothills on the east converge (Walker and Williams 1982, 96). South of this gap are the towns of Gilroy and Morgan Hill; the northern area is more urbanized, with the cities of San José, Sunnyvale, Mountain View, Palo Alto, and Milpitas connected by a network of roadways (see Figure 5.2). This study is concerned with a small northern portion of the valley, encompassing the land between Coyote Creek and the Guadalupe River, extending north into the tidal marsh and south to Agnew (see study area indicated in Figure 5.2).

The area has been occupied by people for at least 10,000 years before the present but the last two centuries have seen a sharp rise in the population and a marked increase in manipulation of the environment (Friedly 2000, 23). Successive populations—the Ohlones, Spanish, Mexicans, and Americans—each imposed their cultural point of view and economic structure on the valley, effectively replacing previous cultures, though remnant evidence of each culture remains on the landscape.

The Santa Clara Valley is characterized by a mild Mediterranean climate, with few days of frost. Yearly rainfall of 10 to 20 inches occurs mostly in the winter

Figure 5.2. Study area. Santa Clara Valley is situated at the southern end of San Francisco Bay. Coast range hills and mountains flank the valley's east and west sides. The contemporary landscape shown here is dominated by the cities of San José, Sunnyvale, Mountain View, Palo Alto, and Milpitas, along with the roadways connecting the urban centers. In the mid-nineteenth century, the town of Alviso played a pivotal role as a landing and shipping port, creating the link between the goods produced in the valley and the larger commercial market (Grossinger and Askevold 2005b).

months, while the surrounding mountains receive from 30 to 50 inches. With a few exceptions—such as the Coyote Creek and Guadalupe River—the streams are small and often are dry in the summer months. Deep alluvial deposits held significant groundwater aquifers, which were pumped extensively for agricultural purposes after a drought in the late 1890s until the wells dried up and land subsidence occurred as a result (Walker and Williams 1982, 96).

Land use has varied over the time of human habitation, but in general has intensified over the last two hundred years. The landscape before European contact (i.e. pre-1769, when the Spanish explorers arrived) is often seen as pristine (see Denevan 1992), but it is unlikely thousand of years of occupancy left an untouched landscape (Friedly 2000; also see Endfield and O'Hara 1999). Friedly suggests that the Ohlone, who probably arrived in the area about 3500 years ago, lived in a "co-evolved" landscape, a landscape which was shaped by the native population's land management practices, and which provided the population with a range of opportunities (2000, 37-38). The collection of staple foods such as acorns, salmon, and shellfish affected the supply of these resources and the intensive hunting of deer and elk may have seriously diminished these mammal populations; use of wood for heating and cooking decreased the abundance of some local trees; the harvesting of plants and transport of seeds shaped the flora; and management practices such as fire shaped the valley landscape by reducing competition for oak trees, encouraging certain plants, reducing fire danger through elimination of the understory, and aiding in hunting small mammals such as rabbits (Friedly 2000, 58-60).

The Ohlone practiced a well-established manipulation of the land to increase yield of prized resources, though this is contrary to a widely held belief in a virgin landscape prior to European colonization (see Denevan 1992). In 1922, a local history of Santa Clara County described the Ohlone population as "a race of mild-mannered, ignorant, and generally inoffensive Indians...[who] subsisted on the spontaneous fruits of the soil and the small game which they killed or captured with their rude weapons" (Sawyer 1922, 34), articulating a persistent view that the native Ohlone did little to affect their landscape.

This type of land management shifted at the end of the 18th century, when the native Ohlone population dramatically declined from disease after Spanish colonization, and the Spanish imposed their own land use practices (Friedly 2000). Broek characterizes the change between the extensive but low-intensity land use by the native Ohlone to a more intensive use of land by the Spanish as a turning point, "as man gains increasing control of his landscape" (Broek 1932, 33). Friedly notes a similar milestone in land management with the arrival of the Spanish, but frames the consequences differently. He notes that local control of land by the native population was replaced by a distant power; land became a commodity, controlled by the state; increased manipulation of the environment led to degradation of local resources; and the introduction of agriculture threatened the existing ecosystem (Friedly 2000).

A group of Spanish explorers, led by Gaspar de Portolá, reached the area in 1769, seeking a site for a new mission in the area meeting the following criteria—the location must be close to a year-round supply of water, have access to a nearby native population, and have access to a supply of wood for fuel and building. Several sites were considered and rejected before a tract of land along the Guadalupe River, near the present-day city of Santa Clara, was selected (Payne 1987, 23). Flooding soon made relocation of the mission to slightly higher ground necessary (Arbuckle 1986, 11). The Spanish period—between 1769 and 1821—was characterized by a close relationship between the state and church. Missions and pueblos were established to convert the native population and encourage Spanish and Mexican settlers in the area, in an attempt to gain control of a northern outpost (Pitti 2003, 19). The native Ohlone population declined dramatically during the Spanish period, as diseases to which the native population had no immunity to swept through the crowded and unsanitary conditions of the mission (Friedly 2000, 161). A measles epidemic in the area missions killed more than one-third of the native population between 1806 and 1810 (Paddison 1999, xv).

The Spanish pueblo and mission in the Santa Clara valley engaged in intensive cattle grazing, with irrigation systems consisting of ditches and small dams to support small-scale cultivation of garden crops, vineyards, and orchards. A ditch almost two miles in length, constructed in 1795, ran from the Guadalupe River to the mission gardens and back to the river (Broek 1932, 48).

In 1821, after Mexico engaged in 10 years of revolution against Spain, the area became a Mexican territory rather than Spanish. The missions were secularized after 1833, and the land formerly owned by the state and church was now available for private ownership—including ownership by native Ohlone, at least in theory (Pitti 2003, 21). Taking away the rights of the church and granting property to individuals was a radical departure from the Spanish system of land allocation (Friedly 2000), and though it transferred property from the entrenched church, property ownership remained a privilege only for the well-connected. Little land ever was distributed to the native population, but instead large land grants were given as rewards to favored citizens of Mexico (Robinson 1948, 66).

The era of Mexican control before American conquest is often typified as a relatively quiet period, in which the Mexican government did little to improve the area. Payne dismisses Mexican rule, noting that "Mexico did little in the province, other than to send governors and a few soldiers" (Payne 1987, 37). Friedly disagrees, citing the increase in trading activity that had largely been forbidden by the Spanish (Friedly 2000, 193). With foreign trade came foreigners, and Mexico, eager to not lose their northern outpost, allowed foreigners who would become Mexican citizens to settle and apply for land grants, hoping this would strengthen Mexico's claim on the area. Economic activity in Santa Clara Valley—especially trade in cattle hides and wheat—increased after the Spanish relinquished power (Friedly 2000, 199). The growing presence of foreigners—especially of Americans, who felt the Mexican land owners were not making appropriate use of the land by cultivating it—created a tension that spanned the years before and after the American takeover (Pitti 2003, 35).

The United States takeover came less than 30 years after Mexico took control of California from Spain, but the Americans inherited from Mexico a new and complex patterns of land ownership (Robinson 1948). Prime land along the coast had been divided into relatively large land grants, and the treaty agreement between Mexico and the U.S. was written to ensure the land grants were honored—though economic and political forces often resulted in the loss of much of the land grant to speculative interests (Pitt 1966).

The relatively short-lived Gold Rush contributed to change in the area, as population in California exploded, and Santa Clara Valley became a supply center for the new residents, providing much needed locally-grown produce, beef, and eventually wheat. Goods were shipped from *embarcaderos,* or landings, which were small peninsulas of terrain that intruded into the tidal marsh and came near to a navigable slough, and thus were ideal for shipping (Grossinger and Askevold 2005b). Many miners, having failed to make their fortune in the Gold Rush, returned to Santa Clara to establish farms, selling produce at highly inflated prices (Friedly 2000, 277).

American farming replaced Mexican cattle grazing, and by 1865 wheat farming dominated the valley. As other areas of the country grew wheat more successfully than the Santa Clara Valley, specialized dairy farms and fruit orchards replaced grain growing (Broek 1932, 60). Large scale mercury mining at New Almaden, timber harvesting in the hills, and mechanized tools for farming all became part of the American landscape (Friedly 2000).

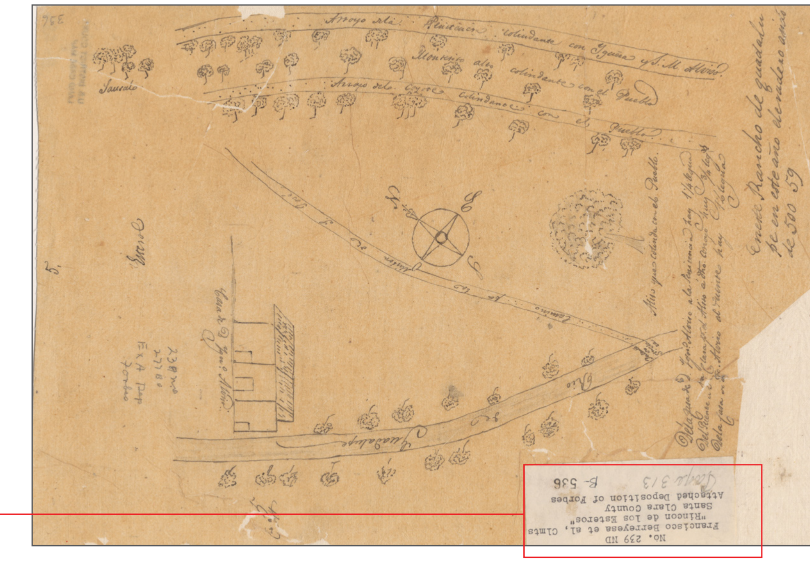
Even though the Spanish and Mexican cattle grazing had an impact on the valley, Friedly notes that the urgency with which the recent American immigrants mined gold in the Sierra Nevada brought an urgency to economic activities in the valley; for example, wheat was farmed until the land was exhausted; mercury was mined, at the expense of the miners' health; and timber was harvested until it was depleted (Friedly 2000, 327). Droughts in the 1860s and 1870s resulted in overuse of artesian wells by the area farmers (Friedly 2000, 338)

A railroad connected San Francisco with San José in 1864, and the South Pacific Coast Railroad linked Oakland with San José by 1877, crossing Coyote and Mud Sloughs, and creating the town of Drawbridge, a community of about 80 houses built on stilts in the tidal marsh (Dewey 1989, 9). By 1872, San José was connected to the transcontinental rail lines running east. Transportation of freight via rail lines replaced the specialized flat-bottomed scows developed to carry goods from the landings down the sloughs to the San Francisco Bay (MacGregor 1968, 30; Dewey 1989, 2).

By the 1930s, factories began to replace farms, and increasingly farmers sold their land to the government for defense sites, to expanding corporations, and to small businesses (Payne 1987, 175). In the late 1940s and 1950s, the farm acreage decreased by 27 percent in the county; and by 1978 only 1 percent of the population was involved in agriculture (Payne 1987, 178-179). The growing population drawn to job opportunities required a place to live. The G.I. Bill, signed by President Roosevelt in 1944, provided low-cost loans for home purchase, and contributed to the increase in home ownership. Hayden suggests that suburban housing followed a predictable pattern of single-family houses, in part from government policies that encouraged an "idealized life in single family houses with generous yards" (Hayden 2003, 4), and through Federal Housing Authority funding that favored the building of single-family houses by "large developer-builders who could handle the government paperwork [and] achieve economies of scale" (Hayden 2003, 132). New housing in Santa Clara Valley was built as single-family houses, and resulted in sprawling suburbs replacing farms. This trend increased dramatically in the 1950s as electronics and computer technology corporations located in the valley, growing in force and number through the turn of the century. Santa Clara Valley is often referred to as Silicon Valley, a nickname coined by a local journalist in 1971 (Payne 1987, 201).

Maps selectively recorded features of the landscape a number of times throughout the rapidly changing history of the valley. The maps—compiled for a variety of often mundane purposes—can be used to reconstruct the area's landscape, though interpretation requires careful deciphering and an understanding of context (Grossinger and Askevold 2005a). For example, the 1838 *diseño* (land grant map) described in the next chapter was drafted to satisfy the requirements of a real estate transaction with the Mexican state, but also contains information about natural features used to define the boundaries of the rancho. The U. S. Coast Survey map of the tidal marshland from 1857 was created to assist safe and efficient commerce on the complex network of sloughs of the San Francisco Bay shortly after the U.S. took control of the area from Mexico, but now the maps provide the best early pictures of coastal and estuarine habitats prior to substantial Euro-American modification. The Thompson and West map was designed to sell subscriptions to atlases but also documents the dramatically changing patterns of land use, ownership, and modifications of the area's natural features after the U.S. took control.

FIGURE 6.1-A. *DISEÑO* OF *RANCHO RINCON DE LOS ESTEROS*, CIRCA 1838 (United States District Court 1873 [*circa* 1838]).



SOCIAL CONTEXT

The *diseño* was used to establish land tenure through a complex system of petitions and approvals. Boundaries were loosely defined, and sometimes the edge of one rancho overlapped another. These differences were easily resolved where land was a plentiful commodity but became more difficult to settle as land values grew. *Diseños* were often considered inaccurate, misleading, and probably contrived by American surveyors (Arbuckle 1986,55).

TECHNOLOGY: SYMBOLS

Diseños represent the world as both a plan view, as if looking down from above, and in profile, where objects are seen from the side. The land grant maps employ pictograph—or images that have a likeness to the original object—such as the trees and house. Pictographs are in contrast to symbols on maps, in which a legend is needed to interpret the sign; the symbol is selected arbitrarily and does not resemble the original object (Casey 2002,143).

TECHNOLOGY: PEN AND INK COPIES

Diseños were hand-drawn and not printed. When more than one map was needed, pen and ink copies were drawn, though the duplicate might vary in features, placement, and coloring. Above, the copy contains mostly the same features but color is not applied as it has been to the map to the right.

SOCIAL CONTEXT

After United States took control of the area, former Mexican citizens who had been granted land were required to prove their ownership by presenting the Land Commission with all documents associated with their original land grant, including the *diseño* that was created when the land was originally petitioned. The typewritten note affixed to the original map identifies it as part of the "Francisco Berreyesa et al, Clmt" for the "Rincon de los Esteros" in 'Santa Clara County'. The copy, top right, affixes the identifying note on the opposite side of the map, probably to prevent covering up the Guadalupe River. The Land Commission kept copies of all material, now archived at the University of California's Bancroft Library.

SOCIAL CONTEXT & TECHNOLOGY: WORDS

Features are identified with hand-written descriptions, place names, and notations identifying the owners of specific houses.

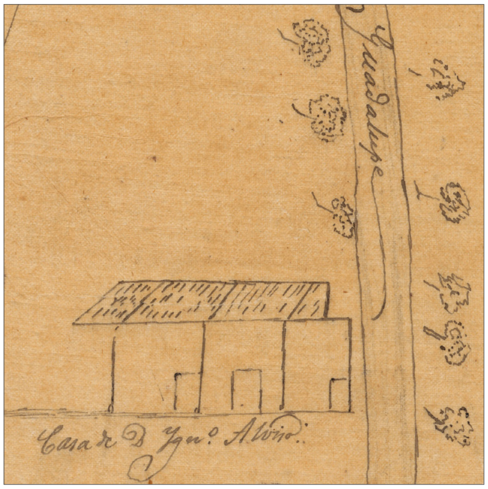


Figure 6.1-B. Detail from the *diseño* of *Rincon de los Esteros.* The *diseño* uses pictographs to represent an adobe house. A pictograph is an image that has a likeness to the original object, while a symbol is an arbitrary graphic requiring a legend to understand (United States District Court 1873 [*circa* 1838]).

6. MEXICAN LAND GRANT *DISEÑO* AS A SOURCE

Colonization of the Southwest United States by Spain and the subsequent disbursement of land through the Mexican government as land grants resulted in a unique system of land tenure. When the United States took control of the area from Mexico in 1846, district courts and land commissions were used to confirm (and often deny) the land rights of the Spanish and Mexican claimants (Pitti 2003, 38). The land grants occupied some of the most potentially productive agricultural land in the state, and U.S. citizens were eager to establish the boundaries of the land grants so that at least adjacent public lands could be settled (Uzes 2005, 47).

The *diseño* (a sketch or map) of *Rincon de los Esteros,* establishes the extent of land granted to Francisco Berreyesa, a Mexican citizen of Spanish descent, *circa* 1838

(Figure 6.1-A and 6.1-B). On initial inspection, the *diseño* of *Rincon de los Esteros* appears to be nothing more than a crude sketch, but a closer look reveals a personal map detailing natural features, establishing topological relationships, and providing a complex narrative of the landscape. The *diseños* are the first widespread detailed maps of the California landscape, and are important evidence in historical ecology (Grossinger and Askevold 2005a, 11). Though the landscape mapped in the *diseños* was already modified in places by mission grazing, construction of dams, irrigation, and water ditches, and timber harvesting, the *diseños* predate the more intensive American development that followed (Grossinger and Askevold 2005b; Wilkinson 2003, 10). As such, the *diseños* are significant as maps of the area before tidal marsh reclamation, major drainage alterations, and agricultural development. Settling the land grants resulted in several decades of litigation and created a voluminous set of court records (Grossinger and Askevold 2005a, 14). The *diseños* and other materials used to establish the grants were collected as part of the court records, resulting in a substantial archive of land-related documents.

How and why this map was made reveals much about the society at the time, and the social context of the time informs the study of the map. The following sections discuss the individuals responsible for making the map; the social, political, and economic context in which the map was made; and the map-making techniques used to create and reproduce the *diseño* of *Rincon de los Esteros.* I conclude with a discussion of how this understanding can increase the usability of maps for science-based historical ecology projects.

CONTEXT OF THE INDIVIDUALS RESPONSIBLE FOR THE DISEÑOS

Unlike maps developed by a public agency or by a commercial enterprise, the *diseños* were generated only by individuals, to satisfy the requirements of a complex real estate transaction—first between a Mexican citizen and the Mexican state, and later between the same land holder and the U.S. government. Spain began colonizing California in 1769 (Robinson 1948, 24), ignoring the land tenure rights of Native Americans established by native occupancy and enslaving many of local tribes through Mission-related work (Friedly 2000, 105). Mission or pueblo land was owned by the church or state, and not held by individuals, though at the end of the Spanish tenure, provisional cattle-grazing permits were issued to individuals (Friedly 2000, 51-52). After Spain relinquished power over Mexico in 1822, Mexico secularized the missions, and gave the Mexican governors of Alta California the authority to distribute land to favored citizens (Pitti 2003, 21).

The Mexican land grant system required a series of approvals before title was formally granted. An individual could apply by petition for the land in question, and the petition to the governor included a description and *diseño* or sketch of the land. The governor would then issue a document to serve as title; the governor was required to keep a record of all petitions and grants, including the *diseños* (Robinson 1948, 66). The creation of the *diseño* was one step of many required by the Mexican government in the finalization of a real estate transaction (Montoya 2002). This process was complicated by the distance of the territory to Mexico. Symbolic of their growing detachment, the Mexican citizens in California began referring to themselves as *Californios,* rather than Mexicans.

The Mexican government attached a number of conditions to land grants. Grantees had to cultivate the land and improve the property through buildings and infrastructure and the sale of the land grant was restricted. The process of satisfying the Mexican requirements usually took many years, and the conditions of most grants were not settled when the U.S. seized the territory in 1846. After the U.S. took control of California from Mexico, the *Californios* were forced to prove the legitimacy of their individual land grants to the new government, even though the property rights of the Mexican land grantees were protected by the 1848 Treaty of Guadalupe Hildago between Mexico and the United States (Hosen 1988, 175). In 1851, the California legislature enacted a Land Act, establishing a Land Commission to hear all claims.

Forty-one *ranchos* were granted in the Santa Clara Valley after 1821 (Pitti, 2003, 23). Among them was the *Rancho Rincon de los Esteros,* a grant issued to the Berreyesa family. The family came to California when Nicolás Antonio Berreyesa traveled to California as part of the Anza expedition in 1776 and settled permanently near San José. The Berreyesa's were a well-established family in the valley with political ties to Mexico (Hart 1978, 38), and in 1838 received a 4,500 acre grant for the land between the Guadalupe River and Coyote Creek (Broek 1932, 43). The *diseño* shows an area bounded by the two rivers on the east and west, and beginning near the road to the Mission, as the bridge crosses the Guadalupe River on the south, and extending north to a series ponds marked "Esteros" (see Figure 4.2).

When presenting their case before the Land Commission, the claimants were required to pay for surveys performed by civil engineers, under the direction of the U.S. Surveyor General (Bowman 1941, 4). These maps are referred to as confirmation surveys (Grossinger and Askevold 2005a, 14), and were collected and preserved as part of the court hearings. The *Rancho Rincon de los Esteros* was surveyed by John Wallace in May and June of 1859, who found the grant consisted of 9,424 acres (Wallace and U.S. District Court 1859). The boundary encompassed the land between the rivers with a straight line drawn across the south end of the land grant about a mile south of Alviso, and north to the San Francisco Bay, where Coyote Slough runs horizontally across the map (see Figure 9.3, in Chapter 9).

In court transcripts from 1862, this initial survey was contested by the United States. The case presented by the government begins with the argument that, "The survey in this case is objected to...It manifestly includes a large tract of land not ever traced within the limits of the grant or *diseño*" (United States vs. F. Berreyesa 1863, 227). The government's argument against the survey relies on a different interpretation of the location of the *esteros* on the north, based in part on the relative location of the bridge crossing the Guadalupe River on the south; and that Penitencia Creek is shown as running parallel to but never joining Coyote Creek. This new reckoning was presented as another confirmation survey completed in 1862 (Reed and U.S. District

Court 1862; see Figure 9.3 in Chapter 9 for additional delineation and discussion).

The new survey by Reed reduced the Berreyesa land grant to 1,844 acres, and the Berreyesa family lost most of that to an American land speculator who counseled the family to respond to the land laws by squatting on their own land (Pitt 1966, 101). The *rancho* was further reduced when another land speculator, representing the adjoining Alviso land, convinced the court that the Alviso holdings were so extensive that they encompassed prime Berreyesa land, including the house and crops (Pitt 1966, 102). Pitti notes that elite families such as the Berreyesa's fell rather quickly from landed gentry to "wage workers at the margins of Valley society" (Pitti 2003, 40).

The author of the *diseño*—who sketched the land to satisfy the requirements of the land grant process—remains anonymous, and was probably not trained in surveying. The original *diseño* was used in the U.S. court system in a manner never intended—the *diseño* roughly located the rancho, using natural features for landmarks. Sometimes the boundaries of *ranchos* overlapped, but that imprecision never presented a problem when the population was sparse and land was plentiful. The *diseño* was held to a different standard of precision than it was intended to provide, and the difficulty of exactly locating features based on the sketch was used against the claimants. When a Mexican *diseño* came up against a U.S. survey it could be exploited for it's loose topological rather than exact locations.

SOCIAL, POLITICAL, AND ECONOMIC CONTEXT

The *diseño* represents a feudal system of land tenure, replacing a system of land ownership solely by state and church imposed by Spain. Two key points are pertinent regarding the social system reflected in the creation and disposition of the lands portrayed by the *diseños.* One, the Mexican and U.S. attitudes toward land use and laws regarding property were often in conflict; and two, the system designed by the U.S. Congress and court system to settle Mexican land claims was inherently unfair and resulted in the loss of most land by former Mexican citizens. Both of these points are discussed more fully below.

The land grants were rewards to preferred Mexican citizens—large parcels of land on which the grantee was expected to establish a network of family, infrastructure, and cattle. The land grant and grantee, in turn, would serve as an outpost to defend the outer edges of the Mexican territory from foreign intruders. This feudal system of land allocation stood in contrast to the American system of assigning smaller parcels of land through a relatively equal-opportunity lottery (Montoya 2002, 47), and for many U.S. citizens, was part of the justification for the war with Mexico.

Taking away the rights of the church and granting property to individuals was a radical departure from the Spanish system of land allocation (Friedly 2000). Between 1833 and 1846, Mexico issued more than 500 grants—called *ranchos*—in California (Robinson 1948, also see Figure 6.2). Mexican law

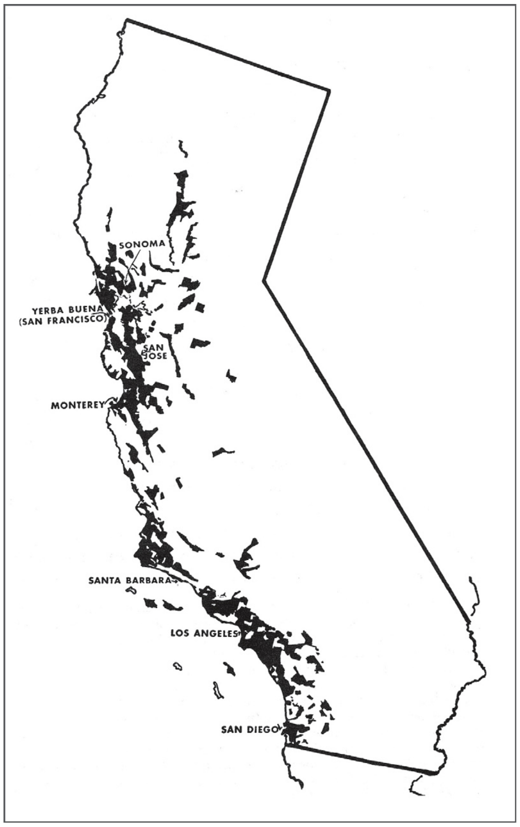


Figure 6.2. California land grants. Most of the Mexican land grants in California occupied the narrow coastal strip (Robinson 1948).

specified that the size of a *rancho* should be under 11 square leagues, or about 50,000 acres, (Robinson 1948, 34), and the average size of a land grant was 17,000 acres (Hornbeck 1979).

Many American arrivals to the Santa Clara Valley in the 1840s expressed dismay at the way land was used by the Mexican citizens, as they considered cattle grazing a waste of potentially productive agricultural land. The communal grazing areas shared by the community were viewed with suspicion by the Americans, who argued that the landscape would be more productive under more precisely defined property rights (Pitt 1966, 28). The 1840s saw increasing lawlessness on the part of the Americans, who squatted on rancho property, slaughtered cattle, and stole horses that were grazed on communal property (Pitti 2003, 29).

The Gold Rush, bringing an immediate influx of Americans seeking their fortune, had the impact of almost instantaneously diluting the political, social, and economic power of the *Californios* (Pitt 1966, 32). The U.S. soon dominated the state, as California's population grew from 14,000 in 1849 to more than 100,000 by 1850 (Hornbeck 1979, 437). Perhaps this was felt no more keenly anywhere than in the Santa Clara region, where the non-Mexican, non-Native American population of San José grew from 150 immediately before the Mexican War to 12,000 by 1870 (Pitti 2003).

Much like the Spanish government before it, the U.S. officials had the attitude that the west was largely unsettled and ready for appropriation. However, the land the U.S. seized from Mexico was not devoid of settlement; though U.S. citizens were eager to settle the new area and felt that it should be freely allocated as part of the public domain, the best land in Santa Clara Valley was already owned by Mexican citizens who were now to be granted full rights of U.S. citizenship and land ownership (see Hosen 1988). Montoya suggests the American takeover was part of a territorial land grab and acquired much of the West as an "imperial, colonizing state that incorporated the western half of its present-day territory under some rather unequal forms of entry" (Montoya 2002, 8).

Though the Treaty of Hidalgo promised that Mexican land rights would be honored, Congress considered the Mexican land grants feudal in nature and unfair. Congress did not include the article in the treaty regarding transfer of property rights (Montoya 2002, 81), throwing land titles into confusion. The holders of land grants had to prove they owned the land by presenting proper documentary evidence of ownership. For a number of reasons—the Mexican process took many years and many grants were still in process when the U.S. took control, often the necessary papers were misplaced or not complete, and the Mexican system of loosely defined boundaries was considered inferior by U.S. courts—proving ownership was difficult and the rules were in favor of U.S. interests. A regional land claims board was established in 1851 by Congress to rule on Mexican land grants, but between the difficulty of meshing the two opposing land systems and the pressure by the American settlers to turn property over to the public domain, many land grantees lost their land long before the court battles were settled, often years later (Hornbeck 1979, 437). The average length of litigation was 17 years (State Lands Commission 1984, 4).

For the first time in California, land became a commodity to be bought and sold (Friedly 2000, 283). The *rancho,* within the loosely defined boundaries of the land grant, supported not only the specific grantees but a wide array of workers and their families. The eradication of the *patrón* and *peón* relationship was cited as a reason for conquest by the Americans, but the incorporation of land in the American system resulted in a new type of private property that no longer provided an umbrella of protection for the loosely assembled community at large (Montoya 2002, 78). The capitalist market system required clearly defined title to land and was not well-served by the informal and personal relationships between the *patrón* and *peón*, the loosely defined boundaries of the land grant, and the communal grazing areas. To connect the Mexican economy—largely based on products derived from cattle—to a greater national and world economy required restructuring private property so that land was well-defined and supported competitive endeavors.

Montoya suggests that the Mexican land grant system was defined by three concepts—"executive discretion, enormous parcels, and an emphasis on community formation and border control" (2002, 166)—all diametrically opposed to U.S. views on property ownership and land distribution. The concept of Manifest Destiny—that populating the entire continent by a system of small plots of land distributed without preference to independent farmers was a God-given right—ran contrary to the Mexican land grant system (Jacobson 1984, 30).

U.S. land boundaries and distribution were based on a rectangular grid, which could be easily divided and subdivided, ascertained readily, and distributed impartially to any citizens who desired the land (Johnson 1976). The *Hispanos* and Native Americans must have considered the imposed grid an odd way to regulate land, as they had always relied on natural features in the landscape—creeks, trees, ridges—to define boundaries (Montoya 2002, 167).

TECHNOLOGY: CREATING, DISTRIBUTING, AND INTERPRETING THE DISEÑO

Given our 21st century cultural expectations of what a map should look like, the *diseños* hardly resemble maps. There is no scale, legend, or title, and the relationships between features seems inexact when compared to a contemporary map. Drawings of a house and trees on the map are clearly out of scale. The north arrow is placed oddly in the middle of the page and its directional accuracy is suspect. Though there are often several copies of each diseño available, each appears to be hand drawn, and features on each copy vary slightly. How were these maps made and how can they best be interpreted?

Diseños are related in cartographic lineage and content to Spanish *pinturas,* which were late 16th century maps of land grants in Mexico, required by the Spanish colonizers (Endfield 2001, 7). Spain started using maps in the 15th century to illustrate land title and water rights; the practice then was exported for use in Spain's colonies (Endfield 2001, 11). Though European mapping at this point is often associated with a mathematical grid of the world suggested by Ptolemy, scientific mapping existed alongside a symbolic cartographic tradition. The symbolic cartographic tradition—in pictographs representing objects rather than precise locations were valued—"had less to do with observation and careful measurement than with religion and representation of space as highly symbolic terms" (Kagan 2000, 55).

Only minimal expertise in scientific surveying existed in California before it became a state (Uzes 1977, 150). This had been true in Spain, where map-makers were imported from Italy and Portugal and the same held true in Spain's colonies (Kagan 2000, 59). In the Americas, "the shortage of trained cartographers was, if anything, apparently more acute than in Spain itself" (Kagan 2000, 61). Both the *pintura* of colonized Mexico and *diseño* of colonized California are related less to scientific mapping and more to symbolic mapping.

The land grant *diseños* are freehand drawings on white letter-size or smaller paper, done in black ink, with occasional color added (Bowman 1941, 3). They were produced without survey equipment or specialized expertise. Bowman suggests they were made by "standing at some central point of the grant and sketching the skyline of the four directions from this point, and then filling in the rivers, springs, houses and other features from memory or observation" (Bowman 1941, 3). Montoya notes that in the Spanish and Mexican tradition of property conveyance, the owner and official would walk the perimeter of the grant, creating markers at boundaries where natural features such as a creek edge, hill, or isolated tree were not available (Montoya 2002, 33).

Uzes describes an alternate method that was sometimes used and provides "the nearest approach to a survey" (Uzes 1977, 150), in which the boundary was measured with either end of a rope tied to two long poles (see Figure 6.3). The method required two men on horseback. One of the men would hold one pole and measure a distance by planting the pole at a point, the other man riding along the property edge until the rope was drawn tight, and then planting his pole, with measurement

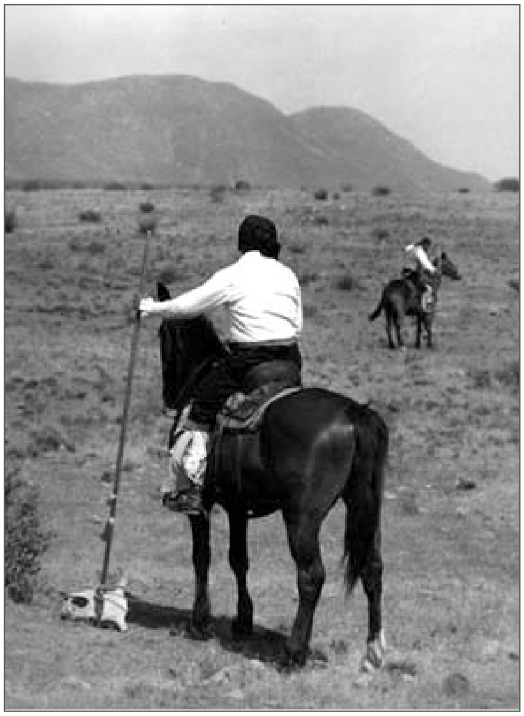


Figure 6.3. Measuring a land grant. Re-enactment of measuring a land grant through use of a rope the length of a *vara* (137.5 feet) on horseback (Bauer 1953).

progressing in "leapfrog fashion" (Uzes 2005, 48). The rope was fifty *varas,* equivalent to about 137.5 feet. The men were called *cordeleros* and the rope, made of sisal, hemp, or rawhide, was called a *cordel* (Pauley 2003).

Exact and standardized measurement was a relatively new concept. As recently as the 18th century, farms and estates in England were measured not by size but by the richness of the soil and how many people they could support (Linklater 2002, 5). One measurement of area used in Mexican California was the *fanega de* *sembradura* (capacity of grain), in which the acreage measurement was based on the amount of grain that could be grown on the land. A measurement of corn was 7 acres, while wheat was 1.75 acres; this measurement was highly contested because the weather could affect the yield (Bowman 1951, 324). Mexico and Spain both adopted the metric system in 1867, but prior to that it was difficult to enforce standardized measurements (Pauley 2003). During early Spanish rule of Mexico, the *vara* was a relatively standard unit, but by 1800 the standardization mandates were largely ignored. A *vara* is roughly 33 inches long, but after 1855, the U.S. land grant standard became 33⅓ inches (Pauley 2003).

Many times these areas would be expressed and duly recorded with the words *poco más o menos,* a little more or less. (Bowman 1951, 326). The petition and diseño would state an area measurement in square leagues or a fraction thereof (one square league is about 4,500 acres) and the diseño would depict the area encompassed by a land grant. Nor surprisingly, when U.S. surveyors tried to reconcile the two, they seldom matched, and the verbal amount of land might be more or less than the measured land indicated by the *diseño* (Uzes 1977, 150).

Variable measurement allowed for the possibility of deceit, or at least the perception that it had occurred (Pitt 1966, 90). The changing *vara*, the inexact boundaries with sometimes vague markers, and the difficulty reconciling the stated measurement of the grant and the *diseño* measurement, led California senator William Gwin, in 1851 to declare most of the titles fraudulent (Pitt 1966, 85). Because the Mexican archival records were not always complete, with documents and *diseños* missing from the record, individuals could resubmit paperwork; this led to accusations of fraud as well (Clay 1999, 126). The Americans were quick to suspect fraud, especially when many of the squatters felt that homesteading small plots of land was their right (Jacobson 1984, 30), and this contributed to the impatience with the aberrations found in the Mexican land grant documents.

Interpreting the *diseños* requires an understanding of the perspective—the vantage point of the map maker—and of the objects on the map, which are highly individualized and not standardized from map to map. The *diseños* represent the world as both a plan view, as if looking down from above, and in profile, where objects are seen from the side (see Figure 6.1-B). The land grant maps employ pictographs, or images that have a likeness to the original object, such as the trees and house. Pictographs are in contrast to symbols on maps, in which a legend is needed to interpret the sign; the symbol is selected arbitrarily and does not resemble the original object (Casey 2002, 143). The pictographs and symbols used in the map are discussed in more detail in Chapter 9.

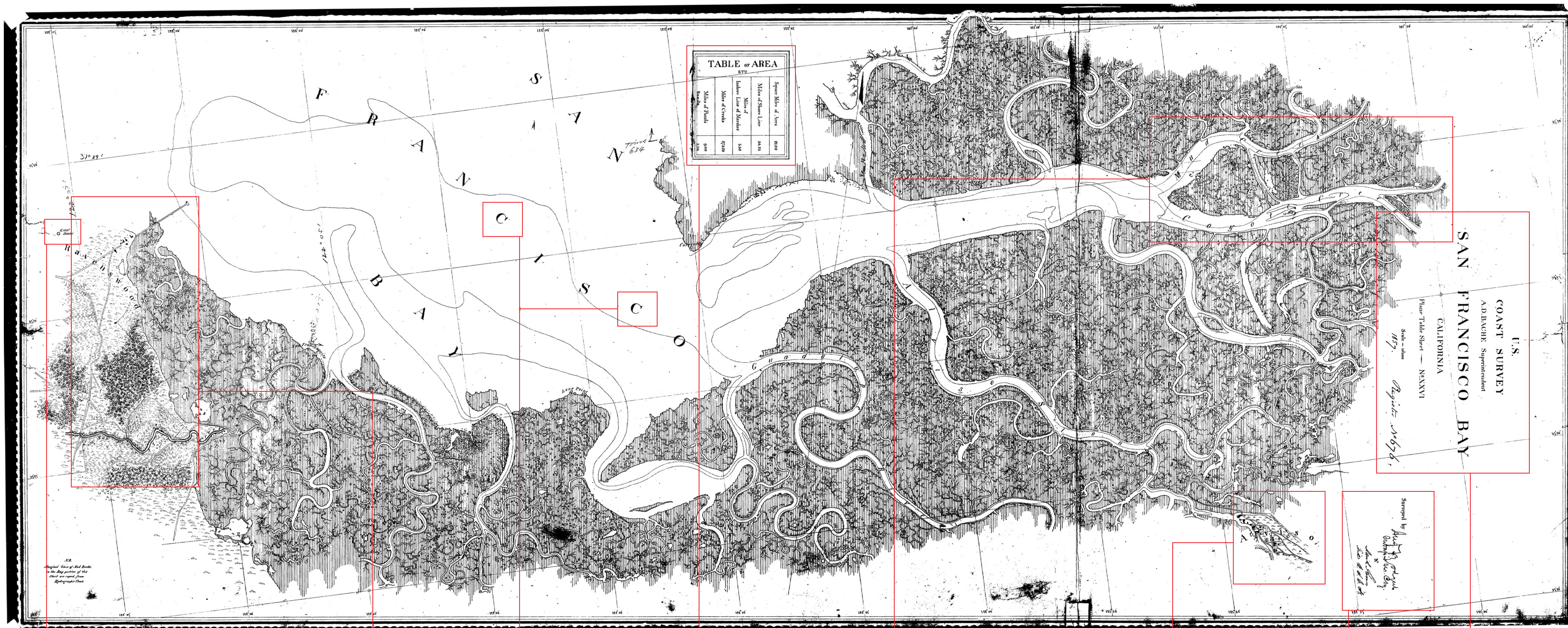
The *diseños* were originally filed as part of the petitions for land, but Uzes notes that there was no systematic method for recording titles and that many were lost or misplaced in the Mexican archives (Uzes 1977, 149). When the U.S. took control of California the land grant claims needed to be reviewed before public domain land could be distributed (Hornbeck 1979). Copies of *diseños* were created and certified by the U.S. Surveyor General in preparation for the land commission hearings (Bowman 1941, 4). As a result, many copies exist of the same land grant, each with small differences, making it difficult and often impossible to identify the originals.

HOW THIS EVIDENCE CONTRIBUTES TO HISTORICAL ECOLOGY

Kagan notes that art historians tend to focus on early maps and birdseye views with artistic merit; map historians tend to emphasize the aspects of maps that are topographically accurate, and excluding from study "more amateurish and often more personal views and therefore the multiplicity of ways in which [the landscape was] represented in the past" (2000, 8). *Diseños* are such a product—what appears to be amateurish perspectives and distorted topology make them a source difficult to assimilate into a scientific study. However, not using them would leave out a significant source of information as they contain notes and icons representing natural features of great interest, including stream courses, oak trees, willow groves, ponds, and hills. Perhaps most significantly, they represent another point of view, a voice otherwise unheard, that can inform us of the past.

By defining the context of the *diseño*, the information on the map can be better incorporated into a science-based study. The relative inexactness of the locations of the map may initially deter its use by scientists expecting accurate spatial data, but by incorporating the court testimony and the confirmation maps, information about the relative location of various natural features such as tree density along a stream channel, the placement of pannes in the tidal marsh, and the proximity of sausals can be gathered. Understanding the differences in social values between the Mexican system of land and the American commodification of property can help the historical ecologist to better understand the possible uses of the *diseño,* since the American property surveys are based on exact measurements, while the Mexican system relied on topological relationships that may have contained overlapping boundaries and inconsistencies. Developing a comprehension of the technology is key to interpreting the copies of the same map, and this explanation is enhanced by a knowledge of the various measurement units in use by the Spanish and Mexican. Finally, map interpretation is improved by a knowledge of the symbology used on the *diseños,* and an understanding of the lack of standardization in symbols, legends, measurements, and level of information presented on each *diseño.* Though this makes each map more difficult to interpret, it also means each map can yield unique clues about the past landscape.

FIGURE 7.1-A. U.S. COAST SURVEY TOPOGRAPHIC MAP SHEET NO. 676, 1857 (Rodgers and Kerr 1857)



TECHNOLOGY: MAPPING

The dot within a circled marked as 'East Base' depicts a primary baseline corner, used to establish accurate distances and locations on the map. In a larger sense, it ties T-sheet 676 to the other sheets in the series and, ultimately to the triangulation baselines connecting the entire continent.

TECHNOLOGY: MAPPING

The Coast Survey's topographic sheets often contained detail about non-tidal features. Shown here is the early Ravenswood landscape, with rudimentary roads, field lines and fences, houses and outbuildings. The Coast Survey symbology used to depict these features—hatches, dashed lines, and solid rectangles—was not yet consistent, and varies from map to map.

SOCIAL CONTEXT

The surveyors have summarized their work in a *Table of Area Et'c,* noting various totals for surveyed miles of shoreline, creeks, ponds, and the miles of roads surveyed.

TECHNOLOGY: ENGRAVING AND PRINTING

Coast Survey maps were printed from engraved copperplates. Each letter form was engraved separately, resulting in slight variations, as can be seen in the two letter 'C's selected here.

SOCIAL CONTEXT

The survey of 1857 depicts the intricate relationships between various wetland features, including the broad Mud and Coyote Sloughs, small sinuous channels, mud banks (representing low tide), pannes, and tidal marsh.

SOCIAL CONTEXT

Though the U.S. Coast Survey's primary mission was to map navigable waterways, landings such as Alviso were so integrated into the surrounding tidelands that they were often portrayed in great detail.

THE AGENCY

The title area identifies not only the agency responsible for the map but also the superintendent of the Coast Survey, the area mapped, identifying sheet numbers, scale, and date.

THE CARTOGRAPHER

The signatures of the surveyors who measured the sloughs and marshlands in 1857—'August Rodgers & David Kerr, Aid U.S.C.S.'—are barely legible.

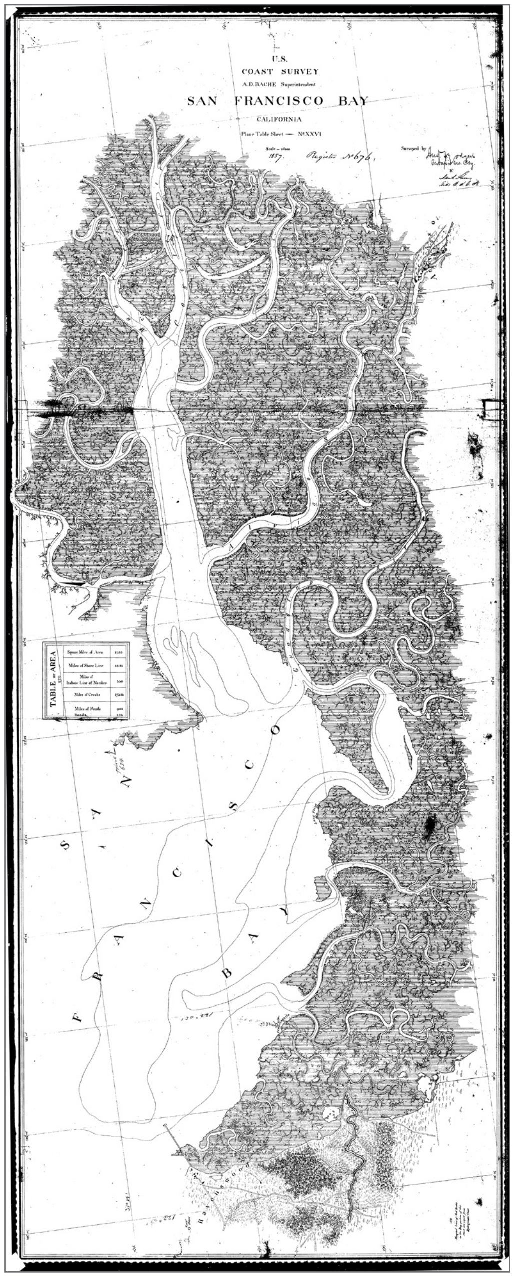


Figure 7.1-B. U.S. Coast Survey Topographic Map Sheet No. 676, 1857 (Rodgers and Kerr 1857).

7. U.S. COAST SURVEY AS A SOURCE

At first glance, the complex network of sloughs and channels on U.S. Coast Survey map sheet Register No. 676 appears to reflect nothing more than objective scientific observations of carefully measured angles and baselines. Peeling back the veneer of scientific objectivity and placing the map in social and historical context reveals much more. Surveyed in 1857, less than 10 years after gold was discovered in the foothills and the U.S. took control of California from Mexico, sheet No. 676 represents an orderly inventory of one of the new state's most important resources—a water-based transportation system for moving goods throughout the region's booming economy (Vance 1964). The Coast Survey sheet No. 676 creates a sharp contrast to the loosely defined ownership and communal grazing grounds of the Mexican and Spanish era, and a radical departure from the less rigid resource management of the native populations.

The Survey of the Coast was established in 1807 by Thomas Jefferson and charged with "completing an accurate chart of every part of the coasts" (Shalowitz 1964, 4). The Survey of the Coast became the U.S. Coast Survey in 1836; was renamed the U.S. Coast and Geodetic Survey in 1878, when the agency began establishing a geodetic connection between the two coasts; and since 1970 has been part of NOAA as the National Geodetic Survey (Edney 1986, 299; and Shalowitz 1964, 21).

The agency initially mapped topographic and hydrographic features separately for the San Francisco Bay at a scale of 1:10,000 in the 1850s, and the two maps were then combined to create navigation charts. The topographic sheets are referred to as 'T-sheets', followed by their register number. Register No. 676—or T-sheet 676—is a topographic map, depicting tidal marsh channels, tidal marsh ponds, and the marsh outer edges. Coast Survey topographic maps often included landscape and cultural features adjacent to the tidal marsh landscape, and T-sheet 676 shows freshwater creeks, woodlands, roads, and a landing used for shipping local goods.

While the Native Americans shaped the landscape and affected the land cover through management practices (Friedly 2000), the tidal marsh terrain remained relatively unchanged, and the Coast Survey maps provide the best early pictures of coastal and estuarine habitats prior to substantial Euro-American modification (Leatherman 1983, 31). Tidal channels depicted on these early T-sheets of San Francisco Bay are extremely detailed and accurate (Grossinger and Askevold, 2005a). When georeferenced and overlaid with aerial photography, the T-sheet channels correspond closely to remaining channels (see Figure 7.2).

The following discussion assesses T-sheet 676 and how the map differs from previous ways of spatially organizing the area by examining the agency (the U.S. Coast Survey) and individual cartographers within the agency who made the map; exploring the social, political, and economic context in which the Coast Survey operated and made T-sheet 676; and reviewing the cartographic techniques and printing methods used to create the map. (T-sheet 676 is compared to other maps

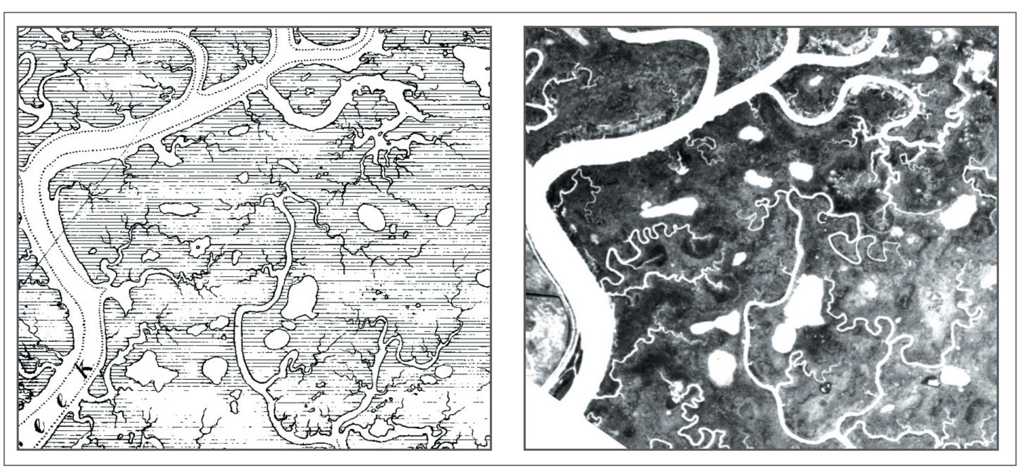


Figure 7.2. Comparison of U.S. Coast Survey Topographic Sheet T817 (1860) to 1955 aerial photograph at Petaluma marsh, Sonoma County. Comparison of corresponding features shows that the map closely represents most of the sloughs and pannes visible in the photograph (U.S. Coast Survey 1860; U.S. Department of Agriculture 1953).

depicting similar features or in the same geographic area in Chapter 9.) By doing this, I seek to understand the rhetoric of the map and to analyze hidden agendas not apparent on the surface, revealing the complex network of social forces that interact on many levels to create T-sheet 676, and rendering the map more useful for recreating a past landscape in historical ecology. As with the previous chapter on *diseños,* I conclude with a discussion of how this understanding can increase the usability of Coast Survey maps for science-based historical ecology projects.

CONTEXT OF THE AGENCY (U.S. COAST SURVEY) & INDIVIDUAL CARTOGRAPHERS

What part did the U.S. Coast Survey play in mapping the United States? Why did the U.S. Coast Survey map the intricate network of channels at the south end of San Francisco Bay? What purpose did exacting measure of large and small slough, Alviso landing, and surrounding topography serve? Did the intention of the map maker (the individual cartographer) differ from the intent of the institution (in this case the Coast Survey)? In answering these questions, I look at issues affecting the nation as a whole and therefore the Coast Survey, as well as the local issues concerning the San Francisco Bay region.

Several points are integral to understanding the Coast Survey's mapping efforts (Figure 7.3). Each of these affected the outcome of the maps produced by the agency and is explored more below.

- The agency was established because of the urgent need for coastal maps for safe navigation and defense of the coastline, but the Coast Survey was slow in producing the necessary charts (Slotten 1993).

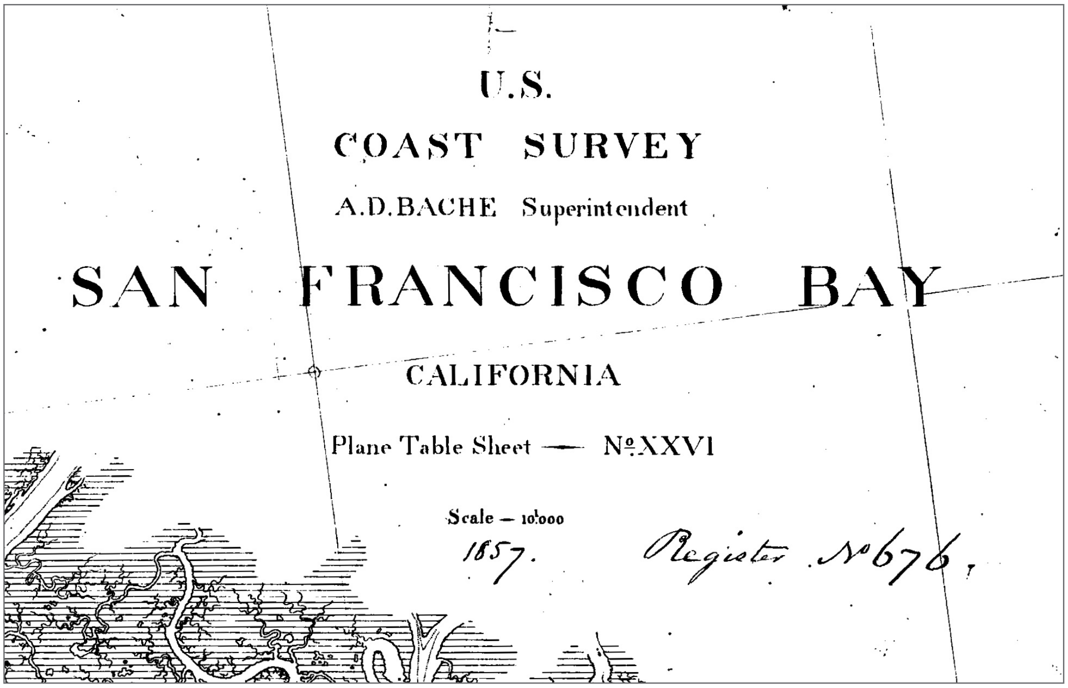


Figure 7.3. Detail from U.S. Coast Survey Topographic Map Sheet No. 676, 1857. The title block on the map identifies the Coast Survey as the responsible agency, and Bache as the superintendent (Rodgers and Kerr 1857).

- Congress was ambivalent and at times even opposed to any comprehensive national mapping effort and almost eliminated the Coast Survey several times (Manning 1988).
- The Coast Survey—and the Coast Survey employees—regarded science as their primary reason for existence (Dupree 1986).
- Individual surveyors working in the field—from superintendents to aids—had significant impact on the final product, despite attempts to standardize procedures and methods (Manning 1988).

Safe navigation. The reasons Congress funded the agency were myriad, but the most pressing was the need for accurate navigational charts for safe passage of ships carrying foreign trade and commerce between states (Slotten 1993). Until the transcontinental railroad was completed in 1869, coastal ports and waterways were the only viable way to move freight and passengers from place to place. There were no buoys, lighthouses, or nautical charts, and shipwrecks were common and costly (Shalowitz 1957, 290). Additionally, coastal charts were needed for military purposes and the settling of the west required both safe navigation and a better understanding of a little understood area (Manning 1988, 3). Dupree suggests that commercial needs ultimately pushed the funding forward, while the information the maps record for military use provided Congress with the constitutional basis for funding (Dupree 1986).

Jefferson—who himself had a keen interest in both science and precise measurements (Linklater 2002)—appointed Ferdinand Hassler as superintendent of the new agency. Hassler was a Swiss engineer brought to the United States in 1805 by the U.S. Military Academy at West Point to teach mathematics (Thompson 1979, 1). He embraced modern mapping techniques, having applied the latest theories when working as a surveyor in Europe (Guthorn 1984). When asked to develop a methodology for the survey, Hassler proposed an approach that incorporated geodesy—the accurate measurement of the size and shape of the earth—with topographic and hydrographic surveying (Thompson 1979, 1). Hassler was a visionary who sought to bring the most exacting standards of science to the Coast Survey, but was not adept at the political maneuvers required to ensure support for the agency.

Hassler's meticulous and exacting standards did little to produce immediate results and the coastal charts that were needed. Hassler spent his first field seasons measuring the distance of two baselines with carefully calibrated rods for use in triangulation and using a theodolite (ordered by Hassler from London) to measure angles (Dracup 2001). Hassler refused to publish any report or charts until the surveys were complete, and jealously guarded the outcome of any survey. This brought him little favor with Congress, which saw no end to the spending, and worse, no results (Dupree 1986, 54).

Congressional ambivalence. Congress was already reluctant to fund any comprehensive mapping program (Edney 1986, 296). Though it seems fairly obvious that a systematic program to map coastlines and the nation's interior would be beneficial to 19th century America, Jefferson and Congress both were concerned about the constitutionality of any federal program. Additionally, the War of 1812 diverted the nation's attention and resources, and the equipment and personnel to carry out the European-based scientific method of mapping proposed by Hassler were not available in the United States, making the task seem daunting (Theberge 2001).

Though coastal charts were urgently needed for safe navigation, lack of support by Congress, ambivalence about the need for a federal mapping program, and the painstaking science-based approach taken by the Coast Survey almost resulted in the agency's elimination several times (Manning 1988). The Coast Survey was never intended to be a permanent agency, but rather was expected to be dismantled once the coast was surveyed. Edney (1986) argues that both the Coast Survey and the U.S. Geological Survey were established through *ad hoc* legislation in Congress and individual efforts, and not by any accepted notion that a comprehensive mapping program should be funded by Congress.

While the Coast Survey was the first comprehensive mapping agency established, support was at best sporadic, and the Coast Survey had to compete for funding with other federal surveys sponsored by Congress. In addition to the Coast Survey, a multitude of mapping efforts were sponsored for the nation's interior (such as the Corps of Topographic Engineers, the four surveys of the West, and the General Land Office public lands) and they were often inadequately funded and in many cases competed directly against each other. In 1878, the multiplicity of the various mapping programs led Congress to ask the National Academy of Sciences to make recommendations for consolidation. Though the Academy recommended that the Coast Survey and the General Land Office be combined into a Coast and Interior Survey, and that a Geological Survey be established to study geology and minerals of public lands, Congress only acted on the latter, and the U.S. Geological Survey began topographic mapping to create base maps for geological studies, while the Coast Survey continued mapping the coast (Dupree 1986).

Science-based. The motivating force within the Coast Survey and by individuals participating in the mapping efforts was driven not by conquest of territory but by competition with Europe in use of the latest scientific techniques (Dupree 1986, 64). When the Coast Survey was first established by Jefferson, the practice of geodetic mapping in the U.S. was nonexistent and science in general was in an unsophisticated state when compared to European practices (Dupree 1986, 9). Jefferson envied the large-scale and precise surveys made by France and Great Britain and while Coast Survey's immediate purpose was to provide charts for safe navigation, Jefferson also had in mind establishing a scientific agency that would rival European efforts (Linklater 2002, 204).

Ironically, that required hiring European-born Hassler, and sending him to London to acquire precision instruments—theodolites, barometers, chronometers—not available locally. Hassler also recruited other Europeans to carry out the early work of the Coast Survey (Allen 1997, 14). Indeed, it was noted with annoyance by American politicians that only European accents could be heard in the offices of the Coast Survey (Dupree 1986). The following superintendent, Bache, continued to apply scientific ideas imported from Europe, but no longer had to rely on Europeans or European instruments, as the U.S. was rapidly developing internal resources.

Early in the 19th century, science as it is known today did not really exist. Science was not separate from philosophy, the arts, or literature, and there were no professionals, specialization, training available, or boundaries between theoretical and applied science (Dupree 1986, 7). Additionally, things we take for granted—such as consistent units of measurement and accurate reckoning of longitude—are relatively new advances. For example, as late as 1789, less than 20 years before the Coast Survey was established, land was often measured in France by a variable unit called *journées,* which was the amount of land one man could plough in a day (Linklater 2002, 88).

The Coast Survey considered itself a science-based agency, applying the latest in technology to its mapping program. The methods Hassler introduced were consistent with emerging scientific thought, and while they initially slowed the progress of the Coast Survey, ultimately gave it credibility (Manning 1988). Hassler considered any national agenda or political considerations secondary to science; his allegiance was to "an international ideal of science and mathematics" (Slotten

1993, 28). Though Bache held a similar view to Hassler's that the results of the Coast Survey should be assessed by other scientists and not by the politicians that funded the agency, Bache understood the need to convince politicians and the public of the agency's utility. He made scientific reports and agency charts readily available and also wrote popular articles publicizing the activities of the Coast Survey (Slotten 1993, 37). This helped spread the perception of the Coast Survey as a science-based agency.

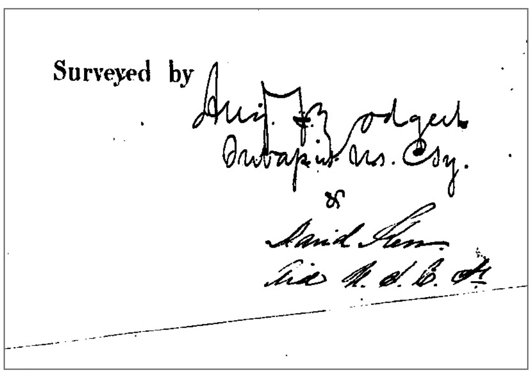


Figure 7.4. Detail from U.S. Coast Survey Topographic Map Sheet No. 676, 1857. Coast Survey employees signed the completed surveys; on this map sheet, August Rodgers and David Kerr have certified their work (Rodgers and Kerr 1857).

Influence of individuals. In 1857 the Coast Survey was still establishing itself as an agency and still developing standardized methods and procedures. The decisions the directors and assistants made affected the direction of the agency's work and decisions made in the field affected the contents of any given map. The influence that individual employees had on the final map is significant, and reflects the effect individuals can have on an organization before standardization is defined and entrenched. This is vividly depicted when comparing sections of surveys made by two separate employees of the same area.

T-sheet 676 bears Alexander Bache's name as supervisor (see Figure 7.3), and the signatures of assistant August Rodgers and aid David Kerr (Figure 7.4). George

Davidson, though his name does not appear on the map, was instrumental in establishing the geodetic stations that anchored T-sheet 676 to real world coordinates. Though only an aid, David Kerr had a profound effect on many of the map sheets he was responsible for. The areas he surveyed are richly detailed in comparison to maps completed by August Rodgers (see Chapter 9).

Much is written on the supervisors of the Coast Survey, and extensive information is available for Hassler, Bache, and subsequent directors. They were invariably scientists interested in pursuing the astronomy, hydrography, geodesy, tidal-related studies, and terrestrial magnetism related to surveying, and in keeping the Coast Survey at the forefront of science (Slotten 1993, 27). Less is available regarding the various assistants, though notable assistants such as George Davidson have been more widely considered (see Lewis 1954 and Manning 1988). Even less is known about the aids, many of whom worked several seasons at relatively low pay before disappearing from Coast Survey accounts.

In the first decades of the agency's operations, all Coast Survey employees—except those involved in administrative duties and printmaking activities in the Washington, D.C. office (see U.S. Coast Survey 1865)—participated in field work. Supervisors Hassler and Bache both measured baselines and made angle measurements with the theodolite. Hassler died in 1843 from pneumonia after suffering a fall when protecting surveying equipment during a storm (Dupree 1986). Bache was involved in supervising field operations on the east coast, especially the measurement of baselines, and though he was never directly involved in field work on the West Coast he fine-tuned efforts through correspondence and direction to his assistants (Lewis 1954).

Several points are pertinent regarding Bache's influence on the direction of the Coast Survey surveying operations. Bache had a military background, and he trained as army engineer at West Point. "Because army officers considered him one of their own," Slotten notes, "he was in an ideal position to forge compromises" (Slotten 1993, 33). Bache was not only a scientist, but a well-connected politician, who understood how to please Congress and the public with a steady stream of survey charts and publications, unlike his predecessor. He belonged to a scientific elite that formed a well-connected aristocracy and avoided being directly accountable to Congress by arguing that the Coast Survey work was scientific, therefore unbiased and objective (Slotten 1993, 47).

Several examples illustrate the effect of these influences during Bache's reign. Bache curried such favor with corporate interests that various railroads, insurance companies, and chambers of commerce defended the work of the Coast Survey to Congress in 1849 (Slotten 1993, 35), and topographic maps frequently depicted infrastructure necessary for commerce-related activities. Topographic mapping—i.e. mapping inland areas beyond the coast boundary—was established by Hassler and continued by Bache. Allen suggests mapping inland areas was part of a "hidden agenda" that benefited the military (1997, 43).

Bache actually improved the somewhat precarious standing of the Coast Survey with Congress and the military during the Civil War by supplying charts of critical harbors and waterways (Muntz 1963, 93). He went as far as to provide personnel who made sketches and maps on site prior to battles (Manning 1988, 3; figure 7.5). Bache courted public favor and local support, even detailing specific homes or plantations (in the south) on topographic maps and focusing efforts on specific cities. In 1853 the Coast Survey made a map of San Francisco "making no pretense of serving a navigational purpose" (Allen 1997, 56), and the city benefited from a local map of city streets, public buildings, and contour lines (Figure 7.6).

Before joining the Coast Survey, Bache was an instructor of science at Central High School, a prestigious technical and scientific academy in Philadelphia (Lewis 1954, 2). Many early Coast Survey employees were students from Central High hand-picked by Bache, including Augustus Rodgers, George Davidson and James Lawson, all located on the West Coast during their careers (Theberge 2001).

Both Rodgers and Davidson had an effect on the Coast Survey mapping on the Pacific coast. Rodgers came to San Francisco in 1850 and remained there until his death in 1908 (Theberge 2001) and was a sub-assistant at the time T-sheet 676 was made, though he quickly rose in rank and authority (Manning 1988, 17). Rodgers came from a military family—his father was Navy Commodore John Rodgers and his brother became a Civil War hero. Rodgers and Davidson were both well-connected and established a scientific elite on the West Coast (Manning 1988). Davidson had a similar long-term career and was instrumental in establishing the triangulation surveys and astronomical observations required for geodetic mapping. He was actively involved in West Coast science and had an early connection to the California Academy of Sciences; after his retirement from the Coast Survey, he was appointed Professor of Geography at the University of California at Berkeley (see Lewis 1954, 129-134).

Figure 7.5. Coast Survey employee in Tennessee adjusting a tripod signal in 1864. The Coast Survey provided significant technical mapping services for the Union during the Civil War, undertaking topographic surveys in the field (Library of Congress *circa* 1864).

Figure 7.6. Detail from map entitled 'City Of San Francisco And Its Vicinity California', U.S. Coast Survey, 1853. Note detail in street names and early use of contours (Cutts and Rodgers 1853).

For the most part, Bache, Rodgers and Davidson were aligned with military and corporate interests. Bache argued that understanding the nature of harbors, coastlines, and waterways through surveying allowed engineers to control nature (Slotten 1993, 40) and he was never associated with the conservation movement initiated a few years later by John Wesley Powell (Reingold 1970, 166). Slotten suggests Bache embodied the "Whig culture" of post-war America, embracing industrial growth and conservative social and moral authority (1993, 32). Rodgers provided tracings of his maps to the Corps of Engineers when they located defense batteries near San Francisco (Manning 1988, 16). Davidson testified as an expert witness against a Mexican claimant in a land grant case. His testimony centered around the seals on the documents in question, which he declared forgeries; his expertise in this area, he stated, was from the operation of precise measuring instruments for the Coast Survey (Lewis 1954, 32). Though they were involved in cutting-edge science, the Coast Survey employees were "traditional in their social ideals" (Manning 1988, 150).

However, this is not to suggest there were not exceptions to their ideology. Later in his career Rodgers argued against railroads and steamboat companies that built wharves and piers, causing shoaling banks of mud to build up in natural harbors (Manning 1988, 16). Davidson was responsible for assigning place names for use in maps and charts, and he was committed to restoring original Native American or Spanish and Mexican names to features. Bache supported him in this endeavor (Lewis 1954, 90).

Coast Survey aids worked in the field with the assistants and sub-assistants. Field work was rigorous and often dangerous. James Lawson, who arrived on the West Coast as an aid to George Davidson (who was then a sub-assistant) in 1850, recorded his experiences in an autobiography (Lawson 1879), and his account may be considered typical of the experiences an aid faced in the field. Lawson arrived by ship—after passing through Panama in a canoe with all the Coast Survey equipment—in San Francisco, where the Coast Survey could ill afford the highly inflated Gold Rush wages, housing, and food. While each of the aids received only $30 per month, the cook they hired for field work received $125. Lawson describes field work in detail, describing various hardships and difficulties from West Coast weather, stormy seas, a Native American community suspicious of the Coast Survey motives, and repeated illness (Lawson 1879).

Much can be gathered from reports generated by the Coast Survey (e.g. U.S. Coast Survey 1857). Included in the annual report to Congress detailing the Coast Survey's progress are accounts of Coast Survey employees. The work accomplished by Davidson, Rodgers, and Kerr in the San Francisco Bay in 1857 is summarized as follows.

> This work has been vigorously prosecuted within the year by two parties under the charge of Sub-Assistant A. F. Rodgers, and the survey of the shore-line is now complete. Seven topographical sheets in all have been completed during the season, of which five contain in connection the shore-line, creeks, and water courses of the lower part of the bay (U.S. Coast Survey 1857, 111).

However, while the names of Bache and Rodgers appear on T-sheet 676, the following suggests the primary work was accomplished by David Kerr.

> In order to secure the largest result in field work practicable within the season, a second party was organized by Sub-Assistant Rodgers, and placed in charge of Mr. David Kerr, who had served as aid for several years in the topographical party, and previously the triangulation party engaged in the work on San Francisco bay (U.S. Coast Survey 1857, 111).

Individual employees are noted by name and tasks performed in the Coast Survey annual reports, and Kerr can be traced through the annual reports, appearing first in the 1850s and dropping from the reports after 1863 (U.S. Coast Survey 1858 and 1863). He also appears in the 1860 U.S. Census (U.S. Census Bureau 1860), apparently living with Rodgers and the rest of the Coast Survey crew (Figure 7.7), but is not found in California by the 1870 census. Though little information can be discovered about Kerr, the level of detail he recorded in the sloughs and channels of the bay indicates the influence an individual can have on the final map. Comparison of sheets where Rodgers was the primary surveyor reveal that the work Kerr accomplished was much more detailed than that of Rodgers. Chapter 9 shows the same area mapped by Rodgers in 1853 and Kerr in 1857; Kerr's map shows numerous pannes and smaller

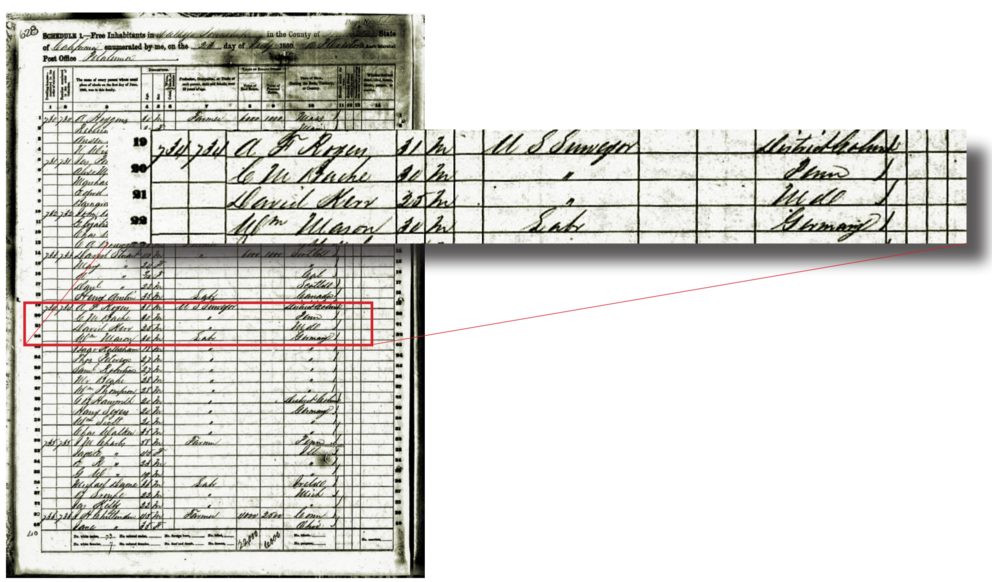


Figure 7.7. Census records for individual USCS employees (U.S. Census Bureau 1860). On a census data sheet enumerating "free inhabitants", A.F. Rogers, age 31, U.S. Surveyor, is listed along with three other USCS employees, including David Kerr, age 25. The Coast Survey employees probably took rooms together as they worked in an specific area.

sloughs while Rodgers only depicts larger channels. (See Chapter 9 for a discussion on differing degrees of detail on the maps by Kerr and Rodgers.)

SOCIAL, POLITICAL, AND ECONOMIC CONTEXT

In 1857, the San Francisco Bay Area was in transition between several cultures and economies. The epidemic of diseases encountered during Spanish mission era had decimated much of the Ohlone population and culture; however, small communities of natives survived in the 1860s in mixed tribes scattered throughout Northern California (Margolin 1978, 166). Though no longer controlled by either Spain or Mexico, the area still was culturally influenced and shaped by residents of Hispanic heritage. The region's economy, which had been limited to cattle ranching for hides and tallow, and rudimentary agriculture for local consumption, had exploded during the Gold Rush (Vance 1964). The Bay Area's population—which had been restricted to non foreign born by the Spanish—had grown exponentially during the Gold Rush. The San Francisco Bay saw little activity as a harbor until the Gold Rush, but shipping traffic rose dramatically with the sudden influx of population (Lewis 1966).

Congress was relatively slow to respond to the rapidly changing and rather urgent situation. California was ceded to the United States from Mexico by the Treaty of Guadalupe-Hidalgo on February 2, 1848, and the United States acquired California for $15 million (Hosen 1988, 177). Even prior to this—no doubt in anticipation of this event after the annexation of Texas by the United States in 1845—Coast Survey Superintendent Bache suggested in his reports to Congress that surveying parties be sent to the Pacific (Theberge 2001). Early in 1848—before President Polk's announcement in December of that year set off the gold rush—Congress agreed with Bache, and the Coast Survey sent a party to begin the survey of the West Coast.

In many respects, the survey of the West Coast began too late for the safety of American ships and interests. The massive migration touched off by the discovery of gold brought intense economic forces to bear on the area, and the U.S. had not yet fully gained control of the area (Cutter 1999). Hundreds of ships ventured into San Francisco Bay without the benefit of accurate charts, and shipwrecks (Figure 7.8) were numerous and frequent (Lewis 1954, 10). Vancouver's charts from 1798 guided some; others used maps torn from school atlases; William Beechey's map from 1826 was used by some; and others were fortunate to use more recent maps prepared by the Wilkes expedition in 1841 (Lewis 1954, 10). However, none had the benefit of the lighthouses, buoys, markers, and detailed charts that would ultimately result from the Coast Survey work.

The Gold Rush made the survey of the West Coast an immediate priority for commerce and safety, though ironically, the Gold Rush made it virtually impossible to hire the required crew (Theberge 2001). The pressure the Gold Rush placed on the infrastructure and social fabric of both the Sierra Nevada and San Francisco Bay area is well documented (see Brechin 1999). The Gold Rush increased the shipping traffic into the bay, as most supplies had to be imported. Ready-made houses were transported via ships along with passengers (Peterson 1965, 319). Food was in such short supply that it was imported by ships, crowding the already packed harbor (Fite 1999, 438). Not only were adequate charts unavailable, but shipping traffic was significantly increased, making navigation more difficult. Figures 7.9 and 7.10 give an indication of the crowded conditions in the San Francisco harbor after the start of the Gold Rush. A large percentage of the population of San Francisco left the city for the gold fields, also leaving a harbor of largely abandoned ships (Hubbard 1912, 106).

The Santa Clara Valley became a supply center for the new residents, providing much needed locally-grown produce, beef, and eventually wheat and other grains. Goods were shipped from *embarcaderos,* or landings, which were often small peninsulas of terrain that intruded into the tidal marsh and came near to a navigable slough, and thus were ideal for shipping (Grossinger and Askevold 2005b).

One of the few cultural features on T-sheet 676 depicts the town of Alviso, a small but important landing on the edge of the tidal marsh (Figure 7.11). The Alviso area had probably been utilized by the Ohlone native peoples for its natural proximity to waterfowl and fish. Chester Lyman, a surveyor who laid out San José, mapped the streets of Alviso in 1849. Shortly after, during the Gold Rush, Alviso became a primary

Figure 7.8. Shipwreck off the coast of California in *circa* 1860, presumably when Coast Survey charts were already available. (Lawrence and Houseworth, publishers, *circa* 1860)

shipping center for agricultural products—fruits, vegetables, grains, and beef—being shipped from Santa Clara to San Francisco for distribution. When depicted on the Coast Survey map in 1857, Alviso was an important shipping center; only a few years later in 1864, the once vital landing slipped into obscurity when a narrow gauge railroad connected San José with San Francisco, providing a faster and less expensive shipping method (Broek 1932, 73). (Also see discussion of Alviso in Chapter 9.)

The Gold Rush was the first of many intensive extractions of natural resources the state experienced. Gold was followed by "silver, wheat, citrus, timber, copper, hydropower, petroleum, sardines" notes Walker, "...propelling California along the fast-track of capital development" (Walker 2001, 175). If the Gold Rush jump-started the state into capitalism and a lucrative series of natural resource related extractions, the Coast Survey maps helped pave the way for the early American economy. The surveys probably facilitated the safe arrival of masses of gold miners via ship; the flow of locally-grown agricultural products from the Santa Clara Valley to San Francisco via the landings and navigable sloughs; the export of wheat, barley, hides, and tallow from Santa Clara to the East Coast; and the import of goods not produced in the area from South America, Mexico, Hawaii, and Australia (Broek 1932, 56). For example, increased shipping—made safer by coastal charts—lowered the cost of imports, allowing Californians to import necessary good more cheaply (Hutchins 1939).

TECHNOLOGY

The motivating force within the Coast Survey and by individuals participating in the mapping efforts was driven by competition with Europe in use of the latest

Figure 7.9. Detail from a panorama of San Francisco in 1851. This image shows thousands of ships in the harbor. Most were abandoned by gold seekers leaving their ship to find gold (Unknown photographer 1850-1851).

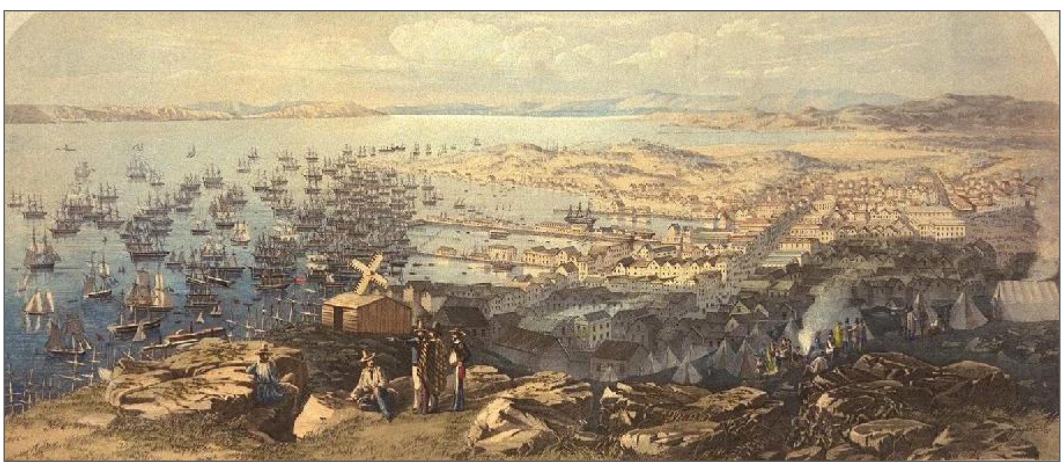


Figure 7.10 Lithograph from 1851 depicting the crowded state of the harbor. Also note cluster of people—presumably Mexican citizens—gathered in foreground, with their backs turned to the ensuing influx of gold seekers (Collison 1851).

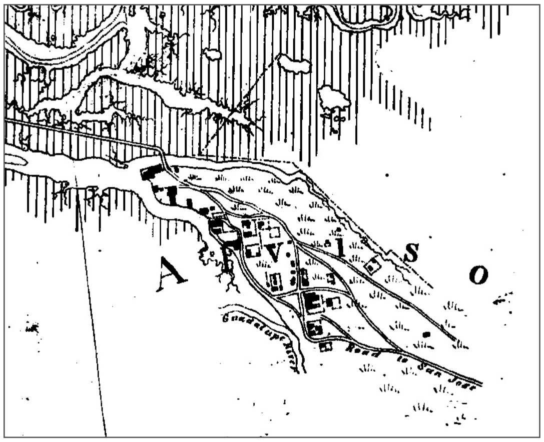


Figure 7.11. Alviso, depicted on the U.S. Coast Survey map of 1857. Within 20 years, Alviso was no longer a significant port, as shipping from the landings around the bay was surpassed by the railroad as a means to transport freight (Rodgers and Kerr 1857).

scientific techniques. From its inception, the Coast Survey used highly accurate methods and the latest science-based techniques to map the coast and shorelines (Manning 1988). The agency adapted a rigorous and innovative approach to mapping that included developing geodetic controls (taking into account the shape of the earth); plane table surveying and triangulation in the field; and such innovations as geomagnetic measurements and use of the telegraph to determine exact longitude (Shalowitz 1957, 292). Geodetic measurements and plane table mapping are both discussed more fully below.

Geodesy. Without taking the curve of the earth into account, independent but adjacent surveys would not fit together at the edges, and discrepancies as to size, scale, and shape would be evident. A coordinated survey using geodetic controls employs a horizontal geodetic datum and a single point from which all other positions are tied to. Datums—established by the algorithms used to calculate the shape of the earth—change as geodesists develop a new understanding of the earth's shape and the varying density of the earth's crust (Shalowitz 1957, 292). While we currently use the North American Datum of 1983, which replaces the datum developed in 1927, the pre-1927 Coast Survey maps were based on earlier measurements. While determining this datum can present problems when georeferencing pre-1927 Coast Survey maps (Grossinger and Askevold 2005c), the early Coast Survey maps show remarkable consistency and accuracy because a systematic method of measuring the earth was used.

Plane Table Surveying. Most early surveying in the U.S. used a compass traverse method, in which each corner of the area of interest was used to measure the angle to the next station, and a metal chain was probably employed to measure the distance between stations (Uzes 2005). Writing about 19th century property surveying, Hilliard notes that surveying involved the following steps—"laying out a tract of land, locating and marking the corners, running lines by compass direction to connect all corners, measuring the lines, and calculating the acreage of the tract" (Hilliard 1982, 418). A rough sketch may have been made of the survey, but the final map was usually made from the survey notes indicating compass direction and distance (Greenhood 1964, 210).

Unlike the compass traverse method, the Coast Survey used a plane table (Figure 7.12) combined with the geodetic tie points to survey an area. A plane table is simply a drawing board—usually about 30 by 24 inches in size—that rotates on a tripod and can be leveled. An alidade—which resembles a telescope on top of a compass and allows the surveyor to measure angles—is mounted on top of the plane table.

The surveyor worked in the field with the plane table (Figure 7.13), alidade, and a field survey sheet marked with the available triangulation stations (Shalowitz 1964, 160).

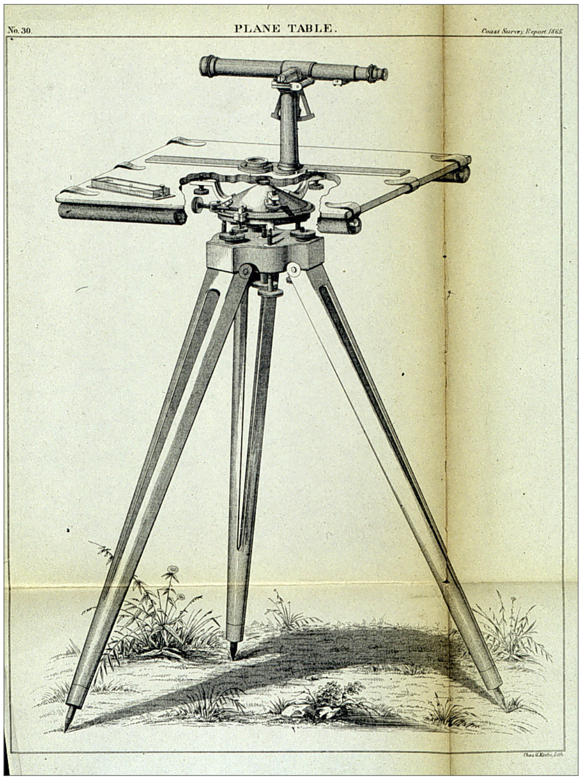


Figure 7.12. Plane table. The 1865 Superintendent's report included a diagram of plane table with cutaway showing tripod head, which allowed the table to rotate and level independently of the tripod. The alidade is mounted on top, with a ruler for establishing lines. (U.S. Coast Survey 1865 [drawing]).

The field team would locate one of the triangulation stations, placing the table directly on top of it, and orienting the plane table so that features on the field survey sheet would line up with and parallel the features in the landscape (Shalowitz 1964, 161). A distant triangulation station would be located in the sights of the alidade, which sits on a ruler that corresponds to the direction the alidade is pointed, and the two stations would be connected with a line on the map. Undetermined points would be located in a similar way—i.e. features lined up within the sights of the alidade, with a line drawn to their location. The actual geographic locations were determined through triangulation, when the plane table was moved to the second triangulation station, and all the undetermined points were connected with a third line (Figure 7.14). To map a coastline, the plane table surveyor was assisted by another Coast Survey employee who would walk along the shoreline

Figure 7.13. Coast Survey plane table mapping. The surveyor is using the plane table on an offshore rock in Cook Inlet, Alaska, *circa* 1910. The alidade can be seen on top of the surface of the plane table (U.S. Coast and Geodetic Survey *circa* 1910).

and set a rod when the shoreline changed direction. The plane table surveyor would align the rod with the alidade and draw in the corresponding line, and the shoreline in between would be sketched on the map (Shalowitz 1964, 162).

Using the plane table in this fashion, the surveyor had the advantage of completing the map in the field, while all the features being captured were still visible (Denny 2000). In instructions on plane table mapping, published in the 1867 superintendent's report, notes that "sketching and plotting in the office from notes, unless the country be near at hand for reference in the case of doubt of a defective sketch, is objectionable" (U.S. Coast Survey 1867, 230). Because all angles and distances

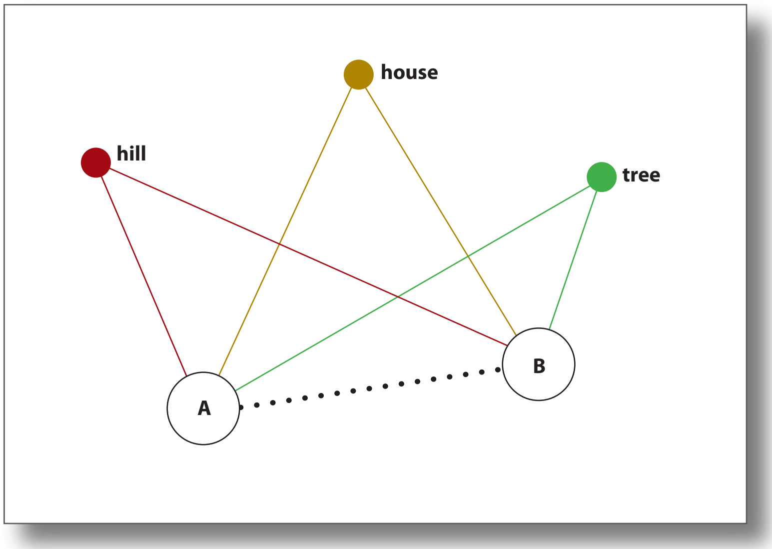


Figure 7.14. Example of plane table mapping (Grossinger, Askevold, and Collins 2005). The surveyor would place the plane table directly over a triangulation station (A) and locate the second triangulation station through the alidade (A to B). From station A, the surveyor would use the alidade to draw lines to the features to be mapped (such as the hill, house, and tree, above). Then, moving to station B, the surveyor would draw lines to the same features, creating a triangle. Triangulation operates on knowing the length of one side of a triangle—the distance between A and B). The angles of the other sides of the triangle are measured, and then the lengths of the other sides are computed.

were transferred immediately to the field sheet, there was usually no record of the measurements—especially on the earlier maps—and field notes were not typically kept (Shalowitz 1964, 160). This is in contrast to General Land Survey maps, in which the surveyor kept detailed notes regarding witness trees, bluffs, roads, soils, and vegetation types (Johnson 1976, 78). The lack of Coast Survey notes had "regrettable consequences for historians", who might have found useful information in the field notes (Allen 1997, 46).

The Coast Survey adapted and developed innovative methods for accurately completing the surveys. While the chain had commonly been used as a measuring device in the field, there were several concerns that made it less than ideal, as sources of error could be introduced when the chain stretched, pacing instead of measuring was occasionally substituted, and chaining required additional employees to both make the measurements and check the results (U.S. Coast Survey 1867, 226). The 1867 report notes that "care should be exercised in the selection of intelligent chainmen... [as the] correctness of the survey in a great measure depends" on their measurements (U.S. Coast Survey 1867, 226). To largely replace the problematic chain as a measuring device, the Coast Survey was an early adapter of the telemeter, a wooden rod about 10 feet long with graduated numbers painted on the surface that could be sighted through the alidade (Shalowitz 1964). The use of the telemeter (also called a stadia rod) reduced the time measurements took, the number of employees required, and could be used where the chain was not practical (U.S. Coast Survey 1867, 227). The telemeter was widely accepted by 1865, though it was used by Coast Survey employees earlier (Shalowitz 1957, 293). It is possible the telemeter was in use in 1857 when T-sheet 676 was surveyed, though the area may have been largely measured by chains.

Making accurate longitude measurements had been problematic for map makers through the first half of the 19th century. In theory, because longitude was known at the Greenwich Meridian, it could be measured by comparing local time to time at the Greenwich Meridian and then converting the time difference into degrees (Stachurski 2003, 1). In theory, these measurements were accurate with possible errors of +/-0.50 seconds, though in reality errors were often larger (Stachurski 2003, 4). In 1846, Bache began directing experiments to use the telegraph, rather than chronometers or lunar measurements, to determine longitude (Shalowitz 1964, 19). Use of the telegraph proved highly accurate, and the new technique of measuring longitude became known as the "American Method" (Stachurski 2003, 5).

While using the telegraph for longitude was a regular part of Coast Survey work on the East Coast by 1856, because it entailed considerable infrastructure, the telegraph was not used on the West Coast for Coast Survey measurements until 1869 (Stachurski 2003, 4). It was not part of T-sheet 676, though would have been employed at the time of the Coast Survey re-surveys in 1897. Assistant Supervisor Schott described the measurements he made before and after the telegraph was employed and notes that the early longitude of Telegraph Hill was three-quarters of a mile westward of where it was found to be once the telegraph was used. "Thus the country was considerably wider than had been known before the advent of the telegraphic method," he notes (U.S. Coast and Geodetic Survey 1897).

Printing Processes. Described in the previous chapter, the *diseño* existed only in manuscript form, and if additional copies were required, they were made by hand. The Coast Survey maps were printed on a press, making multiple copies available, and the choices the Coast Survey made about reproducing its maps are indicative of both the careful attention to detail and innovation methods practiced by the agency (Shalowitz 1964). Printed maps required a cooperation between the cartographer and the printer, and Robinson notes the advantage of multiple map copies through publishing meant the cartographer had to submit his work to the compromises introduced by someone else engraving and printing the map (Robinson 1975, 3). The Coast Survey controlled all steps of mapmaking from initial authorship to production and publishing, which meant some of the potential conflict between the cartographer and printer was lessened.

From the inception of the agency, the Coast Survey maps were engraved on copper plates, constraining their production to a limited print run for each engraving (Figure 7.15). The delicately engraved lines on the copperplates could only withstand perhaps 500 to 2000 impressions before they required re-engraving. Guthorn refers to this process as "slow, laborious, and cumbersome...[resulting in] maps with intricate detail from nearly microscopic size to large lettering, fine to heavy lines, tone variations, and great character" (Guthorn 1984, 23).

Copper plate engraving entailed use sharp tools to incise the surface of a smooth copper plate. The surface was coated with ink; the ink was wiped from the plate except for where it remained in the engraved recesses of the plate; a slightly damp printing paper was placed on top of the copperplate; the plate and paper was run through rollers to exert tremendous pressure and imprint the ink in the incised areas onto the paper. The next print required the process be started over with the inking of the plate forward (Guthorn 1984, 23).

This was a tedious and costly method of printing, and the Coast Survey experimented with various techniques for reducing the inefficiencies of this process while still maintaining the high standards afforded by engraving. By the early 1850s, the agency was successfully combining copperplate engraving with a process called electrotyping, in which a cast was made of the plate (Harris 1975, 133). This innovation made it possible to print from a raised surface, and

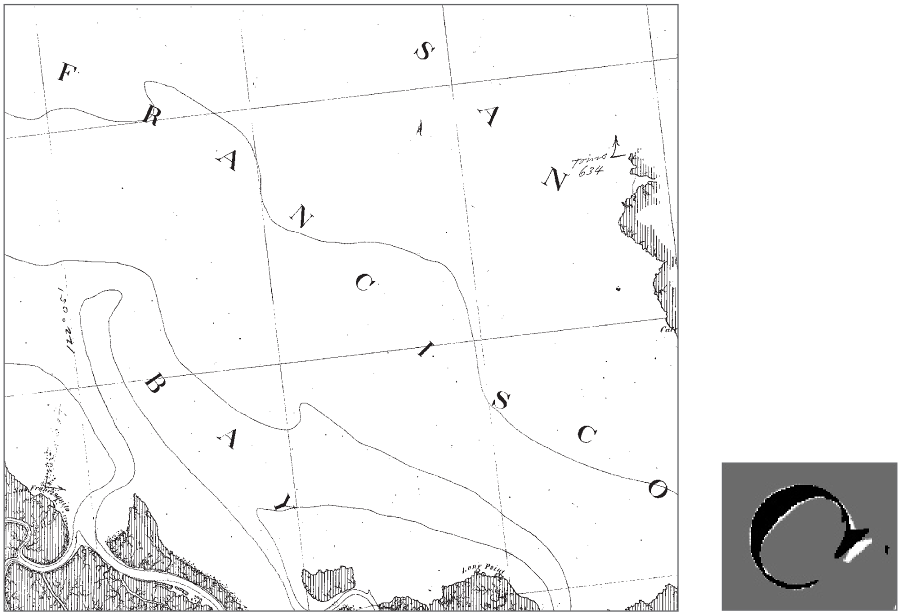


Figure 7.15. Detail from T-sheet 676, showing example of copperplate engraving. The Coast Survey printed maps from incised copper plates. All text and lettering was engraved backwards on the plate so that once printed, it would read correctly. Note the slight differences in the two "C"s found in the word 'San Francisco', evident when the two letters are superimposed in detail on right (Rodgers and Kerr 1857).

imbed type, rather than engraving type into the plate (Harris 1975, 131). Guthorn suggests this was primarily used for preliminary charts that were bound into the annual superintendent's reports and not for final charts, which remained printed by traditional copperplate engraving (Guthorn 1984, 23). After the Civil War, the agency also experimented with photomechanical printing (Harris 1975, 135).

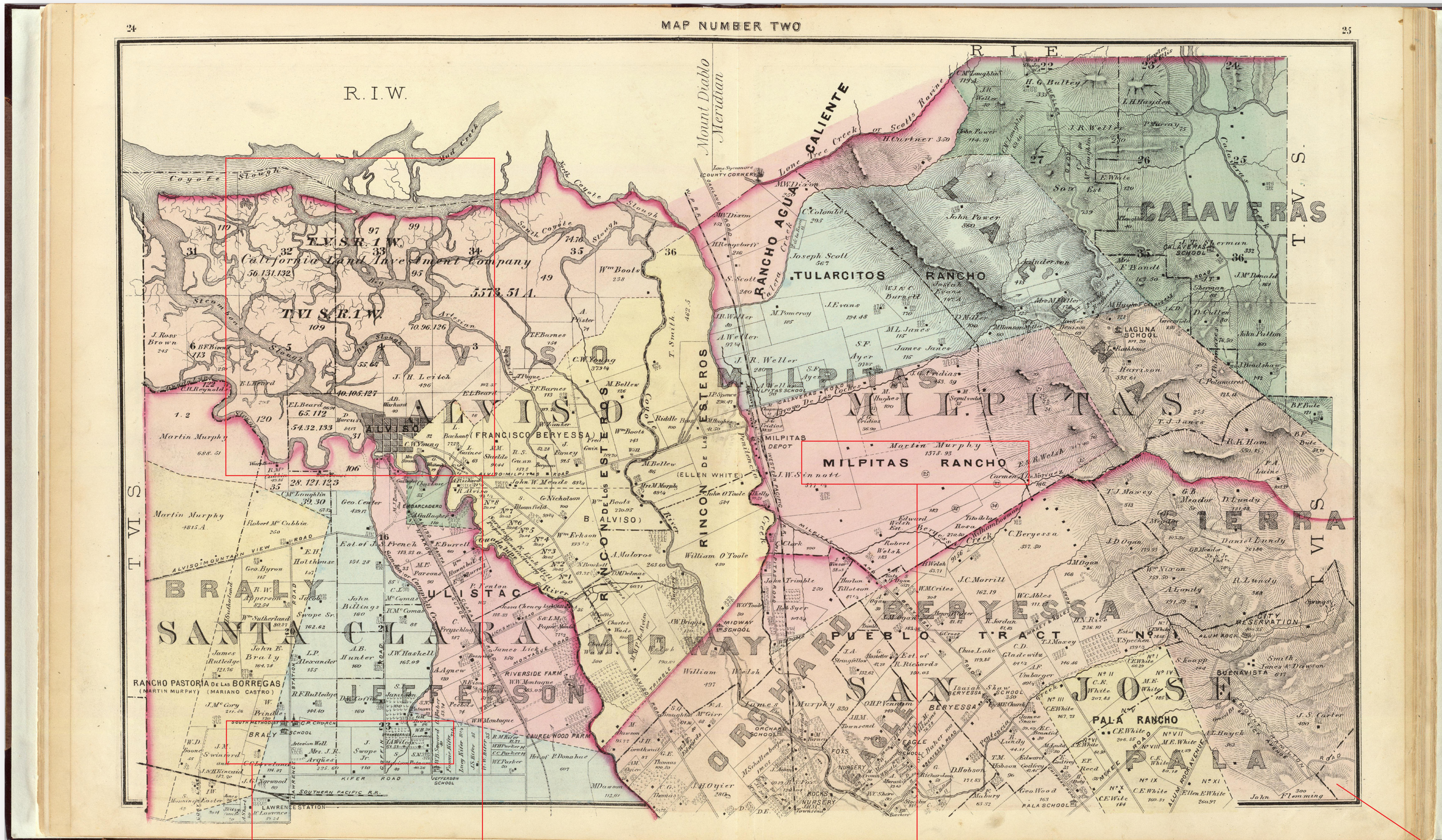
The Coast Survey, while experimenting with innovative methods, resisted quick printing solutions. This contrasts sharply with production and distribution of commercial cartography products. At the same time that the Coast Survey was creating charts and printing finished products primarily through copperplate engraving, commercial map publishers in the U.S. were creating products from both lithography and cerography (Schulten 2001, 23). Lithography is discussed at greater length in the next chapter (see section on 'Printing Techniques'). Cerography—or wax engraving—was a uniquely American form of printing practiced between 1840 and 1950 (Woodward 1977). It was less expensive than copperplate or intaglio printing and could supply the post-Civil War demand for inexpensive information about the economy and commerce. It also contributed to the use of many more place names on the surface of maps, since type could be easily set and inserted in the metal plate rather than engraved in the copperplate (Schulten 2001, 26).

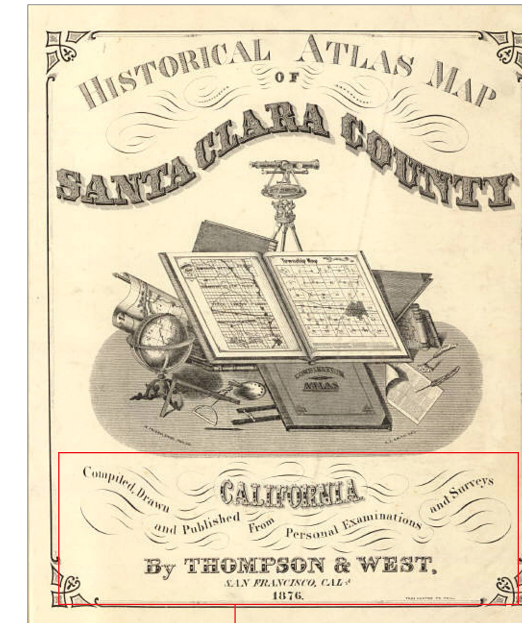
HOW THIS EVIDENCE CONTRIBUTES TO HISTORICAL ECOLOGY

The historical T-sheets represent an important source of information about San Francisco Bay. The California State Lands Commission uses the T-sheets in legal delineations of lands of Public Trust. Landmark scientific studies of intertidal processes in the Bay were illustrated with T-sheets (Gilbert 1917, Atwater *et al.* 1979). Reports on the changing distribution and abundance of intertidal habitats have referred to the T-sheets to estimate historical conditions (Dedrick 1983). Efforts to restore the Bay have used the T-sheets to guide restoration design (Goals Project 1999).

Because the U.S. Coast Survey was the premier scientific agency promoting precision cartography to exacting standards, the highly detailed sloughs, channels, pannes, and tidal marsh boundaries can be used with a high level of confidence in their location accuracy. Use of the Coast Survey maps can be enhanced in scientific studies by understanding the context in which the maps were made. A study of the T-sheets social context reveals that the maps were completed during a time of rapidly changing economic and political structure, and the pressure this brought to bear upon the mapping efforts had the potential to rush the results. Additionally, variability between maps occurred because of a lack of cartographic standards. Understanding that the maps did not represent cultural features until the resurveys done of the area in the 1890s can cause the historical ecologist to find other sources for that type of evidence. Finally, an understanding of the high level of printing and reproducing engaged by the Coast Survey can add to the sense of confidence in the locational precision of the maps.

FIGURE 8.1-A. MAP NUMBER TWO, FROM THOMPSON AND WEST SANTA CLARA ATLAS, 1876 (Thompson and West 1876)





THE AUTHORS

The title page identifies Thompson and West as the authors of the atlas, operating their business from San Francisco. A small note on the bottom right of the page identifies "Thos Hunter Pr Phil." as the printer, located in Philadelphia. The casual reader might assume that Thompson and West themselves compiled, drew, and published the atlas after personal examinations and surveys, but the preface thanks several of the county's surveyors (A.T. and Charles Herrmann, J.H. Pieper, and J. Comb) and credits H.S. Foote, a local journalist, for writing the history of the county (Thompson and West 1876, preface).

TECHNOLOGY: MAPPING

Thompson and West county atlases borrowed heavily from existing cadastral surveys to build their maps. The ownership lines on this maps were probably copied from the plat maps created by the county surveyors, though natural features were probably sketched in as an agent for Thompson and West rode in a buggy from place to place (Guedon and Fisher 1976, Preface).

SOCIAL CONTEXT:

The map turns its back on the tidal marshes, which frame the top of the map but do not intrude on the largely agricultural activities of the valley south of the bay. Alviso's importance as a landing has already come and gone, and the railroads crossing the map now move agricultural products to San Francisco for shipping.

SOCIAL CONTEXT

Owning land in Europe signified power and wealth. Land was plentiful in the United States, though much of the prime land in the area was already taken through the Mexican land grants. By 1876, most of the original Mexican land owners had sold their land to speculators and squatters. The resulting pattern of ownership is imposed on top the land grants, shown in contrasting colors with the land grant name in capital letters.

TECHNOLOGY: HAND COLORING

The maps were engraved on lithographic stones but the color was applied by hand (Rumsey 2005). Darker red wash separates the county wards—San José, Milpitas, Alviso, etc.—while the broader colors indicate land grant boundaries.

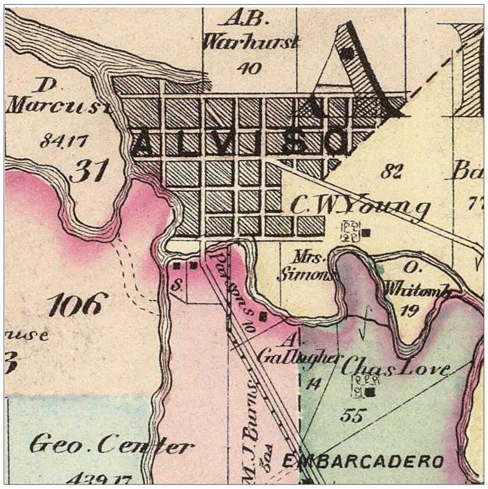


Figure 8.1-B. Detail from the map sheet in Thompson and West county atlas, depicting the town of Alviso, the Guadalupe River close to where it enters the tidal marshlands, and various property lines and owner names in 1876 (Thompson and West 1876, 24-25).

8. THE COUNTY ATLAS AS A SOURCE:

THOMPSON AND WEST 1876

County atlases—produced by private companies in the late 1800s—occupied a niche not filled by the maps made by public agencies. The rather limited funding available for government efforts was stretched thin and barely covered the basic surveying required to record the political and natural features of a growing territory. County atlases were an amalgamation of maps and plats, lithographic views of prominent county landmarks, historical and statistical information, and illustrations of the property or portraits of the subscribers, who paid additional fees to be featured in the atlas (Schwartz and Ehrenberg 2001, 293). Designed to show ownership of individual land owners and land parcels in rural areas, atlases also showed natural and cultural features such as rivers, major hills, railroads and roads (Conzen 1990, 186).

Thompson and West's 1876 atlas of Santa Clara County was published only 19 years after the U.S. Coast Survey T-sheet 676 was printed in 1857, but presents a vastly different landscape. Turning away from the waterways, the atlas is concerned with land-based commerce and focuses on patterns of ownership connected by networks of roads and railroads (Figure 8.1-A and 8.1-B). The Mexican and Spanish landscape can be traced though place names, remnant road patterns, and the occasional mission, but virtually no evidence of the native Ohlone people is found on the maps.

The following section examines how and why Thompson and West created the atlas, and discusses the atmosphere in which county atlases flourished. Following that, I place the atlas in social, political, and economic context, emphasizing local Santa Clara history. The technical map-making and printing methods used—different from both the *diseño* and the Coast Survey map—are then discussed. In the final section, I discuss how this understanding can increase the usability of Thompson and West maps for science-based historical ecology projects.

CONTEXT OF THE ENTITY RESPONSIBLE FOR THE COUNTY ATLAS

Thomas H. Thompson was an engineer and map maker, while his business partner, Augustus West, was a historian specializing in biographies. The Santa Clara atlas in 1876 was the first in a series of California county atlases that ended in 1892 with an atlas of Tulare County (Robinson 1959). The series are invariably referred to as Thompson and West atlases, but a number of authors, editors, and illustrators contributed to each book, though the team was selected and directed by Thompson and West (see Figure 8.2).

Figure 8.2. Title page from the Santa Clara County atlas, with their names prominently displayed, though much of the writing, editing, mapping, compiling, engraving, and printing was performed by other more anonymous authors (Thompson and West 1876, title page).

County maps started in the Eastern U.S. as large wall maps, sold to schools and businesses. The first county map that featured cadastral ownership was a map of two counties in Pennsylvania in 1814, "marrying the detail of individual cadastral surveys to the geographical comprehensiveness of a county map" (Conzen 1984a, 11). County wall maps in the midwest—because of the rectangularity of land ownership lines driven by the township and range grid—added lithographic views in the margins for interest (Conzen 1984a, 17).

The 1860s saw the rise of the county atlas, in which the a wall-sized county map was split into sections that could be shown on a single page of a large format book (Thrower 1999, 138). Repackaging the county wall atlas into book format allowed the map publishers to reach new markets and incorporate additional material such as narrative histories, lithographic illustrations, and statistics.

The rise of county atlases can be tied to gazetteers, which were listings of places and statistical facts relating to commerce, population distribution, agriculture, and transportation infrastructure. Reaching a zenith of popularity during the Civil War era, "gazetteers became manuals of economic geography designed to chronicle progress from one era to the next", commodifying nature rather than presenting a unified landscape (Schulten 2001, 18). In areas where the public land survey was employed, the grid of the township and range system served as means to break up the county into separate pages; the block of land encompassing a township could be shown on one page. This contributed to how the land was viewed, and farmers used section numbers as a sort of address, and referred to section lines rather than natural geographic features in county histories (Johnson 1976, 148).

The county atlas map reflected another change in the way Americans perceived the landscape. In Europe, owning land required wealth and was beyond the reach of most people, while in America land was plentiful. Rumsey suggests it was no longer enough to own land, but it became important to visualize the land you owned—in the form of a portrait of your land, published in a book (Rumsey and Punt 2004, 38). The innovation of county atlases was stimulated by a land-owning agrarian republican society, rather than feudal land tenure with a rigid hierarchy and property rules (Conzen 1984b). Additionally, the maps became useful for business and administrative purposes (Thrower 1999, 138).

Historically, maps have been specialized documents only for the well-educated within specific occupations—explorers, surveyors, military commanders (Conzen 1984a, 47). The county atlases were successful because they were vehicles for "cultural expression of pioneer pride, material accomplishments, and civic self-congratulation—a winning formula", and they featured ordinary farms, prized bulls, and pig operations (Conzen 1984a, 48). Subscription atlases appealed to a mass market, unlike any previous map product (Schulten 2001, 18). By selling atlases to ordinary citizens and encouraging them to purchase a lithographic view within the atlas, the atlas makers made more money. This had a democratizing effect on who and what was depicted as important, since for a nominal fee, a farm could become as important as the court house (Conzen 1984b; also see Figure 8.3).

Thompson and West both came from Illinois, where Thompson had been engaged for years in county map-making (Robinson 1959). Thomas Thompson, with his brother Moses Thompson, had surveyed several Illinois and Iowa counties for county wall maps before the Civil War (Guedon and Fisher 1976, Preface). After the war, Thompson continued mapping, joining forces with two friends from the army, L.H. Everts and Alfred Andreas. Andreas was a map peddler with Thompson and Everts, though after

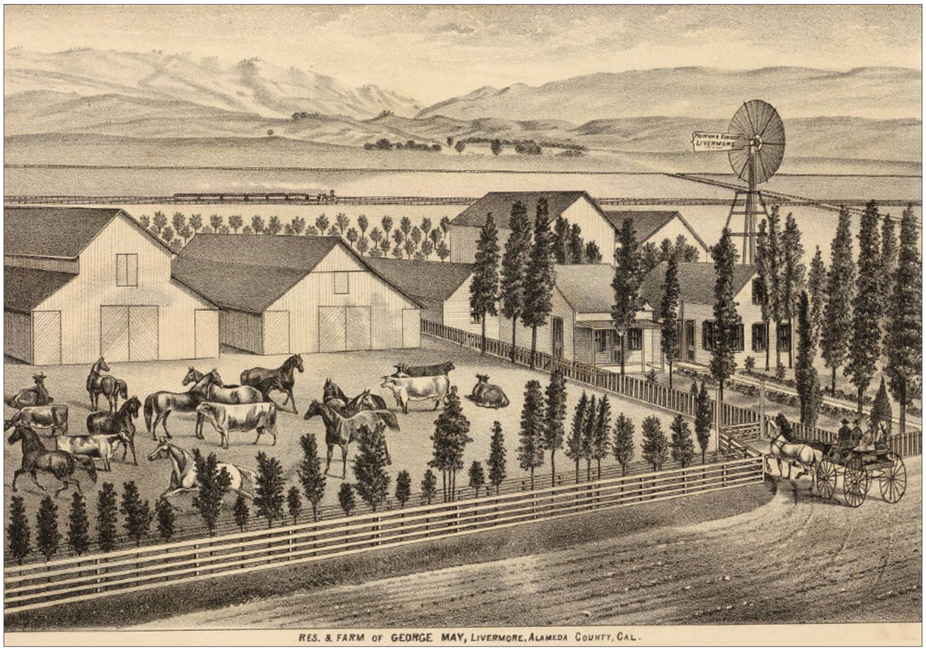


Figure 8.3. Lithograph of farm of George May, depicted on a half-page in the Thompson and West 1878 Alameda County atlas. For a nominal fee, local residents could have their property depicted in a county atlas (Thompson and West 1878, 122).

he realized county atlases would be more profitable than just one map depicting the entire county in 1869, he left to form his own company in Chicago. Everts followed suit, forming a company in Philadelphia (Conzen 1984a, 49).

Thompson and West published several atlases in California, and produced at least one illustrated history—without any maps—of Los Angeles (Robinson 1959). The Santa Clara County atlas included a state map; a narrative history of the county; a listing of various local enterprises and improvements, including newspapers, banks, churches, schools, grist mills, miles of railroad line, breweries, and libraries; statistics about California population, agriculture and manufacturing; twelve separate map sheets depicting the entire county; various town plats; and lithographed views and illustrations (Thompson and West 1876, 9-18).

Thompson and West left an increasingly competitive field of companies creating county atlases in the midwest (Conzen 1984b, 20). The popularity of county atlases peaked between 1850 to 1880 (Schulten 2001, 18), but coverage was not universal across the United States. The midwest and rural northeast were well represented by county atlases (Conzen 1984b, 29-31) and some counties in the midwest had ten editions of an atlas by the turn of the century, while half the counties in the U.S. had no atlas at all (Thrower 1999, 138). The counties without atlases tended to be in the very arid west, or in states where land holdings were so large as to make ownership maps depicted on the page of a book impractical. California must have seemed an alluring business opportunity to Thompson and West, with a market largely untapped and the same features—relatively small farms and a growing rural population—that made the atlases so successful in the midwest.

SOCIAL, POLITICAL, AND ECONOMIC CONTEXT IN 1876

The maps in the Thompson and West atlas of Santa Clara County represent a vastly different social order from the landscape depicted in the *diseño* of *Rincon de los Esteros,* and signify a rapidly changing economic focus, with a land-based transportation network and a profit-based agricultural community. The following section explores the social, political, and economic context which is reflected in the Thompson and West maps, focusing on the events taking place in Santa Clara Valley rather than a national or world context. Three converging changes in land use affected how the maps were shaped, what was depicted on the maps, and how the maps shaped the residents' perception of community and land use. By 1876, the pattern of land ownership had shifted from large ranchos to smaller farms as the original land grants were divided; closely related to this was a widely held belief by the farmers who saw the land as a resource to be profitably mined by aggressively pursuing profit; and, because of a rapidly changing transportation technology, the valley was turning away from water-based commerce networks to land-based transportation modes, affecting the infrastructure and the relative importance of individual towns.

Pattern of land ownership. The large land grants of Santa Clara Valley that saw more cattle than people gave way to a flood of immigrants during and after the Gold Rush (Friedly 2000, 260). As discussed in Chapter 6, American immigrants resented the ways in which the Mexican residents used the land, insisting that agriculture improved the land, while simply grazing cattle on it did not (Pitti 2003, 37). As Mexican land grants were dissolved, the land was subdivided, bought by immigrants and sold through speculators, as reflected on Thompson and West's Map Number Two.

For example, the *Rincon de los Esteros* grant covered one square league, or 4,437 acres. The rancho was initially split and divided between three petitioners—the

Berreyesa family, Ellen White, and the Alviso family—but by 1876, no fewer than 40 names occupy the same land (see Figure 8.1-A). The angular lines of the newer plots contrast with the more fluid lines of the Rincon de los Esteros Rancho, which is bounded by Coyote Creek and Guadalupe River (see Figure 6.1-A). The average size of a farm in Santa Clara County in 1880 was 213 acres, while Mexican land grants were on the order of a square league (4,500 acres) or more (Broek 1932, 84).

Farming for profit. The farmers of the valley were fortune seekers, attracted to California because of the allure of the Gold Rush. Unlike most farmers, they skipped the phase of creating a self-sufficient farm in which they grew crops for their own consumption, and moved directly to specialized farming for maximum profit (Friedly 2000; Broek 1932, 69). The number of cattle initially increased after Americans took control of the area, with ranchers placing more cattle on less land (Friedly 2000, 300). Wheat farming largely replaced cattle raising by 1870, and reached a peak in Santa Clara Valley in 1874 with over 1.7 million bushels grown (Thompson and West 1876, 12). The grain crops were initially grown by squatters who did not intend to stay on the land (Broek 1932, 63); as a consequence they often depleted the soil to turn a quick profit (Friedly 2000, 323).

The farms close to the bay depicted on Thompson and West's Map Number Two were covered with a heavy black adobe soil, initially considered not as suitable for growing grains as the areas farther away from the bay, but over time the bay farmers learned to drain and till the adobe for successful grain farming (Broek

1932, 77). Farmers attempted to reclaim tidal marsh land by ploughing into the adobe the soil sediments deposited by freshwater creeks. When testifying in the Berreyesa land grant case, John Smith told the court in 1863 that he first considered the salt marsh worthless, capable of growing nothing but salt grass, but that "ploughing, cultivation, and the floods [have] improved the land considerably since then" (United States vs. F. Berreyesa 1863, 227).

The farming landscape captured in the Thompson and West map of 1867 was in the process of shifting from grain farming to new and equally profitable horticultural ventures—orchards, strawberries, vineyards. Plums and prunes became a dominant crop, first making headway in the 1870s, (Thompson and West 1876, 12). Local resident B. Fox opened a nursery in 1853 (evident in Figure 8.1-A, at the south of the map), successfully cultivating a large orchard on both sides of Coyote Creek and encouraging new horticultural activity in the valley (Sawyer 1922, 136).

Scows and railroads. The landscape depicted in the U.S. Coast Survey map was dominated by sloughs and channels connecting the land to the bay, but by 1876, railroads crisscrossed the landscape, and the importance of landings had diminished. Before the arrival of the railroads, landings dotted the edge of the bay, serving as shipping and distribution centers for the area's grain, fruit, vegetables, hides, and timber (Grossinger and Askevold 2005b). Scow-schooners were a specialized form of transportation, with broad, flat bottoms designed to navigate the narrow and shallow sloughs near the landings, used to move goods around the bay and to San Francisco (Dewey 1989). While the Coast Survey map only gave the slightest clues about the land south of the Bay, the Thompson and West map only hints at the complex network of sloughs north of the land. Figure 9.1-A shows Mud Creek abruptly ending, and Coyote Slough is depicted only where it connects with the valley's creeks.

By the mid-1870s, 72 miles of railroad track crossed Santa Clara Valley, allowing the valley to connect not just with San Francisco to the north but to establish market ties to the East Coast (Vance 1964). The first railroad that came to Santa Clara Valley connected San José with San Francisco in 1864 (Friedly 2000, 385), and within a few years connected the valley to Los Angeles. The transcontinental railroad was completed in 1869, and the Western Pacific built a connection from the cross-country railroad terminus in Oakland to San José in 1872 (Sawyer 1922). The South Pacific Coast Railroad—a narrow gauge connecting Oakland with Santa Cruz and arriving in San José in 1877—provided a connection for local farmers who had grown tired of paying the freight prices charged by the Southern Pacific (MacGregor 1982). The landings, scows, and steamers competed for a time with the railroads, but rather quickly lost the battle.

The rise and fall of the town of Alviso—the main town on Thompson and West Map Two—represents the changing focus from water to land. The town of Alviso was named for Ignacio Alviso (1772-1848), who came from Mexico with the de Anza expedition in 1776. The town was well situated to dominate shipping traffic at the south end of the bay, and from 1850 to 1865, Alviso enjoyed its greatest period of development, when warehouses, hotels, stores, and dwellings were added (Sawyer 1922, 296). "In 1849, it was predicted that [Alviso] was destined to become a great city", but in 1865 the railroads began to divert trade from the embarcaderos on the bay, and "the town became practically deserted" (Sawyer 1922, 296). The South Coast Railroad stopped in Alviso, but the town never recovered (Broek 1932, 96).

MAPPING AND PRINTING TECHNOLOGY

The Thompson and West map shows a complex interlocking pattern of land ownership, farms and orchards nestled in between the area's tidal marshland, rivers and creeks. Unlike the *diseño* for *Rincon de los Esteros* and the Coast Survey T-sheet 676—which were created as originals for a specific purpose—the Thompson and West map was compiled from many sources, a compendium emphasizing the tenurial aspects of the landscape. Thompson and West used a new printing technology—lithography rather than copperplate engraving—that in part drove the ability to produce atlases quickly and cost-effectively. These points are explored in more detail below.

Compilation. Thompson and West borrowed heavily from existing survey work. In the preface to the Santa Clara County atlas, Thompson and West thank a number of surveyors, including A.T. Herrmann, Charles Herrmann, J. Comb, and J.H. Pieper. They write that "the thorough knowledge of the County, its lands, divisions, and topographical features possessed by these gentlemen, and derived from actual field work as surveyors and engineers, has been freely placed at our disposal" (Thompson and West 1876).

Conzen describes a typical process for a county atlas as follows. Field surveyors—who probably did not perform any actual surveying—would copy county plat maps, creating a basemap of administrative boundaries, roads and railroads, and natural features such as rivers, hills, and marshes. Onto this base, the Thompson and West surveyors would add ownership information, gathered from the land records or tax lists (often held at the local courthouse). Finally, the field surveyors would visit the county on horseback to sketch in details from direct observation, filling in missing cultural features such as "roads, houses, railroads, town sites, schools, mills, and woodland cover" (Conzen 1984a, 50).

While the colorful map sheets dominate the atlas, Guedon and Fisher suggest they were Thompson and West's least expensive item, because they were compiled from existing surveys. "Man-made and natural topographic features of interest were sketched in on the basic map 'on the spot' by an agent for the company as he rode from place to place in his buggy" (Guedon and Fisher 1979, Preface). Thus, the artesian well, strawberry field, South Methodist Church, Lawrence train station on the Southern Pacific line, Jefferson School (see Figure 8.4), were sketched in by Thompson and West, using a basemap compiled from county sources. Guedon and Fisher suggest that George Allardt's "beautifully executed, hand-colored, cadastral map of 1874" was used for Thompson and West's 1878 atlas of Alameda County

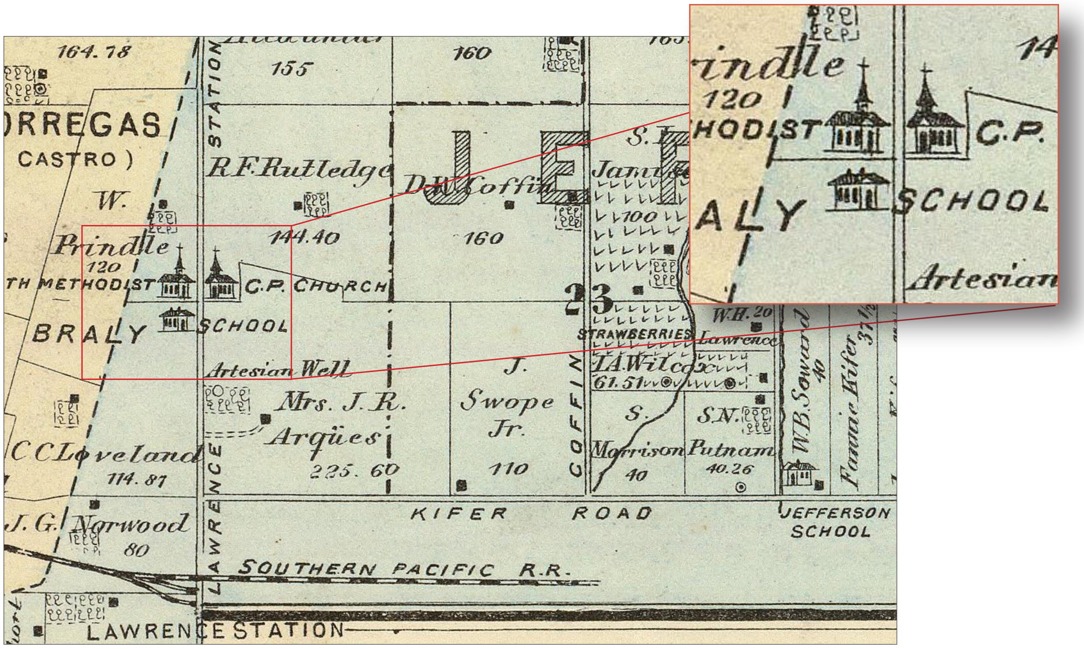


Figure 8.4. Detail from a Thompson and West map sheet. The basemap was compiled from county plats, tax lists, and land ownership records, but a Thompson and West agent traversed the area on horseback, sketching onto the basemap various cultural features, including the Lawrence Station of the Southern Pacific Railroad, Jefferson School, the strawberry field of I.A. Wilcox, and the trio of churches and school on Lawrence Station road. While most features are in planimetric form—as if viewed from above—certain features, such as the schools and churches are drawn in profile (Thompson and West 1876, 24-25).

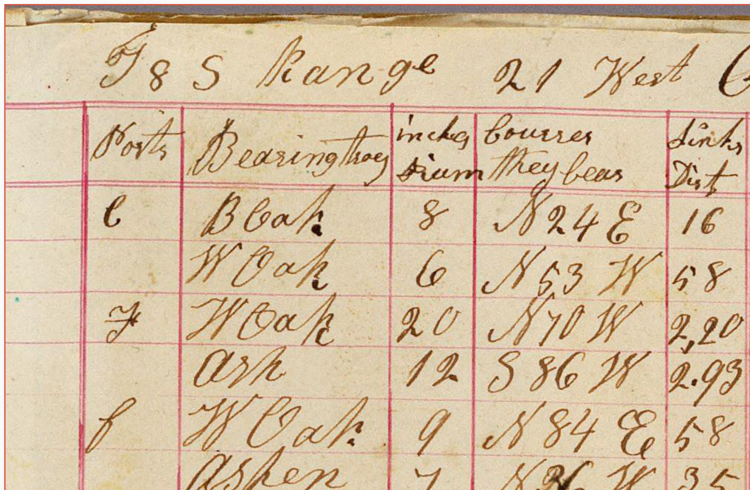
(Guedon and Fisher 1979, Preface). It is likely Thompson and West used a county map, probably created by A.T. Herrmann, in Santa Clara County.

How were the survey maps Thompson and West used to compile the county atlases developed? Unlike the geodetic plane table surveys performed by the U.S. Coast Survey, cadastral surveyors used a compass traverse method, in which each corner of the survey was used to measure the angle to the next station, and a Gunter's chain was probably employed to measure the distance between stations (Uzes 2005).

Writing about 19th century property surveying, Hilliard notes that surveying involved the following steps—"laying out a tract of land, locating and marking the corners, running lines by compass direction to connect all corners, measuring the lines, and calculating the acreage of the tract" (Hilliard 1982, 418). A rough sketch may have been made of the survey, but the final map was usually made later from the survey notes indicating compass direction and distance (Greenhood 1964, 210). Figure 8.5 shows an early survey of the Michigan-Indiana boundary with the associated surveyor notes.

Proponents of geodetic plane table surveying claimed compass traverse surveying was inaccurate. One author, in 1888, claimed compass traverse surveying was "liable to serious error" (Boutelle 1886, 460). In 1935, another author wrote that all the surveying done with the compass and the chain resulted in "measurements of angles and the distance made by methods that were crude and unreliable," in an essay praising the geodetic control as practiced by the U.S. Coast and Geodetic Survey (Steinberg 1935, 55). Uzes notes that "it is difficult to generalize on the precision to which the early land surveys were made, as there was considerable variation between types of surveys, dedication of surveyors, and methods employed" (Uzes 1977, 55).

Conzen suggests these maps "project an aura of accuracy and authority that any self-respecting historian should suspect"—not because the maps are inherently inaccurate but because of the myriad sources that are used to compile them (Conzen 1990, 189). However, many topographical details are "reasonably reliable"



T 8 S Range 21 West C

Posts	Bearing trees	inches Diam	Courses they bear	Links Dist
C	B Oak	8	N 24 E	16
	W Oak	6	N 53 W	58
F	W Oak	20	N 70 W	2,20
	Ash	12	S 86 W	2.93
f	W Oak	9	N 84 E	58
	Aspen	7	N 36 W	35

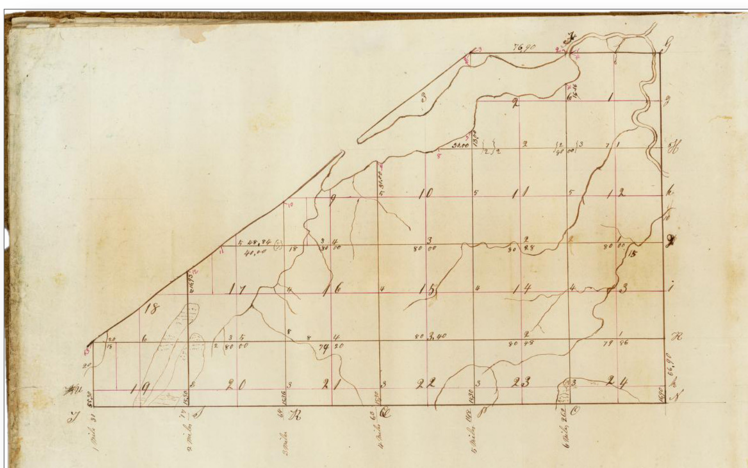


Figure 8.5. A 1835 field manuscript by Lucius Lyon to determine the boundary between Michigan and Indiana. Trees were used as corner monuments, listed by species and diameter in inches, and other columns provide the bearing and distance to the next marker (Lyon 1835).

though not as reliable as the accuracy of turn of the century USGS maps, according to Conzen. Even though roads and houses reflect the presence of a feature, the actual "alignment and exact positions may be off somewhere (they were usually interpolated from other landmarks by eye from horseback or buggy in the field)" (Conzen 1990, 189). These maps represent a relatively early source of historical evidence for the entire county. Clifford Darby, in a conversation with map historian Norman Thrower, remarked that "the county atlas is the 'American Domesday' in terms of its potential value for studies in historical geography" (Thrower 1999, 282).

Printing. The last half of the 19th century brought several developments in printing that changed the market for atlases and other printed maps. County atlases were printed using lithography, a method developed in 1796 by Alois Senefelder. In the United States, lithography was not applied to map printing until after the Civil War. While copperplate printing uses a plate in which the outlines and lettering of the map are engraved into a smooth surface, lithographic printing uses a smooth surface on which the map image is transferred through a chemical process (Ristrow 1975, 78). The process relies on oil and water not mixing, as described below.

> An image is drawn on a flat stone surface with an oil-based crayon, pen, or pencil. Water is spread over the stone to moisten all areas except the oil-based image, which repels the water. Then an oil-based ink is rolled over the stone, adhering to the image but not to the wet areas of the stone. A sheet of paper is placed over the image and a printing press is used to transfer the inked image on the paper (Meggs 1992, 155)

Fairly shortly after the process of lithography was invented, a method was developed that allowed a map image to be drawn on a special paper and then transferred to the lithographic stone. The significance of this was that while both copperplate engraving and initial lithography required that the map be drawn backwards on the plate or stone, the new transfer process allowed the image to be drawn right-reading (Ristrow 1975, 111). The significance of this "was as profound a development at that time as the Xerox copying process of today" (Robinson 1975, 15). Smooth pieces of limestone used in lithography were replaced by zinc plates (Ristrow 1975, 93). Photography was later incorporated as part of the process, making duplication of virtually anything anyone could draw a possibility (Robinson 1975, 21).

Copperplate engraving was expensive, and had never been suitable for mass markets (Schulten 2001, 23). The techniques of lithography—especially when the map could be prepared right-reading rather than reversed—were much easier, though the results were not considered as aesthetically pleasing (Robinson 1975, 20). Evolving techniques improved lithographic results and at the same time, the market was driven the need for immediate information, and the new base of consumers preferred the immediacy, updating, and relatively inexpensive costs rather than the "flawless execution" afforded by copperplate engraving (Schulten 2001, 23).

Robinson suggests this may have changed the relationship between the printer and the cartographer. Copperplate engraving required an "interpretive craftsman" to render the cartographer's manuscript map before handing the plate to the printer (Robinson 1975, 21). Lithography—when combined with photography—meant the cartographer could bypass the engraver, and go directly to the printer (Koeman 1975, 139).

The transition from copperplate engraving to lithographic printing occurred over decades (Woodward 1977, 39). Thompson and West took advantage of lithographic printing, making their products easier to develop, cost-effective to update, and relatively inexpensive for the consumer. Thompson and West maps show some evidence of hurry in the compilation process. Pages are numbered oddly—with page 15 followed by pages 15¼, 15½, and 15¾—perhaps because of insertion of late material. The authors note their atlas "is not free from error", though they assure the reader they have "spared neither money nor expense to make it nearly perfect as possible" (Thompson and West 1876, Preface). Though chromolithography—or the ability to print different colors by applying separate colors to individual plates registered to each other—was widely available, Thompson and West hand-colored their maps (Rumsey 2005).

HOW THIS EVIDENCE CONTRIBUTES TO HISTORICAL ECOLOGY

The Thompson and West atlas presents a relatively early representation of the entire county, and as such is useful for assessing early American impacts on the landscape in historical ecology studies. Understanding that the maps were made for profit, rather than for scientific study, is important when integrating the map sheets into a larger study. At first glance, the maps appear to have been created for the atlas, but more involved study reveals they were compiled from a number of sources, and restraint in using the maps directly is called for. For example, the ownership lines appear enticingly accurate, but probing their provenance reveals they were probably sketched into existing basemaps from courthouse records or in the field. The technology used to reproduce the maps—while state of the art by using newly emerging lithography—hints at an operation more interested in cost-cutting and efficiency than precision mapping. As such, the maps can be used in collaboration with other sources when seeking agreement, rather than as primary sources for historical change. Understanding the context of the map helps interpret the map and indicate appropriate levels of use.

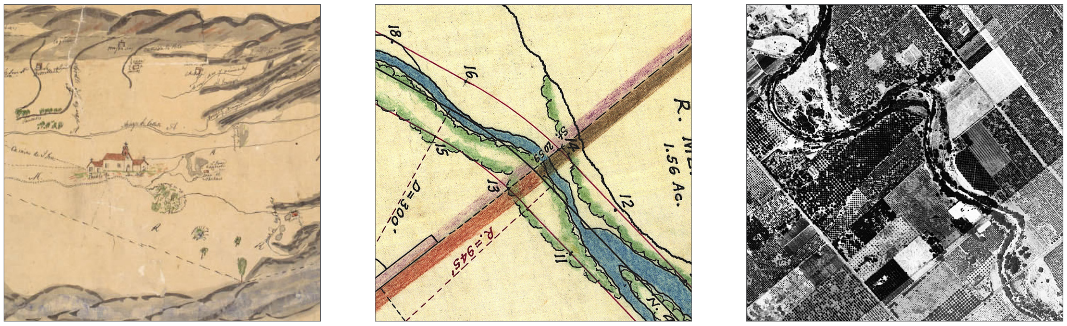


Figure 9.1. Three contrasting views of the Santa Clara Valley. Left, *diseño* of San José *pueblo* (U.S. District Court, date unknown); center, detail from survey of Coyote Creek, 1874, for early flood control (Herrmann 1874); and right, aerial photography from 1939 (Agricultural Adjustment Administration 1939.).

9. COMPARISONS AND ANALYSIS: MAP TO MAP

> *Sooner or later early map interpretation becomes an exercise in comparative cartography* (Harley 1990, 42).

Harley suggests map-to-map comparisons provide additional insight (Harley 1990). A map can be compared to other maps of the same era (time); to maps of the same subject matter (theme); and to maps of the same area (space; see Figure 9.1). Maps can be studied systematically to compare linear features such as coastlines, river channels, or roadways; to compare placenames or symbology to discern changes or differences between maps; or to engage in traditional comparative cartobibliography (comparison of a series of maps with minor changes all printed from the same printing surface—i.e. the various editions of the same map).

The following section considers each of the three maps discussed in the previous chapters in association with other maps. In the course of comparisons, it was necessary to understand the context of the additional maps being used—of the agency and individual cartographer; society and economy; and the technology used. The comparisons became not only comparisons of lines on the map, but of the forces driving the creation of the maps. For example, the *diseño* of *Rincon de los Esteros* is compared to the confirmation maps required by the U.S. courts to prove ownership, and the comparison necessarily becomes a comparison of not only the different line work and symbology, but of changing technology, attitudes toward land ownership, and political powers.

Harley's suggested categories—comparing maps of the same time, theme, and geographic space—are applied to each of the maps used in this chapter, below. The categories are somewhat ambiguous—i.e. are the *diseño* and the Thompson and West atlas map sheet, both depicting land ownership lines, of the same theme? How many years apart can maps be made and still be considered linked in time? Is a map of the southern end of Santa Clara Valley in the same geographic space as a map of the northern end? These questions are largely dependent on the array of maps necessary in a project. Studies encompassing a wider range of thematic, geographic, and time spectrums will have different criteria.

In the section below, the *diseño* is compared to other maps required in the court case, to the Thompson and West atlas map sheet, to a 16th century map from

Mexico, and as part of a comparison of how buildings are depicted on various maps. Coast Survey maps are compared to each other, with parallels drawn between legends and symbology on different maps; between two different levels of effort to capture tidal marsh detail in the same area by different cartographers; and between changing values of the importance of different landscape features in maps of the same area made 40 years apart. In the final comparison, a detailed surveyor's map of Coyote Creek is compared to the USGS and Coast Survey maps of the same area, in addition to a 1939 aerial photograph.

COMPARISONS

At first glance, it would seem as if the *diseño* and the confirmation maps represent two entirely different areas—and in some ways, they do. The Mexican *diseño* (Figure 9.2) represents a landscape in which the exact boundaries mean less than the community around them (Pitt 1966, 20), while the American confirmation surveys (Figure 9.3-A and 9.3-B) represent a landscape in which ownership is a commodity, requiring exact measurement (Uzes 2005). The first confirmation map was surveyed in 1859 (Figure 9.3-A), and was commissioned by the Berreyesa family to satisfy the American court as to the validity of their claim. The U.S. court contended that the original *diseño* represented a far smaller area than depicted on the 1859 survey. The courts required a new survey of the property, and in August 1862, John Reed surveyed the same area mapped approximately 20 years before as part of the *diseño* application. This time, instead of running the northwest boundary at the bay's edge, the new boundary runs from Alviso to the northeast.

The original land grant allotted one square league, or 4,437 acres to the Berreyesa family, but the final confirmation survey only measured 1,844 acres.

The U.S. court contended that the 'Esteros' marked on the *diseño* did not refer to pannes at the edge of the tidal marsh where it met the bay, in part because the confluence of Penitencia Creek with Coyote Creek was not depicted.

Figure 9.2. *Diseño* of the *Rancho Rincon de los Esteros* (United States District Court 1873 [*circa* 1838]). The original *diseño, circa* 1838, showing the rancho boundaries depicted by two rivers, pannes to the north, and a bridge as it crosses the Guadalupe. The map is oriented so that north is aligned to the top of the page.

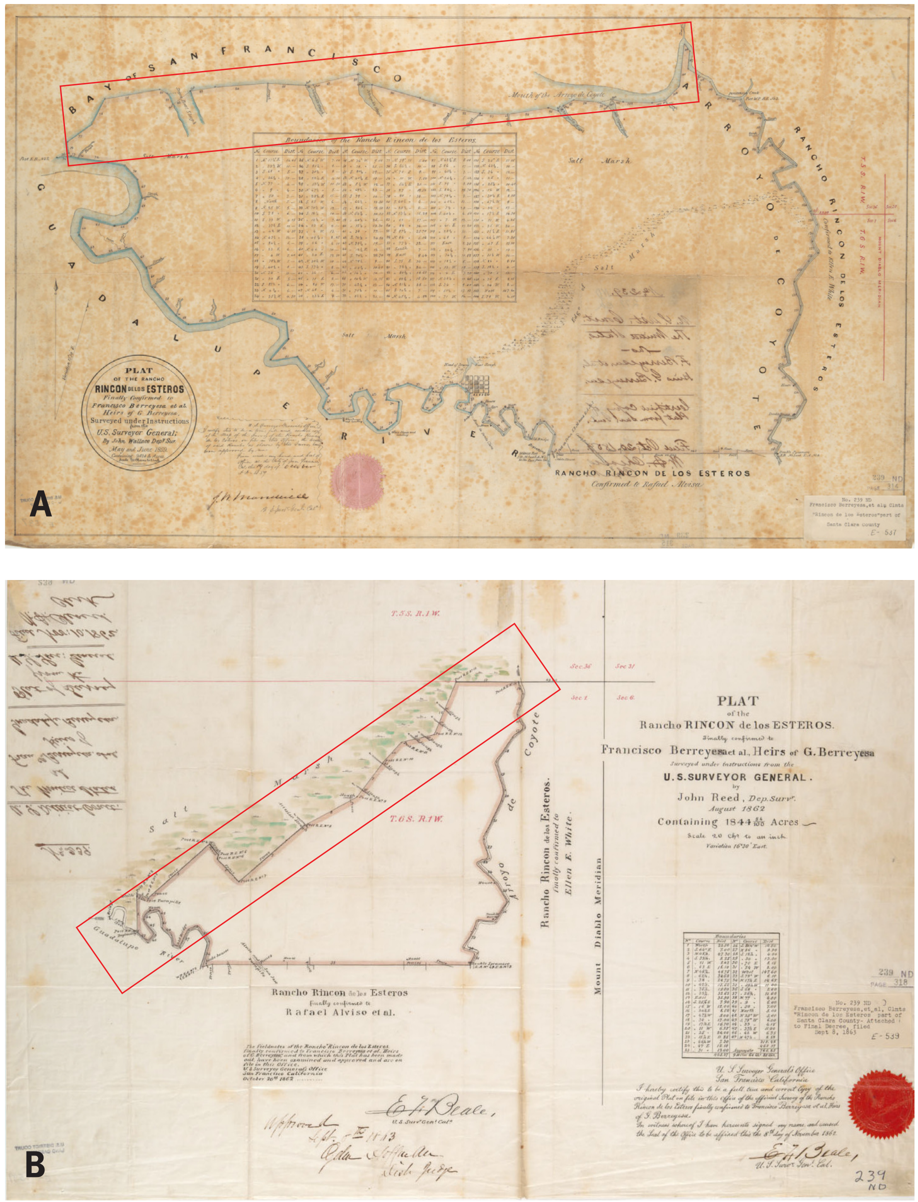


Figure 9.3. Confirmation maps of the *Rancho Rincon de los Esteros*. The two confirmation surveys, above (A and B), are two different interpretations of the same land grant shown in the original *diseño* (see Figure 9.2.). The top survey (A) was completed in 1859 (Wallace and U.S. District Court 1859), and the bottom (B) in 1862 at the request of the court (Reed and U.S. District Court 1862). The location of the *'esteros'*, indicated by the red box in all three maps, was key to the ultimate size of the land grant.

> It is obvious that no part of the Coyote Creek below the junction of the Penitencia was intended to be represented for the latter stream is represented as flowing parallel to but not meeting with the Coyote. It is equally clear from the scale of the map and a comparison of the distances between various objects laid down upon it, that only a small portion of the long and devious course of the Guadalupe below the house of the Bay was intended to be represented. The survey...which includes all the land lying between the Coyote and the Guadalupe is clearly erroneous (United States vs. F. Berreyesa 1863, 192).

The court further argued that "certain sloughs which penetrate far into the arable and dry land to the southward are the Esteros delineated on the *diseño*", even though the claimants contended otherwise (United States vs. F. Berreyesa, 1863).

The Thompson and West map (Figure 9.4-A) shows the area included in the final confirmation of the *Rancho Rincon de los Esteros* in green. The sloughs the court refers to that "penetrate the dry land" are Artesian Slough and two other unnamed sloughs. Penitencia Creek joins Coyote Slough in the top right of the map (though where Penitencia joins Coyote is not always clear on other maps), indicated by a green circle. If the original confirmation survey had been accepted, the rancho would have included the entire area in pink on the Thompson and West map between Coyote Slough, Coyote Creek, and Guadalupe Creek. By 1876, it was owned by the California Land Trust Company, a syndicate of land speculators (Sawyer 1922, 65).

The disposition of the land grant claim by the Berreyesa's was probably affected by the American views on both the land grant process and by the prejudice toward Mexican land use. Charles Lyman, who was hired by San José officials to subdivide

Figure 9.4. Thompson and West atlas map sheet (Thompson and West 1876), *diseño* (United States District Court 1873 [*circa* 1838]), and photograph of house on rancho property (Hare *circa* 1905). Above, a detail from Map Number Two (A), Thompson and West 1876, showing the area covered by the original confirmation survey, with the final confirmation area shaded in green. The Alivso adobe depicted on the diseño (B) is probably the same as in the photograph by Alice Iola Hare, *circa* 1905 (C).

some of the ranchos granted before 1848, complained about the Mexicans' "laziness" and contrasted it with Yankee ingenuity (Pitti 2003, 35). William Lewis, surveyor for Santa Clara County between 1849 and 1856, was responsible for interpreting the Mexican land grant documents and verifying their legitimacy in the county (Pitti 2003, 38). He later admitted he knew little Spanish and had even less interest in the place names used as landmarks in the *diseños.* Lewis felt that many of the *diseños* were drawn up after the Mexican War to cheat the Americans (Pitti 2003, 38).

The image of the Alviso adobe was taken by Alice Iola Hare *circa* 1905 (Figure 9.4.C). Hare was a prolific photographer who left an archive of Santa Clara images, including many of streams and natural features (Hare *circa* 1905). The photograph provides a later and different geographical representation; though the reason Hare had for selecting the Alviso adobe is long gone, her photograph continues to shape our geographical imagination of the area (Schwartz and Ryan 2003, 5).

The *diseño* uses pictographs, or representations of the actual objects, for houses and trees (Figure 9.5). *Pinturas* from colonial Mexico are similar in purpose and design to *diseños* (Figure 9.6). Endfield suggests the pictographs and more abstract symbols found on the maps were part of the shared interactions and exchanged information that passed between the colonizers and the indigenous population (Endfield 2001).

The use of a pictograph rather than an abstract symbol contributes to the perception that the maps are careless depictions of the landscape (Uzes 1977). Smith suggests that the early maps have followed a trajectory of progress, moving from pictures to

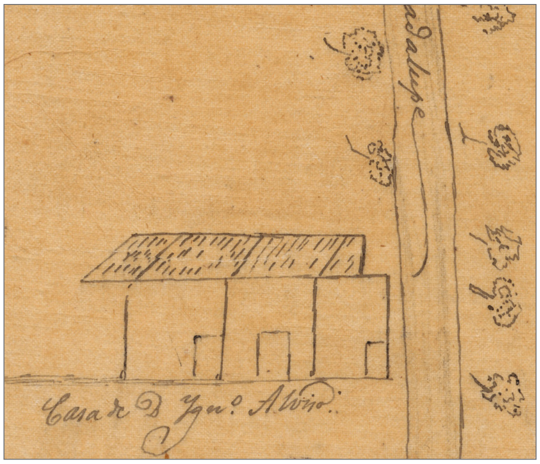


Figure 9.5. Detail from the *diseño* of *Rincon de los Esteros*, showing trees and the profile of a house to represent the same objects on the ground (United States District Court 1873 [*circa* 1838]).

Figure 9.6. Colonial Mexican map—called a *pintura*—from 1587. This map combines a plan-form street layout (lower left) with several pictographs, including the house on the gridiron, fish in the lake, and sheep in the corral (from Endfield 2001, 14).

abstract symbols (Smith 1982), though Casey disagrees, noting that contemporary maps have continued to use a combination of text, abstract symbols, and pictographs (Casey 2002). Nine examples of how various cartographers have depicted buildings on maps are shown in Figure 9.7. All the maps—except for the pintura from the 16th century—were drawn within 60 years of each other, and the use of pictographs is interspersed throughout the maps. The maps made by the agencies that considered themselves more scientific—the Coast Survey and USGS—depict buildings as abstract symbols.

The Coast Survey uses symbols rather than pictographs on their maps, but the symbols were not always standardized. Individual surveyors for the Coast Survey had wide latitude in the depiction of symbols representing various vegetation types and cultural features on maps. Despite Hassler's meticulous control of Coast Survey mapping tasks, Allen suggests early surveyors were given little direction for keys or legends, and that individual surveyors may have been experimenting with symbology on map sheets (1997, 47). It is plausible the West Coast surveyors developed their own set of symbology to depict unique features. On T-sheet 676, Kerr depicts salt marshes with a series of closely drawn parallel lines, though the standard already used widely and adapted as a standard by the 1860 incorporates tufts of grass at regular intervals along each line (see Figure 9.8). By 1865, symbols became more standardized through instructions provided to survey employees and appended to the annual report (U.S. Coast Survey 1865). Figures 9.8 and 9.9 show changing symbols in Coast Survey maps.

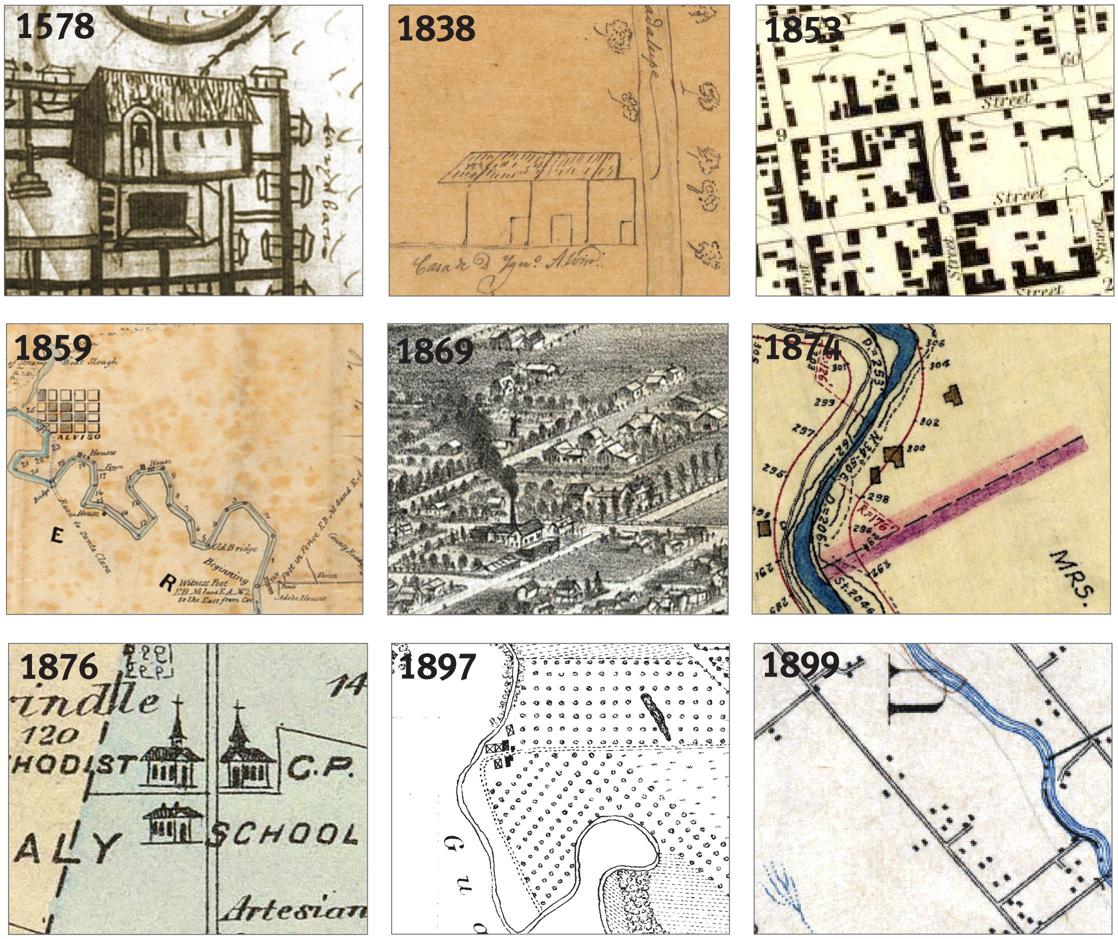


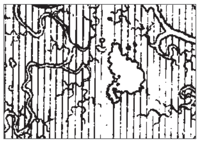
Figure 9.7. Symbols and pictographs representing buildings. Shown here are nine examples of how various cartographers have depicted buildings on maps. All the maps—except for the *pintura* from the 16th century—were drawn within 60 years of each other. The *pintura* from 1587 bears a remarkable resemblance to the *diseño* from 1838, as do the bird's eye view map from 1869, and the Thompson and West map from 1876. The depiction of the buildings on the Thompson and West map uses a pictograph but the similarity of the two churches depicted suggest that the pictograph is used also simply as an abstract symbol representing all churches, and not the specific church in that location. The other maps use a more abstract symbol for a building, showing the building as a rectangle. The 1859 confirmation map notes the occurrence of a building as both a rectangular symbol and as a notation on the map. However, the Coast Survey maps from 1853 and 1897 make an attempt at representing the actual footprint of the building, as does the Herrmann surveying map from 1874. The USGS map in 1899 represents all buildings equally in the area, regardless of size. Sources, top row, left to right: Endfield 2001, 14; United States District Court 1873 [*circa* 1838]; Cutts and Rodgers 1853. Middle row, left to right: Wallace and U.S. District Court 1859; Gray and Gifford 1869. Bottom row, left to right: Thompson and West 1876; Westdahl 1897a; U.S. Geological Survey 1899 [1895].

Between 1854 and 1857, the Coast Survey mapped over 100 square miles of tidal marsh in the southern portion of the San Francisco Bay (Grossinger and Askevold 2005b). During this time, David Kerr worked as an Coast Survey aid to Subassistant August Rodgers, and was responsible for completing several of the T-sheets. The USCS annual report noted that

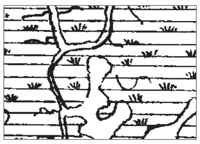
> In order to secure the largest result in the field-work practicable within the season, a second party was organized by Sub-Assistant Rodgers, and placed in charge of Mr. David Kerr, who had served as aid for several years in the topographical party, and previously in the triangulation party engaged in the work on San Francisco Bay (U.S. Coast Survey 1857 [report], 111).

David Kerr produced highly detailed portraits of the sloughs and channels of the tidal marsh. The level of detail he recorded on the maps he was responsible for indicates the influence an individual can have on the final map. Though only one area of overlap between Kerr's and Rodger's work exists, comparison of the area where Rodgers was the primary surveyor reveal that the work Kerr accomplished was much more detailed than that of Rodgers. Figure 9.10 shows the same area mapped by Rodgers in 1853 and Kerr in 1857; Kerr's map shows numerous pannes and smaller sloughs while Rodgers only depicts larger channels.

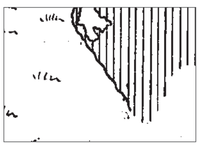
Differences between level of detail on surveys can be attributed to a number of factors, including the urgency of the survey, the individual surveyor, and the relative importance of the area being mapped. One Coast Survey employee argues that such an "elastic system" for standards of accuracy was not practiced (Maher 2004); however, Shalowitz suggests areas considered relatively unimportant were



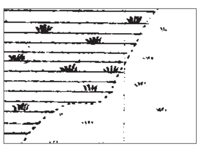
1857, Tidal marsh pattern. Tidal marsh was indicated in 1857 by closely spaced parallel lines (without tufts of grass); sloughs and channels running through the tidal marsh were drawn with double or single lines, and pannes were depicted as round or irregularly shaped pond-like features.



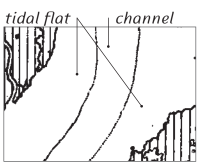
1897, Tidal marsh pattern. By 1897, tidal marsh was depicted by straight lines with tufts of grass added; similar to the 1857 map, sloughs and channels running through the tidal marsh were drawn with double or single lines, and pannes were depicted as round or irregularly shaped pond-like features.



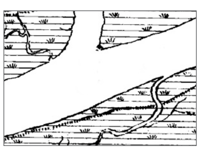
1857, Tidal marsh and upland interface. On early Coast Survey maps the line between the tidal marsh and uplands was indicated in one of two ways. The first method used a solid line to separate the tidal marsh from other features. The second method was simply a cessation of the parallel lines of the tidal marsh.



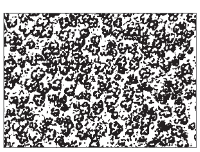
1897, Tidal marsh and upland interface. By 1897, the line between the tidal marsh and uplands is indicated with a dotted line separating the two (note tufts of grass indicating tidal marsh, used consistently by 1897).



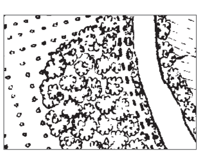
1857, Channels and tidal flats. Tidal flats were shown on either side of the deeper channel, and the two features were separated by a series of very closely spaced dots. Showing the deeper channels was important for navigating the sloughs between landings and bay during this time period.



1897, Channels. Channels were shown without the location of the tidal flats. By 1897, railroads replaced channels as a primary means of navigation, and the depiction of tidal flats became far less important.

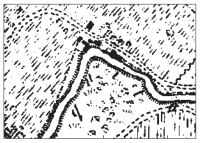


1857, Riparian habitat. Early Coast Survey maps depicted wooded areas close to the tidal marsh. This symbol indicated the presence of deciduous trees or thick undergrowth, and in the South Bay, could indicate a sausal or dense grove of willow trees.

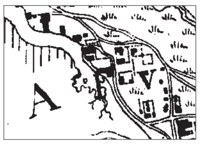


1897, Riparian areas along creek. Trees and brush along a creek are depicted with clusters of tree symbols on either side of the creek. Note crop symbols beyond riparian areas and dashed double lines indicating a road along creek.

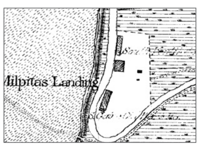
Figure 9.8. Examples of changing symbology used on Coast Survey maps in tidal marsh patterns, channels and tidal flats, and riparian habitat. These symbols are found on T-sheet 676, 1857 (Rodgers and Kerr 1857), and contrasted with symbols on T-sheet 2313, 1897 (Westdahl 1897a).



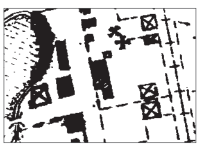
1857, Cultural features. Cultural features such as towns, roads, buildings, structures, and farms were shown less frequently on T-sheet 676, which concentrates on the tidal marsh to the exclusion of anthropogenic features. Only areas immediately adjacent to the tidal marsh that entail cultural features were shown. For example, buildings were shown as solid rectangles; levees along the creek were depicted as closely spaced hatches; a field crop was indicated with broken parallel lines; roads were shown as parallel dashed lines.



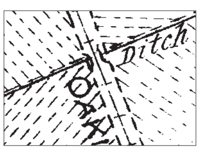
Landings—where a deepwater channel came close to land and infrastructure was established for shipping—were shown on the Coast Survey maps with roads, levees, and buildings at the edge of or jutting into the tidal marsh.



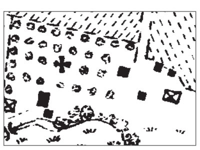
1897, Cultural features. Cultural features were much more commonly depicted by 1897 in T-sheet 2313. Shown to the left is the Milpitas Landing, which was largely replaced by railroads by 1897. Westdahl described the landing as "practically abandoned" (Westdahl 1897b, 4).



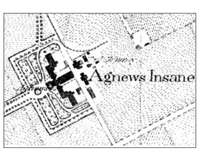
Shown here are houses and buildings in Milpitas, with a railroad line running vertically on the east side. Westdahl described Milpitas as a "small but apparently thriving town" that was the center of a farming area "devoted to the raising of asparagus" (Westdahl 1897b, 4).



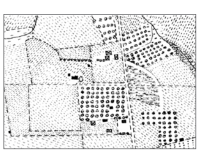
Railroad lines were shown as lines with evenly spaced hatches. Shown here, the railroad crosses a ditch, depicted as a dashed line, running under the rail line. A bridge was indicated by two back-to-back curved lines.

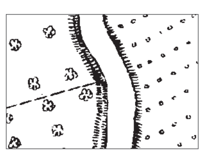


Houses were typically depicted as rectangles with a solid fill; outbuildings are open rectangles with a 'X' in the center. Windmills are indicated by a solid thick cross symbol.



By 1897, prominent features of economic or social interest—such as the Agnews Insane Asylum and the Lick Paper Mill—were shown on the surveys.





Farms were shown in detail, with varying symbols depicting different crops. "To protect the valuable orchards and fields in the low country through which it flow, Coyote Creek has been dyked," notes Westdahl (1897b, 2). These levees were depicted by closely spaced hatches.

Figure 9.9. Examples of changing symbology for cultural features on Coast Survey maps. These symbols are found on T-sheet 676, 1857 (Rodgers and Kerr 1857), and contrasted with symbols on T-sheet 2313, 1897 (Westdahl 1897a).

mapped to a lesser degree of accuracy. "To have surveyed every then unimportant creek or slough with the same degree of detail as was included in surveys of an important river of harbor," notes Shalowitz, "could not have been justified administratively or otherwise" (1964, 80).

The contrasting degree of detail on the maps by Kerr and Rodgers suggests that one of them was not following Coast Survey direction. Perhaps Kerr, working in the absence of his supervisor, felt compelled to add more detail rather than less; certainly if navigability

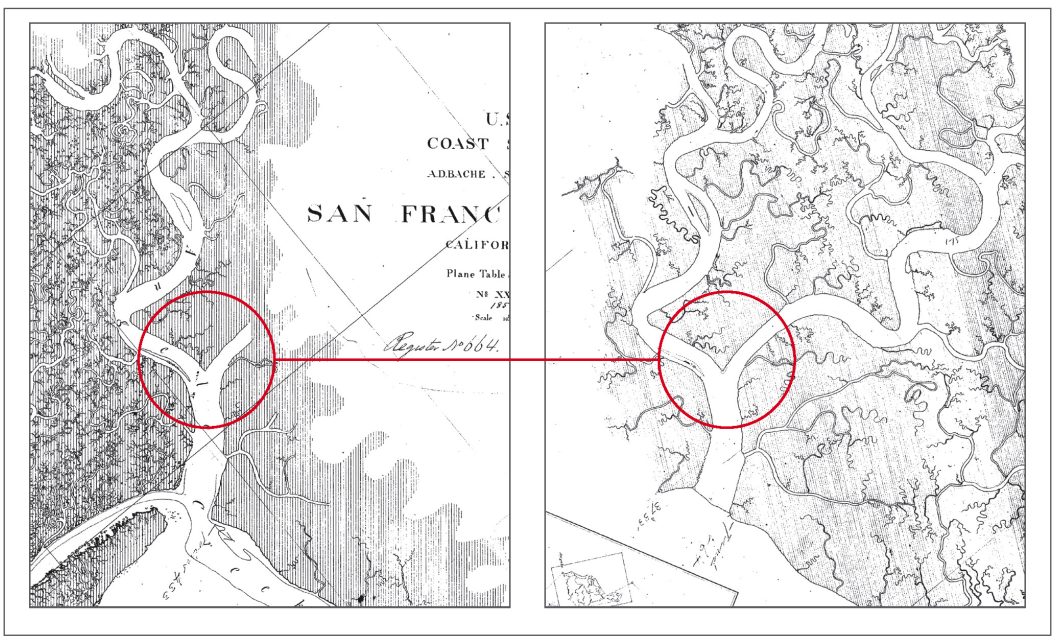


Figure 9.10. Different levels of detail in Coast Survey mapping. The survey on the left (Rodgers and Kerr 1857b) adjoins the survey on the right (Rodgers 1853) at Angelo Slough in San Mateo County (indicated by red circles). While the major sloughs overlap, the differences are in the level of detail that Kerr shows, with numerous pannes and intricate slough not depicted by Rodgers.

of the sloughs for commerce was the primary impetus in mapping the area, Rodgers' maps are adequate to the task. As historical evidence, Kerr's maps—presenting a level of channel and pond detail not evident on Rodgers' surveys—are an invaluable resource. Because Kerr rather than Rodgers was the primary surveyor for a significant number of the early Coast Survey maps in the Bay Area, the maps he completed provide a highly precise historical image of a complex estuary system.

The initial survey in the 1850s was followed by a resurvey of the same area in 1897, even though the country was facing difficult economic times (Manning 1988, 150). The two maps—made forty years apart—show the changing social and economic climate. The original T-sheet 676, surveyed by David Kerr in 1857 (Figure 9.11), contrasts with Coast Survey T-sheet 2313, surveyed by Ferdinand Westdahl in 1897 (Figure 9.12). In T-sheet 676, Kerr had stopped short of even mapping the entire salt marsh and Alviso is the only hint of land. In contrast, T-sheet 2313 embraces the land, depicting farms, orchards, roads, towns, and freshwater creek courses (see also Figure 9.9). On the 1897 map, the landings that had served as shipping points have largely fallen out of use, replaced by railroads as a means of transportation. Farms are numerous, and orchards are replacing grain as the area's primary crop (Broek 1932). Running north from Alviso and cutting across the Coyote and Mud Sloughs, the South Pacific Coast Railroad—by this time swallowed up by the Southern Pacific (MacGregor 2003)—even defines the western edge of T-sheet 2313. Coast Survey employees wrote descriptive reports for each sheet of the resurvey. Ferdinand Westdahl described the area in his report:

> In the rainy season both [Guadalupe River and Coyote Creek] are considerable streams. To protect the valuable orchards and fields in the low country through which it flows Coyote Creek has been dyked. These dykes rise twenty and more feet above the general level at the Southern limit of the sheet, are broad enough for a road along the top, and are covered with willows and bushes. ...Artesian wells are numerous and ditches to carry off the surplus flow are everywhere in evidence. The debatable area immediately adjoining the Salt-marsh, which is sometimes covered at high tides, is used for pastures: all the rest is highly productive and valuable. Vineyards and orchards alternate with large fields devoted to the culture of continuous crops of asparagus, straw berries, black berries, and other small fruit and vegetables (Westdahl 1897b, 2-3).

The land has turned into a valuable commodity, and the Coast Survey has enthusiastically embraced the new land-based economy, reflected in Westdahl's descriptions of the towns and villages encompassed on the sheet. Though Alviso was an important shipping port before the railroad between San José and San Francisco was completed, the now decaying warehouses testify to the town's former importance (Westdahl 1897b, 4). Milpitas Landing is "practically abandoned", while Milpitas itself is "thriving" and "center of a large area devoted to the raising of asparagus and other vegetables" (Westdahl 1897b, 4).

Changes in the landscape are reflected in the new scope of the Coast Survey's map; however, new additions were not always welcomed by the survey parties. Rodgers, who mapped the area in the 1850s, returned in 1894 and 1895, and complains that the county road

> ...is now lined on both sides with eucalyptus trees as are other portions of the same road. These trees are a marked features and a great detriment to the use of the plane table, as they form an impenetrable barrier to vision and present sight of stations (Rodgers 1894-95, 3).

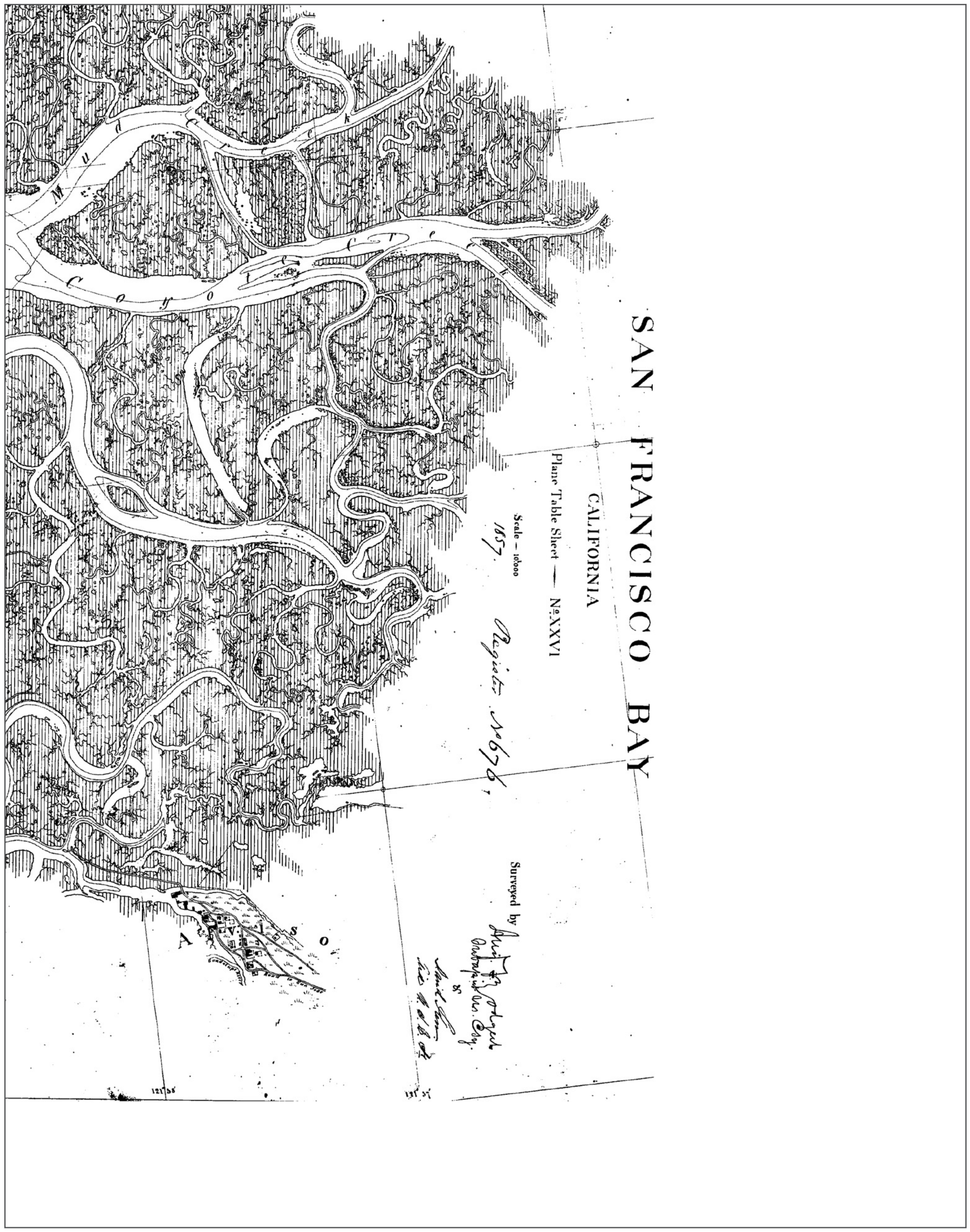


Figure 9.11. T-sheet 676 (Rodgers and Kerr 1857), reflects an economy dependent on shipping for moving goods and products from the South Bay to San Francisco. Limited amounts of wheat, others grains, and cattle-based products were grown during this time (Broek 1932). The world drops off at the edge of the salt marsh in T-sheet 676.

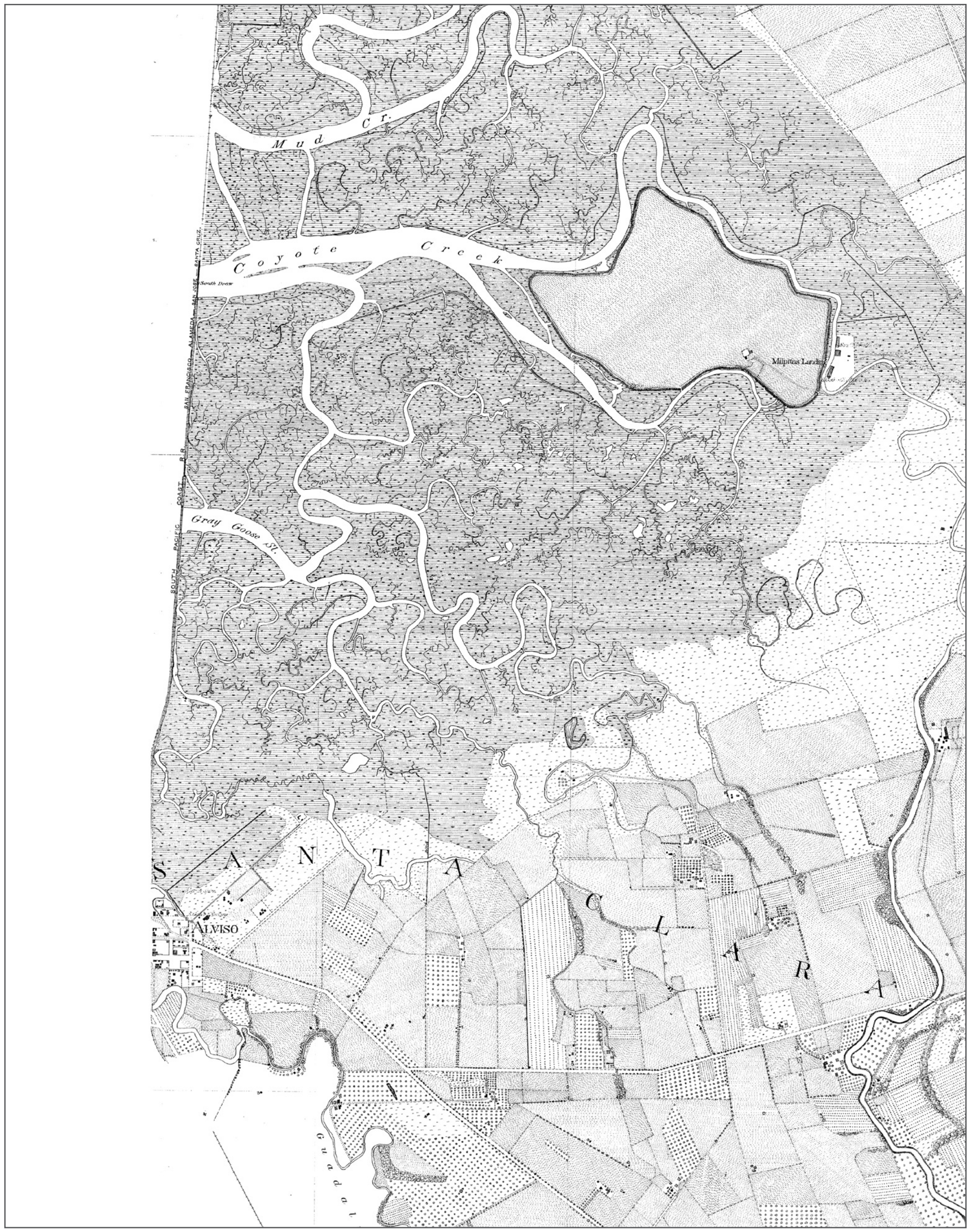


Figure 9.12. T-sheet 2313 (Westdahl 1897a). The territory of interest has been extended, and the productivity of the land is emphasized. In 1897, the surveyors spent considerable time surveying the fields, crop types, roads, railroads, and towns adjacent to the tidal marsh; even the map edge is defined by the South Pacific Coast Railroad running north from Alviso on the western edge.

Mapping the tidal marsh and adjoining lands had the effect of contributing to and confirming a new social and economic view. In 1857, T-sheet 676 shows mostly sinuous channels carved into a backdrop of land inundated by the tides; one has to look closely to detect any human influence on the landscape, so strongly portrayed by 1897. Only Alviso—an early and successful landing—and the roads on the eastern edge of the map sheet give an indication of any social context.

A distinctive bend of Coyote Creek depicted on Coast Survey T-sheet 2313 is also shown by a number of other maps, including a confirmation map, a local surveyor's map, the U.S. Geological Survey (USGS) quadrangle, and on early aerial photography (Figure 9.12). Comparing these maps help to distinguish error from change. The USGS map (Figure 9.12-C), published in 1899, though surveyed in 1895 (US Geological Survey 1899 [1895]), shows a simplified meander pattern when compared to both maps before and after, which all show a similarly complex channel pattern. The USGS map, at a scale of 1:62,500, compromises detail to show a larger area when compared to the other maps, which are all at a larger scale. The confirmation map of 1859 was surveyed by John Wallace at a scale of 1:15,840 (Figure 9.12-A). Instructions to deputy surveyors engaged mapping land claims in the state directed the surveyor to "run the line along the channel, or middle of the bed of such stream, and not on either of its banks" (Uzes 1977, 213), which results in a angular stream course.

Figure 9.12 A-D. Comparison between several map sources along lower Coyote Creek. The land grant confirmation survey (Wallace 1859), Herrmann survey (1874), US Coast and Geodetic Survey (1897), and aerial survey (1939) all show a similar meander pattern, while the USGS map (1895) shows a more generalized channel course. Sources, top row, left to right: Wallace and U.S. District Court 1859; Herrmann 1874; U.S. Geological Survey 1899 [1895]. Bottom row, left to right: Westdahl 1897b; Agricultural Adjustment Administration 1939.

In 1874, Santa Clara County commissioned A.T. Herrmann (Figure 9.13) to complete a detailed survey of Coyote Creek after repeated flooding downstream of San José threatened adjacent farms (Grossinger 2005, personal communication). At 1:3,000 scale, the resulting survey provides a detailed view of the creek's channel (Figure 9.12-B). Herrmann was a well-established surveyor and civil engineer in the county (Foote 1888, 365) who had been instrumental in establishing licensing rules and

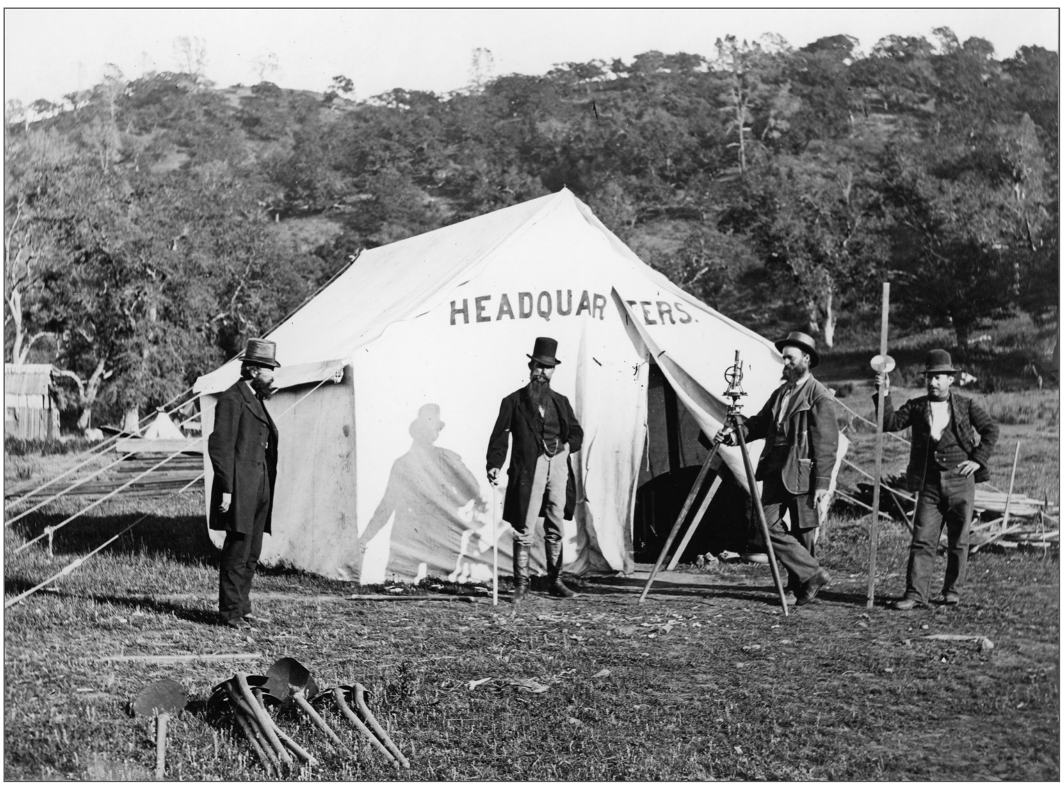


Figure 9.13. A.T. Herrmann, surveyor. A.T. Herrmann is third from left, with transit. His brother, Charles, stands in front of the surveying headquarters. Herrmann served as both U.S. Deputy Surveyor and twice as Santa Clara County Surveyor (Unknown Photographer *circa* 1885, courtesy Sourisseau Academy for California State and Local History, San José State University).

regulations at the state level for surveyors (Uzes 1977, 195). Herrmann's detailed survey is in contrast to the more generalized lines of the USGS map (Figure 9.13-C). In 1939, the aerial survey shows the pattern is still much the same (Figure 9.13-E). The photography is available because of the ambitious program of the Agricultural Adjustment Administration (AAA) of the USDA to ensure compliance with crop stabilization and soil conservation programs (Monmonier 2002, 1257).

Harley suggests we use comparison to help search within these maps for what is omitted (Harley 1990, 36). What the maps in this chapter do not show is at least as significant as the features they do show. For example, none of these maps show the features important to the Ohlone, such as inter-tribal trading network, centers of community life, the locations of shellmounds and burial grounds, or the areas important for acorn, shellfish and waterfowl gathering that were so critical (Friedly 2000, 46). For the most part, the maps do not show the communities, structures, and cultural features of the prior inhabitants. The maps show an increasing tendency away from the personalized view of the *diseños,* and move instead toward depicting the landscape as a standardized set of features in the Coast Survey and U.S. Geological Survey maps.

These comparisons are essential to reliable historical analysis for science-based studies. Each map—because of differences in technique, scale, purpose, and scope—provides a unique glimpse at the landscape, and reconstruction of the landscape is easier when multiple sources are available. When combined, multiple sources can help assess the potential errors or confirm the existence of specific features. Multiple sources allows for “intercalibration” and can increase the confidence level for source material. The following chapter summarizes and discusses the results of research about and comparisons between maps.

Figure 10.1. Surveyors for the U.S. Coast and Geodetic Survey, *circa* 1900, using plane table survey methods on the West Coast (U.S. Coast and Geodetic Survey *circa* 1900).

10. SUMMARY OF RESULTS, DISCUSSION, AND CONCLUSION

The previous chapters present the results of research and provide supporting evidence for placing maps in context, and this chapter summarizes and discusses the results. Table 10.1, below, summarizes the maps discussed in this chapter and references the figure and page number where they can be viewed. The first section summarizes the ways in which science-based studies benefit from contextualizing maps. This is followed by several table-based summaries that present the results of contextual research, along with a discussion about integrating the tables into historical ecology studies. The final section of the chapter, the conclusion, discusses the implications for science-based studies, and suggests further avenues for research.

Table 10.1. Map, agency, year, and figure number. Maps are referred to in this chapter as described below in the first column. The individual maps can be viewed by referring to the figure and page number in the last column.

Title of map as used in this chapter	Agency	Year	Figure and page number
Diseño of *Rincon de los Esteros*	Mexican government	*circa* 1838	6.1-A, page 73
T-sheet 676	U.S. Coast Survey	1857	7.1-A, page 92
T&W Map Sheet Two	Thompson and West	1876	8.1-A, page 126
U.S.G.S. San José quadrangle [detail]	U.S. Geological Survey	1899 [1895]	9.12-C, page 167
Bird's Eye View, San José [detail]	Private lithography	1869	9.7, page 157
Wallace confirmation survey	commissioned by land grant owner; surveyed under instructions from the U.S. Surveyor General	1859	9.3-A, page 151
Reed confirmation survey	commissioned by land grant owner; surveyed under instructions from the U.S. Surveyor General	1862	9.3-B, page 151
Herrmann Coyote Creek survey [detail]	county	1874	9.12-B, page 167
AAA aerial photograph [detail]	Agricultural Adjustment Administration	1939	9.12-E, page 167

SUMMARY OF CONTEXTUALIZING MAPS

Context of the entity and cartographer responsible for the map. Understanding the mission of the agency and the particular biases of the individual cartographer can provide a new level of confidence in the map's use. For example, users can have a high level of confidence in the locational accuracy of the U.S. Coast Survey maps, based on an understanding of the agency's scientific agenda (Figure 10.1). Investigation of the specific cartographer and their practices can yield additional information about individual map sheets. For example, the areas of tidal marsh surveyed by David Kerr provide more detail than maps completed by August Rogers. Potential users—interested in quickly incorporating locational data—might be put off by the inconsistency and apparent lack of spatial accuracy of the *diseños*, but understanding the context can reveal ways in which the information on the *diseños* can be used in a historical ecology study. For example, by combining the narrative court transcripts and the subsequent confirmation surveys with the *diseños,* the location of a specific feature can be located with more confidence. Additionally, a study of the context may reveal that the information on the *diseño* provides such a unique view of the relatively unmanaged landscape that we seek new ways in which to incorporate the data, perhaps through use in a narrative description of the historical landscape. Understanding the motivating forces behind the Thompson and West maps, in which the atlases were designed to appeal to individual subscribers and to turn a quick profit for the authors, might be a warning flag for the scientific user. The following table summarizes the context of the entity or agency for the three primary maps considered in this study (Table 10.2).

Table 10.2. Summary of context of agency.

Title of map as used in this chapter and responsible agency	Summary of context of agency
Diseño of *Rincon de los Esteros* (Mexican government)	Generated by individuals to satisfy requirements of state (Mexico) in a real estate transaction; the *diseño* was a sketch rather than a formal map, and was only one part of a number of documents required; maps were usually created by individuals not trained in scientific cartography, and show relationships rather than carefully defined boundaries
T-sheet 676 (U.S. Coast Survey)	Agency established because of urgent need for coastal maps for safe navigation and defense; commerce and new economy drove funding, but agency regarded science and scientific mapping methods as their primary reason for existence; individuals within agency had significant impact on final product, despite attempts to standardize; agency was active in exploring and promoting highly exact mapping methods and standards
T&W Map Sheet Two (Thompson and West)	Atlases developed for profit through commercial sale; connected to early wall maps of individual counties and gazetteers; Thompson and West took advantage of a growing Western U.S. market; sold subscriptions to individual farmers and land owners; atlas maps were compilations of existing maps, updated to please subscribers; profit was motivating factor

Social, political, and economic context of the map. Understanding the context in which a map is made provides additional insight into the potential uses of a map. For example, appreciating that the *diseño* was a document in what was essentially a real estate transaction helps orient the potential user, but a deeper understanding of the transition between Mexican and U.S. rule is important for interpretation of the map, and the map is only fully understood by comprehension of the different cultural attitudes toward property and boundaries. When assessing the Coast Survey maps, building an understanding of the rapidly changing political, economic, and social fabric of the San Francisco area informs the use of the maps. Understanding how important bay and navigable sloughs were to the economy—coupled with the agency's scientific zeal—helps explain the precision and detail of the resulting surveys. Knowing that there was tremendous economic pressure to produce the Coast Survey maps quickly might lead to questioning the quality of the maps, though further research reveals that this urgency was countered by the drive in the agency for scientific accuracy. Knowing the changing focus from a water-based transportation network to a land-based system of railroads assists in using the Coast Survey maps created in the 1890s, as the focus of the maps turned landward. Thompson and West atlases are better used after considering the context in which they were made, as the atlases reflect a new pattern of land ownership that evolved rather rapidly from the loose boundaries of land grants and communal grazing land into carefully defined farms, carved out of the land grant property. The following table (Table 10.3) summarizes the social, political, and economic context of the three primary maps considered in this study.

Table 10.3. Summary of social, political, and economic context.

Title of map as used in this chapter and responsible agency	Summary of social, political, and economic context
Diseño of *Rincon de los Esteros* (Mexican government)	When Mexico took control of area from Spain, Mexico allowed individuals to own land, which was a radical departure from Spain's ownership solely by the state and church; the short-lived system of Mexican ownership was replaced by the U.S. system, which required scientific-based surveying methods (in the form of confirmation surveys) for the establishment of land ownership; the *diseños*—with their symbolic portrayal of the landscape—were in conflict with the U.S. courts and system of land ownership, but also provide a unique view of the landscape
T-sheet 676 (U.S. Coast Survey)	The Bay Area was in transition between several cultures (Native American, Spanish, Mexican, American) when T-sheet 676 was created; T-sheet 676 represents an interest in a water-based method of transporting goods; the Gold Rush made the survey of the West Coast an immediate priority for safety and commerce
T&W Map Sheet Two (Thompson and West)	Thompson and West atlases represent a changing economic focus, with a land-based transportation network and a profit-driven agricultural community; the pattern of ownership had changed radically from a few land grants supporting cattle grazing to smaller land owners and farming for profit; the water-based economy of T-sheet 676, dependent on navigable sloughs and quick bay transport, was largely replaced by railroads

Mapping and printing technology. Understanding how a map was constructed, printed, and distributed can help inform the user as to its appropriate use. For example, knowing the author of the *diseño* was not trained in science-based cartography and was instead employing a symbolic type of map-making, invites the user to understand the maps as unique and personal statements. Knowing that multiple copies of the same map exist may make the *diseños* more challenging to use, but can provide useful alternative views. Understanding how measurement units varied and were not standardized assists in interpreting the *diseños.* Developing an understanding of the technology that the Coast Survey employed is key to determining the locational accuracy of the Coast Survey maps, and requires an understanding of the differences between plane-table surveying with a geodetic framework and a compass traverse survey. The printing technology the Coast Survey used is important, as copperplate engraving made the extremely fine line work possible, and a study of the methods shows that the Coast Survey sought the most innovative technology, which was consistent with the innovative methods used for the actual surveying. Thompson and West maps, on the other hand, were compilations of existing surveys. The study incorporating them should understand that they were not original surveys, but were copied from existing base maps with details sketched onto the base maps while in the field. Learning this may prompt the user to seek out the original surveys the Thompson and West maps were based on to provide more accurately delineated data, or to corroborate the information on the Thompson and West maps with other sources. The following table (Table 10.4) summarizes the mapping and printing technology for each of the three primary maps considered in this study.

Table 10.4. Summary of mapping and printing technology.

Title of map as used in this chapter and responsible agency	Summary of mapping and printing technology
Diseño of *Rincon de los Esteros* (Mexican government)	The *diseños* were created without specialized survey equipment; a *diseño* is a sketch rather than a formalized map and usually has no scale, legend, or title; features are often represented by pictographs rather than symbols; locations are not exact, but represent the relationship between features; sketch was created by either standing at a central point in the property and filling in features or by riding the perimeter on horseback, measuring *varas* with ropes; the measurement unit was not standardized; maps are letter-size, done in black ink, with occasional color added; the *diseños* were not printed—if additional copies were needed (such as for the U.S. court system) they were made by copying the original
T-sheet 676 (U.S. Coast Survey)	The Coast Survey utilized some of the most advanced scientific mapping methods available; T-sheet 676 used geodetic measurements to account for the shape of the earth and plane table surveying to precisely map features; T-sheets were mapped at 1:10,000 scale and match up with features that are still persistent; Coast Survey developed innovative and precise printing methods, continuing to use copperplate engraving even after the less precise lithographic technology was available but also experimented with photo-engraving techniques
T&W Map Sheet Two (Thompson and West)	The atlas maps were created by compiling existing maps, gathered by Thompson and West employees, who would create base maps from county and city maps; the base maps were updated in the field by sketching in features and correcting ownership information from horseback; the maps were reproduced using the relatively new lithographic printing technology, which allowed for quick and inexpensive updating; atlases were printed as quickly as possible to keep expenses down and to keep information current

TABLES PRESENTING SUMMARY OF RESULTS

How does this knowledge affect their usefulness in science-based studies? The following section summarizes the results through a series of tables that can be applied to any historical maps in preparation for use in a science-based study. These tables include an index of strengths and weaknesses of source material, ranking maps based on date of publication, extent of coverage, spatial precision and scale, and descriptive detail; a table comparing the map's original purpose with possible uses in historical ecology; a "certainty level" table, ranking the potential of a map to allow for correct interpretation and accurate placement of features of interest; and a table of "usability", which summarizes the usability of maps for appropriate use, based on the previous tables.

These tables represent an integrated approach for the applied use of historical maps in a science-based study. In the tables, I used a narrative description to compare the map's attributes instead of attempting to assign a numerical score. This allows the user to understand the variability between the data sources without forcing a quantitative precision not supported by the maps. The tables are conceptual rather than prescriptive—developing the tables can reveal new relationships about the maps rather than simply being an end. The tables reveal variation between the available maps, and should encourage a thoughtful integration of the maps, dependent on the project objectives.

For the purpose of the tables, it is assumed that the maps are being used for a project involving the restoration of tidal marshes and the upland creeks that feed them; hence the features of interest are historical sloughs, channels, pannes of the tidal marshland, as well as the active and high water creek channels. Several maps beyond the three primary maps (the *diseño* of *Rincon de los Esteros,* T-sheet 676, and T&W Map Sheet Two) have been added. Maps added include the 1899 USGS Palo Alto quadrangle; the Wallace confirmation map and the Reed confirmation map, (both confirmation maps for the *diseño* of *the Rincon de los Esteros);* the bird's eye view of San José; Herrmann's Coyote Creek survey from 1874; and the AAA aerial photography from 1939 (see Table 10.1). These maps were either discussed at length in Chapters 6, 7, and 8 (the *diseño* of *Rincon de los Esteros,* T-sheet 676, and T&W Map Sheet Two), or used as a comparison map in Chapter 9.

Strengths and weaknesses of source material. The overall strengths and weaknesses of source material can be developed from information gathered during research of the map. Historical maps for an area provide alternate views of the past landscape, each map depicting varying features at different scales, levels of accuracy, and covering differing geographic extents, depending in large part upon the maps' context and technology used to develop the map.

Criteria that might be used to evaluate maps for a restoration project seeking to develop an understanding of how the pre-European landscape worked were used, including understanding when the map was published; how continuous the coverage of the map is over the study area; the scale of the map, which often is connected to how spatially accurate the data is; and if the map contains useful descriptive data. While these are somewhat subjective, comparing maps to each other can increase a user's understanding of the relative usefulness of the maps. For example, the table can be used to help determine which sources might best be used in a geographic information system, based on scale and spatial accuracy; which maps would be best used in a narrative description of the historical landscape; and how the maps might complement each other.

The strength and weakness table relies on comparisons between maps, as the strengths and weaknesses of various sources are in many ways relative to the other sources available. For example, while the U.S. Coast Survey maps may be spatially very precise, they may not cover the entire area of interest, as they extend only to the edge of the tidal marshes. Other sources—such as the U.S. Geological Survey maps at the turn of century—may not be as spatially precise but may provide continuous coverage across the study area.

In Table 10.5, 'Date of publication' is included because the date of the map directly affects the features depicted on the map. If the user is interested in establishing a time series of conditions, a wide range of published dates is preferable. If the user is attempting to recreate the pre-Euro-American landscape, as is assumed here, then the earlier maps are significant resources. 'Continuous spatial coverage' indicates

Table 10.5. Summary of strengths and weaknesses of sources. Each criteria is ranked from 1 to 5, 5 being the best and 1 being the least desirable. 'Date of publication' is broken into three categories: 'prior to 1875; very early'; 'after 1875 but before 1925; early'; and 'after 1925 but before 1950; recent'. 'Continuous spatial coverage' is classified as either covering only a portion of the study area or covering the entire study area. 'Scale' is ranked as small (above 1:25,000), medium (above 1:10,000 but below 1:25,000), or large (below 1:10,000), and the elated spatial precision is categorized as very precise, precise, or imprecise. Descriptive detail—which includes notations, placenames, and useful symbols or icons—is categorized as many, some, few., or none.

Characteristics / Map and year	Date of publication	Continuous spatial coverage	Scale and spatial precision	Descriptive detail
Diseño of *Rincon de los Esteros, circa* 1838	prior to 1875; very early	available *diseños* cover only portion of study area	unknown scale; imprecise	contains many notations, placenames, and symbols or icons
T-sheet 676, 1857	prior to 1875; very early	combined T-sheets cover only portion of study area	large scale; very precise	contains some notations, and placenames
T&W Map Sheet Two, 1876	after 1875 but before 1925; early	T&W atlas covers entire study area	small scale; precise	contains many notations, placenames, and symbols or icons
U.S.G.S. Palo Alto quadrangle, 1899	after 1875 but before 1925; early	available quadrangles cover entire study area	small scale; precise	contains many notations, placenames, and symbols or icons
Bird's Eye View, San José, 1869	prior to 1875; very early	covers only portions of study area	unknown scale; imprecise	contains many symbols or icons
Wallace confirmation survey, 1859	prior to 1875; very early	available confirmation surveys cover only portion of study area	medium scale; precise	contains few notations, placenames, and symbols or icons
Reed confirmation survey, 1862	prior to 1875; very early	available confirmation surveys cover only portion of study area	medium scale; precise	contains few notations, placenames, and symbols or icons
Herrmann Coyote Creek survey, 1874	prior to 1875; very early	available surveys cover only portion of study area	large scale; precise	contains some notations, placenames, and symbols or icons
AAA aerial photographs, 1939	after 1925 but before 1950; recent	flight lines available for entire study area	large scale; precise	contains none

Past Purpose / Present Possible Use Table. The following table (Table 10.6) notes the original purpose of the map, based on research investigating the map's context. Researching the original purpose allows the user to understand the range of possible contemporary uses in historical ecology studies. For example, the Herrmann Coyote Creek survey of 1874 may provide accurate channel and bank delineation. The same survey also indicates the location of houses and farm buildings along the creek, but they may not be located accurately, since the purpose of the survey was to delineate creek boundaries. The Thompson and West Map Sheet Two, 1876 could be used to gather information about the location and extent of natural features, but given the original purpose—to create an atlas from compiled sources that would appeal to a commercial market—using it for this purpose may not be the best use, at least without confirmation from other sources.

Table 10.6. Summary of original purpose and possible contemporary uses.

Map and year	Original purpose	Possible contemporary uses in historical ecology studies
Diseño of *Rincon de los Esteros, circa* 1838	To establish ownership boundaries and to satisfy requirements of a real estate transaction between an individual and the state	Useful for symbolic and descriptive detail of natural features, especially along boundaries, including sausals, stream channels, riparian areas, pannes, sloughs, perennial wetlands; also shows relationships between features (i.e. bridge crossing is above the willow trees; house is located where road intersects creek, etc.)

Table 10.6, continued. Map and year	Original purpose	Possible contemporary uses in historical ecology studies
T-sheet 676, 1857	To survey and S.F. Bay, sloughs, and channels for safe navigation; secondary purpose to advance scientific mapping methods	Comparison with modern data sets such as aerial photography to identify remnant tidal marsh areas; use pattern of sloughs, pannes, and tidal lands in restoration efforts (for example, determine locations of levee breeches or appropriate combination of tidal channels and pannes in restoration)
T&W Map Sheet Two, 1876	To create atlases showing land ownership that would appeal to local farmers and business people	Useful for establishment of farm boundaries, land and business ownership; indicates network of early road and railroad system; relative widths of stream channels and relationships with other natural features; also provides continuous coverage of entire county and may be suitable as a base map
U.S.G.S. Palo Alto quadrangle, 1899	Objective of agency was initially to map geology; however, this was expanded to include topography, and the 1899 Palo Alto quadrangle is one of the agency's early topographic maps; maps show natural and cultural features including elevation contours, bays, sloughs, upland creeks, towns, roads, and railroads	Useful because of continuous extent across a given study area, but captures landscape after significant post-European impacts; provides a relatively small scale but consistent image of both cultural and natural features; can be used to build a segment of a time sequence in a historical ecology
Bird's Eye View, San José, 1864	Commercial print for sale to the public; for profit venture; to create a compelling and attractive image that would appeal to residents	Drawing can be used to interpret relative amount of vegetation along stream channels; relative width of stream channels; vegetation on hillsides; amount of development relative to open space; degree of modification along creeks
Wallace confirmation survey, 1859	Commissioned by the land owner to survey the land to the U.S. court's satisfaction; unlike the original *diseños,* carefully controlled compass traverse methods were employed to establish a tightly controlled boundaries	Early but highly spatially accurate survey at a relatively large scale; limited natural features are indicated on maps, but where they coincide or are part of the ownership boundaries, they are accurately depicted in detail; for example, the Wallace confirmation survey shows the boundary demarcating the edge of the salt marsh, the channels of both Guadalupe River and Coyote Creek, and various trees used as surveying markers

Table 10.6, continued. Map and year	Original purpose	Possible contemporary uses in historical ecology studies
Reed confirmation survey, 1862	Required by the courts to assert a tightly controlled surveying process over land grant boundaries; and to legally satisfy the conditions imposed by the U.S. courts	Early but highly spatially accurate survey at a relatively large scale; limited natural features are indicated on maps, but where they coincide or are part of the ownership boundaries, they are accurately depicted in detail; for example, the Wallace confirmation survey shows the boundary demarcating the edge of the salt marsh, the channels of both Guadalupe River and Coyote Creek, and various trees used as surveying markers
Herrmann Coyote Creek survey, 1874	The County of Santa Clara commissioned Herrmann to survey the creek in preparation for flood control	Reconstructing channel width with large-scale surveyed data; understanding channel length, sinuosity, topography and propensity to flood
AAA aerial photographs, 1939	Part of a nation-wide effort to track agricultural and crop patterns on individual farms	Analyzing environmental changes after European contact but prior to extensive urbanization; using stereopairs to evaluate type of vegetation; taking measurements of features on the landscape

The original purpose of the map can also be compared to a more specific contemporary use, as in the following table (Table 10.7) In this table, it is assumed that the maps are being used for a project involving the restoration of tidal marshes and the upland creeks that feed them; hence the features of interest are historical sloughs, channels, pannes of the tidal marshland, as well as the low flow and high flow creek channels. The possibility of extracting these features, given the original map's purpose, are evaluated. It should be noted that this is only one indication of the utility of a map, and even a map that was created for a very different original purpose can be used for comparative purposes at the very least.

Table 10.7. Ranking of how close contemporary use is to original purpose. Each map is rated as to its appropriate use in constructing a map of historical tidal marsh habitat and upland creeks. Maps whose original purpose match most closely the intended contemporary use are given the designation of 'very close'; maps whose original purpose has overlap with the intended contemporary use are designated as 'close'; maps whose original purpose deviate significantly from the intended contemporary use are designated as 'distant'. See also Table 10.6.

Map and year	Rank of how close contemporary use is to original purpose
Diseño of *Rincon de los Esteros, circa* 1838	distant
T-sheet 676, 1857	very close
T&W Map Sheet Two, 1876	close
U.S.G.S. Palo Alto quadrangle, 1899	very close
Bird's Eye View, San José, 1864	distant
Wallace confirmation survey, 1859	close
Reed confirmation survey, 1862	close
Herrmann Coyote Creek survey, 1874	very close
AAA aerial photographs, 1939	close

Certainty Table. Historical maps are often incorporated into a map that shows past conditions based on a number of maps and sources. Geographic information system (GIS) software is well-suited to combine data, and the ability to create any number of attributes to describe the map source and associated certainty levels makes GIS an ideal tool for synthesis. When placing information gathered from historical maps into a GIS, it is unfortunately relatively easy to make boundaries that were uncertain in the historical map appear accurate through incorporation into a GIS (Knowles 2000). By recording a series of 'certainty' levels describing the confidence level in a map, the GIS can depict varying levels of interpretive, areal, and locational certainty. Establishing a certainty level is particularly useful for synthesis of data into a GIS, and can also determine which maps are more appropriately used in a narrative description.

The following table (Table 10.8) establishes three different possible levels of certainty of interpretation, size, and location of features: high certainty; probable certainty; and possible certainty (Grossinger and Askevold 2005a, 34). Each of these levels is described in Table 10.8 and then applied to each of the maps considered in the study (Table 10.9).

Table 10.8. Description of certainty levels. This table describes a rating system that can be applied to features on a map after an investigation of the map's provenance. Based in part on the context of the map, the techniques used to create the map, and the nature of the feature being interpreted (i.e. the closer the feature is related to the original primary purpose of the map, the higher certainty the feature has).

	Interpretation of feature	Size of feature	Location of feature
High (definite)	Data on map directly support strong interpretation of feature	Data on map directly support mapped size (estimated max. error +/- 10%)	Data on map directly support mapped location (estimated max. error 500 feet)
Medium (probable)	Data on map directly or indirectly support strong interpretation of feature, with some qualifications	Data on map directly or indirectly support size, but with some qualifications (+/- 50%)	Data on map directly or indirectly support location, but with some qualifications (+/- 2000 feet)
Low (possible)	Data on map are limited or contradictory, and supports interpretation of feature only with corroborative map sources	Data on map are limited or contradictory, and supports size of feature only with collaborative map sources	Data on map are limited or contradictory, and support size of feature only with collaborative map sources

Table 10.9. Summary of certainty levels for each map. Each of the maps is rated for the confidence level of interpretation of features, and the accurate depiction of the size and location of features. This table describes a rating system that can be applied to features on a map after an investigation of the map's provenance. Here it is assumed that the maps are being used for a project involving the restoration of tidal marshes and the upland creeks that feed them; hence the features of interest are historical sloughs, channels, pannes of the tidal marshland, as well as the low flow and high flow water creek channels.

Certainty / Map and year	Interpretation of feature	Size of feature	Location of feature
Diseño of *Rincon de los Esteros, circa* 1838	Low	Low	Low
T-sheet 676, 1857	High	High	High
T&W Map Sheet Two, 1876	Medium	Medium	Medium
U.S.G.S. Palo Alto quadrangle, 1899	High	Medium	Medium
Bird's Eye View, San José, 1864	Low	Low	Low
Wallace confirmation survey, 1859	Low	High	High
Reed confirmation survey, 1862	Low	High	High
Herrmann Coyote Creek survey, 1874	High	High	Medium
AAA aerial photographs, 1939	High	High	High

Usefulness Index. The index of usefulness is a relatively subjective one, developed from exploring the context of each map but largely dependent on the purpose of the historical ecology study. The 'Usefulness Index' (Table 10.10) can help reveal the importance of data that might be overlooked because of its low rating on the 'Certainty Rating'. For example, a study relying on locating features accurately for use in geographic information system may find scientific-based mapping products such as those completed by the Coast Survey more useful than the *diseños.* However, the *diseño* may provide such an early and unique picture of the landscape that the study will find a way to incorporate the information despite its lack of spatial certainty. Though the scores for each map are totaled into one cumulative score, critical individual components—such as earliness—should be considered as well.

Overall rankings reflect the relative usefulness of a source, but need to be adjusted to match the needs of the study. It is assumed that in a restoration effort, spatial accuracy is important for locating historical features using a GIS. However, the relative earliness of a map is also critical for creating a landscape before the tidal marsh and upland creek habitats were degraded. Depending on the study, it might be useful to weight certain important criteria. For example, the Coast Survey T-sheet 676 receives rather high ranking in most categories The T-sheets extend only as far inland as the tidal marshes, so the map receives a lower rating for geographic extent; and the maps record a landscape that has already been significantly altered by human manipulation. The map receiving many lower rankings—the *diseño* of *Rincon de los Esteros*—is one of the earliest detailed maps of the area. If earliness became one of the primary indicators of useful data, that factor could be weighted to reflect the importance of that criteria.

Table of Comparisons. In Chapter 9, several maps were compared, which allows the user to better understand each map's particular technical and social context. Table 10. 11 summarizes several factors, and allows the user to compare several factors such as cartographic technique, geographic extent, and printing technology.

Table 10.10. Summary of usability attributes for each map. This table can be used to quickly compare various features of maps, including characteristics regarding the map's strengths and weaknesses; an assessment of how closely the contemporary desired use is to the original purpose of the map; and ranking of the map's certainty levels, for interpretation, size, and location of features.

	Characteristics				Original Purpose	Certainty		
Map and year	Date of publication	Continuous spatial coverage	Scale and spatial precision	Descriptive detail	Score of how close contemporary use is to original purpose	Interpretation of feature	Size of feature	Location of feature
Diseño of *Rincon de los Esteros, circa* 1838	very early	portion only	unknown scale; imprecise	many	distant	Low	Low	Low
T-sheet 676, 1857	very early	portion only	large scale; very precise	some	very close	High	High	High
T&W Map Sheet Two, 1876	early	entire area	small scale; precise	many	close	Medium	Medium	Medium
U.S.G.S. Palo Alto quadrangle, 1899	early	entire area	small scale; precise	many	very close	High	Medium	Medium
Bird's Eye View, San José, 1869	very early	portion only	unknown scale; imprecise	many	distant	Low	Low	Low
Wallace confirmation survey, 1859	very early	portion only	medium scale; precise	few	close	Low	High	High
Reed confirmation survey, 1862	very early	portion only	medium scale; precise	few	close	Low	High	High
Herrmann Coyote Creek survey, 1874	very early	portion only	large scale; precise	some	very close	High	High	Medium
AAA aerial photographs, 1939	recent	entire area	large scale; precise	none	close	High	High	High

Table 10.11. Summary of maps and photograph compared in Chapter 9. Categories of comparison in the table include cartographic technique, summary of main features shown on map, which features are not shown, what is shown in margins, printing technology, scale, perspective, area depicted, and responsible agency. This allows the user to quickly assess the various graphical sources and look for suitable maps and rule out less suitable maps for a specific project.

	Diseño of Rincon de los Esteros	T-sheet 676	T&W Map Sheet Two
Year	c. 1838	1857	1876
Cartographic Technique	symbolic map	plane table survey with geodetic controls	compiled from existing surveys
Main features depicted on map	Guadalupe River, Coyote Creek, Penitencia Creek, road to mission, esteros (pannes), sausal (willows), pictographs (trees, Alivso adobe)	sloughs, channels, tidal marsh, pannes, connecting upland waterways, Alviso, some uplands	on Map Sheet 2, not just detail area: sloughs, creeks, roads, railroads, towns, ownership boundaries, owner names and acres, orchards, strawberry fields, occasional pictograph (houses, churches), hachures indicating hills, land grant names, ward names
Notable features not shown?	the edge of the bay,	cultural features; any land beyond the tidal marsh	any natural vegetation
Shown in margins	north arrow, text	north arrow, scale, title, surveyor's names, table of measurements	page is all map material; no legend elsewhere in atlas
Printing technology	drawn by hand	copperplate engraving and printing	lithographic printing; then colored by hand
Perspective	plan form with pictographs	plan form	plan form
Scale	none stated	1:10,000	none stated
Area depicted	Rancho Rincon de los Esteros	area between Ravenswood on west and Coyote Creek on each; only encompassing tidal marsh	detail from map showing Rancho Rincon de los Esteros area (whole map sheet covers from west from Alviso, east to the hills north to SF Bay, and south almost to Agnew
Responsible agency, entity, or individual	commissioned by Berreyesa	U.S. Coast Survey	Thompson and West, county atlas publishers

[Table 10.11 is continued on next page]

Table 10.11, continued

	Wallace confirmation survey	Reed confirmation survey	U.S.G.S. San José quadrangle
Year	1859	1862	1899 (printed); 1895 (surveyed)
Cartographic Technique	compass traverse survey	compass traverse survey	
Main features depicted on map	Guadalupe River, Coyote Creek, edge of salt marsh, S.F. Bay, town (Alivso), road crossing, text (marker posts and trees, house, salt marsh, landing, name of surrounding ranchos), Mount Diablo Meridian	Guadalupe River, Coyote Creek, edge of salt marsh, S.F. Bay, town (Alivso), road crossing, text (marker posts and trees, house, salt marsh, landing name of surrounding ranchos), Mount Diablo Meridian	contour lines, railroads, roads, houses, creeks and rivers, tidal marsh, towns and cities, trails, bench marks and triangulation stations, mines and quarries, some cultural features are named
Notable features not shown?	map shows only outside boundary; except for the 'edge of the salt mash' and Alviso town grid, all sloughs, roads, fences, etc. stop just inside the boundary	map shows only outside boundary; except for the 'edge of the salt mash' and Alviso town grid, all sloughs, roads, fences, etc. stop just inside the boundary	Native American settlements or shellmounds; owner's names of houses and farms; ownership lines are not depicted; vegetation is not shown
Shown in margins	north arrow with magnetic declination, title block, seal indicating validity, table of boundaries (listing of station, course or angle, and distance)	north arrow with magnetic declination, title block, seal indicating validity, table of boundaries (listing of station, course or angle, and distance)	legend showing "conventional signs", scale, printing information, adjoining map sheet names, title, surveyor names
Printing technology	drawn by hand	drawn by hand	lithographic printing with three color plates (black, brown, blue)
Perspective	plan form	plan form	plan form
Scale	20 chains to inch	20 chains to inch	1:62,500
Area depicted	Rancho Rincon de los Esteros (9,424 acres)	Rancho Rincon de los Esteros (1,844 acres)	north of Milpitas, south to Los Gatos, east to Alum Rock, west to Alviso
Responsible agency, entity, or individual	commissioned by Berreyesa; U.S. Deputy Surveyor General	required by U.S. Deputy General	U.S. Geological Survey

[Table 10.11 is continued on next page]

Table 10.11, continued

	Photograph of Alviso adobe	Bird's Eye View, San José	Herrmann Coyote Creek Survey	AAA aerial photographs
Year	c. 1905	1869	1874	1939
Cartographic Technique	[photograph]	oblique view, drawing	compass traverse survey	aerial photography
Main features depicted on map	Alviso adobe house, probably depicted on original diseño	streets, buildings, topography, rivers, varying channel width of rivers, railroads, vegetation, factories (with plumes of smoke), farms, bridges, individual people and horses in foreground	active channel of Coyote Creek; high flow channel of creek; riparian vegetation; peripheral ownership boundaries; road and railroad crossings	features are photographed and not interpreted; all features that show at approximately 5,000 feet flying height; aerial photographs were taken specifically to capture agricultural information
Notable features not shown?		any evidence of previous occupants is not shown	anything out side of narrow strip of creek is not shown	unable to see individuals
Shown in margins	notation: "Old Adobe South of Alviso' and 'Mrs. Hare Photo.'	title, designer, lithographer, printer	title, survey points	fiducial marks, flight line number, photo number, date of photograph
Printing technology	profile of house	lithographic printing	drawn by hand (redrafted after fire damaged originals)	black and white photographic prints made from same size negative, or copied from other print
Perspective	profile of house	oblique	plan form	plan form
Scale	n/a	none stated	1:5,000	1:20,000
Area depicted	shows house, barn behind, brush to right of house	city of San José is in foreground and Coyote Creek and Guadalupe River empty into bay in background	three sheets depict Coyote Creek between area north of Milpitas and bay	flight lines from this era cover entire Coyote Creek watershed
Responsible agency, entity, or individual	Alice Hare	published by Geo. H. Hare, Bookseller and Stationer, San José	County of Santa Clara commissioned survey; surveyed by A.T. Herrmann	Agricultural Adjustment Administration (USDA)

CONCLUSION

When introducing this paper, I suggested that answering the following questions would be useful. Does Harley's approach provide a useful framework for using maps in historical ecology? Does understanding the context of a historical map improve its usability in reconstructing a past landscape? Does this awareness allow for better integration into the historical ecology study? Or conversely, can historical maps be successfully used *without* placing them in context?

In the previous pages, I have discussed the results of research using Harley's framework for placing maps in context, applying a theoretical framework to a new domain of historical ecology. Without placing the map in social and technical context, historical maps have the potential to be misused, misinterpreted, or ignored. Historical maps represent an enormous amount of potential environmental data, but cannot be used effectively without understanding the context. The results of this paper suggest several implications for use of historical maps in general, potential applications of the tools developed in the paper, and avenues for further research.

Information collected about maps of a given region becomes synergistic. While researching one map it becomes apparent that knowledge about one map informs the study of another. For example, contrasting the U.S. Coast Survey maps with the U.S. Geological Survey maps reveals that because of the scale and methods used by each agency, the U.S. Coast Survey maps are preferable as sources, but are lacking in continuous coverage. While the U.S. Geological Survey maps are tempting because of their relatively early wall-to-wall coverage, they mapped at a coarser scale and with different standards that may mislead restoration efforts. Understanding the differences between the Coast Survey maps and U.S. Geological Survey maps suggests that USGS maps can be useful as a basemap, and possibly used in conjunction with localized sources such as the 1874 Herrmann survey of Coyote Creek. Gathering information about maps becomes a multi-layered effort—one map may lead to another, and information about the context of a map may help use another map more effectively. The tools and tables developed in Chapter 9 can help organize the array of information that can be collected about maps.

Comparing historical maps is key to assessing sources. Harley's suggestions about map comparisons are critical to reliable historical analysis for several reasons. Each historical map source provides a highly subjective view of the landscape, determined in part by the map's purpose, technique, scale, and time in which it was made. Multiple map sources can confirm the existence or form of a feature; conversely, differing views can bring into question the form of a landscape feature and call for additional research. Independent sources can be used to calibrate the synthesis of a past landscape. As Harley suggests, corroboration through comparisons (when available) can assist in assessing the array of available sources.

Using historical maps in historical ecology requires specialization. Acquiring, interpreting, researching, and integrating historical maps into a historical ecology study requires a wide variety of skills, and requires a multi-disciplinary approach. For example, acquiring maps requires expertise in historical research at libraries, museums, and archives, as well as an understanding of digital sources, compression, and resolution so that maps can be acquired digitally for integration into a GIS. Integrating various historical maps into a GIS requires knowledge and experience in GIS software, the ability to georeference raster maps using GIS tools, database creation for attributing, and an understanding of basic GIS modeling for landscape synthesis. Synthesizing the various sources requires knowledge of current and past habitats, and a literacy in reading past landscapes. While these myriad skills are best served by a multi-disciplinary team approach, I suggest a historical geographer specializing in these areas would serve the team well in a variety of roles.

GIS is a logical tool for synthesizing historical maps. Increasingly, high resolution scans of historical maps are available that can be georeferenced for use in a geographic information system (GIS). It is very difficult to bring the many diverse data sources available and required in historical ecology without using a GIS to georeference them. GIS may be seen by a many as a return to quantitative and positivist methods that Harley warned against (Pickles 1995), without awareness of the social and political implications of the source material. Harley suggested that use of computerized mapping methods would only lead to more strident "scientific rhetoric" by map makers (Harley 1989a, 151). However, early indications are that GIS is bringing a new sensitivity to combining the myriad data sources available to historical ecologists. Georeferencing allows us to better understand the data by resolving conflicts between sources and assessing where there are gaps in the record.

Geographic information systems could be used to effectively present some of the tools described in Chapter 9. Attributes in the GIS can be used to record such variations as certainty levels, allowing the user to present data in new and innovative ways depicting uncertainty. Additionally, the GIS can be used to store detailed information about sources.

Using historical maps this way may require different presentation of results. GIS has the capability of bringing new insights to historical ecology studies, and early research is promising—perhaps not providing the analysis Harley would hope for—but certainly there appears to be a trend to discuss source material, how the sources are combined, and to bring a sensitivity to the resulting maps that answers Harley's concern about strident rhetoric. Indeed, it appears that Harley's concern for the illusion of objectivity in computerized mapping was misplaced, and the most interesting work in historical geography is being done with geographical information systems. While much room for abuse abounds (Pickles 1995), early work using GIS in historical geography shows GIS as a potentially invigorating method for examining the past.

Presenting the results of historical ecology using historical maps would be improved by discussing methods—source material, how the sources are combined, and where sources conflict and where they corroborate. GIS can be used to bring a sensitivity to the resulting maps that answers Harley's concern about strident rhetoric. As long as the research considers the context and subjectivity of the source material, historical maps can contribute "to the dazzling array of new ways of seeing, and imaging, the past" (Holdsworth 2003, 491), something even Harley might agree with.

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