

Authors

Fuel Use and Landscape in the Peruvian Andes:
a Study from the Mantaro Valley.

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INTRODUCTION

Ethnobotany was defined by Volney Jones in 1941[✓] as the study of the complex web of interrelationships between people and the plants they use. The discipline has often focused on food plants, ^{leaving} but a class of interactions of equal importance to eating ~~has been~~ neglected - that between people and their fuel plants.

A notable exception to this neglect is Heizer's (1963:192) demonstration that "the prosaic search for fuel for fires enters significantly into a good many social and economic activities of groups...". Heizer's study and later fuelwood studies spurred by development agencies (Campbell et al. 1985[✓]; Chandola 1976[✓]; Devres, Inc. 1980[✓]; Fleuret and Fleuret 1978[✓]; Jones 1982[✓]; Martinez 1982[✓]; Skar 1982[✓]; and Tibaijuka 1985[✓]) show many ways in which, as people use fuel, both the human and plant populations involved are influenced by their^{se} interactions. Such systems of interaction between people and plants are dynamic -- changes and adjustments are ongoing (Anderson 1952[✓], Harlan 1975[✓], Rindos 1984[✓]). Clearly most people in the world now use fuel differently

from fifty years ago, and paleoethnobotanical studies have begun to show that changes in fuel use occurred throughout prehistory (Johannessen 1981, 1984; Lopinot 1988; Miller 1985; Minnis 1978; Pearsall 1983; Willcox 1974).

The interaction between people and their fuel plants is affected by the type and distribution of available fuel, cooking and eating habits, washing and heating requirements, type of land-use, the human population and its distribution vis-a-vis the sources of fuel, cultural perceptions of suitable fuel, the agricultural and fallow cycle, and social factors, as well as external economic and political factors (Agarwal 1986, Alcorn 1981^a, Devres, Inc. 1980, Jones 1982, Knowland and Ulinski 1979, Laarman and Wohlgenant 1984). ok

These relationships are especially critical in areas where fuel is scarce, such as the Andes. Here fuel collection involves a considerable expenditure of time and energy, especially by women who are the major gatherers and users of fuel. People use a diversity of fuel types, resulting in a complex pattern of collection and use. Fuel availability affects cooking styles and the frequency of meals. The relative scarcity of fuel results in discrepancies in fuel availability for different segments of society.

Overuse of fuel may have very serious consequences, as indicated by the large literature on the crisis in areas of the world today (Agarwal 1986; Allen 1983; Arnold 1978; Eckholm 1975, 1976; Eckholm et al. 1984; Siren and Mitchell 1985). Forest cover may disappear, affecting other plants and the animals, the soils, and, most importantly, the hydrologic cycle. Reduction in the availability of woody plants may also increase use of crop residues and dung for fuel, thus removing valuable soil additions. With fuel over-use,

women must increase their time spent gathering fuel, leaving less time for other tasks. They may change cooking practices and schedules so as to use less fuel, for example by cooking meals in advance along with the morning meal, thereby affecting nutritional standards (Skar 1982). As nearby fuel sources are used up, transportation costs and labor specialisation increase, for fuel may no longer be available to individual families on a ^{daily} day-to-day basis (Martinez 1982). People must buy fuel, thus farther widening the gap between those who have adequate fuel and those who do not. Woodlots may be started, thus contributing to land speculation and privatization (Tibaijuka 1985). One study suggests that when faced with a fuel shortage people may increase their family size so that enough ^{then} daily fuel can be gathered by the children (Reddy and Prasad 1977).

The subject of this present study is the long-term changes in a particular system of fuel use -- that of the Wanka people of the Mantaro Valley ^{of} the Peruvian Andes. We begin with a study of modern fuel use in the Mantaro Valley. We then compare the modern pattern with the changing landscapes and fuel systems of the past that can be traced through written records from the area. Our purpose is to track the changes in the system of fuel-use in order to understand the cultural and ecological factors at work.¹

PRESENT AND PAST LANDSCAPES AND FUEL USE IN THE MANTARO VALLEY

The upper Mantaro Valley is a high intermontane valley in the south-central Andes of Peru. The study area is near Jauja in the Department of

Junin at about 3500 m in elevation (Fig. 1). The residents of the region have been farmers and herders for at least 2500 years. Although autonomous for centuries, they were incorporated into the Inka empire about A.D. 1460 and were the first group to rebel against the Inka by allying with the Spanish in 1532 (Browman 1970; D'Altroy 1987; Earle et al. 1987; Matos and Parsons 1979; Parsons 1976). The Wanka people still farm and herd in the ^{region} valley.

The present landscape of the Mantaro Valley reflects thousands of years of human occupation and use. The high valley and surrounding slopes have little woody vegetation, and fuel has probably long been sparse (Fig. 2).

The following sketch of the fuel resources of the area is compiled from Bird (1971), Gade (1975), Hastorf (1983), Mayer (1979), Pearsall (1979), Tosi (1960), Pulgar Vidal (1967), and Weberbauer (1936, 1945). The high cold puna surrounding the valley (above about 4000 m) supports no trees, being covered mostly with grasses, notably bunchgrass (*Stipa ichu*). The only woody growth is the bromeliaceous *Puya*, which provides fuel and building material (Gade 1975). *Puya* and the grasses are virtually the only fuel plants in this zone. The plants of this zone also serve as pasture for cows, sheep, and llamas.

The high slopes between about 3600 and 4000 m are characterized by grassy steppes with scattered shrubs and small trees, mostly of *quinual* (*Polylepis* spp.) and *quisual* (*Buddleia* spp.), with some *aliso* (*Alnus jorullensis*), *chachacoma* (*Escallonia* spp.), and *sauco* (*Sambucus peruviana*). Barley, tubers, native legumes and quinoa are grown here. The lower hillsides of this zone are step-slope terraces often edged with hedge-rows, and the upper fields are without hedges and in periodic fallow. These field systems provide fuel from the shrubs of the hedge-rows (see also Gade 1975:88), the stalks of threshed

crops, and the grasses growing in the fallow cycle, and in higher areas dung from animals grazing on fallow fields.

The Mantaro River basin, tributary valleys and lower alluvial slopes (about 3000-3600 m) are the site of the most intensive settlement and agriculture today. Tosi (1960:103) suggests that this zone may at some time in the past have been wooded, but it is now transformed by human use, and little wild vegetation remains. Woody shrubs include *chilka* and *tayanka* (*Baccharis* spp.), *retama* (an introduced shrub, *Spartium junceum*), *molli* (*Schinus molle*), *tara* and *pactae* (*Cassia* sp.). *Chaghual* (the Mesoamerican maguey, *Agave* sp.) also grows here and is used for fuel. The most common tree is the cultivated introduced eucalyptus (*Eucalyptus globulus*). The *guinda* (the introduced mazard cherry; *Prunus* sp.), as well as the native *aliso*, *quinual* and *quisual* are also planted (Adams 1959, Dickinson 1969, Gade 1975, Mayer 1979).

Another zone available to the inhabitants of the valley for fuel gathering is the cloud forest or *ceja de la montana* on the eastern slopes of the Andes, some 30-40 kilometers from Jauja. Here the warmer and more humid conditions support a dense forest. Wood products from this zone, perhaps including firewood, may have been obtained through trade in the past as they are today, although access can be difficult. For example, in 1947 more than a million board feet of wood was brought into Jauja from Satipo on the eastern slopes, but in 1954 the export had shrunk to nothing due to the destruction of the only ^{connecting} railroad by an earthquake (International Development Services, Inc. 1954). These eastern-slope forests may long have been a place for fuel gathering as well as for wood for certain industrial needs; Tosi (1960:152) states that the upper slopes of the *ceja* have been much deforested and

replaced by secondary growth. This, according to Tosi, is a result of repeated use of the zone for firewood, due to its proximity to the dense population of the interior valleys, where woody material has been very scarce in recent centuries.

The zones described above contain the principal types of woody vegetation used as fuel. However, wood from naturally occurring trees is today only a minor component of the total fuel used, and probably has been long into the past. Straw, leaves, crop residues, dung, and wood from cultivated trees, all part of the anthropogenic landscape, form the major part of the pattern of fuel use.

Modern fuel use in the Mantaro Valley.

As part of a long-term study of Andean fuel use, a pilot study on modern fuel use was begun with interviews made in August 1985. Questions were asked about types of fuel used, fuel preferences, collection and storage practices, cooking and hearth use, and disposal and use of hearth debris. Fifteen interviews were made. Six of the interviews were with women, three with men, five with a couple or group containing both men and women, and one with two boys who gave very incomplete responses. The responses are grouped for discussion under three sections: fuel use and preference, fuel collection and storage, and use of the hearth and of hearth residue.

Fuel use and preference.-- People were asked what fuel they burned and in what

proportion. The fuel categories asked about were firewood (*leña*), dung (*bosta*), straw (*paja*), cobs (*mazorcas*), and other (*otro*). In general, the people interviewed said they used a combination of firewood, dung, and straw for fuel. Figure 3 illustrates the relative frequency of use of the fuel categories, as well as of the specific types of fuels used within each category. About half the people said they used firewood most often, and about half said dung was most frequently used. Straw is also in frequent use, mainly to get the fire started. Maize cobs are seldom used.

The most commonly used firewood is eucalyptus. Several people added *aliso* (*Alnus jorullensis*), *quinual* (*Polylepis* spp.), and *pactae* (*Cassia* sp.) to the list of kinds of firewood used.² The dung used is from cows and sheep, although sheep dung is not as suitable and is used less often. Straw for fuel is from both naturally occurring plants of the fields and countryside, and the crop stalks of *quinoa* (*Chenopodium quinoa*) and *habas* (*Vicia haba*). Seven people also mentioned "other" fuels; these included kerosene and charcoal bought in the market but other types mentioned in this category are woody

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between use and preference is that while firewood (*leña*) is the number one preferred fuel most often, (dung never listed first), dung is in fact used most frequently in about half the cases.

For light, kerosene used in lanterns is preferred by almost everyone. Responses to questions about preferences for heat and for cooking were very mixed; the answers including various mixtures of wood, dung, and straw, with no clear pattern. There was no indication of widespread agreement that the cooking of particular foods required particular fuels, although the oily leaves and branches of eucalyptus are preferred for the special earth ovens (*pachamancas*) which require hot fires to heat the stones.

Obtaining and storing fuel.-- The interviews indicated considerable variation in when and where each of the main categories of fuel is collected (Fig. 5).

Patterns of fuel use also vary throughout the year with the seasonal cycles of weather and agriculture. The frequent rains from November to March make it difficult to collect such fuel resources as dung, shrubs, and grasses. In the dry months from May to August these are easily available, and crop residues provide an additional source of fuel in these months.

The main fuelwood, eucalyptus, is cultivated mostly on good land on the valley bottom. The wood is most often obtained once a year in the span of a few days and stored for the year. One to four trees are bought, cut, and hauled home, or cut on the person's own land. Eucalyptus, for those who can buy or grow it, is the staple fuel in the wet season.

To augment this supply, shrubby woods are collected daily or weekly from the hills, the lower slopes, and the ravines. More frequent shrub gathering

occurs in the dry season. One woman said she walked three hours every day to get firewood, while another reported 1-2 hours, and another a hour a day.

Dung is collected daily, in the corrals, fields, puna, or anywhere it can be found. Four people said this was done when dry or in the dry season, because, as one woman explained, it needs to dry for one week (Fig. 6.). One person said dung collection took about an hour a day, and another said dung was collected during other errands.

Straw of grasses and weedy plants is also collected daily in the fields or pastures during the dry season. Two boys who were interviewed coming down into the valley with bundles of straw said they went everyday to the hills to get grass. At harvest time, the crop straw are all saved either for fodder or for fuel. They are dried, stored in the house compounds, and used for as long as they last.

Answers to questions about where fuel was stored were varied. Fuel is dried on the roofs or in piles and stored in covered areas. Generally people keep some fuel in the kitchen, with the main storage in a ramada or covered area outside in the walled patio but near the kitchen. Some people also keep the fuel in piles in storage areas in the house or patio. In one case, a family had an old house that was used only for storage - fodder, crops, and fuel. Several others had storage structures especially for fuel.

Use of the hearth and hearth residue.-- Most people light their hearths twice a day for cooking, once in the morning and once in the afternoon, but let them go out when not in use (Fig. 7). Only two people said that their fires were going all day, and one said it was lit only once a day in the afternoon.

The hearths are most often swept and emptied every morning. Generally the ashes are thrown onto a pile (*guano de corral*) outside near a wall of the house. These piles contain vegetable waste, dung, ashes, and other rubbish. The pile is left to compost and is then used for fertilizer (Sikkink 1988). Some people keep the hearth residue in a container and take it out once a week or so to throw on the fields. Two people said they threw the ashes from the hearth directly onto the fields daily.

The ashes from the hearth are definitely considered as valuable field fertilizer. Every person who responded said that the ashes were used on the fields. The most frequent pattern is that the *guano de corral* pile that has accumulated near the house is taken once a year at planting time and put on the fields. Papas (potatoes, *Solanum tuberosum*) and habas (broad beans, *Vicia faba*) are the two crops mentioned that receive the ashes.

Discussion.-- Because of its relative scarcity, getting fuel in the Mantaro Valley is expensive in time, effort and/or money, and fuel is carefully used. Most people light their hearths only for the preparation of morning and afternoon meals, which are generally *motes* or soups that can be boiled in a single pot over a small fire. The hearths are not used for heating the rooms. The variation in the time the hearth was alight that was seen in the interviews may reflect differential access to fuel and perhaps nutritional standards. Sarah Skar (1982) found that in three Andean communities the time spent cooking varied inversely with the time spent collecting fuel. She describes fairly well-to-do women in the town of Huancarama who, using primarily eucalyptus logs bought or cut on their own land, spend only half an

hour a day collecting fuel and so have time to prepare three hot and varied meals a day. In contrast, the women in the high farming community of Matapuquio spend an average of one hour and 40 minutes a day collecting fuel, and with less time to spend cooking, can prepare only two and in some cases only one hot meal a day. Another illustration of the relationship between hearth use and fuel availability can be seen in a comparison of two fuel studies from Africa. In the mountains of Tanzania, where women have relatively free access to a nearby forest reserve, the hearths are lit to cook three meals a day and may be left burning throughout the afternoon and evening and sometimes at night. The average family of five used 22.4 kg of wood each day (Fleuret and Fleuret 1978). In a situation of scarcer fuel in Upper Volta, where women spend more than four hours a day getting wood at some times of the year, an average family of five burns only 4.2 kg per day (Ernst 1978).

The assemblage of fuels used in the Mantaro Valley is varied and includes several kinds of wood, kindling, dung, grass, crop stalks, and maize cobs. Wood is the preferred fuel, but dung and straw are used as much as wood is. This preference for wood fuels is also seen in Skar's findings that of eight fuel types used by three Andean communities, only kindling and eucalyptus were reported by all three. She also found that where fuel is relatively abundant and many people own land, only wood fuels (with kerosene) are used, while where fuel is scarce and people have less cash they use a greater variety of fuel types (Skar 1982). In the Mantaro Valley, although most people buy some eucalyptus, they must supplement it heavily with gathered fuels. Jones (1982:55) also found that several areas of Panama vary in the concordance of fuels preferred to fuels used, indicating varying degrees of access to fuel.

Much of the fuel used in the Mantaro Valley is not from naturally occurring plants, but is either cultivated or is a by-product of crops or domestic animals. Fuel production is not uncommon in fuel-poor areas; Chandola (1976) found that in an Indian village almost all the fuel was either dung, agricultural wastes, or wood from cultivated trees.

Acquisition of fuel in the Mantaro Valley forms a complex pattern, varying with the seasons and the agricultural cycle, and with several overlapping systems of land-use, land-tenure, and economics .

Fuel ~~use~~ ^{collection or use?} varies throughout the year; the daily collection time for fuel other than the ~~main firewood supply~~ ^{bulk wood acquisition applies to the} appears to be a dry-season pattern, indicating that less time and more cash are needed for fuel during the rainy season. Other field studies have found considerable seasonal variation in fuel use; the women of the mountains of Tanzania ~~also~~ ^{more?} build up a stock of wood for the rainy season when collecting is difficult (Fleuret and Fleuret 1978). The ^{availability} use of crop residues at certain times of the year also affect the seasonal pattern of gathering and use. Ernst (1978) found in a study ^{and} in West Africa that millet stalks are the principle fuel for six months of the year, while ~~for~~ the rest of the year the women spend about four hours a day gathering wood.

Today's "ideal" Andean fuel, eucalyptus, is a cash crop cultivated on prime agricultural land that would otherwise be used for growing food (Dickinson 1969). The trees are individually owned and are available only to those who have cash or land. Auxiliary wood fuel such as *aliso* and *quinual* may also involve tree cultivation and individual ownership. Obtaining these

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large trees for the main fuel supply appears to be a male task, and it is accomplished yearly or seasonally, with several days of cutting and hauling the wood home. Whether this wood actually provides the greatest proportion of the total fuel used is still unknown, - the woody shrubs, dung, and straw collected on a more frequent basis probably contribute as much or more to the fuel supply.

This frequent or daily gathering task is done mostly by women or children, although men also collect fuel on a daily basis when out on other errands. Shrubs and kindling can be gathered from hills and ravines. Traditionally these lands are held communally, as is firewood land in the Marañon Valley to the north (Brush 1977:77), but with increasing scarcity and privatization this right may be ~~en~~ curtailed. For example, Skar (1982) found that cooperatives that control land are beginning ^{to} demand payment from neighbors for pasturage and wood collected while pasturing. People are indignant about this, she says, and sneak in at night to get wood since they consider it their right.

The less valued dung, straw, and weedy plants are more easily available and are collected in the corral, fields, puna, or "anywhere". In the Jauja region, only the owners have rights to dung and straw from their corrals or from fields in crops, but anyone may collect dung and straw from the communal grazing lands of the upper slopes and the puna, and from fallow fields. Dung may be much more efficient than shrubs and kindling to collect, especially if obtained from the corral close to the house (Winterhalder 1974). ^{et al.} ✓

~~It is not the only determination of fuel collection.~~
 All people living in a similar environment do not necessarily use the same combination of the ^{various} fuel collection strategies described above. How an

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individual family collects fuel depends on many particulars: where they live, what kin and community ties they have, the composition of the family, and their access to cash and land. Historical factors may also create differences in fuel use within similar environments; Skar (1982) found that in two relatively fuel-rich Andean valleys the kinds of fuel used and the proportions of grown fuel to gathered fuel are quite dissimilar, due to different histories of land tenure in the two valleys. ✓ good.

Fuel use, then, varies with the seasons, with agricultural activities, and with land tenure, with access to cash, and with social factors, but fuel is always relatively scarce. Keeping the hearth alight is a major concern in Andean domestic ^{life} economy. People manage fuel with care and effort and use it thriftily. Nor does fuel use end with the cooking of meals; the ash is afterwards returned to the soil as fertilizer.

Past landscapes and fuel management in the Mantaro Valley

How does this present pattern of landscape and fuel management compare with past patterns?

The valley has been densely populated by towns of agricultural and herding people at least since the Early Intermediate (ca. A.D. 200) and probably long before (Browman 1970; Hastorf et al. 1988). We don't know at this time what the original vegetation of the valley was like, but it has probably been changing in response to human activities for thousands of years.

Cook (1916) argues persuasively that the present vegetation pattern is anthropogenic, and that its natural state before human occupancy was forest cover right up into the high puna. However, early Spanish accounts indicate that even by the time of the Spanish Conquest fuel and wood products were relatively scarce, and fuel sources were managed and cultivated. The first Spanish capital that Pizarro founded in 1533 was Jauja in the Mantaro Valley, but Juan de Henestrosa, writing in the 1570's, says that the settlement was moved to the coast to Lima in 1535 when it was perceived that there would be a lack of firewood and water for irrigation in the Jauja Valley: "*el primer pueblo de españoles que don Francisco Pizarro pobló en este reino, fue en el tambo de Hátun Xauxa, y estuvieron poblados dos años; y por parecerles que era falta de leña este valle y de agua de regadío para poder her [hacer] guertas e otras sementeras, acordaron de irse a poblar en el valle de Lima...*" (Jiménez de la Espada 1965, volume 1:170).

This does not imply that people were totally without sufficient fuel and water; *in the early colonial times, but the* Spanish perception of fuel needs were probably much greater than those of the local Wanka people. Nevertheless, one gets the impression that wood and fuel were not abundant and that careful use and management was necessary at that time. For example, Juan de Henestrosa wrote that only two kinds of trees grew in the Jauja Valley, *aliso* (Alnus) and *quixuar* (Buddleia), and that these were planted by hand and brought in from outside in order to get enough wood for their houses and the building of churches, and that only with work could they find enough wood for their needs: "*esto es puesto a mano y traído de fuera para el servicio de sus casas y edificios de iglesias, que con trabajo se halla madera competente para ellas...*" (Jiménez de la Espada 1965, volume

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There is ~~some~~ evidence that similar fuel management in the form of tree cultivation and regulated fuel use was a pre-Hispanic pattern. Rowe (1947:216) writes about the time of the Inka: "Fuel was a serious problem in most valleys because of the scarcity of trees. Bushes and scrub from the hillsides were burned, and dried llama dung was a supplementary fuel. Dried llama dung burns like coal with little smoke or odor. Under the Inca, wood-cutting areas were strictly controlled to prevent stripping. Wood for roof timbers was imported from the tropical valleys when possible, or improvised from the twisted branches of the Qiswar tree." Fuel was enough of a valued commodity to be collected as tribute and stored in the Inka *qollqa* or state storehouses. Listed among the *qollqa* stores of the Jauja area given to the Spanish up to 1554 were firewood, charcoal, grass, and straw (D'Altroy and Hastorf 1984:340; Espinoza 1971)). Trees such as *quisual* may have been cultivated in ^{the valley at least} ~~by the Inka times~~ ^{pre-Hispanic times} (Gade 1975:198; Yacovleff and Herrera (1935:41-42), as they were in the seventeenth century ^{1891-1893 1639} (Cobo (1893 [1653], volume II, Libro sexto:54), and as they are in the present. ^{It has been suggested that} ~~Molli~~ ^{being} trees may also have been cultivated and their distribution increased by the Inka (Gade 1975:184, Latcham 1936:53, Sauer 1950:542).

Fuel use undoubtedly underwent a change after the Spaniards were established in Peru. The per capita need for wood for fuel and building probably increased. In the 1570's in the Jauja Valley they were already building small square houses after the Spanish fashion, requiring more beams for construction than the traditional round houses of adobe, stone, or clay, and roofed with grass and *aliso* branches (Jiménez de la Espada 1965, volume

1:171). Padre Cobo commented in 1639 that the Spanish were very wasteful in their use of fuel; he says that a Spanish household will use in a day fuel that would last an Indian household a month (Cobo 1893:volume II, Libro Sexto:6-9). An earlier chronicler, ¹⁸⁹¹⁻¹⁸⁹³ Garsilaso de la Vega (1985:345) ^{writing between 1609 and 1617} says that most of the abundant *molli* trees (presumably encouraged or cultivated) near Cuzco were cut down in short order after the Spanish arrived because they made such good charcoal; "*conoscí el valle del Cuzco adornado de innumerables árboles destos tan provechosos; y en pocos años le vi casi sin ninguno; la causa fué que se haze dellos muy lindo carbón para los braseros...*". Already in 1551 there was a dearth of firewood in Lima for three leagues around, since all had been cut. A program of planting was instituted and ordinances issued requiring the planting of trees and punishing the cutting of trees, the making of charcoal, and the use of large quantities of wood in baking or in lime and brick kilns, by Spaniards, Indians, or slaves (Jiménez de la Espada 1965, volume 1:123).³

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Other changes in fuel use under Spanish rule probably resulted from the resettling of the people into clustered settlements (*reducciones*) starting in the 1570's, which may have made fuel collection more difficult for the nucleated population. Land use and the landscape changed as new crops were grown and pastures were extended for introduced sheep and cows. Tribute in the form of firewood was still paid by indigenous communities, but now to the Spanish (Gade 1975:25) rather than the Inka.

On the other hand, pressure on fuel sources in some areas may have been alleviated by the population decreases that followed the Spanish conquest. In Jauja province, ^{it has been estimated that} population size decreased by about 75% between 1525 and 1571.

By 1754 the population of the province was further reduced by about half (to 21,000), then began to recover, and by 1940 (at 258,000) was twice what it had been in 1525 (figures from Adams 1959:11). One would expect, then, that new pressure on fuel sources was felt during the rapid population rise of the 19th century. Ruiz and Pavon, Spanish botanists travelling in Jauja in 1779, report a population for the province of about 53,000, and although their description of the landscape is disappointingly brief, they do mention that "The plants that are produced in this valley are very few, and the fruit trees and other trees very rare" (Ruiz and Pavon:55). By the end of the nineteenth century the increased population in the Mantaro Valley may have prompted renewed fuel management -- in 1887, records from the town of Muquiyauyo just 5 km ^{south} from Jauja indicate a town resolution to make a community planting of *aliso* (Adams 1959). In 1911 and 1920, the first plantings of eucalyptus were made in Muquiyauyo (Adams 1959). ^{Since then} The use of the eucalyptus spread rapidly throughout the valley. ^(*Martinezia pers. com.*) It has replaced the major indigenous trees in preference and planting, having the advantage of fast growth and straight trunks.

The adoption of ~~the~~ ^{hard} eucalyptus had a major impact on the fuel-use patterns and landscape of the Mantaro Valley. First, cultivation of the eucalyptus differs from the native trees; eucalyptus must be started from seed in special beds (Dickinson 1969), whereas the others are reproduced vegetatively from shoots from mature trees (Adams 1959). Also, it has changed the landscape and ^{SP} landuse. Eucalyptus was first planted as a dooryard tree and a field border, and fulfilled only local demand, but commercial demand for the wood in the 1940's greatly increased production, and Dickinson (1969) reports that irrigated fields in the best crop land are now solid-planted in

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eucalyptus. The large number of eucalyptus planted around the irrigated fields also has a local climatic effect : "El gran número de árboles de eucalipto que bordean los campos, prácticamente en todas las zonas bajo irrigación, ejercen indudablemente una influencia climática local." (International Development Service 1954). The adoption of eucalyptus has changed the economics of fuel use, since people without trees of their own must have cash to buy them. Dickinson (1969:302) reports that a mature tree is equivalent in value to a week's labor. Those with cash can buy their main fuel supply; others must expend considerable time and energy collecting it.

CONCLUSIONS

The major changes in the pattern of fuel use in recent centuries have resulted from higher fuel use by the Spanish, ^{expanded} new uses for fuel, great population fluctuations, changes in land tenure, ~~and~~ the growth of a cash economy, ^{as well as} and the introduction of new plants and animals, especially eucalyptus. In spite of considerable change over the centuries, the pattern of fuel use has retained a number of basic characteristics throughout. At least since the Spanish Conquest, fuel has been relatively scarce and a limiting factor. The scarcity has been dealt with by 1) sparing use of fuel, 2) maintaining a simple cooking style for low heat cost, 3) making use of all possible available fuels, (wood, dung, shrubs, straw, etc.), and 4) the cultivation of trees. The relative scarcity also means that 5) the availability of fuel to different segments of the population has been uneven. Ethnohistoric documents suggest that these characteristics were also a part of

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pre-Spanish fuel use, but further knowledge of prehistoric fuel use patterns is needed. We are approaching this through the analysis of archaeological fuel remains from the area.

Several points have emerged from this study of modern and historic fuel use that illustrate the complexity of the interactions between people and their fuel plants. First, it appears that simple availability does not determine the pattern of fuel use. We have seen that social, cultural, and historical factors have created differences in use within the same environment. Second, we have seen a human group using its setting in a way quite different than what is often portrayed by archaeologists-- of a group exploiting the natural resources in its environment and then collapsing when they run out. Rather, the system of fuel use is one of dynamic interaction as there are continuous small changes in the landscape and ^{resource} ~~land~~ use in adjustment to the conditions of the moment -- people manage their landscapes ^{as well as} ~~and~~ adjust to its changes. We have seen that even though the Mantaro Valley ^(see Alcorn 1981 a + b) ~~apparently~~ had its natural vegetation altered at an early time, this was not a major hindrance to the growth of towns and cities and complex political entities. The people made productive use of the landscape they had created. The paucity of naturally available fuels has been compensated for by a complex system of fuel management and fuel production. Creative interaction with the anthropogenic landscape is apparently an ancient and continuing feature of Andean fuel use. How this interaction between the people and their fuel plants evolved awaits our completion of fuel remains from prehistoric households in the valley. ok

NOTES

¹ Although not the focus of the present paper, we are also extending our study of long-term changes in fuel use back in time by means of paleoethnobotanical analysis of fuel remains from a series of archaeological sites excavated by the Upper Mantaro Archaeological Research Project (Earle et al. 1987, Hastorf et al. 1988).

² It is curious to note that no one mentions *molli* (*Schinus molle*). In the Vilcanota area Gade (1975:84) says that after eucalyptus *molli* is the most important fuel. Yet in the Mantaro Valley we have no evidence of its use presently or prehistorically, although it grows in the area today.

³ Municipal ordinances of Lima made in November of 1551:"2a) those who have fields are obliged to plant a thousand feet of willows and other trees within one year or be penalized by losing their field. 3a) For making charcoal within four leagues of the city the penalty for a Spaniard will be 50 pesos , for an Indian the loss of the charcoal and ten days in jail, for a slave 30 pesos or

for
100 azotes, whatever his master desires; and for a second offense 100 pesos
for a Spaniard, and to the Negro or Indian 100 azotes and the loss of the
charcoal; and the same penalty applies to girdling trees. 4a). If anyone cuts
a fruit tree, except on their own property, the penalty will be 30 pesos to a
Spaniard and 100 azotes to an Indian or Negro. 5a) If anyone burns large logs
(leña gruesa) in ovens, the penalty will be 12 pesos if bread is being made,
and 50 if lime or bricks are being made." (Jiménez de la Espada, 1965:123).

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REFERENCES CITED (29 June 1988)

- ✓ ADAMS, R.N. 1959. A community in the Andes: problems and progress in Muquiyauyo. University of Washington Press, Seattle.
- ✓ AGARWAL, B. 1986. Cold hearths and barren slopes: the woodfuel crisis in the third world. Allied Publishers, New Delhi.
- ✓ ALCORN, J. 1981a. Factors influencing botanical resource perception among the Huastec: suggestions for future ethnobotanical inquiry. Journal of Ethnobiology 1(2):221-230.
- ✓ ----- . 1981b. Huastec non-crop resource management: Implications for prehistoric rain forest management. Human Ecology 9(4):395-417.
- ✓ ANDERSON, E. 1952. Plants, man and life. University of California Press, Berkeley.
- ✓ ARNOLD, J.E.M. 1978. Wood energy and rural communities. Eighth World Forestry Congress. Jakarta, 16-28 October 1978. Vol. II:604-626.
- ✓ BIRD, R. McK. 1970. Maize and its cultural and natural environment in the sierra of Huanuco, Peru. Ph.D. dissertation, University of California, Berkeley. University Microfilms International.

✓ Allen 1983 J.C. Deforestation, soil degradation, & wood energy in developing countries. Ph.D. Thesis, Johns Hopkins University University Microfilms International

- ✓ BROWMAN, D.L. 1970. Early Peruvian peasants: the cultural history of a central highlands valley. Ph.D. Diss. Harvard University.
- ✓ COBO, B. ¹⁸⁹¹⁻¹⁸⁹³ ~~1893~~ [1639]. Historia del nuevo mundo. Seville. (1639) ←
- ✓ BRUSH, S.B. 1977. Mountain, field, and family: the economy and human ecology of an Andean Valley. University of Pennsylvania Press.
- ✓ CAMPBELL, B.M., R.F. DU TOIT, AND R.A. HOVEY. 1985. Relationship between wood resources and use of species for construction and fuel in the communal lands of Zimbabwe. Paper presented at the 1985 AETFAT conference, St. Louis.
- ok ✓ CHANDOLA, L.P. 1976. A pilot survey of fuel consumption in rural areas. Indian Forester 102(10):692:700.
- ✓ COOK, O.F. 1916. Agriculture and native vegetation in Peru. Journal of the Washington Academy of Sciences 6:284-293.
- ✓ D'ALTROY, T. 1987. Transition in Power: Centralization of Wanka political organization under Inka rule. Ethnohistory 41(1):78-102.
- ✓ D'ALTROY, T.N. and C.A. HASTORF. 1984. The distribution and contents of Inca state storehouses in the Xauxa region of Peru. American Antiquity 49(2):334-349.

✓ DEVRES, Inc. 1980. The socio-economic context of fuelwood use in small rural communities. A.I.D. Evaluation Special Study No. 1.

delete DE WET, J.M.J. AND J.R. HARLAN. 1975. Weeds and domesticates: evolution in the man-made habitat. Economic Botany 29:99-107. *ok*

✓ DICKINSON, J.C. 1969. The eucalypt in the sierra of southern Peru. Annals of the Association of American Geographers 59:294-307.

✓ EARL, D.E. 1975. Forest energy and economic development. Clarendon Press, Oxford.

✓ EARLE, T., T. D'ALTROY, C. HASTORF, C. SCOTT, C. COSTIN, G. RUSSELL, E. SANDEFUR. 1987. Archaeological Field Research in the Upper Mantaro, Peru, 1982-1983: Investigations of Inka Expansion and Exchange. Institute of Archaeology Monograph 28, UCLA, Los Angeles.

✓ ECKHOLM, E.P. 1975. The other energy crisis: firewood. Worldwatch Paper No. 1. Worldwatch Institute, Washington, D.C.

✓ ----- . 1976. Losing ground: environmental stress and world food prospects. W.W. Norton and Co., New York.

✓ ECKHOLM, E.P., G. FOLEY, G. BARNARD, and L. TIMBERLAKE. 1984. Fuelwood: the energy crisis that won't go away. Earthscan.

- ✓ ERNST, E. 1978. Fuel consumption among rural families in Upper Volta, West Africa. Preceedings of the Eighth World Forestry Congress. Jakarta, 16-28 October 1978. Vol. II:709-717.
- ✓ ESPINOZA SORIANO, W. 1971. Los Huancas, aliados de la conquista. Tres informaciones sobre paticipacion indigena en la conquista del Peru 1558-1560-1561. Anales Cientificos de la Universidad del Centro del Peru 1:3-407. Huancayo, Peru.
- ✓ FARRINGTON, I.S. n.d. Contemporary agriculture and the vertical aconomy. Cusichaca Project: Land use and irrigation Research Report No. 2. Department of Prehistory and Anthropology, Australian National University, Canberra.
- ✓ FLEURET, P., and A. ^{FLEURET} Fleuret. 1978. Fuelwood use in a peasant community. Journal of Developing Areas 12(3) : 315-322.
- ✓ GADE, D.W. 1975. Plants, man and the land in the Vilcanota Valley of Peru. Dr. W. Junk, The Hague.
- ✓ GARSILASO DE LA VEGA, EL Inca. 1985 [1609-1617]. Comentarios reales de los Incas. Biblioteca clásicos del Peru no. 1. Editorial Andina.
- ✓ HARDY, O. 1914. Cuzco and Apurímac; a report on the commercial and industrial outlook of southcentral Peru. Bulletin of American Geographic Society 46(7):

500-512.

- ✓ HARLAN, J.R. 1975. Crops and man. American Society of Agronomy, Madison, Wisconsin.
- ✓ HASTORF, C. 1983. Prehistoric agricultural intensification and political development in the Jauja region of Central Peru. Ph.D. Diss., University of California at Los Angeles. University Microfilms International, Ann Arbor.
- ✓ HASTORF, C., T. EARLE, H. WRIGHT, G. RUSSELL, C. COSTIN, and E. SANDEFUR. 1988. Settlement archaeology in the Jauja region of Peru: Evidence from the Early Intermediate through the Late Intermediate- A report on the 1986 field season. Andean Past.
- ✓ HEIZER, R.F. 1963. Domestic fuel in primitive society. Journal of the Royal Anthropological Institute 93(2):186-194.
- delete* ✓ HEIZER, R.W. [CHECK THIS] 1977. Primitive man as an ecologic factor. The Kroeber Anthropological Society Papers No. 13, 1-31.
- ✓ HOUGH, W. 1925. Fire as an agent in human culture. Smithsonian Institution, U.S. National Museum, Bulletin 139. Washington D.C.
- ✓ INTERNATIONAL DEVELOPMENT SERVICES, Inc. 1954. El desarrollo agrícola y económica da la zona del Mantaro en el Perú. Vol I and II, New York.

- [1881-1897]
- ✓ JIMENEZ DE LA ESPADA, M. 1965. Relaciones geograficas de Indias. Madrid 1881-1897. Edición?, Biblioteca de Autores Españoles, Ediciones Atlas, Madrid JK
- ✓ JOHANNESSEN, S. 1981. The effect of aboriginal populations on the vegetation of the American Bottom of Illinois. Paper presented at the Fourth Ethnobiology Conference, Columbia, Missouri, March 13-14, 1981.
- ✓ _____. 1984. Paleoethnobotany. Pp. 197-214 In American Bottom Archaeology. (C.B. Bareis and J.E. Porter, eds.). University of Illinois Press, Urbana. JK
- ✓ JONES, J.R. 1982. Diagnostico socio-economico sobre el consumo y produccion de leña en fincas pequenas de la peninsula de Azuero, Panama. AID publication PN-AAM-107.
- ✓ JONES, V.H. 1941. The nature and scope of ethnobotany. Chronica Botanica 6(10):219-221.
- ✓ KNOWLAND, B. and C. ^{caps}Ulinski 1979. Traditional fuels: present data, past experience and possible strategies. AID publication PN-AAH-451
- ✓ LAARMAN, J.G. and M.K. WOHLGENANT. 1984. Fuelwood consumption: a cross-country comparsion. Forest Science 30(2):383-391.
- ✓ LATCHAM, R.E. 1936. La agricultura precolombiana en Chile y los paises

vecinos. Santiago.

delete LATHRAP, D.W. 1977. Our father the cayman, our mother the gourd: Spinden revisited, or a unitary model for the emergence of agriculture in the New World. In C.A. REED (ed.) Origins of Agriculture, pp. 713-751. Mouton, The Hague.

+ W F Woods. Archaeobotany, environmental degradation and
 ✓ LOPINOT, N. 1988 (SAA paper? need to call him about this) the collapse of Cahokia. Paper presented at 53rd
 54th

✓ MACLEOD, W.C. 1925. Fuel and early civilization. American Anthropologist
 27:344-346.

delete MAKHIJANI, A. and A. POOLE. 1975. Energy and agriculture in the third world.
 Ballinger Publishing Company, Cambridge, Mass.

→ ✓ MARTINEZ, H. 1982. Estudio sobre leña en hogares, pequeña industria y ←
 distriuidores de Guatemala. AID publication ON-AAL-799.
 distri bui dores

✓ MATOS, R. and J. PARSONS. 1979. Poblamiento prehispanico en la cuenca del
 Mantaro. In Arqueologia Peruana, Ed. R. Matos, pp. 157-171. Lima.

✓ MAYER, E. 1979. Land-use in the Andes: ecology and agriculture in the Mantaro
 Valley of Peru, with special reference to potatoes. Centro Internacional de
 la Papa. Lima.

- ✓ MILLER, N.F. 1985. Paleoethnobotanical evidence for deforestation in ancient Iran: a case study of urban Malyan. *Journal of Ethnobiology* 5(1):1-19.
- ✓ MINNIS, P.E. 1978. Paleoethnobotanical indicators of prehistoric environmental disturbance: a case study. Pp. 347-366. In *The nature and status of ethnobotany*. (R.I. Ford, ed.) *Anthropological Papers*, Museum of Anthropology, University of Michigan, No. 67.
- ✓ PARSONS, J. 1976. Prehispanic settlement patterns in the Upper Mantaro, Peru: A preliminary report of the 1975 field season, Unpublished MS. submitted to the Instituto Nacional de Cultura, Lima and to the National Science Foundation.
- ✓ PARSONS, J. and C. ^{Hastorf}~~HASTORF~~. 1977. Prehispanic settlement patterns in the Upper Mantaro, Peru. A progress report for the 1976 field season. Unpublished report submitted to the Instituto Nacional de Cultura and the National Science Foundation.
- ✓ PEARSALL, D.M. 1979. The application of ethnobotanical techniques to the problem of subsistence in the Ecuadorian Formative, Ph.D. Diss., University of Illinois at Urbana-Champaign, University Microfilms International, Ann Arbor.
- ✓ _____. 1983. Evaluating the stability of subsistence strategies by use of paleoethnobotanical data. *Journal of Ethnobiology* 3(2):121-137.

✓ PULGAR VIDAL, J. 1967. Geografía del Perú: Las ocho regiones naturales del Perú. Editorial Universo, Lima.

✓ REDDY, A.K.N. and K. PRASAD 1977. Technological alternatives and the Indian energy crisis. Economic and Political Weekly, Tribandrum, India. August, pp. 1465-1502.

✓ RINDOS, D. 1984. The origins of agriculture: An evolutionary perspective. Academic Press. New York.

✓ ROWE, J.H. 1947. Inca culture at the time of the Spanish conquest. Pp. 183-330. In Handbook of the South American Indians (J.H. Steward, ed.).
 → Volume 2. (CHECK VOLUME NUMBER) Smithsonian Institution, Washington, D.C.. ok

✓ RUIZ LÓPEZ, H. 1940. Travels of Ruiz, Pavón, and Dombey in Peru and Chile (1777-1788). (Translation of Relación del viaje). Translation by B.E. Dahlgren. Botanical Series, Field Museum, Chicago.

✓ SAUER, C.O. 1950. Cultivated plants of South and Central America. Pp. 487-543. In Handbook of South American Indians. (J.H. Steward, ed.) Volume 6. Smithsonian Institution, Bureau of American Ethnology Bulletin 143, Washington, D.C.

✓ SIKKINK, L. 1988. Ethnoarchaeology of harvest and crop-processing in

- traditional households in the Mantaro Valley, Central Andes of Peru. M.A. thesis, Department of Anthropology, University of Minnesota, Minneapolis.
- ✓ SIREN, G. and C.P. MITCHELL, eds. 1985. Forest energy and the fuelwood crisis: proceedings of the IUFRO Project Group P1.09.00 Meeting in Uppsala, Sweden June 8-9, 1984. Sveriges Lantbruksuniversitet, Avdelningen for energiskogsodling Rapport 41.
- ✓ SKAR, S. ^{arab} L. 1982. Fuel availability, nutrition, and women's work in highland Peru. World Employment Programme Research Paper No. WEP 10/WP 23, International Labour Office, Geneva.
- ✓ TIBAIJUKA, A.K. 1985. Firewood production at household level: a survey on small-holder banana-coffee farms, Kagera Region, Tanzania. Pp. 134-135. In Forest energy and the fuelwood crisis. (Siren and Mitchell, eds.) Sveriges Lantbruksuniversitet, Avdelningen for energiskogsodling, Rapport 41.
- ✓ TOSI, J.A. 1960. Zonas de vida natural en el Peru: memoria explicativa sobre el mapa ecologico del Peru. Instituto Interamericano de Ciencias Agricolas de la OEA, Zona Andina, Boletin Tecnico 5.
- ✓ WEBERBAUER, A. 1936. Phytogeography of the Peruvian Andes. Field Museum of Natural History. Botanical Series, volume 13.
- ✓ ----- . 1945. El mundo vegetal de los Andes Peruanos. Estudio

Fitogeográfico. Estación Experimental Agrícola La Molina, Lima.

✓ WILLCOX, G.H. 1974. A history of deforestation as indicated by charcoal analysis of four sites in Eastern Anatolia. *Anatolian Studies* 24:117-133.

✓ WINTERHALDER, B., R. LARSEN and R.B. THOMAS. 1974. Dung as an essential resource in a highland Peruvian community. *Human Ecology* 2:89-104.

delete YACOVLEFF, E. and F.L. HERRERA. 1934. El mundo vegetal de los antiguos peruanos. *Revista del Museo Nacional* 3:241-322. Lima.

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OK

-----, 1935. El mundo vegetal de los antiguos peruanos. *Revista del Museo Nacional* 4:29-102.



Upper Mantaro
River Valley

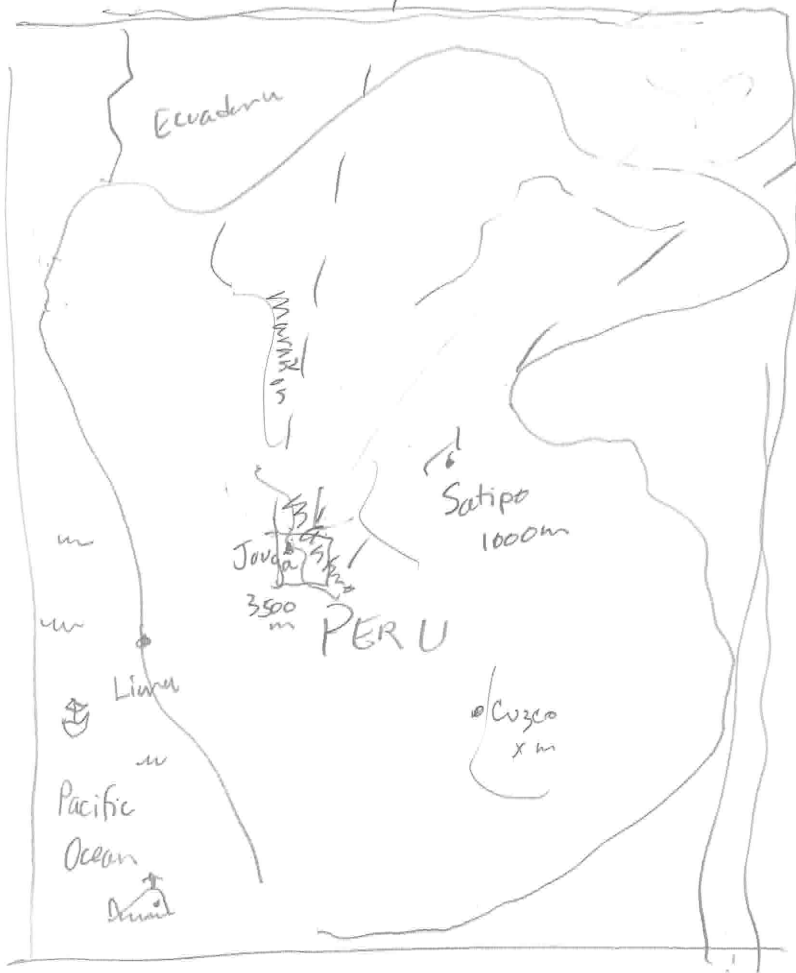


Figure 1.
The study area



Photo of Valley

Figure 2. A view across the Yanamarcu Valley, a tributary valley to the Mantro Valley. Note the treeless slopes and the cultivated eucalyptus trees in the valley bottom.

CATEGORIES

firewood	dung	straw	cobs	other

TYPES

eucalyptus: ¹⁰ x xxxxxxxxxxx xxx aliso: xxx quinal: xxx pactae: xx jiljil: x chaile: x taraca: x	cow & sheep: x xxx cow: x of the countryside: x	of fields: ³ xx of the mountains: x quinoa: x habas: x	sometimes: xxx 	chilca: xxx pactae: xx kerosene: xx retama: x tantal: x charcoal: x
---	--	--	--	--

- aliso - *Alnus*
- quinal - *Folylepis*
- pactae - *Cassia*
- jiljil - ? *Berberis*
- chaile - ?
- taraca - ? *Sambucus*
- retama - *Spartium*
- tantal - *Citharexylum*
- quinoa - *Chenopodium*
- habas - *Vicia faba*
- chilca - *Baccharis*

or x - number of times mentioned as being used, out of 15 interviews.

Figure 3. Kinds of fuel and how frequently they are used.

Rank Order	Firewood	Dung	Straw	Kerosene	Charcoal	Shrubs	Cobs
1	6 +++++ + 000000 000	6 +++++ 01	+ 0	+ 0	0		
2	++++ 00	+ +++ 4 000 3				+ 1 0 1	
3		0	+++			0	
4							+

+ - number of mentions of use

0 - number of mentions of preference

FIGURE 4. Fuel use vs. fuel preference

		other firewood and			
		eucalyptus	shrubs	dung	straw kerosene
WHEN	Daily		(5) xyxxx *	xxxxx * xxxxx	xxxxx *
	Weekly	x	x		x
	Monthly		x		
	Yearly	(11) xxxxx xxxxxx			
WHERE	Bought	//////// (6) xxxxxx			x
	own land	xx (3)			
	fields			5 xxxxx	xx
	corral			5 xxxxx	
	valley		x		
	ravines		x		
	low slope		x		
	mountains		xx	xx	x
	puna			xx	xx
anywhere			xx		

* collection of shrubby wood, dung, and straw occurs most frequently in the dry season

FIGURE 5. When and where fuel is obtained

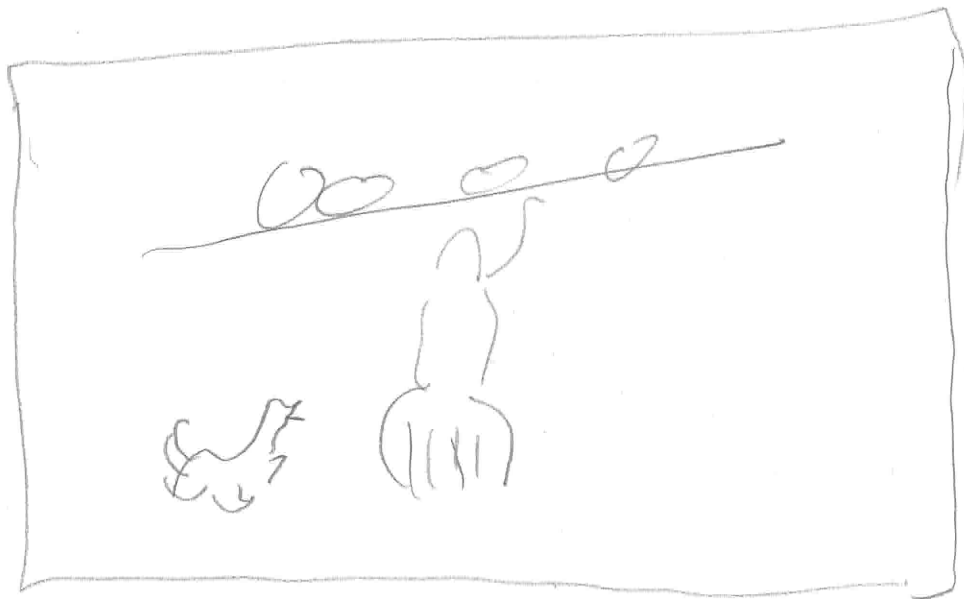


FIGURE 6. Woman putting dung to dry
on her roof.

Sikkim

Hearth is lit:

twice a day, morning and afternoon:	XXXXXXXXXX
alight all day:	XX
once in afternoon:	X

Hearth is swept and emptied:

every day:	XXXXXXXXXX
twice a day:	XX
when full (every 3-4 days):	X

Residue is stored:

in pile outside house:	XXXXXXXXXX
in <u>conatiner</u> in house:	XX
emptied directly on fields:	XX

Residue is used:

once a year at planting time on fields:	XXXXXXXXXX
taken weekly to fields:	XX
specific mention of use on potatoes and broad beans:	XXXX

FIGURE 7. Use of the hearth and
The hearth residue

FIGURES

Fig. 1. Map of the study area.

Fig. 2. A view across the Yanamarca Valley

Fig. 3. Kinds of fuel and how frequently they are used.

Fig. 4. Fuel use versus fuel preference

Fig. 5. When and where fuel is obtained

Fig. 6. Woman putting dung to dry on her roof, *Photo by L. Silkinde*

Fig. 7. Use of the hearth and the ashes

Hearth is lit:

twice a day, morning and afternoon:	XXXXXXXXXX
alight all day:	XX
once in afternoon:	X

Hearth is swept and emptied:

every day:	XXXXXXXXXX
twice a day:	XX
when full (every 3-4 days):	X

Residue is stored:

in pile outside house:	XXXXXXXXXX
in container in house:	XX
emptied directly on fields:	XX

Residue is used:

once a year at planting time on fields:	XXXXXXXXXX
taken weekly to fields:	XX
specific mention of use on potatoes and broad beans:	XXXX