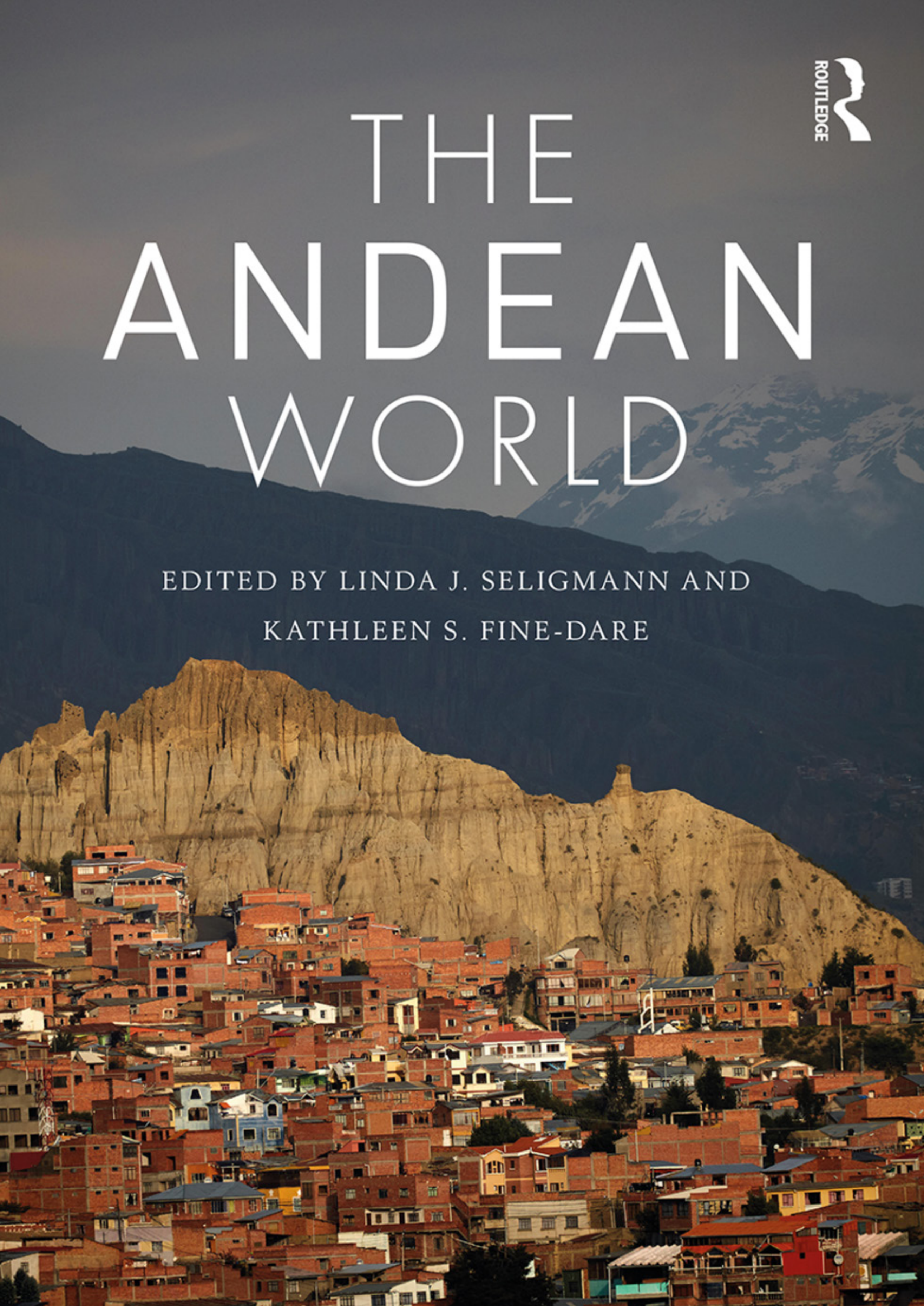

THE ANDEAN WORLD

EDITED BY LINDA J. SELIGMANN AND KATHLEEN S. FINE-DARE

THE ANDEAN WORLD

This comprehensive reference offers an authoritative overview of Andean lifeways. It provides valuable historical context and demonstrates the relevance of learning about the Andes in light of contemporary events and debates. The volume covers the ecology and pre-Columbian history of the region, and addresses key themes such as cosmology, aesthetics, gender and household relations, modes of economic production, exchange, and consumption, postcolonial legacies, identities, political organization and movements, and transnational interconnections. With over 40 essays by expert contributors that highlight the breadth and depth of Andean worlds, this is an essential resource for students and scholars alike.

Linda J. Seligmann is Professor of Anthropology at George Mason University, USA. Her most recent book is *Broken Links, Enduring Ties: American Adoption across Race, Class, and Nation* (2013).

Kathleen S. Fine-Dare is Professor of Anthropology and Gender & Women's Studies at Fort Lewis College, USA. Her most recent book is *Border Crossings: Transnational Americanist Anthropology* (2009).

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ABBREVIATIONS

A.	Aymara
Q.	Quechua
Sp.	Spanish

Note: Cusco is the local spelling of Cuzco. Authors use one or the other as their preference.

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INTRODUCTION
The Andean world

Kathleen S. Fine-Dare and Linda J. Seligmann

> What people think of as the Andes has been at least as powerful as any purported objective description of their content and character.
>
> Daniel W. Gade (1999, p.41)

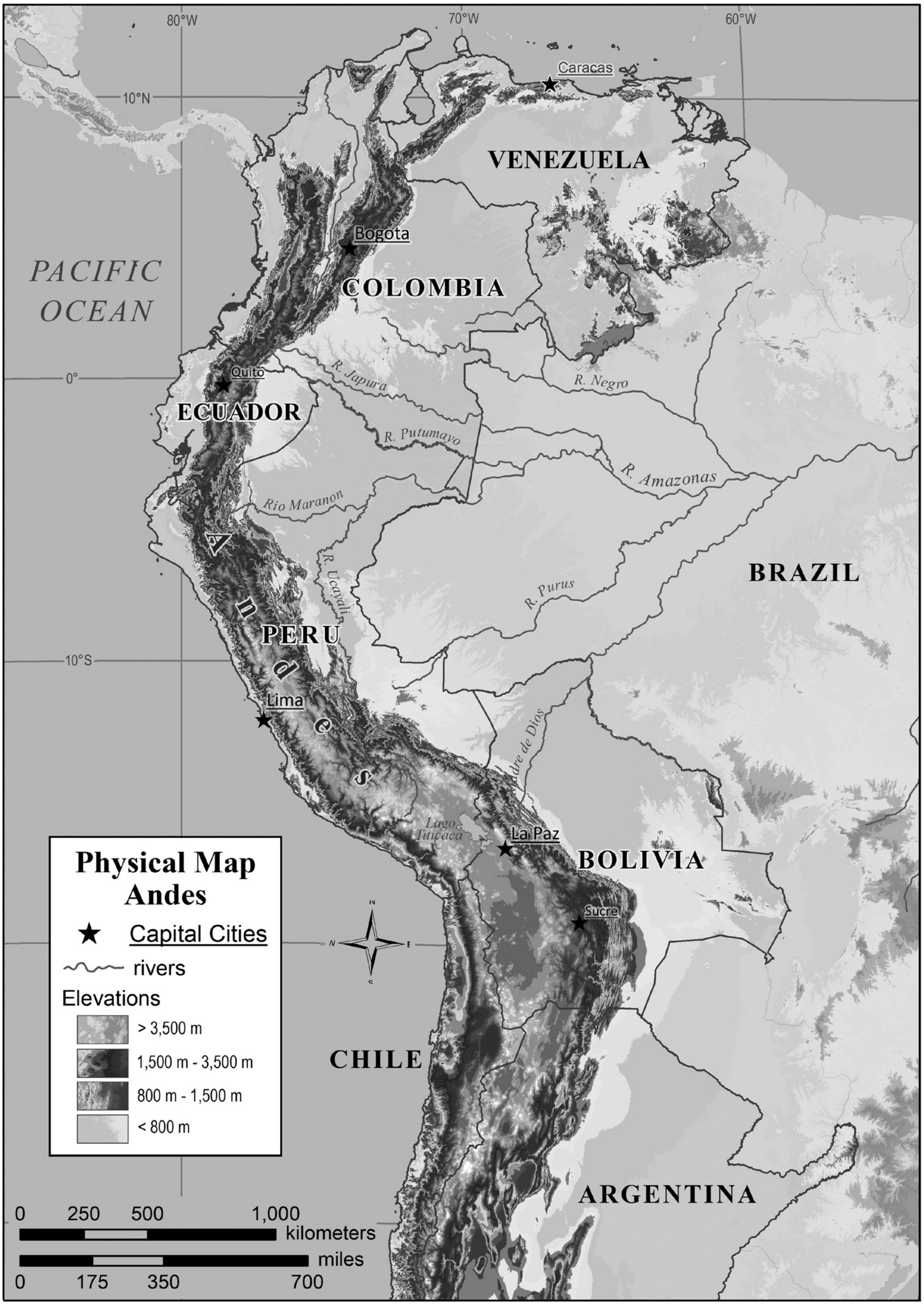
This volume is intended to be a resource for students and scholars interested in learning more about the Andean region of Latin America. Yet to speak of "the Andean world" is to generalize in ways that demand explanation. The Andes is a vast and ecologically complex region, encompassing maritime ecosystems, deserts, rain forests, and the high ranges and plateaus of the Andes mountains. Politically, the nation states of Bolivia, Colombia, Ecuador, and Peru are considered to belong to the Andes (see Map 0.1); while geographically, the region stretches from sea level to over 5,486 meters above sea level (one meter is equivalent to 3.28 feet), and includes all of Peru, Bolivia, Ecuador, and Colombia, as well as parts of Chile and northwestern Argentina (see Map 0.2). It is home to many different indigenous populations and language groups.

At the same time, the thousands of years of habitation the region has experienced means that interactions among language groups and populations—including many who have come as colonizers and conquerors—have created a remarkably complex cultural, political, and economic terrain that is neither easily described nor comprehended. Given its vastness, a reasonable question to ask is whether or not it is even feasible to craft a volume that could touch on all these dimensions. We return to this question below, but first provide a brief overview of ways *lo andino*—how scholars have sought to define characteristics of what could be called "Andean," as well as how that which constitutes and has been considered essentially "Andean"—has been critiqued.

Some scholars, who have focused on the specifically "Andean" nature of the ecology and geography of the region, with all its geological and climatic variation, have nevertheless noted that the "natural" region has undergone substantial cultural

Map 0.1 Political map of the Andean states

Map credits: Scott White, based on ESRI and USGS.



Map 0.2 Geographic map of the Andean region

Map credits: Scott White, based on ESRI and USGS.

changes over time due to human perceptions of and interactions with the environment. Geographer Daniel W. Gade opens a chapter reflecting on "the meaning of *lo Andino*" in his 1999 work *Nature and Culture in the Andes* by stating: "The Andes form a fundamental region of South America, but also a mythic space whose configuration has changed through the past 500 years" (Gade, 1999, p. 31). On the same page from which the epigraph that opens this chapter is drawn, he notes that changing perceptions of the Andes over the past four hundred years have shifted the definition twice: "from a nonregion to a region, and from a physical entity to a culture area" (Gade, 1999, p. 41).

General agreement exists that the word "Andes" may derive from the Quechua *Anti*, which referred to forest-dwelling peoples who lived in *Antisuyo*, or the southeastern quadrant of the Inca Empire. Citing sixteenth-century writer Juan López de Velasco (1971, p. 81) and seventeenth-century author Antonio Vásquez de Espinosa (1969, p.272), Gade states that during the colonial period the Andes "referred not to the continuous highlands, but rather to the forest-covered hot valleys east of Cusco" (Gade, 1999, p. 31). The iconic nature of the Andes as essentially mountainous was established "in the mental geography of the world" (Gade, 1999, p. 32), most notably by Enlightenment naturalist Alexander von Humboldt (1769–1859) who, in the course of his expedition to South America from 1799–1804 (along with French explorer and botanist Aimé Jacques Alexandre Bonpland), "came to see the exuberant landscapes he traversed as monuments to the underlying unity of the natural world, majestic symbols that man-made objects could never equal" (Safier, 2008, p. 55).

Humboldt drew from the researches and travels of precursors such as Charles-Marie de La Condamine and Pierre Bouguer (France); Jorge Juan de Ulloa, Antonio de Ulloa, and Alejandro Malaspina (Spain); and Juan Larrea, Francisco José de Caldas, and Carlos Montúfar (Ecuador), who were seeking to establish the location and expanse of the equator and poles, the origin of rocks (presaging the studies of minerology and volcanology), as well as investigate the possibility of reconstructing the large pyramids (Holl, 2001, pp.16–19). Humboldt's vision of the Andes was not only scientific; as a German naturalist, his thinking went beyond "the arrangement of climate and vegetation" to demonstrate "biophysical verticality" (Gade, 1999, p. 32), to an appreciation of ways that landscape painting could serve as an interface connecting the realities of the natural world to human subjectivity (González, 2001, p. 99; Kennedy-Troya, 2001). This subjectivity of the natural/human interface is apparent in the often luminously rendered works of landscape painters such as those of the American Frederic Edwin Church (1826–1900), who used South American scenes to modify Enlightenment realism by creating Romantic, light-filled renderings of nature (Figure 0.1)

This European focus on Andean physical landscapes in the early to mid-nineteenth century was joined shortly thereafter by another kind of "physiognomy," the search for ideal physical types that could be represented on small "calling card" photos (*cartes de visite*) for purchase by foreign travelers (Poole, 1997, p.74ff.) These popularly circulating images, as well as larger format photographic projects, would feed into at least four connected projects: scientific studies of purported biological races; nationalist and Indigenist political projects that used "types, customs, and landscapes" to literally paint a picture of a nation (Kennedy-Troya, 2005, p.25);[1] concerted efforts to expropriate land, life, and livelihood from indigenous and African-descended

Figure 0.1 Painting by Frederic Edwin Church, *The Andes of Ecuador*, ca. 1855. Height: 121.9 cm (47.9 in); width: 194.3 cm (76.4 in) [public domain]. Reynolda House Museum of American Art, Winston-Salem, NC

peoples; and ethnographic work conducted by anthropologists who mapped indigenous, "mixed race," and African-Andean types onto what would be called culture areas. The couple whose photo was included in an 1868 Peruvian souvenir book that ended up in the U.S. Library of Congress were likely chosen as photographic subjects because of some "quintessentially Indian" characteristics found in their shabby but nonetheless elegant costumes, brooding countenances, and lack of shoes (Figure 0.2).

Although type- and racially-focused photographic and other artistic projects proliferated in the nineteenth century both in Europe and the Andes, the results were not generalized or systematic.

By 1943, anthropologist and cultural ecologist Julian Steward was to note that an ethnological study of the complex nature of the Andean area, where "a fairly well integrated mixture of native and European elements predominates" called for "long range, preferably interdisciplinary, studies." Steward went on to remark that "[d]espite a tremendous literature on [Andean] peoples, including many *Indigenista* writings, not a single thorough community study has been published" (Steward, 1943, p. 32).[2] He averred that both research problems and subject matter were undergoing "continuous change" and that "the status of anthropological research of all types in South America is little short of chaotic" (Steward, 1943, pp. 20–21), something he hoped would be addressed by the imminent publication of the five-volume *Handbook of South American Indians*,[3] (a project begun by Alfred Métraux) for which Steward served as general editor. Steward argued forcefully that culture areas were the outcome of the dynamic interaction of features of the environment itself and the cultural arrangements by which the environment was exploited, including the technology employed, and the economic organization of the society in question. He was curious

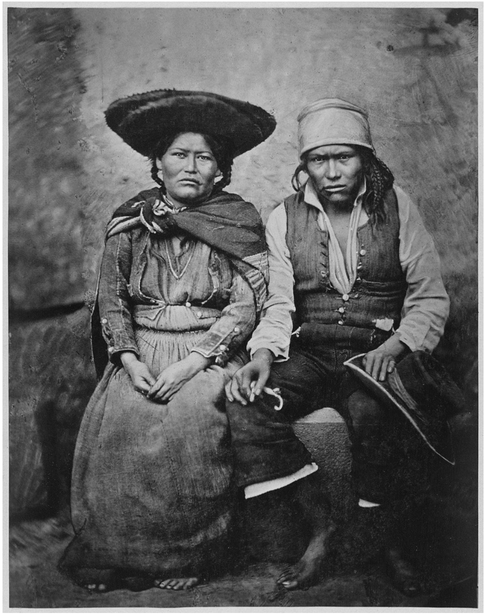


Figure 0.2 *Indigenista* style photo, Courret Hermanos studio, Lima, *Indians from Quito, Ecuador*. From 1868 album, "Recuerdos del Peru," v. 1, p. 45. Photograph shows portrait of indigenous woman and man in traditional dress

Washington, D.C., Library of Congress LC-DIG-ds-03188.

to ascertain whether or not one might find regularities in light of the interactions of these features.

Volume II of the series, *The Andean Civilizations* (1963[1944]), is nearly a thousand pages in length and summarizes information ranging from environmental to archaeological on through historical and a variety of ethnographic categories divided among societies assigned to the central, southern, and northern Andes. In the preface to this volume, Steward identifies "The Andean Civilizations" as comprised of "the high-culture, farming peoples of the Andean Highlands and Pacific Coast from Colombia to Central Chile." The "Andean peoples," continues Steward, "are distinctive for their high native cultural development, for their rich archaeological remains, and for their strong survival, both numerically and culturally, at the present day" (Steward, 1963, p. xxv). In a similar fashion, Enrique Mayer, two decades later, coined the term "production zones" to stress how what might appear as "natural" is instead the result of coordinated human–natural interactions that include infrastructural features, modes of rationing resources, and rule-making mechanisms that regulate how these resources are used (Mayer 1985, pp. 48–51).

Three quarters of a century later—and as the ethnographic work in this volume attests—although our definition of the scope and what Steward and others of his time would perhaps identify as key "culture area" characteristics of the region remain uncertainly delineated by geographic or other criteria, direct field research in the Andes has indeed proliferated and permitted scholars to discern patterns, variations, and remarkable differences in the lifeways that constitute this vast region. It has also allowed them to fruitfully explore the ways that inhabitants themselves conceptualize their place(s) in the Andes and the skills and knowledge they have brought to bear on their movements throughout the region and beyond, culturally, politically, and economically.

In a markedly different effort to arrive at what might be generalizable about the Andean region, more recent scholars have argued that the violence visited on Andean communities and peoples in the 1980s refocused interrogations of what it means to be "Andean." Ethnographer Orin Starn launched a provocative critique of "Andeanism" in 1991, arguing that the theoretical predilections and perhaps emotional inclinations of many anthropologists had impeded their ability to anticipate the violence of Peru's bloody internal war that lasted from 1980–2000 and that resulted in the deaths of at least 69,000 people, 75 percent of whom were speakers of native languages and 79 percent of whom lived in rural areas (Rojas-Perez, 2017, pp. 4,7). By emphasizing continuity of ecology, symbolism, and ritual within bounded communities, Starn claimed that some anthropologists had painted a picture of a largely homogeneous and "timeless" Andean world separated from coastal, urban, and mestizo (mixed Spanish and indigenous) places and peoples, which in turn created a static, essentialized, and inaccurate portrayal of Andean peoples' diversity and intercultural complexity (Starn, 1991, pp. 66–70; see Salomon, 1982, for a nuanced bibliographic discussion of the nature of Andean studies that Starn only partially addresses).

Seligmann, responding to Starn's critique, observed that while scholars in the north had all too frequently contributed to the static way that the Andes had been represented, at that time, many native Andean scholars and, even more broadly, historians, had hardly viewed the Andes as a timeless, monolithic entity, and were well aware of the political dynamics, economic inequalities, and regional migratory and urban interactions and flows that had catalyzed Peru's civil war (See Seligmann, 1992, pp.93–102 for references that did take account of the turbulent character of the Andes).

While it is true that Starn's observations and critique had an influence on (or at least reflected the directions being taken by) a new generation of scholars (Goodale, 2006, p. 645; Stein, 2016), there were others who had also been questioning entrenched notions of *lo andino* as the world reflected on the Columbian Quincentenary. For example, in a 1992 edited volume on Andean cosmologies, editor Robert V.H. Dover admitted that he could not explicate in his Introduction any "ready definitions of the term *Andeanness*," stating instead:

> although these essays collectively begin to elaborate a working concept Andean peoples are linked by a common social history, if not a cultural one. They are also linked by the structural and incorporative discourse with which they constantly interpret and authenticate their reality. The strength of their reality, the centrality of their identity as Andean peoples, the tenacity of their Andeanness from the period of its coalescence in the Inca period to the recent return to Andean cultural and political autonomy in the context of Western nation-states: these facts enjoin us to learn this discourse if we want to talk about the Andes at all. It is an experiential discourse and not a taxonomic one, and no one culture system encodes all of it.
>
> (Dover, 1992, pp. 13–14)

Anthropologist Norman E. Whitten, Jr., would add history, politics, and ecosystems to these discursive and experiential arenas. Although Whitten is best known for his work on the upper Amazon, he has throughout his career emphasized the interactive and porous nature of the various regions of South America, preferring to characterize, for instance, the Oriente, or Amazonian, region of Ecuador, not as a backwater area "marginal" to the great civilizations of the Andes, but rather an "interface" defined by "*the contrasts to be drawn between Andean and Amazon ecologies, stratified bureaucratic and egalitarian social systems, and political nationalist and indigenous ideologies*" (Whitten, 1981, pp.122–123, emphasis in original; see also Greene, 2006).

At the same time, there is no question that the overwhelming corpus of research and writing on the Andes, up until the 1990s, did not delve deeply into the heterogeneity of the Andes, the ways in which the various regions within the Andes were connected to and shaped one another, how the methodologies and theoretical assumptions of scholars unduly led to the mythical creation of a monolithic Andean mentalité, or how global and transnational flows and their histories had contributed to what was thought to be Andean. This was especially evident in English-language publications, which in itself is yet another indicator of the challenges to arriving at a neat definition of what constitutes the Andes.

For us, the Andes is both place and experience. It is a region where we have carried out extensive research over long periods of time and one that occupies much of a continent as well as our hearts and professional lives. We have both taught courses focused on Andean peoples, cultures, and societies at the graduate and undergraduate levels, and each time we have been challenged to find a volume that could serve as a core reference for students as they delved into the topic. In preparing this collection, we admit that it is as much a product of our own dissatisfaction at finding an existing volume that works well, as it is a desire to continue to build on fine efforts made in the past to bring this remarkable region into focus. When we began to work on this, we realized that we would partly be re-inventing the wheel—that is, incorporating knowledge about the Andes that was very familiar to specialists. Yet we also hope that we have contributed a few new perspectives and brought up-to-date an overview of Andean lifeways within a general historical context that reaches into the second decade of the twenty-first century. What is new about this volume?

We have asked contributors to reflect on and interrogate the notion that there is a single, homogeneous, and monolithic Andean world. While the volume begins with an initial grounding in the ecology and pre-Colombian history of the region, rather than proceeding in a purely chronological fashion, the volume is organized into sections that address key themes that appear to us as having significance for those who live in the Andes—cosmology, sociality and social organization, sustenance, conquest, religion, resistance, states and state formation, post-colonial legacies, violence, aesthetics, writing, education, identity, economic extraction, tourism, migration, and transnational collisions and kaleidoscopes. In each of these major sections, the contributing authors have tacked between legacies of the past, current manifestations of Andean practices and values, and future trajectories. And although there are a few recent volumes devoted to archaeologically focused themes, we decided that the "past" and "present" should not be artificially separated, especially given that many Andean peoples themselves would not make such a temporal distinction.

The chapters in each thematic section have been selected to convey differing perspectives on the Andes, including examples from multiple geographical regions. These perspectives are not exhaustive, but contributors have sought to introduce readers to both the breadth and depth of Andean worlds so that they can then strike out and pursue their interest in one region or another on their own.

The Andean World has also been crafted with an eye to demonstrating the relevance of learning about the Andes in light of more contemporary conflicts, debates, and events. We are cognizant of multiple, innovative theoretical frameworks that have emerged with respect to Andean studies over the last thirty years or so. For example, the dynamics of scale are embedded in almost all of the chapters as authors move—as do many Andean peoples—among local, regional, and transnational milieus. And we use "milieu" as a poor substitute to indicate that these movements take place across language groups, cultural practices, economic realities, and value systems. Indeed, without falling into an idealistic romanticism, we call attention to the key tropes of adaptability and pugnacious and well-honed tactics of resistance and resilience that repeatedly emerge among Andean populations. Decolonizing places, gendered relationships, and people; examining extraction as a mode of living with deleterious consequences yet one that permeates Andean worlds; following the tracks of looters and cultural heritage practices and policies; and demonstrating the tremendous power of aesthetic genres—dance, music, art, and film—to communicate and perform what is culturally as well as politically meaningful to Andean peoples are among the frameworks that have proved to go hand in hand with the sustainability and struggles of Andean lives. The two collages that follow this introduction (Figures 0.3 and 0.4)—one prepared by Seligmann, the other by Fine-Dare—are intended to convey visually at one and the same time common themes as well as the remarkable variation that constitute Andean worlds.

A final goal we had was to include more voices of native Andean scholars as well as those whose academic base was not in the U.S., and to present a range of generational perspectives among the contributors. If readers peruse the authors' biographical sketches and examine the assumptions that guide their chapters, they will see notable differences in the methodological and theoretical approaches and frameworks among the scholars that are structured as much by new findings and research they have gained access to, as by the generational and political context in which they are working. One also finds a growing desire among scholars to make their scholarship meaningful to and for inhabitants of the Andes themselves—whether it is to demonstrate how trauma, violence, and the brutality of state interventions and collusions have been processed, analyzed, and acted upon by inhabitants themselves, or to valorize the many forms and combinations of forms that history and history-making take for Andean peoples ranging from the admixture of oral and written traditions to aesthetic and kinesthetic sensory modes, such as films, music, dances, and fiestas. These modes of history-making have become significant catalysts for political mobilization, assertions of citizenship, territorial control, the making of organic intellectuals, and the means to making a living, often under the umbrella of tourism.

Our volume ends, not exactly with a conclusion, but with some reflections and projections based on a dialogue held among scholars of different generations, training, and background, whose motivations for engaging the study of the Andes differ. We hope that this dialogue continues to leave wide open the doors for newcomers as well as seasoned researchers to reflect on what it means to speak of worlds that are Andean, to raise many more questions that have yet to be answered about the dynamics that constitute these worlds, and to encourage fruitful debate about how these dynamics are interconnected and shape the complex processes of globalization in which we are all embedded.

NOTES

1 Although a great many outsiders contributed to the image-fashioning of the Andes—particularly in the pages of travel journals such as the French *Le Tour du Monde*, created in 1860 by Édouard Charton (Gómez Rendón, 2011)—others were quite local, such as the Ecuadorian watercolorists Joaquín Pinto (1842–1906; Samaniego Salazar, 1977) and Juan Agustín Guerrero (1818–1880; Hallo, 1981); and later, the indigenous Peruvian photographer Martín Chambi (1891–1973; Vargas Llosa, 1993).

2 The Indigenista movement, which began in the 1920s, was particularly prominent in Mexico and Peru, and was comprised of philosophers, anthropologists, linguists, and politicians, who sought to emphasize indigenous cultural identity in positive ways. However, it did not particularly seek to overturn the economic and political status quo of indigenous peoples, which had contributed to deep-seated inequalities.

3 Steward explains in the Preface to Volume II that the *Handbook* "has been prepared by the Bureau of American Ethnology as part of the Department of State's general program of Cooperation with the American Republics. It is an inter-American undertaking, written by scientists from throughout the Hemisphere" (Steward, 1963, p. xxv).

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Figure 0.3 L to R

Row 1: Puno, Peru, city located on shores of Lake Titicaca (2013); women marketing naturally-dyed textiles in Cusco (2013); *majeño* dancers representing merchants in leather jackets, scarves, riding breeches, spurred boots and with bottle of beer in hand in Virgen del Carmen celebration, Pisaq, Peru (2011); *qhapaq negro* dancers from Paucartambo, representing liberated black slaves of Spanish colonial era in Peru, Virgen del Carmen festival, Cuzco, Peru (2011)

Row 2: Cuzco, ancient capital of Incas, and now a city of 427,000 (2006); tiny plots of irrigated valley fields, Combapata, Peru (1979); men and women sowing potatoes in lower *puna*, Santa Barbara, Peru (1974); women selling flowers on the street in Cuzco (2010)

Row 3: Dances and music for tourists in Arequipa (2013); protest against sale of oil at low prices to U.S., Cusco, Peru (2010); *retablo* made of potato dough, depicting clashing protesters for and against nationalization and democratization (1989), courtesy of Nicario Jiménez; *altiplano* (2013); marketing of *quinua* cereal (2010), courtesy of Kathleen Fine-Dare; elaborately terraced fields of Colca canyon, Arequipa (2013); posters and crosses on Inca wall in Cuzco ennumerating human rights violations committed by President Alan García (2010); marketing coca candy (2010), courtesy of Kathleen Fine-Dare

Photo credits: Linda J. Seligmann unless otherwise noted.

Figure 0.4 L to R

Row 1: Yumbo *danzantes* Geovanny Chiliquinga and Pablo Gómez in Yumbada procession, Cotocollao, Quito, Ecuador (2012); mass for San Juan testimonial given by Haitian restaurant owner, Barrio San Enrique de Velasco, Quito, Ecuador (2012); Catholic procession sponsored by Yumbo dancer in Barrio Santa Anita, Quito, Ecuador (2007)

Row 2: Doña Luz María Semanate making chicha for San Juan festival, Barrio San Enrique de Velasco, Quito, Ecuador (2012); Ecuadorian environmental anthropologist Dra. Alexandra Martínez in coffee plantation near Salinas, Ecuador (2012); Doña Augustina Semanate, ex–hacienda worker (*huasipunguera*) and resident of Barrio San Enrique de Velasco, Quito, preparing for her sister's sponsorship of a festival Ecuador (2012)

Row 3: sporting goods factory, Quito, Ecuador (2011); Parents' Day celebration at elementary school Juan Pablo I in El Condado parish, Quito, Ecuador (2010); pre-Columbian shaft tomb pottery exhibit at Museo de Sitio La Florida, Quito, Ecuador (2010)

Photo credits: Kathleen S. Fine-Dare.

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PART I

GEOGRAPHIES, LANDSCAPES, AND ENVIRONMENTS

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CHAPTER ONE

STRATEGICALLY RELEVANT ANDEAN ENVIRONMENTS

Gregory Knapp

STRATEGICALLY RELEVANT ENVIRONMENTS

Geographers understand that there are no objectively given environmental parameters, but that humans throughout history, in the Andes and elsewhere, have evaluated their environment in accordance with the strategic and cultural norms of their respective societies. These norms do not necessarily separate altitude, latitude, slope, soil, or climate, but integrate all of these as strategically relevant (Knapp, 1991, pp. 19–52) to such cultural goals as crop yields.

Thus, the relevant environmental zones for early foragers and specialized hunters would have included the ranges of seasonally important game animals and food plants. For later agricultural societies, fertile soils and optimal temperatures and precipitation (or access to irrigation) would have been important; these optima would of course vary by crop. Relevant mineral resources also changed with cultural history. Salt and raw materials for tools would have been important early. During colonial times, gold placer deposits and silver lodes were decisive for economic development and location of such major cities as Potosí. More recently, industrial minerals such as copper, tin, and lithium, along with hydrocarbons such as the coal deposits of the Colombian Andes, have assumed importance and shaped demographic patterns and environmental practices.

In addition to providing resources for human projects, Andean environments have also presented challenges and hazards. Easily predictable challenges, such as the normal dry season, can result in effective human adaptations, such as seasonal adjustment of sowing dates. Other challenges, such as earthquakes, volcanic eruptions, and El Niño events are less predictable and can be termed "natural hazards." Hazards should be considered in terms of their strategic importance to prevailing adaptive strategies. A drought that is devastating to an agricultural civilization may therefore not matter as much to a foraging society or an urbanized, industrial society

Research by geographers and others has shown that, despite a range of variation in their responses, individuals and societies cope less well with hazards than with more predictable events. All too often, attitudes of optimism or fatalism, or excessive confidence in technological solutions, get in the way of more effective policy solutions such as hazard mapping, land use zoning, and promotion of resilience. Recent anthropogenic climate change presents similar challenges.

Finally, many Andean environments have been appreciated in aesthetic and ideological (including religious) terms, and this too varies by society. Mountain peaks, springs, caves, and even individual trees may be seen as important, in shamanism, organized religions, or other folk beliefs. Modern Andean travel and tourism is often oriented around the beauty or sublimity of natural features such as mountain peaks, lakes, high grasslands, and waterfalls, for example. Ever since the day when the Enlightenment era naturalist and explorer Alexander von Humboldt (1769–1859) traversed the Andes, the importance of combining scientific and humanistic methodologies, avoiding ethnocentrism, and appreciating the interconnectedness of life has been understood as necessary to make sense of the environmental dynamics of the Andes (Wulf, 2015).

These observations complicate the notion of "environmentalism" or "conservation," which are always socially constructed. What is seen as valuable, hazardous, or ethically worth preserving by traditional agricultural villagers may be very different than what is defined in these terms by representatives of modern industrial societies in the global north. These different perceptions can result in misunderstandings. In the worse case scenarios, scientists and representatives of environmental NGOs or state agencies may be seen by local people as practicing a sort of neo-colonialism, imposing their views in ways that disempower local people and silence local voices.

Given these considerations, it is still possible to provide an overview of Andean environments in terms of characteristics that have proven to be strategically significant to multiple societies. A distinction between the tropical and non-tropical Andes is useful, for example. Elevation is of broad relevance, but needs to be complemented with a recognition of slope, aspect, and soil. Precipitation—amount and timing—is of great importance for agriculture, but needs to be seen in light of the availability of sources for artificial irrigation. Major hazards include earthquakes and volcanic eruptions, as well as El Niño events. Climate change is certainly relevant as well, including changes in glaciers.

LANDFORMS, GEOLOGY, AND SOIL

The Andes are a continuous chain of mountains extending from northern Venezuela to southern Argentina and Chile (Troll 1988; Caviedes and Knapp, 1995, pp. 86–96; Veblen, Young, and Orme, 2007; Borsdorf and Stadel, 2015). These mountains are relatively young in geological terms, primarily created as a result of the ongoing collision of the South American continent and its underlying "plate" with neighboring oceanic plates, including the Nazca plate. The resulting overriding (subduction) has resulted in uplift and the injection of material, including the creation of volcanoes, past and present (Lamb, 2004). Although much of the Andes contains volcanic rocks and even active volcanoes, other parts of the Andes contain older rocks lifted up by the general thickening of the continental crust. Thus, in some areas sedimentary and metamorphic rocks and exposed batholiths are found in the high Andes.

The Andes are almost uniformly high in elevation; some of the lowest passes are found in far northern Peru, but these are still above 2,000 meters. As is the case with other mountains, the prevailing steep slopes have presented problems for surface transportation, which only recently have been partially overcome with the development of railways, air transport, and modern paved highways and tunnels. The steep slopes may easily erode, resulting in poor soils for agriculture; this problem can be addressed with terracing, but terraces may be difficult to construct and maintain. Finally, air pressure decreases at higher elevations, potentially causing transitory altitude sickness in humans.

Usually the tropical Andes consist of two or more high ranges separated by intermontane valleys or more extensive high plains (*altiplanos*). Since prehistoric times, the valleys and altiplanos have often been favored sites for settlement and agriculture. Often the altiplanos are high in elevation, but some valleys are deeply incised and their bottoms are tropical in climate.

In northern Venezuela, the initial part of the Andes includes two ranges, a Coastal Range and the Cordillera Interior. Between these two ranges is the valley containing Caracas, the capital, and Lake Valencia. Farther west, the two ranges come together to form the high Cordillera de Mérida, which continues into Colombia as the Cordillera Oriental.

A spur range, the Cordillera de Perijá, extends to the north, forming the boundary between modern Colombia and Venezuela. Nearby Lake Maracaibo is rich in oil deposits, and rich coal deposits are also found in this region. To the west of this spur range, in far northern Colombia, the Sierra Nevada de Santa Marta is a separate high uplifted block of metamorphic and intrusive rocks, with elevations exceeding 5,700 meters close to the Caribbean coast.

In the rest of Colombia, the Cordillera Oriental continues as the easternmost Andean range, with rounded topography and few high peaks. It contains many high, flat-floored basins between 2,500 and 3,000 meters in elevation, including the Sabana de Bogotá, locations of major pre-Hispanic chiefdoms and present-day large cities, including Bogotá and Pasto.

The Cordillera Oriental is complemented by two additional mountain ranges, the central Cordillera Central and the western Cordillera Occidental; these three join together at the Nudo ("knot," or transverse ranges) of Pasto just north of the Ecuadorian border. The Cordillera Oriental is separated from the Cordillera Central by the deep Magdalena River valley. The Cordillera Central contains numerous active volcanoes, and as a result has rich volcanic soils which have long supported productive agriculture, such as recent coffee farms. To the west of the Cordillera Central is the Cauca River valley, with large flat areas of rich alluvial soils suitable for farming tropical crops. The westernmost range in Colombia is the Cordillera Occidental; it is relatively low (3,000 meters) and receives high rainfall amounts.

South of the Nudo of Pasto, in Ecuador, there are two major Andean ranges, a western Cordillera Occidental (or Cordillera Real) and an eastern Cordillera Oriental. Between the two can be found a series of isolated high valleys, in some cases containing small high plains, which have been the sites of dense population from pre-Hispanic times to today. These high valleys (*hoyas*) include, for example, the Hoya del Guayllabamba (containing Quito), and the Hoya del Paute (containing Cuenca). The hoyas are separated by transverse ranges (nudos). Both ranges include numerous volcanoes, which have resulted in extensive areas of rich volcanic soils. To the east of the Cordillera Oriental there is another set of isolated active volcanoes, while near the coast there are the much lower Coastal Ranges topped by uplifted sedimentary rocks; between these ranges and the Cordillera Occidental can be found the fertile alluvial valley of the Guayas River and its estuary.

In southern Ecuador the ranges again combine in the complicated Nudo of Loja, before re-organizing in northern Peru as three separate ranges: the eastern Cordillera Oriental (Cordillera Real), the central Cordillera Central (Cordillera Blanca), and western Cordillera Occidental (Cordillera Negra). The western Cordillera Negra borders (and partially causes) the Peruvian Coastal Desert; its western flanks are typically dry at lower elevations. Some rivers originating further east (such as the Chicama and Santa) slash through this range, but scores of additional rivers originate in the Cordillera Negra itself. These rivers create a series of oases on the Peruvian coast that have been important centers of settlement for millennia.

Between the Western and Central Cordilleras are a series of valleys, including the Callejón de Huaylas. The Central Cordillera or Cordillera Blanca contains high peaks and substantial glaciers. In central Peru, the western and central Cordilleras merge; farther south in Peru, there can be found a complex array of ranges and high basins, including the basins of Junín, Huancavelica, and Ayacucho, with good soils and moderate temperatures suitable for agriculture.

The eastern range of Peru, the Cordillera Oriental or Cordillera Real, extends south into Bolivia. Facing the humid Amazon Basin, this range has lush forests. Powerful rivers such as the Huallaga, Apurimac, Mantaro, Urubamba, Ucayali, and Marañon have cut deep river valleys on their way to the Amazon lowlands, with highly diverse environmental gradients and great importance for cultural history (Gade, 2015).

Near the Peru–Bolivia border, the eastern and western Andean ranges separate further, enclosing a wide high plain, the Altiplano. On the eastern side, the Cordillera Oriental (Cordillera Real) includes many high peaks, with incised valleys (*yungas)* and complex groups of lower ranges. In this eastern region can be found the Cochabamba valley. To the west, the dry Cordillera Occidental includes many volcanoes. In between, the high Altiplano includes both freshwater (Titicaca) and saline lakes and salt pans which have been subject to recent drying events; the brine pools of Bolivia contain one of the world's major reserves of lithium.

South of Bolivia, on the eastern side of the Andes, can be found a series of north–south trending valleys, or *bolsones*, including the sites of the contemporary cities of Jujuy, Salta, and Tucumán. Otherwise, the southern Andes constrict into a relatively narrow high range. The cooler climates have resulted in extensive past and present glaciation and, unlike the tropical Andes, agriculture is not possible at higher elevations. Chile's fertile Central Valley is located between the Andes and a lower Coastal Range; it receives water from the snowcapped peaks to the east, and benefits from soils renewed by volcanic eruptions. Farther south, the ocean occupies the valley between the Coastal Range and the Andes, while the peaks of the Coastal Range appear as islands such as Chiloé, which remain suitable for temperate crops such as potatoes. Fertile lands east of the Andes at Mendoza and elsewhere also benefit from Andean water supplies.

The far southern Andes is bordered by the cold Patagonian Desert to the east, and cold, humid forests to the west, with limited suitability for agriculture. Past and present glaciation is widespread, with numerous lakes and opportunities for mountaineering tourism in places such as Bariloche. Fiords are common, and flooded glacial troughs include the Strait of Magellan (separating mainland South America from Tierra del Fuego). The southernmost peak of the Andes protruding from the ocean is the island of Cape Horn.

EARTHQUAKES AND VOLCANISM

The formation of the Andes has resulted in frequent earthquakes (Giesecke et al., 2004). Although earthquakes can occur anywhere, the pattern of documented severe earthquakes since 1600 indicates some regions are at special risk. These areas include the Venezuelan Andes (Caracas and Merida were destroyed in 1812) and the Andes in northern Ecuador (Riobamba was destroyed in 1797; Ibarra and Otavalo in 1868, and Ambato in 1949). Trujillo in northern coastal Peru experienced major earthquake damage in 1619 and 1725, while in the northern Peruvian Andes, the Callejón de Huaylas experienced an earthquake in 1970 that triggered avalanches killing perhaps 70,000 people. Lima was destroyed by an earthquake in 1746 (which included a tsunami). Cusco experienced major earthquakes in 1650 and 1950. The coastal regions of southern Peru and northern Chile have experienced major earthquakes (Arica and Arequipa, 1868), as have cities farther south in Argentina (Mendoza in 1861 and San Juan in 1944) and Chile (Valparaiso in 1906, Chillán and Concepción in 1939, and Valdivia in 1960).

These earthquakes destroyed many buildings, especially those built of adobe. Often earthquakes disrupted transportation and irrigation infrastructure and sometimes led to the relocation of cities (as occurred in Riobamba). It is difficult to estimate death tolls, but estimated deaths frequently ran into the tens of thousands. All of the listed earthquakes had substantial impacts on society and politics (Buchenau and Johnson, 2009).

Volcanic hazards are also widespread in the Andes, including corridors of volcanoes extending (1) from central Colombia to central Ecuador, (2) from southern Peru through Bolivia to the northern Chilean Andes, (3) in central Chile, and (4) far southern Chile. Volcanic hazards include lahars (mudflows caused by melting snow and ice), catastrophic caldera[1] eruptions, as well as (usually less catastrophic) ash falls. A notable eruption of the Quilotoa volcano in 1280 devastated settlements and agriculture in much of what is now Ecuador and may have affected global climate (Mothes, 1999). A major eruption of Huaynaputna near Arequipa in 1600 killed many and also apparently affected global climate. An eruption at the Nevado del Ruiz in 1985 in Colombia caused the icecap to melt; the resulting mudflow buried the town of Armero, causing about 25,000 deaths. Other eruptions may have affected the course of cultural history, and volcanic deposits offer a promising resource for dating buried archaeological sites. Volcanic ash events usually do not cause many deaths, but may create hazards for human and animal health and difficulties for transportation.

Volcanic monitoring equipment and observatories have been set up at multiple sites in the Andes, with warning systems for the evacuation of susceptible populations if needed. However, volcanic regions often have high population densities, since volcanic soils (andosols) can be highly fertile and attractive to farmers, including (in modern times) the coffee plantations of Colombia, wine grapes in Chile, and the flower plantations of high mountain regions in Ecuador (Knapp, 2017). Volcanoes also provide water resources (ice caps and lakes formed by volcanic deposits), and scenic resources for tourism.

The Andes contain many ore bodies that have been exploited by various cultures. Gold is widespread both in subsurface lodes and in placer deposits; the latter have been exploited for thousands of years. Major silver deposits are located in the central and southern Andes. Localized salt deposits have long been exploited. Many other minerals including tin, copper, nitrates, and lithium have been economically important.

CLIMATE

Temperature patterns and altitude

Climates are characterized by average temperature and precipitation patterns, including average seasonal variations and possible hazardous events. As first demonstrated by von Humboldt (Wulf, 2015), average temperatures vary predictably by latitude and elevation. Near sea level, the tropical Andes experience no frost and minor seasonal variations. The southern Andes are located outside the tropics, so can experience severe winters. During the southern hemisphere winter (June–September), cold fronts (*friagems*) can penetrate as far north as the equator, causing unusual drops in temperature and rainfall events even at high elevations.

Because temperatures drop with increasing altitude, the Andes exhibit altitudinal variations in plant and animal life and agricultural potential. Various schemes of altitudinal zonation have been created by geographers; one of the best known, for the tropical Andes, involves four zones: *tierra caliente, tierra templada, tierra fria*, and *tierra helada*. Tierra caliente, below about 800 meters, has typical tropical temperature patterns and biota. Tierra templada, from 800 to 2,000 meters, lacks frosts but has more moderate temperatures, ideal not just for human comfort but also for optimal productivity of key crops such as coffee. Tierra fria, from 2,000 to 4,000 meters, can have frost, so is not suitable for tropical plants including crops; however, it can be ideal for other kinds of vegetation and crops, and is free of such insect-borne diseases as yellow fever and malaria. Tierra helada, from 4,000 meters up, has frequent frosts and very short growing seasons. It is normally not suited for agriculture, but has high grasslands (*puna* or *páramo*) suitable for grazing.

At the very highest elevations there may be permanent ice caps and glaciers. The Cordillera Blanca in north central Peru and the Quelccaya Ice Cap are the most extensive glaciated areas in the tropical Andes, and indeed in the global tropics. The Chacaltaya glacier in Bolivia served as the site of world's highest lift-served ski area until the glacier disappeared in 2009.

Although this four-zone scheme is common in textbooks, local people utilize different terminologies. Rather than distinct zones, the Andes tend to exhibit gradients of ecological change, with each species following its own altitudinal patterning. Also, in addition to altitude, slope and aspect play important roles, as do soil, precipitation, and geology. A variety of additional schemes have therefore been developed to classify and map environmental zones in the tropical Andes, both by local people and by scientists (Troll, 1988; Zimmerer, 2011a; Zimmerer, 2011b).

Precipitation

Precipitation in most of the Andes is sufficient for a native woodland vegetation (or agriculture without irrigation). In the tropical Andes, rain is associated with seasonal movements of the Intertopical Convergence Zone (ITCZ) which brings rain in the high sun season, which would peak in January in much of Peru and Bolivia. In those regions there is a dry season (*verano*) roughly from May to September. During the wet season (*invierno*) the landscape turns green and agriculture is possible without irrigation. That said, irrigation is often desirable to extend the growing season and/or cope with potential droughts.

In the northern Andes there may be dual dry seasons and dual wet seasons, or other patterns. The eastern flank of the Andes facing the Amazon basin may experience high rainfall amounts with an associated "cloud forest"; high rainfall amounts are also characteristic of the Pacific coast of Colombia. Very low rainfall may be associated with intermontane valleys where the "rain shadow effect" results in drying, descending air masses. These valleys may exhibit shrubby, thorny vegetation adapted to drought stress and may not be suitable for agriculture without irrigation.

The western flank of the Andes and the coastal plain become a desert (dry climate) from northern Peru to north central Chile. This is due to a variety of factors, including the rain shadow effect and persistence of a subtropical high-pressure cell off the coast. The Peru–Chile current off the coast is very cool; low temperatures are usually maintained as the prevailing easterly winds skim off warmer surface waters to be replaced by cooler subsurface waters (upwelling). The cool waters have multiple effects. Firstly, the upwelling brings nutrients to the surface that nurture a highly productive food chain including fish (such as anchovies) and seabirds. The seabirds defecate on islands, which create persistent deposits of dung (*guano*) that have long been an important resource for agriculture. Secondly, the cool water inhibits convective uplift of air masses, further reducing the potential for rainfall. This helps maintain the world's dryest desert. The chilled air can however result in fog and drizzle (*garúa*) which is captured by certain hardy plants that survive on fog drip.

The Peruvian and Chilean coastal deserts are crossed by rivers deriving from higher elevations. These create oases that have long been utilized for agriculture. Otherwise, vegetation may be sparse or absent, with sand dunes in some areas.

The far southern Andes have other precipitation patterns. Central Chile has a Mediterranean climate with hot, dry summers and cool wet winters, resulting in a patchy natural vegetation of woodlands, shrubs, and grasses and suitability for such Mediterranean-origin crops as wine grapes. Far southern Chile has a Marine West Coast climate with mild wet summers and cool wet winters suitable for extensive native forests. The eastern flank of the southern Andes tends to be dry, grading into the Patagonian desert in far southern Argentina.

ECOLOGY

Given the wide range of temperatures, precipitation, and altitude, the Andes are world's most ecologically diverse mountain range (Meserve, 2007; Young, Berry, and Veblen, 2007). The central Andes are adjacent to the Amazon basin, the world's greatest single storehouse of biodiversity with extensive areas of rain forest. Diversity is enhanced by the fact that South America was isolated from other continents after the breakup of Pangaea, allowing for the development of new plants and animals. It is part of the Neotropical Realm, with such originally unique groups as hummingbirds, toucans, anteaters, sloths, armadillos, New World monkeys, and caviomorph rodents (guinea pigs), as well as cacti and the ancestors of potatoes, cacao, cassava, and quinoa. When South America was united with North America via the central American land bridge, new animals and plants came from the north, including the ancestors of pumas, jaguars, and the spectacled bear.

The native vegetation of the more humid parts of the tropical Andes, including the cordilleras bordering the Amazon basin is a dense "montane" forest up to the tree line (3,500 meters or so). Oak trees have migrated as far south as Colombia, but in general the forests of the Andes lack many of the characteristic trees of temperate regions of North America; instead they consist of a number of broadleaf evergreen trees with a dense understory of shrubs. The stature of the trees tends to decrease with increasing elevation. There may be many epiphytes, including ferns, mosses, and orchids.

The dryer parts of the Andes may have shrublands, thorny woodlands, and/or cacti, while near the Peruvian coast there may be found a true desert with little or no vegetation except for knolls (*lomas*) watered by fog drip. In many cases, in both the humid and dry montane areas, the native vegetation was removed or impacted long ago by farmers; it can be difficult to reconstruct the original vegetation. Much of the

Figure 1.1 Laguna Llaviucu (3,168 meters) in Cajas National Park, Cordillera Real, Ecuador. The mountain slopes have a humid montane forest, with páramo (high grasslands) at the top. A major Inca route leading from Tomebamba (Cuenca) to the coast was located next to this lake. Studies of the lake show evidence of ecosystem changes due to climatic warming in recent decades (Michelutti, et al., 2016)

Photo credit: Gregory W. Knapp, 2014.

Andes today is a patchwork of farm fields, fallow, grazing lands, and introduced plantings of exotic trees such as Eucalyptus and pine. Native species may persist in hedgerows, steep slopes, isolated patches, and protected areas. There is much endemism, with species limited to small ranges (Young, Berry, and Veblen, 2007).

Unlike in most of North America where higher elevations contain a variety of conifers and "alpine" plants, high elevations of the Andes are characterized by herbs, small shrubs, and grasslands, called *puna* in the central Andes and *páramo* in the northern Andes (Figure 1.1). Currently the grasslands are maintained in part by fires set by humans. Since humans penetrated the Andes at the end of the last Ice Age, it is possible that these high grasslands have been largely extended and maintained due to human influence. Isolated high-altitude forests do exist, in areas protected from fire, including stands of *Polylepis*, the highest naturally occurring angiosperm tree in the world (White, 2013).

In the Southern Andes, the tropical species drop out. Central Chile has a Mediterranean climate with hot dry summers and cool winters, and a corresponding patchy vegetation of drought-tolerant shrubs and trees. Farther south, taller forests of the broadleaf *Nothofagus* genus are found.

CLIMATE CHANGE

Although normally cool conditions prevail in ocean waters off Peru, every few years a weakening of the trade winds diminishes the amount of upwelling, resulting in warmer conditions. These conditions can result in reduction of fish numbers, impacting fisheries, and can also result in increased rainfall from Ecuador to Chile. This is "El Niño," (the Christ Child, so called because the effects are often seen in December). Although it was first observed in South America, it is now known that this phenomenon involves climate changes worldwide. As a result, it is now referred to as ENSO (El Niño—Southern Oscillation). Worldwide effects are also associated with the opposite condition of extremely cold waters off South America; this has come to be called "La Niña" (Caviedes, 2001; Veblen, Young, and Orme, 2007, pp. 53–55).

Because it is a global event, many factors may be used to define ENSO events—air pressure, winds, ocean temperatures, and/or rainfall. Depending on which definition is employed, the sequence of defined historical ENSO events may differ. The U.S. National Weather Service Climate Prediction Center (2017) uses the Oceanic Niño Index (ONI) to define episodes. By this measure, the following years experienced Niño events: 1951–52, 1953–54, 1957–58*, 1958–59, 1963–64*, 1965–66*, 1968–69*, 1969–70, 1972–73*, 1976–77, 1977–78, 1979–80, 1982–83*, 1986–88*, 1991–92*, 1994–95*, 1997–98*, 2002–03*, 2004–05, 2006–07, 2009–10*, and 2014–16*. Starred events were especially strong. Not all events defined by the ONI resulted in catastrophic rains in South America. Also, not all catastrophic rains are associated with events defined by the ONI. For example, the catastrophic rains in Peru of early 2017 were not associated with an El Niño event as defined by the ONI and the U.S. National Weather Service. However, this event was in fact associated with localized warm waters and was identified as an El Niño by many in Peru. The phrase "Coastal El Niño" has been used by the South American media to distinguish between official global ENSO events and catastrophic local events.

El Niño rains can be devastating to desert locations unaccustomed to rainfall; normally dry watercourses fill with water causing flash floods (*huaicos*), which in turn can damage roads. Irrigation canals may be washed out. Sanitation systems may be damaged, resulting in outbreaks of such diseases as cholera.

The Niño event has apparently taken place for thousands of years, perhaps affecting cultural history. There is some evidence of exceptionally large Niño events, so-called "Mega El Niño events." In Southern Peru, such events have been documented by geomorphologists for approximately 700 and 1330 AD (Goldstein and Magilligan, 2011). In recent years, El Niño events have been correlated with the collapse of the Peruvian coastal anchovy fishery (1972–73) and extensive damage on the Ecuadorian coast (1998). As with all natural hazards, the human consequences of these events depend on societal responses, resilience, and adaptation.

It is still unclear whether changes in El Niño severity or frequency are correlated with other aspects of climate change, including anthropogenic global warming. It is possible that the increased frequency of severe Niño years after 1975 may have been an independently contributing factor for glacier retreats.

The Quelccaya Ice Cap, the largest glaciated area in the worldwide tropics, has provided additional evidence for climate change. Ice cores taken by Lonnie Thompson's team show long term changes in temperatures, with a relatively cool period between 1550 and 1850 AD flanked by warmer periods (Bowen, 2005). This has led some to infer possible additional connections between temperatures and the course of Andean civilization, but such connections remain tentative.

Since the 1970s, temperature and other records in the Andes show considerable warming, in addition to the effects of Niño events (Michelutti et al., 2016). This is consistent with expectations of anthropogenic global warming associated with the increase in greenhouse gases and the associated greenhouse effect. This warming has led to an upward movement in the altitudinal zones suitable for different crops and wild plants. For example, Humboldt's careful diagram of the zones suitable for various plants on Chimborazo (Zimmerer, 2011a) has been compared with modern distributions, showing that plants now are found at elevations hundreds of meters higher (Morueta-Holme et al., 2015). Because temperature and growing season are limiting factors for many plants, warming in the Andes has been associated with an expansion of the area suitable for agriculture, which is potentially a very positive thing. On the other hand, pathogens and insect vectors such as mosquitos have also been enabled to migrate upslope, creating potential problems for crop survival and human health.

Trends in precipitation are more complicated. Some areas have more rain while others have less, and climate models disagree on predicted regional rainfall patterns. Many farmers report changes in rainfall patterns, but these don't necessarily correlate with actual precipitation records. So far climate change models have not been helpful in unambiguously indicating precipitation changes in the future.

Andean glaciers provide water to watercourses, irrigation canals, urban water supplies, hydroelectric power, ground water, and wetlands. Since the 1970s, however, glaciers and ice caps have been rapidly shrinking throughout the Andes. The last glaciers in Venezuela are predicted to vanish in the near future. Although changes in El Niño frequency and precipitation may be factors, probably the major factor is an increase in temperature. Initially, glacial melt may increase delivery of water to watercourses, irrigation canals, and wetlands, but in the long run glacial shrinkage could threaten those dependent on runoff. Melting could also cause glacial lakes to burst their natural dams, resulting in flooding (Carey, 2010; Bury et al., 2013).

CONCLUSION

The unmatched diversity of Andean environments has provided extraordinary opportunities for varied human adaptations, including those utilizing multiple ecological zones. In principle, adaptation to climate change—by plants, animals, or humans— should be made easier by the availability of options to shift geographically to warmer or colder, and/or wetter or drier sites. However, organisms—including humans—have multiple requirements, and it may be difficult to exactly replicate them in nearby locations.

Although studies of Andean environments have tended to focus on temperature and precipitation, many other factors can be strategically relevant, including seasonality, susceptibility to hazards (earthquakes, volcanoes, El Niño, drought, frosts, and other climatic anomalies), presence of disease vectors, soil characteristics, and slope, for example. An environmental shock such as an eruption or drought may not necessarily be followed by a return to the previous state. Human activity has also impacted the Andes for 15,000 years through fire, agriculture, mining, hunting, and urbanization. Excessively static "ecosystemicist" approaches may be less useful than approaches focusing on adaptive dynamics, resilience, and secular change (Knapp and Cañadas, 1988; Knapp, 1991; Knapp, 2017).

The Andes mountains will continue to inspire many research trajectories for natural scientists, including the study of human impacts on the environment. They will continue to be appreciated as a source of resources, and respected as a site of unexpected events and hazards. Equally importantly, they will remain a source of inspiration for art and poetry, mountaineering and ecotourism, and even religious responses, which can complement scientific approaches to better understand these mountain worlds (Wulf, 2015).

NOTE

1 Calderas are large volcanic craters that have been formed as a result of volcanic eruption or the collapse of rock found on the surface into an empty magma chamber.

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CHAPTER TWO

THE DOMESTICATED LANDSCAPES OF THE ANDES

Clark L. Erickson

INTRODUCTION

Agriculture, including the farming of domesticated crops and herding animals (agro-pastoralism), is key to the development of settled life and civilizations. The domestication of plants and animals involving control of their reproduction and survival, selection for higher yields (better taste, color varietals, longer storage, and other traits) and related infrastructure took hundreds of years of experimentation and careful tending by humans. The result was an impressive complex of crops and animals suited to diverse needs and specific environments. Domestication also included the human built environment such as the creation of the domestic sphere and cultural landscapes from nature. The domestication of landscape involved intentional permanent changes to the natural environment to meet human needs, specifically the creation, transformation, and management of important resources. This domestication includes transformation of the environment for crops and economically important wild species of plants and animals, as a result increasing their numbers, quantity, and availability, often in competition with natural biodiversity. The process involved clearing of land; physically reshaping or "terraforming" the surface of the earth for fields, residences, roads, and other human features, and substituting natural biodiversity with agrodiversity.

Early Andean farmers faced an environment that was both challenging and of considerable potential due to its diversity, including deserts to tropical forests, sea level plains to glacial capped mountains. The Andean region is characterized by dynamic geological, climatic, and ecological systems with unpredictable and disruptive events such as droughts and floods caused by the El Niño phenomenon, earthquakes, landslides, and tidal waves, and longer cycles of climate change over time. Despite these risks, Andean peoples learned to thrive in this environment through their labor, ingenuity, and cultural practices, much of these expressed in landscapes of everyday life. Though only a brief survey of the rich complexity and variation of Andean agriculture across time and space, this chapter tries to capture the most remarkable and unique inventions, innovations, and landscape transformations of the pre-Columbian farmer.

DOMESTICATION, CROPS, ANIMALS, AND TOOLS

The processes of domesticating plants and animals; raising food that complemented or replaced hunting, gathering, and fishing; and the adoption of village life took thousands of years in the Andes. As in most societies, Andean farmers produce surpluses rather than a "hand to mouth" existence at a subsistence level for sustaining their social, economic, and political life.

Domestication of plants and animals began long before Andean peoples settled in permanent villages. Many crops (manioc, capsicum pepper, peanut, achira, and coca) were adopted from the tropical forest peoples in Amazonia or from Mesoamerica (maize) while other key crops (potato, quinoa, cañihua, sweet potato, isañu, oca, ulluco, pumpkin squash, lupine, cotton, lima and jack bean, lucuma, avocado, chirimoya, and pacae) were indigenous (Pearsall, 2008). Domesticated animals included llama, alpaca, guinea pig, and dog (Stahl, 2008). Increasing reliance on farming and herding over hunting, gathering, and fishing increased at the same time as the first appearance of public monumental architecture and irrigation around 3500 BCE (Haas and Creamer, 2012), although adoption of domesticates was not uniform in that crops appear late in some valleys. The demands of Andean social life inspired beer brewing (*chicha*), diverse cuisines, and expansion of farming and herding. Freeze-drying techniques and sophisticated storage structures provided a means of accumulating resources for times of need and support of social life (Peñarrieta et al., 2011).

Compared to Andean farmers' rich environmental, climatological, agronomic, and organizational knowledge, the tools they used were perhaps more simple but nonetheless quite effective. Often referred to as "hardware poor" (Donkin, 1979; Denevan, 2001), the primary tools are the *chaquitaqlla* (Q. *chaqui* = foot; *taqlla* = plow), mattock or hoe (A. *liukanas*), clod buster or club (Q. *watana*), and digging or planting stick (Donkin, 1979; Bourliaud et al., 1998), in addition to carrying cloths and baskets for moving earth. The chaquitaqlla is composed of a vertical shaft, a hand hold, and foot peg of wood, a blade (of either a wide flat extension of the vertical shaft, ground stone, chipped stone, copper, or bronze), all tightly bound by a long leather lashing. This tool is commonly used in teams with two men working at right angles to cut and raise sod, often with women turning the sod bock over to bury the surface vegetation to prepare the field for sowing.

Throughout late prehistory, Andean agriculture was intensive, meaning that farmers cultivated most fields many years in a row with short fallow or rest periods. Rotated camelid herds consumed sparse grass at high altitudes and its energy and nutrients were concentrated in potent dung deposited in corral areas (Winterhalder, Larsen, and Thomas, 1974). The camelid dung (of domesticated llamas and alpacas) was carefully collected into piles to dry and carried to plowed fields as an organic fertilizer for the first year's crop of potatoes. In high altitude above the tree line, camelid dung was burned as fuel for its high heat content and lack of smoke. Although many Andean communities were agropastoral, combining farming of crops and herding of animals, specialization often promoted a symbiosis between full time pastoralists at high altitude and farmers in the warmer valleys below involving trade of crops for camelid meat, wool, skins, and dung. Coastal farmers had access to concentrated bird guano on offshore islands, an abundant and rich fertilizer. Due to its high value, trade for guano extended throughout the southern Andes.

CULTURAL STRATEGIES

The key to the transformation of the Andean environment into a productive agricultural landscape was the use of traditional social institutions for the mobilization and organization of labor rather than development of a complex tool technology and/or use of draft animals. The basic organizational unit of Andean farming and herding communities is the *ayllu*. Although variable in form, the ayllu is made up of groups of related households with a common identity around a *pacarina* or place of origin and links to important past ancestors. Various ayllus are combined into moieties, a form of dual organization of individual communities whereby two paired moieties or "halves" compose a community (Murra, 1979; Weismantel, 2006). Nested ayllus can be also arranged hierarchically to form "macro-ayllus" when needed, such as for defense or war.

As in many regions of the world, the farm or herding family is the basic unit of labor. Traditionally, farm and pasture land was communal property except for family house plots and corrals. The community allotted sufficient land to support each family themselves and assigned fields were periodically rotated throughout the community territory. Community leaders controlled other lands for the support of local *huacas* or shrines and the cults of important ancestors and they drew upon the labor of the community to cultivate the land. The typical Andean community was dispersed in hamlets and small settlements throughout its territory; often, individual households maintained multiple houses to be close to fields, pasture, and other resources in various environmental zones and connected to neighbors for sharing labor and social life. The community's center was often highly visible cemeteries with houses of the dead (*chullpa*) dedicated to important ancestors which legitimatized the right to use land, public plazas for ceremonies, and shrines for local sacred *huacas*, which were recognized and named places or objects of ritual importance for community identity (Salomon, 1995). In some cases, communities held land in distant regions and diverse ecozones to access non-local resources (a model also known as vertical archipelagos and zonal complementarity) (Brush, 1976; Murra, 1979). The long-term occupation of and identity with territory as a community ensured that the improvements to land and infrastructure made over centuries were passed down over generations.

Andean irrigation could range from small local operations to entire lower valley networks covering hundreds of square kilometers and in some cases even crossing drainage basins. Irrigation often required coordination of farmers organized along irrigation canals who were responsible for equitable distribution of water and the building and maintenance of canals, canal intakes, and other infrastructure (Treacy and Denevan, 1994). Farmers using irrigation could lower risk of droughts and farm the vast coastal deserts. The Andean practice of "field scattering" in multiple local environmental zones spread potential risk for farm families (Goland, 1992). Farmers also developed storage techniques for food preservation such as freeze-drying of tubers (*chuño* and *tunt'a*) and meat (*charqui*). Later they developed large, specialized below and above ground silos (*qolqas*) to survive bad years and store surpluses to finance non-subsistence social and political life (Peñarrieta et al., 2011).

Ayni is a traditional form of delayed exchange of labor and/or goods between farm families, which is especially important in times when coordinated labor is the most efficient way to plant, harvest, store, and process crops, and to shear animals

(Mayer, 2002). *Minka* is communal labor of multiple farm families organized by a sponsor, commonly a community leader, for construction of public works or farming community lands supporting the infrastructure and cults, often "paid for" by the sponsor through feasting and drinking. *Mit'a* is an advanced form of labor organization used by the Inca and, presumably, other Andean states (D'Altroy, 2003). In the past, Andean peoples paid their taxes to local, regional, and later imperial leaders through labor rather than crops, animals, or valuable objects. This practice involved several weeks or more a year of labor dedicated to public or state works by all adults. Thus, the labor tax was used to produce resources for the state on state-controlled farms, mines, and quarries, and was often used to expand agriculture into new areas through construction of terraces and irrigation networks or to create more efficient transportation such as roads, bridges, waystations, and pasture for llama caravans (D'Altroy, 2003).

FARMING AGROSYSTEMS

Dry fields/permanent fields

Most Andean farming was done in simple fields (*chacra*) watered by rainfall and periodically fertilized. The earliest and simplest fields were relatively unmarked spaces that were infrequently used. To restore and maintain fertility, fields were regularly fallowed, often over longer periods than the years in cultivation. The early fields had little formal built environment that is characteristic of more intensive forms of agriculture, thus remaining largely invisible in the archaeological record. The constant encounter of stone during each year of cultivation and its placement on the edges of fields in year after year of plowing created permanent rock piles and wall features marking past cultivation. Over time, considerable investments in time and energy were taken to maintain and sometimes increase production. With the continuous use of landscapes and growing populations, these mundane fields gradually acquired formal walls and other field boundary markers, canals, aqueducts, level surfaces for terracing, and crop rotation systems (Denevan, 2001). Everyday life in farmed landscapes required movement and circulation among households, fields, pasture, water, and other resources spread across space, resulting in complex networks of paths, trails, roads, ramps, and stairs that were permanently inscribed in the landscape (Erickson, 2000).

Stone-walled corrals of herders at high altitude are used to gather and protect camelids at night. Their dung accumulates in the floors and after many years the corral is taken out of use. The fertile space now can be used to cultivate potatoes, which thrive in the rich soil and within the protection from the elements and thermal heat provided by the walls, thus permitting their cultivation far above the range of most crops where frosts are common.

Raised fields

Raised fields (Sp. *camellones*, Q. *waru waru*, A. *suka kollus*) are one of the most impressive and well-studied forms of Andean agriculture and have been documented in the highlands, coast, and tropical lowlands (Erickson, 1992; Kolata, 1993; Denevan, 2001; Figure 2.1). Raised fields are generally found in flat areas that are

Figure 2.1 Experimental raised field planted in potatoes in Huatta, Peru in 1982
Photo credit: Kay L. Candler.

prone to shallow seasonal flooding and/or high waterlogging, often located in natural or artificially enhanced wetlands. Sufficient local drainage must be created for crops to survive these conditions; thus farmers created alternating raised earthwork platforms and canals of consistent patterns of groupings, orientations, wavelengths, and sizes. Rectangular flat platforms are made of earth excavated from adjacent canals. The process of construction, in effect, doubles the depth of fertile topsoil, provides local drainage, and creates a dry surface for farming.

The canals trap, capture and store water from rain, runoff, river and lake flooding for use for crops on the platforms through percolation to the root zone or direct application as irrigation. These water-filled canals provided a “green manure” and other nutrients in the form of waterborne sediments from nearby hillslopes and topsoil eroding from the field platforms; decomposing blue-green algae, totora reed, duckweed, and crop debris; and animals such as frogs, fish, snails, insects, and aquatic birds that thrive in this habitat. A complex web of interconnected raised field canals can be opened for drainage of excess water or closed for capture and storage of water, depending on farming needs. Long straight canals radiating from settlements on nearby hills and mounds in the wetlands provide aquatic navigation routes for access to households, raised fields, and open water in the wet season and serve as roads during the dry season. Experiments have shown that standing water in the canals can store solar energy as heat that warms the air and soil of surrounding raised field platforms, providing protection against frequent frosts (Erickson, 1992; Sánchez de Lozada, Baveye, and Riha, 1998).

Although raised fields cycled in and out of use at various times in prehistory and were finally abandoned with the Spanish Conquest, experimental archaeology and programs to rehabilitate pre-Columbian agriculture have shown that raised fields can be highly productive and efficient, despite the initial high labor costs of their construction. Debates about their role in pre-Columbian lifeways and status as sustainable agriculture have been intense (e.g., Erickson, 2003; Swartley, 2002; Bandy 2005; Baveye, 2012; Renard et al., 2012).

Terraces

The most visible transformation of landscape for agricultural production was the establishment of dry and irrigated terracing (Q. *andenes*, A. *pata pata*) on steep slopes throughout the Andes (Donkin, 1979; Figure 2.2). Terracing probably began with simple earth berms protected by vegetation running along slope contours (lynchettes) and later developed into formal stone faced retaining walls and fill to level them. Most Andean terraces continue in use today, although they tend to be poorly maintained and many have been modified or destroyed through mechanized agriculture. Formal terracing involves the excavation of a wall foundation ditch along the contours of a hillslope, construction of a sturdy stone retaining wall, and the cutting into the slope for earth fill to level a platform for crops behind each wall. In general, at the same level of a terrace wall top and platform surface, the base of an adjacent terrace wall upslope is constructed, creating a continuous stair-like

Figure 2.2 Terraced landscapes of the Colca Valley, Peru in 1985

Photo credit: Clark L. Erickson.

arrangement from valley floor to ridge top in many valleys—a monumental landscape of everyday life. Pre-Columbian terraces are estimated to cover large areas of the Andean highlands (Donkin, 1979; Denevan, 2001).

Terraces can range from simple isolated earth faced platforms to complex networks of well-built stone-faced architecture covering mountain sides. The simplest are lynchettes, where a row of dense vegetation (such as maguey or grass) is planted along a slope contour and erosion gradually and passively fills and builds up behind the living wall to create a flattened planting surface. The most complex examples are bench terraces, carefully engineered massive retaining walls supporting stone buildings and fields of important Inca sites such as Machu Picchu, Chinchero, Ollantaytambo, Moray, and Cuzco. Bench terraces often had carefully layered soil fills of graded rock and earth, from coarse on the bottom to fine on the top, which permitted internal drainage and prevented waterlogging, collapse, and landslides (Treacy and Denevan, 1994; Donkin, 1979). Most terrace walls were constructed of local fieldstones collected onsite during surface clearing and construction, often rolled or slid downslope from above. Farmers often incorporated projecting stones in walls that served as stairs to allow movement vertically up and down field systems; wall niches for storage or refuge for workers during storms; irrigation canals to distribute water; water drops or slides from one field to the next; and stones of contrasting colors to create simple patterns.

Although terracing is a recognized strategy of soil conservation, Andean farmers note that the purpose of terracing is to create flat surfaces to distribute irrigation water, runoff, and/or rainfall evenly and effectively (Treacy and Denevan, 1994). Water was often brought from distant glacial sources through irrigation canals winding around mountain slopes to be distributed where needed. The addition of irrigation increased crop production, reduced risks of drought, and allowed multiple crops per year. By terracing, farmers also took advantage of warmer slopes above low-lying areas where freezing air from frosts drains and accumulates at high altitude (Grace, 1983; Earls, 1989).

Although considerable cooperative community labor is necessary to construct well-built terraces, once constructed the fields can produce for decades with about the same labor input as a dry, rainfed field. Despite abandonment, no soil amendments, and lack of maintenance over the past 500 years, terrace soils maintain considerable fertility and many are still in use (Sandor and Eash, 1991; 1995; Goodman-Elgar, 2008; Nanavati et al., 2016).

Sunken gardens

Qochas (Sp. *chacras hundidas, pozas, ojos de agua*; Q. *q'ochas* or *kochas*; A. *q'otanas, cotaña, cota*) are shallow artificial "sunken" gardens or heavily modified natural ponds, lakes, and sinkholes that are used to manage water and other resources (totora, algae, organic matter, small fish) for agriculture (Figure 2.3). The best studied are the qochas of Lake Titicaca (Flores-Ochoa and Paz 1983; Albarracín, 1996; Craig et al., 2011). Some scholars argue that the sustained use of qochas in the Ramis River basin is possible due to a thick impermeable clay layer that created a perched or high-water table (Craig et al., 2011). While this geological insight explains the high density of these features in this location, the thousands of similar features throughout

Figure 2.3 Sunken garden prepared for potatoes (foreground) and sunken garden in fallow with water (background) near Nicasio, Peru in 1985

Photo credit: Clark L. Erickson.

the region demonstrate widespread use of the technique in a variety of contexts. Qochas have been dated to the Early Intermediate Period (200 BCE–600 CE) and continue in use today. Most show evidence of having been excavated in low-lying areas to reach the water table and capture rainfall. The management strategy is impressive. When they are not farmed, the water bodies accumulate organic matter in the form of aquatic plants and sediments over a period of years. Totora reeds used for thatch and reed boats can be cultivated and small fish raised. The qochas are then drained and the now dry and fertile surfaces planted with potatoes and other crops over a series of years. Qochas managed by a family or ayllu are often interconnected by complex networks of canals that regulate water levels.

Another form of sunken gardens characteristic of the coastal valleys are *mahamaes* (Q. *wachaques*), which are located on the coast of Peru (Denevan, 2001; Lane, 2014). In the wide deltas in the lower course of these rivers, most river water has been tapped for irrigation far upstream. Farmers found that they could dig through the desert to recapture irrigation water lost to seepage and access ground water, often meters below the surface to create fields with excavated fill forming rectangular grids of low berms.

Filtration galleries

Throughout the highlands and southern desert coast of Peru, a sophisticated means of obtaining water from deep aquifers for irrigation using underground aqueducts was developed. Filtration galleries or *puquios* are either an open trench or a horizonal gallery/tunnel that serve as canals to capture and direct underground water to the surface for irrigation (Barnes and Fleming, 1991; Schreiber and Lancho, 2003; Lane, 2017).

Trench puquios are dug down to the water table with the floor of the trench slightly sloped to direct flow towards irrigation canals and fields in the river floodplains, often over long distances. To prevent erosion, the open walls of the trench are lined with stone (Schreiber and Lancho, 2003). Where the soil is compact and stable, a gallery puquio—a long horizontal tunnel excavated through the earth to the water table—is constructed. In unstable soil, trench puquios are made and the walls are then stoned lined, roofed with wood beams, and covered with a deep layer of soil to create a narrow tunnel or filled-trench gallery. In both types, the size of the tunnel can vary from a crawl to walk space. A series of stone-lined vertical shafts from the ground surface to the tunnel provide light and access for periodic maintenance. Puquios often combine both trench and gallery structures throughout their course and many are still in use.

Scholars debate whether the puquios are indigenous or introduced by Europeans. Similarities between gallery puquios and the widespread *qanāts* of north Africa and the Middle East and early historical documents mentioning the technique are used to argue for late introduction (Barnes and Fleming, 1991). Association with Nasca Period sites (400–500 CE), artistic representations, and the long history of desert occupation by farmers in the region have been used to claim pre-Columbian origins in the Nasca and Ica valleys (Schreiber and Lancho, 2003).

Canal irrigation

In addition to experiencing frequent drought, much of the Andean region is arid or has irregular rainfall, making agriculture risky. In a manner similar to other indigenous solutions practiced worldwide, Andean farmers developed irrigation to move water from locations where it was abundant to dry areas that were to be farmed. The process often involved complex hydraulic engineering and coordination over large valleys. Although used in the highlands to extend growing seasons and mitigate risks, the most impressive irrigation systems were established in the north coastal valleys where arid conditions predominate but good soils are present (Denevan, 2001; Lane, 2009).

In laying out contour canals over long distances, farmers had to be aware that if the water moved too fast, the sides of the canal could be eroded and breached; if flow was too slow, sediments built up and filled the canals. Construction through trial and error or possibly the creation of simple surveying devices using open containers of water established optimal grade levels for the volume of water necessary (Ortloff, 1988). High volume canals are often associated with other engineering works including aqueducts crossing ravines and valleys, stone retaining walls on steep slopes, water drops, and channel "friction" structures to dissipate some of the force of rapid and high flow (Ortloff, 1988). The most ambitious projects were three vast intervalley irrigation networks where long canals crossed adjacent river basins to increase crop production on the coast (Ortloff and Moseley, 2009).

The Andean region is dynamic and irrigation farmers had to constantly mitigate droughts, floods, and landscape changes. Tectonic uplift caused by the meeting of two continental plates which form the Andes mountains raises the ground surface 1.8 cm/year. Over time, the accumulated impact of this phenomenon is significant as rivers adjust by eroding deeper in the channels, thus increasing the distance upstream to where river water can be diverted into irrigation canals for fields in the desert along the rivers (Moseley, 1983). Over time, the locations for maximum capture of river water migrates to the base of the Andes where higher water velocity and landslides make the establishment of canal intakes impossible, resulting in reductions of irrigated areas.

Dams and reservoirs

Some Andean irrigation systems require collection and storage of water far upstream for use at various times of the year in fields below. Pre-Columbian dams and reservoirs of stone and earth with complex inlets, outlets, and other hydraulic engineering have been documented for many highland regions, and many are still in use tapping runoff and glacial melt (Salomon, 1998; Lane, 2009). Check dams are simple barriers of earth and stone built across ravines and narrow valleys in dry areas to capture and retain infrequent runoff water and rich topsoil eroded from above for cultivation and conservation of resources.

Channelized rivers and other flood control engineering

During El Niño years when periodic and abrupt changes in ocean temperature and currents disrupt global climate, heavy rains cause flooding. When previous major earthquakes have loosened soil structure, these events cause massive erosion and landslides of mud and rock, which in turn lay down thick sediments in fields and canals in the coastal valleys (Ortloff and Moseley, 2009; Sandweiss et al., 2009). The earth berms of the mahamae of the same area have been proposed as flood control structures to protect the sunken gardens from similar fate (Knapp, 1982). By the Initial Period (1800 BCE), massive earthen flood barriers and diversions were constructed in Lurín Valley to protect temples and fields from the periodic waves of water and soil from the mountains (Burger, 2003).

The most impressive hydraulic feat was the channelization of the Vilcanota/Urubamba rivers near Cusco (Farrington, 1983). According to colonial documents, the Inca empire mobilized 40,000 workers who worked for many years to straighten and contain the meandering river by temporarily rerouting water for the construction of a massive stone-walled channel of tens of kilometers to serve as the new course. While this massive undertaking provided flood control and additional farmland, the primary goals may have been to straighten the river for aesthetic effect and to show political power.

Artificial pasture

Bofedales (Sp. *bofedal*, A. *oqho*) are large, high altitude spring-fed wetlands or bogs traditionally used for grazing of camelids. In Andean ethnography and historical documents, bofedales can be classified into three types: natural spring-fed wetlands, artificial wetlands created through irrigation, and enhanced natural wetlands through

Table 2.1 Guide to Andean agriculture landscapes on Google Earth

Type	*Location*	*Longitude/latitude*
Raised fields (*waru waru, suka kollu*)	Huatta	15°37'29.39"S 69°59'15.83"W
Terraces	Pomata	16°17'42.49"S 69°19'21.01"W
Canal irrigation	Casma	9°29'2.44"S 78°22'5.35"W
Sunken gardens (*qochas*)	Corpa	15°11'4.83"S 70°14'41.37"W
Sunken gardens (mahamaes)	Chilca	12°31'17.02"S 76°45'12.80"W
Irrigated pasture (*bofedales, oqho*)	Nunoa	14°34'12.16"S 70°31'45.77"W
Filtration Galleries (*pukios*)	Cantayo	14°49'35.71"S 74°54'37.28"W

addition of canals (Palacios, 1977; Erickson, 2000; Maldonado, 2014–2015). Bofedales often involve the construction of long canals tapping water from distant springs and a network of dendritic secondary canals to distribute water over a few hectares to many square kilometers. A bofedal under artificial irrigation provides forage year-round, thus solving the problem of seasonal availability for camelid caravans carrying cargo to camps and waystations along trails and roads. Large herds of alpacas, the most valuable of the camelids for their wool and meat but with more finicky diet, thrive on the artificial pasture of bofedales. Irrigated bofedales take years to establish and are easily degraded through overuse or neglect; thus, they require considerable maintenance and protection (Palacios, 1977).

The Inca state established additional large bofedales along the *Qhapaq Ñan* or royal road, a network of over 30,000 linear km. Combined with corrals, storage, and lodging in waystations or *tambos*, bofedales met the needs of large traveling llama caravans transporting resources throughout the empire (Hyslop, 1984; Arkush and Marcone, 2017).

PEOPLE AND THEIR LAND

When traveling through the Andes, visitors soon come to appreciate how pre-Columbian farmers and their communities over time transformed a highly diverse environment into a highly productive cultural landscape that eventually sustained millions of people and civilizations. While obviously created for practical reasons through human agency, the Andean landscape also holds allure due to the rich geometric patterning of agricultural fields and farm infrastructure, often distributed continuously from valley bottom to mountain top, creating a stunning visual pattern of diverse colors as crops mature and a vibrant example of everyday life at harvest time of farmers where still farmed. Even where abandoned and in ruins, the permanent landscape features of terraces, raised fields, qochas, irrigated fields, and other features built long ago remain impressive and can be appreciated as landscape art, memory, and community pride. The finest works of civilizations are often considered "monumental": aesthetically pleasing, valuable cultural heritage, highly patterned, and beyond practical function often involving enormous amounts of labor, energy, materials, and engineering (Burger and Rosenswig, 2012). One could consider Andean terracing, raised fields, and irrigation in which entire environments were converted into vast productive cultural landscapes as monumental in terms of labor, engineering, patterning, and aesthetics (Erickson, 2013). To the many generations of farmers who created and inhabited these farmed spaces, the landscape represented community, territory, ancestors, sacred places, memory, legitimacy to occupy and use, and at times, political power.

Traditional Andean agriculture is considered by most scholars to have been sustainable and appropriate within its temporal and spatial context. Sustainability in this case implies that society lives off the "interest" without drawing upon or exploiting the "capital" of available agricultural resources. Andean farmers were continuously adding additional resources and potential for surplus production through their labor and engineering over generations. Archaeologists have shown that Andean agriculture supported large and dense urban and rural populations over considerable periods of time on landscapes that are often considered marginal for modern agriculture. Some scholars argue that the contemporary world has much to learn from these time-tested technologies and practices (Kendall, 2005; Erickson, 2003; Renard et al., 2012).

Why have many of these landscapes, farming practices, and crops documented for the pre-Columbian past disappeared or been abandoned? In some cases, climate change may have been a factor (Ortloff and Moseley, 2009), but Andean societies have always faced this adversity and developed strategies of survival and resilience (Erickson, 1999). The most significant reason was massive demographic collapse due to the introduction of Old World diseases, civil wars, and population relocations after Spanish conquest of the Andes. Introduction of foreign crops, animals, and political economies; inequality and colonialism; harsh native labor exploitation; unequal land distribution and land appropriation; and urban migration over time have transformed how contemporary Andean peoples use and maintain landscapes (Newson, 1993). Despite these dramatic changes, threats, and risks, many Andean farming communities continue to thrive by relying on time-tested elements of traditional labor organization, farming techniques, crops, and animals, however modified.

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CHAPTER THREE

WATER AND POWER IN THE PERUVIAN ANDES

Barbara Deutsch Lynch

ANDEAN WATERSCAPES

In his novel *Yawar Fiesta*, Jose Maria Arguedas tells how indigenous peoples' control over water high in the mountains of Ayacucho becomes a source of leverage over the more powerful *mistis* (non-indigenous Peruvians, in this context) who hold valuable arable lands, but depend for irrigation on water from springs that dot high altitude community grazing lands. The conflict that Arguedas dramatized has played itself out since Europeans arrived in the Americas, and very likely earlier. The cast of characters has changed, but the struggle continues as government agencies, international institutions, energy producers and agribusiness enterprises seek to control waters that are vital to the livelihoods of highland communities. Arguedas also shows that by its very nature water is simultaneously social and physical, connecting ecosystems, people, places, cultures, and economic activities in hydrosocial systems and shaping Andean waterscapes (Arguedas, 1985).

In the Andes, water gives life and destroys it. It must be respected, placated, and carefully governed. This entails protection of water bodies and aqueous ecosystems, disaster prevention, and allocation to competing water users in the face of extreme spatial and temporal variation. Peru has more fresh water per person than any other South American nation (Olson, 2006), but nearly 98 percent goes to the sparsely populated Amazon basin. The Pacific drainage, which includes the arid coast and much of the Sierra, receives less than 2 percent although it is home to 86 percent of Peru's inhabitants and most of its agriculture and industry. Access to water also varies with altitude and location with respect to springs, streams, and rivers, which are often deeply entrenched, flowing through narrow canyons or *quebradas*. Water supply varies widely seasonally and from one year to the next. During El Niño events, Sierra droughts are coupled with rain and flooding on the coast. Northern Peru's coastal deserts may turn green, providing pasture for thousands of goats, only to dry out a few weeks later. Climate change also contributes to glacial melting and to greater variability in water supply.

To make water available for crops and domestic use, fast-flowing streams are diverted into elaborate networks of ditches or *acequias* and stored in reservoirs or *cochas*. Acequias range from hand-dug earth structures to formidable engineering works that channel water for kilometers along the edge of steep canyons at an even grade, delivering water to a network of canals that distribute water to farm fields. No matter how well built, irrigation infrastructure is easily damaged by landslides, floods, and earthquakes. Canals must be cleaned every year. Reservoirs silt up and must be repaired. Managing variability entails decision making, administration and the mobilization of labor for system operation and maintenance.

In sum, the factors that shape Andean hydrosocial systems are complex. Therefore, to understand the role of water in the region, one must take into account the extraordinary hydrological and environmental variability of the region, the varied local and national institutions that have governed water access and use over time, and the implications of land tenure patterns and industrial activities for different watersheds and the people whose livelihoods depend upon them. This chapter begins by offering some tools for thinking about hydrosocial systems in the Peruvian Andes. It then shows how water has shaped Andean societies over time, with an emphasis on the twentieth century, which brought new forms of state intervention in water governance It concludes with a discussion of the water stresses that emerged in this century, the reform project intended to control them, Andean responses to both, and their implications for water and power in the wake of the reform.

WATER, NATURE, AND POWER

While many Andean waterscapes predate human settlement, they have become cultural artifacts, shaped and governed by social practices, norms, and rules. The ways that different social groups understand water and the power dynamics that govern interactions among these groups reconfigure hydrology on the ground.

WATER AS CONNECTOR

Orlove and Caton (2010) emphasize water's role in connecting people, places, ecosystems, and economic activities ranging from smallholder cultivation and livestock production to massive agribusiness and extractive enterprises. As Arguedas showed, water connects high-altitude *puna* grazing lands with downstream cultivated zones and towns. It also connects the city and the country: the conflict that shook the Bolivian city of Cochabamba in the year 2000 seemed, at first glance, to be an urban event catalyzed by the takeover of a municipal water system by a transnational corporation. But, while intense protest occurred in the city, nearby farming communities also participated fully in the conflict.[1]

In the Andes, water also connects the quotidian to the cosmic, the present to the past, and people to place. According to Andean origin myths, ancestors of the region's peoples arrived at their lands by travelling underground from a point in Lake Titicaca to springs on the lands belonging to their descendents. Irrigators see their labor in irrigation system operation and maintenance as validating their rights not only to use water, but also to cultivate the lands to which the water belongs (Sherbondy, 1998). Water connects diverse economic activities, provoking tensions when water uses are incompatible. Lastly, water connects the social and the natural, erasing the distinction between the two.

In light of these connections, international water policies emphasize integrated water resource management (IWRM). IWRM proponents view the watershed as the natural unit for water governance, but watersheds are not independent hydrosocial systems. Regional, national and international actors—public and private—make decisions that affect water allocation and use and reshape Andean watersheds (Budds and Hinojosa, 2012). For example, the recently constructed canals of the huge Chavimochic and Chinecas irrigation systems divert waters from the westward flowing Río Santa into seven additional watersheds. The Olmos project, also built with international capital, tunnels water from the Amazon basin under the Andes into the Pacific watershed. And the Majes project in Arequipa captures water high in the Andes, diverts it from Sierra farmlands and delivers it to the coast for irrigation, energy production, and urban water supply. We therefore have to think about hydrosocial systems as operating simultaneously at scales ranging from the farm field to the globe.

IS WATER AN ECONOMIC GOOD?

Peruvian government officials often view water as a resource to be used for maximizing economic growth. The use of the word "resource" in the term IWRM underscores the fact that international policy makers also see water as an economic good. This premise is codified in the 1992 Dublin Principles, which state that "water has an economic value in all its competing uses and should be recognized as an economic good." Economists working with international institutions often argue that water will not be used efficiently unless it is priced. Opponents of this position argue that pricing water and treating it as a resource inevitably entails dispossession and loss of access for those who depend on water for their livelihoods (Swyngedouw, 2006).

Irrigated agriculture is a key component of Andean livelihoods, and high-altitude wetlands (*bofedales*) and glacial lakes provide water for wildlife and domestic animals. Water in streams and ditches is used to mill grain, wash wool, and leach toxins out of food plants like quinoa and *tarwi* (an edible lupine also known as *chocho*). Seepage from unlined acequias—which irrigation engineers view as waste—nourishes plants that feed small animals. Fish from highland lakes are a key component of livelihood strategies, and in recent decades, fish farming has expanded to serve a growing tourist market. These activities are undervalued by the Peruvian state.

Policymakers argue that mining and energy production make more significant contributions to the national economy. While neither industry is seen as consuming much water, they have had massive environmental impacts. Mine and processing waste can render water too toxic for irrigation, livestock, or human consumption. Hydropower can be sustainable as in the case of microhydro systems that light small towns and villages by rechanneling irrigation waters after dark. In contrast, big dams displace farming communities and divert water from where it is needed for agriculture, livestock, and domestic use (Urteaga, 2014). At the end of the day, allocation of water to particular activities depends on legal stipulations, the power of dominant economic actors, and the ability of those without power to mobilize in resistance to elite water capture.

Poder hídrico

Peruvian anthropologist Gerardo Damonte and co-authors (2016) use the term "*poder hídrico*" (power over water) to analyze these relationships. They ask how certain groups in society gain the ability to direct the flow of water in ways that serve their interests. At an individual level, poder hídrico is having a right to water and the ability to exercise that right. At a societal level, it is the power to make and enforce rules governing the definition and allocation of water rights, access to water, and the protection of bodies of water from contamination. Enforcement includes the ability to monitor, and to produce and disseminate information about water flows and quality in forms that are seen as legitimate, as well as the power to enforce rules and to exclude others from access whether by requiring cash or labor payments or through use of coercion. Access to water may be limited to members of water user associations invested with the power to make and enforce rules governing allocation. While some associations in highland Peru enjoy legal recognition, others do not (Boelens, Guevara Gil, and Panfichi, 2010). This puts the latter at a disadvantage in competitive situations. Poder hídrico can also refer to the ability to move water away from rivers and lakes and into irrigation ditches, industrial plants or urban water systems.

At a discursive level, poder hídrico is the power to define some uses of water as legitimate and others as illegitimate, to label some as essential and others as marginal, and to decide whose knowledge about water counts and what kind of knowledge counts. How, for example, does knowledge about the ways in which plants use water or about the impacts of pollution on public health rank in comparison to information about the performance of different kinds of hydraulic infrastructure? In Peru, the power to define the terms of water governance at the national level rests with an elite cadre of irrigation engineers associated with the National Agrarian University at La Molina and belonging to an international community that includes experts from the World Bank, the InterAmerican Development Bank, the FAO, and international consulting firms (Oré and Rap, 2009).

Discursive power includes the ability to assign meaning to water. Boelens and Seemann (2014) find that the ways in which government officials, international donors, and NGOs understand water security problems and the solutions that they propose "are often entirely different from the way that marginalized user groups and highland communities themselves define water (in)security." For Andean social movements "el agua es la vida"—water is life, a fundamental component of landscape, culture, and cosmos. This complex construction contrasts sharply with the IWRM understanding of water as an economic good and the neoliberal conceptualization of water as a resource to be allocated to its "highest and best" use, but it has a long and distinguished history in the Andes.

ANDEAN HYDROSOCIAL SYSTEMS IN HISTORICAL PERSPECTIVE

The waterscapes that evolved over the course of human occupation of highland Peru form the template for many contemporary hydrosocial systems in the sierra. They have been built upon and contain infrastructural elements like canals and small reservoirs as well as technological information and management rules that date to the