A Native American System of Wetland Agriculture in Different Ecosystems in the Ecuadorian Andes (15th–18th Centuries)[1]

CHANTAL CAILLAVET

Centre National de la Recherche Scientifique – Paris.
Email : chcaillavet@hotmail.com

IN AFFECTIONATE MEMORY OF ELINOR MELVILLE

ABSTRACT

Ridged fields and wetland agriculture are a key element in the culture and ecology of pre-Hispanic societies, and their role often survived well beyond the immediate aftermath of the Spanish conquest. Their importance was highlighted in a series of groundbreaking publications which have appeared from the mid-twentieth century onwards.

In marked contrast to Mexico, however, there is much less historical data on this type of native agriculture in South America. Was this silence caused by these techniques falling into centuries of disuse on the arrival of the European colonisers? Or, despite ongoing use, did they fail to attract enough attention to surface in the literature?

In the absence of descriptions written by the Spanish chroniclers, what other types of historical sources provide significant information on native traditions of land use? Native voices are recorded in legal texts that Indians dictated to satisfy Colonial bureaucratic requirements: wills, declarations during land litigation, and judicial ceremonies associated with land possession.

In this paper, I have identified a range of archival sources which provide evidence of the nature, functions and ecology of these agricultural techniques in the northern Ecuadorian highlands.

KEYWORDS

Wetland agriculture, ethnohistory, camellones, Andes, Otavalo

Environment and History **14** (2008): 331–53. doi: 10.3197/096734008X333554

CHANTAL CAILLAVET

WETLAND AGRICULTURE AND RIDGED FIELDS IN LATIN AMERICA

Ridged fields and wetland agriculture are a key element in the culture and ecology of pre-hispanic societies, and in some areas they survived beyond the immediate aftermath of the Spanish conquest. Their importance was first established in a series of groundbreaking publications which appeared from the mid-twentieth century onwards. West and Armillas' study (1950)[2] of the famous 'chinampa' system of wetland agriculture in Mexico paved the way for a series of later studies in archaeology, agronomy and ethno-history. These provided valuable information on the use and functions of the 'chinampas' in the years after Contact. Research that stressed the economic and ecological success of these native systems drew on surprisingly abundant pre-Hispanic documentation, as well as, more predictably, the Spanish Colonial records.[3] Geographers, archaeologists and historians all clarified different aspects of pre-Columbian raised fields and wetland agriculture.[4] At the same time, research on specific wetland techniques clearly lies within the wider frame of reference of the study of pre-Hispanic landscapes.[5]

In terms of South America, pioneering research was carried out by Parsons and Bowen on the ridged fields of the Colombian San Jorge river flats (1966); near Lake Titicaca by Smith, Denevan and Hamilton (1968); and by Broadbent on the Andean highlands near Bogotá (1968).[6] Subsequent surveys of these fossil agrarian forms have established that they can be found in a variety of archaeological areas and climatic and ecological environments, ranging from cold highlands to tropical lowlands.[7] Nevertheless, in marked contrast to Mexico, there is much less historical data on this type of native agriculture in South America. Was this silence a result of these techniques falling into centuries of disuse on the arrival of the European colonisers? Or, despite their ongoing use, did they simply fail to attract enough attention to appear in the literature?

In the absence of any descriptions by the Spanish chroniclers, what other types of historical sources can provide significant information on native traditions of land use? The voices of the native peoples were recorded now and again, but indirectly, and only through the filter of Eurocentric forms of recorded history. Specifically, they can be traced in the legal texts that Indians dictated to acculturated Indian translators ('indios ladinos') to satisfy Colonial requirements: wills, declarations during land litigation, and judicial ceremonies associated with land possession. In these circumstances, the witness had to describe the land that he or she was bequeathing or claiming, and would frequently give very detailed information about its location, its key geographical features, climate and crops that were grown there. Place-names, too, were often mentioned. By compiling and comparing archival data of this kind from the northern highlands of Ecuador, the present-day provinces of Pichincha, Imbabura and Carchi (located between 1ºN and 1ºS), I have identified a range of evidence on the character

and functions of raised fields and wetland agriculture (see Figure 1). I was also able to establish the meaning of some local place-names that may be connected to native forms of land use.[8]

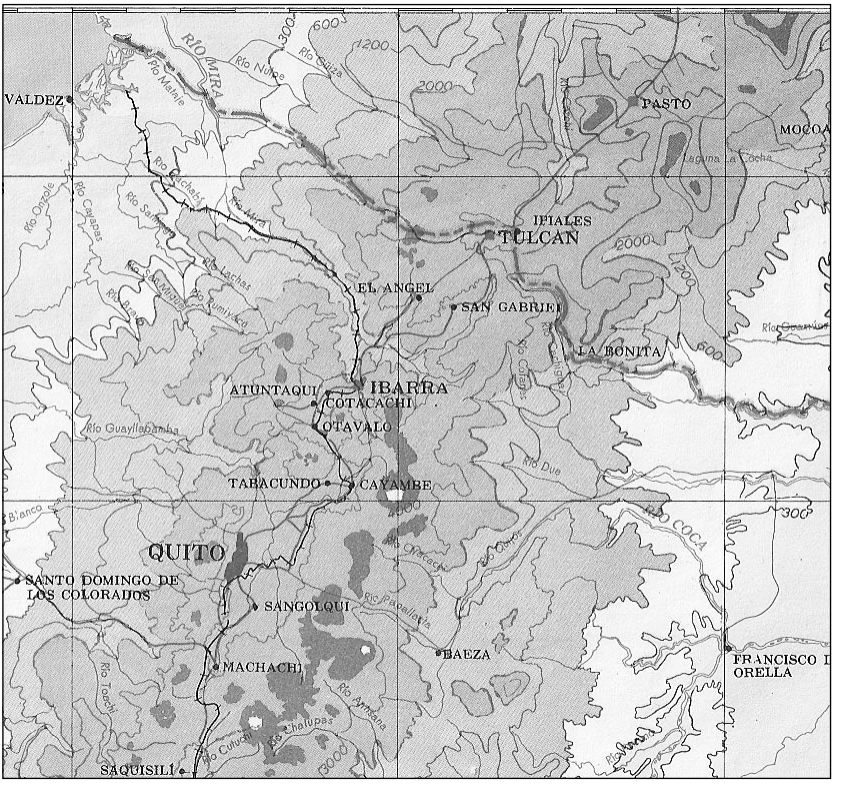

FIGURE 1. Map showing location of study sites

ARCHAEOLOGICAL EVIDENCE OF RIDGED FIELDS IN THE NORTH ECUADORIAN ANDES

My analysis of the available historical data will take into account major innovative work that has been carried out in the fields of archaeology, agronomy and climatology. Archaeologists and geographers have discovered fossil ridged fields ('camellones') in many parts of the north Ecuadorian Andes.[9] Gondard and López carried out a highly interesting and comprehensive survey[10] in which they

identified about fifteen sites in cold climates covering roughly 2,000 hectares, at altitudes rising from 2,400 to 3,100 metres. Of these sites, San Pablo – at that time the best preserved – was the subject of archaeological excavations and experimental reconstruction. The scientific results provided us with the most complete information hitherto available on the technique's morphology, functioning and cultural characteristics. The combined ridge and ditch (that is, including both the land above water and the submerged area) has a total width of between 3 and 7 metres. The proximity of still water raises nocturnal temperatures, and mitigates the effects of frost. The mud accumulating in the ditch, that is collected to reinforce the ridge, has a high phosphorus content that will have made up for the lack of animal fertilisers in the northern Andes in pre-Hispanic times.

Experiments carried out at the end of the twentieth century by agronomists and climatologists highlight the positive effect of stagnating water in combating frost. Vacher, Lhomme and Erickson have measured an increase of 1 to 2 degrees in temperature in the area of reconstructed ridged fields near Lake Titicaca. This has had a decisive effect in reducing annual frosts, and, therefore, in saving harvests during key periods of crop growth. Maximum efficiency is obtained through a distribution of 4 metres of platform to between 1.5 and 2 metres of water.[11] The wind-breaks identified on the plain of Cayambe, where screens of trees were planted along the ridges, may also have helped to mitigate the effects of frosts.[12] This hypothesis is consistent with the archaeological evidence that makes use of phytolith remains to reconstruct the area's agrarian landscape.[13]

The best-studied cases – those of the Cayambe and San Pablo plains, north of Quito, in the inter-Andean basin – perfectly illustrate the conclusions reached by a number of geographers, as summarised by Bouchard and Usselmann.[14] In each case, the palaeotechnique of wetlands has a distinct purpose. It may help to resolve problems – permanent or seasonal – such as excess of water in marshlands, or the irregularity of hydraulic supply when a given area is affected by both drought and flooding at different times.

A series of early nineteenth century historical testimonies describe the geographical conditions in these areas. In accordance with modern scientific conclusions, they clearly show how problematic climate and soil type were. In the case of Cayambe in 1808, for example, it was said: 'when there are icy spells (as there have been this year), excessive rain or drought, the crops are destroyed and there is great scarcity'. In the same year, Otavalo, north of Quito (see Figure 1), was described in the following terms: 'the harvests in Otavalo are more abundant in less rainy years, because the ground is naturally humid and irrigated by the many streams that descend from the heights, so that great amounts of rainwater are damaging'. Finally, there was a description of San Pablo: 'on account of the great amount of water from the hillsides … the village near the Lake has several marshy areas, as it is wet even at a considerable distance from the Lake'.[15]

Archaeologists have recently established a chronological framework for the agricultural practice of raised fields. Recent research in vulcanology has led to considerable advances in the dating of population movements and pre-Hispanic settlements in Ecuador.[16] In the Ecuadorian Andes, the most significant event occurred in approximately A.D.1280 when the Quilotoa volcano erupted and scattered ash over a considerable part of the sierra that we now associate with the use of ridged fields. Research based on textural pedofeature characteristics shows that intensive efforts were made to clear away volcanic ash and re-establish the ridged fields.[17] With regard to its subsequent influence, both Villalba working on Cayambe, and Knapp and Mothes studying San Pablo, stress the chronological concurrence of the technique of ridged fields and the use of ceremonial mounds ('tolas') and raised platforms associated with the major highland chiefdoms up to the arrival of the Spaniards.[18]

THE ETHNOHISTORICAL EVIDENCE

What then is the additional information that may be retrieved from the historical documentation? Taking my earlier work on early Colonial sources as my starting point, I will suggest here that a quite specific vocabulary (such as 'camellon' and 'pijal'), as well as more indeterminate terms such as 'marshland' ('cienagas') and 'lakes' ('lagunas'), may refer quite explicitly to a deliberate modification of the landscape and to some form of wetland agriculture. A close linguistic reading of early texts allows us to enlarge our inventory on the basis of case-by-case analysis. In this way I identified various sectors of 'camellones' in the sixteenth century. The area of San Pablo was one such of course, but there was also Cochecarangue (the term for an extensive swathe of territory that ranges from the lower reaches of the valley of Tahuando, Las Monjas, Angochagua and Zuleta and could reach Caranqui). A donation of 1606 by the encomendero of Caranqui of the grazing land ('estancia') of Cochecarangue established its frontier with another one in Caranqui, bordering on 'the village itself and marshland' ('el mismo pueblo y cienagas').[19] At the beginning of the sixteenth century, part of the plain of Cayambe was known as 'the marshland' ('la cienaga'). And in the area near Otavalo there was 'a lake and marshland called Quinchuqui and others called Guabizi', according to Indian title deeds of 1596.[20]

Using the same methodology, I established that the toponym 'Pixal/Pijal' referred to wetland agriculture, and I can now add that another linguistic particle 'Pifo/Biafo' refers to some comparable agrarian form. It is not, however, possible to say whether this was ascribed to another morphological feature, such as distinct types of 'camellones' distributed in a 'chessboard' form, parallel or curvilinear. Up to the 1980s, the varied typology of these remains was visible to the naked eye. An aerial photo dating from 1963 shows very clearly the remains of different types of 'camellones' on the edge of the San Pablo lake (see

FIGURE 2. Aerial photograph showing remains of ‘camellones’ near San Pablo Lake.

Figure 2).[21] Three examples are directly related to sites on the edge of the San Pablo Lake where 'camellones' have been specifically identified. In Oyagata, in 1580, a witness attests to having 'two fields of maize, the rest are camellones of potatoes' in a 'place called Abiafu'. A second example comes from San Miguel, 1680, where the witness has 'two sources next to the lake of San Pablo … and land and marshland … and a spring called Cuspifu'. Finally, in Cusin, in 1690, land in the 'Rinconada de Cusin' is called 'Intapifo'.

Intriguingly, this toponym also appears in hot lowlands, which raises another question: what is a 'camellon' in warm areas? Why do the same terms ('camellon', 'pifu') refer to arguably distinct techniques of wetland agriculture? In 1560, for instance, cotton is mentioned as being grown in 'Lachipichig Bifu' in the hot valley of Pisque, near the pre-Hispanic settlement of Alchipichí.[22]

While archaeological research has advanced our understanding of wetland agriculture in the northern highlands, similar work has yet to be carried out on neighbouring warmer valley slopes and low-lying areas. The main point of comparison we have is with the Ecuadorian coast – namely 'camellones' in the Guayas basin in the south, and in the Tumaco-la Tolita region in the north – as well as with the hot lands of the San Jorge river in Colombia.[23]

THE ADVANTAGES OF RIDGED FIELD TECHNIQUES IN WARM AND COLD AREAS

With only historical data to count on, it is difficult to reconstruct agrarian techniques in the warmer areas of the northern Ecuadorian Andes. Returning to material I have previously studied,[24] I would argue here that the terms 'camellon' and 'raya' (row or line) and the toponym 'pifu' correspond to the same closely inter-connected logic. 'Camellon' and 'raya' were Spanish words used by the Indians in the sixteenth and seventeenth centuries to designate coca crops, and orchards with fruit such as avocados, guavas and bananas in the tropical valleys of the rivers Coangue-Chota, Ambuquí and Palacara. The toponym 'pifu', on the other hand, was associated with cotton growing on the lower stretches of the River Pisque, so it may be that the similarity was more in form than function. Irrigation is essential for these tropical crops, and they were to be found in economically valuable locations in warm valleys. They were grown on the riverbanks and often exiguous land surfaces known as 'banks' ('playas') that accompany the rivers on their descent through lower ecological levels.

In these tropical fields, the goal is to retain water, and these terms seem to describe both the raised ridge where trees are planted, flanked by water on each side, and the elongated form of the fields. They may refer to wetland orchards ('huertas') or some system of irrigation inherent to plots on riverbanks. Detailed descriptions of coca growing make it clear that there is an association with taller trees that alternate with coca plants, or surround them, probably so as to

protect them from the burning Equatorial sun. An example from Pimampiro in 1629 mentions avocado trees growing both within and around the coca plants: 'I have a plot of coca … with five rows ('rayas') of coca and five avocado trees, and with more than twenty-three avocado trees around the said area'. As to the cotton that is also grown in hot valleys, this was either under the direct control of the Otavalo ethnic group (in the valleys of Intag, Pisque, Guayllabamba, Palacara, Coangue-Chota, Ambuquí), or of the more western ethnic groups around Lita and Cahuasquí, that specialised in its production.[25] It is possible that the terminology refers to a kind that is comparable to irrigation in form, but whose specificity does not emerge from the documentation. Both in cool climates at high altitude, and in hot lowlands, the availability of abundant water (via rain, poor drainage, access to rivers or through artificial measures to retain it) seems to be the common denominator.

The historical data also allows us to identify the distribution of crops by area, taking into account both the region's historical evolution and Spanish Colonial cultural impositions. On various occasions in the sixteenth century, the autochthonous population and its ethnic leaders answered questions for Spanish surveys. Their opinions on agriculture represent a valuable testimony on the Indian approach to risk-taking in agriculture, and their preference for certain crops, whether for their food value or symbolic importance.

For the period 1578–82 archival documentation has survived which includes declarations by Indians from the area of Otavalo. For example, an inhabitant of Sarance (the present-day town of Otavalo at 2,600 metres) said they 'harvest potatoes, squash and beans' and many witnesses declared that the Otavalo area was not ideal for growing maize. Two ethnic leaders ('caciques') from San Pablo, in particular that of Pixalquí (where the 'camellones' mentioned above were located), said that Otavalo had 'a cold climate. Maize doesn't grow'. Other Indians from the same area specified that 'maize does not grow as well in the village of San Pablo as in the other villages'. The principal cacique of the ethnic group blamed the frosts: 'there is no maize … because although the Indians plant it, most years it freezes and is lost'. The wheat introduced in Colonial times was even more vulnerable to the cold and in 1581 and 1582 there were both droughts and frosts[26]: 'the caciques of Otavalo owe 1500 fanegas of wheat and maize this year and last year … on account of the great drought which occurred and because their crops froze'.[27]

Frost and drought were the most dreaded climatic conditions. In contrast, no reference was made to problems that might have been caused by excess water, nor by possible drainage problems. When referring to the technique of cultivation of 'camellones' in cold areas, only potatoes and vegetables are mentioned: 'camellones' with potatoes on the edge of San Pablo Lake, in Pijal y Oyagata, 'camellones' of vegetables ('verduras', 'guacamullos') in San Pablo, Caranqui and Guápulo.[28] I now consider that the only documentary reference to the cultivation of maize in 'camellones' in the Quito area, one that comes from a non-

indigenous source, does not in fact refer to the technique of ridged fields. The term 'camellón', as used in 1573 by a Spanish official, allowed him to contrast cultivation on flat plains for the wheat and barley coming from Europe, with the undulating ground used for maize. This would have made his description clearer to European readers.[29]

An investigation by Knapp[30] on the present-day distribution of maize and potato crops at different altitudes around the Imbabura volcano helps to address a problem that is of great interest for the sixteenth century and the pre-Hispanic period. He inquires about the preference for potato crops at altitudes above 3,000–3,200 metres, and maize production at lower altitudes of around 2,600–2,800 metres. He examines the classic division into ecological levels, noting that an economic rationale does not provide us with a complete answer insofar as both crops can compete at similar levels, while a combination of calorific value and lower labour requirements favours maize. He provides data on hacienda production in the same areas as those known for traces of 'camellones', San Pablo, La Vega, Zuleta and the neighbouring upper slopes of the Imbabura (Topo, Angla).

I believe we can adopt a similar approach for the sixteenth century. We do not have direct references to the technique of 'camellones' being applied to maize production in cold areas, although Veintimilla's archaeological work suggests intermittent maize production in the 'camellones' on the Cayambe plain.[31] We do, however, have this evidence for potato production. High altitude maize was not highly prized, possibly out of cultural preference or for reasons of agronomic efficiency. This is open to conjecture. The Indians much preferred agricultural products from the hotter lowlands. For the Otavalo ethnic group, as well as other local groups under their control, the areas of maximum economic value were the low-level tropical valley enclaves in the sierra, and the hot lowlands in the western foothills of the Andes. The complementary nature of production in cool highlands/warm lowlands parallels findings from studies of Ecuadorian chiefdoms.[32]

The Indians of the northern highlands express this idea quite explicitly. The distinctions they draw between cold and hot areas is synonymous with that between the poor and the rich. Cotton, capsicum, coca and tropical fruit can only be produced in scarce and privileged areas, generally under the control of the autochthonous elite. For example, the highly prized hot land at Alchipichí (at 1,700 metres), where cotton and coca but also maize was cultivated, was held by the descendants of the principal cacique of the Otavalo ethnic group. This was also the case in the hot valley of Ambuquí, where maize, capsicum and coca were planted. This tropical maize was also grown by the Lita ethnic group in the dense tropical forest ('montaña') of the western slopes of the Andes, as well as by other lowland groups that were linked to the Pasto and Otavalo ethnic groups.[33] Perhaps the varieties of tropical maize were appreciated for their taste or other gastronomical qualities. It is quite clear that one feature was especially

appreciated by the Indians: 'the maize is harvested every two months'. In the hot valleys of the south of Colombia that were controlled by high altitude Pasto Indians, the double annual harvest was also highly valued.[34]

It is difficult to estimate productive capacity. As often happens when we study ancien régime conditions, we can indicate the relation between seeds and harvest, but not agricultural extension. Nevertheless, a comparison between four habitats with distinct ecological characteristics is highly revealing, with maize cultivation in the hot lands of Otavalo proving the most productive. Thus we find that in the cold Chambo area, at 3,200 metres, the surface measure of 1 'fanega de sembradura' had a harvest capacity of 8 to 10 fanegas; near Quito, which is also cold, lying at 2,800 metres, 1 fanega produced 20–40; in the warmer valley of Chillos at 2,500 metres, 20–30 and 60–70 fanegas were produced; and in the hot valleys at 1,700–2,000 metres in the Otavalo region, this figure rose to 50–60 and 100.[35] We can only be sure that irrigation was involved in this final example. A logical inference, I think, is that preference was given to maize from the more productive hot lands, while the 'camellones' of cool areas were limited to the cultivation of potatoes and other autochthonous crops (other tubers, lupine, quinoa, beans).

These two autochthonous groups of products were viewed quite differently by the Colonial authorities. Consumption of tubers was left to the exclusive sphere of the autochthonous population, while increasingly, maize was preferred both for new Colonial economic requirements and Indian consumption. Maize fed the local workforce who laboured for the Spaniards, and also fed European cattle which were increasingly numerous from as early as the sixteenth century onwards.[36] The colonisers shifted the pattern of distribution of agricultural land: they assigned a greater area to cereals and grazing, sacrificing autochthonous priorities with regard to tubers, quinoa. Marshy areas were gradually dried out to make way for grazing land, while the amount of land sown with wheat, barley and maize cultivation was expanded.[37]

Another advantage of wetland agriculture is that it seems to be unnecessary to leave land fallow, a practice that was already widespread from the eighteenth century onwards when some land was regarded as infertile. The palaeotechnique of 'camellones' maintained the fertile layer in situ and helped to deter soil erosion.

THE PRODUCTION OF SUBMERGED LAND

The technique of 'camellones' also afforded benefits from the area under water. Archival data show that various aquatic varieties of vegetables were cultivated, although they were not described in detail as they did not form part of Spanish diet. They were green vegetables ('verduras') for strictly Indian consumption. For example, near Caranqui in 1626 we find 'the place called Pigalqui where

we have our vegetables as it is marshy land covered in water'. An ethnographic comparison I conducted in 1979–81 revealed the survival of herbs ('yerbas'), in Indian peasant food consumption; these were aquatic herbs ('yuyos' and 'pima' in Quechua), turnip leaves and water cress ('bledo' and 'berro' in Spanish). The Royal administrative surveys, or *Relaciones Geográficas,* of 1573 and 1582 drew attention to the diversity of cultivated varieties and their major role in consumption. A naturalist traveller in the nineteenth century could still observe the cultivation of a variety of aquatic plants in marshland. Reeds ('totora') are also cultivated in water and come up on the colonial market place in the form of mats ('esteras') which are required in the tax assignments of 1551 and 1562.[38]

The flooded part of the 'camellón' will also have been used to raise molluscs and edible fish. The historical information of the sixteenth century is not very detailed, but comparison with the sunken gardens ('huertas') of the Peruvian coast and the Mexican 'chinampas' lead us to this conclusion.[39]

River and lake fish, as well as fish from natural wells within lakes ('preñadillas'), were abundant and provided surplus production, since the colonial taxation refers to fresh but also dried fish. The description of Otavalo in 1582 offers a nice description of how to fish the abundant and highly appreciated well fish at the very point where the lake and mountain streams intersected. In marshy areas, fish, crustaceans, molluscs and water insects attracted aquatic birds. This is well documented from the sixteenth to the nineteenth centuries.[40] These data refer to the cold areas of Otavalo territory. Archaeological work on the 'camellones' of the San Jorge river in Colombia have identified nine species of fish and many types of birds in the remains of flooded ditches. On the plains, or 'llanos' of Mojos, agricultural and hydraulic remodelling, consisting of large and numerous 'camellones' over an extended area, also reveals an abundance of fishes and birds.[41]

For a direct point of comparison, we may mention the intelligent autochthonous management of 'renewable natural resources' on the coast of Peru in the sixteenth century. There, ethno-historical evidence reveals important food reserves with a semi-aquatic milieu of coastal hills ('lomas'), fish farms, the cultivation of reeds and other plants, and the exploitation of aquatic fauna.[42]

The raised field/flooded ditch complex appears to be inextricably associated, a distinctive exploitation of natural resources that was not valued by the Spanish colonisers. It is true that within an emerging market economy, this system, however sustainable, did not correspond to production priorities. I would especially emphasise one cultural factor that was directly involved in the abandonment of these techniques. The colonial policy of 'reducciones' or reductions, that is, the forced relocation of the autochthonous inhabitants into nucleated settlements involved the collapse of the traditional habitat, and the separation of houses from cultivated fields. This exercise of control over the Indian population was accompanied by the firm belief that the way of life in traditional settlements was incompatible with the concept of civilisation, and

indeed could barely be considered human at all. In particular, the occupation of marshland was unacceptable to the Spanish mind-set, shaped as it was by traditional contempt for the irrigated agriculture that was practiced by the moors and moriscos. This contempt may also have been related to the fact that Europeans at that time held strong views about the unhealthy properties of marshlands. The only agricultural practices considered worthy of a Christian population were non-irrigated tilling ('labranza de secano') and cattle grazing.[43] A Colonial official summed up the moral value he attributed to this role of 'reduction' for the very area of Otavalo itself: 'I worked in settling them in villages and withdrew them from the mountains and the marshes and ravines where they were living, and put them in proper order'.[44] Virtually from the outset, Colonial initiatives involved almost systematic drainage of still water, although archival documentation usually refers to the larger lakes. The goal was to retrieve cultivable land, and grazing pasture. Thus a lake was drained in the valley of Chota-Coangue, near Pimampiro. And the lake of Iñaquito, which was where the Inca Huayna Capac had maintained his hunting reserves, was drained and given over to the common lands of the city of Quito.[45]

In Spanish eyes, native exploitation of the environment produces an incongruous configuration of the landscape. The agricultural terrain, modified by the autochthonous inhabitants, is one of continuities and inter-relations between lakes, the lake rims with their reeds ('totora'), and the flooded fields whose ditches link up in turn with rivers and lakes. There is no clear borderline between dry and wet, fishing and agriculture. Yet this was synonymous with barbarism to the colonisers who could not accept that Christian human beings were not firmly rooted on dry land.[46] The technique of 'camellones' consists precisely in the 'intricate presence, very close together, of environments with very different characteristics … handled in ways that are not contradictory but compatible' – this was a logic far removed from Spanish tradition.[47] And this, I think, explains the almost total indifference of the colonisers to this way of exploiting the environment as well as their likely incomprehension of its economic rationale. Hence the scarcity of discussion in the historical documentation, and the ambiguity of terms like marshland ('ciénagas'), lakes ('lagunas') and wetlands ('tierras pantanosas').

SOCIO-ECONOMIC CONDITIONS AND THE SURVIVAL OF NATIVE TECHNIQUES

Certain historical testimonies prove the survival of the technique of 'camellones' in cold areas throughout the sixteenth century and much of the seventeenth century. The final data comes from the legacy of Indian land in 1649 in the area of Cumbayá to the north of Quito, another dated 1653 from the banks of Lake Pablo, and a third in 1668 in the area of Gualapuro, near Otavalo.[48] This

enduring survival of wetland cultivation in cold areas may be compared with the historical evolution and late disappearance of 'camellones' on the sabana of Bogotá.[49]

At lower ecological levels, the survival of autochthonous techniques and cultivation is even more noteworthy. We find data on 'camellones' and 'rayas de coca' and fruit trees in the valley of Ambuquí and the Coangue-Chota all through the seventeenth century and up to beginning of the eighteenth century.[50] In this case, the close link with coca plantations – invariably in the hands of the autochthonous elite – explains their gradual disappearance, as trade in coca was gradually marginalised in the northern Andes by the colonial elite which ascribed a minor economic role to it, in contrast to the central Andes where it has been prevalent right up to the present day. Christian morality, and also the existence of other economic alternatives, combined in the excoriation of coca or the 'devil's weed'. There was considerable competition for resources in the hot valleys, which were quickly monopolised by sugar cane plantations, which had, incidentally, a greater demand for water than was the case for coca and cotton.[51]

It has been possible to establish that on the Ecuadorian coast the tropical 'camellones' of the Daule river plain were in use from the fifteenth to the eighteenth century.[52]

What do the historical data tell us about the topographical distribution of wetland agriculture? And what kind of socio-economic organisation does this type of environmental management imply? Archaeological surveys show a great variety in the morphology of wetland fields, which is adapted to the varying geophysical possibilities. Documentary references from the sixteenth and seventeenth centuries show us distinct toponyms referring to each plot, on the evidence of the owners of 'camellones', themselves. These plots are not contiguous, and the plots group the 'camellones' in very varied numbers: small ones of 2, 6, 8, and more extensive ones of 30, 40 and up to 70. The interpretation of the historical sources suggests variety in topographical organisation: we can imagine some parallel 'camellones' and others breaking the geometry, as suggested in a reference from 1668: 'another plot named Pigudpuela which has about 40 camellones and two more…'. The dimensions could vary enormously, especially in length: for example, in 1606, in Pimampiro, '8 very small rows of coca fields' … 'a coca plot of 4 rows and more land, measuring about a quadra'. A reference to 28 'camellones' that occupy 'two and a half quadras in width and length' gives us an overall surface that may be calculated as 6 hectares, but does not allow us to see the form or the size of each one. The distribution on the same site of small, differentiated groups of 'camellones' with their own toponyms, could correspond to the organisation of perpendicular plots, with a chessboard distribution. In San Pablo, in 1614, we find 'ten camellones named Piroguchi and 5 more camellones named Mimbuara and another one called

Calupigal with 6 camellones and another 5 camellones called Ytumiza plus 7 camellones named Lagabiro'.[53]

Insofar as these references can often be found in the context of how a land inheritance was divided up, they seem to indicate the extension of the property as well as the owners who would benefit. Nevertheless these data, which come from the Colonial period, may have already been affected by European-style rules of succession and property laws.

It would be more apposite to ask what kind of human pre-Hispanic settlements were associated with these agrarian techniques, in order to understand what level of socio-economic organisation corresponds to their maintenance and exploitation. The historical texts reveal the existence of dwellings interspersed among cultivated fields and 'camellones', an autochthonous form of settlement surviving the introduction of the forced settlements. For this very area of the northern Ecuadorian Andes, a document of 1649 describes this interlacing of Indian houses and 'camellones' in the Tumbaco area, north of Quito ('and 30 camellones amid thatched huts').[54]

A comparison with hot areas in Colombia, according to the early testimony of one of the discoverers of the province of Antioquia, supports the archaeological evidence for short 'camellones' with dispersed dwellings. Towards 1540, the conquistador Robledo described the dispersed aboriginal habitat, which he associated with dwellings and a hydraulic system: 'and here there was a hut, and another one 2 leagues further on, and in each one (they) had a plot of maize and manioc, and he found big irrigation channels that they had dug'.[55] We may add that this testimony conclusively demonstrates that irrigation channels were used in pre-Hispanic times, as Salomon has shown with ethnohistorical data on Quito and the northern Andes.[56] Bray has assembled the archaeological and geographical evidence on this very question for the northern Andes.[57]

In these cases, agricultural exploitation was in the hands of a family group and seems to have been limited to the production for autarchic consumption. It is true that there are not many studies of native family organisation at the moment of Contact. The most likely conclusion points to an extended family providing the labour necessary to build and maintain the ridges and the ditches of the 'camellones' throughout the year, as well as sowing and harvesting. My studies of the demography and settlements in the area of Otavalo in the sixteenth century are consistent with an organisation, partly collective, of agricultural work at the level of the 'parcialidad', that is, the basic ethnic unit of pre-Hispanic societies. These had between 200 and 500 people, but were also sub-divided into family groups of around 10 to 15 members.[58] The Pacific Coast, on the frontier between Colombia and Ecuador, provides a similar picture in the period of the Tumaco-La Tolita culture, with production for local supply, but no evidence of surplus production.[59] Work on the same area and present-day continuities in the management of the environment suggest that maintenance tasks involve large families, but not necessarily a complex socio-political organisation.[60] The most

complete study of pre-Hispanic Chimu society, on the Peruvian coast, gives us very interesting conclusions as to functioning, and political hierarchy: the network of inter-connected irrigation channels that form the basis of that state's prosperity are maintained exclusively at a local level, and through family groups, without the need for state control and management. Archaeology reveals that the construction of the irrigation channels was achieved in piecemeal fashion by distinct groups, and that there was no overall plan executed by a higher authority.[61] In Mexico, it has been estimated that 6 to 8 families were necessary to get a 'chinampa' functioning, and a Colonial example shows the spatial and social organisation of the house/'chinampa' complex in 1585 in Huehuecalco, where a modest-sized family orchard was stuck to a building.[62] This exceptional document presents the spatial distribution of the farm holding and allows us to calculate its dimensions, expressed in a Spanish-Nahua system of measure. It can be estimated that the width of three chinampas was rather more than 14 metres (ditches and ridges), which would correspond to an average of 4.2 metres in width by 'chinampa'. The length would be 7.50 metres, orientated east–west on its longitudinal axis.

It is probable, if we look at the documented cases, that during centuries of Colonial rule, this type of small-scale agricultural use was maintained in the Indian domestic economy, in a form that was barely visible to the Colonial market. But it is also appropriate to recall that the data on the economy of the Otavalo ethnic group in the sixteenth century make it clear that agricultural production in hot areas produced a surplus, which led to the exchange of products. Transactions were based on surplus production of cotton, coca and capsicum.[63]

PRESENT-DAY ECOLOGICAL AND ECONOMIC CHALLENGES

In view of the apparent success of this form of management of water and the environment in pre-Hispanic times, various researchers in archaeology and agronomy – beginning with Erickson's pioneering work in the late 1970s – have looked for ways of experimenting with these same ancient techniques. They have sought out comparable agrarian environments, and selected traditional crops with the aim of studying the feasibility of adapting their production to present-day markets. These experiments generally evaluate which crops would benefit from cultivation in 'camellones', how the cycles of production and profitability are structured, take into account labour costs and the process of rehabilitation.[64] One hypothesis, inspired by archaeological work, favours the possibility of maintaining higher population densities: after assessing carrying capacity, they conclude that potato double-cropping or potato/maize double cropping are feasible.[65]

With regard to these patient and systematic experiments, it is helpful to distinguish between highland and tropical ecosystems.

Reconstruction of 'camellones' has been carried out in distinct areas of the hot Ecuadorian coast with archaeological remains. Results show that agricultural production reaches higher levels than usual especially for maize, sweet potatoes, beans and capsicums, and that two harvests can be expected each year.[66] In the similarly hot area of the Mojos in Bolivia, the experimental study of 'camellones' shows that they enable very infertile land to be productive, which is another confirmation of their importance.[67]

With regard to other climatic conditions, experimental cultivation in the high altitude zone of Puno, in Peru and Bolivia, has shown which are the most successful practices in terms of land, water, labour force and seed planting, and has also established the most suitable agricultural calendar.[67] In this case, protecting the crops against frost and guaranteeing the regularity of harvests constitute the most important achievements.

In conclusion, we can say that archaeological and historical research, as well as field experiments by agronomists, has shown that the palaeotechniques of raised fields and wetland agriculture have clear and notable benefits for agricultural production. They aid hydraulic control and the fight against erosion, promote production of fertilisers and raise temperatures, a series of results which taken together can at least guarantee self-sufficiency, if not surplus harvests.

In terms of present-day agrarian development, we can ask ourselves whether these techniques could be redeployed in places where they were once used so successfully.

Quite clearly, it will not always be possible to turn the clock back. The northern Ecuadorian landscape is a palimpsest on which successive generations have left their traces, and land use and landscapes have been progressively transformed over the centuries. During the Colonial and Republican periods,[68] land was turned over to grazing pastures and the cultivation of cereals; more recently, floriculture has predominated. On the coast, mangrove swamps and wetland fields are threatened by the growth of shrimp farms that draw in sea water.[69] In other areas, the difficulty lies in the nexus with the market economy. The retrieval of ancient techniques is not a viable option if they cannot be sustained under present-day economic conditions.

Nevertheless, knowledge of native forms of land use, and of the autochthonous landscape, needs to be revived and prized, as proof of human creativity in managing the resources of diversified ecosystems. These techniques could still be of great value today, if applied to new circumstances and re-invented as solutions to quite different problems. This rediscovery would need to be accompanied by an open-minded approach and a spirit of shared enterprise in the fields of commercial development and ecological management.

NOTES

ABBREVIATIONS:

AGI/S: Archivo General de Indias, Sevilla.

AHBC/I: Archivo Histórico del Banco Central, Ibarra.

AHBC/Q: Archivo Histórico del Banco Central, Quito.

AIOA/O: Archivo Instituto Otavaleño de Antropología, Otavalo.

ANH/Q: Archivo Nacional de Historia, Quito.

AM/Q: Archivo Municipal, Quito.

[1] A first version of this article was presented at the International Water History Association/ UNESCO, Paris, December 2005.

[2] R. West and P. Armillas, '"Las Chinampas de Mexico". Poesía y realidad de los "jardines flotantes"', *Cuadernos Americanos* IX, 2 (1950): 165–182.

[3] Teresa Rojas Rabielo, 'Les techniques indigènes de construction des champs artificiels dans la vallée de Mexico', *Techniques et culture* 4 (July 1984): 1–33; 'La agricultura prehispánica de Mesoamérica en el siglo XVI', in M. Miño Grijalva, ed., *Mundo rural, ciudades y población del Estado de México* (Toluca: El Colegio Mexiquense, 1990), 17–40.

[4] Andrew Sluyter, 'Intensive Wetland Agriculture in Mesoamerica: Space, Time and Form', *Annals of the Association of American Geographers* 84 (1994): 557–584, doi: 10.1111/j.1467-8306.1994.tb01877.x.

[5] See for example the contributions of natural scientists, archaeologists and cultural ecologists in David L. Lentz, ed., *Imperfect Balance. Landscape Transformations in the Pre-Columbian Americas* (New York: Columbia University Press, 2000).

[6] J. Parsons and W. Bowen, 'Ancient Ridged Field of the San Jorge River Floodplain, Colombia', *The Geographical Review*, no. 56 (1966): 317–378, doi:10.2307/212460; C. Smith, W. Denevan and P. Hamilton, 'Ancient Ridged Fields in the Region of Lake Titicaca', *The Geographical Journal* 134 (1968): 353–367, doi:10.2307/1792964; Sylvia Broadbent, 'A Prehistoric Field System in Chibcha Territory', *Ñawpa Pacha* no. 6, 135–147.

[7] William Denevan, 'Hydraulic Agriculture in the American Tropics: Forms, Measures and Recent Research', in K.V Flannery, ed., *Maya Subsistence* (Academy Press, 1982), 181–203.

[8] Chantal Caillavet, 'Toponimia histórica, arqueología y formas prehispánicas de agricultura en la región de Otavalo. Ecuador', *Bulletin de l'Institut Français d'Etudes Andines* XII, 3–4 (1983): 1–21; 'Las técnicas agrarias autóctonas y la remodelación colonial del paisaje en los Andes septentrionales (siglo XVI)', in J.L. Peset, ed., *Ciencia, vida y espacio en Iberoamérica,* (Madrid: CSIC, 1989), vol. III, 109–126.

[9] On the Cayambe plain: Bruce Batchelor, 'Los camellones de Cayambe en la Sierra de Ecuador', *América Indígena*, vol. 40, no., 4 (1980): 671–689. On the 'vega' of Lake San Pablo: John Stephen Athens, *El proceso evolutivo en las sociedades complejas y la occupación del período tardío Cara en los Andes septentrionales del Ecuador* (Otavalo: Pendoneros, IOA, 1980); Gregory Knapp, 'Ecology of prehistoric wetland agriculture in some highland basins of Ecuador', 13th International Botanical Congress, Sydney, Aus-

tralia, 21–28 Aug. 1981; 'El nicho ecológico llanura húmeda, en la economía prehistorica de los Andes de altura. Evidencia etnohistórica, geográfica y arqueológica', *Sarance* 9 (1981): 83–94; 'Soil, Slope and Water in the Equatorial Andes: A Study of Prehistoric Agricultural Adaptation' (Ph.D. diss., University of Madison, 1984).

[10] Pierre Gondard and Freddy López, *Inventario arqueológico preliminar de los Andes septentrionales del Ecuador* (Quito: MAG-PRONAREG-ORSTOM, 1983).

[11] Knapp, 'Soil, Slope and Water in the Equatorial Andes'; *Riego precolonial y tradicional en la sierra norte del Ecuador* (Cayambe: Ed. Abya-Yala, 1992); Jean Vacher and Jean Paul Lhomme, 'El uso de los camellones y el control de las heladas en el altiplano', paper for the symposium 'Agricultura Prehispánica. Sistemas agrícolas andinos basados en el drenaje o elevación de la superficie cultivada', Quito, July 2003; Clark L.Erickson, 'El valor actual de los camellones de cultivo precolombinos, experiencias del Perú y Bolivia', in F.Valdez, ed., *Agricultura ancestral, camellones y albarradas. Contexto social, usos y retos del pasado y del presente* (Abya-Yala, IFEA, IRD, Banco Central del Ecuador, INPC, CNRS, DRC, Universidad ParisI, Quito, 2006), 315–339; J.P. Lhomme and J.J. Vacher, 'La mitigación de heladas en los camellones del altiplano andino', *Bulletin de l'Institut Français d'Etudes Andines* 32, 2 (2003): 377–399.

[12] Fabián Villalba, 'Los camellones de Cayambe', paper for the symposium 'Agricultura Prehispánica', Quito, 2003.

[13] César I. Veintimilla, 'Análisis de opal-fitolitos en camellones del sector Puntiachil, Cantón Cayambe, provincia de Pichincha', in Ernesto Salazar, ed., *Memorias del Primer Congreso Ecuatoriano de Antropología,* (Quito: PUCE-MARKA, 1999), Vol. III, 149–181.

[14] Jean-François Bouchard and Pierre Usselmann, 'Espacio, medio ambiente y significado social de los camellones andinos', in: F.Valdez, ed., *Agricultura ancestral, camellones y albarradas*, 57–68.

[15] AHBC/Q Fondo Jijón y Caamaño. Serie 1ª, Vol. 7, Exp. 22 in Pilar Ponce Leiva, ed., *Relaciones Histórico-geográficas de la Audiencia de Quito (siglos XVI–XIX)* (Madrid: CSIC, 1991), 733, 742, 748; 'cuando hay contratiempos de heladas (como al presente año) muchas lluvias o exceso de sequedad, se aniquilan las sementeras y hay notable escasez'; 'las cosechas en Otavalo son más abundantes en los años menos lluviosos, porque siendo el terreno por su naturaleza húmedo y regado de tantos arroyuelos que descienden de los altos, las muchas aguas llovedizas le perjudican'; 'por las muchas aguas de los montes… participa la población a la parte de la Laguna de algunos pantanos pues a bastante distancia de ella, es cenegoso'.

[16] Minard Hall and Patricia Mothes, 'La actividad volcánica del Holoceno en el Ecuador y Colombia Austral : Impedimento al desarrollo de las Civilizaciones pasadas', in P. Mothes, ed., *Actividad volcánica y pueblos precolombinos en el Ecuador* (Quito: Abya-Yala, 1998), 11–39.

[17] John Stephen Athens, 'Volcanism and Archaeology in the Northern Highlands of Ecuador', in Mothes, *Actividad volcánica,* 157–189; Project, Universities of York and Stirling (UK), 'Soil management in pre-Hispanic raised field systems, Ecuador' (2002). See also: C. Wilson, I.A. Simpson, and E.J. Currie, 'Soil management in pre-hispanic raised field systems: micromorphological evidence from Hacienda Zuleta, Ecuador', *Geoarchaeology* 17 (2002): 261–283, doi:10.1002/gea.10015.

[18] Fabián Villalba, 'Aprovechamiento de campos anegables para la agricultura en la época prehispánica. El caso Cayambe', in Mothes, *Actividad volcánica,* 191–205; Gregory

Knapp and Patricia Mothes, 'Quilotoa Ash and Human Settlements in the Equatorial Andes', in Mothes, *Actividad volcánica,* 146–148.

[19] AM/Q Censos Libro 15, f. 83r.

[20] Caillavet, 'Toponimia histórica', 1–21; 'Las técnicas agrarias', 109–126; AM/Q. Vol. 90, Tierras de Cayambe, 1672–1686; ANH/Q Indígenas 16, Doc. 1687–XI–18 f. 6r, 40–42; 'una laguna y sienaga llamadas Quinchuqui y otros nombres llamada Guabizi'.

[21] Photo of the Instituto Geográfico Militar, Quito, ref. nº 6754.

[22] ANH/Q Indígenas, Doc.18–11–1728, f. 25v; AHBC/Q Fondo Jijón y Caamaño, 20ª Colección, Doc. 841, f.7r; AIOA/O Paquete especial. Varios años, Caja 1b, Doc. 2 f. 6r; 'dos chacaras de mais la otra son los camellones de papas'; 'dos ojos de manantial junto en la laguna de San Pablo … y tierras y sienaga … y manantial llamado Cuspifu'.

[23] Jorge Marcos, ed., *Proyecto arqueológico y etnobotánico 'Peñón del Río'* (Guayaquil: ESPOL, 1980); James Parsons and Roy Shlemon, 'Nuevo informe sobre los campos elevados prehistóricos de la cuenca del Guayas, Ecuador'*, Miscelánea Antropológica Ecuatoriana* 2 (1982): 31–36; William Denevan and Kent Mathewson, 'Preliminary results of the Samborondon raised field project, Guayas basin, Ecuador', in J. P. Darch, ed., *Drained Field Agriculture in Central and South America* (Oxford, 1983), 167–181; Jean-François Bouchard, *Archéologie de la région de Tumaco, Colombie* (Paris: Ed. ADPF, 1984); Francisco Valdez, 'La evolución demográfica en los manglares de la costa noroeste del Ecuador en los períodos formativo y de desarrollo regional', *Cultura – Revista del Banco Central del Ecuador*, 24b, vol. VIII (1986): 593–610; Jean-François Bouchard and Pierre Usselmann*, Trois millénaires de civilisation entre Colombie et Equateur. La région de Tumaco La Tolita* (Paris: CNRS Editions, 2003); L.F. Herrera, G. Romero, P. J. Botero and J. C. Berrío, 'Evolución ambiental de la Depresión Momposina (Colombia) desde el Pleistoceno tardío a los paisajes actuales', *Geología Colombiana* 26 (2001): 95–121.

[24] Caillavet, 'Toponimia', 'Las técnicas agrarias'.

[25] Chantal Caillavet, *Etnias del Norte. Etnohistoria e Historia de Ecuador* (Quito: IFEA – Casa de Velázquez – Abya-Yala, 2000), 115–116, 245–249; Marcos Jiménez de la Espada, ed., *Relaciones Geograficas de Indias* (Madrid: Atlas, BAE, t. 184, 1965), 246; 'tengo una chacara de coca … que tendrá cinco rayas de coca y cinco paltas con mas de veinte y tres arboles de paltas alrededor de la dicha chacara'.

[26] Greg Knapp, 'Vertical Agricultural Differentiation in the Andes: A Result of Historical Adaptative Action', Annual Meeting of the Association of American Geographers, Washington, 1984; Pierre Morlon, 'Variations climatiques et agriculture sur l'Altiplano du lac Titicaca (Pérou-Bolivie): une approche préliminaire', in *La Météorologie* (Paris, CNRS–CNFGG, 1991), 10–29; Lhomme and Vacher, 'La mitigación de heladas'.

[27] AGI/S Cámara 922A, 3ª pieza, f. 503r/v; 506v, 508r, 644v, 671v, 673r ; AGI/S Cámara 922A, 2ª Pieza, f. 88r, 156r; 'cogen papas çapallos frizoles'; 'tierra fria. No se coge maiz'; 'en el pueblo de San Pablo no se da tan bien el mays como en los demas pueblos'; 'no ay maiz … porque aunque lo siembren los yndios se les yela y pierde los mas de los años'; 'los caciques de Otavalo deven de este año y el pasado mill y quinientas hanegas de trigo y maiz … por la mucha esterilidad que acudio y por averseles helado sus sementeras'.

[28] Caillavet, 'Toponimia', 'Las técnicas agrarias'.

[29] Jiménez de la Espada, *Relaciones Geograficas,* 212.

[30] Knapp, 'Vertical Agricultural Differentiation'.

[31] Veintimilla, 'Análisis de opal-fitolitos', 160–165, 175–178.

[32] Udo Oberem, 'El acceso a recursos naturales de diferentes ecologías en la sierra ecuatoriana (siglo XVI)', *Actes du XLIIe Congrès International des Américanistes,* vol. IV, (Paris, 1976), 51–64; Frank Salomon, *Native Lords of Quito in the Age of the Incas. The Political Economy of North Andean Chiefdoms* (Cambridge: Cambridge University Press, 1986).

[33] Caillavet, *Etnias del Norte*; Chantal Caillavet, 'Masculin–Féminin: les modalités du pouvoir politique des seigneurs et souveraines ethniques (Andes, XV– XVI e siècles)'. in B. Lavallé. ed., *Les autorités indigènes entre deux mondes* (Centre de Recherche sur l'Amérique Espagnole Coloniale, Université de la Sorbonne Nouvelle, Paris III, 2004), 37–102; AHBC/I Juicios, Paquete 6; 1674–1696. Repartición del agua de Ambuquí, f. 2v; Jiménez de la Espada, *Relaciones Geograficas,* 240–244.

[34] Chantal Caillavet, 'Entre sierra y selva : las relaciones fronterizas y sus representaciones para las etnias de los Andes septentrionales', *Anuario de Estudios Hispanoamericanos*, t. XLVI (1989): 71–91; AGI/S Quito 25, Quito, 1600, Relación de los caciques de Tulcán, f.4r; AGI/S Quito 60, Doc. 1, 1558, f.1–47.

[35]Chambo 1557: AGI/S Justicia 671, f. 225r; Quito 1573: Jiménez de la Espada, *Relaciones Geográficas,* 212; Chillos 1559: AGI/S Justicia 683, f.817r, 838r, 856r, 869r; Otavalo 1578: Cámara 922A, Pieza 3ª, f. 760v.

[36] Jiménez de la Espada, *Relaciones Geográficas,* see especially '*Relación de Quito*' *(1573),* 211–213, nº 63, 69, 80, 81 and 'Relación de Otavalo', 235, nº 4, 239, nº 27. For a suggestive comparison with Mexico, and the striking success of European-introduced cattle, see Elinor Melville, *A Plague of Sheep. Environmental Consequences of the Conquest of Mexico* (Cambridge: Cambridge University Press, 1994). Melville highlights the importance of land-carrying capacity in historical contexts.

[37] Pierre Usselmann, 'Un acercamiento a las modificaciones del medio físico latinoamericano durante la colonización: consideraciones generales y algunos ejemplos en las montañas tropicales', *Bulletin de l'Institut Français d'Etudes Andines* XVI, 3–4 (1987): 127–135; Daniel Gade, 'Landscape, System, and Identity in the post-Conquest Andes', *Annals of the Association of American Geographers* 82, 3 (1992): 460–477, doi: 10.1111/j.1467-8306.1992.tb01970.x.

[38] Chantal Caillavet, 'La nourriture dans les projets de développement: le cas d'un village indien de la région d'Otavalo-Equateur', *Bulletin de l'Institut Français d'Etudes Andines* XI, 1–2 (1982): 1–9; AM/I Papeles sueltos nº 216; Caillavet, *Etnias del Norte,* 125; Jiménez de la Espada, *Relaciones Geográficas*; Enrico Festa, *Nel Darien e Nell'Ecuador. Diario di viaggio di un naturalista* (Quito: Abya-Yala, 1993 [Torino, 1909]), 330–331; Alan White, *Hierbas del Ecuador, Plantas medicinales. Herbs of Ecuador, Medicinal plants* (Quito, 1976); Plutarco Naranjo, 'Plantas alimenticias del Ecuador Precolombino', *Miscelánea Antropológica* 4 (1984): 63–82; 'el sitio llamado Pigalqui donde tenemos nuestras verduras por ser tierras pantanosas y encharcadas de agua'; 'yuyos, pima, bledo, berro …'.

[39] R. Kautz and R. Keatinge, 'Determining Site Function: a North Peruvian Coastal Example', *American Antiquity* 42, 1 (1979), 86–97; West and Armillas, '"Las Chinampas de Mexico"'; Teresa Rojas Rabielo, 'Xochimilco: cambio ecológico y agrícola', Paper at the 45th International Congress of Americanists, Bogotá, 1985.

[40] Jiménez de la Espada, *Relaciones Geográficas,* 237; for example, in 1573, 'donde hay lagunas o rios o pantanos con agua, hay garzas' (Jiménez de la Espada, *Relaciones Geográficas,* 214); in 1808, 'En la laguna (de San Pablo) se mantiene la gallereta, los patos, chirlillos, zambullidores y garzas, que todos estos son en abundancia' (Ponce Leiva, *Relaciones Histórico-geográficas,* 750); in 1896, Festa, *Nel Darien*, 298–299, 330–331) describes the 'gallinas de agua', 'somorgujas' and ducks of Lake Yahuarcocha, that are drawn by the 'gran botin de crustaceos, insectos de agua, irrudineos y Planarie', as well as the 'preñadillas, doradillas y sabaletas' of the river Mira and neighbouring streams and sources.

[41] Luisa Fernanda Herrera, 'Paleoecología en la depresión Momposina. 21 000 años de cambios ambientales', in Valdez, *Agricultura ancestral*, 227–239; Sneider Rojas Mora and Fernando Montejo, 'Manejo del espacio y aprovechamiento de recursos en la depresión momposina. Bajo río San Jorge', in Valdez, *Agricultura ancestral*, 81–91; Clark Erickson, 'Sistemas agrícolas prehispánicos en los llanos de Mojos', *América Indígena* Vol. XI, 4 (1980): 731–755.

[42] María Rostworowski de Díez Canseco, *Recursos naturales renovables y pesca, siglos XVI y XVII* (Lima: IEP, 1981), 25–31, 49–50.

[43] Pierre Ponsot , 'Les morisques, la culture irriguée du blé, et le problème de la décadence de l'agriculture espagnole au XVIIIe siècle', *Mélanges de la Casa de Velázquez* VII (1971): 255–256; Caillavet, *Etnias del Norte,* 140–141.

[44] AGI/S Justicia 683, f. 80v, 1566; Caillavet, *Etnias del Norte,* 124; 'Yo travaje en poblallos y sacallos de los montes y cienagas y barrancos en que estavan poblados ponyendolos en toda buena orden'.

[45] Jiménez de la Espada, *Relaciones Geográficas,* 248, 210–212.

[46] Nathan Wachtel, 'Hommes d'eau: le problème uru (XVI–XVII siècle)', *Annales E.S.C.* 33, 5–6 (1978): 1127–1159.

[47] Pierre Morlon, 'Informe de consultoría sobre la rehabilitación de camellones en el altiplano de Puno, Perú', Ms, 1990.

[48] ANH/Q Indígenas 18, Doc. 1690–VI–30, f. 2v, Tumbaco, 1649: 'en la loma de Apianda para abajo de Pillagua…y en medio de las casas de paxa treinta camellones'; IOA/O EP/J 1ª (1655–6) f. 17v, San Pablo, 1653: 'cuatro camellones llamado Simpia Pigal', 'ocho camellones llamado Lupifu Pigal', 'dos camellones llamado Pirachu', 'ocho camellones llamado Ytambiquincha', 'cuatro camellones llamados Pirachipigal', 'seis camellones llamado Cutpipigal'; ANH/Q Cacicazgos, Libro 29, f.132v, Gualapuro 1668: 'otro pedaso llamado Pigudcapuela que sera cuarenta camellones y dos más'.

[49] Inés Cavelier, 'Perspectivas culturales y cambios en el uso del paisaje. Sabana de Bogotá, siglos XVI–XVII', in Valdez, *Agricultura ancestral*, 127–139.

[50] For example, in Yromina, in 1625: 'tierras y chacaras de cocales en el lugar llamado Yromina en el término del balle de Amboqui que tendra seis o siete pedaços de tierras y chacaras de cocales ansi de camellones y los demás rinconados' (AHBC/I Juicios, Paquete 16 (1685–1692); Pimampiro, 1629: 'otra chacara de coca que es como tres rayas y dos arboles de paltas'… 'dos rayas de coca con paltas'… (AHBC/I Juicios, Paquete 21 (1605–1699); Ambuquí, 1651: 'en el valle de Ambuquí siete rayas de coca' (AHBC/I Juicios, Paquete 4 (1654–1659); Ambuquí, 1703: 'tengo en el Balle de Ambuquí… once

rayas de tierras donde tengo una huerta con seis árboles frutales y coca que las tuve y herede de mis antepasados (ANH/Q Cacicazgos, Libros Empastados, t. 55, f. 27v).

[51] Chantal Caillavet, '"La disparition". La coca du Nord andin: où, quand, pourquoi?', in *Recueil en hommage à Nathan Wachtel*, Paris (forthcoming).

[52] David Stemper, 'Campos elevados y producción agrícola en los siglos XV a XVIII – Río Daule – Ecuador', in *The Ecology and Archeology of Prehistoric Agriculture in the Central Andes*, 45th International Congress of Americanists, Bogotá, 1985.

[53] AHBC/I Juicios, Paquete 21 (1605–1699); ANH/Q Tierras 21, Doc. 1895–25, f. 819r; AHBC/I Juicios, Paquete 2 (1640–1686); 'otro pedaco llamado Pigudpuela que sera cuarenta camellones y dos más…'; 'ocho rayas muy pequeño (sic) chacaras de cocales'; 'una chacara de coca de quatro rayas y mas tierra, abra una quadra'; 'dos quadras y media de ancho y largo tambien'; 'diez camellones llamados Piroguchi y mas cinco camellones llamados Mimbuara y mas otra llamada (sic) Calupigal que son seis camellones y mas otra cinco camellones llamada Ytumiza mas siete camellones llamada Lagabiro'.

[54] ANH/Q Indígenas 18, Doc.1690–VI–30, f. 2v; 'y en medio de las casas de paxa treinta camellones'.

[55] Herrera et al., op. cit; Hermés Tovar Pinzón, *Relaciones y Visitas a los Andes, siglo XVI*, (Bogotá: Colcultura, 1993), 289; 'e estaba aqui un bohio e a dos leguas otro, e en cada uno habia sembrado su comida de maiz y yuca, e hallo muy grandes acequias de agua, hechas a mano'.

[56] Frank Salomon, *Native Lords of Quito,* 56, 60, 63, 166.

[57] Tamara L.Bray, *Los efectos del imperialismo incaico en la frontera norte. Una investigación arqueológica en la sierra norte del Ecuador* (Quito: Abya-Yala 2003), 33–34.

[58] Caillavet, *Etnias del Norte*, 151–153.

[59] Bouchard and Usselmann, 'Trois millénaires…', 20–23; 'Espacio, medio ambiente y significado social de los camellones andinos'.

[60] Valdez, 'La evolución demográfica'; 'Drenajes, camellones y organización social: usos del espacio y poder en La Tola, Esmeraldas', in Valdez, *Agricultura ancestral*, 189–225; Alexandra Yépez, 'Visiones y uso actual del espacio en la Laguna de la Ciudad' in Valdez, *Agricultura ancestral*, 341–355.

[61] Patricia Netherly, 'The management of Late Andean irrigation systems on the North Coast of Peru', *American Antiquity* 49, 2 (1984): 228, 247–248; 'Out of Many, One: The Organization of Rule in the North Coast Polities', in M.E. Moseley and A. Cordy-Collins, ed., *The Northern Dinasties. Kinship and Statecraft in Chimor* (Washington: Dumbarton Oaks, 1990), 461–87.

[62] James Parsons, 'Political implications of prehispanic chinampa agriculture in the valley of Mexico', 45th International Congress of Americanists, Bogotá, 1985; James Lockhart, *The Nahuas After the Conquest* (Stanford University Press, 1992), 61.

[63] Caillavet, *Etnias del Norte*, 65–67, 245–246.

[64] Clark Erickson, 'Applications of Prehistoric Andean Technology: Experiments in Raised-Field Agriculture, Huatta, Lake Titicaca, Peru, 1981–1983', in I.S. Farrington, ed., *Prehistoric Intensive Agriculture in the Tropics*, (Oxford: BAR, 1985); 'La agricultura en camellones en la cuenca del Lago Titicaca: Aspectos técnicos y su futuro' in *Andenes y camellones en el Perú Andino*, (Lima: Consejo Nacional de Ciencia y Tecnología, 1986),

331–350; 'El valor actual presente de camellones de cultivo precolombino, experiencias del Perú y Bolivia'; C. Erickson and K.L. Candler, 'Raised Fields and Sustainable Agriculture in the Lake Titicaca Basin of Peru', in J. Browder, ed., *Fragile Lands of Latin America : Strategies for Sustainable Development* (Boulder: Westview Press, 1989), 230–248; Ignacio Garaycochea , 'Agricultural Experiments in Raised Fields in the Lake Titicaca Basin, Peru : Preliminary Considerations', in W. Denevan, K. Mathewson and G. Knapp, eds., *Pre-Hispanic Agricultural Fields in the Andean Region* (Oxford: BAR, 1987); 'Recuperación de campos elevados en el altiplano peruano : veinte años después', paper for the international symposium 'Agricultura Prehispánica', Quito, 2003; Pierre Morlon, 'Du climat à la commercialisation : l'exemple de l'Altiplano péruvien', in Michel Eldin and Pierre Milleville, eds., *Le risque en agriculture* (Paris*:* ORSTOM, 1989), 187–224; 'Informe de consultoría sobre la rehabilitación de camellones en el altiplano de Puno, Perú', Ms, 1990; 'Variations climatiques et agriculture'; *Comprendre l'agriculture paysanne dans les Andes centrales (Pérou-Bolivie)* (Versailles: INRA, 1992); P. Morlon, B. Orlove and A. Hibon, *Tecnologías agrícolas tradicionales en los Andes Centrales : perspectivas para el desarrollo* (Lima: COFIDE-PNUD-UNESCO, 1982).

[65] Greg Knapp and Roy Ryder, 'Aspects of the origin, morphology and function of ridged fields in the Quito altiplano, Ecuador', *44th International Congress of Americanists,* Manchester, 1982; Valdez, 'Drenajes'.

[66] Samborondón: Kent Mathewson, 'Proyecto Camellones: interim progress report', Museo Arqueológico del Banco Central del Ecuador, Guayaquil, 1980; W. Denevan and K. Mathewson, 'Preliminary results of the Samborondon raised field project, Guayas basin, Ecuador', in J.P. Darch, ed., *Drained Field Agriculture in Central and South America* (Oxford, 1983), 167–181; Peñón del Río: Marcos, Proyecto arqueológico; M. Muse and F. Quintero, 'Experimentos en agricultura: resultados del primer ciclo anual en Cooperativa Las Delicias. Proyecto arqueológico-agrícola, Peñón del Río, Ecuador', paper at the 45th International Congress of Americanists, Bogotá, 1985.

[67] Clark Erickson, 'Sistemas agrícolas'; Óscar Saavedra Arteaga, 'El sistema agrícola prehispánico de Camellones en la Amazonía boliviana', 295–313.

[68] Piwandes project 2000–2003.

[69] On colonial transformations of the agricultural landscape and the redeployment of prehispanic features, see Caillavet, 'Las técnicas agrarias autóctonas y la remodelación colonial del paisaje... ', in Peset, ed., *Ciencia, vida y espacio en Iberoamérica*.

[70] Charles S. Spencer, 'Prehispanic Water Management and Agricultural Intensification in Mexico and Venezuela: Implications for Contemporary Ecological Planning', in David L. Lentz, ed., *Imperfect Balance. Landscape Transformations in the Pre-Columbian Americas* (New York: Columbia University Press, 2000).