Relations of Subsistence of the Vegetation Mosaic of Vilcabamba, Southern Peruvian Andes[1]

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Andean *puna* vegetation extends in a narrow band from northern Peru to the northern border area between Argentina and Chile. The *puna* has two principal characcteristics: an absence of trees, and variety in its constituent plant formations. These formations include tussock grassland, brushland, and carpet meadow (Weberbauer 1936, 13-81). In some cases they extend uninterrupted over large areas, and in others they are all combined within close proximity, forming a mosaic.

I had occasion to study one of these puna-mosaic areas, in the District of Vilcabamba, to the north of Cuzco in Peru. My observations, carried out over a three-year period, were confined to about 1500 km^2 on the eastern slope of the Andes. Vegetation ranges from montane forest at 1000 meters to high puna at 4600 meters, with frost desert above that elevation, but those areas of greatest interest for the current study are between 3200 meters and 4500 meters. The terrain is quite rugged, having been heavily glaciated during the Pleistocene. Glaciers still survive on the highest mountains (which range up to 6000 meters), descending to as much as 4400 meters in some places. The inhabitants of the District of Vilcabamba are farmers, depending largely upon their cultivation of tubers, including potato (*Solanum tuberosum*), oca (*Oxalis tubersoa*), lisa (*Ullucus tuberosus*), and añu (*Tropaeolum tuberosum*). They plant these in rotation, using the same site for only one year, then plowing another site the following year. A minimum of six years of fallow is customary. They graze sheep on the fallowing fields, and some have cattle that graze primarily in tussock grass areas.

In the early part of my residence in Vilcabamba my attention fell to the distribution of the tussock grasslands. These grasses, of different genera but collectively called *ichu*,[2] are bunch-forming, generally yellow in color from their older growth, and sometimes quite vigorous, reaching waist-height and achieving complete ground coverage. Something immediately puzzled me about ichu: although the conventional wisdom holds that as a formation ichu grassland replaces tree growth at elevations where there are environmental limitations for trees, I often found ichu not only above but also below, or interspersed with, woodland or brushland. Some ichu far above forest patches (e. g. 4600 meters) was clearly altitude-related, but how could its presence at lower elevations, especially between 3400 meters and 4200 meters, be explained? For a time I considered site specific, micro-environmental factors, including slope and aspect, soil moisture and drainage, soil type, depth and parent material, and daily wind regime. No correlation emerged between most of these factors and the observed distribution of ichu. It was found on sandy and clayey soils, on dry and waterlogged soils, on slopes of any aspect, and on any position on the slope. The only corrrelation I found was between steepness of slope and ichu: steeper slopes tended to be in ichu, although ichu can grow quite vigorously as well on flats.

For these intermediate altitudes a consideration of cultural factors proved more fruitful than purely environnmental ones. I began to see that where ichu predominated, cattle were present, although they did not abound, and that fire was a periodic occurrence. It simultaneously became clear why steeper slopes were often in ichu: they burned easily but were not as likely as flats to be heavily grazed. And another anomaly was explained. I noticed that in areas bordering Vilcabamba that had once been haciendas, ichu grass predominated over broad areas, while in native communities--at the same elevations and local climate--ichu was restricted to discontinuous patches. The reason, I realized, was that the haciendas (now converted to cooperatives) were concerned with extensive cattle production. They depended heavily on fire to clear the pre-existing vegetation and to periodically renew the new ichu growth. Native communities such as Vilcabamba, on the other hand, are concerned with subsistence potato production. Their lands are taken up in fields and former fields, while cattle grazing is a distinctly secondary occupation.

My residence in Vileabamba was long enough to observe the creation and maintenance of ichu grasslands. A grassland I had visited a few months before would, on my return, be reduced by fire to stubble, from which **[end p. 3]**

Fig. 1. General view of a *ch'ampa-matorral* mosaic surrounding the village of Vilcabamba. The valley bottom, at an elevation of 3330 meters, is partly under potato cultivation and partly in *chp̄a*. (The top of the photograph is approximately 3650 meters.) Newly formed, vertical planting furrows are visible behind the church steeple; remnant furrows, currently in *ch'ampa*, can be detected to the foreground right of the village. *Ch'ampa* also occupies the gently sloped surfaces of the lateral moraine (which runs diagonally across the photograph), because these slopes have been planted in tubers previously. *Matorral* occupies the steeper slopes, above and below *ch'ampa*, because these slopes are not commonly used for cultivation. *Matorral* also occupies rocky areas, as in the lower right; and individuals of the *matorral* formation are found growing along rock walls, where they are not disturbed by cultivation and where they aid in keeping sheep out. *Ichu* grasslands do not figure in the photograph, because grazing and farming pressures are high and fire frequencies are low so close to the village. At this same elevation range, in remote areas subject to frequent burning, *ichu* predominates over large areas. Proximity to the village explains the total absence of trees, with the exception of the cultivated eucalipts on the village periphery.

new, green growth was sprouting; villagers would repair special walls around old, valued stands of tall ichu (ichu has several non-forage uses) to prevent these stands from burning; farmers would purposefully burn ichu from very steep slopes to allow their cattle better visibility and footing, and thus reduce their likelihood of falling down the slope; trees along the margins of woodland patches would be burned whenever the surrounding grassland was burned, and the dead trees were always replaced by ichu. That the use of fire was long-standing I had few doubts, and less so after I once asked a neighbor if the mountain deities, or *apus*, were not angered (this being one of their common moods) at the burning of the hillsides. His annswer was, "No, by now the *apus* are used to it."

This awareness of ichu grasslands as a natural formation at high elevations, but largely a cultural (and, specifically, fire-determined) one at somewhat lower elevations, made me curious about the other formations of the puna plant mosaic, namely the carpet meadows and the brushlands. Despite the broadly held view that they are natural formations, could they, in fact, also be cultural artifacts? Did they also reflect a particular kind of human intervention? I found, slowly and as the result of many comparative observations, that the answer to both these questions was "yes."

The carpet meadows are composed of short, soding grasses and herbs that, when grazed intensively, may be as crowded and neat as a putting green. This formation is called *ch' ampa*, locally. The sod is sometimes cut and used to build walls and temporary shelters. The constituent species of *ch' ampa* are easily found in infrequently burned ichu grasslands or those at higher elevations, or **[end p. 4]** as a scattered ground cover in the brushland formation, but only when they form a dense mat are they called *ch' ampa*. [3] Like ichu grassland, the distribution of *ch' ampa* does not correlate well with any salient ecological variable. Although better developed on wet sites, it can be found on quite dry ones; it prefers no particular orientation to the sun, and no particular soil type. Although the mix of constituent species changes with elevation, as a formation *ch' ampa* is found from below 3000 meters to more than 4200 meters. It does, however, tend to dominate on flatter slopes and be absent on steep slopes-the opposite, it is noted, of ichu.

Again, the cultural correlations are quite strong. In the majority of *ch' ampa* areas, in fact, low ridges running up and down the slope can be detected. These are remnant planting ridges and furrows of previous tuber cultivation, suggesting that the *ch' ampa* cannot be undisturbed native vegetation, and that cultivation has at least a part in its genesis. For this same reason, *ch' ampa* is very often associated with stone fences, as these mark the location of periodically farmed sites. *Ch' ampa* is also more abunndant close to settlement sites, because these are subject to the highest demand for agricultural land. Flatter areas are generally preferred to steeper ones for planting tubers, so we find that the flatter areas are more frequently in *ch' ampa,* while the surrounding, unplanted, steep land may be in ichu or brush.

But planting is not the only way to derive *ch' ampa,* as I had occasion to observe. If a plowed area is in *ch' ampa* before cultivation, it will tend to return to *ch' ampa* after cultivation. If the plowed area is in ichu before cultivation, then it will tend to return to ichu, unless there is heavy grazing pressure. In this last case the ichu, which when young is easily uprooted and trampled as it is grazed, is unable to survive, and the lower-growing herbs and grasses will invade. But even without plowing, ichu can be replaced by *ch' ampa* if fires are sufficiently frequent (making the ichu vulnerable to uprooting and trampling), and subsequent cattle grazing is heavy enough. Cattle prefer the flatter areas for grazing and congregating, and, in the case of frequent fires and heavy grazing, there is a strong tendency for the ichu grassland to first be replaced by *ch' ampa* in those flatter areas, creating patchy green areas within a larger sea of yellowed bunch grass. Eventually, the *ch' ampa* comes to predominate, leaving ichu only on the steepest and most inaccessible places, where cattle cannot reach it.

Once the *ch' ampa* areas are established, whether by plowing or cattle grazing or both, then they are subjected to intense sheep grazing. Sheep do not eat mature ichu, but they do eat *ch' ampa* vegetation. So although cattle are instrumental in converting an ichu grassland to *ch' ampa,* it is primarily sheep that maintain the *ch' ampa*.

The other formation that occupies extensive areas of Vilcabamba's mountainsides are the brushlands, locally termed *matorrales*.[4] This woody vegetation is often considered to be transitional between montane forest and high altitude grassland, but I observed no such altitudinal zonation. Like ichu, matorral could be found above and below the tree zone and above and below zones of grassland. Also like ichu, matorral is not restricted to any identifiable microhabitat: it grows on a variety of soils--wet and dry, sandy and clayey, sedimentary and volcanic derived--on any slope aspect and in any position on the mountain profile. There is, however, some tendency for matorral to be found on steeper slopes, poorer soils, and in rocky areas, sometimes mixed with ichu, sometimes in discrete patches. There is a tendency for matorral to be more vigorous at lower (3200-4100 meters) rather than higher elevations.

My suspicion that the matorral is a secondary formation was initially aroused by examining the individual shrubs. Many are in fact old trees that have been pruned repeatedly; others are very young trees that have not had the opportunity to develop. In other cases the shrubs grow up from ground that clearly (from the presence of remnant ridges and furrows) had once been planted. This formation, I learned, is intensively used for firewood colllection, for construction materials, and for wild plant medicines. It is also grazed by cattle, who consume the ground cover between shrubs, and browse the shrubs themselves. The tendency for matorrales to be located on steeper slopes and on slopes of poorer soils is a funcction of their marginal usefulness for agriculture. Scattered shrubs eventually invade *ch' ampa*, but these shrubs are uprooted and discarded when the field is again plowed within six to ten years.

Matorrales often cover rocky areas such as talus slopes, and they are often surrounded, beyond the rock field perimeter, by ichu. It became clear that the persistence of the woody vegetation owed itself to the protection from fire provided by the rocks, and not (below 4100 meters) to the warmer environment within the rock field. Sometimes a simple terrain break will inhibit fire enough to allow a matorral to persist.

Thus, matorrales sometimes represent areas that have incidentally escaped the burning of surrounding ichu grasslands, but very often, too, there is a conscious effort on the part of Vilcabamba farmers to keep fire away from their matorrales, because they recognize this formation as a valuable resource. If we were to look at the major constituents of the plant mosaic--ichu, ch' ampa, and matorral--we would see that each formation is purrposeful; each has a part in a complex farming-grazing subsistence system. Ichu provides not only feed for cattle but also material for roofing, packaging, and bedding. Ch' ampa provides feed for sheep, sod for walls, and fertilized and rested cropland every seventh year. The matorral provides firewood, construction materials, medicinal herbs, and some cattle feed, especially in the dry season when open pasture grasses, because of frost and dryness, become unproductive.

It is no coincidence that these separate formations exist, and that each is exploited in particular ways. They **[end p. 5]** are, in fact, created and sustained by the local populace; in my view, they are as clearly cultural artifacts as cornfields or tree farms. They allow us to see the vegetation mosaic as social and economic history: haciendas, which depend on cattle, produce large expanses of pure ichu; native communities, which depend on many different resources, produce a complex vegetation mosaic. Presumably as the needs or aspirations of Vilcabamba farmers change, their vegetation will change: if the price of cattle or sheep rises, matorral will be burned and connverted to ichu or ch' ampa; if. potato prices were to rise sufficiently, ichu would be plowed up and planted, and subsequently remain in ch' ampa.

Throughout this puzzling-out of the vegetation mosaic, the question persisted: What was the original vegetation? I could not step back in time and I had no facilities for engaging in a palynological investigation. Yet I was free to observe areas that were marginal to the agricultural communities and where presumably there might be remnants of the pre-existing vegetation.

One of these marginal areas is a mountain called Puncuyoc; it lies about 25 km from the village where I lived, and I had the opportunity to go there a number of times. Briefly, what I observed were trees (in a variety of microhabitats) growing at higher elevations on Puncuyoc than anywhere I observed in the densely settled Vilcabamba. Some grasslands (up to 4000 meters) contained standing, burned stumps of trees up to 35 em in diameter. Woodland patches, from 20 to 100 meters across, were often surrounded by grasslands, and charred stumps on the woodland perimeters suggested that trees had forrmerly occupied a larger area. Although no one lives on the entire south side of Puncuyoc, the grasslands are nonetheless periodically burned by visitors or farmers pursuing their cattle. The only resident on the northeast side of the mountain, where extensive ichu grasslands alternate with forest patches, proudly explained to me how, when he arrived twenty years before, the land was plagued with forests, but that by cutting, burning, and planting, he had made it habitable.

Fig. 2. An *ichu-ch'ampa* mosaic. The hilltop in the foreground has gentle slopes to the left and precipitous slopes to the right. The foreground elevation is approximately 4000 meters. The left side is grazed intensively by cattle and is in *ch'ampa*. The right side is periodically burned, is too steep for grazers, and is in *ichu*. In the background the steep slopes, at the same elevation as the foreground, are occupied by *matorral*. This is because they are located close to the village of Vilcabamba and are protected from fire to preserve their fuelwood, medicine, and browse uses.

[end p. 6] Even within agricultural communities such as Vilcabamba, it was possible to obtain some clues regarding the former vegetation. Older villagers told me about forrests in Vilcabamba that they had cut down for firewood; I investigated the site of those forests and found them to be now in ch' ampa. Later I chanced upon a high (4,200 meters) forest in a remote area of Vilcabamba. Although most of the trees were standing, a portion had been cut down and was being left to dry. The woodcutter, I discovered later, was a villager who lived more than 10 km away. Only a few farmers are still using these last, remote forest remnants to provide their firewood. Most now go east, over the lip of the Andes, and descend into the neighboring montane forest, even though this entails an entire day's trip with mules. The effect of their deforestation, now occurring at about 3,200 meters, is to artificially suppress the tree line. Replacing these montane forests are either ch' ampa grasslands or extensive bamboo brakes, depending upon how intensively the site is burned, grazed, and cropped following forest clearance.

In answer to my underlying question, everything seemed to suggest that trees had occupied much of the land area of Vilcabamba.[5] How high this tree growth extended is still an open question, but my observations of healthy *Polylepis* woodlands at elevations up to 4,500 meters suggest to me that a forest cover is possible up to this altitude. The woodlands I observed, it should be emphasized, were not usually growing in favorable (wettter, warmer, more sheltered) microenvironments. They were, in fact, found in a great variety of environments, [6] some of them quite unfavorable--either very exposed, or on thin soils, or in places subject to cold air drainage. What these woodland sites did have in common was either their protection from the passage of fire-a break in the terrain, intervening cliff faces, or a rocky gound covering over which fire could not travel--or their inaccessibility to the resident human population.

How connected these hypothesized woodlands were is uncertain. The extremely dissected terrain of Vilcabamba is responsible for a tremendous variety of local environments. Tree growth at high elevations responds to the slightest environmental variations. Thus I do not expect that the forest cover was continuous at 4,500 meters, although it may have been so at 4,100 meters, the altitude where the current matorral begins to break up. This, at any rate, is about 700 meters higher than continuous tree growth is found today in any of the areas surrounding Vilcabamba. This massive conversion of woodland to open grass and brushland took place, at least in part, quite recently, and it is continuing today. Nonetheless, extensive evidence of Inca and pre-Inca occupation in the Vilcabamba area suggests that earlier periods of deforestation may have taken place. If this were the case, then perhaps woodlands were able to reestablish themselves during the colonial period, when native populations were radically reduced.[7]

What are the implications for other areas of the Andean puna? Did the extensive puna of southern Peru, whose treelessness has long been ascribed to climatic and edaphic factors, once support widespread woodlands? At least for the wetter portions of the puna in general, and the altiplano in particular, I believe this to be quite posssible, and I wish to briefly indicate my reasons for thinking so.

First, however, it needs to be acknowledged that the constraints on vegetation at puna elevations are quite severe. A combination of temperature, precipitation, soil, and radiation factors make any kind of plant growth difficult, and for these reasons productivity is characteristically very low. The daily temperature regime is extreme: at 4,000 meters as much as a 15°C. range is common, and the temperature during the night is often below freezing. Thus, a plant must adapt to relatively high temperatures during the day, particularly when the sun is out, and also to a cessation of its metabolic activities at night, on a daily basis. Precipitation is also limiting. Annual totals for the moister portions of the puna range from only 400 mm. to 800 mm., hardly abundant given the low humidity and intense solar radiation at 4,000 meters. Furthermore, the precipitation is highly seasonal, occuring mainly during a five to seven month period, beginning in October or November. (The seasonality is more pronounced, and the rainy period shorter, in the southern than the northern puna). In addition, the date of onset of the rainy season is variable, particularly toward the south. If the rains come late, another limit is placed on the already marginal growing season.

Soils are quite variable in the puna, but they are characteristically poorly developed, owing generally to cold and dryness, to a short period since glaciers retreated and left exposed surfaces, or sometimes to extreme slopes, which are subject to erosion of their A horizons.

As a result of these limitations, and in accord with what is readily observed in the higher (above 3,500 meeters) portions of the central Andes, botanists have come to regard the puna grasslands, carpet meadows, and brushlands as natural plant communities. The evidence from Vilcabamba, however, suggests that grasslands, carpet meadows, and brushlands are derived communities and that what they often replace, even at elevations up to 4,500 meters, are woodlands. Very little evidence has been produced in support of a wooded formation at puna altitudes. This, I believe, is at least in part because so few researchers have even entertained the idea, thus they fail to see the evidence for it in their data. It has been established, however, that during the Pleistocene glacial periods the altitudinal zone of puna moved downslope, and that during interglacials the puna may have existed at somewhat higher elevations than today (Van der Hammen 1979; Simpson 1979b). No acknowledggment is made that within its climatic parameters (at whatever elevation) the puna supported a more elaborate or wooded vegetation than can be observed today. But certain evidence in the literature suggests that tree growth
[end p. 7]

is currently possible on the puna and may have occupied extensive puna areas at some time in the past:

1. Forests on the altiplano are frequently reported above and below the grassland communities.[8] These are sometimes merely mentioned, sometimes considered anomalies for which no explanation is attempted, and sometimes explained as a function of a favorable microenvironment, though data is rarely given in support of the supposition.

2. Place names exist that refer to trees, in places where a single tree is not to be found for many miles. The Collao region around Lake Titicaca is named after the colla tree (*Buddleia*; Pulgar Vidal 1946, 110), of which surviving specimens are extremely rare. The survival of groves of *Polylepis* trees in some high altitude areas has been ascribed to local cutting taboos (Pulgar Vidal 1946, 109).

3. The contemporary puna climate supports planted tree growth in many places. Plantations, wind breaks, and ornamental trees have been planted, and, when protected from fire, cutting, and domestic grazers, they do quite well without further human assistance.[9]

4. Numerous authors note, and usually lament, the widespread, on-going destruction of remaining woodlands.[10] Projecting

this deforestation backwards (as we must, because human occupation of the puna is long-standing) we can conclude that woodland areas were formely more extensive than they are now. It may even be suggested that the depopulation of the puna in prehistoric times was a reponse to the depletion of the fuel supply (Rick 1980, 3). It is also possible that early Andean hunter-gatherers purposefully fired existing puna grassland (1) to attract game (inadvertently burning the surrounding forests), or (2) to consciously convert forests to grasslands (as has been suggested for Great Plains and California Indians in North America), and thus expand the ecological niche that supported their primary food supply.

5. Using different types of evidence,in completely independent investigations, various scholars have reemarked upon the probability that woodland extended to much higher elevations than at present.[11] Among these authors, Ellenberg (1979, 401-406) has been the only one to compile the various local evidences and to argue for an extensive tree covering, up to 4,600 meters, over much of the present puna. [12] A great deal of investigation, using coordinated palynological, tree ring, and geomorphic evidence, needs to be done if this matter is to be properly addressed.

Given the scatter of evidence highly suggestive of a more widespread tree cover in the past, the question arises as to why this issue has been scarcely recognized or researched. I see two fundamental reasons. First, human types of intervention (e.g., fire, tree felling, soil exposure and erosion, grazing) may differ in scope and intensity from natural forces, but often do not differ in kind (Kellman 1980, 141; Mangenot 1963,117-132). It is therefore difficult, especially in historical reconstructions, to distinguish human from natural causation. When there is no natural baseline established (e.g., the frequency of lightning fires or the impacts of native grazers on native vegetation), the problem is compounded. These difficulties are further exacerbated by the tendency for a disturbed site to be occupied by vegetation from a colder or drier environment, mimicking a natural zonation (Buudowski 1968, 157-162). In the Andes, this zonation is altitudinal.

The second reason, I believe, is our tendency to ascribe necessity to what we observe, particularly if the phenomenon of interest is outside our ordinary experience. We tend to assume that what we observe could not be otherwise. By making rules about the world we codify this assumption, which assures its perpetuation through the expectations that the rules generate. We also someetimes fail to see that although the present responds to the present, it is largely a function of the past. Only when the anomalies pile up do we change our explanation. This, of course, is the Kuhnian process. But the solution, it seems to me, is not to replace one orthodoxy with another. In the case of high Andean vegetation, I think we would do best to remind ourselves, as a starting point, that the observed vegetation could be radically different from what it is now. This places the burden on us to establish why it is not different; it forces us to consider factors that otherwise we could ignore. We are accustomed to employing familiar causes to explain a particcular phenomenon, but when these fail, another task is required: to identify the unseen causes. With respect to the conventional wisdom, I found much of the Vilcabamba vegetation to be anomalous and, after study, I think the anomaly extends to the moist puna of the central Andes. The problem for me has been to identify the unseen causes. The ones I keep finding are cultural.

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NOTES

1. This paper, with illustrative slides, was presented at the annual meeting of the Association of American Geographers held in San Antonio, Texas, in April, 1982; and at the III Congreso Internacional de Botánica held in Lima, Peru, in July 1982.

2. In Vilcabamba these grasses include *Calamagrostis ovata* (Presl.) Steud., * *Calamagrostis recta* (HBk.), * *Stipa ichu*, and *Festuca* spp. The more frequently the grassland is fired, the greater its proportion of these grasses, the smaller the proportion of herbs and low-growing vegetation.

At higher elevations (above 4000 meters). where bunch-grasses are separated by patches of bare ground and where fire is infrequent, scattered shrubs, mosses, herbs, sedges, and non-bunch grasses are a part of the grassland. These include *palkayso* (*Loricaria Lucida* Cuatr.), * *ch'ilca* (*Diplostophium goodspeedi* Cuatr., * and *Diplostophium repestre* *), *Senecio adenophylloides* Sch.-Bip., * *phufzu* (*Senecio canescens* [HBk.]*), *Muutisia cf. comptoniaefolia* Rusby, * *Gentianella* sp., * *Perrnettya prostrata* (Cav.) White, * *Arracacia* sp., * *Plantago* sp., **Carex* sp., * *Luzula/i> sp. (probably)., * Lyycopodium sp.,* Bomaria sp.,* Poa sp.,** Werneria nubigena (HBk.), * and *Cortaderia bifida* Pilger. *

3. The constituent plants of ch' ampa are highly varied. Among them are *paco kishka* (*Aciachne pulvinata* Benth. and Hook), * *chokan* (Trifolium sp.), * *erucaychu* (*Acaena cylindrostachya* R. & P.),* *rata-rata* (*Acaena ovalifolia* R. & P.),* *waka callo*(*Plantago* sp.),* phrotilla (*Alchemilla* sp.), * *k' et-k' eto* (*Gamochaeta spicata* [Lam.] Cabrera), * *t' otora* (*Juncus stipularis* Nees & Meyer), * and *sajsara* (*Poa* sp.). *

4. Matorral includes: (a) shrubs, among them *yawli* (Barnadesia polycantha Wedd.), * *kaywincha* (*Brachyotoum grisebachii* Cogn.), * *opa kaywincha* (*Brachyotum rostratum* (Naud.) Tr. (probably), * *tinta-tinta* (*Miconia salicifolia* (Bonpl.) Naud.),* *sajra mate* (vine-like; *Jungia malvaefolia* Munschler), * *tayanca* (*Baccharis peruviana* Cuatr.*), *k"arwancha* (*Rubus* sp.),* *Siphocampylus* sp. * (probably), * *Hesperomeles languinosa*, * and *Pernettya prostrata*;* and (b) trees that are continually pruned and come to resemble shrubs, among them *q' uello kishka* (*Berberis* sp.), * *t'iri* (*Miconia cf. thyrsiflora* [Don] Triana* and *Miconia latifolia* [Don] Naud.), * and *tocarway* (*Buddleia incana*). * Ground cover in the matorral includes many of the herbs and grasses of the ch' ampa, a great many mosses, and some of the tussock grassland elements. The tussock grasses themselves are limited, however, if the matorral is densely wooded (i.e., infrequently burned), or heavily grazed.

5. Above about 4,000 meters the woodlands I observed were almost exclusively of *yuraj kaywifza* (*Polylepis serricea* Wedd.). * At slightly lower elevations Polylepis was joined by *asta* and tocarway (Buddleia coriacea). * Beetween 3,700 and 4,000 meters these three trees were joined by *t'iri* (Miconia latifolia [Don] Naud.),* *kishwa*r (Budddleia sp.), * *q' uello kishka* (Berberis sp.), * and Gynoxys nitida Muschler. * Below 3,700 meters i>yuraj kaywifza dissappears and is replaced by another species of Polylepis, *Polylepis pauta* Hieron., * though at this elevation and below, Polylepis is never more than a minor constituent of an increasingly complex tree cover. At 3,400 meters the vegetation includes Miconia cf. thyrsiflora (Don) Triana, * Miconia cf. hygrophila (Naud.), * Miconia bulllata (Turcz.) Triana (probably),* Clusia sp.,* Weinnmania sp., * Baccharis pentlandii DC., * Tibonchina dimorphophylla Gleason, * Gymnoxys caracensis Mussehler, * Vallea stipularis L., * Saracha sp., * Demosthenesia dudleyi Simpson. *

6. For a general discussion of these matters, see Winterhalder and Thomas (1978), Walter (1971), and Troll (1968,] 5-56). More specific information is available in Cabrera (1968,9]-116), and Schwerdtfeger (1976).

7. I have, for example, observed Inca roads at 4,000 meters covered by mature forest.

8. Examples abound, both in scientific studies and in travel literature. See Weberbauer (1936, 42); Lynch (1980,7,9); Pulgar Vidal (1946, 107, 109, 131); Winterhalder and Thomas (1978, 57); Cabrera (1968, 97); Troll (1968, 35, 44); Bowman (1916, 59); Fountain (1902,203); and Bingham (1948,241). Weberbauer disscerned no correlation between existing Polylepis forest and particular microhabitats, but Troll related Polylepis to favorable microhabitats, i.e., ones that simulate lower altitudes.

9. Pulgar Vidal (1946, 109, 131). Simpson (1979a, 16), however, takes issue with the viability of puna tree growth.

10. See Rick (1980, 16); Dorst (1967,196); Fountain (1902, 203); Schnell (1971, 774,776,797); Smith (1980, 65); Pulgar Vidal (1946, 136); Winterhalder and Thomas (1978,77-78); Von Tschudi (1849, 213-214); and Cabrera (1968, 97).

11. See Walter (1971, 191-192); Cook (1916a, 284-293); Cook (1916b, 474-534); Gade (1975, 16).

12. For a refutation of Ellenberg's argument, see Simpson (1979a, 16-17).

*Plants identified by and through the University of Wisconsin Herbarium, Madison, Wisconsin, from specimens collected by the author in 1979 and 1980. **[end p. 9]**

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