HUMAN ECOLOGY AND ANCIENT AGRARIAN LAND USE AT WAWAKIKI SPRING, SOUTH COAST PERU, A.D. 1000-2000

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DEDICATION

To my grandparents, parents, siblings, and nieces
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ABSTRACT OF DISSERTATION

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Agricultural landscapes constitute a critical point of articulation between humans and their environment. Consequently, they present an avenue through which to examine household, community, or regional level strategies to production, the various conditions and motivations that surround those strategies, and the impacts humans have in altering courses of environmental change on our planet. To understand the courses and consequences of agricultural land use, this dissertation specifically traces capital investments, cultigens, and areas of cultivated terrain at the site of Wawakiki in the hyper-arid coastal environment of southern Peru. The resultant data are contextualized within a series of nested analytical units that include site, micro-region, and macro-region in order to explain changes in agriculture and landscape transformation on multiple scales.

This study draws several conclusions. First, it reveals the complexity of variables that surround agricultural production strategies. Too often, emphasis is placed on causes
of agricultural intensification, alteration, or abandonment without first coming to a more balanced and developed understanding of the processes at play or the courses agrarian evolution can take on multiple scales. This research demonstrates that there is no single cause or course of agricultural land use; rather, demography, culture, and environment wholly interact on multiple levels to shape and re-shape the conditions surrounding the evolution of agrarian landscapes.

The historical depth employed in this investigation also sheds light on the ecological relationships contemporary human groups in southern Peru hold with their environment, and the pathways that have conditioned those relationships through time. These results indicate that many of the direct and indirect impacts coastal Osmore populations have had on their environment over the past millennium have enhanced the landscape for agricultural purposes, while concomitantly diminishing potential land use and resource management in other areas. Over the long term, biodiversity has diminished in the area, and consequently changes in sustainable activities like farming and herding have accelerated. Furthermore, these changes are rooted in more than one thousand years of late pre-Hispanic, Spanish colonial, and post-colonial agriculture and resource management. This study holds implications for issues related to agricultural land use, resource renewability, and long-term sustainability in arid environments.
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Chapter 1:
INTRODUCTION

First-time visitors to the town of Ilo on the far southern coast of Peru cannot help but be overwhelmed by the extreme arid environment in which this small port of roughly 50,000 people lies. Nestled along the mouth of the Ilo River between coastal desert hills and the Pacific Ocean, Ilo lies near the northern limits of the Atacama Desert, known to be one of the driest landscapes on Earth. Yet, hunting and gathering groups roamed this desert coast for thousands of years, while subsequent agricultural communities have flourished for several thousand more into the present era. Today, the Ilo River flows 25 km through a narrow coastal valley canyon, continuing to support nearly 400 ha of irrigation agriculture in this hyper-arid region.

Traveling northward along the coast toward the Tambo valley, the relative greenery surrounding the Ilo River disappears and the land reverts to a virtual lunarscape flanking the Pacific Ocean. A dry, gravel road travels along the coast, crossing deep cut ravines and dry stream beds as coastal, barren hills continue to migrate toward the coastline. Nearly fifteen kilometers north of the Ilo River, the road passes Carrizal, the first of a series of small olive groves that are sustained solely by the slow trickle of freshwater springs. Here the grove appears to be lightly maintained, with only a small group of drying trees huddled on the south bank of the main quebrada channel. Farther north is a triad of olive groves—Alastaya, Miraflores, and Pocoma—each within a kilometer of the next and supporting between five and fifteen hectares of olive trees.
Just north of Pocoma, steep and rocky hills rise directly from the ocean, creating a coastal landscape with much more vertical relief than to its south. Here, a steep and desolate promontory retains evidence of a heavily transformed landscape that once supported intensive agriculture: ridging and terracing of permanent fields; canal channels traversing steep hillsides; secondary canals that in turn lead to tertiary canals; complex patterns of curvilinear sediment furrows; small check dams; water impoundment tanks; depressions from uprooted trees; and even a single olive tree perched near the main channel of Quebrada Agua Buena. From the road high above, it is clear that this promontory and associated quebrada canyons of roughly 12 ha, known in the archaeological community as Wawakiki, was once an oasis of cultivated terrain that required huge capital investments and considerable amounts of planned, organized labor to sustain production. Wawakiki is not an anomaly, however, as other coastal groves that continue to be maintained today also reveal evidence of large abandoned tracts of land that had been previously transformed into circumscribed units of intensive agriculture.

Clearly, the degree to which agricultural production along the coast between the Ilo and Tambo rivers has been maintained varies considerably, ranging from total abandonment of previous spring-fed agricultural systems, to differing degrees of maintenance. Yet, the permanently transformed landscape visible today presents only a synchronic view of the manner in which humans have impacted this coastal desert plain. These circumscribed tracts of land once dedicated to intensive cultivation display several thousand years of natural and anthropogenic processes resulting in a number of cumulative effects, both micro and macro, temporary and permanent: nutrient alteration,
changes in sediment composition, shifts in vegetation patterns, sediment deposition and erosion, terracing, and manipulation of water distribution.

Agricultural landscapes constitute a critical juncture in the relationship between humans and their environment. Agriculture is, after all, a conscious effort on behalf of humans to directly alter their physical surroundings. Long-term trajectories of agrarian land use often result in highly modified and permanently transformed terrain, which ultimately plays a profound role in future human endeavors on the landscape. The courses of change resulting in highly anthropogenic landscapes like those of Wawakiki and the coastal Osmore region are very dynamic, and any explanation of shifts in production strategies must be anchored to historical process.

Situating long-term agricultural land use in its proper context can help delineate the relationships past communities had with their environment, while clarifying current relationships and perhaps projecting future courses of human impact and environmental policy. This dissertation is concerned with tracking nearly a millennium of changes in agrarian land use at Wawakiki from the late pre-Hispanic period through the present era, while contextualizing shifts in production within historical processes of cultural and environmental changes. This study therefore treats agriculture as an apex of the human-environment relationship, and it addresses issues pertaining to cultural pathways to production on local and regional scales, resource renewability, environmental regeneration, and long-term sustainability.

Through the physical remains of production systems, archaeological case studies can identify structured sets of relations that change through time and across space (Hassan 1994: 156). Monitoring changes in agricultural production requires that
archaeologists identify the often-ephemeral material indicators of past agrarian activities, including artifacts, remains of agricultural fields, canals, reservoirs, botanical remains, and settlement patterns (Morrison 1994). Each variable may offer a slightly different perspective on agrarian production strategies, and diachronic changes in those variables offer clues to particular courses of change undertaken by agricultural communities. This study traces capital investments, cultigens, and areas of cultivated terrain at Wawakiki, and the resultant data are contextualized within wider cultural and environmental trajectories in order to understand changes in agriculture and landscape transformation on the far south coast of Peru. This research is explicitly historical and ecological in that (1) it treats variables as part of a diachronic process where there is a cumulative, temporal dimension to land use, and (2) it seeks to illuminate the dynamic relationships among humans and between humans and their physical environment as they shape agricultural production.

Though this investigation defines nearly a millennium of developments, studies of past agrarian production schemes are necessarily limited by a number of factors, including the degree of chronological resolution offered up by the archaeological and historical records, the preservation of agricultural landscapes and associated features, and the kinds of information recorded in historical documents as well as the detail in which they were recorded. Given these limitations, the focus here is primarily upon those variables that are visible archaeologically and historically such as capital investments, cultigens, and limits of cultivated areas. These are examined within three broad chronological phases in order to identify changing trends in long-term land use. Archaeology can rarely distinguish among daily, weekly, monthly, or even seasonal
events that manifest themselves in the material record. Consequently, efforts focus on
the late pre-Hispanic period, the Spanish colonial period, and the post Spanish colonial
period and early 20th century, while continuing to recognize the kinds of cultural and
natural variability that may occur within these broad chronological phases. In this
manner, agriculture is not viewed to be a stagnant and uniform element of production
within these periods; rather, because of the limitations imposed by the data, broad
chronological units are constructed as analytical tools to better understand diachronic
shifts in the human-environment relationship.

**Organization of Chapters**

Chapter two discusses the active relationship between humans and their wider
environment through long-term trajectories of agricultural production. Rather than
seeking simple cause-and-effect relationships between climate, environment, and cultural
modes of production, this chapter anchors investigations of long-term land use in an
ecological framework that recognizes both historical contingency and the dynamic, non-
linear nature of agrarian production. This chapter emphasizes two points that are
prevalent throughout this study. First, it illuminates the complexity of variables that
surrounds agrarian production, clarifying that there is no single cause or course of
agricultural land use. Rather, demography, culture, and environment wholly interact to
shape and re-shape the conditions surrounding agrarian decisions. Second, this chapter
emphasizes the co-evolving nature of humans and the environment. There is no
“pristine” state of the environment, nor any true state of stability. Change is the natural
state of our planet, and the “socio-natural” environment (a term I have adopted from Van
der Leeuw and Redman 2002) is a continuously evolving process, one in which humans play an active role in conditioning through time. Consequently, production decisions are implemented within such a dynamic context.

Chapter three describes the physical environment, natural resource distribution, and economic opportunities and limitations that characterize Wawakiki and the coastal Osmore region. It also describes the climatic and environmental history of the area for the past one thousand years using palaeoclimatic and historic data. Rather than focusing strictly on climatic and environmental “averages,” this chapter discusses the range of variation and the heterogeneity of resource distribution in the lower and coastal reaches of the drainage to stress the fluid and evolving nature of the physical environment through time.

Chapter four addresses cultural developments of the Osmore drainage during the second millennium AD. It focuses on general changes in demography, politics, and economics, as well as general shifts already documented archaeologically and historically in agricultural land use practices in the wider Osmore drainage. Weight is given to the late pre-Hispanic Chiribaya period, where local communities along the lower and coastal reaches of the drainage predominantly specialized in the procurement of agricultural or marine resources, and the profound demographic, political, economic, and social transformations that accompanied the arrival of European colonists, when production was largely organized first around the encomienda, and subsequently around a system of small chacras (small farmsteads) and haciendas. A final point of emphasis in this chapter pertains to 20th century land use, demographic growth, and corporate enterprises like
Southern Peru Copper Corporation. More specific cultural issues pertinent to agricultural transformations at Wawakiki are discussed in greater detail in later chapters.

Chapter five explains methods to chronologically evaluate agricultural production at Wawakiki. While it briefly discusses chronology of land use at the site, the primary intent of this chapter is to detail the field methods used to identify and chronologically assess agricultural infrastructure.

Chapters six, seven, and eight present the results of field excavations and pollen analysis as they relate to agricultural infrastructure and production. They are organized chronologically into Late Pre-Hispanic, Spanish Colonial, and Post Spanish Colonial phases, respectively. These chapters evaluate engineering, technology, landscape transformation, and cultigens within these broadly defined chronological periods. Together, they point to a highly complex pattern of landscape evolution at Wawakiki, where demography, cultural values, technology, and the socio-natural environment interacted to varying degrees to condition the long-term evolution of the agrarian landscape.

Chapter nine contextualizes agricultural trajectories at Wawakiki in a series of nested analytical units that include the wider coastal Osmore region, and the entire Osmore drainage and beyond. It includes a discussion of scale—both spatial and temporal—and multi-scalar approaches to understanding changes in production and the often fragile relationship between humans and their physical environment. Particularly, this chapter evaluates production trajectories at the levels of site (Wawakiki), micro-region (coastal springs), and macro-region (Osmore corridor and beyond) to provide a more developed context for understanding agrarian land use. The results suggest that
local and more regional units of production waxed and waned through time in response to a completely interlocked cultural and environmental relationship.

Chapter ten concludes the investigation with a discussion of the dynamic nature of agricultural land use and strategies to economic production. This chapter specifically underscores the need to contextualize agriculture as a historical process within the active interplay of culture and environment.
Chapter 2:

AGRICULTURAL LAND USE AND HISTORICAL CONTINGENCY:
A THEORETICAL FRAMEWORK

With the development of an increasingly global economy, the manner in which people interact with their environment holds cross-cultural implications for the successful reproduction and prosperity of other communities. Decisions that humans make today with respect to environmental policy and resource management will have differential consequences for other human groups, both contemporary and future, just as land use in the past has affected the myriad of ways humans interact with the environment today. Agriculture forms one major nexus of the critical interaction between people and their natural surroundings, and the investigation of that relationship begins at the local level. While human decisions with respect to production strategies vary considerably across space and time, the variables involved in those decisions—environment, culture, and demography—are global and historical consistencies. How these variables affected social and economic decisions in the past becomes relevant to present communities. As people modify their physical surroundings, irreversible changes may occur that diminish opportunities for particular production strategies, while at the same time creating possibilities for other strategies not initially feasible. Courses or trajectories of changing agricultural landscapes are thus rooted in historical contingency, where the relationships between communities and production are necessarily conditioned by the interplay of culture and environment.
Landscapes are not stagnant entities upon which agricultural communities operate; rather, they are fluid and constantly changing. Indeed, change is the natural state of the environment, evidenced by four and a half billion years of evolutionary formation of our planet. As a process of production, exchange, and consumption, human economies are interactive and wholly dependent subsystems of our changing ecosphere (Rees 2002); hence, landscapes co-evolve with culture. It is within this context that agriculturally related decisions take place, decisions that further promote—advertently or inadvertently—landscape enhancements or degradation. Because change is the natural state of our planet, human activity merely accelerates, retards, or alters particular courses of change and biodiversity. Agricultural issues like expansion, intensification, alteration, or collapse are therefore fundamentally anchored to and differentially affect historical changes in the “natural” environment. As a co-evolutionary process, the line between anthropogenic and natural environments has become blurred, compelling Van der Leeuw and Redman (2002) to champion the term “socio-natural environment” as a way to speak of this wholly interconnected and co-evolving relationship between humans and their surroundings.

This chapter presents an ecological framework that is equipped to understand long-term courses of agrarian land use, production strategies, and human impacts on the environment. As a point of articulation between humans and their environment, agricultural land use provides an excellent avenue through which to investigate the interdependence of humans and landscapes. This relationship is truly dynamic, and its complexity calls for long, diachronic analyses of particular courses and consequences of agrarian evolution. Archaeologists can thus provide significant historical depth to both
the complexity of agricultural decision-making processes and the multitude of variables involved, while concurrently providing insight into contemporary practices of land use, environmental policy, and the continuous human impact on the “socio-natural” landscape.

**AGRICULTURE, POPULATION, AND INTENSIFICATION**

Early efforts to decipher the relationship between agriculture and humans focused on population and technology. In the 1960s, these variables were formally embedded in agricultural intensification, a concept that became popular in agrarian studies after Boserup (1965) reversed the Malthusian relationship between population growth and technological development. Malthus suggested that population levels are positively correlated with technology and availability of resources, where technological achievements either permit or restrict population growth. As technology improves, so does the productive potential of agricultural practice, which ultimately results in greater surplus to feed a growing population. Importantly, in the Malthusian approach technological developments occur more or less autonomously, and population equilibrium would be achieved shortly thereafter. Julian Simon (1977, 1981) refers to this as the ‘invention pull’ view of population history, where technological innovation is the independent variable that ‘pulls’ population growth to equilibrium. A basic assumption within this approach is that population, barring any checks on available resources, remains in a constant state of growth. The Malthusian model, then, stipulates that technology as an independent variable provides a check on population.
Boserup (1965) inverts the relationship between population growth and technology by arguing the former to be an independent variable, whereby population growth drives technological innovation. In this sense, to continue with the illustration from Simon (1977, 1981), population growth ‘pushes’ technological development to allow food production to keep up with increases in population. Boserup claims that increases in population growth and density will spark changes in agricultural systems along a unilineal course from a long fallow to an increasingly shorter fallow strategy; indeed, a decrease in fallow period is the hallmark of agricultural intensification in her model. In Boserup’s approach to agricultural land use, innovative change may occur from within a given community; that is, it is not reliant upon extra-community forces. Certainly, this is an anthropologically valuable and attractive element of Boserup’s model.

Agrarian societies rely on successful cultivation of plants. It is therefore no surprise that population and agricultural production hold a strong relationship in many parts of the world. However, the context in which agricultural intensification occurs according to Boserup has received its share of criticism since the 1960s. Most notably, her model fails to explicitly recognize environmental and climatic contexts, and it ignores culturally defined mechanisms of production, exchange, and consumption. This proves limiting in the model’s application in settings that differ environmentally and culturally from those defined in her study. By-and-large, however, despite the plethora of criticisms following Boserup’s 1965 publication, a result of major importance from her seminal work was that it inspired further significant research that has since highlighted
the complexity of the relationship between agricultural intensification and variables beyond—but not excluding—population.

**BEYOND POPULATION IN AGRARIAN LAND USE STUDIES**

Boserup’s work led to multivariate approaches that went beyond population to understand agricultural land use, sustainability, and historical contingency that surround local and regional decisions involved in production. Like Boserup, Brookfield (1972) concerns himself with *causes* of agricultural intensification. However, he attempts to move beyond theories that consider population to be the primary stimulant of intensification by emphasizing multiple production incentives and environmental constraints. Brookfield explicitly notes that population-based theory focuses principally on subsistence production needs, which is often structured in terms of per capita caloric returns. As he so aptly states, however, “…man does not live by subsistence alone…” (Brookfield 1972: 37), and perceived production “needs” will vary among societies, based largely upon culturally valued means of production and consumption. Brookfield recognizes this and distinguishes between production for subsistence from that for trade and market or for social purposes. The latter may be further segmented according to culturally specific norms, as well as to the desire of an individual, household, or community to confirm or even bolster their status or prestige within a larger social entity. In this manner, decisions to intensify agricultural production may not result primarily from an increase in population or density.

The use of fallow period as the measure of intensification, as in Boserup’s model, is also limiting because of its lack of environmental and climatic consideration.
Acknowledgement of ecological constraints to particular production strategies should not conjure thoughts of determinism, but rather it should be viewed as the reality within which agricultural communities operate. Swidden agriculture—the primary production strategy involved in Boserup’s model—is not plausible, or even possible, in many parts of the world. In fact, most arid environments in the world cannot support slash and burn agricultural strategies; vegetative regeneration during fallow period often will not occur such that sufficient nutrients will be replenished in the soil after burning. Direct application and testing of Boserup’s model, then, should be limited to environmental conditions comparable to those conducive to swidden-type agriculture (e.g., Stone and Downum 1999); otherwise, alternative measures of how and why changes in agricultural landscapes occur should be devised.

While Boserup measures intensification through decreasing fallow periods, Brookfield offers a more explicit definition of the concept, which retains fundamental elements of Boserup’s perspective as well:

Strictly defined, intensification of production describes the addition of inputs up to the economic margin, and is logically linked to the concept of efficiency through consideration of marginal and average productivity obtained by such additional inputs. In regard to land, or to any natural resource complex, intensification must be measured by inputs only of capital, labor, and skills against constant land. The primary purpose of intensification is the substitution of these inputs for land, so as to gain more production from a given area, use it more frequently, and hence make possible a greater concentration of production (Brookfield 1972: 31).
Brookfield employs this concept in his study of Pacific Island agriculture and concludes that an ecological approach to the study of agricultural strategies must consider environmental context, and it requires an understanding of human needs and motivation as they vary from culture to culture. Most importantly, Brookfield (1972: 46) hints at the necessity of understanding process, warning of the potential presence of parallel processes leading to equifinality among production strategies. By extension, archaeological landscapes may be included. Abandoned agricultural landscapes may exhibit similar elements of production strategies, yet the processes that led to morphological similarities in those landscapes may have been, in fact, very different. Consequently, over-emphasis on cause of intensification with little regard for process may prove misleading. Brookfield’s work represents an important evolutionary step from Boserup’s seminal 1965 effort by specifically defining intensification and introducing new variables into the complex relationship between population and agrarian evolution.

**Multivariate Approaches to Agriculture**

Since Brookfield’s work in the 1970s, scholars began to employ a number of different variables to both understand and measure agricultural change, due to population increase, changes in local and regional economies, environmental fluctuations, or perhaps some combination thereof. Some have continued to focus on cropping intensity and fallow periods, taking into account the types of agricultural goods produced and their relative duration in a field (Dayal 1978). This has greatest importance for tropical and sub-tropical climates, such as those of the Peruvian south coast, which permit successive planting of crops throughout the year. As the maturation period of particular plants
decreases, the potential for multiple harvests per annual cycle increases. This, of course, refers to the cultigen alone, and does not speak to other concerns such as perennial water availability or soil nutrient replacement, for example. Nonetheless, shorter maturation periods of specific cultigens may potentially offer greater social or economic returns by permitting larger harvests per year per constant unit of land.

Geographers Turner and Doolittle (1978) utilize both technology and frequency of cultivation to develop a surrogate measure of agricultural intensity. Archaeologically, it is difficult—if not impossible—to directly examine frequency of cultivation. Rather, archaeologists are left to infer potential frequency of cultivation based on other variables like technology, water availability, soil nutrient depletion, and crop selection. Their model provides relative indices of agricultural intensity among modern communities, or even historic communities with well documented records, but the level of detail required for frequency of cultivation is often not—if ever—available in the archaeological record.

Crop selection, on the other hand, can be archaeologically visible and it speaks to other changes in agricultural production. In sub-Saharan Africa, Hyden et al. (1993: 403) comment that “The use of new cultigens has led not only to increased yields of production but to substantial dietary changes as well. In almost all of the sites [in this study], major dietary shifts have taken place in response to population growth, substituting less-demanding, higher yielding, or greater-density foods for traditional ones.” This suggests that while population growth may spur on changes in agricultural strategies, responses undertaken by agricultural communities may not be related directly to intensification proper such as decreasing fallow periods or greater investment in labor or capital; rather, change may manifest itself in dietary shifts such as a substitution of
less-demanding, higher yielding crops for traditional ones. Cultivation of different plants requires variable labor, water, nutrients, and time to mature. Local adjustments in crop selection, or perhaps in combinations of crops, can thus represent shifts in economic strategies that relate to changing values placed on particular plants within a wider socio-ecological setting.

Agricultural technologies and their implementation also constitute important measures of agrarian land use. For instance, a distinction can be made between systematic and incremental change, where systematic involves the addition of new fields and associated technologies prior to cultivation while incremental refers to gradual transformation of fields in conjunction with cultivation (Doolittle 1984). Brookfield (1984) makes a similar distinction between innovation and intensification, noting that innovations may result in permanent land modifications such as terraces or raised fields, which after their construction may only require maintenance. Such permanent investments in the landscape create new ecological contexts in which subsequent strategies of production are developed; the notion of a pristine or stagnant environmental backdrop becomes moot because production decisions are made in these newly formed physical environments.

Innovation, however, does not always result in permanent changes to the landscape. It may manifest itself in more abstract ways such as shifts in land tenure. The conceptual distinction is that innovation occurs as a new practice or combination of practices, as opposed to the intensified application of already existing labor or capital inputs within a technological system.
Agricultural strategies can also be partitioned into categories like intensification proper, specialization, and diversification, noting that each of these can be a component strategy within the broader understood concept of intensification (Morrison 1994). In this sense, intensification proper approximates that of Brookfield (1972), where it involves increased labor and/or capital inputs to a plot of land and may involve changes in the types and combinations of cultigens produced. Intensification proper may also take the form of increased investments in practices such as plowing, seed bed preparation, weeding, transplanting, manuring, and the construction of soil and water control facilities, the latter of which are certainly most archaeologically visible (Morrison 1994: 142).

Specialization and diversification form other components of intensive production, and they may be conceptualized as qualitative opposites (Morrison 1994). Specialization does not necessarily imply the cultivation of a single crop, but rather a reduction in diversity. This may be a response to a number of historically contingent circumstances that include shifts in climatic or environmental variables, changing regional economies, or perhaps adjustments in extra-household mechanisms of exchange. Indeed, increased specialization may reflect greater socioeconomic reliance on extra-household exchange of resources or increased interaction with market mechanisms, but it need not be the only response.

Diversification, on the other hand, implies an increase in the number of components within a production system. Specifically, diversification may include “strategies such as staggered planting and harvesting times, dispersed land holdings, and the cultivation of crop mixes and of multiple varieties of a single crop, each with different
growth characteristics” (Morrison 1994: 144). Morrison also urges the importance of looking beyond agriculture itself, as diversification may manifest itself in not only plot sizes and locations, types of crops and forms of soil and water control facilities, but rather in other non-agricultural activities like craft production or the procurement of animal or wild plant resources. This is especially important in the coastal Osmore region, where *lomas* (inland expanses of shrubs and grasses) and marine resources historically have formed significant components of the local and regional subsistence economies. While not the only outcome, greater diversity in economic production strategies permits greater autonomy, and it may certainly reflect periods of less regional interaction and exchange. Greater economic diversity at any scale—e.g., household, community, polity—could conceivably decrease dependence on exchange for subsistence necessities, provided that a given diversified production strategy is directed towards subsistence requirements. When identifying specialized or diversified strategies, it is essential to discuss them relatively to other strategies that perhaps share some spatial, temporal, or analytical relationship. Economic strategies are only specialized or diversified with respect to other strategies of production.

Numerous attempts to define and apply intensification as an agricultural concept within cross-cultural settings contribute immensely to a general body of theory dedicated to understanding agrarian production and land use. The employment of intensification theories in Polynesia (Brookfield 1972, 1984; Kirch 1994; Ladefoged and Graves 2000; Ladefoged et al. 1996), the American Southwest (Stone and Downum 1999; Wills 2001), Mesoamerica (Nichols 1987; Smith and Price 1994), the Andes (Erickson 2000; Hastorf 1993; Kolata 1991), Africa (Stone 1994), and south Asia (Morrison 1995) have
highlighted the impossibility of identifying a single, universal cause for agricultural intensification. Most importantly, these investigations underscore the dynamic processes involved in agricultural decisions and the multiple trajectories intensive land use can take. In this manner, agrarian land use must be conceptualized as part of a dynamic process, one that continuously undergoes change as humans interact with their socio-natural environment.

**HISTORICAL CONTINGENCY AND AGRARIAN CHANGE: AN ECOLOGICAL FRAMEWORK**

To discuss agricultural landscapes, it is pivotal to understand process. Change is rarely systematic, and even then only on a scale relative to time. Decisions to modify agrarian land use—be it to intensify, relax, or totally abandon production—occur in a number of interwoven environmental, cultural, and temporal contexts. To understand how and why agricultural strategies are modified on the levels of household, community, or polity begs for concern with process. Over-emphasis on strictly events of cause or effect may side-step the processes that lead to those events. Agriculture does not occur in a vacuum, nor does it satisfy mere subsistence needs, regardless of how needs are perceived or defined cross-culturally. Rather, it occurs within the context of human lives, and the ever-changing negotiations among households, communities, polities, and the socio-natural environment. As part of a process, then, production decisions are shaped and reshaped by earlier processes of cultural and environmental transformations; certainly, local and regional economic strategies have profound effects on subsequent production trajectories. If cause and effect remain the goal of investigation, then the answer remains embedded within the historical process of agricultural land use.
Agriculture as a process requires both “specification of variables and more contextual considerations of the specific paths or courses of change” (Morrison 1996: 5830). Analyses of past agrarian production schemes are necessarily limited to agricultural variables that can be traced in the archaeological and historical records, and tracking diachronic changes in these variables with respect to shifting cultural and environmental contexts. In this fashion, contextual considerations (both spatial and temporal) of agrarian strategies lead to a clearer understanding of the various trajectories of agrarian evolution.

Importantly, the context in which production decisions are made is multi-scalar, and the view offered to the investigator of how—and particularly, why—agricultural land use transformed through the past will differ depending on both the temporal and spatial scale employed (Morrison in press). The analytical units chosen by the investigator are tools created to understand an idea or concept like intensification, or more precise to this study, agrarian evolution and long-term trajectories of ecological change.

It is becoming increasingly clear that agricultural landscapes result from dynamic cumulative processes, and to adequately assess long-term trajectories of land use, sustainability, and human impact on the environment, historical contingency must be a prime emphasis of research. This requires the investigator to employ historical ecological philosophies that consist of “more than simply cataloging the varied impacts and effects of humans in a landscape over time; [the] aim is ecological understanding, including the complex and reciprocal connections linking human populations with the myriad other life forms that share their world” (Kirch 1997: 19). Indeed, historical
ecology explicitly traces the relationships between human and so-called natural activities as they manifest themselves in the landscape (Crumley 1994a: 9).

While often dichotomized, in reality humans and their environment are richly interconnected and should be treated as a dynamic relationship that continuously transforms the socio-natural environment on multiple scales. After all, human interaction with nature is a process of alteration, one that Patterson (1994: 234) suggests “[transforms] nature into a means of production.” Ingerson (1994: 65) offers a conceptual understanding of this dynamic relationship, urging investigators to conceive of nature and culture as points on a quantitative spectrum rather than as qualitative opposites. With respect to agriculture, then, direct causality between nature and culture becomes a non-issue, and in effect, change becomes an outcome not strictly of natural nor cultural occurrences, but rather as a result of the relationship between the two. Gunn (1994: 67) underscores this point, noting that “biological systems, soils, and hydrology are so completely interactive with humans and culture…that they should be treated as a richly networked analytical unit.” In fact, creating a dichotomy between “natural” and “anthropogenic” causation only fosters the notion of a non-existent “pristine nature” (Crumley 1994b: 239). Anthropogenically transformed landscapes cannot be extracted from their human occupants; they are transformed by humans into new physical settings and therefore should be treated as an interactive whole with them.

Long historical analyses of landscapes—and particular to this study, agrarian landscapes—accomplish several critical and interrelated goals. Revealed in such investigations is the complexity of various courses of agricultural land use strategies. Too often, emphasis is placed on causes of agricultural intensification, alteration, or
abandonment without first coming to a more balanced and developed understanding of the processes at play or the courses agrarian evolution can take on multiple temporal and spatial scales. Diachronic investigations can identify shifts in production strategies that might be represented archaeologically or historically, and such approaches can detail the complexity of relationships among variables such as population, resource distribution, agricultural potential, technology, and organization of production. There are no universal causes or consequences of agricultural decisions, but such long-term investigations in multiple settings across the globe will inform humanity more wholly about the nature of the relationships among variables, and the underlying cultural processes that lead to particular production decisions. As Erlandson and Rick (in review) note, humans both past and present have been “confronted with countless environmental challenges—some of them of their own making—and responded in a variety of ways, both effectively and ineffectively. Learning what worked for those ancient peoples and what didn’t holds valuable lessons for us today as we strive to more effectively manage the environmental impacts of our species on both land and sea.” Diachronic analyses are thus essential to understand changes in production strategies that have directly altered the world around us, strategies that often have ecological consequences—intentional or unintentional—over the long term. Farming communities construct terraces, clear forests, manipulate hydrology, and alter vegetative patterns. In doing so, entire landscapes are transformed. In some respects, agricultural production strategies might improve or enhance the local or regional landscape for such purposes, while at the same time fostering degradation to other regions. Indeed, some farmers consider practices such as fallowing, crop rotation, soil management, and infrastructural investments to the landscape to be long-term
conservation strategies (Erickson 2000: 349). Diachronic investigations emphasizing the *processes* of agrarian evolution can shed light on the conditions surrounding decisions to implement agricultural strategies on local and more regional scales.

Long-term investigations are also pivotal to understand the ecological relationships contemporary human groups hold with their socio-natural environment, and the pathways that have conditioned those relationships over time. One critique of many studies of environmental dynamics is that they tend to focus on direct observation of biophysical conditions, and therefore only consider the tail end of long and complex sequences of ecological relationships, taking at most several decades or perhaps a century or two into account to fully understand that relationship (Van der Leeuw and Redman 2002: 599). As noted earlier, change is the natural state of our planet. The rapidity with which nature changes most certainly varies with perspective, but with respect to human lives, change may seem rapid (on the realm of months, years, or even decades), or it may occur quite slowly over many generations (centuries, millennia, or perhaps tens of thousands of years). Consequently, the only real pathway to understand current ecological relationships is to examine long, diachronic courses of human interaction with and continuous impact on the socio-natural environment. As Redman (1999) convincingly portrays, there is no absolute when referring to the natural state of the environment, and humans have played a substantial role in shaping biodiversity and resource distribution on our planet. Long-term analyses are therefore best suited to define the context in which agriculture and production decisions have evolved over time, and the myriad of ways those decisions have accelerated or diminished the rate of ecological change at a given spatial and temporal scale.
When agricultural landscapes are treated as part of a dynamic process, wholly integrated with and viewed as significantly altering the socio-natural environment, human relationships with their surroundings can be defined as products of historical process. Consequently, projected changes in ecology, sustainability, and environmental impact can be charted given particular pathways of agricultural land use and alteration.
Chapter 3:

TOPOGRAPHY, CLIMATE HISTORY, AND RESOURCE VARIATION
IN THE OSMORE DRAINAGE

TOPOGRAPHICAL SETTING

The Ilo River Valley

Located in the dry Pacific Andean watershed, the Osmore drainage is one of the southernmost valleys of Peru (Figure 3-1). Generally, the drainage can be divided into upper, middle, and lower sectors. In the upper sector of the valley, headwaters originate above 3500 m.a.s.l., where three tributaries capture water from melting snow and seasonal highland rainfall. These tributaries converge in the middle valley at 1400 m.a.s.l. to create the Moquegua River. The valley reaches its maximum width here and provides the greatest amount of land suitable for agricultural production. In fact, today the middle valley sustains roughly 2800 ha of cultivated terrain, while the narrow canyon of the lower valley supports only about 400 ha. (ONERN 1976). From this point, the Moquegua River continues along a narrow linear course through the desert before it ceases on the surface approximately 50 km from the coast and continues only as underflow for the next 20 km or so, creating a natural, virtually uninhabitable hyper-arid zone between the middle and lower sectors of the drainage. Finally, the Ilo River (as it is termed in the lower valley) emerges approximately 25 km from the coast, cutting deeply through the Clemesí Desert before emptying into the ocean (D. Rice 1989).

Marked wet and dry seasons characterize highland precipitation. Consequently, runoff to the middle and lower valleys is highly seasonal, with peak outputs occurring
during January, February, and March (ONERN 1976). Discharge recorded for the Tumilaca tributary in the upper Osmore demonstrates both monthly variation in runoff as well as disparities between maximum and minimum outputs within a single month (ONERN 1976: 332; Table 3-1). Similarly, hydrological data taken from Moquegua in 1999 demonstrate similar seasonal and monthly variation (Oficina de Información Agraria 1999: 13). Because of such variation, at times the Ilo River did not carry water during the height of the dry season throughout the second millennium A.D., reducing Ilo valley agricultural production to a very seasonal activity.

Currently, however, water is being transported to Moquegua from an adjacent drainage by the Past Grande canal system in anticipation of a lower valley agricultural
reclamation project on the desert pampas. As a result, water reaches the Pacific Ocean year round and will likely do so until irrigation of the desert terrain commences, once again reducing the amount of water reaching the desert coast.

<table>
<thead>
<tr>
<th>Month</th>
<th>Volume/Month (m$^3$)</th>
<th>Maximum Discharge (m$^3$/s)</th>
<th>Minimum Discharge (m$^3$/s)</th>
<th>Mean Discharge (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1,829,000</td>
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<td>0.60</td>
<td>0.68</td>
</tr>
<tr>
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<td>0.66</td>
<td>0.78</td>
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<tr>
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</tr>
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</tr>
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<td>0.35</td>
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</tr>
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</tr>
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<td>2,580,000</td>
<td>1.33</td>
<td>0.78</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Table 3-1.** River discharge in the Osmore drainage demonstrating both inter- and intra-monthly variation that might occur within a single annual cycle. Data was taken from the Tumilaca branch of the upper Osmore Drainage, 1951-1952.

**Coastal Quebradas**

North of the mouth of the Ilo River is a coastal plain defined by the Pacific Ocean to the west and a series of inland coastal hills to the east that reach a maximum elevation of approximately 1200 m.a.s.l. (Figure 3-2). The coastal cordillera runs north-northwest, thereby narrowing the coastal plain until it ultimately disappears about one half kilometer south of Wawakiki, where the coastal hills rise directly out of the ocean for at least another 15 km northward. Dry *quebradas* descend from the adjacent Clemesí Desert, pass through these coastal hills, and intersect an aquifer at about 100 to 150 m.a.s.l., creating a series of fresh water springs across the coastal desert (Bawden 1989a; Clement 28
Figure 3-2. Map showing the lower Ilo River and adjacent coastal plain. Vertical scale is exaggerated three times (X:Y:Z = 1:1:3).

and Moseley 1991). Because of the narrowing coastal plain, springs emerge from the desert much closer to the coastline in the north than they do in the south. As the only source of fresh water outside of the river valley, these springs were focal points for localized agricultural production among small communities. The largest of these systems in antiquity was Pocoma, which approached 30 ha of cultivated area during the pre-Hispanic era (Satterlee 1993). Today, Pocoma continues to irrigate the largest amount of land among the coastal springs, though it encompasses only about 15 ha of cultivated terrain.

Low volume and slow flow characterize all of the springs in this area, and to improve the productivity of low discharge, both prehistoric and modern farmers constructed tanks around the source of each spring in order to capture water. The
resultant increase in water pressure allows water to reach distal fields after its release (Clement and Moseley 1991). Today, local farmers note that spring discharge generally correlates with mountain rainfall 40 to 60 km inland and northeast of the Clemesí Desert (Clement and Moseley 1991: 430), leaving water consumption practices of middle and lower valley communities virtually irrelevant with respect to the replenishment of the coastal aquifer. Water flow does, however, vary from one spring to the next, and location and/or rate of discharge can change dramatically, especially following seismic activity. Following the M 8.4 earthquake that struck the Moquegua region of southern Peru in June of 2001, farmers working among the coastal springs of Pocoma, Miraflores, and Alastaya noted a number of changes in the rate of discharge. Regarding the eight independent springs that irrigate these three olive groves, several increased in discharge while others decreased, and yet others remained virtually unchanged (José Jiménez1, personal communication, 2003). Spring flow along the coastal cordillera is therefore very dynamic, and it would have been so even in the context of seasonal and long-term fluctuations in runoff from highland rainfall throughout the second millennium A.D.

Wawakiki

Wawakiki occupies a steep and rocky coastal promontory approximately 27 km north of the mouth of the Ilo River (see Figure 3-2). Specifically, it is located just north of where the coastal plain disappears and the cordillera begins to rise directly from the sea. This configuration continues from Wawakiki northward for at least 15 km, though a high sea cliff with intermittent and isolated sandy beaches exists along the coastline for much of the remaining distance to the Tambo Valley. The site is bordered by Quebrada

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1 José Jiménez oversees the maintenance of these olive groves and pays frequent visits to them.
Agua Buena to the north and by Quebrada Seca to the south, both of which extend some 2-3 km inland (Figure 3-3). Both quebrada channels are deeply incised (at times exceeding depths of four meters), and the adjacent flanks to the north and south of both are very steep and unstable, creating very constricted canyons along their entire courses. The Quebrada Agua Buena channel empties directly into the sea, dropping some 40 m over an escarpment, while Quebrada Seca spills over a similar height onto a 200 m wide sandy beach, enclosed at both ends by rocky outcrops rising from the sea. A coastal road constructed in the past decade to connect the Osmore and Tambo drainages crosses both quebradas and cuts just above much of the site, though many of the terrace and canal features located on the steep slopes just below the road cut have been either destroyed or buried by construction debris. A Spanish colonial period road also traverses the site, running its course just below the modern road, significantly disturbing pre-Hispanic domestic and agricultural terraces.

Figure 3-3. Aerial photograph showing the relationship between quebradas Agua Buena, Seca, and the coastal promontory (Servicio Aereofotográfico Nacional, Lima).
While associated canals and fields present clear evidence of previous spring flow in Quebrada Seca, only Quebrada Agua Buena maintains running water today. Spring flow is discontinuous along its channel, and in May of 2003 active flow was noted in three distinct locations, two of which measured 0.1 liters per second. Today, Wawakiki remains completely abandoned, but using tank-and-canal technology, comparable spring flow continues to support olive groves at locations to both the north and south of the site.

**Climate History**

Oceanic and topographic elements of coastal Peru have maintained a relatively arid climate certainly for several thousand years (Aldenderfer 1997: 49), and perhaps for as long as 38,000 years (Keefer et al. 2003). Oceanic currents uplift cold water along the Peruvian shoreline, creating a relatively cold ocean surface adjacent to a warm, tropical land mass. As clouds pass over from these cold to warm surfaces, they expand and rise up the Andes. Upon reaching elevations of 2000 m.a.s.l., they begin to cool and precipitate. Thus, rain rarely falls below this elevation except during recurrent El Niño episodes. Because rainfall is virtually absent for years at a time, prehistoric agriculture was largely dependent upon highland rainfall and limited to floodwater and canal irrigation technologies throughout much of the middle and lower valleys of the Osmore drainage.

While hyper-aridity generally characterizes the western Andean watershed, analyses of glacial cores taken from the Quelccaya ice cap (5670 m.a.s.l.) of southern Peru demonstrate considerable variation in highland precipitation over the past 1500 years (Figure 3-4). Decadal ice accumulation trends suggest wetter than average
conditions in the highlands from A.D. 760-1040 and from A.D. 1500 to 1720, while drier than average conditions prevailed from A.D. 1040-1490 and from A.D. 1720-1860 (Thompson et al. 1985: 973; Thompson et al. 1994: 85). Sediment cores taken from Lake Titicaca in the Bolivian altiplano also provide support for the precipitation data generated from the Quelccaya ice core (Abbott et al. 1997; Binford et al. 1997; Moseley 1997).

The Quelccaya data also document the rather abrupt onset of the “Little Ice Age” in Peru based on the increase in microparticles and a sharp increase in conductivities. Beginning around A.D. 1490 and lasting until roughly 1880, this period is generally characterized by cooler than usual temperatures and expanded glaciers, and its onset also corresponds to a sharp increase in highland precipitation (Thompson and Mosley-Thompson 1987). Finally, one of the greatest droughts ever recorded in Peru occurred during the first part of the 20th century. The drought is reflected in a significant decrease in ice accumulation and increased particle concentrations corresponding to 1934-1945.
(Thompson and Mosley-Thompson 1987: 105), and in a nearly 5 m drop in Lake Titicaca water levels between 1933 and 1943 (Newell 1949: 15).

Fluctuations in highland rainfall throughout the 2nd millennium A.D. would have affected lower and coastal valley farming communities, as prehistorically and historically they relied principally upon runoff for irrigation. A substantial decrease in highland precipitation would have produced disastrously low runoff levels in the lower and coastal reaches of the drainage. Already a scarce commodity, water reduction would have been disproportionately greater in the lower valley because soils would have continued to absorb a fixed amount of moisture before runoff occurred. During the late Chiribaya period (~ A.D. 1200-1375), Satterlee et al. (2000: 96-97) estimate a 20-30% decline in runoff from the headwaters of the Osmore drainage, a decline that would have been exacerbated in the lower valley as transport distances increased.

Periodically, El Niño episodes dramatically interrupt the arid climatic pattern along the coast, and the accompanying heavy rains usually cause destruction to the landscape below ca. 1500 m.a.s.l., washing away canals, fields, and reservoirs (Nials et al. 1979; Oficina de Información Agraria 2000). Historical records of El Niño activity in Peru since A.D. 1525 suggest the occurrence of ‘strong’ events roughly every four years and ‘very strong’ events once every nine years (Quinn and Neal 1995). ‘Mega’ events, on the other hand, might occur only on extremely rare occasions, with sometimes hundreds or even thousands of years passing between these massive flooding episodes (Keefer et al. 2003). The regular, though somewhat unpredictable, occurrence of El Niño episodes creates a much more complicated pattern of long-term aridity accompanied by punctuated spikes of coastal precipitation.
Despite the potential destruction caused by El Niño events, their effects are differentially felt throughout the lower and coastal reaches of the drainage, often depending on the strength of the event, local topography, and degree of seismic activity prior to such an occurrence (Keefer et al. 2003; Magilligan and Goldstein 2001; Moseley and Keefer *in press*; Satterlee et al. 2000). In addition, local and regional mechanisms of economic organization play a substantial role in the effects of and responses to coastal flooding episodes (Dillehay and Kolata 2004; Dillehay et al. 2004). Some argue that a ‘mega’ El Niño event documented archaeologically between A.D. 1300 and 1400 for the Ilo region ultimately led to the demise of the Chiribaya culture (Reycraft 1998, 2000; Satterlee 1993). Satterlee et al. (2000) have recently extended this argument, suggesting that it was the resultant destruction of convergent catastrophes—this ‘mega’ El Niño following several centuries of below normal highland rainfall—that ultimately catalyzed the Chiribaya collapse. Annual deposits of wet season snow and dry season dust documented in the Quelccaya ice core document this ‘mega’ event more precisely between A.D. 1350-1370 (Thompson et al. 1984). A second late Holocene ‘mega’ flooding episode is also documented in the archaeological record. It has been dated to the early 17th century and particle size and density in debris flows associated with this event may have been exacerbated by the occurrence of a high magnitude earthquake that struck southern Peru several years prior (Keefer et al. 2003; Moseley and Keefer *in press*).

Most El Niño-Southern Oscillation events, however, are not of this intensity, and their occurrences often present a mixed array of both negative and positive effects on coastal communities. Although the severity of rainfall accompanying these events varies along the coast of Peru (often occurring less torrentially from north to south), when
rainfall does impact the Osmore area, a number of detrimental effects can occur, including severe downpours resulting in loss of crops and a reduction in production and productivity; damage to infrastructure such as canals, drains, reservoirs, and roads; over bank flooding of the Ilo River, resulting in inundation of planting surfaces and living spaces; increased disease in cattle and other domestic animals; and an immediate reduction in agro-pastoralism. Conversely, in several ways coastal communities may benefit from El Niño rains, such as from the recharging of coastal aquifers; natural regeneration of lomas-related forests and desert pasture land; and greater availability of water to replenish reservoirs, which may in turn permit the rejuvenation or installation in arid zones of certain forestry species like the Parkinsonia, Molle, Tara, and Tuna (Oficina de Información Agraria 2000: 10-11).

**Resource Distribution in the Osmore Drainage**

Three primary economic potentials are found throughout the lower and coastal portions of the Osmore drainage: (1) agriculture, (2) marine and littoral resources, and (3) lomas, or inland expanses of herbaceous plants and trees primarily supported by fogs during the austral winter. While the productivity of each resource base undoubtedly fluctuated throughout the second millennium A.D., each has been present for several thousand years, offering mixed economic potentials on both local and regional levels of farming, fishing, herding, hunting, and gathering.
Agriculture

Agricultural potential along the course of the Ilo River, though by far the most extensive throughout the lower and coastal portions of the drainage, is quite modest compared to other sectors of the drainage. The river flows through a steep sided canyon rarely reaching 450 m in width, thereby generally restricting agricultural production to the immediate floodplain. During the last half of the 20th century, the Ilo River valley has supported 390 ha of cultivated terrain, though roughly 208 ha (40%) are classified to have strong or excessive salinity (ONERN 1976). By contrast, the middle valley sector supports 2810 ha, where only 2.9% was considered to be even of moderate or strong salinity. Today, roughly 80% of cultivated land in the lower valley is devoted to the olive tree, while coastal quebradas are dedicated solely to olive groves; no other cultigens are currently farmed among the springs in the study region.

Marine Resources

Near-shore currents of coastal Peru bring cold water and nutrients to the surface, promoting an abundance of phytoplankton and other marine plants. In turn, this supports a large concentration of marine biomass, ranging from dense schools of anchovies, to larger cold-water marine species. Furthermore, rocky outcrops and sandy beaches along the shoreline provide habitats for an abundance of littoral resources, including shellfish and marine birds (Moseley 1975).

Much of the immediate shoreline surrounding Wawakiki is very steep and rocky, providing many places from which to procure marine products. During the months of
February through August of 2003, our field crew regularly observed local fisher folk casting line from the rocky shore or exploiting near-shore rocky outcrops from small boats for both fish and shellfish. In addition, the enclosed sandy beach flanking the southern portion of the site provides an excellent landing for water craft. Today, fishermen continue to practice a technique termed *chinchorro*, where they utilize the Wawakiki beachfront to land two water craft at opposite ends of the beach, each dragging behind opposing ends of a single long net (Figure 3-5). Once ashore, a small group of fisher folk hauls in the net, trapping a wide variety of fish, crabs, and other marine delights. Locals continue to use traditional balsawood watercraft, or on occasion, small outboard motor boats for such purposes.

*Figure 3-5.* Shown here at Wawakiki Beach, locals continue to practice a traditional fishing technique termed Chinchorro.
**Lomas Resources**

The *lomas* typically occur above the spring systems (ca. 200 – 800 m.a.s.l.) and flourish during the austral winter season as dense fog rolls off the ocean to provide considerable moisture to the dry terrain (Moseley 1975: 8). Termed *garúa*, this dense fog provides the only measurable precipitation to the coast during non-El Niño years. The *lomas* support a number of plants, shrubs, and grasses within which a number of wild animals are known to seasonally inhabit, such as the guanaco, deer, and two types of Andean foxes. A recent investigation into species variability within the Osmore drainage documented a total of 393 species of plants throughout the entire valley, 63 of which were recorded for the coastal *lomas* (Makishi 1999). Recurrent rains delivered by El Niño events also foster notable surges of growth in herbaceous vegetation, encouraging advantageous use of the zone by nearby herders (Dillon 2004; Makishi 1999: 17).

Sources note that the *lomas* around Ilo were historically some of the most abundant of coastal Peru (Rostworowski 1981), and local populations traditionally utilized this resource for herding the domesticated llama and alpaca in pre-Hispanic times, and primarily sheep, goats, and mules during later Spanish colonial and modern eras. In general, though, the *lomas* areas surrounding Ilo today have declined significantly, suggesting that abundance and presumably diversity in these areas were much greater in antiquity.

The *lomas* behind Wawakiki has all but disappeared, but stumps of tara (*Caesalpinea spinosa*) trees remain scattered among the inland hills behind the site, and historic aerial photographs taken by Peru’s *Servicio Aereofotográfico Nacional* confirm
that many were still standing in 1951. Scatters of tara are also reported to have been quite extensive behind Alastaya several kilometers to the south of Wawakiki (Makishi 1999: 18). Combined with the Osmore drainage botanical data, then, the coastal hills appear to have once been a thriving micro-environment that supported a wide range of vegetation from herbaceous plants to trees.

**Spatial Relationship between Coastal Resources**

Local and regional topographic configurations create a varied distribution of primary resource viabilities throughout the lower and coastal sectors of the Osmore drainage. In the lower valley, fresh water, marine resources, and inland lomas are often spaced widely apart. The primary source of fresh water in the Ilo valley is the river itself, which maintains surface flow from about 25 km inland to the coast. Therefore, potential agricultural production may lie upwards of 25 km from marine resources. Similarly, the proximity of lomas resources to freshwater and marine products is very much dependant on local topography since coastal lomas typically flourish between 200 and 800 m.a.s.l. Thus, expanses of herbaceous plants and trees can be scattered kilometers away among the inland desert hills and pampas.

Conversely, along the coastal plain north of the Ilo river, the three principal resource bases are generally in much closer proximity. As the coastal plain narrows toward the midpoint between Tambo and Ilo, these resources become quite closely spaced. At Carrizal Spring, located approximately 18 km north of the Ilo River, lomas, fresh spring water, and the beach front are spaced within only a couple of kilometers of each other. However, Wawakiki’s position perched on a sea cliff offers easy access to
both fresh water and marine products, while the steep rise of the coastal cordillera from the sea brings *lomas* areas to only a short hike inland, offering access to wild shrubs and animals, wood, and possibly opportunities to herd small populations of domesticated animals. This configuration of closely spaced resources continues northward for at least another 15 km before the coastal cordillera begins to gradually recess from the coastline.

Agricultural communities occupying the lower and coastal sectors of the Osmore drainage throughout the second millennium A.D. had at their disposal a variety of potentially very productive resources in agriculture, fishing, and hunting/gathering/herding. Throughout this period, the generally arid climate of the western Andes encompassed punctuated spikes of coastal precipitation; decadal, seasonal, monthly, and even weekly variation in river and spring discharge; transformation of the desert landscape as humans manipulated patterns of hydrology to irrigate barren land; and waxing and waning of *lomas* vegetation as seasons change, *El Niño* episodes pass, and human activity intensifies or relaxes in those zones. Consequently, the physical environment of the coastal Osmore region should be conceptualized as a dynamic setting rather than as a stagnant canvass upon which agricultural land use evolved.
The Osmore region of southern Peru has played host to a long and complex history of cultural developments. From pre-ceramic hunter-gatherers, to late pre-Hispanic agricultural and marine specialists, to Spanish colonial commercial farmers, Osmore communities have arisen and declined through time, adapting to both micro- and macro-economic influences of the southern Andes and beyond. Production strategies at Wawakiki would have adapted to economic influences radiating from as close as neighboring coastal communities or from those in the Ilo river valley, or perhaps from as far away as Lima, the center of Andean political and economic control during the Spanish colonial period. To understand the forces affecting production schemes, agricultural communities must be contextualized within their proper cultural-historical context.

THE EARLY CERAMIC PERIOD AND ANDEAN MIDDLE HORIZON IN THE OSMORE AREA

The early ceramic era witnessed the first settled occupation of the middle Osmore drainage as early as 2000 B.C. with the Huaracane culture (Feldman 1989), and this little known period most likely represents the transition to agriculture in the Moquegua region. The early ceramic era in the lower valley may also extend as far back as 2000 B.C. (Bruce Owen2, personal communication, 2001), and while less is known of the onset of this period, the latest phase is associated with the *Olla sin cuello* (ca. 100 B.C. – A.D. 42

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2 Bruce Owen has conducted extensive research in the area, some of which relates to the Early Ceramic era.
Owen’s study (1993a) found settlement of this period to be predominantly located along the Ilo River between its mouth and 20 km inland. Sites were situated near the valley bottom to presumably take advantage of arable land, and *Olla sin cuello* populations may have been more agriculturally specialized than later populations of the lower valley, focusing primarily on maize, tubers, and beans (Owen 1993a: 3-6). At least some *Olla sin cuello* domestic sites were quite extensive in the lower valley, containing large areas of habitation terraces and built on steep hillsides flanking the Ilo River flood plain. At Loreto Viejo, the remains of *Olla sin cuello* domestic terraces cover roughly 5.4 ha, and they may have formed part of a larger series of contiguous sites both up and down river (Owen 1993a: 3). Unfortunately, subsequent late pre-Hispanic, Spanish colonial, and modern activities have all but destroyed Early Ceramic phase settlement near the mouth of the river. Many sites are either visible only as strata in erosional trenches and eroding hillsides or they are entirely buried. In any case, there appears to have been a sizeable amount of settlement in the Ilo River valley during this early phase.

Along the coast, Tello (1987) and Bolaños (1987) have each documented the presence of an early ceramic assemblage at the Pocoma and Carrizal springs, respectively. Termed *fase Carrizal*, this ceramic assemblage largely consists of undecorated neckless jar fragments that are consistent with *Olla sin cuello* vessel forms throughout the lower Ilo Valley and other early ceramic assemblages of northern Chile. In his archaeological settlement survey of the coastal plain between Ilo and Wawakiki, Umire-Alvarez (1994, 1996) also documented Early Ceramic settlement along the littoral as well as at a number of spring sites, including Pocoma, Carrizal, and Chuza, among
At Wawakiki, the Early Ceramic era has thus far been principally characterized by a formally bounded cemetery, which yielded a radiocarbon date of $1610 \pm 70$ years B.P. (Bawden 1989a). The burial complex contained individuals of both sexes and all age groups, suggesting that Wawakiki was an inclusive community cemetery (Buikstra 1995: 239). Grave goods were predominantly undecorated neckless jars, though a painted ceramic bowl was recovered from one burial, leading Bawden (1989b) to suggest the possibility of an autonomous coastal tradition. Other commonly recovered mortuary remains include fish hooks and seashells (Buikstra 1995; O Donnabháin et al. 1991), indicating the importance of maritime resources in the local subsistence economy. While the presence of a painted bowl seems to be unique, Wawakiki does appear to share some cultural affiliation with other Early Ceramic groups occupying the coast and lower Ilo valley. In 2003, excavations at Wawakiki recovered countless ceramic fragments that are consistent with *Olla sin cuello* assemblages elsewhere, and on the steep slopes overlooking Quebrada Agua Buena, excavation profiles revealed a thin carbon lens that yielded a carbon date of $1793 \pm 33$ radiocarbon years B.P., with a calibrated age range of AD $212 – 398$ (2-$\sigma$), lending further support to activities at the site during this period (Zaro 2004).

In general, the Early Ceramic era in the lower and coastal Osmore region was characterized by fairly specialized, settled farming communities that primarily exploited arable bottom lands in the Ilo River valley for agricultural production, and perhaps lands immediately below isolated fresh-water springs along the coastal plain. Excavations at Wawakiki did not identify any canal or terrace infrastructure associated with this early period, nor has any been identified at other coastal spring sites or to any large degree in
the main river valley. Because of the destructive nature of agricultural land use, I suspect that physical evidence of early agriculture in the lower and coastal Osmore region is scarce, and that cultivation was restricted to the immediate floodplain and spring channels, with perhaps only minor investment in canal irrigation technologies. Nonetheless, the presence of botanical remains of maize, tubers, and beans recovered by Owen (1993a) from the lower Ilo valley indicate that communities of this era were, at least to some degree, developing a local agricultural economy. Unfortunately, much more research is needed to understand early agrarian production strategies in the area. Beyond agriculture, the lower valley and coastal regions also provided potential for mixed subsistence activities that included hunting/gathering, fishing, and perhaps even herding. Furthermore, the association of Early Ceramic sites with several micro-environments along the coast may suggest the emergence of specialized economic exploitation during this phase, which became the predominant socio-economic structure of later pre-Hispanic and early Spanish colonial period Andean communities along the Pacific coast (see Rostworowski 1977, 1981).

The Andean Middle Horizon marked the first arrival of highland settlers in the middle Osmore drainage. The Omo (ca. A.D. 550 – 1000) and partially contemporaneous Chen Chen (ca. A.D. 850 – 1000) material assemblages represent the occupation of Moquegua by Tiwanaku colonists, and these communities focused on the exploitation of agriculturally rich bottomlands and gently sloping flanks of the middle valley (Goldstein 1989, 1993a, 1993b; Owen 2001). Shortly after the initial appearance of Tiwanaku in Moquegua, the valley witnessed the establishment of a Wari imperial colony on the summit of Cerro Baúl (Moseley et al. 1991). Wari most likely introduced
terraced agriculture of the high sierra to the Moquegua region during this period, and Wari agrarian production was centered primarily in the Torata Valley, a main tributary feeding into the middle Osmore region. Recent investigations conducted around Cerro Baúl suggest that during later phases of the Middle Horizon there was substantial interaction between Wari and Tiwanaku, including co-habitation of the upper sierra (Williams 2001: 81). While it does not appear that they were in direct conflict with each other (see Owen 1994a), the nature of their interaction is yet to be learned. Wari remained in coexistence with Tiwanaku colonists in the Moquegua region until the sudden disappearance of both ca. A.D. 1000 (see Williams 2002).

The occupation of the lower valley during this period is much more ephemeral, and consequently, much less understood. Dubbed the BR-Early Ceramic (after the Burgess-Reinhard site), available evidence suggests this period may have extended from ca. A.D. 400 to the earliest appearance of Tumilaca and Chiribaya cultural materials sometime between A.D. 800 and 950 (Lozada and Buikstra 2002; Owen 1993a). The few identifiable BR-Early Ceramic sites are clustered north of the river, up on the rim of the valley rather than near the floodplain. This may represent a shift in emphasis from a primary dependence on floodplain agriculture to perhaps a more balanced dependence on floodplain and lomas resources. This change in resource exploitation may have been encouraged by intensive irrigation practices of their upstream Tiwanaku and Wari neighbors. Coupled with a hundred year period of below average highland rainfall, water consumption in the middle Osmore may have severely decreased the available water supply to the lower valley, limiting its agricultural potential. On the other hand, middle and lower valley water consumption most likely had little effect on the coastal springs,
where *Olla sin cuello* communities were most certainly experimenting with agricultural products as well. Yet, the ephemeral nature of the BR-Early Ceramic phase might also reflect a real decline in population from earlier *Olla sin cuello* communities (Owen 1993a), especially since available radiocarbon dates from both lower valley and coastal spring sites alike generally fall between 100 B.C. and A.D. 400.

**LATE PRE-HISPANIC PERIOD: A.D. 800-1532**

The subsequent Late Intermediate Period in the Osmore drainage saw a decline in highland political control of the valley and a return to local cultural autonomy (Stanish 1992). Upon the disintegration of Tiwanaku control of the middle valley ca. A.D. 950, the subsequent Tumilaca settlement pattern became more dispersed, reaching into previously unoccupied areas of the upper drainage (Owen 1995) as well as into the lower drainage (Jessup 1990, 1991; Owen 1993b, 1994b). The almost immediate presence of the very similar Chiribaya material remains suggests a close relationship between the Tumilaca and Chiribaya populations. While they co-existed in the lower valley for a short time, the Chiribaya persisted until about A.D. 1350 or 1400, nearly 200 years after the disappearance of the Tumilaca. Despite extensive archaeological and bioanthropological debates over the relationship between these two groups (e.g., Boytner 1998; Lozada 1998; Jessup 1991, Owen 1993b, 2005; Sutter 2000; Wallert and Boytner 1996), it is clear that during this period the lower valley witnessed dramatic demographic and socioeconomic changes from the previous BR-Early Ceramic occupation. Major canals were constructed to irrigate hanging river terraces along the coastal valley and a limited area surrounding the mouth of the river, and agriculture became much more
diversified than that of the *Olla sin cuello* phase. In addition to maize, tubers, and beans, inhabitants of the lower valley exploited pacay, molle, algarrobo, lucuma, and guayaba (Owen 1993a: 6). Finally, distribution of funerary items became increasingly stratified during this period, suggesting the emergence of a visible Chiribaya elite (Buikstra 1995: 261). This elite representation did not, however, persist beyond the A.D. 1350 *el Niño*, which arguably catalyzed the disappearance of the Chiribaya culture within the lower and coastal reaches of the Osmore drainage (Reycraft 1998, 2000; Satterlee 1993; Satterlee et al. 2000).

The subsequent Estuquiña communities in the middle and upper reaches of the Osmore seem to have exercised autonomous control over local resources, and they were notably fortified and in defensible locations (Williams 1997: 117). Upper valley communities practiced localized terraced irrigation agriculture, while middle and lower Osmore communities cultivated the gently sloping flanks of the valley. Coastal communities presumably relied on a mixed subsistence base of marine and agricultural resources, with perhaps greater dependence on marine resources immediately after the A.D. 1350 *el Niño* (Penman and Bawden 1991; Reycraft 1998, 2000).

Along the coast, the most agriculturally intensive use of Wawakiki and the coastal springs may have occurred during this phase as well (Bawden 1989a, 1989b, Clement and Moseley 1991). Clement and Moseley (1991) suggest that the maximum extent of land under production at Carrizal spring occurred during its Chiribaya occupation, and that patterned agrarian contraction at that site through the modern era partially resulted from gradual tectonic uplift. The largest decline in cultivated land at the site (38%) occurred between the Chiribaya and Spanish Colonial periods (Clement and Moseley
1991: 441), although little is known regarding land use at Carrizal within that several hundred year stretch. The initial contraction in land under production, however, was probably sparked by the Miraflores *el Niño* episode that struck the south coast ca. A.D. 1350 (Reycraft 1998, 2000; Satterlee 1993). Ultimately, economic reorganization reflected an increased emphasis on the exploitation of maritime resources by post-disaster communities throughout the lower and coastal Osmore region (Reycraft 2000).

Beyond the collapse of the Chiribaya culture, centralized political control would not return to the region until the expansion of the Inka into Moquegua during the Andean Late Horizon. Inka presence in the valley was primarily limited to the upper and middle sectors of the Osmore, with a heavy investment in agricultural infrastructure of the region (Williams 1997). The Inka held only a minor presence along the coast, most notably reflected by a small surface scatter of decorated Inka ceramics at a single site above the beachfront some five kilometers to the south of Ilo (Bawden 1989a: 47).

**The Chiribaya Culture and Economic Specialization, A.D. 800-1375**

By and large, the late pre-Hispanic period in the lower and coastal reaches of the Osmore drainage was largely associated with the Chiribaya culture (A.D. 800-1375). Indeed, at Wawakiki Chiribaya material remains dominate the pre-Hispanic component of the site (Figure 4-1). Chiribaya cultural remains have been reported as far north as the Tambo drainage, as far south as northern Chile (Jessup 1991), and in very limited quantities in both domestic and funerary contexts as far inland as the upper Osmore sierra at approximately 3000 m.a.s.l. (Stanish 1992: 119). In addition, Chiribaya remains have been identified in the middle Moquegua valley at the site of La Victoria (Feldman 1984),
two small sites near El Ramadón (Garcia 1988), and at the largest middle valley Chiribaya site of Yaral (D. Rice 1993), which occupies the bank of the Moquegua River at its lowest point before disappearing into subterranean channels. By far, however, the majority of Chiribaya settlement known to date occupies the banks of the Ilo River, stretching from the river mouth to some 25 km inland (Owen 1993b, 1994b; Ghersi 1956; Jessup 1990, 1991; Umire and Miranda 2001), and along the coastal plain to the north of the Ilo River (Bawden 1989a, 1989b; Umire 1994, 1996; Umire and Miranda 2001; Figure 4-2). It seems reasonably clear that Chiribaya was largely a coastal development, with relatively little presence in the middle or upper sierra beyond Yaral.

Following the ethnohistoric model propounded by Maria Rostworowski de Diez Canseco (1977), Lozada and Buikstra (2002) argue that the Chiribaya constituted a
señorio in the lower Osmore Valley. Stemming from her ethnohistoric research along the Peruvian north and central coast regions, Rostworowski’s model—termed horizontality—suggests communities along the coast were occupationally specialized and traded with other communities of specialized production. Furthermore, she argues that these communities operated autonomously, each with its own internal social hierarchy, and each succumbing to a single supreme political leader, or señor (Rostworowski 1977). Using biological and cultural data, Lozada and Buikstra (2002) draw three primary conclusions regarding Rostworowski’s model and south coast Chiribaya populations: (1) the Chiribaya originated on the coast and therefore developed genetically independent from highland populations (for various perspectives, see Sutter 2000, 2005); (2) they

Figure 4-2. The lower Ilo and Tambo river drainages showing Chiribaya site distribution within distinct micro-environmental zones.
were composed of economically specialized communities (predominately agriculturalists and fisher folk); and (3) Chiribaya communities were internally stratified socially, with each holding its own elite but united under a single supreme authority at Chiribaya Alta. Materials for Lozada and Buikstra’s study stem from sites located throughout the lower and coastal portions of the valley, and specifically from regions of varied economic potentials. These include Yaral located in the middle valley, Chiribaya Alta located high on the Pampa Inalámbrica (also called Pampa de Descanso) overlooking the lower valley but in close proximity to lomas resources, El Algodonal located adjacent to the floodplain of the Ilo River, and San Gerónimo, which occupies a low river terrace only a few hundred meters from the coast.

Lozada and Buikstra are not the first scholars to find support for economic specialization among lower Osmore Chiribaya settlements. Others have noted the distinct ecological zones in which Chiribaya settlements are found and the associated economic viabilities of each (Bawden 1989a; Jessup 1991; Penman and Bawden 1991). Jessup (1991) first suggested there to be some degree of economic specialization among Chiribaya populations, though probably not limited to food nor to any absolute degree. He suggests specialized production based principally on the location of particular sites and their associated residential and mortuary artifacts. Specifically, he notes that Yaral and Chiribaya Baja were both located near the valley floor, and they were associated with floodplain hydraulics and substantial canal and terrace systems. San Gerónimo, on the other hand, is located only a few hundred meters from the coast, and excavations there revealed stone-lined storage bins of dried fish, and middens dominated by both fish and shellfish. Fishing paraphernalia such as hooks, weights, and floats were common grave
pit assemblages at San Gerónimo as well. Finally, Chiribaya Alta is located high up on the valley rim overlooking the Ilo River but near lomas areas that may have been utilized for herding. Camelid fauna were found at the site, including crania in tombs of all time periods (Jessup 1991: 9), and wool was most commonly used among Chiribaya textiles, suggesting the important role camelids played in the lower and coastal sectors of the Osmore (Boytner 1998; Wallert and Boytner 1996). Indeed, aside from possibly housing the supreme authority, Chiribaya Alta may have held direct control of grazing territories for coastal camelid herds raised in the lower valley.

The coast presents a slightly different configuration than that of the lower valley, though the principal resource bases remain the same. In the lower valley, the principal resource triad of agriculture-marine-lomas is widely spaced horizontally, encouraging specialization of production among local communities situated near these areas. These resources generally become less distant from each other along the coastal plain toward the north, though in the central and southern coastal plain (e.g., Carrizal) they remain kilometers apart. Commenting on specialized intensive exploitation of spring water for agriculture, the marine/littoral zones, and to a limited extent the inland lomas, Bawden (1989a: 47) suggests that north of Ilo, Chiribaya phase sites such as Carrizal, Pocoma, Burro Flaco, and Fanta display a pattern of interdependent micro-environmental exploitation along the desert coast.

Taken in combination, the lower and coastal sectors of the Osmore drainage presented a wide distribution of economic viabilities, and the settlement distribution and residential and mortuary assemblages of Chiribaya populations generally reflect that pattern. Umire and Miranda (2001: 63) assign principal Chiribaya sites of the lower
valley and coast into three categories: (1) sites within 200 m of the coastline whose principal economic concern was marine exploitation; (2) small villages located in coastal quebradas that were associated with small-scale agricultural production; and (3) larger communities occupying the main river valley, whose economic investment was primarily focused on canal irrigation agriculture (Table 4-1). In general, late pre-Hispanic socio-economic organization in the lower and coastal reaches of the Osmore drainage appears to have been structured around principles of specialized production, to which the majority of Chiribaya communities adhered.

<table>
<thead>
<tr>
<th>Coastline/Fishing</th>
<th>Coastal Quebradas/Farming</th>
<th>Ilo River Valley/Farming</th>
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<tbody>
<tr>
<td>San Gerónimo</td>
<td>Pocoma</td>
<td>Chiribaya Alta</td>
</tr>
<tr>
<td>Punta Tres Hermanas</td>
<td>Quebrada Icuy</td>
<td>Chiribaya Baja</td>
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<tr>
<td>Gentilar</td>
<td>Quebrada Tacahuay</td>
<td>Algodonal</td>
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<tr>
<td>Punta coles</td>
<td>Quebrada Chuza</td>
<td>Loreto Viejo</td>
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<tr>
<td>Punta Picata</td>
<td>Quebrada Carrizal</td>
<td>Yaral</td>
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<td>Fanta</td>
<td>Quebrada Alastaya</td>
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<tr>
<td>Playa “Las Enfermeras”</td>
<td>Quebrada Miraflores</td>
<td></td>
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<tr>
<td>Burro Flaco</td>
<td>Quebrada Agua Buena</td>
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<td>Carrizal (NW)</td>
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Table 4-1. Chiribaya and economic specialization (modified from Umire and Miranda 2001: 63)

**THE SPANISH COLONIAL PERIOD: A.D. 1532-1821**

The arrival of the Spanish Europeans in the early half of the 16th century marked the beginning of far-reaching political, social, and economic changes in the Andes. Political power fell more and more on the side of the Europeans as scores of Spaniards continued to pour into Peru. Concurrently, indigenous population levels declined and the traditional structure of Andean socio-political organization began to breakdown. Spanish mechanisms of political and economic exploitation of indigenous labor and wealth often divided *allyus* (local kinship groups often sharing common ancestry), undercutting
traditional Andean networks of reciprocal exchange and redistribution (Andrien 2001; Keith 1976). Still, while the newly developing colonial order deprived the indigenous populations of any real political power, native Andean communities constituted the foundation of the colonial hierarchy. Through their laborious efforts in mines, Spanish agricultural enterprises, and even on indigenous lands, they played key roles in the development of the Spanish colonial economy in the Viceroyalty of Peru.

A wide variety of people participated in the conquest and colonization of the Andes. Within just thirty years following Pizarro’s arrival in 1532, Spanish Peruvian society formed a nearly complete cross section of the Spanish socio-economic hierarchy: there were men and women of all ages, artisans, priests, farmers, merchants, mercenaries and notaries, to name just a few, the majority of whom came with self-serving goals to improve social status and wealth (Lockhart 1968). With these earliest of Spanish colonists came a European system of ideals that were placed upon everything from social organization, to religion, to cultural values of production and consumption (Andrien 2001; Keith 1976; Lockhart 1968).

After the initial arrival of the Spanish, the most influential reform arguably came during the tenure of Viceroy Toledo (1569-1581). As a response to decades of economic and political turmoil prior to his rule, Toledo sought to institute a series of reforms that included congregating Andean peoples into towns (reducciones), imposing a regularized system of taxation, and establishing a system of forced labor to maintain the silver mines of Potosí in what is today highland Bolivia (Andrien 2001: 49-50). His system was able to extract sufficient wealth and direct it towards Spain, though the viceroyalty remained struck with rampant corruption, administrative inefficiency, and indigenous resistance.
In the 18th century, the Bourbon administrative reforms sought to rejuvenate royal authority by breaking up the Viceroyalty of Peru, giving more control to local administrators and officials. This ultimately failed as well, and Peru declared its independence from Spanish royal authority in 1821 (Andrien 2001).

During the initial stages of conquest and colonization, Lima became the seat of Spanish political and economic control of the Andes. The influx of population created economic demands that would soon be felt across the entire Viceroyalty of Peru, and the main economic “trunk line” (as described by Andrien 2001 and Lockhart 1968) that extended from the mines at Potosí to Lima helped foster local market mechanisms along this route. Indigenous and Spanish communities alike began to alter their economic strategies in order to integrate more and more with this expanding network of supply-and-demand. Eventually, a market oriented economy spread away from this main “trunk line,” bolstering evermore complicated networks of economic exchange among local communities throughout the Andes, though Lima and Potosí remained strong forces in many local and regional economies.

From Encomienda to Hacienda: Spanish Colonial Land Use on the Andean Coast

As their power in Peru strengthened, the early Spanish colonial administrators and officials were faced with the daunting task of organization and control of this vast territory, and one of the earliest attempts to organize this new-found wealth was through the encomienda. The encomienda was the principal institution used to extract surplus resources from the indigenous population. In the strictest of terms, it was a grant of indigenous communities that paid a tribute in kind to the encomendero, or recipient of the
encomienda. Spanish efforts were focused on funneling wealth from existing modes of production—that is, traditional Andean mechanisms of production, exchange, and consumption—to the growing Spanish population. Other profit-producing enterprises often came to be associated with the encomienda, but their primary purpose was to redistribute wealth produced by indigenous labor, not to generate it (Lockhart 1968).

Encomiendas were typically associated with the foundation of towns, and in the earliest stages of Spanish settlement, they were often awarded to those individuals who participated in the conquest. Spanish Peruvian society during the early colonial period was markedly urban-centered, with only a select few tribute collectors, minors, and perhaps clergymen living outside the cities (Lockhart 1968: 227). Even encomenderos were expected to maintain residence in towns rather than living on their encomienda, and after 1563, they were expressly forbidden to live among their tribute payers for more than a few days at a time (Keith 1976: 32).

During the early conquest years, encomienda grants were often quite large. Smaller encomienda grants were thought to be inadequate, and in some cases, small coastal encomiendas were granted along with larger, sierra grants to remedy this perception of inadequacy (Keith 1976: 35). Consequently, the relatively small Spanish population at the time held a considerable monopoly on economic wealth and prosperity in Peru. As the Spanish population grew, however, newly awarded encomiendas decreased in size, and ultimately the influx of Europeans found themselves working as dependants of encomiendas to sustain themselves. Indeed, nearly all encomenderos supported a number of clients, some of which formed part of the larger household (Keith 1976: 40). For the most part, encomiendas could produce the necessary items locally to
satisfy the encomendero and associated dependants, like plenty of cotton and maize for instance, but Spanish products like wheat, European clothing, wine, and olive oil required importation from Spain. Prior to any real development of market mechanisms, the encomienda remained the greatest economic influence in early Spanish colonial Peru, serving as the center of economic activity and redistribution of wealth (Keith 1976: 40-41).

One of the largest and wealthiest encomiendas in the early Spanish colonial period was that awarded to Lucas Martinez Begazo in 1540, of which Ilo was a part. The encomienda was awarded by Pizarro to Martinez Begazo as compensation for his participation in the conquest of Peru and his role in the establishment and settlement of both Cuzco and Arequipa. The encomienda encompassed indigenous communities from Ilo to Tarapacá and included the valleys of Tarapacá, Azapa, Arica, Ilabaya, and others, totaling 1637 people (Adriazola Flores 1998: 40-41; Kuon Cabello 1981: 44). As part of this encomienda, the small coastal village of Ilo is reported to have consisted of a mere twenty native Andeans, a testament to the population decline experienced in the lower valley from late pre-Hispanic Chiribaya settlement to the Spanish colonial period.

Population decline everywhere proved to be a pitfall to the encomienda system in Peru. It was, after all, a parasitic institution that fed on the surplus of indigenous labor to support a growing Spanish population. When combined with a sharp decline in indigenous populations due to epidemic disease and emigration, the encomienda as it was founded was slated to fail. While generally indigenous population levels across Peru declined due to similar sets of circumstances, not all valleys were affected equally. Citing tributary populations of selected coastal encomiendas between A.D. 1575 and
1600, Keith (1976: 46-47) notes that the central and southern valleys suffered the steepest declines, with perhaps those valleys around Arequipa suffering the most. However, Keith (1976: 47) argues that the relatively low rates of depopulation in the southern valleys of Ica and Nazca may have resulted from the profitable wine industry that began to develop there in the latter part of the 16\textsuperscript{th} century and early into the 17\textsuperscript{th} century. Opportunities to cultivate wine grapes may have provided incentives to stay in the region rather than emigrate in search of more lucrative opportunities, though epidemic disease would have remained a factor in local demography.

As indigenous populations generally declined and the productivity of the encomienda as it had been instituted decreased, it became clear that in order for the Spanish to have ready access to European items of value such as wheat, wine, or olive oil, they would have to obtain them through trade and importation from Spain (a costly endeavor), or produce them themselves. Typically, though, the Spanish did not engage in commercial agriculture until a market mechanism was in place. Commercial agriculture finally began to take root as more and more Europeans began to diversify their production, directing it more towards their own cultural values of production and consumption rather than on the more traditional Andean system of production from which tribute was taken (Keith 1976). Further bolstering a market mechanism in colonial Peru was the ever growing economic “trunk line” that was established by the transport of silver from Potosí to Lima (Andrien 2001; Lockhart 1968). The early colonial market initially developed most rapidly along this trunk line, but soon after, in efforts to supply more provincial cities and mining zones, various “feeder lines” developed, further
igniting specialization in livestock, agriculture, and other enterprises throughout the Viceroyalty of Peru (Andrien 2001: 81).

Commercial agriculture on the Peruvian coast was anchored primarily to wheat, wine, and sugar (Keith 1976: 65). Initially, wheat held the greatest importance since its importation from Spain was an expensive feat. According to Keith (1976: 67), “The planting of wheat started out as a casual activity, undertaken for a single season without much planning or capital. Typically encomenderos had their Indians plant under the supervision of a Spanish overseer, using the traditional tools and methods associated with the cultivation of maize.” Ultimately, as Keith notes, cultivation of European products like wheat or wine grapes became a more permanent endeavor, and these small farmsteads or *chacras* became more formal agricultural enterprises directed toward the developing market economy. By the late 16th century, the monopoly on wheat production no longer resided around Lima and the central coast; rather, as the network of economic trunk-and-feeder lines grew more complex and the demand for European products increased throughout Peru, more and more provincial *chacras* began to produce wheat, sugar, and other culturally valued products (Keith 1976).

By the early 17th century, arboriculture became the primary focus of resident farmers in the Tambo and Ilo valleys, where olive trees dominated much of the landscape as lower valley and coastal communities exploited the growing regional market for olive oil (Adriazola Flores 1998; Kuon Cabello 1981). Surplus products were sent to Lima via boats along the coast while pack mules hauled loads of oil and wine to highland centers like Arequipa, Cuzco, and Potosí (Rice and Ruhl 1989). In his visit to Tambo in 1618, Vasquez de Espinosa notes that southward along the entire coastline toward Ilo were
highly productive olive groves and mills, where the *hacendado* generated more than 6,000 pesos annually from oil alone. He also comments on the grazing of over 200 mules on the *Lomas de Sauces*, approximately 5 km south of the Tambo River and only 25 km north of Wawakiki (Vasquez de Espinosa 1987[1618]: 27-28), no doubt exploited for transporting oil and other commodities to nearby coastal and adjacent highland market centers.

In the late 16\textsuperscript{th} and early 17\textsuperscript{th} centuries, the crown was faced with the dilemma of too many European settlers pouring into a system that was still largely based on the encomienda system. Gradually, the viceroys of Peru set out to establish new towns, in which settlers would develop modest land grants to participate in local and regional markets. This represented a fundamental difference in the development of the early Spanish colonial economy in Peru. While the encomienda was based on the extraction of wealth from existing modes of production, land grants served as pathways for the Spanish themselves to produce for market in order to sustain their own livelihood. This practice further developed the system of chacras, which ultimately became the foundation for the hacienda system in the 17\textsuperscript{th} century. Few Spanish farmers had the capital and labor necessary to develop enough land to make agriculture profitable in the market place, and thus many chacras were absorbed into larger hacienda estates (Keith 1976).

The far southern coast presents one anomaly to this pattern. In Ica, for example, the wine industry made profitable those small chacras that primarily produced wine grapes (Keith 1976: 98). The arid climate of the southern coast was particularly conducive to the cultivation of wine grapes, and the southern valleys soon held the market for the export of wine, not only to the Lima market, but throughout the
Viceroyalty of Peru. In Ica, Spanish farmers found it more profitable to plant grapevines than wheat or other grains, and moreover, viticulture could be practiced at a relatively small scale and still be profitable to the farmer. Because the market for wine reached far beyond strictly the local arena or distant Lima, small Spanish colonial period chacras dedicated to viticulture flourished as the main agricultural endeavor in valleys like Ica and Nazca (Table 4-2).

The situation was very similar in Moquegua, whose climate is also very conducive to productive viticulture. In a Moquegua Valley archaeological survey in the mid 1980s, P. Rice and Ruhl (1989) identified 128 bodegas, or wineries, most of which ranged in date from 1590 to 1853. While viticulture has somewhat declined in Moquegua over the past century, it flourished for 300 years or so following the middle of the 16th century, significantly directing the local economic structure of Moquegua to regional and macro-regional economic demands (Herrero 1940; Rice and Ruhl 1989; Romero 1953).

Of a similar vein, the southernmost coastal valleys of Peru, particularly those stretching from Tambo to Tacna, held the market on olive oil, since the climate of the

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*Table 4-2.* Early Spanish Colonial Landholding in the Ica Valley, Peru (modified from Keith 1976: 100).
southern valleys is most conducive to successful maintenance of olive trees (Paernio 1908). The flow of oil may have indeed paralleled that of wine, with significant amounts exported to Lima and Potosí in the early Spanish colonial period (Romero 1953), and likely to other parts of the coast and highlands as the network of a market economy became more complex. The importance of a number of olive fundos in the Ilo Valley and along the coast are mentioned for the 17th century, including production in quebradas Agua Buena and Seca at Wawakiki, among others (see Figure 4-3; Adriazola Flores 1998; Kuon Cabello 1981; Paernio 1908; Romero 1953). Indeed, the productivity of grapes and olives in the Moquegua and Ilo valleys, respectively, may have allowed late Spanish colonial period farmers in the Osmore region to retain a system predominantly of chacras and fundos, rather than consolidating lands into large hacienda estates. In the southern valleys, chacras remain the most common form of agricultural land use, sometimes termed small haciendas or fundos (Keith 1976: 81), and locals around Ilo continue to refer to farmsteads in the lower valley and olive groves maintained among the coastal springs as chacras and fundos, respectively.
Figure 4-3. Principal olive fundos of the Spanish colonial period mentioned by name in historical texts. It is important to mention that others existed during the Spanish colonial period northward to the Tambo River, southward along the coast from Ilo, and inland in the Ilo river valley, but too often they are only noted generally and not by specific name.


By the middle of the 19th century, Ilo had developed into a minor port, capable of docking even foreign vessels with permission from customs (Kuon Cabello 1981: 32). During the second half of the 19th century, however, several infrastructural improvements were made to the tiny port that better integrated Ilo with the southern Andes and beyond. Prior to 1868, the pier at Ilo was able to accommodate small vessels, but its limited capacity designated Ilo as only a minor port. In 1868, an earthquake centered off the coast of Arica, Chile, struck the southern Andes and triggered a tsunami, which caused significant damage to the Ilo coastline. Consequently, in the several decades following
1868, Ilo slowly moved from its original location north of the mouth of the Ilo River (what is today known as Pacocha and Pueblo Nuevo) to its current location on the south bank. A new pier was eventually constructed, which elevated its status to a major port of trade—“se elevará a Ilo a la categoría de Puerto Mayor” (Adriazola Flores 1998: 109).

Also as a consequence of the earthquake, a railroad was constructed to connect Ilo and Moquegua, and therefore facilitating transport of people and products up the Osmore corridor to the adjacent highlands, though this was suspended as well for a period of time in the early 20th century due to earthquake damage (Adriazola Flores 1998: 111-112), and transport of items up and down the valley relied once again on the backs of pack mules. The importance of Ilo as a major port connected to the highlands by rail fostered economic growth in the area, and it became a main center for the southern coast and adjacent highland valleys for exporting products, principally wine and olive oil, to Lima and beyond.

As an urban center, Ilo continued to grow in the early 20th century, though it continued to support itself principally through local agricultural endeavors. In addition to the maintenance of olive trees (see Paernio 1908), a variety of products continued to be cultivated in the Ilo Valley, including guayabas, oranges, pacae, higos, mangos, sugar cane, and alfalfa (Adriazola Flores 1998). To some degree, these products may have given way to the olive industry in the valley due to the drought experienced by the adjacent highlands for several decades in the early part of the 20th century (Newell 1949). However, alfalfa production may have also increased somewhat during this period, its primary consumer being the cattle industry in nearby valleys like Locumba, Ilabaya, and Tacna (Adriazola Flores 1998: 191). Still, olives remained the principal enterprise in Ilo
and along the coast, and oil produced at the various mills in the valley remained internationally renowned (Adriazola Flores 1998: 192). Coupled with the nationwide demand for olive oil, the monopoly held in Tambo, Ilo, and Tacna ensured that olives took precedence over other cultigens with respect to water allocation.

The Late 20th Century and Southern Peru Copper Corporation in Ilo

Perhaps the greatest economic influence in Ilo, and throughout southern Peru for that matter, occurred in the middle of the 20th century when the rights to the copper quarry at Toquepala in the upper Osmore drainage were acquired by Southern Peru Copper Corporation (SPCC) from the Northern Peru Mining and Smelting Company. Early explorations of the mine occurred in the early half of the 20th century by the Cerro de Pasco Corporation, but it was ultimately signed over to SPCC in November of 1954 (Hall 1992). SPCC’s exploitation of Toquepala was to be a massive undertaking, requiring huge amounts of labor and capital just to establish its foundation in southern Peru. Naturally, Ilo came to be the essential port through which to import the necessary machinery and equipment and to export processed copper (Adriazola Flores 1998: 199).

Prior to 1954, however, administrators, directors, and engineers of SPCC spent several years in Lima, Toquepala, Moquegua, and Ilo planning their enterprise and specifically the locations of crucial components to the mining operation like the smelter and the refinery. Arthur Hall, who held an administrative position with SPCC in the late 1940s and 50s, detailed his five-year experience working on site in Peru during the foundation years of the company (Hall 1992). He notes that the locations of particular infrastructure like the pier, and more importantly to this study the smelter, were
established after exhaustive studies of the Chilean/Peruvian coastline. Regarding the massive copper smelter that was eventually built roughly 15 km north of Ilo along the coast, Hall comments, “all [the inspectors] had the same goal, the selection of THAT site which would represent the least possible chance of resulting even in any alleged damage to humans, animals or crops” (Hall 1992: 55, emphasis original). For several years prior to deciding the location of the smelter, meteorological stations continuously recorded wind direction, velocity, temperature, and humidity. Hall also explains that on frequent occasions, balloons were released and tracked to verify air currents (1992: 55). In 1960, SPCC finally constructed the smelter in its current location, where for most of the time coastal winds would carry smoke and exhaust northward and away from the primary population centered at Ilo and the 500 ha of cultivated terrain associated with it in the main valley (Figure 4-4).

![Figure 4-4](image_url). Three dimensional map showing the location of the SPCC smelter in relation to Ilo and Wawakiki.
To begin this massive enterprise, SPCC also needed to purchase land upon which to build the smelter along the coast, to construct housing for workers, and ocean front property near Ilo on which to construct a massive pier that would allow large freighter ships to dock (Hall 1992). Importantly, SPCC purchased much of the land located along the coastline north of the smelter, including land at Chuza, Carrizal, Alastaya, Mirafl ores, Pocoma, and quebradas Seca and Agua Buena (Ezio Buselli\(^3\), personal communication 2003).

While the presence of SPCC in Ilo and Toquepala served as an economic boost to the area, the relationship between the mining company and local inhabitants of the lower and coastal reaches of the drainage have not always been amicable. Claims from a number of sectors regarding environmental impact resulted in visits from the Congress of Peru’s Commission of the Natural Environment (Comisión del Medio Ambiente del Congreso) to assess damages to the environment as a result of mining and smelting operations. Common claims typically referenced damage to agricultural enterprises as a result of smoke, and contaminated waters that typically support a significant fishing industry (Adriazola Flores 1998: 245). This problem intensified during the 1980s when SPCC was bombarded with claims of pollution and crop damage from all directions. Ultimately, SPCC paid out more than 6,500 million Peruvian soles in compensation for damages to agricultural sectors in the Ilo Valley; meanwhile, the government deemed those claims from inhabitants of the neighboring Tambo Valley to the north unfounded (Adriazola Flores 1998: 246). Eventually, SPCC established an Office of Environmental

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\(^3\) Ezio Buselli is the current director of SPCC’s *Servicios Ambientales* (Office of Environmental Services) in Ilo, Peru.
Services (*Servicios Ambientales*) to specifically handle compliance issues with local and national environmental policies (Ezio Buselli, personal communication 2003).

The presence of SPCC in Ilo had profound and immediate economic effects on the entire region. It provided jobs for thousands of people during the construction of the smelter, refinery, pier, and the rail service connecting the smelter with the mines at Toquepala, and it subsequently provided thousands of additional jobs for laborers at the mine, smelter, and refinery, as well as administrators and engineers at all levels of the operation (Adriazola Flores 1998). Ilo also benefited from SPCC funds allocated to other civic projects, like sewage disposal, a potable water system, power plant, and schools (Hall 1992: 155-156), and the company continues to be a major economic force throughout Ilo and southern Peru.
Chapter 5:
SORTING THROUGH CHRONOLOGY: METHODS TO IDENTIFY LONG-TERM AGRICULTURAL LAND USE AT WAWAKIKI

Material manifestations of ancient fields and their diachronic changes are important to evaluate transformations in agricultural production because they represent agrarian technology, engineering skills, and the relative amounts of labor invested in the landscape. Wawakiki exhibits a complex array of lengthy canals, stone-faced terraces, linear and serpentine furrows, and water impoundment reservoirs. An increase or decrease in these capital investments in the landscape reflects changes in labor investment and overall agrarian production strategies. Importantly, chronological assessment of fields can reveal technological innovations (Brookfield 1984), incremental additions (Doolittle 1984), or abandonment periods at Wawakiki, and understanding the historical evolution of such constructions is essential for interpreting local agrarian land use strategies in the context of long-term socio-environmental trajectories.

Agricultural landscapes are very fragile and ephemeral remains in the archaeological record because field technologies and planting surfaces are constructed, cultivated, modified, abandoned, re-cultivated, and abandoned again, often resulting in partial or total destruction of earlier production strategies. Consequently, chronological control of agricultural features often presents the greatest obstacle to investigations of past agrarian production systems. To properly identify and assess ancient agricultural technologies in what are often long and complicated trajectories of production,
multidisciplinary approaches involving archaeology, geology, palaeoclimatology, history, and geography are required.

**CHRONOLOGY AND LAND USE AT WAWAKIKI**

Wawakiki displays the effects of over 900 years of intensive—though probably intermittent—agricultural production strategies. While initial cultivation likely occurred at the site during the early half of the first millennium A.D., large investments in landscape modification beginning around A.D. 1200 and followed by subsequent periods of abandonment and re-cultivation by Spanish colonial and modern era farmers have left a very complex pattern of land use. Using a multidisciplinary approach, excavations and profiles performed during the 2003 field season identified buried stone-faced agricultural terraces underlying Spanish colonial and more recent sediment furrows, and long irrigation canals that transported water along steep hill slopes from both near-shore and inland springs to agricultural fields.

Past and present research along the coast has identified a long history of occupation and land use at Wawakiki. As part of a salvage operation just prior to the construction of the coastal road, Ó Donnabháin et al. (1991) excavated an early ceramic period (ca. 100 B.C.-A.D. 400) cemetery at Wawakiki just above a Chiribaya period domestic sector, and excavations in this project in 2003 exposed a buried lens of burned material on the slopes above Quebrada Agua Buena that yielded an uncalibrated radiocarbon date of 1793 ± 33 B.P., with a calibrated age range of A.D. 212-398 (2σ). In addition, ceramic shards of neckless jars were commonly recovered from excavations or observed in profiles, characteristic of the *Olla sin cuello* early ceramic period assemblage.
identified elsewhere in the area. Agriculture likely first occurred during this period, given the presence of *Olla sin cuello* materials and their association with botanical remains in other areas along the coast and lower valley (Owen 1993a). Chiribaya phase occupation at the site was first reported by Umire and Miranda (2001) but is most intensively documented in this project. Early Spanish Colonial period land use is also mentioned for both quebradas Agua Buena and Seca (Adriazola Flores 1998: 61; Kuon Cabello 1981: 139; Romero 1953: 349), but it is also well documented here. Twentieth century land use is reported by the Peruvian *Ministerio de Fomento* for 1908, which provides an estimate of 700 productive olive trees at Quebrada Agua Buena at that time (Paernio 1908: 6). However, it is unclear in this assessment if ‘Quebrada Agua Buena’ includes the promontory of Wawakiki, or merely the quebrada itself with associated terraces located approximately 2 km inland. Excluding the promontory, 700 trees seems to be a rather generous estimate. In any case, aerial photographs confirm that the principal sector of Wawakiki along the coast was completely abandoned by 1951, placing its final period of cultivation in the early part of the 20th century.

**IDENTIFICATION OF AGRICULTURAL INFRASTRUCTURE**

To investigate agricultural land use at Wawakiki, two kinds of field techniques were performed: isolated profiles (-p) and excavations (-e). Isolated profiles targeted natural rills that course their way through the site, most of which run perpendicular to the slope. At least one wall of an erosional cut was straightened and cleaned down to sterile sediments, and a detailed profile was drawn to document depositional pattern, field technology, and chronological evolution of field systems. Sediments removed from these
erosional trenches were not screened nor were artifacts collected, but observations were noted in profile descriptions. Isolated profiles ranged from less than 2 meters in length to 27 meters in length, with a mean of nearly 7 meters.

Excavations, on the other hand, targeted field areas with little erosional disturbance. Excavation units were all 1 meter wide, and ranged from 2 to 5 meters in length. All were excavated to sterile by natural stratigraphy or by 10 cm levels, whichever was encountered first. Sediments were sifted through a 0.5 cm mesh screen, and all artifacts were collected and catalogued. Profiles were drawn of at least one long wall of each excavation, and at times two or even all four walls were profiled. A total of 31 isolated profiles and 10 excavations were performed throughout the site, yielding profile data from 41 unique locations (Figure 5-1).

Technology and spatial limits of ancient and more recent land use at Wawakiki were assessed using radiocarbon dates from a variety of contexts in conjunction with a number of relative chronological markers. These relative indicators include (1) diagnostic ceramics associated with terrace walls, water impoundment tanks, and nearby domestic sectors; (2) stratigraphic positioning of buried field horizons; and (3) relative degree of preservation of agricultural fields and planting surfaces. Preservation of surface remains proved to be most helpful to identify changes in spatial limits of land use during the Spanish colonial and more recent eras, where at least three phases of contraction are noted. In addition, historical records report the eruption of the Huaynaputina volcano of southern Peru on February 19, 1600, which projected tephra over a large area of the southern highlands and coast. Projected depths of tephra for the Tambo-Ilo coastline are 1-2 cm near Ilo, and up to 5 cm at the midpoint between the
Figure 5-1. Air photograph showing the location of excavations (E) and isolated profiles (P).

Tambo and Ilo rivers (Thouret et al. 1999: 436). While its preservation depends on a number of variables, including local topography and both natural and cultural post-depositional activities, tephra thickness at Wawakiki ranges from 1-3 cm, and its
presence allows for chronological placement of planting surfaces, terrace walls, and sediment strata to pre- or post-1600. Finally, characteristics of agricultural features from more securely dated contexts were used to assign chronological affiliation to agricultural technology and land use in other areas, where conditions did not permit such rigorous temporal control. Specific evidence for assigning particular technologies or extent of land use to chronological phases is presented in the following chapters.

**POLLEN AND SPECIES DIVERSITY AT WAWAKIKI**

Botanical remains can provide insight into the nature of agricultural production activities, and when found in the context of ancient fields, they can speak directly to the kinds of plants being cultivated around particular sites. Diachronic changes in the relative proportions of specific plants can suggest the degree of specialization, labor and water requirements, and emphasis on the exploitation of subsistence or economic plants. Decisions to cultivate particular plants are an integral part of agrarian planning, and a contextual consideration of changes in plant varieties partially explains changes in production strategies and labor organization at Wawakiki. Plants pollinate by wind, water, animals, or self-pollination, and pollen continuously accumulates in soils, providing a stratigraphic record of local and regional vegetation patterns (Morrison 1995: 136). Because pollen is widely—albeit unevenly—distributed, it indirectly measures past vegetation, and the quantity found in the archaeological record varies depending on the amount of pollen produced and its means of transport.

A total of 51 soil samples from both excavations and isolated profiles were extracted from a variety of spatially and temporally discrete contexts at Wawakiki
Due to financial constraints on the project, only twenty of those 51 samples were analyzed for pollen, but they are associated with all three general chronological periods: nine samples were extracted from profile strata associated with Late Chiribaya phase agricultural infrastructure, five samples were extracted from contexts determined to be associated with Spanish colonial period land use, and the remaining six were determined to be associated with early modern era land use. All samples were sent to the Paleoresearch Institute for pollen analysis under the direction of Dr. Linda Scott Cummings.

Following procedures outlined in the Paleoresearch Institute field manual, samples were excavated from freshly exposed sediment strata by a hand trowel cleaned with distilled water before each extraction. Once in the Paleoresearch laboratory, a chemical extraction technique based on flotation was used to remove pollen from sand,

![Figure 5-2. Aerial photograph showing the spatial distribution of all soil samples extracted from Wawakiki.](image)
silt, and clay with which it was mixed (for a detailed description see Cummings 2004: 1). This particular process is used for extraction of pollen from soils where preservation has been less than ideal and pollen density is low. After removal, a light microscope was used to count pollen to a total of 100 to 300 pollen grains at a magnification of 500x. Generally, pollen preservation in the Wawakiki samples varied from good to poor.

Pollen aggregates were also recorded during analysis. Aggregates are clumps of a single type of pollen, and their presence may represent pollen dispersal over short distances or the introduction of portions of the plant into an archaeological setting. The presence of aggregates is noted on the pollen diagram by a letter ‘A’ next to the pollen frequency. A plus (+) on the pollen diagram indicates that the pollen type was identified beyond the regular count while scanning the remainder of the microscope slide (Figure 5-3). In the following three chapters, discussions regarding cultigens and vegetation within chronological phases are based on the pollen report produced by Paleoresearch Institute regarding the twenty samples.
Figure 5-3. Pollen diagram of 20 soil samples analyzed from Wawakiki.
Chapter 6:

LATE PRE-HISPANIC AGRICULTURAL LAND USE

Much of the surface of Wawakiki is dominated by sediment furrows associated with more recent land use, but excavations and profiles throughout the site identified a buried agricultural technology consisting of low, stone-faced hillside terraces. Predominantly associated with the late pre-Hispanic period, this technology was identified along the steep canyon walls of both quebradas and in a number of excavations and profiles on the coastal promontory. Figure 6-1 displays the locations of those profiles and excavations that yielded evidence of pre-Hispanic land use, most of which are mentioned in the text, and it should be consulted regularly throughout this chapter.

CHRONOLOGICAL ASSESSMENT OF LATE PRE-HISPANIC AGRICULTURE

Several excavations in Quebrada Seca near the coastal promontory provide evidence for a Late Chiribaya (AD 1200-1400) phase construction and use of stone-faced hillside terraces. Excavation WK5D-e is a 1 x 4 m unit whose western limit overlies a terrace wall. The northern profile of the unit identified a thin lens of Huaynaputina tephra (AD 1600) superimposed over the basal stones of the collapsed terrace wall (Figure 6-2). The preserved height of the terrace near the unit’s eastern end is approximately 1 m above the basal layer, and thus the overall degree of decay exhibited by this terrace suggests that a substantial period had elapsed between its abandonment and tephra deposition, or AD 1600. Also supporting a Late Chiribaya construction and
Figure 6-1. Air photo showing the locations of excavations and profiles that yielded evidence for late pre-Hispanic land use at Wawakiki. Note the Spanish colonial wall (indicated by white arrow).
Figure 6-2. North profile of excavation WK5D-e depicting decayed terrace wall and superimposed Huaynaputina tephra.

Figure 6-3. Profile of isolated profile WK5B-p showing relationship of terrace wall, fill, and sterile colluvium.
cultivation period for these terraces is isolated profile WK5B-p (Figure 6-3). This profile is located near the distal end of this sector in a deep (~1 m) rill, and remains of at least two terrace walls spaced 1.5 m apart are noted. The profile also identified a 5-10 cm thick lens of burned material underlying the base of one terrace wall and at a very abrupt contact between cultural terrace fill and sterile colluvium. This lens contained pellets of camelid dung and remains of maize cobs, which yielded an uncalibrated radiocarbon age of 700 ± 60 BP, and a calibrated age range of AD 1267-1409 (2-sigma) (Table 6-1, sample 1), confirming terrace construction at this most distal end of the irrigation system during the late Chiribaya period. Also important is the use of stone footer walls in front of some principal terrace walls, which remain visible in a number of rills around this area. These basal walls were typically smaller, located within 20-30 cm of the main terrace wall, and may have provided strength at the bases of terraces where greatest pressure is exerted.

The distribution of buried stone terraces, many of which are associated with footer walls and underlie preserved lenses of Huaynaputina tephra, suggests that agricultural landscaping during the late pre-Hispanic era encompassed at least 11 ha, and it included portions of the steep canyon walls of both quebradas Agua Buena and Seca, and the coastal promontory of Wawakiki (Figure 6-4). The entire area was irrigated by two primary canals that traversed steep canyon walls in both quebradas to irrigate hillside terraces, and both extend onto the coastal promontory just below a series of habitation terraces. Diagnostic ceramics and radiocarbon age ranges also confirm these habitation terraces were occupied between AD 1200-1400, further linking the maximum canals and stone terraces to the Late Chiribaya phase (Table 6-1, samples 15-20). Isolated profiles WK4A-p and WK4B-p revealed a somewhat complicated evolution of domestic terraces.
<table>
<thead>
<tr>
<th>Field Sample #</th>
<th>Lab Sample #</th>
<th>Geochron Lab. (GL)</th>
<th>Type</th>
<th>Material</th>
<th>Uncalibrated Radiocarbon Age BP</th>
<th>Calibrated 1-σ cal AD age ranges (relative probabilities)**</th>
<th>Calibrated 2-σ cal AD age ranges (relative probabilities)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-WK5B-P</td>
<td>GL30458</td>
<td>Conv.</td>
<td>Charcoal</td>
<td>700 ± 60</td>
<td>1286-1323 (0.455)</td>
<td>1233-1243 (0.012)</td>
<td>1267-1409 (0.988)</td>
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<td>2-WK5E6-E</td>
<td>GL30459</td>
<td>Conv.</td>
<td>Charcoal</td>
<td>480 ± 90*</td>
<td>1402-1509 (0.779)</td>
<td>1320-1350 (0.038)</td>
<td>1387-1645 (0.962)</td>
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<tr>
<td>3-WK3B8-E</td>
<td>AA56759</td>
<td>AMS</td>
<td>Charcoal</td>
<td>935 ± 32</td>
<td>1051-1063 (0.157)</td>
<td>1046-1088 (0.286)</td>
<td>1104-1219 (0.714)</td>
</tr>
<tr>
<td>4-WK3C4-E</td>
<td>AA56760</td>
<td>AMS</td>
<td>Charcoal</td>
<td>575 ± 31</td>
<td>1399-1427 (1.000)</td>
<td>1324-1341 (0.074)</td>
<td>1391-1442 (0.926)</td>
</tr>
<tr>
<td>5-WK3C5-E</td>
<td>AA56761</td>
<td>AMS</td>
<td>Charcoal</td>
<td>651 ± 32</td>
<td>1317-1356 (0.750)</td>
<td>1298-1370 (0.734)</td>
<td>1376-1404 (0.266)</td>
</tr>
<tr>
<td>6-WK3C-E</td>
<td>AA56762</td>
<td>AMS</td>
<td>Charcoal</td>
<td>685 ± 33</td>
<td>1298-1322 (0.404)</td>
<td>1291-1393 (1.000)</td>
<td></td>
</tr>
<tr>
<td>15-WK4B-P</td>
<td>AA56771</td>
<td>AMS</td>
<td>Charcoal</td>
<td>592 ± 35</td>
<td>1325-1333 (0.117)</td>
<td>1319-1352 (0.262)</td>
<td>1385-1439 (0.738)</td>
</tr>
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<td>16-WK4A-P</td>
<td>AA56772</td>
<td>AMS</td>
<td>Charcoal</td>
<td>627 ± 30</td>
<td>1322-1348 (0.656)</td>
<td>1304-1360 (0.605)</td>
<td>1380-1416 (0.395)</td>
</tr>
<tr>
<td>17-WK4A-P</td>
<td>GL30460</td>
<td>Conv.</td>
<td>Charcoal</td>
<td>640 ± 50*</td>
<td>1305-1306 (0.019)</td>
<td>1276-1321 (0.558)</td>
<td>1349-1387 (0.442)</td>
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<tr>
<td>18-WK4A-P</td>
<td>AA56773</td>
<td>AMS</td>
<td>Charcoal</td>
<td>727 ± 30</td>
<td>1284-1305 (0.487)</td>
<td>1419-1497 (1.000)</td>
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</tr>
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<td>AMS</td>
<td>Charcoal</td>
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<td>1434-1460 (1.000)</td>
<td>1184-1199 (0.014)</td>
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</tr>
<tr>
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<td>Conv.</td>
<td>Charcoal</td>
<td>720 ± 90*</td>
<td>1273-1392 (1.000)</td>
<td>1206-1429 (0.986)</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-1. Radiocarbon Dates, Late Pre-Hispanic Era

** dates calibrated using CALIB REV4.4 Radiocarbon Calibration Program (Stuiver and Reimer 1993) made available by the University of Washington, based on southern hemispheric data sets described by McCormac et al. (2002) and international data sets described by Stuiver et al. (1998a) and Stuiver et al. (1998b).
that may have developed over the course of several hundred years. Profiles revealed a series of shallow and more deeply buried floor surfaces, covering a total of 0.48 ha (see Appendix, Figures A-2 through A-7). Generally, though, radiocarbon dates confirm there was substantial occupation during the late Chiribaya phase, with most age ranges falling between AD 1200 and 1400 (Table 6-1).

Figure 6-4. Air photo depicting extent of land use during the Late Chiribaya phase (AD 1200-1400).

MAXIMUM ELEVATION CANALS

Two maximum elevation canals associated with Chiribaya construction are documented to have extended from both quebrada channels, transporting water along steep canyon walls to the coastal promontory of Wawakiki (Figure 6-5). The Quebrada Seca canal can be traced for a distance of 215 m at an average gradient of nearly 4%.
Profiles confirm that the canal most likely had only one major period of use, and that its base had been at least partially chiseled into bedrock. It passes just below the Chiribaya domestic terraces, further corroborating the construction and use of the canal during this period. Unfortunately, the canal disappears under slope debris and talus from the modern road cut long before intersecting the main channel of Quebrada Seca, rendering it impossible to positively identify its spring source.

The Quebrada Agua Buena canal can be traced intermittently for a distance of at least 430 m at an average gradient of 3%, but given its position high up on the canyon wall, it likely extended inland for at least another 300 m or so before intersecting with the quebrada channel. Like its Quebrada Seca counterpart, this too disappears under slope debris and talus from the modern road as it approaches the quebrada channel. However, profiles of natural rills that cut through this canal along the steep canyon wall suggest that
it was renovated at least once beyond its initial construction during the Chiribaya period, based on two thin alluvial deposits of laminated silt and sand, separated by several layers of loose colluvium. Identified in profile data from WK2A-p and WK2B-p, these colluvial deposits consist of coarse gravels and small angular stones that originated from the steep, unstable hill slopes above. Subsequent excavations into these deposits re-activated the canal (Figure 6-6), presumably during the Spanish colonial period (see Chapter VII). Surface examination along the entire course of the canal also suggests that the degree to which colluvium buried particular sections varied considerably, and thus may not have been as severe in other areas. The initial construction of this canal is dated by the association of its distal end with the Chiribaya domestic area and with buried pre-AD 1600 agricultural terrace features that are discussed in detail below. Its renovation during the Spanish colonial era is supported by its association with linear sediment furrows overlying both Huaynaputina tephra and stone terraces.

These two primary canals extended from their respective quebrada channels, transporting water across steep canyon walls and onto the coastal promontory where they nearly overlapped at similar contours near the southern edge of the coastal promontory. As an integrated hydrological system, they irrigated a minimal area of nearly 11 ha. While calculated gradients of these canals are quite steep (see Doolittle 1990), they are not surprising given generally low spring discharge. As mentioned above, the Quebrada Agua Buena canal may have extended for a total distance of nearly 750 m. Local rates of evaporation and infiltration would require rapid transport as distances increase from spring source to cultivated terrain.
Figure 6-6. Profile WK2B-p displays at least two use episodes (strata 8 and 15 in bold) of this primary canal on the south canyon wall of Quebrada Agua Buena.

**QUEBRADA SECA AGRICULTURAL LAND USE**

Agricultural terraces in this area include those of the steep canyon wall of Quebrada Seca as well as the area immediately south of the Spanish colonial stone property wall (see Figure 6-1, 6-5). Labor-intensive hillside terraces faced with stone are evident throughout this sector, though it shows no indication of use for cultivation beyond the pre-Hispanic era. Of any sector at Wawakiki, this area exhibits the most frequently preserved lenses of Huaynaputina volcanic tephra. Quite regularly, tephra is
noted in both excavations and profiles in very shallow contexts, as well as in many other unexcavated rills that course their way through the hillside. In addition, Spanish colonial and modern era sediment furrows that dominate the surface in other areas of the site are notably absent, further suggesting its pre-Hispanic abandonment.

All excavations and profiles conducted in this zone identified agricultural terraces constructed of stone facing, albeit of a wide range of preservation. While several units noted preservation of terrace walls to be only one course high, other units documented terrace walls still standing as high as 65 cm, associated with fairly homogenous sedimentary deposits of terrace fill, and stratigraphically below Huaynaputina tephra (e.g., Figure 6-7). On a 40% slope, isolated profile WK5E-p best illustrates the labor and technology the Chiribaya invested in agriculture on this coastal promontory. The profile extends nearly 11 m and contains several shallow and intermittent pockets of Huaynaputina tephra. A total of eight stone terrace walls spaced at approximately 1.5 m

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Figure 6-7. Profile from excavation WK5A-e.

1. Stratified alluvial deposits of laminated sediments with coarse gravels and stones
2. Post-Huaynaputina slope wash, sediments with scattered small and medium stones
3. Pre-Huaynaputina fine and medium sediments, possibly associated with terrace fill
4. Terrace fill consisting of fine and medium sediments, ceramic and marine shell fragments, some fine laminated sediments
5. Continuation of terrace fill, medium sediments, increase in small and medium stones, shell and ceramic fragments throughout
intervals are documented in this profile, and each is constructed of stacked uncut/unshaped stones preserved to heights of 25-50 cm (Figure 6-8). Strata associated with the terrace walls are fairly homogenous, and contacts between deposits are gradational with only minor differences in compaction. Stone walls visibly extend laterally across much of the hillside, as well as both up and down slope from the profile.

Though footer walls have not been documented elsewhere along the coast, low stone-faced terrace walls at Wawakiki generally conform to descriptions of Chiribaya agricultural infrastructure recorded farther south at Carrizal Spring. There, Chiribaya stone-faced terraces average 35 cm in height, contain sediment fill with scatters of domestic refuse such as marine shell and ceramics, and they contrast sharply with field technologies of the later Spanish colonial and modern eras (Clement and Moseley 1991: 433). The contrast is just as striking at Wawakiki, which, among other things, allows for identification of buried Chiribaya agricultural terraces beneath colonial fields in both Quebrada Agua Buena and on the coastal promontory.
Figure 6-8. Profile WK5E-p demonstrating the regularity and labor investment in stone terracing on this steep slope near the southern edge of the coastal promontory.

1 Thin alluvial deposit of laminated sediment and medium to coarse gravels
2 Upper strata of terrace fill; very fine to medium sediments with scattered medium gravels, fairly homogeneous along with strata 3; small scatters of rootlets throughout much of this strata, and it exhibits light to medium compaction
3 Lower strata of terrace fill; fine to medium sediments, scattered gravels, underlying strata 2 for the entire length of the profile; primary difference between 2 and 3 is level of compaction, with 3 being much more compacted;
QUEBRADA AGUA BUENA AGRICULTURAL LAND USE

The Quebrada Agua Buena canyon wall angles downward at a 41% slope from the primary canal to the main channel. Data from isolated profiles WK2C-p and WK2E-p confirm that this area was heavily terraced during the Chiribaya period (Figures 6-9, 6-10). Stone-faced terrace walls in these profiles range from 40-60 cm in height, and are spaced at roughly 3 m intervals. Strata associated with terrace walls are typically composed of dark silt, sand, gravel, scattered small angular stones, and fragments of marine shell and ceramics. Combined, the two profiles reveal five cases where terrace walls are associated with small footer walls, much like those observed in Quebrada Seca. Huaynaputina tephra is present in both profiles as well, clearly post-dating the terrace walls. In the case of profile WK2E-p, Chiribaya terraced fields partially overlie buried Early Ceramic period deposits that yielded an uncalibrated age of 1793 ± 33 radiocarbon years BP, and calibrated age ranges of AD 270-340 (1-σ) and AD 212-398 (2-σ).
Figure 6-9. Profile WK2C-p displaying stone terraces with associated footer walls in Quebrada Agua Buena.

Figure 6-10. Profile WK2E-p displaying regularly spaced stone terraces with associated footer walls in Quebrada Agua Buena.
COASTAL PROMONTORY AGRICULTURAL LAND USE

The coastal promontory lies at the distal end of both primary irrigation canals (see Figure 6-5). The terrain slopes downward at a 35% gradient from the Quebrada Agua Buena maximum elevation canal, and its surface is largely dominated by well preserved Spanish colonial and modern era remains of linear and caracol furrows (Figure 6-11; for a description of caracoles, see Chapter 8 of this volume; Rivera 1987: 232). A single water impoundment tank lies near the upper northern extent of the area, and excavations to sterile sediments determined it to be of purely Spanish colonial and post colonial construction and use (discussed in greater detail in Chapters VII and VIII). A total of 16

Figure 6-11. View to the north of the coastal promontory, where the surface is dominated by remains of linear and caracol sediment furrows. Note the Spanish colonial property wall in the lower right (indicated by arrows).
profiles and excavations were performed in this area, five of which lend strong support for intensive terracing and land use during the Chiribaya phase.

Isolated profiles WK3C-p and WK3H-p are located within the same rill and separated by only 2 m. Together they provide 24 total meters of profile data, extending down slope from just below the maximum elevation canal. Despite considerable reworking of this terrain in historic times into linear sediment furrows, buried stone-faced terraces were identified in both profiles. In addition, buried lenses of Huaynaputina tephra are noted in three distinct locations, and by superposition they are associated with sediment strata that post-date terrace walls. Terraces identified in both profiles are constructed of stacked stone, typically preserved to heights of 35-50 cm, and spaced at approximately 2 m intervals. In several instances, footer walls are associated with principal terrace walls (Figure 6-12).

**Figure 6-12.** Buried stone terrace and associated footer wall identified in Profile WK3C-p. Linear sediment furrows dominate the surface in this area.
Farther down slope near the northern sea cliff, remains of similar stone-faced terraces were identified in isolated profiles WK3I-p and WK3J-p, though the terrain in this area is very steep, rocky, and unstable, making for poor preservation of pre-Hispanic agricultural infrastructure. More preserved of the two are terrace walls noted in WK3I-p, which identified two walls spaced about 3 m apart, the lower of which is reduced to a linear pile of stones and lies within 2 m of the sea cliff. The upper wall is preserved to a height of 50 cm, and it is partially buried by linear sediment furrows (Figure 6-13).

While Huaynaputina tephra is absent here and cultural materials are few, terrace

![Figure 6-13](image_url)

1. 10YR 5/3, surface deposits, loose sediments and scattered gravels
2. 10YR 4/2, lightly compacted sediments, small gravels, and scattered coarse gravels
3. 10YR 4/3, transition from 2 to 3 is not well defined, but generally density and quantity of coarse angular stones increases
4. 10YR 4/2, loose sediments, fine gravels and scattered coarse gravels; tiny rootlets are also present
5. 10YR 3/2, similar to 5, though with very few rootlets, slightly more compact
6. 10YR 4/2, sediments, gravel, and an increase in density of coarse gravels; more compact than 5 or 6; possibly associated with the inferior wall
7. 7.5YR 4/4, sterile sediments
8. 10YR 5/4, sterile sediments, though less angular stones than in 8
9. 10YR 5/3, semi-compacted sediments and gravel (immediately below surface)
10. 10YR 4/2, medium sediment
11. 10YR 3/2, sediment and gravel matrix, seemingly associated with terrace construction and fill
12. 10YR 4/3, similar to 10, though greater density of coarser gravel, colluvial
13. 10YR 4/2, dense sediments, gravel and angular stones. Lower portion appears sterile; probably colluvial deposits and/or terrace collapse

Figure 6-13. Profile WK3I-p displaying the remains of two stone terrace walls. The uppermost wall is partially buried by linear sediment furrows noted on the surface.
technology and poor preservation approximate much more that of the pre-Hispanic era than that of the Spanish colonial or modern periods.

Because field deposits are deeply buried near the lowermost portion of the coastal promontory, evidence for pre-Hispanic land use in this area is difficult to find. However, isolated profile WK3K-p lends some support for pre-Hispanic land use. This profile was excavated on the side of an early modern era terrace, but stratified sediment layers up to 1.75 m below the final planting surface were exposed (Figure 6-14). Noteworthy is the lack of cultural debris (e.g., ceramics, marine shell fragments) in strata 1-7, a characteristic of Spanish colonial and post colonial fields. These layers exhibit considerable mixing and are largely composed of silt, sand, and scattered gravels, with light to medium compaction. However, lower levels 8, and especially 9 and 10, reveal an increase of tiny shards of undecorated pre-Hispanic ceramics, scatters of marine shell fragments, and medium angular stones, much more characteristic of pre-Hispanic terrace fill noted in other more secure contexts at Wawakiki. Boundaries between these lower sedimentary layers are very gradational as well, with density of cultural debris being the primary difference. While certainly not as conclusive as agricultural infrastructure identified in other areas of the site, the presence of these deeply buried strata that approximate pre-Hispanic terrace fill provides some support that late Chiribaya cultivation extended to the lower portion of the coastal promontory as well.
Figure 6-14. Profile WK3K-p provides some evidence for Late Pre-Hispanic land use near the lowermost portion of the coastal promontory.
INLAND CHIRIBAYA AGRICULTURE

Survey of the inland quebradas documented two areas that exhibit agricultural features consistent with those associated with the late pre-Hispanic era at Wawakiki (refer to Figure 6-4). The first encompasses roughly 1.8 ha and lies on the very wind deflated summit between quebradas Agua Buena and Seca at an elevation of 320 m.a.s.l. It consists of a series of small, low-lying stone alignments extending from an intermittent stream/erosional channel that may have formed from spring runoff and/or periodic El Niño rains. While no cultural artifacts were located, the presence of at least one footer wall suggests contemporaneity with those identified in both quebrada canyons and on the coastal promontory of Wawakiki.

The second site lies in the upper section of Quebrada Seca at an elevation of 378 m.a.s.l., in a heavily eroded area along the canyon wall. Again, the absence of associated cultural materials makes for chronological ambiguity, but examination of a series of deep rills cutting through stone alignments identified at least one instance of a terrace with an associated footer wall. Unfortunately, this sector is much too eroded to estimate area of cultivation with confidence. Nonetheless, while evidence is scant at both sites, the use of a double stone-wall construction is consistent with similar features more securely dated to the Chiribaya period at the principal agricultural sectors on the coast. Notwithstanding wind erosion or frequent wind impact on the summit, the Chiribaya may have been intermittently exploiting these inland areas for agricultural purposes, at least when hydrological conditions permitted.
POLLEN AND SPECIES DIVERSITY AT WAWAKIKI, AD 1200-1400

Nine soil samples were taken from late pre-Hispanic period sediment strata and terrace fill (Figure 6-15). All exhibit a large quantity of charcoal when compared to samples of later temporal contexts, suggesting farmers regularly burned their fields, or that burning was relatively more widespread. Chiribaya samples also display fluctuating amounts of High-spine Asteraceae and Cheno-am pollen, representing the presence of weedy members of the sunflower and goosefoot families, both of which possibly grew along the margins of canals. Segmented hairs were also present in all samples of this period, probably representing a member or members of the sunflower family. Six of these nine samples also exhibit small quantities of Mesquite pollen (*Prosopis*), indicating their presence in the near vicinity.

A number of plants likely to have been growing in or near the agricultural fields—either cultivated or possibly tolerated—include *Datura* (datura, thornapple, or jimson weed), Solanaceae and *Solanum*, and *Zea mays*. *Datura* pollen was identified in a sample from profile WK5E-p, possibly indicating this hallucinogenic plant was either growing nearby or even tolerated in the fields. Solanaceae and *Solanum* encompass a variety of cultivated plants including tomato and potato, both domesticates of South America, though potato typically does not flourish along the coast. Unfortunately, genus could not be identified for each of the Solanaceae pollen recovered, leaving the presence of specific cultivated members of this family to mere speculation. *Zea mays* was identified in all samples, suggesting that maize was an important subsistence crop cultivated during the Chiribaya occupation of the site and may well have been the dominant crop present. In addition, *Zea mays* starch was recovered from Chiribaya
Figure 6-15. Pollen diagram for all 20 samples analyzed from Wawakiki. Samples associated with the late pre-Hispanic era are identified along the right-hand margin (Chiribaya).
associated sediments in profile WK3C-p, which suggests deterioration of maize kernels in the ground.

Other pollen found in various abundances likely represents weeds growing in fields, in nearby quebrada channels, or in the lomas, some of which may have been specifically exploited by the Chiribaya. Pollen is represented from Low-spine Asteraceae, Spiderling (Boerhaavia), Mustard family (Brassicaceae), Wild Buckwheat (Eriogonum), Spurge (Euphorbia), Plantain (Plantago), Knotweed/Smartweed family (Polygonaceae), Globe mallow (Sphaeralcea), Sida mallow (Sida-type), and Indigo (Indigofera). Indigofera is especially noteworthy, because a blue dye is produced from one species (Kearney and Peebles 1960: 428). In their studies of Tumilaca and Chiribaya textiles, Wallert and Boytner (1996: 858) determined indigo to be the source of blue dye used in Chiribaya textiles sampled from the lower Osmore valley. This plant can be found in the geographical area of the Osmore, and it may have been encouraged to grow in fields at Wawakiki or perhaps near the edges of fields for easy exploitation.

Pollen remains from this limited number of samples suggest local farmers of this period had at their disposal a wide variety of both subsistence and economic plant species. The Chiribaya community at Wawakiki had an agricultural base dominated by maize, with possible supplements of tomato or potato, but a variety of weedy and herbaceous plants in and around the site almost certainly contributed to the local economy at Wawakiki as well. As a hallucinogenic plant, Datura has a number of uses. Pre-Hispanic Andeans are documented to have smoked parts of the roots of one species (Datura stramonium) as a remedy for asthma, and its seeds were extracted for their narcotic properties (Yacovleff and Herrera 1935: 66). Likewise, Indigofera was in all
probability harvested for its economic potential, typically exploited for blue dye to be used in textile decoration.

**OTHER ECONOMIC ACTIVITIES AT WAWAKIKI**

**Marine Exploitation**

By far, the most common artifact observed in the isolated profiles or recovered from excavations was marine shell (n=60,241; weight=63.224 kg). While considerable amounts came from either contexts of slope wash or agricultural terrace fill, a substantial amount came from excavation WK3C-e, a 1 x 2 meter unit located just below the colonial road and Chiribaya habitation terraces. Excavation of this unit encountered dense domestic refuse and cobble fill associated with a terrace wall (possibly domestic). The uppermost strata of this unit are associated with the early Spanish colonial era, but ceramics encountered in the lower levels of dense refuse exhibit bowl forms with interior decoration, and rims painted with black lines and white dots (Figure 6-16). Elsewhere in the lower valley, interiorly decorated bowls of this style have been dated to the Late Chiribaya phase (Jessup 1991; Lozada and Buikstra 2002). Moreover, a burned lens underlying these levels and just above sterile sediments dates to 685 ± 33 uncalibrated radiocarbon years BP, with a calibrated age range of AD 1291-1393 (2-σ), while charcoal fragments floating in the dense domestic debris and cobble matrix of these layers dates to 651 ± 32 uncalibrated radiocarbon years BP, with a calibrated age range of AD 1298-1404 (2-σ). A third charcoal sample from these dense shell and refuse strata provided a slightly later uncalibrated radiocarbon age of 575 ± 31 ¹⁴C yrs BP, and a calibrated age range of AD 1391-1442 (2-σ) (Table 6-1, field samples 4-6). Combined, the radiocarbon
assays and ceramic decoration confidently place this deposit in the Late Chiribaya period (ca. AD1200-1400), and possibly extending into the early 15th century and thus slightly beyond the conventional dates for the Chiribaya.

Figure 6-16. A sample of interiorly decorated bowls from excavation WK3C5-e at Wawakiki. Interiorly decorated bowls are typical of the Late Chiribaya period (Jessup 1991; Lozada and Buikstra 2002).
Marine shell was densely concentrated in these debris layers. In four excavation levels, a total of 8,220 fragments of marine shell weighing 12.783 kg were recovered from a calculated volume of just 0.36 m$^3$ of silt, sand, cobbles, and refuse. Levels stratigraphically above and below those calculated here—while not as dense—also yielded substantial quantities of marine shell. The quantity of shell recovered from this unit is also comparable to the amount and density of marine shell fragments collected in several other excavation units (particularly excavation WK3B-e) or observed in isolated profiles around the site—especially those of the domestic terraces (profiles WK4A-p, WK4B-p). A number of marine species were commonly represented in excavations and profiles around Wawakiki, including conch (*Concholepas concholepas*), mussels (*Choromytilus chorus*), keyhole limpets (*Fissurella sp.*), surf clams (*Donax sp.*), and chitons (*Chitonidae sp.*). All of these are known to inhabit shallow rocky shorelines with the exception of surf clams, which tend to inhabit shallow sandy shorelines (Alamo and Valdivieso 1987). In addition, fragments of crabs and sea urchin were commonly recovered, as were vertebrate fragments of other unidentified fish. Finally, fishing implements such as weights and copper hooks were observed on the surface throughout the various agricultural sectors of the site, no doubt churned up and re-deposited by more than 300 years of Spanish colonial and modern era cultivation. Overall, there is strong evidence to suggest that the Chiribaya community occupying Wawakiki took full advantage of their immediate shoreline, intensively exploiting both the sandy beachfront and rocky outcrops to procure a variety of resources from the sea.
Lomas

Because the primary aims of investigation during the 2003 field season were related more directly to agriculture, data regarding *lomas* exploitation is limited. Nonetheless, there are a few bits of information stemming from both excavations and isolated profiles that suggest at least some use of the nearby inland *lomas*, though to what degree of intensity remains uncertain.

First, the small burned deposit underlying the agricultural terrace wall in isolated profile WK5B-p (Table 6-1, field sample 1) contained small pellets of camelid dung, indicating that camelids had been present at the site. While corrals noted in the *lomas* behind Wawakiki appear to be of historic origins, their presence at least supports the notion that the *lomas* were at one time productive enough to support herding activities, if only on a seasonal basis.

Second, excavations in the main agricultural sector recovered five chert projectile points associated with slope wash or terrace fill. Their presence may suggest that hunting was a supplemental economic activity at Wawakiki, though there is no way to chronologically place them into the Late Chiribaya period with any confidence.

Finally, as mentioned above, there is scant evidence that the Chiribaya utilized the summit area between the two quebradas and the upper sector of Quebrada Seca for agricultural purposes. It seems reasonable, then, that late Chiribaya agricultural presence at elevations near the inland *lomas* may have encouraged additional economic exploits in this zone as well. Given such close proximity to the *lomas* and the wide array of herbaceous and woody plants available to them, it seems only reasonable that the Chiribaya at Wawakiki would have taken full advantage of this resource, especially given
their intensive investment in other economic activities in their immediate physical environment.

**DISCUSSION**

**Economic Specialization and Diversification among the Chiribaya**

The community occupying Wawakiki during the Late Chiribaya period (ca. AD 1200-1400) had at their immediate disposal a number of economic viabilities, and the results of this study suggest that they intensively exploited at least two major resources in the fresh water springs and adjacent coastline, with likely supplements from the nearby inland *lomas*. Agricultural production at the principal zone of Wawakiki reached its greatest spatial extent during this phase, encompassing 11 ha, excluding any possible areas of intermittent cultivation farther inland. Maximum elevation canals extended from both quebradas Agua Buena and Seca, transporting water along steep canyon walls and onto the Wawakiki promontory. Labor intensive, stone-faced terraces were also constructed across much of the steep terrain, at times utilizing perhaps a technological innovation involving the use of footer walls that may have provided extra support at the base of main terrace walls. Clearly, the ancient canal and terrace technology employed by farmers at Wawakiki represents a well-engineered installation, most of which was systematically constructed during the Late Chiribaya phase.

Also evident is the concurrent intensive exploitation of the coastline for both fish and shell fish. The density of marine shell in contexts dating to the Late Chiribaya period coupled with the variety of both rocky shoreline and sandy beach species testify to the degree to which the local community exploited their immediate surroundings to their
fullest potential. There is also scant evidence at the site to suggest the inland *lomas* played an important—though probably supplemental—role in the local economic structure of late Chiribaya phase Wawakiki.

Economic exploitation at Wawakiki occurred in the context of a dynamic social and natural landscape. While conditions surrounding the site presented opportunities for local communities to exploit a number of economic resources, immediately before and even perhaps after the catastrophic flood of the mid 14th century, local decisions to do so occurred in the context of wider cultural ideals of specialized production. Such diverse opportunities may not have been readily accessible farther south in the main river valley, and community decisions there to specialize production throughout much of the Chiribaya period occupation of the lower valley left those communities necessarily dependent on external exchange for both social and economic reproduction. The diversity found near the coastal springs—and more intensely toward the north—certainly presented local groups there more options with respect to production and participation in exchange mechanisms involving other lower valley and coastal Chiribaya settlements. Chiribaya decorated ceramic assemblages found throughout the area certainly reflect a shared ideology within a broad sphere of social interaction, yet decisions to diversify economic activities at the level of community may have provided greater economic autonomy, and perhaps longer sustainability, than their lower valley neighbors in the face of uncertain socio-economic conditions.

Rather than representing simply an alternative production scheme to wider ideals of specialization, decisions to diversify production at the level of community among coastal springs like Wawakiki may have constituted a socio-economic response to
diminishing conditions experienced in the lower valley. In this sense, the more traditional system of horizontal exchange and specialization on the coast was probably quite dynamic. Production schemes of particular communities likely vacillated between ideals of specialized and diversified economies, responding to both cultural demands and the opportunities afforded by the immediate socio-physical environment.

**Chiribaya Agricultural Strategies, Drought, and the 14th Century El Niño**

Data obtained from both canyon walls and the coastal promontory suggest that more than 11 ha. were intensively cultivated during the late Chiribaya period, with much of the steeper slopes heavily modified with stone-faced terraces. In many cases, Wawakiki farmers used a technological innovation in footer walls that would have provided additional support at the base of main terrace walls. Sediment strata associated with stone walls are typically thick and fairly homogeneous, with little evidence of alluvial deposition from gradually eroding topsoil. This indicates that the construction of at least most individual terraces grew in a planned, systematic fashion, rather than incrementally over long periods of use and modification (for incremental construction, see Doolittle 1984; Smith and Price 1994). On a broad level, this irrigation system appears to have achieved its most extensive form during the late Chiribaya period, with terrace construction at the most distal end of irrigation canals still occurring in the 14th century. Such a system is often understood to require socially coordinated planning, engineering, and subsequent labor investments to sustain it, though in this case these were achieved very much at a local level. With huge initial investments, Wawakiki farmers transformed this arid coastal promontory into a highly productive landscape, whose technological features utilizing relatively steep canals and stone-faced terraces...
drastically increased agricultural productivity in an area where water is a very limited commodity and steep barren hill slopes are highly prone to erosion.

The water crisis that was undoubtedly intensifying along the Ilo River during the late Chiribaya period was partly a result of continued, albeit reduced, cultivation practices by middle and upper valley farmers in the context of a diminishing water supply, a consequence that would have been less severe among the coastal springs. While spring-supplied agricultural systems along the coast might respond quickly to fluctuations in highland precipitation (see Ortloff and Kolata 1993), periodic coastal rains stemming from lesser magnitude El Niño events from the 12th to 14th centuries may have been in fact beneficial to local production, since coastal precipitation would have certainly replenished the groundwater aquifer upon which agrarian systems such as Wawakiki were dependent (Magilligan and Goldstein 2001: 434; Dillehay et al. 2004: 273). Indeed, with considerably slower rates of discharge, coastal aquifers may be more apt to store groundwater for subsequent use while main river channels quickly drain excess water into the Pacific Ocean. The very fact that such intensive land use occurred in this context of relatively low highland precipitation further testifies to a fairly secure water supply at the site.

Wawakiki’s position between two closely spaced quebrada channels also permitted the construction of a multi-quebrada irrigation system that would have allowed farmers to take advantage of the dynamic nature of coastal spring discharge. Because of overlapping hydrological regimes (represented by the principal canals extending from each quebrada), farmers could utilize multiple sources of spring water to irrigate much of a single unit of land, principally those terraces located on the coastal promontory.
Ultimately, the use of two independent spring sources may have been a response by local farmers to overcome fluctuations in individual rates of discharge, and therefore maintain a certain degree of stability in agricultural production.

Similarly, agricultural systems like that of Wawakiki may have been in position to withstand the typically detrimental effects of massive floods and debris flows associated with very strong and even rare ‘mega’ El Niño events, such as that documented for the mid 14\textsuperscript{th} century throughout many coastal and middle valleys of Peru (Pozorski 1987; Wells 1987; Moore 1991; Satterlee et al. 2000; Magilligan et al. 2001). Undoubtedly, the 14\textsuperscript{th} century flooding episode differentially affected lower and coastal Chiribaya settlements and production strategies. In the lower valley, widespread destruction of the principal canal by floods and debris flows led to the abandonment of roughly 77% of all Chiribaya sites after the disaster, and there is no evidence of canal reconstruction until the Spanish colonial period (Reycraft 2000: 106). Similarly, some coastal Chiribaya settlements felt equally dramatic effects from the disaster, such as the settlement at Quebrada Miraflores, which was completely destroyed and deeply buried by massive debris flows that extended laterally across the pampa for distances of several hundred meters from the main channel (Satterlee 1993; Satterlee et al. 2000). At Quebrada Carrizal, debris flows covered nearly 75% of the available agricultural surfaces (Satterlee 1993: 215), and agriculture there continued beyond the event at only 50% of its former production (Reycraft 2000: 106). However, the topography in which Wawakiki lies is markedly different than that of many of the spring sites to its south. The steep canyon walls of each quebrada coupled with deeply incised and steep quebrada channels did not permit excessive overland debris flows like those described at Miraflores and Carrizal.
At Wawakiki, deposits of a massive debris flow are noted only along the immediate banks of both quebrada channels. They range from 30-60 cm in depth and contain compacted alluvial deposits of sediments with scattered rounded cobbles as large as 30 cm in diameter (Figure 6-17). This deposit likely represents that of the mid 14th century, as only two massive debris flow deposits are documented for the Late Holocene in the area. The Wawakiki deposit more closely matches compositional descriptions of debris flows associated with the 14th century event, rather than the later event of the early 17th century (see Keefer and Moseley 2003; Moseley and Keefer in press), and it is the only event of any size noted on the banks of the quebrada channels. Unlike the debris flows described at Miraflores and Carrizal springs, this deposit extends laterally out of

Figure 6-17. Profile of the main channel of Quebrada Seca showing over-bank debris flow deposit. Scale (left-center) is set to one meter.
the channel for a distance of only about 4 m on either side, posing little threat to the majority of agricultural features that occupy steep canyon walls or the relatively well-protected coastal promontory (Figure 6-18).

While most of the site remains relatively protected from such flood deposits, sheet flow during coastal downpours would have been the principal cause for concern on cultivated hillsides, as minor alluvial deposits with coarse debris are sporadically noted on terraces below the Chiribaya domestic sector. In fact, in all likelihood the lead-off channels of each canal were completely destroyed by the mid 14th century event, since they are often positioned near the quebrada channels themselves and thus in the paths of large debris flows. Unfortunately, it is virtually impossible to determine by superposition if new canal channels were cut through this debris flow immediately after the 14th century

![Figure 6-18](image-url). View of Quebrada Agua Buena and the relationship of the primary canal (dashed line), stone terraces (profiles WK2C & E), and the lateral extent of over bank debris flow (arrows).
event, since the only preserved segments of canals are located high up on the adjacent
canyon walls (see Figure 6-18). Modern road construction has inconveniently buried
those portions of the canals that would have intercepted flood deposits near the channels.

Radiocarbon age ranges from Chiribaya agricultural, marine, and domestic
contexts at Wawakiki provide some support for minor occupation beyond the flood event,
but to what degree remains ambiguous. Calibrated age ranges suggest that (1) systematic
terrace construction may have at least partially occurred during the middle of the 14th
century (Table 6-1, field sample 1); (2) intense marine exploitation occurred at least from
the middle of the 14th century to the early 15th century (Table 6-1, field samples 4-6); and
(3) habitation terraces were occupied from at least the late 13th century to perhaps the
middle of the 15th century (Table 6-1, field samples 15-20). In addition, limited
quantities of Terminal Chiribaya period post-flood ceramics were reported at Wawakiki
in highly disturbed contexts, further suggesting some degree of post-flood occupation
(Reycraft 1998: 67). The fact that Spanish colonial farmers renovated Agua Buena’s
primary canal suggests damage there did not exceed repair, and that the Chiribaya may
have done the same. Nevertheless, while it appears that Wawakiki did not support an
intensive pre-Hispanic occupation beyond the 14th century flood event, the damage
inflicted by massive debris flows would have been greatly limited compared to that of
their southern neighbors along the coast and in the main river valley. On a smaller scale,
effects of other lesser flooding episodes associated with strong or even very strong El
Niños that likely occurred with greater frequency prior to this massive event would have
also been reduced. In fact, where high relief terrain characterizes the desert coastline,
such as the nearly 20 km stretch midway between the Ilo and Tambo rivers, the lateral extent of debris flows from massive flooding episodes would indeed be minimal.

Both long-term and punctuated environmental shifts—like prolonged drought or periodic flooding episodes—elicit varied responses from different socio-political levels of society regarding agricultural production and organization (Dillehay and Kolata 2004). Along the lower and coastal Osmore drainage, small communities invested heavily in labor-intensive irrigation and terrace systems, often making efficient use of local resources offered by their micro-environmental contexts. Decisions to intensively exploit coastal springs for agriculture during the late Chiribaya period may have in part been a regional response to diminishing agricultural potential in the Ilo River valley. On a more local level, however, small agricultural communities along the coast achieved various degrees of success and failure during this period, intensively pursuing other economic activities—like the procurement of marine species—in order to reach greater economic stability at a local level.

Local topography and fluctuating rates of spring discharge also led to differential degrees of success. High relief, hillside terraces may have been better equipped to withstand the punctuated impact of massive flooding episodes, while multi-quebrada irrigation systems may have permitted greatest stability in the face of long-term periods of aridity and fluctuations in spring discharge of an already reduced aquifer. At Wawakiki, colluvial deposits from steep, unstable canyon walls may have in fact posed greater concern for canal construction and maintenance than widespread flooding episodes, as evidenced by stratified layers of colluvium identified in the Quebrada Agua Buena primary canal.
The late pre-Hispanic configuration at Wawakiki is not unique, as remains of other agricultural communities exhibiting similar features lie farther north. The nearby uninvestigated Chiribaya site at Punta Callango shares many topographical, technological, and production elements as Wawakiki, including its coastal upland position perched on a rocky sea cliff, labor intensive hillside terraces, lengthy canal networks, and dense scatters of marine shell refuse. Future research will tell, but Wawakiki is likely only one of a number of small sea cliff communities whose investment in laborious canal and terrace technologies and the procurement of marine resources may have constituted a socio-economic response by inter-valley coastal communities during this late Chiribaya period of uncertainties.
Historical accounts of the Ilo region during the Spanish colonial period cite quebradas Agua Buena and Seca to be among a number of productive agricultural enterprises in the area, especially with respect to olive fundos. Surface preservation, depositional profiles, and pollen analysis provide further support for agricultural productivity at the site during this period, with the reactivation of some canals and terraces in Quebrada Agua Buena and on the coastal promontory, and the construction of new canals in Quebrada Seca to irrigate fields along the north bank of that quebrada channel. Overall, excavations and profiles that provide evidence of Spanish colonial agricultural production are documented in Figure 7-1, which should be consulted regularly throughout this chapter.

CHRONOLOGICAL ASSESSMENT OF SPANISH COLONIAL AGRICULTURE

Radiocarbon dates associated with Spanish colonial and modern era land use do not provide enough precision to sort through chronology between these periods (see Table 7-1), but they do establish an associated technology that relied more heavily on sediment furrows. Sediment furrows represent a less permanent transformation to the landscape than stone-faced terraces, and consequently, their relative degrees of preservation prove much more valuable to assess the evolution of land use within the historic and modern eras. The relative degrees of preservation of sediment furrows are noted in Figure 7-2, where “5” identifies the greatest preservation and “1” the
poorest (“0” indicates absence of identifiable sediment furrows or post AD 1600 land use). In addition, the degree to which Huaynaputina volcanic tephra is preserved around any particular sector and immediately underlying sediment furrows and other agricultural features offers other clues to discerning the degree to which fields were continuously shaped and modified beyond AD 1600.

Figure 7-1. Locations of excavations and profiles that provide evidence for Spanish colonial period land use.
<table>
<thead>
<tr>
<th>Field Sample #</th>
<th>Lab Sample #</th>
<th>Type</th>
<th>Material</th>
<th>Uncalibrated Radiocarbon Age BP</th>
<th>Calibrated 1-σ cal AD age ranges (relative probabilities)**</th>
<th>Calibrated 2-σ cal AD age ranges (relative probabilities)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-WK3C-E</td>
<td>AA56763</td>
<td>AMS</td>
<td>Excremen</td>
<td>$132 \pm 32$</td>
<td>$1705-1721$ (0.131) $1811-1841$ (0.256) $1850-1870$ (0.160)</td>
<td>$1687-1729$ (0.191) $1805-1958$ (0.809)</td>
</tr>
<tr>
<td>9-WK3D1-E</td>
<td>AA56765</td>
<td>AMS</td>
<td>charcoal</td>
<td>$172 \pm 31$</td>
<td>$1676-1711$ (0.252) $1717-1734$ (0.118) $1800-1813$ (0.085)</td>
<td>$1767-1760$ (0.357) $1765-1780$ (0.027)</td>
</tr>
<tr>
<td>11-WK3D3-E</td>
<td>AA56766</td>
<td>AMS</td>
<td>charcoal</td>
<td>$130 \pm 32$</td>
<td>$1705-1721$ (0.131) $1811-1841$ (0.254) $1850-1870$ (0.152)</td>
<td>$1689-1728$ (0.187) $1805-1958$ (0.813)</td>
</tr>
<tr>
<td>12-WK3D4-E</td>
<td>AA56768</td>
<td>AMS</td>
<td>charcoal</td>
<td>$121 \pm 34$</td>
<td>$1706-1721$ (0.122) $1811-1840$ (0.263) $1852-1869$ (0.126)</td>
<td>$1689-1728$ (0.176) $1805-1957$ (0.824)</td>
</tr>
<tr>
<td>13-WK1F-P</td>
<td>AA56769</td>
<td>AMS</td>
<td>charcoal</td>
<td>$146 \pm 31$</td>
<td>$1698-1725$ (0.204) $1808-1817$ (0.066) $1829-1890$ (0.457)</td>
<td>$1681-1732$ (0.232) $1803-1957$ (0.768)</td>
</tr>
</tbody>
</table>

Table 7-1. Radiocarbon dates associated with Spanish colonial and modern era occupation and land use. Dates were calibrated using CALIB REV4.4 Radiocarbon Calibration Program (Stuiver and Reimer 1993) made available by the University of Washington, based on southern hemispheric data sets described by McCormac et al. (2002) and international data sets described by Stuiver et al. (1998a) and Stuiver et al. (1998b).
Early 17th century agriculture at the site is mentioned in several historical documents (e.g., Vasquez de Espinosa 1987[1618]), while historical air photographs taken by Peru’s Servicio Aereofotográfico Nacional demonstrate that at least the coastal promontory and portions of the lower quebrada banks were abandoned by 1951. Therefore, relative preservation of sediment furrows is specifically used to track changes in land use beginning around AD 1600 and lasting until the early 20th century. While shifts in production described in this chapter and the next may not correlate precisely to
the particular temporal phase indicated, the information here can be used to illustrate at least general trends in production strategies and land use throughout the 300 year period described in these chapters.

**EARLY SPANISH COLONIAL PERIOD AGRICULTURE**

Based on surface preservation of sediment furrows and the location of historic property walls, canals, and the colonial road, it is likely that early Spanish colonial land use initially encompassed a total of about 8.25 ha, including the southern wall of Quebrada Agua Buena and much of the coastal promontory, but contracting slightly from late pre-Hispanic land use in Quebrada Seca (Figure 7-3). Spanish colonial agricultural technology largely consisted of linear sediment furrows that contrast sharply with low, stone-faced terraces of the late pre-Hispanic era (though some use of stone walls did occur in this period), and they often overlie sediment strata associated with Huaynaputina.

![Figure 7-3](image.png)

**Figure 7-3.** Aerial photograph depicting the extent of early Spanish colonial land use at Wawakiki (~AD 1600-1700).
tephra. Immediately south of the stone property wall, sediment furrows that dominate the surface elsewhere at the site are notably absent, and lenses of Huaynaputina tephra are most commonly preserved in excavations, profiles, and natural rills coursing through this sector, suggesting little cultural disturbance to this area after its pre-Hispanic abandonment. With the exception of this area, sediment furrows ranging from poor to good preservation are noted throughout the site and overlie late pre-Hispanic terraces. The Quebrada Agua Buena primary canal was re-activated during this period, while a lower elevation primary canal was constructed in Quebrada Seca, leaving the pre-Hispanic primary canal abandoned (Figure 7-4).

Figure 7-4. Three dimensional map of Wawakiki showing the primary canals used for irrigation in the early Spanish colonial period (blue), and the previously abandoned late pre-Hispanic maximum elevation canal in Quebrada Seca (red).
In the lower portion of Quebrada Seca, a new canal was excavated at a lower elevation than the previously abandoned late pre-Hispanic primary canal, but at a much steeper gradient (see Figure 7-4). The canal can be traced for a distance of about 80 meters, and while two short sections of historic canals were identified farther up the quebrada near its conjunction with the coastal road, significant construction debris and disturbance make it impossible to determine if they are segments of a single canal. Nonetheless, the 80 meter section traverses the north bank of the quebrada at a gradient of nearly 12%, much steeper than its pre-Hispanic predecessor. The steepness of the canal may have been in response to a diminishing water supply in this quebrada, as nomenclature might suggest. In Castilian Spanish, *seca* means dry, and while generally wetter than average conditions prevailed in the neighboring highlands during the early Spanish colonial period (see Chapter 3, Figure 3-4), a decrease in spring discharge in Quebrada Seca would not be entirely unexpected given the general variability among and the dynamic nature of coastal springs in the area. Quebradas Agua Buena and Seca were both named during the Spanish colonial period, and therefore their naming lends support for the relative differences in spring discharge experienced in the two quebradas during this period. A steeper gradient would be consistent with a diminishing water supply, where rapid transport of irrigation water would help to minimize losses to evaporation and infiltration along the canal course.

Unfortunately, construction of a modern road and an access route to Wawakiki Beach in the 1990s significantly destroyed much of the agricultural landscape surrounding the lower portion of the quebrada. Limited remains of agricultural
infrastructure predominantly consist of only small patches of both moderately and well preserved linear sediment furrows between the primary canal and main quebrada channel, and some furrows exhibit similar degrees of preservation to those associated with Spanish colonial and modern era agriculture elsewhere at the site, or preservation indices of three, four, and five (see Figure 7-2).

Quebrada Agua Buena Agricultural Land Use

The primary canal extending from Quebrada Agua Buena was re-activated during this period, and it served to irrigate sediment furrows and post-AD 1600 terraces along the steep canyon wall of Quebrada Agua Buena and the coastal promontory (see Figure 7-4). As noted in Chapter 6, stratigraphic information revealed in profiles WK2A-p and WK2B-p suggest that the primary canal traversing the steep southern canyon wall of this quebrada was reactivated after its initial abandonment. Profile data suggest that colluvial deposits choked the canal along much of its course before subsequent excavations into these deposits reactivated the canal. A Spanish colonial period reactivation and use is based on the association of the canal with terrace fill overlying Huaynaputina tephra on the south canyon wall of Quebrada Agua Buena and with moderately preserved sediment furrows on the uppermost portion of the coastal promontory. Additionally, the colonial period road that traverses the coastal promontory crosses the canal, where in at least two locations small channels were constructed beneath the road to allow for the passage of water from the canal to the colonial fields below. The Spanish colonial component of the canal terminates at the stone property wall near the southern end of the promontory, and its gradient averaged the same as its late pre-Hispanic use, about 3%.
In general, the southern canyon wall of Quebrada Agua Buena displays very little surface evidence of early Spanish colonial period land use, with deep rills and steep, deflated surfaces characterizing much of the terrain below the primary canal. Other than the reactivation of the main irrigation canal in Quebrada Agua Buena, only isolated profile WK2C-p provides conclusive evidence that agricultural landscape modifications were implemented and managed after AD 1600 in this area, if only for a short while.

As discussed in the previous chapter, profiles WK2C-p and WK2E-p reveal a series of late pre-Hispanic agricultural terraces and associated footer walls. However, profile WK2C-p also reveals a fairly pronounced lens of Huaynaputina tephra underlying sediment strata that are characteristic of terrace fill. Furthermore, while the profile itself did not cross any terrace walls associated with this post AD 1600 sediment layer, a stone terrace was identified approximately four meters to the west of the profile (Figure 7-5, wall 7). Based on surface analysis, this wall is clearly associated with the post AD 1600 fill noted in the profile. The lack of surface evidence of colonial land use (i.e., there are no remains of sediment furrows in this area) coupled with only limited—though fairly conclusive—evidence recovered from excavated profiles suggests that this area was modified and cultivated to only a limited degree during the early Spanish colonial period. The steep gradient and unstable slope of the canyon wall may have limited the efforts of Spanish colonial farmers in this area. Further evidence for a rather brief use of the Quebrada Agua Buena primary canal during the early Spanish colonial period is presented in the following section regarding the coastal promontory, which, throughout portions of the late pre-Hispanic and early Spanish colonial periods, was irrigated with the same primary canal.
Coastal Promontory Agricultural Land Use

Evidence from several excavations and profiles from the coastal promontory suggest that at least its uppermost portion—and most likely much of the promontory—was cultivated during the early Spanish colonial period. Stratigraphic data from isolated profile WK3C-p and excavations WK3B-e and WK3C-e reveal that moderately preserved linear furrows dominate this area, and they cover the landscape immediately below the primary canal.

Unlike late pre-Hispanic terrace fill, which most often exhibits fairly homogeneous deposits of sediments and gravels with very gradational changes between strata, sediments associated with early Spanish colonial period land use are often composed of stratified alluvial deposits of fine sediments and gravels. Located just below the primary irrigation canal, isolated profile WK3C-p reveals thin strata with very
sharp contacts between layers, suggesting that punctuated and recurrent alluvial episodes along the courses of furrows led to their deposition and accumulation (Figure 7-6). A thin lens of Huaynaputina volcanic tephra is also noted near the lower end of the profile,
and low, stone-faced terraces are seen underlying and clearly pre-dating the stratified sediment deposits associated with surface furrows. While the late pre-Hispanic terraces appear to have been constructed more or less systematically, Spanish colonial landscape modifications occurred incrementally, with sediment furrows largely accruing as a result of repeated irrigation practices. With each passage of water, alluvial deposits of fine silt, sediments, and gravels stratigraphically accumulated on the landscape, continuously shaping the terrain until its abandonment.

Farther south, excavations WK3B-e and WK3C-e lend additional support for early Spanish colonial period use of the terrain, though sediment deposits are less prominent in profile. Excavation WK3B-e is a 1 x 5 meter unit oriented perpendicular to the slope, and it is located below the primary canal amongst a series of linear furrows (Figure 7-7). Stratum 2 is identified in three separate locations in the southern profile, and it consists of fine alluvial deposits of silt and sand, all of which correspond to moderately preserved linear sediment furrows noted on the surface. Nearby, excavation WK3C-e identified the foundations of a small quadrangular structure located on a small terrace amongst sediment furrows just below the primary canal. Assessment of surface remains indicates contemporaneity between the linear sediment furrows and the small structure, as the courses of small secondary canals consistently pass around the foundations of the structure and its immediate vicinity (Figure 7-8). A thin lens of mule dung was identified during excavation of the unit and noted in the northern profile. While radiocarbon dates associated with deeper layers of considerably more dense domestic debris consistently date to the late pre-Hispanic era (see Table 6-1, Samples 4-6), the mule dung lies in the uppermost sediment strata associated with structural features.
Figure 7-7. Plan (upper) and profile (lower) of excavation WK3B-E located just below the early Spanish colonial primary canal on the coastal promontory. While not as prominent in profile as was noted elsewhere, sediment stratum 2 consists of fine alluvial deposits of sand and fine gravels that correspond to linear sediment furrows on the surface.

1. 10YR 5/4, surface deposits, very soft and loose, mixed with gravels and angular stones
2. 10YR 4.5/4, thin alluvial deposits of fine sediments; deposits correspond to linear sediment furrows noted on surface
3. 10YR 4/3, terrace fills; sediment deposits most likely associated with latest use of this terrain during the early Spanish Colonial period
4. 10YR 4/2, terrace fill, nearly identical to stratum 3, though a light mixture of domestic debris is associated, probably from late pre-Hispanic use
5. 10YR 7/1, Huaynaputina tephra
6. 10YR 4/2, thin lens of cultural ash; carbon fragments, marine shell, appears to be cut by stratum 3 and possibly 4
7. 10YR 4/2, coarse angular stones and domestic debris directly underlying cultural ash. 7 directly overlies bedrock
8. 10YR 4/4, very similar to 4
9. 10YR 4/3, fine sediment, gravels, and angular stones; cultural debris is present, but less than in stratum 7
10. 10YR 4/3.5, terrace fill, perhaps earliest period of land use
11. 10YR 4/4, sterile, yellowish red
Figure 7-8. Excavation WK3C-E showing the position of structural foundations and their relationship to surface furrows. The structure and furrows are associated with the early Spanish colonial primary canal on the coastal promontory.

identified on the surface. While it seems likely that the small structure was erected during the early Spanish colonial period (given its apparent contemporaneity with surrounding agricultural features), it may have remained in use for some time into later periods as a small temporary shelter or storage unit. Unfortunately, there are very few artifacts associated with the structural foundations, rendering any conclusions only speculative.

While it is difficult to determine exactly how long the landscape described here remained under production during the early Spanish colonial period, it does not appear to
have been for any extended period of time (perhaps for less than a century). First, despite the steep incline and expected amount of erosion, the poor condition of colonial period landscape modifications observed on the southern canyon wall of Quebrada Agua Buena suggests only a brief period of use for that area, or perhaps minimal investment in more permanent infrastructure. Second, the uppermost furrows on the coastal promontory are linear and fairly coarse in nature, yet they show no evidence of large tree depressions. During the early 17th century (and perhaps slightly earlier), the olive tree became the principal cultigen in the Ilo Valley and along the coast. Several historical texts mention quebradas Agua Buena and Seca as productive olive fundos at that time (Adriazola Flores 1998; Kuon Cabello 1981; Romero 1958), and olea (olive) was identified in pollen analyses of Spanish colonial sediment samples. The uprooting of dead or unproductive trees among many of the coastal spring sites has resulted in large depressions on the landscape, many of which are associated with isolated, crescent-shaped stone terraces that supported individual trees. The absence of tree depressions on this uppermost portion of the promontory suggests that either they were not grown in this area, or perhaps they did not mature to the extent to warrant construction of individual terraces around specific trees, as is noted farther down slope in association with later Spanish colonial infrastructure (discussed below). Ultimately, the kinds of infrastructure and their relative degrees of preservation seen among coastal promontory furrows below the primary Quebrada Agua Buena canal suggests that it was abandoned in favor of a more productive spring source at a lower elevation on the promontory itself.
LATE SPANISH COLONIAL PERIOD AGRICULTURE

At some point during the late Spanish colonial period, farmers at Wawakiki constructed an impoundment tank around a coastal promontory spring source in order to capture water for irrigation. Based on excavations of the tank and examination of alluvial trenches that cut down slope from the Agua Buena primary canal to the tank, it is likely that both sources may have been in use for a brief transitional period. Preservation of surface remains above and below the tank suggest that ultimately farmers began to rely principally on the promontory spring for irrigation, resulting in the abandonment of the Agua Buena canal and thus a slight contraction in land under production from the early Spanish colonial period (Figure 7-9).

The impoundment tank at Wawakiki generally conforms to those noted elsewhere along the coast for the historic period, where farmers constructed stone walls (and later, Figure 7-9. Three dimensional map of Wawakiki showing the primary canals used for irrigation in the late Spanish colonial period (blue), and the previously abandoned canals in Quebrada Agua Buena, Seca, and on the coastal promontory (red).
cement) around the locations of spring sources (Clement and Moseley 1991). Trenches were often excavated into the springs as well, which typically resulted in an increase in spring discharge. This tank-and-trench pattern thus marks the locations of previous spring sources. On the coastal promontory at Wawakiki, farmers excavated a trench into the spring source to increase its discharge, and they constructed an impoundment tank of stacked stone and sediments around the source in order to capture water. Archaeological excavations into the water impoundment tank to sterile sediments determined it to be of purely colonial and post colonial construction and use, recovering colonial *mujica* ceramics, porcelain, and glass in the lowermost strata. Excavations also revealed the tank to have been renovated at least once beyond its initial construction. Finally, the location of the impoundment tank on the coastal promontory is at a considerably lower elevation than the maximum elevation canal extending from Quebrada Agua Buena, and coupled with changes in Quebrada Agua Buena land use, total cultivated terrain at the site contracted to 5.83 ha, ultimately leaving the southern canyon wall of Quebrada Agua Buena and upper portions of the coastal promontory abandoned (Figure 7-10).

*Figure 7-10.* Aerial photograph depicting the extent of land under production during the late Spanish colonial period.
Quebrada Seca Agricultural Land Use

Agricultural land use in the lower portion of Quebrada Seca likely remained similar to that of the early Spanish colonial period, though disturbance to the terrain from modern construction renders it very difficult to make any conclusive statements. However, small patches of furrows in this area do exhibit moderate to good preservation, suggesting that cultivation of the terrain between the primary canal and quebrada channel extended to some degree into the late Spanish colonial era.

Quebrada Agua Buena Agricultural Land Use

While cultivation of the southern canyon wall of Quebrada Agua Buena fell into disuse, a small (0.63 ha) terrace on the north bank of the mouth of the quebrada displays at least two phases of agricultural production based on the remains of two canal courses and relative preservation of associated fields. The first phase corresponds to the maximum elevation canal cut along the base of the canyon wall towards the rear and could have potentially irrigated the entire terrace (Figure 7-11). The canal carried water at an average gradient of 9%, and linear furrows associated with this canal exhibit moderate preservation, likely correlating to the late Spanish colonial period. By contrast, furrows associated with the lower elevation canal on this terrace are very well preserved and are likely associated with its latest cultivation during the late 19th or early 20th century (see Chapter 8).

The surface is characterized by loose colluvium that originated from above and scattered shallow and more deeply entrenched rills that course their way across the
Figure 7-11. Aerial photograph of the small coastal terrace on the north bank of Quebrada Agua Buena. The dashed line denotes the location of the primary canal used during the late Spanish colonial period, while the solid line denotes the course of a second canal constructed sometime later, most likely during the post Spanish colonial era (discussed in Chapter 8).

terrace. Remains of agricultural terraces, canals, furrows, and stone walls are also differentially preserved, including a small circular stone-lined pen that perhaps served as a temporary enclosure for small domesticated animals. This was likely constructed in the post Spanish colonial era, however, as it overlies moderately preserved furrows and terraces (for further details, see Chapter 8).

Based on preservation of agricultural infrastructure, cultivated terrain during this period likely encompassed the entire terrace (0.63 ha), and farmers utilized a series of linear and more crescent-shaped sediment furrows. Furrows exhibit moderate preservation, with some areas heavily affected by colluvial debris originating from the slopes above. Stratigraphic profiles from several excavations also reveal depositional data that are consistent with those described elsewhere for Spanish colonial period sediment furrows. Particularly, isolated profiles WK1C-p and WK1E-p reveal evidence of recurrent alluvial deposits of fine sediments and gravels in the uppermost layers (Figures 7-12 and 7-13). Contacts between these deposits are sharp, suggesting that these
terracettes or sediment furrows accrued incrementally on the landscape, rather than as a result of a single systematic construction. Also noteworthy is the regular presence of colluvial deposits and pockets of large angular cobbles and boulders in both profiles. This indicates that collapse of loose colluvium from the steep hill slopes above was a frequent occurrence in this sector and may have posed a nuisance to local farmers cultivating the terrain nearest the primary canal.

Coastal Promontory Agricultural Land Use

On the coastal promontory, the maximum elevation canal during this period extended southward from the impoundment tank toward the stone-constructed colonial property wall at a gradient of 3.2%. Though preservation among furrows below
Figure 7-13. Profile WK1E-P displaying evidence of repeated alluvial deposits associated with surface furrows as well as scattered pockets of colluvium, presumably originating from the unstable hill slopes above.
the tank and canal varies considerably, most exhibit greater preservation than those above the tank, suggesting relative age differences in land use. Excavations and profiles below the tank only rarely identified intact lenses of Huaynaputina tephra, suggesting considerable use and mixing beyond the early Spanish colonial period. Conversely, excavations and profiles above the tank canal identified several preserved lenses of Huaynaputina tephra, which underlie moderately preserved linear furrows.

The impoundment tank is located near the northern edge of the coastal promontory, and excavations WK3D-e and WK3E-e identified it to be of purely Spanish colonial and post colonial construction and use. These two excavations are adjoining, providing eight continuous meters of excavation data, and a two-meter profile extension was added to excavation WK3D-e, providing a total of ten continuous meters of profile data (Figure 7-14). These excavations reveal at least two construction episodes and several contention walls on the exterior side of the tank. Wall 4, seen in both profile and plan views of the excavation, is associated with the earliest construction of the impoundment tank, and it consists of stacked cobbles and at least one large boulder measuring close to one meter in height. Construction of the impoundment tank may have in fact incorporated large boulders into its original construction, taking advantage of their original position on the landscape. Strata 7 and 9 in excavations WK3D-e and WK3E-e, respectively, are composed of extremely compacted alluvial deposits of silt and sand. These strata constitute the base of the tank, overlying what appear to be mixed sterile sediments and scattered cobbles. Immediately overlying these strata are a series of alluvial deposits of mixed gravels and sediments. These distinct stratigraphic layers vary in their relative compositions of fine silt, sand, and medium and course gravels, perhaps
Figure 7-14. Profile and plan view of excavations WK3D-e and WK3E-e. Terrace walls four and five indicate at least two construction phases, where wall four represents the tank’s original construction, and wall five a renovation.
indicating changes in the amount and velocity of water that entered the tank from the spring or from the Agua Buena primary canal. Coupled with the compacted basal layer, these alluvial deposits of silt and gravels continue along the entire base of the impoundment tank and terminate against wall 4, the original perimeter wall of the tank. When full, the initial form of the impoundment tank was able to hold a maximum volume of about 65 m$^3$ of spring water.

The entire perimeter wall is covered with fine, compacted sediments that contain a very dense matrix of tiny rootlets. Farmers likely cleaned the base of the tank periodically to avoid clogging the sluice gate, ultimately depositing the muck on top of the perimeter wall. In addition, excavation of WK3D-e revealed thin lenses of burned material overlying the wall, and extending only slightly onto the interior slope of the tank wall. Carbon fragments and other vegetal material suggest the presence of *carrizo*, a grassy reed that typically grows among the coastal springs, often flourishing around stagnant pools of water in the quebrada channels, in soils with considerable moisture, or around impoundment tanks constructed around spring sources. *Carrizo* currently grows among spring tanks at Pocoma, Alastaya, and Miraflores, and because growth can become quite extensive, farmers sometimes burn excessive vegetation growing along the banks of impoundment tanks. This presence is helpful to some degree, however, as the resultant shade can slow evaporation rates, especially during the austral summer months of December, January, and February, when coastal skies remain clear. Carbon samples taken from several burned lenses overlying the perimeter wall of the tank generally yielded calibrated age ranges extending from the 18th to the early 20th centuries (Table 7-1, Samples 9-12).
A small sluice gate allowed for irrigation water to be released, most likely by removing a small wooden “door.” Water would then be directed southward across the promontory through a primary canal, or immediately down slope and into secondary canals and furrows that traversed the promontory. Isolated profile WK2H-p is located just below the maximum elevation canal and in the same rill as profile WK2C-p (discussed above with respect to early Spanish colonial agriculture and in Chapter 6 regarding late pre-Hispanic agriculture). Profile WK2H-p measures twelve meters in length, and it displays many of the features identified in profile WK2C-p (e.g., incremental growth of surface furrows through repeated irrigation) (Figure 7-15). Late pre-Hispanic terraces and associated footers are noted in several areas of the profile and stratigraphically underlying isolated lenses of Huaynaputina volcanic tephra. Strata above tephra lenses consist of alluvial deposits of fine to medium sediments, gravels, and small angular stones. The sharp contacts between these upper strata indicate rapid deposition, and these deposits correlate with furrows visible on the surface. Surface furrows in this profile exhibit slightly greater preservation than those above the maximum impoundment tank canal, suggesting relative age differences of agricultural land use above and below this primary canal.

Both the primary tank canal and three parallel secondary canals just down slope are characterized by a series of isolated but fairly evenly spaced crescent-shaped stone-faced terraces, each surrounding a depression from an uprooted tree. Based on historical documents, pollen remains, and cultigens among nearby springs, it is likely that these isolated stone terraces each supported a mature olive tree. Elsewhere along the coast, Clement and Moseley (1991: 433) suggest there to be a correlation between the diameter...
of depressions and the age of the uprooted tree. In this sense, relative sizes of tree
depressions speak indirectly to the relative lengths of time a particular area was

Figure 7-15. Profile WK3H-P depicting buried late per-Hispanic terraces, Huaynaputina volcanic tephra, and surface furrows shaped through repeated alluvial processes.
agriculturally maintained. Depressions along these four canals ranged from 0.65 to 2.20 meters in diameter, with no statistical difference in depression diameters among the four canals\(^4\). This suggests that these four secondary canals remained operable for comparable periods of time and in all likelihood were planted at the same time, at least with respect to olive production. The fact that uprooted tree depressions do not characterize the terrain above the maximum elevation canal of the water impoundment tank further supports the notion that there is some significant difference in land use above and below the water impoundment tank, perhaps owing to the suggestion here that the reactivation of the Quebrada Agua Buena canal did not persist long into the Spanish colonial period. While later production strategies on select portions of the terrain farther down slope render it impossible to discern patterns of sediment furrows associated with the Spanish colonial era, areas with comparable preservation exhibit linear and crescent-shaped sediment furrows in addition to the isolated stone terrace and tree depression pattern described here.

**POLLEN AND SPECIES DIVERSITY AT WAWAHIKI, AD 1600-1821**

Five of the twenty soil samples extracted from Wawakiki came from strata or terrace fill that were associated with Spanish colonial period land use (Figure 7-16). They are typically marked by a reduction in relative quantities of charcoal, perhaps indicating a decrease in burning or that burning was less widespread. In addition, they are also marked by larger quantities of both Brassicaceae and *Tidestromia* pollen.

\(^4\) MINITAB version 11.2 was used to perform a one-way ANOVA on the natural logarithms of tree depression diameters of the four canals. The test produced a \(p\)-value of 0.108, where \(\alpha = 0.05\), concluding that there is no statistical difference among diameters of uprooted tree depressions associated with the impoundment tank irrigation system.
Figure 7-16. Pollen diagram with results from all twenty soil samples analyzed. Samples associated with the Spanish colonial period are indicated along the right-hand margin.
reflecting either weedy plants of the mustard and amaranth families, or perhaps growth of a member of the mustard family as an agricultural crop. Quantities of High-spine Asteraceae pollen drop slightly in these samples, suggesting a decrease in members of the sunflower family growing in and around the agricultural fields. Also identified were small quantities of Fabaceae, Nyctaginaceae, and Onagraceae pollen, representing plants in the legume, four o’clock, and primrose families. In addition, samples representing this period contained *Sphaeralcea*, *Sida*-type, and *Thespesia* pollen, representing three members of the mallow family. *Sphaeralcea* is a more herbaceous plant, while the latter two are woody.

Cultivated plants identified in these samples include maize (*Zea mays*), squash (*Cucurbita*), and olives (*Olea*). Also present was a member of the Solanaceae family, and possibly wheat (*Triticum*) or another cereal grain. In addition, pollen from long moss (*Tillandsia*) was recovered, suggesting the possibility that this member of the bromiad family was present as an epiphyte on a tree within the agricultural system, most likely that of the olive.

**DISCUSSION**

The early Spanish colonial period represents the first intensive use of quebradas Agua Buena and Seca for agricultural purposes beyond the late pre-Hispanic Chiribaya occupation of the site. Portions of both quebradas and the coastal promontory were agriculturally maintained during the early Spanish Colonial period, totaling upwards of 8.25 ha. Not long into the colonial period exploits of the site did land under production contract significantly from 8.25 ha to 5.83 ha, when the previously operable Quebrada
Agua Buena canal fell into disuse. While the transition from one irrigation source to the next may have been gradual, farmers ultimately began to rely solely on the irrigative potential of a coastal promontory spring source.

Spanish colonial farmers also transformed the agricultural landscape in a very different manner than their pre-Hispanic predecessors: landscape modifications grew incrementally with the accruement of predominantly linear furrows as opposed to systematic construction of labor-intensive, stone faced terraces. Indeed, Spanish colonial farmers seemed more attached to the use of stones for property walls or for infrastructural improvements to the colonial road than for agricultural terraces. The colonial administration in the Viceroyalty of Peru periodically collected taxes from provincial agricultural enterprises, based largely on land under production (Andrien 2001; Keith 1976). As a strict measure of land use at Wawakiki, Spanish colonial farmers invested heavily in stone property walls, possibly in attempts to curtail over-taxation by a largely corrupt colonial administration.

The Spanish colonial order brought with it a new system of values placed on everything from world view, to political order, to their organization of production. The new colonial order was decidedly urban in nature, with very few individuals residing outside major cities or even more provincial towns. Wawakiki, while certainly supporting intensive agricultural land use at the time, did not support a local community as it did during the late pre-Hispanic era. The small casita just below the early colonial primary canal may have served as a temporary shelter or storage, but it displays no evidence of domestic use. Other areas above the primary canal on the coastal promontory exhibit evidence of significant Spanish colonial activity, particularly in the
presence of large quantities of mule dung, but by and large there is nothing to suggest that anybody other than perhaps a *dueno* or laborer resided at Wawakiki for any extended period of time. Moreover, while the Wawakiki beachfront and adjacent rocky shoreline were likely exploited for quantities of fish, shell fish, and other marine products (as they were in the pre-Hispanic era and continue to be today), these items were likely processed elsewhere among population centers in the principal valleys. The lack of any great amount of domestic debris—including marine shell—associated with slope wash, colonial period sediments and fill, or midden areas, further points to the absence of any significant processing or consumption of products on-site.

The absence of a community residing at Wawakiki during the Spanish colonial period might be explained by several factors, not least of which is the urban mindset of the European colonizers. All but a few Europeans settled into cities and towns, with even encomenderos and their dependants expected to live amongst the urban population (Lockhart 1968: 227). With significant declines in indigenous populations, new European ideals of residence largely dominated the Spanish colonial pattern of settlement. Furthermore, much of the surviving Andean populations were consumed by this new order, especially after the reforms by Viceroy Toledo in the 16th century. For purposes of taxation and religious instruction, native Andeans residing in the more “rural” provinces were often relocated into *reducciones* (Andrien 2001).

Many of Wawakiki’s neighboring spring systems along the coast did, in fact, support small residential communities in the pre-Hispanic era. However, while most of the them bloomed into productive agricultural centers in the colonial period, none housed any significant population beyond the arrival of the Europeans. The lone exception may
have been Alastaya spring several kilometers to the south of Wawakiki, where an 
hacienda of the same name was located (Kuon Cabello 1981; Paernio 1908). Today, 
adobe walls, structural foundations, and other infrastructural remains from the hacienda 
and its olive industry remain on the south bank of the quebrada. Historical documents 
also point to a single hacendado along the coast that oversaw some two hundred mules in 
the Lomas de Sauces, and resided amongst his olive fundos to the south (Vasquez de 
Espinosa 1987[1618]: 27-28). It is possible that the hacendado of the area resided at 
Alastaya spring, which, given the extent of remains of infrastructure required for olive oil 
manufacture, may have served as the principal olive press for the coastal fundos.

Ilo and the coastal springs were part of a large encomienda grant in the early 
Spanish colonial period, a likely supplement to the highland areas (see Keith 1976). 
Despite depleted populations and a dwindling encomienda system, however, production 
in the lower Ilo valley and among the coastal springs continued. In the early 17th century, 
the village of Ilo is reported to have consisted of a mere twenty native Andeans (Vasquez 
de Espinosa 1987[1618]). By the early 18th century, demographic levels had not 
recovered much, as Frezier (1982[1713]: 154) reports a group of only 50 wooden 
structures in Ilo, most of which were inhabited by French:

El valle de Ilo…parece solo una pequeña grieta que se ve abrirse poco a poco…hasta que se descubre la iglesia y una cincuentena de cabañas construidas 
con ramas de árboles, dispersas aquí y allá cerca del arroyo que serpentea en 
medio del valle; en esto consiste la aldea de Ilo, casi toda construida y habitada 
por franceses.
The valley of Ilo…is like a small crack that opens little by little…until the church appears alongside a group of 50 cabins constructed of branches and trees, dispersed here and there and near the arroyo that winds its way through the center of the valley; this is the village of Ilo, almost entirely constructed and inhabited by French (my translation).

Frezier further mentions that while many of the coastal hills surrounding Ilo were once covered with trees, the French had cut down so many over the prior 14 years that the forests had receded inland about a league (Frezier 1982[1713]: 156), suggesting that the surrounding landscape may not have been as desolate as it appears today.

Despite low population levels throughout the lower valley and coastal region, agriculture was an intensive and productive activity for much of the 17th century. Like many of the coastal springs in the 1600s, quebradas Agua Buena and Seca were intensively cultivated within the context of European values of production. As part of a large encomienda, early production at the site may have indeed prospered from the labor of native Andeans, though low population levels in the 17th century suggest that perhaps production became more and more directed by hacendados and their dependants. Even the presence of a non-subsistence crop like olives suggests that by the early 1600s, the network of a market economy had begun to branch significantly from the primary trunk line that connected Potosí and Lima. Moreover, the extent to which olives were produced during this century, and certainly their mention in historical documents as a primary focus of agricultural production throughout the colonial period, point to the incorporation of Ilo and the coast into a increasingly widespread, macro-regional economy. The large quantities of mule dung at Wawakiki, along with historical mention of 200 mules in the
nearby Lomas de Sauces (see Vasquez de Espinosa 1987[1618]), lends support to the transport of olives from quebradas Agua Buena and Seca, and oil likely pressed at Hacienda Alastaya, by pack mules along the immediate coastline and up the Osmore corridor to neighboring economic centers in the highlands.

Early Spanish colonial production along the coast did not abandon more traditional Andean crops like maize (*Zea mays*) or squash (*Cucurbita*); rather, their presence at Wawakiki suggests that these continued to play important roles in the local subsistence economy. These products can be successfully cultivated throughout the coastal and middle valleys of Peru, leaving it very unlikely that they were exported beyond the local economic arena. Given the low population levels described by Vasquez de Espinosa in 1618 and by Frezier in 1713 for the surrounding coast, production of these items was most likely directed towards the local hacienda and its dependants, with surplus perhaps exported inland. In addition, the likely presence of wheat (*Triticum*) associated with Spanish colonial agriculture at the site likely followed the same path to consumption as maize and squash. Wheat can also be successfully cultivated throughout many coastal and middle valleys of Peru, and consequently, its production and export as a commercial crop in the early colonial period never prospered beyond local arenas (Keith 1976). Its presence does indicate, however, that values placed on imported foodstuffs were growing enough to warrant local production of this European plant. Its presence also suggests that Europeans in the coastal Osmore region were beginning to take an active role in directing production, no longer satisfied from merely extracting surplus wealth and foodstuffs from native Andeans under the old structure of the encomienda.
Along with culturally valued foods produced from wheat, its consumption was merely part of a complex of European norms and ideals that were quickly transferred from Spain. Based on pollen remains, historical records (Vasquez de Espinosa 1987[1618]; Frezier 1982[1713]), and archaeological remains at Wawakiki, especially those associated with late Spanish colonial land use, olives (Olea) quickly grew in importance as an agricultural enterprise at Wawakiki and among its neighboring springs and valleys of the Peruvian south coast. Unlike wheat, which could be successfully cultivated throughout many regions of Peru, olive cultivation required strict conditions to ensure high returns on its investment. In late 20\textsuperscript{th} century Peru, Lima was the only province outside of the southern provinces of Tambo, Moquegua (of which coastal Ilo is a part), and Tacna that supported a significant olive industry (ONERN 1976).

Generally, the olive tree matures in 25 to 50 years, though they can exceed 500 years in age if properly tended. The life span of most, however, average about 200 years. They first begin to bear fruit after about six to eight years, and hence, their planting represents a long-term investment in the landscape. Olive trees are particularly tenacious: they need little water, can withstand a fair amount of neglect, and can easily produce for decades with only the slightest of care (Paernio 1908). At Wawakiki, this is evidenced by a few isolated trees that remain standing near the mouth of Quebrada Agua Buena’s main channel, and several trees scattered about the inland-most spring area of Quebrada Agua Buena. These areas were last agriculturally maintained about a half century ago, though several trees continue to bear olives, a strong testimony to their resilience. Overall, however, olive cultivation and harvest is most successful when there
is sufficient moisture or heavy garúa in the lomas to augment the irrigative potential of the coastal springs (Paernio 1908: 12).

The olive was highly valued culturally during the early colonial period, mostly because of the demand for oil pressed from the fruit. As encomenderos and their dependants (and later, haciendas) began to practice commercial agriculture for a developing market mechanism in the Viceroyalty of Peru, olives became a principal focus of those farmers that had the capital, know-how, patience, and economic stability to invest in the production and processing of olives. Because of the strict climatic conditions required to maximize the economic potential of olives, the Ilo valley and neighboring coastline was transformed into one of the most productive producers and exporters of olives and processed olive oil. Thus, the environmental parameters of the far south coast coupled with an increasing demand for olive oil along the Lima-Potosí trunk line ensured that the Ilo region quickly became linked to a widespread and developing macro-economy. Such widespread demands for a local product ensured successful returns on these items for centuries.

**Climate Shift in the late Spanish Colonial Period?**

Europeans arrived in Peru during a relatively wet period in the southern Andean highlands. According to data from the Quelccaya ice cap of southern Peru, the Andean highlands were experiencing wetter than average conditions between AD 1490 and 1720, with a notable surge in relative precipitation beginning around AD 1600 (Figure 7-17). Spanish colonial farmers exploiting southern coastal valleys like that of Ilo in the early 17th century may have indeed arrived upon hydrological conditions that were favorable
for runoff-dependant irrigation agriculture. Historical records suggest that much of the lower Ilo Valley was farmed during this period, while many of the coastal Osmore springs also contributed significantly to the volume of products cultivated in the region. The principal cultigen in the area during the 17th century was without question the olive, though considerable efforts were placed on the cultivation of other perennials like oranges, higos, guayabas, bananas, and lucumas, and notable annuals like wheat, legumes, sugar, and alfalfa (Adriazola Flores 1998; Frezier 1982[1713]).

By the early 18th century, however, hydrological conditions in the coastal valleys diminished considerably, with a remarkable 140 year-long period of below normal highland precipitation beginning in 1720 and lasting until 1860 (see Figure 7-17).

Haciendas and commercial farmers alike in the coastal valleys of southern Peru likely felt the consequences of low precipitation and runoff. The effects of this highland drought may have in fact been somewhat more intense than those experienced during the late pre-Hispanic period. Based on the shape of decadal ice accumulation curves, Quelccaya glacial records point to considerable “peaks and valleys” associated with highland

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**Figure 7-17.** Detail of ice accumulation trends from the Quelccaya glacial core, AD 1080-1980. Horizontal line represents the 1500-year average (modified from Thompson et al. 1985 and Thompson et al. 1994).
precipitation during the late pre-Hispanic drought that terminated around AD 1490; conversely, that of the 18th and 19th centuries grew in intensity, peaked, and declined within its 140-year cycle (see Figure 7-17). The extreme arid conditions experienced in the Ilo valley near the onset of this period even prompted the French traveler Frezier to comment, noting that the area was suffering from intense aridity (Frezier 1982[1713]: 156).

While generally the coastal Osmore springs may have experienced differential effects from changes in highland precipitation during the late pre-Hispanic era (see Chapters 3, 6), the intensity with which the late Spanish colonial drought occurred may have catalyzed significant changes in land use among coastal springs like Wawakiki. Long-term aridity may have affected the rate of discharge, or perhaps even the location of spring discharge along the coast. It also would have affected the success with which particular cultigens may have been produced, and certainly it would have limited the number of plantings per annual cycle that farmers may have been able to harvest, especially given the highly seasonal nature of runoff and spring discharge in the area.

Agrarian land use at Wawakiki shifted around this period, defined primarily by the abandonment of the Quebrada Agua Buena primary canal, and a principal reliance on a lower elevation spring source on the coastal promontory itself. Unfortunately, a precise correlation cannot be established between highland drought and changes in land use documented at the site based on preservation of fields alone. However, the use of the coastal promontory spring source would have significantly decreased the distance from spring source to field, which would be consistent with a decline in spring discharge. If both the inland and coastal promontory spring sources experienced a decrease in
discharge, the transport costs defined by infiltration and evaporation would likely render inoperable that spring farthest from cultivated terrain.

Still, land use at Wawakiki persisted through this time of low highland precipitation, most likely because of a mixed strategy of subsistence and non-subsistence crops at the site. Because olive trees constitute a semi-permanent change to the landscape (they typically survive for several hundred years or more) and represent the primary link to a growing macro-regional economy, they likely held precedence over other cultigens with respect to any depleted water supply. During times of exceptionally low spring discharge, irrigation water would have been reserved for maintenance of olive trees, while in other years (or seasons), other plants like wheat, squash, and maize may have been cultivated when hydrological conditions permitted it, as suggested by pollen remains at the site. Regardless, the natural tenacity of olive trees would have enabled them to survive the period of aridity during late Spanish colonial era, as long as they continued to receive only the slightest of care. As will be discussed in the following chapter, olive production continued into the post Spanish colonial period, perhaps even growing in importance at the site, as higher counts of Olea pollen are noted in sediment samples associated with that period (Cummings 2004).
Chapter 8: 

POST COLONIAL AND EARLY 20\textsuperscript{TH} CENTURY AGRICULTURAL LAND USE

The latest use of surface furrows at Wawakiki for agricultural purposes likely occurred in the post Spanish colonial period and perhaps extended into the early 20\textsuperscript{th} century. Based on historical records and local farmers in the area, the main agricultural sector of the site along the coast was in all likelihood abandoned in the early part of the 20\textsuperscript{th} century, as production shifted several kilometers inland in both quebradas, possibly in response to changes in spring sources. Historical records of Peru’s Ministerio de Fomento cite significant olive production in Quebrada Agua Buena in 1908, indicating roughly 700 productive olive trees at that time (Paernio 1908). Excluding the coastal promontory of the site, seven hundred trees would be a very generous estimate for Quebrada Agua Buena alone, especially given the nature of narrow, linear furrows that characterize sites along the steep inland slopes of the quebrada. Therefore, I suggest that the coastal promontory continued to produce olives and other seasonal cultigens into the 20\textsuperscript{th} century, but was abandoned shortly thereafter. As was the case along the entire coast, the remaining trees on the coastal promontory were subsequently uprooted as a significant source of fuel.

POST COLONIAL AGRICULTURAL LAND USE

Based on surface preservation, agricultural land use contracted slightly during the post Spanish colonial era in Quebrada Agua Buena and on the coastal promontory. Portions of the surface in both areas exhibit pristine furrows that likely correlate to the
latest use of both sectors for agricultural purposes. Preservation of furrows suggests a total of 4.70 ha were agriculturally maintained along the north bank of Quebrada Agua Buena and on the coastal promontory, with perhaps a slight amount of land cultivated in Quebrada Seca (Figure 8-1). Primary canals utilized during the Spanish colonial period continued to irrigate portions of the coastal promontory and Quebrada Seca, though the primary canal along the north bank of Quebrada Agua Buena was abandoned in favor of one positioned closer to the main channel (Figure 8-2). Patterns of surface furrows associated with this period indicate that a significant portion of the site was dedicated to the cultivation of smaller plants like maize, beans, or tomatoes, while both historical records and pollen analysis suggest that olive production remained an important component as well.

Figure 8-1. Air photograph depicting the extent of land use during the post Spanish colonial era (~ AD 1821-1940).
Agricultural Land Use in Quebradas Seca and Agua Buena

While some isolated patches of sediment furrows along the lower banks of Quebrada Seca exhibit preservation comparable to that noted on the coastal promontory, land use in this sector remains only speculative. However, the relative preservation of agricultural infrastructure on the north bank of Quebrada Agua Buena suggests production there extended beyond the Spanish colonial era, where exceptionally well preserved sediment furrows were irrigated by a second, more recently constructed canal stemming from the quebrada channel (Figure 8-3). This canal is located at a lower elevation than its upslope predecessor, and its positioning may have been in response to the unstable canyon wall above. As discussed in Chapter 7, isolated profiles above this...
canal commonly revealed colluvial deposits consisting of large cobbles and angular stones, a testimony to recurrent collapses onto cultivated fields. The most recent canal extends away from the canyon wall, where surface debris associated with well preserved furrows is minimal. Based on the course of the lower, more recent canal, land under production contracted from 0.63 ha in the Spanish colonial period to 0.26 ha in the post colonial era.

In addition to well preserved furrows, a rectilinear stone wall and a small quadrangular enclosure were constructed above the canal and overlying late Spanish colonial fields. Historical accounts of agrarian land use and stock raising along the Peruvian coast describe farmers who built small pens in which to hold wandering goats or pigs that found their way onto cultivated terrain (Keith 1976). During the colonial period, the farmer who discovered the lost animals took them to particular pens, where they would remain until their owner had come for them. A fine was usually paid to the
farmer, or a single animal was kept as payment (Keith 1976: 63-64). Thus, where agreements were not made between herders and farmers, pens were constructed near agricultural fields to hold such animals. Alternatively, agreements were sometimes made between farmers and herders, where for a said fee, animals were allowed to graze on agricultural fields after harvest. This would have also provided fertilizer for fields. In such cases, animals were kept in small pens when not grazing so that they might not escape. In the Wawakiki area, such stone-constructed pens are noted in the nearby *lomas*, where middle and upper valley herders would seasonally bring their livestock.

Whether the small, completely enclosed pen at Wawakiki temporarily held unwanted stragglers from coastal herds, or it housed small animals that were occasionally brought down to the nearby *lomas* to graze, its presence suggests a regular occurrence of domesticated animals at the site and along the coast. Finally, the fact that both the stone wall and pen overlie more eroded sediment furrows lends further support to agricultural abandonment associated with the upper canal.

Sediment furrows preserved in this sector are primarily linear, with some crescent-shaped and box-shaped furrows. Both crescent and box shaped furrows are significant in that they tend to hold water and slow its passage through an agricultural system. Based on surface examination, it seems likely that each crescent shaped furrow (both in this sector and on the coastal promontory) likely held a single plant or several small plants or shrub-sized cultigens. It seems unlikely that they were used in arboriculture, though they could have served as seedling beds by supporting immature trees or generally smaller trees before transplant. Furrows associated with the lower elevation canal on the north bank of Agua Buena also exhibit similar degrees of
preservation and cleanliness to fields with an index ranking of 5 on the coastal promontory, suggesting this area too was cultivated during the latest use of the site (Figure 8-4). While chronological evaluation is difficult, the wall and corral for possibly holding wandering pigs or goats was most likely associated with this period, since they overlie more poorly preserved furrows.

Figure 8-4. Relative index of preservation of post-AD 1600 land use. A “5” indicates the greatest preservation, while “1” indicates the poorest. A “0” indicates absence of evidence for post-AD 1600 land use.
Coastal Promontory Agricultural Land Use

Based on preservation of sediment furrows, a further contraction of cultivated terrain occurred on the coastal promontory into the post-Spanish colonial era, though the spring and impoundment tank continued to serve as the principal source of irrigation. Encompassing roughly 4.07 ha., fields and furrows toward the lower and southernmost portions of the coastal promontory constitute the final phase of cultivation in this sector. They all exhibit excellent preservation, displaying a complex array of primary and secondary canals leading to linear, crescent-shaped, and sinuous furrows. The relative cleanliness of these fields also suggests a very late use. In contrast to furrows on the northernmost portion of the promontory and those above the water impoundment tank, these fields are relatively free of medium and large stones. Indeed, stones are scattered about the perimeter of this well-preserved field system, some piled as high as 1.5 meters and as long as 15 meters. It is clear that surface stones and other debris were cleared from these fields and left in piles near the edges of cultivated terrain, suggesting those fields upon which stones were tossed or those that were not cleaned were no longer in use (see Figures 8-1, 8-4). Well-preserved furrowed terraces discussed in this chapter are identified in Figure 8-5, which should be consulted regularly.

Several distinct patterns of pristine furrows are identified on the promontory, most of which exhibit characteristics that are very consistent with the cultivation of smaller plants like peppers, tomatoes, squash, or perhaps even maize (as opposed to perennials like olives). Some patterns represent more traditional Andean technologies of preparation of soil upon terraces, like *caracoles*. *Caracoles* are sinuous secondary furrow canal systems that rationalize water use by providing moisture to the greatest area of
cultivation and maximizing infiltration to cultivated plants. The slow flow of water through the system also minimizes soil erosion (Doussoulin 1981: 36). In an agrarian development program organized by the Association Campesina Andina (A.C.A.) in the 1970s, a group of Andean campesinos from five localities in the Azapa region of northern Chile experimented with several traditional Andean agricultural technologies, one of which being *caracoles* (Rivera 1987). A decade later, Andean technologies had
transformed parts of the Azapa Valley into a highly productive garden spot, where *caracoles* were primarily dedicated to the early cultivation of vegetables like tomato, squash, and beans (Rivera 1987: 231-233).

Caracoles are not a recent development in the Andes, however. Moderately preserved (though unmistakable) *caracoles* have been identified in the Jequetepeque Valley of northern Peru and are clearly associated with late pre-Hispanic irrigation canals (Eling 1987). Elsewhere, Amadeo Frezier (1982[1713]: 141) comments on a sinuous furrow technology in his early 18th century visit to the Azapa valley of northern Chile. He specifically cites the cultivation of smaller plants like *aji*, or peppers, in conjunction with such furrow patterns:

Una vez que el grano ha germinado y se encuentra en condiciones de ser trasplantado, se colocan las plantas en filas sinuosas, de manera que la misma disposición de los canales de riego conduzca el agua suavemente al pie de las plantas; entonces, en cada pie de pimiento se pone tanto guano como cabe en el hueco de la mano.

Once the seed has germinated and grown sufficiently to be transplanted, the plants are placed into sinuous lines, in such a way that the arrangement of irrigation canals carries water slowly past the foot of each plant; then, enough guano to fill the cup of a hand is placed at the foot of each pepper plant (my translation).

As a pre-Hispanic agricultural technology, *caracoles* have been re-introduced several times in the historical and modern eras, and furrows on the coastal promontory clearly conform to this pattern.
Idealized examples of caracoles (e.g., Rivera 1987: 249) depict evenly spaced sinuous furrows running the entire course of a terrace or field plot (Figure 8-6). Irrigation water enters the system at one end and continues through until draining out the distal end. Caracoles on Field 12 at Wawakiki hold steadfast to the idealized pattern, with only a slight modification, perhaps as a technological innovation in response to the nature of tank-and-canal irrigation. Field 12 consists of a terrace measuring approximately 20 x 50 meters, upon which are six evenly spaced caracol furrows (Figure 8-7). While preservation is poor in the southern portion due to alluvial activity, the northern two-thirds remain in pristine condition. While each of the six furrows run the length of the terrace, there are several secondary canals that permit water to bypass portions of the system in order to irrigate specific sections. These bypass canals and secondary entrances to the furrows shorten the distance water must travel to irrigate more distal sectors, while at the same time continuing to exploit the advantages offered by caracol furrows (e.g., minimum erosion, efficiency of water consumption). In the case of Field 12, small cobbles were placed at critical locations to direct water through the system, a rudimentary—though very efficient—network of sluice gates or check dams. Ultimately, their placement in the furrow system would decrease labor investment during irrigation. When properly positioned, a single laborer could periodically release water from the impoundment tank upslope and irrigate select portions of terraces, even at the most distal ends of the field system.
Figure 8-6. Idealized depiction of *caracoles* based on descriptions of those in the Azapa valley of northern Chile (redrawn from Rivera 1981: 249).
Figure 8-7. Furrows on terraced field 12 clearly exhibit *caracoles*, with only slight modifications to the idealized pattern. Bypass canals may have been incorporated into the basic *caracol* pattern in response to a limited water supply. In this manner, to reach select portions of the terrace, irrigation water could bypass much of the system and enter through a series of small rudimentary check dams.
While Field 12 exhibits caracoles in their truest form, other furrowed terraces on the coastal promontory show elements of the basic *caracol* pattern and are also clearly for the cultivation of smaller plants. Field 4, for instance, displays a well preserved pattern of interlocking “blind channels,” where water passed through alternating sets of five or six furrows in a sinuous manner (Figure 8-8). Like Field 12, small stones were placed at critical points to guide water through the system.

*Figure 8-8.* Furrows on terraced field 4 show similar elements to the basic *caracol* pattern.
Other well preserved furrow patterns associated with the post Spanish colonial era vary considerably from those discussed above. Fields 8 and 11 clearly point to the cultivation of other cultigens like squash that require considerable spacing between individual plants (Figures 8-9 and 8-10). In the case of Field 11, this same pattern constitutes the final stage of production on that terrace, where closely spaced linear furrows were previously irrigated before the soil was reshaped and water re-routed to isolated plants, effectively cutting off earlier furrows (Figure 8-10). Similar to other fields of this period, small stones and rounded cobbles were used to guide water, and in this case they were placed at the foot of each plant to slow the passage of water, reduce erosion, and maximize infiltration.

Figure 8-9. Furrows on terraced field 8 exhibit patterns that would be consistent with the cultivation of small trees or larger plants that require considerable spacing. This pattern is also noted on field 10 (seen in figure 8-8), as well as on field 11 (Figure 8-10).
Figure 8-10. Furrow patterns on terraced field 11 suggest a transition from closely spaced linear furrows to those more consistent with plants like squash that require considerable spacing. Small stones and cobbles noted on the surface clearly point to a system of rudimentary check dams placed at the foot of each plant. Their purpose was to slow the flow of water and allow for necessary infiltration during irrigation.

Regardless of patterns of soil manipulation, furrowed terraces on the coastal promontory during the latter half of the 19th century were intricately connected through a network of secondary and feeder canals that ultimately stemmed from a single impoundment tank. Such a system would have required careful planning and organization to successfully maintain production. As an irrigation system with discontinuous flow, strict schedules would have been necessary to repeatedly release
water from the impoundment tank and irrigate specific field terraces, or perhaps even portions of field terraces. Sufficient time would have also been required to allow the tank to replenish prior to subsequent irrigation. Depending on the labor and water requirements of particular cultivated plants, some terraces may have needed more frequent irrigation than others. In addition to olives, the diversity of furrow patterns among terraces suggests that multiple plants were in fact cultivated simultaneously, and therefore it seems likely that proper scheduling of planting, tending, and harvesting was crucial for their success.

**Pollen and Species Diversity at Wawakiki, Post-1821**

Of the twenty soil samples analyzed for pollen, six are associated with post-Spanish colonial era sediment strata and furrowed terraces (Figure 8-11). Patterns observed in this Spanish colonial era continue into this period, including a further decrease in quantities of charcoal from Spanish colonial samples, indicating a further slight reduction in burning. Like the colonial period samples, *Tidestromia* and Brassicaceae pollen are found in these samples, though *Tidestromia* is found in greater abundances. Quantities of both High-spine Asteraceae and Cheno-am pollen decline in
Figure 8-11. Pollen diagram with results from all twenty soil samples analyzed. Samples associated with the post Spanish colonial period are indicated along the right-hand margin (modern).
these samples, while *Prosopis* pollen was identified in four of the six samples, indicating the nearby presence of mesquite.

Other pollen representing non-cultivated plants in these samples include *Portulaca*, indicating the presence of purslane as a weed that produces edible leaves and seeds. *Sphaeralcea* pollen was much less abundant in these samples, suggesting that it had been all but eradicated from the agricultural fields by the post colonial era. *Tribulus* pollen was identified in one sample, representing the presence of puncture vine or a similar plant. Finally, the presence of *Rauvolfia* pollen indicates regional or perhaps local growth of a large shrub or small tree, common in dry forests. This pollen type was only noted in these samples, suggesting that it became more abundant locally than it was previously.

*Zea mays* pollen was identified in all six samples, while *Cucurbita* and *Olea* were each identified in three samples, representing continued cultivation of maize, squash/pumpkin, and olive into the modern period. Olive trees appear to have been more abundant in the agricultural fields during the post-Spanish colonial period than in the previous era, at least with respect to the twenty samples analyzed. Solanaceae pollen is also present, possibly representing a member of the tomato/potato family. Also, *Datura* pollen appears in one sample, indicating its presence during the post colonial era in addition to the late pre-Hispanic period.

**EARLY 20TH CENTURY LAND USE**

By 1951, the entire coastal promontory and much of the lower portions of quebradas Agua Buena and Seca were abandoned, with only limited terrain continuing to
support olive trees in Quebrada Agua Buena near the coast (Figure 8-12). Some time during the early 20th century, production in both quebradas seems to have shifted several kilometers inland, perhaps to take advantage of changing spring sources. In both inland quebradas, expanses of land strictly delineated by dry brush or stone property walls exhibit well-preserved primary and secondary canals and sediment furrows, and in the case of Quebrada Agua Buena, these are preserved on the very steep northern wall of the canyon (Figure 8-13). There are no surface artifacts associated with any inland system, but the fact that furrows are even moderately defined on such steep gradients (~40%) suggests a very late period of construction and agricultural use, and most likely the final stage of production in either canyon. Combined, agricultural land use associated with these inland systems did not exceed a total of one hectare in either quebrada.

**Figure 8-12.** Air photograph depicting the extent of land use during the early 20th century (~ AD 1910-1950), indicating that production along the coast was at some point abandoned in favor of inland zones.
Inland Quebrada Agua Buena Land Use

During the early half of the 20th century, and perhaps up to the early 1950s, a series of inland terrace systems were constructed and cultivated in Quebrada Agua Buena, most of which lie on the steep north canyon wall. However, the inland-most system, site WK7-6 lies on both sides of the main quebrada channel, but primarily on the south bank. Furrows associated with these inland systems are generally linear in nature and typically very well preserved. Their preservation on steep canyon walls suggests a very late period of construction and use, especially given there susceptibility to erosive activities. Indeed, comparisons of historic aerial photographs and photographs taken in the late 1990s suggest moderate terrace construction may have occurred at site WK7-4 shortly after 1951, though this remains inconclusive.

Figure 8-13. Aerial photograph showing the locations of production sites associated with the early 20th century.
Among these inland systems, sites WK7-4 and WK7-5 exhibit the greatest preservation. Both consist of mixed sediment furrows and stone-faced terraces, and each is surrounded at least partially by stone-wall and dry-brush property delineations. Of any inland system, site WK7-4 exhibits the greatest use of stone-faced terrace walls, with furrows lining the hillsides between terraces (Figure 8-14). Cultivated terrain of the site encompasses approximately 0.3 ha, which was irrigated by two canals, the first of which enters the northeast corner of the system from site WK7-5, and the second of which enters midway up the system and just above several stone terraces. This second canal passes through the lower third of the site, continuing on to site WK7-3 located a short

\[\text{Figure 8-14. Plan view of Site WK7-4 as seen from the south canyon wall of Quebrada Agua Buena. The site lies on the steep north canyon wall of the quebrada.}\]
distance down the quebrada channel. The remains of site WK7-5, on the other hand, consist primarily of linear furrows and two principal stone terrace walls (Figure 8-15). The upper half of the system is very eroded and wind deflated, while the lower half is bounded by stone walls and contains moderately preserved furrows. The entire system is fed by a single irrigation canal entering the northeast corner, and cultivated terrain encompasses approximately 0.18 ha. A second canal extends from site WK7-6, passing just below the cultivated portion of WK7-5 and continuing on to site WK7-4.

Soil samples for pollen analysis were not extracted from any of these inland systems, rendering it difficult to speak in any direct sense to cultigens. However, closely spaced linear furrows noted at all terrace systems suggest a significant emphasis on

**Figure 8-15.** Plan view of Site WK7-5 as seen from the south canyon wall of Quebrada Agua Buena. The site lies on the steep north canyon wall of the quebrada.
cultivation of smaller plants like maize or beans, though the presence of a few standing olive trees at Site WK7-6 indicates their maintenance as well.

Importantly, while each inland terrace system is bounded by either dry brush or stone wall property delineations, the distribution of feeder canals leading to each system indicates a fairly complex and interrelated system of production among these sites. Canals ultimately extending from the inland most site of WK7-6 pass through each successive site to irrigate prepared fields. Thus, sites located nearest the coast were necessarily at the mercy of their more inland neighbors, especially during periods of low spring discharge. If indeed tank-and-canal irrigation was utilized among these inland springs, then careful planning and cooperation during irrigation would have been necessary. Some measures were taken, however, to maximize the shared commodity, as bypass canals were constructed in order to shorten the distance traveled between spring to field, such as the case of the lower canal identified below site WK7-5. The fact that cultivated areas were not continuous and each was delineated by stone or dry brush boundaries suggests each was managed by an individual owner or usurper, with at least some interrelated sense of cooperation. Each may have constituted individual *chacras* or *fundos* that provided subsistence for a farmer or surplus for the Tambo and Ilo markets.

### Inland Quebrada Seca Land Use

Unlike Quebrada Agua Buena, there appears to be only one area of significant landscape modification and cultivated terrain in the inland portion of Quebrada Seca, identified at site WK6-3 (see Figure 8-13). The area of preserved sediment furrows at the site is quite small—about 0.125 ha—but a number of low stone alignments supporting
very shallow terraces with moderately preserved furrows are noted along portions of both banks of the quebrada, totaling nearly 1 ha of modified terrain. All agricultural features are confined to the area delineated by the steep walls of the canyon; unlike the terraced systems in Quebrada Agua Buena, those here were constructed only on relatively low-gradient terrain. The preservation of furrows and feeder canals is consistent with those noted in Agua Buena, suggesting contemporaneous land use among the inland quebradas in the early 20th century.

**DISCUSSION**

By the post Spanish colonial period, cultivated terrain at Wawakiki was reduced to about 4.70 ha, which included portions of the north bank of Quebrada Agua Buena, the coastal promontory, and perhaps only a slight area in Quebrada Seca. The spatial limits of agrarian land use during this phase are defined largely by preservation of furrows, where parts of Quebrada Agua Buena and the lower coastal promontory exhibit furrows that remain in pristine condition. Distinguishable patterns of furrows indicate that a variety of products were cultivated in addition to olives during the post colonial period, many of which were designed to irrigate smaller plants like tomato or peppers.

By the early 20th century, agricultural production at the site shifted inland, leaving abandoned the entire coastal promontory and the lower portions of both quebradas. Historical records estimate 700 productive olive trees for Quebrada Agua Buena in 1908, and given the kinds of infrastructure noted among inland spring systems (closely spaced sediment furrows not well suited for olive trees), it seems unlikely that the quebrada itself could have supported such a generous number. In all probability, the coastal promontory
was included in the 1908 estimate, where olive trees continued to be maintained below
the primary canal of the impoundment tank. Abandonment of the coastal zone, then,
likely occurred sometime after 1908, and probably not long after 1951 as suggested by
historic air photographs snapped in 1951 by Peru’s Servicio Aereofotográfico Nacional.
Based on historical documents, furrow patterns, pollen remains, and standing trees, it
seems relatively clear that both the coastal and inland zones supported a mixed
agricultural strategy that included perennial cultigens like olives, and smaller, annual
plants like maize or tomato. The primary change in land use, then, was location between
the two phases.

**Agricultural Technology and Desiccation along the Wawakiki Coast**

Since today the spring source on the coastal promontory remains completely dry,
a diminishing water supply at that location must be considered a chief component of
agrarian contraction on the promontory, ultimately leaving farmers to focus solely on
inland spring systems. As noted in previous chapters, a period of low highland
precipitation characterized much of the late Spanish colonial and immediate post colonial
periods. Ice accumulation records from the Quelccaya glacier suggest below normal
highland precipitation lasting from AD 1720 to 1860, while historical records indicate
another period of intense highland drought several decades later in the 1930s and 1940s.

Changes in land use identified on the coastal promontory during its final stages of
cultivation are generally consistent with a depleting spring source, and farmers
maintaining production at Wawakiki during this period tended to employ irrigation
technologies that were designed to maximize the use of a limited water supply. First, the
impoundment tank that surrounded the coastal promontory spring source was renovated sometime beyond its initial construction in the late Spanish colonial period. A new interior retention wall was constructed, reducing the maximum volume of water the tank could hold from 65 m$^3$ to about 43 m$^3$. A reduction in tank size would be consistent with diminishing rates of spring discharge. Olive trees require irrigation at least once every three weeks, while other more seasonal plants like maize and squash might require weekly irrigation, depending on the cultigen. As discharge decreases, more time would be required to replenish the tank to a sufficient level that water could reach cultivated fields upon its release. When a tank becomes constricted, less time is needed for it to fill, and consequently, strict irrigation schedules can be maintained. With lower discharge and smaller impoundment tanks, however, smaller areas of land can be agriculturally maintained. This is evident on the coastal promontory, where land under production contracted from 5.20 ha to 4.07 ha. This technique was also recently employed by local field managers at Alastaya spring several kilometers to the south, where one of its two functioning cement-lined spring tanks was effectively reduced by half: a wall was inserted down the center of the tank in direct response to a diminishing rate of spring discharge.

Like renovations made to the impoundment tank, furrow technology employed by local farmers on the lower coastal promontory also represents an arid adaptive strategy during this period of low moisture. *Caracol* furrows and basic innovations to this technique were identified on a number of field terraces, a strategy particularly known for its efficient and maximizing use of water. In at least one instance, modifications were made to the basic *caracol* pattern so that water could bypass specific sections of terraces.
in order to minimize transport costs to distal portions of those fields. In other cases, small stones were also placed at critical points on a furrowed terrace to serve as rudimentary check dams, another strategy to slow the flow of water through an irrigation system. Indeed, the intricate network of steep primary canals leading to low-gradient, sinuous secondary feeders and rustic check dams provided local farmers with a technology designed to transport water quickly from spring source to field, where it would then slow considerably and pass gently through sinuous furrows to permit maximum infiltration with minimal erosion. The very presence of *caracol* technology indicates that at least some ancient Andean farming strategies have permeated through generations of Spanish colonial land use and organization, either through direct involvement with descendants of native Andeans that retained such strategies in the colonial and post colonial periods, or as a local strategy adopted by European farmers to maximize water efficiency. These technologies are well suited for arid climates, some of which have certainly persisted in coastal Andean valleys for centuries.

Sometime between 1908 and 1951, the coastal promontory spring dried up completely, and cultivation in this sector fell into abandonment. The decision to relinquish production on the coastal promontory may correlate with conditions of severe drought in the neighboring highlands between 1934 and 1945 (Newell 1949), the hydrological effects of which may have ultimately extended to the lower Osmore area, detrimentally influencing rates of discharge or spring location with respect to coastal promontory agriculture. Production continued inland, however, as farmers took advantage of a very dynamic spring system, especially in Quebrada Agua Buena. Today, several areas in that quebrada boast active (though modest) spring flow registering 0.1
liters per second, including one near the headway of the quebrada nearly two kilometers from the coast. Inland agricultural systems are located just below this spring source, suggesting that it may have been an active area of discharge for at least the past half century or so.

**Late 20th Century Agriculture, Southern Peru Copper Corporation, and Wawakiki**

In the 1950s, SPCC purchased each of the olive *fundos* to the north of its copper smelter along the coast at Quebrada Chuza, which was established based on extensive coastal surveys that determined it to pose the least possible damage to agricultural endeavors in the region. In the decades to follow, SPCC maintained the groves, hiring local laborers to care for the trees and harvest their fruit. In addition, farmers hired to work among the springs were permitted to cultivate additional plants, at least when hydrological conditions remained sufficient. Local farmers that have worked in the area for several decades describe a pattern where a number of smaller plants and shrubs were cultivated at the same time as olive trees. For instance, one farmer who labored at Pocoma spring in the 1960s and again in the 1980s mentioned that in addition to olives, they farmed peppers, sweet potato, watermelon, *higos*, *guayabas*, plantains, tomato, maize, onion, and carrots (Clemente Zeballos⁵, personal communication, 2003). It was also mentioned that these “other” cultigens (secondary to olives) were taken to market for sale on Sundays.

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⁵ Zeballos is a long-time local resident and has labored at several springs along the coast over the past few decades, including Pocoma. He currently cares for the olive grove at San Jose spring, several kilometers to the north of Wawakiki. When asked about the latest period Wawakiki had been used for agricultural purposes, he replied ‘not in his lifetime, nor in that of his father. I estimate Zeballos to be around 65 years of age.
Today, olives are the only agricultural product supported among the coastal springs north of Ilo; no other cultigens are currently farmed in the area managed by SPCC. Laborers hired to maintain the groves at Alastaya, Miraflores, and Pocoma springs today comment that while farmers were once allowed to cultivate other products for market, too often the olive trees—their primary responsibility—remained neglected. Consequently, SPCC established a policy that forbids local laborers from managing products other than the olive.

By 2003, spring discharge had generally decreased from previous years. There is, in fact, insufficient water to irrigate plants in addition to olives on a year-round basis. However, local farmers comment that there would be sufficient water to cultivate products other than olives during the three months of descansa, a period typically in June, July, and August when the olive trees are not irrigated. During these months, water is periodically flushed from impoundment tanks and allowed to drain out the distal end of the irrigation system, even though plants with shorter maturation cycles like onion (70-110 days), wheat (80-120 days), beans (80-120 days), or even tomato under the right conditions (90-180 days), could be successfully cultivated in this span of time. Because SPCC does not permit additional agricultural exploits among these sites, no other cultivation occurs and the excess spring water remains un-used.

Testimonies to agricultural practices at neighboring springs like Pocoma and Alastaya may provide some clues to the final stages of production at Wawakiki during the early 20th century, especially among the coastal sectors of both quebradas and the promontory. While the organization of production may have differed at Wawakiki from these late 20th century groves (the coastal sectors of Wawakiki were most certainly
abandoned prior to the SPCC mining and smelting operation along the coast), similar patterns in agricultural infrastructure and furrow technologies are noted. Like Wawakiki, other springs systems exhibit well preserved furrowed terraces at the distal portions of the olive groves, including *caracol*-type patterns. While olive maintenance likely took precedence among these *fundos* over the long term, especially given their resilience to fluctuations in available moisture, other plants represented by various furrow technologies (squash, tomato, peppers, or maize) were likely cultivated year-round when hydrological conditions were met, or seasonally when olives reached a period of *descansa*. This very well could account for the pattern identified at Wawakiki along the coast during the late 19th and early 20th centuries, or perhaps among inland spring systems during the early half of the 20th century.

Throughout the late 20th century, the presence of a large corporate enterprise in SPCC significantly boosted the local and regional economy surrounding Ilo and the coastal plain. It is also clear that the dynamic relationship between SPCC and local farmers holds particular relevance to intensification, expansion, or contraction of production along the coast. Most *fundos* north of Ilo were purchased by SPCC in the 1950s, knowing well that 90% of the time coastal winds would carry exhaust from the smelter to the north, heavily impacting groves at Carrizal, Yara, Alastaya, Miraflores, Pocoma, and perhaps even quebradas Seca and Agua Buena (though production there was certainly limited to the inland zones by this time, and likely abandoned by the time construction on the smelter was complete). While smoke and exhaust has undoubtedly affected the health of agricultural produce along the coast (Ministerio de Energía y Minas 2001), corporate policy has perhaps had a greater and more immediate impact on local
agrarian production among the coastal springs. Such circumstances cannot be applied to Wawakiki, however, as coastal production there ceased long before SPCC policy or any environmental effects could take hold in the region.
Chapter 9:  

WAWAKIKI CONTEXTUALIZED: MICRO- VS. MACRO-REGIONAL  

INVESTIGATIONS OF AGRARIAN LAND USE

In earlier chapters, I laid the foundation for this study by stressing the importance of investigating diachronic aspects of agrarian land use in order to understand contextual and historically contingent changes in human-environment interaction. However, to this point I have only partitioned time at Wawakiki into archaeologically “visible” analytical units that pertain to late pre-Hispanic, Spanish colonial, and post Spanish colonial land use. These units are necessarily synchronic because of the inherent limitations archaeological data pose for the investigator. The very nature of a diachronic analysis suggests that some how archaeologists can examine the continuous human condition, be it agricultural land use and the human-environment relationship, sociopolitical relationships across regions, shifting mechanisms of power and control, or changes in micro- and macro- socioeconomic organization. Given the often gross nature of the archaeological record, the question is not whether archaeologists can ever really approach anthropological inquiries diachronically, but rather how it can be accomplished when our chronological resolution is often visible only on the realm of hundreds of years. We can never really partition time beyond what the material record permits, so the answer lies necessarily in understanding a series of synchronic slices of the human condition and examining broad trends or changes that might be visible from one period to the next.

The gross temporal classification employed here is by no means intended to imply stagnant, homogenous cultural and environmental relationships within phases; to the
contrary, I believe that agrarian land use was quite dynamic throughout the late Chiribaya period, and certainly during the Spanish colonial and post colonial eras as well. Coarse as they may be, the synchronic units an archaeologist constructs constitute the only pathway to understand diachronic shifts in the manners in which humans relate to their physical environment, to each other, and the myriad of ways those relationships are expressed across the landscape. In this investigation, temporal units have been constructed first to understand relationships within the late pre-Hispanic, Spanish colonial, and post colonial eras; only now can diachronic shifts be defined among periods, the very subject of this chapter.

**Scales of Analysis: Site, Micro-region, and Macro-region**

If we are to understand and explain long-term human behavior pertaining to agricultural land use, it is paramount to construct appropriate spatial units of analysis (Morrison *in press*). The relationship between humans and their physical surroundings, and particularly as it manifests itself in agriculture, must be examined at multiple spatial and temporal scales. For instance, if the focus of study were solely on the household, our understanding of socioeconomic organization at the level of community or region will be skewed. Likewise, a strict focus on regional patterns of land use will mask the variability that operates at the level of community or household.

The spatial scales employed here are explicitly nested, where trends in agrarian land use at the level of site (Wawakiki) are contextualized within the micro-region (the Osmore coast), and again within the macro-region (the Osmore corridor and beyond). In this chapter, diachronic changes in land use identified at Wawakiki and presented in
chapters 6, 7, and 8 are briefly summarized at the level of site. Specific trajectories of production at Wawakiki are then projected against information detailed at other coastal spring sites like Carrizal, Pocoma, and Miraflores to understand the variability in land use across the micro-region. Finally, agriculture among the coastal springs is contextualized again at the level of macro-region. This nested approach permits a more balanced understanding of local production at Wawakiki, and hence a more powerful explanation of historically contingent and agriculturally related human behavior throughout the second millennium A.D.

THE SITE: WAWAKIKI

Agrarian Land Use and Technology at Wawakiki

Wawakiki displays the effects of over 900 years of intensive agriculture and landscape modification, though it seems probable that the earliest form of agriculture in either quebrada occurred during the Early Ceramic period sometime between about 100 B.C. and A.D. 400. Ceramic vessel forms consistent with regional variations of Early Ceramic period populations are common at Wawakiki, and one radiocarbon date from a buried lens of burned material on the south slope of Quebrada Agua Buena produced a calibrated age range of A.D. 212-398 (2-σ). These data are consistent with other information regarding Early Ceramic period agricultural populations in the area, specifically from nearby Pocoma and Carrizal springs (Bolaños 1987; Tello 1987). Unfortunately, indisputable evidence of agricultural landscape modification associated with this era is not available. In all likelihood, farming was restricted to the margins of the quebrada channels, perhaps using rudimentary irrigation technology.
During the 12th or 13th century, a small Chiribaya population situated themselves along the upper portion of the coastal promontory between quebradas Agua Buena and Seca. This late pre-Hispanic community instituted the first of a series of archaeologically visible phases of land use at Wawakiki (Table 9-1). The Chiribaya community systematically transformed the arid coastal promontory into productive agricultural fields, investing heavily in stone-faced hillside terraces and steep canals that transported water from inland springs to prepared fields along the coast. Elsewhere, Williams (1997: 71) has argued that hillside terrace technology was likely first introduced to the Moquegua region after the Wari established a colony at Cerro Baul in the Middle Osmore valley early in the 7th century A.D. Terrace technology likely diffused to the coast, though the use of footer walls at the base of some terrace walls appears to have been an innovation of coastal Chiribaya farmers to reinforce terraces along steep terrain. It is unclear how widespread this innovation was employed, since to date it has only been documented at Wawakiki. However, I suspect it may have been more common farther north among

<table>
<thead>
<tr>
<th>Chronological Period</th>
<th>Total area under production</th>
<th>% of previous phase land use</th>
<th>% of maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiribaya</td>
<td>(AD 1200-1400)</td>
<td>10.96 hectares</td>
<td>N/A</td>
</tr>
<tr>
<td>Post Chiribaya</td>
<td>(AD 1400-1600)</td>
<td>??</td>
<td>??</td>
</tr>
<tr>
<td>Early Spanish Colonial</td>
<td>(AD 1600-1700)</td>
<td>8.25 hectares</td>
<td>75</td>
</tr>
<tr>
<td>Late Spanish Colonial</td>
<td>(AD 1700-1821)</td>
<td>5.83 hectares</td>
<td>70</td>
</tr>
<tr>
<td>Post Spanish Colonial</td>
<td>(AD 1821-1925)</td>
<td>4.70 hectares</td>
<td>80</td>
</tr>
<tr>
<td>20th Century</td>
<td>(AD 1925-1951)</td>
<td>&lt; 2.00 hectares</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 9-1. Area under production at Wawakiki from the Chiribaya period to the late 20th century. Column three presents cultivated areas in percentages of the previous phase with measurable land use. For example, during the early colonial period, farmers cultivated 75% of the terrain cultivated during the Chiribaya period, while during the late colonial era, farmers cultivated 70% of that farmed during the early colonial phase. Column four displays cultivated areas in percentages of the maximum. Production was most extensive at the site during the Chiribaya period and is thus used as the maximum against which other phases are compared.
coastal Chiribaya agricultural spring systems situated on high-relief terrain.

Local production during the late Chiribaya phase was decidedly diversified, persisting until the early 15\textsuperscript{th} century. Pollen analysis suggests maize (\textit{Zea mays}) was a common crop around the site, while other economic and hallucinogenic plants may have been important as well, represented by \textit{Indigofera} and \textit{Datura}, respectively. In addition to agriculture, this small coastal community also intensively exploited their immediate shoreline, harvesting both sandy beach and rocky shoreline species of fish and shell fish, and they supplemented their local subsistence economy with wild plants and perhaps hunting or herding in the inland \textit{lomas}. Currently, there is no available evidence to indicate that the site was intensively occupied beyond the beginning of the 15\textsuperscript{th} century, but it is clear that massive debris flows associated with the 14\textsuperscript{th} century flood had little direct impact on Chiribaya agricultural infrastructure.

Farming had certainly become the focus of economic activity once again at Wawakiki during the early Spanish colonial period. There is no direct evidence to indicate that colonial farmers engaged in agriculture prior to A.D. 1600, but agriculture did become a productive activity at least by the early 1600s, given historical references to quebradas Agua Buena and Seca in early 17\textsuperscript{th} century Spanish colonial contexts. Spanish colonial farmers utilized much of the existing agricultural infrastructure, renovating the Quebrada Agua Buena primary canal and subsequently irrigating much of the same terrain as their Chiribaya predecessors. However, they chose not to reactivate the Quebrada Seca primary canal, preferring to excavate a new channel at a lower elevation. Farmers also erected stone property walls around field systems, making expedient use of abandoned late pre-Hispanic terraces and other construction materials at the site. Overall,
cultivated terrain contracted from 10.96 ha in the Chiribaya period to 8.25 ha in the early Spanish colonial period (Table 9-1). Late Spanish colonial farmers also constructed an impoundment tank on the coastal promontory from which to irrigate prepared fields below, leaving the primary canal in Quebrada Agua Buena abandoned. Including the activation of an additional sector of irrigated fields along the north bank of that quebrada, total agricultural land use contracted again from 8.25 ha to 5.83 ha (Table 9-1). Analysis of pollen samples, infrastructure, and historical documents indicate that olives (Olea) became the focus of agricultural activity during the Spanish colonial period, perhaps increasing in importance into the post colonial era. Maize (Zea mays), squash or pumpkin (Cucurbita), and perhaps wheat or another cereal grain (Triticum) were also likely cultivated during this period, probably directed in part towards satisfying local subsistence needs.

The impoundment tank on the coastal promontory was renovated at least once during the post colonial era, constricting the overall size of the tank and reducing total volume from 65 m$^3$ to 43 m$^3$. This likely corresponds to another contraction in agricultural land use at the site, decreasing from 5.83 ha to 4.70 ha (Table 9-1). In contrast to late pre-Hispanic agriculturalists, Spanish colonial and post colonial farmers relied principally upon furrows of silt, sand, and gravels, utilizing stone terraces to only a limited degree.

By the early 20$^{th}$ century, the spring on the coastal promontory had dried, and cultivation along the coast migrated inland to a series of hydrologically integrated field systems that constituted no more than about one hectare of total cultivated terrain in either quebrada (Table 9-1). Agricultural production had finally ceased in both
quebradas around 1951, though a few olive trees remained standing along the Quebrada Agua Buena channel at that time.

Demographic Trends at Wawakiki

Population estimates for ancient sites are always difficult to construct, though published research in the Osmore area provides at least a basis for estimating Chiribaya period populations, if only for intellectual comparisons (D. Rice 1993). In his examination of Late Intermediate period domestic architecture and residential organization at the Chiribaya site of Yaral along the north bank of the Moquegua River, Don Rice (1993) determined that 150 terraces and structures, or 45% of all terraces, were potentially domestic (D. Rice 1993: 74). This is based primarily on size of terrace, where 30 m² was the minimum area for a terrace to be considered habitational. Assuming contemporaneity of mapped terraces and structures and an arbitrary number of 5 persons per terrace, Rice estimated the population of Yaral to be on the order of 750 people during the Chiribaya period. If, on the other hand, total area of potentially habitation terraces was employed rather than number of terraces, and assuming a minimum requirement of 10 m² of domestic space per person (following Naroll 1962; LeBlanc 1971; Puleston 1973), then the population estimate would be on the order of 1,322 individuals for Yaral during the Chiribaya period (D. Rice 1993: 74).

At Wawakiki, the domestic terraces associated with the Chiribaya phase occupation of the site are configured differently than those identified at Yaral. At Yaral, terraces and structures are numerous (n=334) with a mean terrace area of 68.6 m² (D. Rice 1993: 73). Conversely, the Chiribaya domestic area at Wawakiki is comprised of

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only 4 or 5 individual terraces, though a single long terrace measuring roughly 13 x 100 m accounts for much of the area\(^6\). Consequently, number of persons per terrace should not be used to estimate population at Wawakiki. Rather, for comparative purposes, if 45% of total domestic terrace area is taken as a base number for domestic use at all Chiribaya sites (following that described for Yaral), then a calculated area of 2,161 m\(^2\) at Wawakiki would constitute livable domestic space (where total area equals 4,800 m\(^2\)), yielding a generous population estimate of about 216 individuals (10 m\(^2\)/individual). The Chiribaya domestic sector at Wawakiki requires much more intensive investigation to determine more accurately the number of habitation terraces present, and perhaps more importantly, the number of identifiable structures positioned on each terrace. It is also clear from profiles WK4A-p and WK4B-p that the evolution of domestic terraces was complex, with earlier floor sequences buried by both domestic debris and later construction episodes (see Appendix, Figures A-2 through A-7). As a whole, however, a total of 216 individuals can be used comparatively in the following sections regarding Chiribaya population estimates among other coastal springs and within the lower Ilo River valley.

Radiocarbon age ranges also suggest that while a limited population may have continued at Wawakiki immediately beyond the mid-14\(^{th}\) century flood event, the site did not support any significant population after the Chiribaya collapse in the region.

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\(^6\) Because of post occupational activity from the Spanish colonial period through the late 20\(^{th}\) century, exact counts of individual terraces in the domestic sector is not possible. Much is covered by talus and blast debris from the modern road cut, while another significant portion has been buried or significantly disturbed by bulldozer activity near the north end of the domestic zone. Furthermore, based on landscape analysis and excavation data from WK3C-e, it is likely that remains of Chiribaya domestic terraces extend beneath the Spanish colonial road as well, limiting both count and area of Chiribaya-associated domestic terraces. Also, profiles WK4A-p and WK4B-p identified buried living surfaces beneath more shallow surfaces, suggesting a more complicated evolution of habitation terraces than surface area measurements can capture.
Furthermore, there is no evidence to suggest that the site was repopulated to any degree during the Spanish colonial or modern eras either, the lone exception being perhaps a single caretaker or two that remained on site temporarily, perhaps taking shelter in the small structure identified in excavation WK3C-e (see Chapter 7). Additionally, there are foundation remains of a modest structure overlooking Quebrada Agua Buena at the termination of the colonial road, along with remains of Spanish colonial ceramics, glass, and porcelain nearby; unfortunately, the amount of disturbance to that area precludes any real understanding of it as residential area at this time. While it is likely that a caretaker lived on-site during the Spanish colonial period, the Chiribaya and their immediate post-flood descendents were the last group of any size to occupy this coastal promontory, though they were by no means the last to exploit it economically.

**Conclusions at the Level of Site**

An examination of agrarian evolution at the level of site identifies several general trends. It seems clear that a series of successive changes were undertaken that related to both technology, spatial extent of agrarian land use, and organization of production. There is an overall decline in agrarian land use at Wawakiki, with emphasis shifting from permanent landscape modifications in stone terracing to more provisional shaping of the terrain in various furrowing techniques. Long term shifts related to modes of production and consumption are also evident, with earlier emphases on diversified production strategies for local consumption, while production later became more specialized and organized toward consumption beyond the local arena. Agricultural technologies that were identified in all time periods hold particular value in arid climates, though later
strategies suggest a growing concern with aridity through time. Beyond the early Spanish colonial period, distances between cultivated terrain and spring sources decreased, while renovations to the water impoundment tank and mixed furrowing technologies were increasingly geared towards efficiency of water use.

The maximum amount of land under production occurred during the late pre-Hispanic era, which coincides with the largest population to have lived on-site. The small Chiribaya community invested significant time and energy in transforming the landscape for intensive agricultural purposes, constructing stone terraces and lengthy canal networks to achieve their desired production. With little evidence to suggest the area had been previously modified for such purposes, Chiribaya modifications to the terrain represent considerable initial investments in and alteration to the agricultural landscape. The degree and kind of permanent changes to the land further indicate a long term strategy directed towards local production. The proximity of this community to a diversity of economic viabilities in agriculture, marine, and *lomas* and their intensive exploitation of these multiple resources also suggests a particular degree of autonomy that existed at the local level. The fact that agricultural abandonment correlates with rapid depopulation at the site near the end of the 14\(^{th}\) or early into the 15\(^{th}\) century further bolsters the argument that production was directed towards local subsistence and consumption rather than long distance exchange or reciprocity.

Nearly two centuries later, this arid coastal promontory was revived by European farmers. However, the “natural” environment into which the Spanish colonial farmers entered was hardly the same “natural” environment that Chiribaya farmers modified centuries earlier. The steep canyon walls and entire coastal promontory had been
permanently transformed, and much of the infrastructure built by Chiribaya laborers remained on the landscape. Spanish colonial farmers were quick to take advantage, choosing to renovate the primary canal in Quebrada Agua Buena and cultivate much of the same terrain as their predecessors. The primary canal in Quebrada Seca was not reactivated, probably due to several conditions. First, it was initially constructed on a very steep and unstable canyon wall with little top soil, drawing Chiribaya farmers to partially chisel its course into bedrock. Perhaps initiated by sheet wash from the 14th century flood, erosive activities likely went into effect immediately after its abandonment, destroying most of it in the following two hundred years. Second, nomenclature suggests this quebrada was dry (or better yet, drier, since irrigation agriculture was maintained during the colonial period), and therefore a lower elevation canal was constructed to irrigate a smaller parcel of land.

Land tenure and the organization of production changed significantly with the transition into the early Spanish colonial period. New crops were introduced, including wheat and olives, and there were no on-site residents beyond a caretaker and perhaps his immediate dependants, even though 75% of land cultivated during the pre-Hispanic period was reactivated during the colonial era. A growing emphasis on olives through this and the subsequent post colonial periods suggests production was directed towards export and regional patterns of consumption. The original planting of olive trees during the early 17th century also indicates a long term investment in the landscape since they do not produce for six to eight years. Nevertheless, farmers of this period were quite expedient and opportunistic to take advantage of existing agricultural infrastructure at the site.
Minimal population levels throughout the Spanish colonial and post colonial eras suggest that local population pressure did not play a direct role in agrarian decisions to initiate and maintain an intensive form of agriculture (e.g., canals, impoundment tanks, soil manipulation), which also included a heavy emphasis on non-dietary crops. Likewise, decreases in land under production through time do not correlate with any local demographic changes since the site remained relatively depopulated. On the other hand, changes in spring source and discharge rates may account for diminishing areas of cultivation and the myriad of arid adaptive agricultural strategies that were identified throughout the study period.

Final abandonment of agricultural activities in either quebrada occurred around 1951, and while desiccation should be considered a chief catalyst to abandonment on the coastal promontory, continued spring flow today in three distinct locations in Quebrada Agua Buena clouds the issue of agrarian contraction in the upper and middle portions of that canyon.

THE MICRO-REGION: THE OSMORE COASTLINE

Agrarian Land Use and Technology along the Osmore Coast

Archaeological and historical data related to past land use among other coastal springs is very spotty, but previous research does provide some opportunity for comparative discourse centered on the degree and kinds of variability that existed at the level of micro-region. Much of what can be reconstructed stems from archaeological research centered at Carrizal spring (Clement and Moseley 1991; Reycraft 1998; Satterlee 1993), with supplementary information from patterns of land use at Pocoma,
Miraflores, and Alastaya springs (Satterlee 1993). Historical records and aerial photographs also provide information regarding changes in land use along the coast during the 20th century (Paernio 1908; Servicio Aereofotografico Nacional 1951).

Because little is known from Pocoma and Miraflores springs regarding Spanish colonial and immediate post colonial agrarian land use, the emphasis here is necessarily on agricultural sequences at Carrizal spring, with supplemental information presented from other springs when applicable. Table 9-2 provides a summary of available information regarding agricultural land use among coastal springs from the late pre-Hispanic era to the late 20th century.

During the late 1980s, Carrizal was the focus of an investigation that set out to test a hypothesis of agrarian collapse (Clement and Moseley 1991), while during the 1990s investigations focused on the Chiribaya response to a flood-related natural disaster.

<table>
<thead>
<tr>
<th>Chronology</th>
<th>Wawakiki</th>
<th>Pocoma</th>
<th>Miraflores</th>
<th>Alastaya</th>
<th>Carrizal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clement/Moseley 1991</td>
</tr>
<tr>
<td>Chiribaya</td>
<td>10.96 ha</td>
<td>29.7 ha</td>
<td>18.49 ha</td>
<td>Unknown</td>
<td>Max: 16.8 ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PreHisp: 13.2 ha</td>
</tr>
<tr>
<td>Spanish Colonial</td>
<td>Early: 8.25 ha</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>6.8 ha</td>
</tr>
<tr>
<td></td>
<td>Late: 5.83 ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Colonial</td>
<td>4.70 ha</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>5.1 ha</td>
</tr>
<tr>
<td>1908</td>
<td>~700 Olives</td>
<td>~4690 Olives</td>
<td>~1200 Olives</td>
<td>~3500 Olives</td>
<td>~800 olivos</td>
</tr>
<tr>
<td>1951</td>
<td>&lt; 50 Olives</td>
<td>~1247 Olives</td>
<td>~633 Olives</td>
<td>~603 Olives</td>
<td>103 Olive ~1 ha</td>
</tr>
<tr>
<td>Late 19th Century</td>
<td>Abandoned</td>
<td>15 ha</td>
<td>8.83 ha</td>
<td>Unknown (Maintained)</td>
<td>96 Olives ~1 ha</td>
</tr>
</tbody>
</table>

Table 9-2. Summary of land use data regarding five coastal springs in the study region, including Wawakiki. It is likely that, with respect to both Wawakiki and Carrizal, the Post Colonial and 1908 figures represent similar periods of land use.
Reycraft (1998) and the regional impact of the flood on both coastal and main valley populations (Satterlee 1993). Both Satterlee (1993) and Clement and Moseley (1991) provide areas of agrarian land use at Carrizal for the pre-Hispanic era and the late 20th century, but only the latter specifically tracks changes in land use between those periods (Table 9-2). Although calculated areas of land under production for the pre-Hispanic period and late 20th century vary significantly between the two studies (for reasons unknown), Satterlee (1993: 12-13) qualified those differences by comparing percentages of land use:

…the percentage of land used by modern agriculture is 9.6% of the prehistoric land usage, which compares favorably with the results of a field study conducted by Clement and Moseley…who concluded that the late modern agriculture accounted for only 6% of the total land under cultivation compared to prehistorical farming activities at the Carrizal Quebrada.

While it remains unclear how these two studies arrived at such different calculated areas, changes in land under cultivation from the pre-Hispanic to the late 20th century as described by Clement and Moseley (1991) may serve as a gauge of agrarian evolution at the site.

According to their study, agrarian contraction began during the prehistoric period, where cultivated terrain was reduced from 16.8 to 13.2 ha, or a reduction of about 21% from the maximum. Clement and Moseley determined that 13.2 ha corresponded to the maximum agricultural area at some point during the Chiribaya phase (1991: 441). Another reduction in land use occurred during the Spanish colonial period, where only 6.8 ha were cultivated, representing a reduction of 48% from the Chiribaya period.
Finally, they describe further contraction during the post Spanish colonial and 20th century eras, where cultivated terrain was reduced to 5.1 ha (25% reduction) and again to about 1 ha (80% reduction). More specific details regarding 20th century land use stem from counts of olive trees, where 800 trees are estimated to have remained in 1908 (Paernio 1908: 5), while 103 trees were standing in 1951 and only 96 trees at the time of Clement and Moseley’s investigation in the 1980s (1991: 434).

Agricultural decline among other springs during the 20th century mimics that described for Carrizal, specifically with respect to counts of olive trees. At Pocoma, Miraflores, and Alastaya springs, there were an estimated 4690, 1200, and 3500 olive trees, respectively (Paernio 1908). From examination of historic aerial photographs, I counted only 1247, 633, and 603 standing olive trees at those springs in 1951 (Table 9-2). At Wawakiki, there were estimated to be 700 trees in Quebrada Agua Buena in 1908 (Paernio 1908), while in 1951 there were no more than 50 that remained scattered in several locations along the primary channel of the quebrada. Notwithstanding potential error in generating counts from historic aerial photographs, reductions of 47%, 72%, 83%, 87%, and 93% at Miraflores, Pocoma, Alastaya, Carrizal, and Quebrada Agua Buena, respectively, point to a significant decrease in agricultural activity among the coastal springs between 1908 and 1951, at least with respect to the olive7 (Figure 9-1).

Agricultural technologies documented for Carrizal appear to have been historically similar to those at Wawakiki. Pre-Hispanic terraces are typically smaller, incorporate refuse, average about 0.35 m in height, and are often faced with stone. On

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7 MINITAB version 11.2 was used to perform a Chi-Square test on the observed counts of olive trees of the two periods. The test produced a p-value of 0.000 and a Chi-Square statistic of 449.344, where α=0.05, concluding that there is a very significant statistical difference between expected and observed counts of olive trees between the two periods.
the other hand, Spanish colonial fields often incorporate switch-back furrow channels leading to oval basins that held water at the base of each olive tree (Clement and Moseley 1991: 433). At the distal ends of the olive grove are well-preserved remains of variously patterned furrows that would have been ideal for smaller variety plants.

Spanish colonial, post colonial, and 20th century fields were irrigated by low-discharge springs, around which were constructed impoundment tanks. Nine are identified at Carrizal, where earlier tanks were constructed variously of earthen embankments, masonry, or some combination of the two; more recent tanks were constructed of cement and likely correspond to the late 19th and 20th centuries (Clement and Moseley 1991: 433). In the early 1990s, the only operable tank at the site was constructed of cement and had a capacity of 15 to 16 m$^3$ (Clement and Moseley 1991: 430).
There is very little information regarding the kinds of plants cultivated among other spring systems along the coast, especially with respect to the late pre-Hispanic and Spanish colonial periods. Historical records indicate that olives have certainly played an important role among the springs to both the north and south of Wawakiki, but texts remain silent with respect to additional cultigens that may have been farmed.

Today, local farmers working among several remaining olive groves along the coast have offered insight to the kinds of plants cultivated beyond olive trees at these springs, at least during the late 19th and early 20th centuries. While plants other than the olive are not currently tended, this was not the case prior to the past decade or so. One local farmer who tended the grove at Pocoma spring in the 1960s and again during the 1980s mentions that in addition to olives, local farmers cultivated the chili pepper, sweet potato, watermelon, higos, guava, plantain, tomato, alfalfa, maize, choclo, onion, and carrot. These were typically farmed in years of increased spring discharge or seasonally during periods of “descansa” for the olive trees; after harvest they were taken to Ilo to sell in the market (Clemente Zeballos, personal communication, 2003). This practice results in mixed patterns of field use on the surface, often with distinct olive furrows more closely located to the spring source, and plots of linear and caracol furrows toward the more distal end of the system. Similar patterns of furrow technology are noted at Pocoma, Miraflores, and Carrizal, and they may represent an investment in similar kinds of annual cultigens prior to the late 20th century.

South of Wawakiki, olives remain the only agricultural product maintained along the coast. North of the site, however, a different pattern emerges. In the 1950s, SPCC purchased olive fundos along the coast as far north as Punta Callango (also termed
Platanar), located only 4 or 5 km north of Wawakiki. In the 1990s, the company instituted a policy that restricted laborers and grove caretakers from cultivating smaller variety plants among the coastal springs. Corporate policy, however, does not reach northward beyond Punta Callango to the numerous spring systems scattered across the desert coast up to the Tambo River. Among springs north of Callango, olives remain a principle cultigen, though other plants continue to be irrigated and harvested along side the olive, including alfalfa, *aji*, and a variety of fruits (Adán Umire Alvarez, personal communication, 2005).

**Demographic Trends along the Osmore Coast**

The same methods used to generate population estimates at Yaral (D. Rice 1993) can be used to create population estimates of other agricultural spring sites along the coast, at least for comparative purposes. While limited research has been conducted in domestic areas at Carrizal (e.g., Reycraft 1998), few domestic areas have been investigated to any depths at other coastal settlements. Nevertheless, Satterlee (1993) provides some information that can be useful in this study. In his investigation regarding the impact of the mid 14th century flood on lower valley and coastal populations, he documents the spatial extent of Chiribaya domestic terraces identified at Pocoma, Miraflores, and Carrizal. From total domestic area (m²), generous population estimates for those sites can be projected in the same manner as Wawakiki. The results suggest that out of the coastal springs discussed here, Pocoma likely housed the largest Chiribaya population while Wawakiki supported the smallest (Table 9-3).
<table>
<thead>
<tr>
<th>Coastal Spring (Chiribaya Phase)</th>
<th>Total Domestic Terrace Area (m²)</th>
<th>45% of Total Domestic Area (m²)</th>
<th>Estimated number of individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pocoma</td>
<td>26,100</td>
<td>11,745</td>
<td>1,174</td>
</tr>
<tr>
<td>Miraflores</td>
<td>19,600</td>
<td>8,820</td>
<td>882</td>
</tr>
<tr>
<td>Carrizal</td>
<td>16,500</td>
<td>7,425</td>
<td>742</td>
</tr>
<tr>
<td>Wawakiki</td>
<td>4,800</td>
<td>2,160</td>
<td>216</td>
</tr>
</tbody>
</table>

Table 9-3. Domestic terrace areas and maximum population estimates among coastal springs during the Chiribaya period.

Population levels immediately beyond the mid 14th century flood varied. While there is insufficient data to generate estimates, there are bits of information that suggest at some sites occupation decreased after the Chiribaya period, while others were abandoned. At Miraflores, for instance, the Chiribaya domestic complex was almost completely covered by debris flow. The site was subsequently abandoned, and the agricultural sector fell into disuse until the early Spanish period. On the other hand, at Carrizal and Pocoma large portions of each site were abandoned, but they continued to be occupied into the 15th century by much smaller populations (Reycraft 1998: 66-68).

During the early Spanish colonial period, none of these springs housed more than a single caretaker or laborer and perhaps their immediate dependants, with the possible exception of Alastaya Spring just south of Miraflores. Historical records point to an hacienda located at that quebrada (Kuon Cabello 1981), though it remains unclear how many individuals actually lived on-site. Today at Alastaya, adobe walls of the main edifice and the foundations of several subsidiary structures are situated on a small rise on the south side of the quebrada channel. If this was the residence of the local hacendado, it probably did not house more than the hacendado himself plus his dependants, servants, and laborers at any given time.
Informal surface inspection at each of the coastal springs suggest that indeed Alastaya may have housed the only population beyond immediate caretakers in the study area, though very little is known regarding settlement and land use along the coastline north of Wawakiki.

Today, population levels have further declined among the coastal springs. A caretaker resides in a modest structure perched atop a hill behind the Pocoma spring system and associated olive trees, but no other springs south of Wawakiki currently support any on-site residents. Thus, the late pre-Hispanic era witnessed the last residential communities of any significant size situated among the coastal springs (Figure 9-2).

![Figure 9-2. General trends in population levels among coastal springs in the study area.](image-url)
Conclusions at the Level of Micro-Region

Several broad trends emerge at the level of the micro-region, including rapid agricultural decline and depopulation along the coast around the transition from the 15\textsuperscript{th} to the 16\textsuperscript{th} century, and a reemergence of agricultural activity during the Spanish colonial era. Olive production appeared among all coastal spring sites and became the principal economic activity, suggesting that forces beyond the immediate coastline played a significant role in shaping production strategies and the coastal economy from the Spanish colonial period to the 20\textsuperscript{th} century. However, a closer comparison of Wawakiki and Carrizal illuminates several historically contingent points of divergence embedded within the generally parallel trajectories of agrarian evolution along the coast (Figure 9-3).

![Figure 9-3](image_url). Diachronic trajectories in aerial extent of agrarian land use at Carrizal and Wawakiki.
All of the coastal springs appear to have reached their greatest demographic levels and aerial extent of agricultural land use during the Chiribaya phase, but analysis at the level of micro-region points to variability in production strategies among communities. For instance, other scholars have argued that communities situated among coastal quebradas specialized in agricultural production, while beachfront communities specialized in the procurement of marine and littoral resources. Generally, coastal settlements do appear more occupationally specialized southward toward the main river valley as the distribution of resource viabilities becomes more widespread.

In contrast, the Chiribaya community situated at Wawakiki embraced a diversified production strategy, where residents intensively pursued both agricultural and marine resources. This mixed strategy was also supplemented by other economic activities associated with the nearby lomas, such as hunting, gathering, and perhaps herding. The inherent differences in economic livelihoods along the coast presented diversified communities greater autonomy than economic specialists who relied necessarily on exchange networks beyond the local arena. It is also possible that a diversified strategy was common among Chiribaya sites north of Wawakiki as well, since sites like Punta Callango share many of the technological and environmental configurations with Wawakiki. Indeed, the divergence of economic strategies from south to north along the coast suggests that northern Chiribaya communities may have been less integrated socially and economically with their southern neighbors, who remained more dependant on local exchange networks to satisfy subsistence needs.

While generally the coastal Osmore springs experienced population decline in the immediate aftermath of the large 14th century flood, the severity of decline at each site
varied. Other investigations (e.g., Reycraft 1998; Satterlee 1993) have identified up to 50% post flood occupation and land use at Carrizal and Pocoma, and although no such activity as been directly identified at Wawakiki, a remnant population probably continued beyond the even, as Reycraft (1998) suggests. Elsewhere, canals were cut into the debris flow immediately beyond the flood to reclaim agricultural fields. Unfortunately, disturbance from modern road construction precludes any investigation of those critical junctures of flood debris and canal intakes at Wawakiki, rendering it impossible to directly assess post-flood canal reconstruction. Nevertheless, the high relief terrain surrounding Wawakiki left most of the agricultural infrastructure well protected, and much of it may have been reactivated immediately beyond the flood.

Whatever remnant populations remained among the springs immediately beyond the flooding episode were greatly reduced or gone by the early Spanish colonial period, though all springs were converted into productive olive groves by the early 17th century. Both Carrizal and Wawakiki were cultivated to lesser extents than during the pre-Hispanic era, and it seems most likely that extent of production during the Spanish colonial period was directly related to the degree of infrastructure that remained on the landscape from pre-Hispanic farming activities. At Wawakiki, high relief terrain left most of the agricultural infrastructure well protected from the 14th century flood; consequently, 75% of the pre-Hispanic agricultural landscape was irrigated by Spanish colonial farmers who reactivated the primary canal in Quebrada Agua Buena (see Figure 9-3). On the other hand, Reycraft (1998) and Satterlee (1993) comment that only 50% of the agricultural landscape at Carrizal was reclaimed by farmers immediately beyond the flood; consequently, European farmers there reactivated about 50% of the total area
under cultivation during the late pre-Hispanic period, choosing to directly exploit existing infrastructure rather than invest heavily in widespread landscape transformations (see Figure 9-3). More extensive infrastructural improvements were clearly made at Miraflores spring, since that site was completely destroyed and abandoned, though Spanish colonial agriculture was restricted to gentle slopes along the flanks of the quebrada, much like colonial period agriculture in Quebrada Seca at Wawakiki. Agrarian contraction associated with the transition from the late pre-Hispanic to Spanish colonial period might be more fully explained by cultural decisions towards land use and production, rather than by widespread climate variability, aridity, or a diminishing water table. The variation observed in Spanish colonial agriculture appears to be more directly related to the historically contingent intersection of opportunistic mentalities of early colonial farmers and the socio-natural landscape on which they settled.

After agricultural reclamation was instituted along the coast around the turn of the 17th century, Wawakiki and Carrizal followed similar paths of production throughout the Spanish colonial and immediate post colonial periods. Shifts in aerial extent of land use at the two sites may have resulted largely from fluctuating rates and locations of spring discharge, since both variables are reflected in infrastructural changes at the two sites. At Wawakiki, hydrological changes are evidenced in the abandonment of the Quebrada Agua Buena canal, the construction and subsequent renovation of the promontory impoundment tank, and a growing concern with desiccation inherent in arid adaptive furrowing technologies between the late Spanish colonial and early 20th century eras. At Carrizal, the locations of nine individual impoundment tanks suggest diachronic changes
in spring location, perhaps following a drop in the local water table (Clement and Moseley 1991; Satterlee 1993).

Production among coastal springs diminished considerably during the early half of the 20th century. All springs in the immediate study area demonstrated a significant reduction in olive trees between 1908 and 1951, suggesting that conditions external to the coastal micro-region—be they culturally or climatically related—heavily influenced production among the springs. The most severe drought ever recorded historically in Peru occurred between 1933 and 1945 (Newell 1949), which may have adversely affected production in the lower valleys and coast during this period.

By the late 20th century, production trajectories at Wawakiki once again diverged from its neighboring springs, ultimately falling out of production shortly after 1951. Spring systems immediately north and south of the site maintained arboricultural and horticultural activities for much of the latter half of the 20th century, but production among groves directly influenced by SPCC corporate policy during the 1990s was reduced to the maintenance of olive trees only; spring systems farther north continue to maintain mixed agricultural strategies of both perennial and annual cultigens.

A contextual consideration of agricultural production at Wawakiki indicates that throughout the second millennium A.D. the degree to which the site paralleled trajectories of other coastal springs waxed and waned through time, shaped by both local and regional cultural and socio-environmental conditions. During the late pre-Hispanic period, Wawakiki held greater autonomy than its southern neighbors, and organization of production differed considerably from that of Carrizal or Miraflores. During the Spanish colonial period, the initial reactivation of agrarian systems along the coast varied,
depending largely on the advantages afforded by a heavily anthropogenic landscape to a very opportunist class of European settlers. After colonial period reactivation, production trajectories converged, where agrarian land use among coastal springs followed similar trends throughout the colonial, post colonial, and early 20\textsuperscript{th} century eras. Production diverged once again during the late 20\textsuperscript{th} century, where agriculture among some coastal springs was abandoned, while at others it was reduced strictly to the maintenance of olives; still, other springs continued to support a mixed strategy of perennial and annual cultigens.

**THE MACRO-REGION: THE OSMORE CORRIDOR AND BEYOND**

**Macro-Regional Trends in Agriculture in the Lower Osmore Corridor**

Some information regarding long-term trajectories of land use in the lower valley is available, though generally not to the level of detail described for the coastal springs. Nevertheless, several investigations provide some description of late pre-Hispanic, Spanish colonial, and more recent agricultural strategies, though references of technology lean more toward the pre-Hispanic era, particularly Chiribaya, than any other period.

Most noteworthy of Chiribaya hydraulic endeavors was the construction of a nearly 7 km long canal along the north margin of the lower valley. Roughly 2.4 km of the canal traversed steep rocky faces, and it was cut into exposed bedrock and supported by multiple stone retention walls. The canal irrigated four distinct areas of terraced fields that constituted roughly 23 ha of cultivated terrain situated on alluvial terraces well above the active floodplain and the 390 ha of modern arable land (Owen 1993b). Another investigation suggests this canal was in use by the 11\textsuperscript{th} century and was completely
obliterated by the mid 14th century El Niño (Satterlee et al. 2000). Presumably, the river flood plain was also farmed during the pre-Hispanic era, meaning the total area of cultivated land encompassed more than 400 ha. Thus, with the destruction of the primary irrigation canal along the north canyon wall of the river valley, farming during the Spanish colonial and modern eras contracted roughly to its current form. Unfortunately, continued land use from the past several hundred years has rendered any further information regarding pre-Hispanic agricultural technologies on the flood plain unattainable.

Abandoned terraced fields immediately below the 7 km long canal exhibit a fair amount of variation from area to area. Some fields are small, nearly square, and have no visible subsidiary canals, while others are elongated and have stone-lined canals along the back edge of the prepared field. Yet, others are very long with feeder canals running down slope across fields. Owen (1993b: 532-533) suggests that while some variation stems from irregularities in underlying land forms, other variation has no evident purpose and may owe itself to separate construction projects or the work of distinct social groups.

Both the canal and terraced fields fell into agricultural disuse by the end of the 14th century, and they were not reactivated by immediate post Chiribaya residents in the valley nor by Spanish colonial farmers, the latter of whom instead elected to construct several small, low-elevation canal systems along the north side of the valley (Reycraft 2000: 106). Less information is available regarding the aerial extent of Spanish colonial farming and associated technologies, though it seems likely that it approximated modern limits of agrarian production in the lower valley since the olive tree is nearly ubiquitous throughout all arable land in the area. Technologies associated with arboriculture in the
early 20th century primarily employed an irregular rendition of the *caracol* furrow that varied according to the terrain (Paernio 1908: 7-9). In all probability, this farming technology has been available to local olive farmers for centuries, stretching back to the Spanish colonial period.

There are greater amounts of information regarding the choice of cultigens than spatial extent and technology of agrarian land use throughout the lower valley. Late pre-Hispanic midden deposits associated with Chiribaya habitation sites have been described in some detail (Owen 1993b), while historical texts document a number of important plants during the Spanish colonial period along the Ilo River and farther inland along the Moquegua River in the middle valley (Bauza 1987[1791]; Frezier 1982[1713]; Vasquez de Espinosa 1987[1618]). There are also excellent records of land use related to the latter half of the 20th century (ONERN 1976).

Owen (1993b) identifies a number of plants in middens associated with Chiribaya domestic sites. These include annuals like maize, tubers (mostly yucca), squash, and beans, and perennials like pacay, molle, and lucuma. Middens also contain amounts of animal bone of large land mammals (camelids), marine shell, and fish bone (Owen 1993b: 154). All sites on which his midden analysis is based are located about 12 kilometers inland along the Ilo River. While relative percentages discussed in his study probably do not represent the entire valley, especially near the river mouth where marine species constitute larger percentages (e.g., Jessup 1991), Owen’s study does provide an idea of the kinds of products available in the valley and the diversity of products found among some inland valley Chiribaya settlements.
During the early Spanish colonial period, Vasquez de Espinosa (1987[1618]: 28) reports many chacras in the lower valley that cultivated a variety products for both local consumption and export to the neighboring highlands (e.g., Moquegua, Arequipa, Chucuito). Annuals include wheat, maize, beans, lima beans, and peppers, while important perennials include *higos* and olives along the coast and in the principal valley. In the early 18th century, Frezier (1982[1713]: 154-160) comments that in many parts of the valley there are beautiful rows of olives and fruit trees, including oranges, limones, higos, guayabos, bananas, lucumas, paltas, and pacay. He also mentions wheat, legumes, and alfalfa to be important cultigens along the Ilo River. In addition to lower valley agriculture, wine grapes constituted a principal cultigen in the middle valley throughout much of the Spanish colonial era (Bauza 1987[1791]; Frezier 1982[1713]; Vasquez de Espinosa 1987[1618]; P. Rice and Ruhl 1989). Of the products mentioned historically in the main valley, alfalfa is especially noteworthy because it was frequently cultivated for livestock, and particularly for large herds of mules. Mules were often employed as pack animals to traffic items up and down the Osmore corridor, especially while large boats were docked along the coast (Frezier 1982[1713]: 158).

In the latter half of the 20th century, there was at least 390 ha of arable terrain along the Ilo River. Eighty two percent of all irrigated land in the lower valley supported the olive tree (320 ha), while other plants farmed during this period include maize (20 ha), potato (10 ha), and alfalfa (10 ha). An additional 20 ha of land was dedicated to various other plants, and 10 ha remained forested (ONERN 1976).

In contrast to the lower valley, the middle valley supported 2,810 ha of cultivated terrain, nearly half of which was dedicated to alfalfa (1,250 ha). Other important
perennials included a variety of fruits (350 ha), palta (50 ha), and grapes (50 ha), while notable annuals included barley (330 ha), wheat (120 ha), maize (80 ha), and potato (20 ha) (ONERN 1976).

**Regional Demography in the Osmore Corridor**

Archaeological research and historical records provide clues to demographic trajectories in the main Ilo River valley and the inland Osmore corridor throughout the period of investigation. For this study, total areas of domestic sites are used to understand demographic changes in the late pre-Hispanic era, while historical documents can be used to address population dynamics in the Spanish colonial and post colonial periods.

Settlement studies in the early 1990s confirmed early and late phase Chiribaya settlement along the Ilo river, but specific areas of habitation terraces were not recorded. Rather, total areas of domestic sites are documented, paying specific attention to habitation terraces, structures, and midden deposits (Owen 1993b). While using total domestic area may inflate population estimates of lower valley Chiribaya communities compared to those based solely on habitation terraces, they do create a picture of general trends in regional demography in the lower Osmore drainage. In his study, Owen (1993b) identified a total of 39 habitation sites that likely correspond to Early Chiribaya (Algarrobal), Late Chiribaya (post-Algarrobal), or the following Estuquiña period (Owen 1993b: 546). Based on calculated areas of sites and the population estimation methods outlined above, a maximum of 15,898 individuals is estimated for the lower valley during the Early Chiribaya period and peaking to a maximum of 25,024 individuals during the
Late Chiribaya period. Population levels decline significantly during the subsequent Estuquiña period, with an estimated maximum of 3,213 individuals in the lower valley (Table 9-4).

While the numbers presented here are probably overstated, the substantial increase in total area of habitation sites from early to late Chiribaya periods suggests a considerable rise in population in the lower river valley. It also seems relatively clear that population levels declined significantly from Late Chiribaya times to the Estuquiña period. Owen qualifies this sentiment, stating that if the absolute chronology he presents is correct, then the post-Algarrobal phase lasted about twice as long as the Algarrobal phase. He further emphasizes that while “margins of error are large here, the net result suggests that the Chiribaya population probably increased over time, and possibly increased substantially” (1993: 526).

By the early Spanish colonial period, population levels had declined significantly along the Ilo River. According to Lucas Martinez Begazo, principal recipient of an encomienda of which the Osmore region was a part, Ilo consisted of “veinte indios”, or

<table>
<thead>
<tr>
<th>Lower Valley Phase</th>
<th>Number of Sites</th>
<th>Total Domestic Area (m²)</th>
<th>45% of Total Domestic Area (m²)</th>
<th>Estimated number of individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Definite</td>
<td>Probable</td>
<td>Definite</td>
</tr>
<tr>
<td>Early Chiribaya (Algarrobal)</td>
<td>2</td>
<td>15</td>
<td></td>
<td>32,200</td>
</tr>
<tr>
<td>Late Chiribaya (Post Algarrobal)</td>
<td>15</td>
<td>17</td>
<td></td>
<td>458,000</td>
</tr>
<tr>
<td>Estuquiña</td>
<td>1</td>
<td>7</td>
<td></td>
<td>1,700</td>
</tr>
</tbody>
</table>

Table 9-4. Domestic areas and maximum population estimates of the lower valley during the late pre-Hispanic period (after Owen 1993: 546).
20 Indians, in the 16th century (Kuon Cabello 1981: 21-22). By 1618, Ilo had grown to only 199 people, witnessed by Vasquez de Espinosa (1987[1618]) during his travels through the region. Nearly a century later, Amadeo Frezier (1982[1713]: 50) reported Ilo to have consisted of 50 wooden cabins, inhabited entirely by French. Demographic levels continued to rise very slowly through the Spanish colonial period, and by the late 18th century, the governor of Arequipa Antonio Alvarez y Jiménez found in Ilo “435 almas de todas edades, clases y sexos”, or 435 souls of all ages, classes, and sexes (Kuon Cabello 1981: 31). While demographic accounts of Ilo may not be representative of the entire lower valley, there is nothing to suggest that any other significant populations beyond local chacras and haciendas were situated along the river’s course.

There are very few references to population levels during the post Spanish colonial era, but according to a July census in 1981, the entire province of Ilo was home to 38,627 inhabitants at that time (Kuon Cabello 1981: 34), suggesting that the 19th and 20th centuries saw widespread demographic growth in the lower drainage. Generally speaking, regional population levels likely did not return to those of the 13th and 14th centuries until the middle of the 20th century.

Conclusions at the Level of Macro-Region

While particular courses of production in the lower Osmore drainage are in some ways less detailed than among coastal springs, several general statements can be made. Overall, production during the late pre-Hispanic era was subsistence-oriented and driven by a more localized exchange-based economy throughout the lower valley and coastal areas of the drainage. A major shift in the organization of production occurred during the
early 17th century, where production became directed largely towards regional economic influences, and it was based on the export of specialized commodities in olives and processed olive oil throughout the colonial and immediate post colonial eras. Other cultigens like wheat, maize, and fruits were almost certainly directed towards both local subsistence needs and exported to the neighboring highlands during the much of the Spanish colonial period, especially since population levels remained low. By the 20th century, however, population levels were growing exponentially, and it seems likely that produce was consumed more locally within the lower valley. Nevertheless, since the early 17th century, the olive has constituted a semi-permanent change to the agricultural landscape, and it quickly became the focus of commercial agriculture within a market-driven economy.

Diachronic assessment of economic organization and production strategies throughout the lower valley indicate several significant points of divergence throughout the second millennium A.D., including considerable regional variation in late pre-Hispanic organization of production. At Wawakiki, production strategies at the level of community were explicitly diverse, while local communities operating in the lower valley and around the mouth of the Ilo River participated in a specialized subsistence economy, exchanging for goods with other community specialists (Jessup 1991; Lozada and Buikstra 2002; Umire and Miranda 2001). Spring sites situated along the coast between Wawakiki and the Ilo River may have achieved various degrees of specialization, depending on the level of economic integration with main valley communities and the opportunities afforded by their position on the landscape. Overall, the organization of production among communities throughout the lower and coastal reaches of the drainage
was probably quite dynamic during the late pre-Hispanic period and varied considerably from locale to locale. In the most general of terms, communities like Wawakiki that were situated among inter-valley coastal zones probably emphasized principles of diversity most intensively, especially as multiple economic viabilities increasingly overlapped.

By the early Spanish colonial period, the region became more unified by growing macro-regional economic demands and the shared micro-climate of the far south coast of Peru. The entire region remained relatively depopulated for several centuries, and land tenure and production became fairly homogeneously organized first under the sweeping umbrella of the encomienda system, and second under smaller partitioned units of production in the system of *haciendas* and small *chacras*. Primary emphasis on the cultivation and maintenance of the olive throughout lower valley and coastal areas indicates that circumstances beyond even the macro-region strongly influenced production strategies among most farmsteads in the area. The fact that viticulture also grew into a strong agricultural activity in middle valley around Moquegua throughout much of the early Spanish colonial period further identified the Osmore drainage as a chief contributor to economic demands for wine and oil at the level of viceroyalty. Irrigation seasons for wine grapes and olive are also complimentary, a point not lost to lower valley olive farmers dependant upon often scarce and highly seasonal runoff from the neighboring highlands.

While regional population levels remained low throughout the 17th through the 19th centuries, population exploded throughout the main river valley and immediate surrounding coastline in the middle of the 20th century. The coastal springs, however, remained depopulated, representing a coastal point of departure from main valley trends.
Contributions of subsistence plants relative to the olive during the late 20th century also remained low, suggesting that imported produce, particularly from the bread basket that is Moquegua, probably grew in importance.

A final significant point of divergence also occurred during the late half of the 20th century with respect to production among coastal springs and that of the main valley. Since the 1950s, SPCC has held dominion over the maintenance of olive *fundos* along the coast north of the Ilo River and the degree to which secondary plants are tended among them. Since the 1990s, corporate policy has restricted agricultural activities to the olive tree. However, still firmly rooted in a long standing tradition of *chacras* and local haciendas, production in the lower valley and farther northward from Punta Callango along the coast towards Tambo continues to support mixed cultivation strategies of olives and other produce such as maize, wheat, sugar, and peppers in response to both subsistence needs and local market demands.

**DISCUSSION**

A nested approach to contextual analysis highlights local and more regional units of production as they waxed and waned through time in response to a completely interlocked cultural and environmental relationship. Figure 9-4 illustrates shifts in general production trends throughout the second millennium A.D. by identifying the degree to which patterns of production were integrated on multiple scales.

During the late Chiribaya period, the organization of production at Wawakiki and perhaps at other inter-valley coastal sites to the north differed from communities situated farther south and within the main river valley. These latter populations were comprised
of more specialized communities of agriculturalists and fisher folk that were integrated into a larger exchange-based subsistence economy. After the flood disaster of the late 14th century, production varied from spring to spring along the coast, where variation in local topography accounted for differing degrees of damage caused by massive debris flows. Farming communities within the main valley probably experienced less variation, since much of the agricultural landscape was linked to a single, 7 km long irrigation canal. Such a system is more difficult to reactivate than independent coastal springs, as Reycraft (2000) notes, and upon its destruction, much of the arable landscape fell into agricultural disuse until farming became once again a viable and productive activity in the late 16th century.

The intersection of a Mediterranean micro-climate, low population levels, and high demand for European valued products within a strengthening market economy provided Osmore drainage farmers a lucrative enterprise in olive groves and viticulture throughout the Spanish colonial and post colonial eras. Macro-regional production was directed first towards the Potosi-Lima economic trunk line, and subsequently to other more “provincial” regions as market demand branched to other areas of the Viceroyalty of Peru. The olive, highly resistant to neglect and aridity, permanently altered the agricultural landscape throughout the lower valley and coastal regions surrounding Ilo, where trees several hundred years old continue to provide successful harvests today.

Population explosion and the establishment of large corporations in the lower valley during the 20th century significantly altered production once again. SPCC’s
Figure 9-4. Illustrations depicting the degree to which production trajectories throughout the region were parallel. The relative homogeneity experienced across the agricultural landscape from the Spanish colonial through the post colonial era owes itself to historically contingent circumstances related to low population, micro-climate, and a growing macro-regional demand for European valued products.
purchasing of olive groves along the coast north of the Ilo River and the construction of the copper smelter situated at Quebrada Chuza sent coastal and main valley courses of production onto divergent paths. Although issues of contamination among coastal spring sites have not been explicitly investigated, a study in the main valley concluded that while wind carries exhaust northward for much of the time, agricultural produce including the olive had suffered enough smoke damage from the smelter to warrant compensation by the corporation to local haciendas and chacras along the Ilo River (Ministerio de Energía y Minas 2001). However, because of the resilience of the olive tree, corporate policy during the late 20th century has probably played a more significant role in coastal agricultural decline than contamination issues, at least among those groves owned and cared for by SPCC. North of their property, groves continue to produce cultigens in addition to the olive, following a different agricultural trajectory than their southern neighbors along the coast or in the Ilo Valley.

Once argued to be the impetus to agrarian expansion and intensification (e.g., Boserup 1965), population levels in the study region probably played only a minor role. If the temporal unit of analysis were to remain at the level of millennium, then population would indeed be inversely correlated with land under production, especially since population today for the province of Ilo exceeds 50,000. Furthermore, in many respects agricultural technology has remained fairly constant and deeply rooted in centuries-old olive groves, whose technologies are founded upon many of the same arid adaptive principles instilled in the cultivation of other plants throughout the period of study. Certainly, as this investigation has demonstrated, gross temporal scales often gloss over the complexity and variation in which agricultural landscapes evolve. Here, population
pressure was likely a greater force behind agricultural expansion and intensification among the coastal springs during the late pre-Hispanic era than in any other period. Most evidence at Wawakiki points to late Chiribaya construction and maintenance of intensive agricultural terraces and lengthy irrigation canals. Elsewhere, Owen (1993b) suggests that Chiribaya population levels in the lower valley were likely increasing considerably during the late phase. While chronological resolution within the broader Chiribaya period has not been established among other spring systems, I suspect the maximum and most intensive use of the coastal landscape came during the late Chiribaya phase, and perhaps more so towards northern, inter-valley coastal settlements like Wawakiki and Punta Callango. Still, population pressure in the lower valley cannot be isolated from historical contingency, as increased aridity in the adjacent highlands coupled with increasing population levels would have probably led to growing stress within a largely specialized subsistence economy. Consequently, population expansion northward and the pursuit of a diversified subsistence economy may have constituted a socioeconomic response by some coastal Chiribaya communities to reduce risk associated with a dependence on external exchange. Likewise, decisions to invest in olive production may also represent a vision of long-term economic stability by local farmers, one that continues to characterized the socio-natural environment of the Osmore region today.
Chapter 10:

CONCLUSIONS AND SIGNIFICANCE

The conditions under which agriculture evolved at the level of community, micro-region, and macro-region were complex, and farmers of all periods made historically contingent decisions with respect to production. To fully comprehend and explain agriculturally related human behavior, historical contingency must remain a prime focus of investigation. In this study, a series of nested analytical units and a diachronic approach to agriculture has illuminated the complex intersections of population, cultural mentality, economic organization, micro-environmental variation, and socio-natural landscapes that have formed the historical contexts in which coastal Osmore agrarian landscapes have evolved.

There is no single cause or course of agrarian evolution. Farmers around the globe and throughout history have employed agricultural strategies within the context of their socio-natural environment. A long, historical analysis of agricultural production and land use at Wawakiki has demonstrated the complexity of variables that affect the human-environment relationship, while shifting temporal and spatial scales of analysis have highlighted the heterogeneity of agricultural decisions through time and across space. Fixing a scale of analysis without considering smaller or larger units will often skew the investigator’s attempt to understand the co-evolution of humans and landscapes and the conditions surrounding decisions to alter particular courses of production strategies. For example, in this investigation, if the scale of analysis were to remain at the level of micro-region and at the level of the millennium, Boserup’s (1965)
supposition that population growth drives agricultural intensification would indeed be inversely related. However, by shifting scales of analysis, it becomes clearer that population may have played a more significant role in agricultural expansion and intensification during the late Chiribaya period throughout the lower Osmore region—and especially among the coastal springs—than during any other period under examination. In fact, during the Early Spanish colonial period, agriculture was regenerated among most of the coastal springs despite miniscule local and even regional population levels. Clearly, as Brookfield (1972, 1984) notes, other variables factor into agricultural practices, like production incentives beyond directly satisfying subsistence requirements, or ecological constraints and opportunities of a given area, or the manner in which the socio-natural landscape evolves through time and across space. Along the Osmore coast, it is clear that population, organization of production, choice of cultigens, topographical variability, and the dynamic nature of spring discharge have played disproportionate and ever-changing roles in shaping local and regional strategies of production.

Because the conditions surrounding agricultural land use are complex, production strategies must be contextualized within their proper historical and physical place. To approach issues of *cause* of agricultural intensification, contraction, or abandonment, *process* must first be teased from the archaeological record. In this investigation, archaeologically visible indicators like extent of land use, capital investments, and the kinds of plants cultivated in and around the site were tracked diachronically to acquire a better understanding of process. Courses and consequences of agricultural decisions can thus be more appropriately defined, and therefore a more developed and comprehensive
understanding of long-term agrarian evolution can be achieved. In this sense, *courses* and *consequences* of agrarian land use decisions are promoted while *causal* arguments are de-emphasized. This, I believe, holds greater value for understanding the relationships humans hold with their environment, and the kinds of short and long-term impacts particular courses of land use can generate.

**Socio-environmental Change and Sustainability**

A nested analysis of long-term agricultural activities at Wawakiki also sheds light on the perpetually evolving socio-natural environment and the manners in which human activities across the landscape may have effected change in biodiversity and resource distribution. Today, the coastal Osmore region is largely thought to be marginal or peripheral to the main valley. Population centers, commerce, and biodiversity all reside within the principal river valleys; in contrast, the inter-valley coastal desert is unpopulated, highly desiccated, and ranks low in biodiversity.

Precipitation records documented in the Quelccaya ice core indicate oscillating periods of below and above normal highland precipitation, which without a doubt differentially affected spring flow and river discharge upon which coastal farming communities were dependent. However, while precipitation data may have waxed and waned through time, farming strategies at Wawakiki suggest an increased concern with aridity through time. The truth is that within the past millennium, the coastal Osmore landscape has undergone considerable ecosystemic changes. This begs the question, What role did human activity play in the apparent increased desiccation throughout the past 1000 years? At Wawakiki, intensive terrace construction on the coastal promontory
and along the steep coastal portions of the quebrada channels enhanced the steep, barren—and otherwise unusable—terrain into a viable and agriculturally productive landscape. Infrastructural investments by Chiribaya farmers significantly altered patterns of sediment erosion, deposition, and drainage, where stone-faced terraces increased soil and moisture retention and minimized erosive activities along steep slopes. Chiribaya terraces among the inland *lomas* would have also greatly reduced soil erosion, even after areas were in part cleared for agriculture. As Redman (1999: 132) asserts, however, heavy investment in hillside terraces is also risky. If they are not adequately maintained and terrace walls become breached, the augmented height of soil behind terraces would lead to rapid erosion of the hillside, a consequence they may have had long lasting effects on the inland *lomas* over time.

Coastal excavations and inland reconnaissance indicate that there was considerable activity among the inland *lomas* during the late Chiribaya period. The presence of camelids during the late pre-Hispanic era plus large herds of mules during the Spanish colonial era suggest the Osmore *lomas* were once a vibrant micro-environment that supported expanses of herbaceous plants and trees. As noted in Chapter 3, historical records also indicate that the *lomas* around Ilo were once some of the most productive of coastal Peru, and Chiribaya populations likely utilized resources among the inland hills for camelid grazing, fuel, and farming. Terraces were constructed in several locations, suggesting that some areas had likely been cleared prior to their construction for farming purposes. Upon the fairly rapid collapse of coastal Chiribaya populations around the turn of the 15\textsuperscript{th} century, terraces along the coast and inland hills alike fell into disuse, and erosive activities began immediately.
Agricultural activities did not return to the inland zone until the early or middle 20th century, more than 500 years after Chiribaya terraces ceased to be maintained. Most of the terrace walls documented among the inland hills in this study were first identified in profiles of deep rills. Walls were typically buried deeply on both their upslope and down slope faces, indicating that substantial erosive and depositional activities had occurred since their abandonment.

Along the coast, excavations of Spanish colonial period agricultural fields on the promontory and in select portions of the coastal quebradas indicate that field surfaces accrued over time through incremental deposition of eroding upslope sediments. It seems likely, then, that once late pre-Hispanic grazing, clearing, and farming activities among the inland hills were no longer maintained, erosive activities began to intensify as terrace walls fell into disuse and were breached. Erosion continued into the Spanish colonial and immediate post colonial eras as irrigation practices focused on agriculturally maintaining the coastal sectors. In addition, a substantial amount of trees were removed from the inland hills around Ilo, primarily for construction purposes around the turn of the 18th century. Over time, loss of vegetation coupled with terrace abandonment would have further accelerated erosion of the inland hills, the transport of soil toward the coast, and a lowering of the water table. Today, the steep slopes behind Wawakiki are barren and deflated, though the myriad of activities noted on the landscape suggest that was not the case centuries ago and that the coastal environment has progressively taken on its desiccated state over the past six or seven centuries. While this remains a working hypothesis to be tested elsewhere along the Osmore coast, information gathered in this study points to environmental alteration that was truly a socio-natural occurrence.
throughout the second millennium A.D. Landscape enhancement, degradation, and changes in biodiversity were interrelated and co-evolving processes, where in some cases human activities enhanced the landscape at the expense of degradation and diminished biodiversity elsewhere.

These results hold several implications for visions of sustainable land use, both locally, regionally, and globally, but what exactly is meant by ‘sustainability’? Too often it is an ill-conceived concept suggesting that humans can somehow achieve a stagnant balance on the planet, when in fact our planet is a finite entity in a constant state of evolution: Earth had a beginning, and it will most certainly come to an end in a few billion years. While such grandiose scales of thought may seem useless to humanity, especially given our relatively recent arrival on the landscape, the notion of a finite though perpetually evolving planet requires that humans critically examine the concept of ‘sustainability’.

Change is the natural state of our ecosphere, and consequently, any meaningful concept of sustainability must include explicit ideas of scale, both spatially and temporally. Whether determining the long term potential of agricultural land use strategies at the site of Wawakiki, the southern Andes, or the globe, sustainability must revolve around issues of time and space. How long can humans sustain themselves (socially, economically, environmentally) under a specified economic strategy dependent on both renewable and non-renewable resources? Humans impact (alter, accelerate, retard) courses of planetary evolution and biodiversity. Approaches to and understandings of sustainability, then, must account for the pervasive and wide-ranging changes humans inflict on their surroundings. Robert Goodland (1995: 10) defines
environmental sustainability as “a set of constraints on the four major activities regulating
the scale of the human economic subsystem: the use of renewable and non-renewable
resources on the source side, and pollution and waste assimilation on the sink side.” He
also implies questions of scale involved with sustainability issues, noting that “source and
sink functions must be unimpaired during the period over which sustainability is
required” (1995: 10, emphasis added). Thus, humans define the temporal scale of
sustainability—be it years, decades, centuries, or millennia—and ultimately, both growth
in resource consumption and growth in human population will diminish the period over
which local, regional, or global sustainability can be achieved.

The degree to which coastal Osmore farmers actively practiced sustainable land
use strategies may be a moot point. We may never really know to what extent ancient
peoples were conscious of the impacts they had on their environment, though it would be
arrogant to assume they did or did not fully understand the effects of their actions. We,
of course, have the advantage in that we can critically examine long term effects or
erlier activities, just as our descendants will have an advantage over us, in that they will
soon learn of the consequences of our decisions, and how current resource management
on local, regional, and global scales has differentially affected the socio-natural
environment and biodiversity of which we are a part. Nonetheless, this investigation
indicates that some of the many direct and indirect impacts coastal Osmore populations
have had on their environments over the past millennium enhanced the landscape for
agricultural purposes, and therefore increased the sustainability of agriculture along the
coast, while concurrently diminishing potential land use and resource management in

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8 Goodland defines the scale of the human economy as a function of throughput: the flow of materials and energy from the sources of the environment, used by the human economy, and then returned to environmental sinks as waste.
other areas. Over the long term, biodiversity—and hence resource renewability—has diminished in the area, and consequently changes in the sustainability of activities like farming, herding, hunting, and fishing have accelerated. Human impacts on the environment vary from situation to situation, but they often alter biodiversity so that their net yield for human consumption increases while native plant and animal conditions often decrease (Redman 1999: 215).

Humans will always alter, enhance, degrade, and co-evolve with the environment, and therefore change is inevitable. The key to sustainability on any scale is thus to understand the kinds of impacts humans have on the environment and how they may serve to advance or decrease changes in biodiversity. Though not the only point of articulation between humans and their environment, agricultural land use presents an avenue through which to examine household, community, or regional level strategies to production, the various conditions and motivations that surround those strategies, and the impacts humans might have in altering the courses of socio-environmental change at multiple scales.

**Future Courses of Research**

While this dissertation has accomplished its primary goals of identifying the complexity surrounding long-term evolution of agrarian land use at the site of Wawakiki and assessing the role humans have played in shaping the socio-natural landscape, a number of questions have arisen that such a study by itself cannot fully answer. Particular issues raised at the level of site—such as population growth and decline, shifting technologies of agrarian land use, and human impact on the local socio-natural
were successfully compared to regional landscape information to understand more widespread trajectories of agrarian land use and human impacts on the environment. However, the regional information upon which this study relied was not always comparable kinds of information, and it was often spotty in nature, both spatially and temporally. It was not always possible to obtain the same kinds of data from other spring systems along the coast or from within the Ilo river valley, nor was it possible to achieve the same degree of resolution. This becomes particularly apparent in Chapter 9, where diachronic patterns of land use at spring systems like Alastaya and Miraflores remain virtually unknown. Also, most previous investigations along the coast were limited to the plain south of Wawakiki; none ventured into the rugged coastline northward from the site. Consequently, there are very few pieces of information stemming from landscapes that are potentially very similar to the configuration seen at Wawakiki. Clearly there is much to be done in order to better comprehend the dynamic nature of and variability in coastal agricultural landscapes in far southern Peru.

**Early Ceramic Period Land Use and Resource Management**

The Early Ceramic period constitutes one of the least understood phases of human settlement, land use, and resource management in the lower and coastal Osmore region. It is clear from related studies (e.g., Owen 1993a; Umire 1994; 1996) that significant populations of settled farmers occupied the banks of the Ilo river and the flanks of freshwater springs along the coast. The origins of agriculture in the area, however, remain largely unknown. What were the conditions surrounding the transition to an agriculturally based economy in the Ilo region, and what kinds of agricultural strategies
were undertaken by such communities? What other resources were these early settled populations exploiting, and how did these communities impact the marine, estuarine, and terrestrial ecosystems of which they were a part?

**Transition from Early Ceramic Period to Chiribaya Fluorescence**

Also unknown is the transition from early ceramic period populations of settled farmers to the earliest beginnings and subsequent florescence of Chiribaya communities along the coast. While previous reconnaissance investigations have identified remains associated with these two phases all along the Ilo River and among the coastal springs, none have explicitly focused on the potential relationship between the two. Owen (1993a) suggests there was a real population decline between the two periods, where a very limited number of remains were found higher up near the valley rim, potentially situated to take advantage of a mixed strategy of arable flood plain below and lomas resources above. Most radiocarbon age ranges associated with Early Ceramic period sites within the Ilo Valley fall in the early half of the first millennium A.D., while the earliest Chiribaya occupation is dated to the 9th century. Along the coast, most spring sites contain elements of both Early Ceramic *Olla sin Cuello* and Chiribaya groups, though their chronological relationship has not been fully worked through. At Wawakiki, the only Early Ceramic period radiocarbon age range was calibrated to the third and fourth centuries A.D., while Chiribaya age ranges fall decidedly during the late period, between the 12th and 15th centuries A.D. Was there really a population decline between them? Are *Olla sin cuello* populations the ancestors of Chiribaya? How did each group interact with the wider environment? Agricultural land use may be difficult to identify
among early ceramic populations, though some *Olla sin cuello* sites have been identified that do not have an overlying Chiribaya occupation (Umire 1994; 1996). Also, while differences have not been quantified, shell size of some marine species (e.g., conch, mussels) seem to vary considerably between the two periods. Deposits stemming from Early Ceramic period contexts identified at Wawakiki in this project and elsewhere (Umire, personal communication, 2003) exhibit consistently larger specimens than their Chiribaya counterparts, suggesting that harvesting rates and volumes may have begun to exceed regeneration rates over time. Clearly, a more comprehensive and explicit investigation along the coast is called for to better understand the relationship between these two archaeologically distinct groups, and the long-term environmental impacts of their management of coastal resources.

**Late Chiribaya Resource Management and Economic Organization**

Previous investigations centered on the Ilo River valley and along the adjacent coastal plain found support for a specialized subsistence economy during the Chiribaya period (e.g., Jessup 1991; Lozada and Buikstra 2002; Umire and Miranda 2001). This investigation suggests that the community situated at Wawakiki pursued a diversified strategy of production that may have constituted risk reducing efforts to sustain themselves socially and economically. I suspect that a diversified strategy was more the norm among Chiribaya sites north of Wawakiki and situated amongst high relief terrain near the coastline. I further suspect that, like Wawakiki, the Chiribaya occupations of these inter-valley coastal springs occurred late in the cultural chronology established in the Ilo river valley. It is becoming more and more clear that Chiribaya occupation among
the Osmore springs was intense, and while previous investigations do not explicitly
differentiate between early and late Chiribaya occupation, some (e.g., Clement and
Moseley 1991) imply that the springs were occupied throughout the Chiribaya period. To
date, no other investigation along the coast has presented radiocarbon age ranges
associated with Chiribaya settlement, where those from Wawakiki overwhelmingly
 bracket the late period. Investigations to the north of Wawakiki are clearly required to
more fully test both of these hypotheses.

**Historical Ecology and Multidisciplinary Perspectives**

This dissertation has but opened the door to other, more broadly significant
questions that relate to our place on this planet. As a relatively recent academic
emergence, Historical Ecology is well equipped to undertake investigations into the
nature of human-environment interaction. Ecologists can define ecosystemic
relationships among organisms at multiple scales in attempts to understand the
relationships among species, and the impacts that changes in one arena may have on
another. Archaeologists bring historical depth to such issues, serving to build diachronic
perspectives and understand historically-linked ecosystemic relationships within a
continuously evolving biosphere. Humans are but one part of the larger ecosystem,
though we arguably impact the course of environmental change with far greater force
than any other organism.

A multidisciplinary project involving historical and ecological principles will
serve to answer many of the above mentioned issues that this investigation has
illuminated in the coastal Osmore desert: transitions to agriculture; marine resource
management; the organization of production; capital investments in the landscape; alterations to drainage patterns; shifts in vegetative patterns through specialized mono-cropping; diversified subsistence strategies; manipulation of annual vs. perennial plants across the landscape; regeneration of marine and terrestrial species; land tenure and values on production; and biodiversity. Each of these elements is intricately related to the human-environment relationship, and the decisions that people make on local, regional, and global scales will have long-lasting effects—for better or for worse—for the successful development and maintenance of our landscapes in the future.
**Table A-1. Inventory of Soil Samples.** Those samples marked in bold were selected for pollen analysis.

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<th>Comments</th>
<th>Date on Bag</th>
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Figure A-1. Soil Sample Provenience.

### Table A-2. Inventory and Provenience of Radiocarbon Samples.

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*Because of the small amount, sample 14 was not able to yield a radiocarbon date.
**Table A-3. Radiocarbon Dates**

* samples were measured using extended counting time

** calibrated dates were generated with CALIB REV4.4 Radiocarbon Calibration Program (Stuiver and Reimer 1993) made available by the University of Washington, based on southern hemisphere data described by McCormac et al. (2002) and international data described by Stuiver et al. (1998a, 1998b).

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<td>Conv. charcoal</td>
<td>700 ± 60</td>
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<td>1233-1243 (0.012) 1267-1409 (0.988)</td>
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<td>480 ± 90*</td>
<td>1402-1509 (0.779) 1554-1556 (0.013)</td>
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<td>AMS charcoal</td>
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<td>132 ± 32</td>
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Figure A-2. Plan view of isolated profile WK4A-p, located in the Chiribaya domestic zone.
Figure A-3. Isolated profile WK4A-p; profile 1 of 3.
Figure A-4. Isolated profile WK4A-p; profile 2 of 3.
Figure A-5. Isolated profile WK4A-p; profile 3 of 3.
Figure A-6. Plan view of isolated profile WK4B-p, located in the Chiribaya domestic zone.
Figure A-7. Isolated profile WK4B-p.
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Bauza, Felipe  

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Boytner, Ran

Brookfield, Harold C.


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Ó Donnabháin, Barra, Maria C. Lozada, and Jane E. Buikstra

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Reycraft, Richard Martin


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Romero, Emilio

Rostworowski, Maria de Diaz Canseco


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