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A HISTORY OF FUEL MANAGEMENT (A.D. 500 TO THE PRESENT) IN THE MANTARO VALLEY, PERU

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ABSTRACT.—We present evidence for a long history of active management of fuel resources by the inhabitants of a relatively tree-less high Andean Valley. Three types of information are used in this study: archaeological data of fuel remains from prehistoric sites, native and Spanish documents concerning aspects of 16th century fuel use, and an ethnographic survey of present fuel practices. Presently, fuel is managed by tree cultivation, use of a wide variety of fuel types including the by-products of crops and herds, rules for fuel collection, and cooking practices emphasizing its sparing use. These practices have great antiquity in the area; in pre-Spanish times the Inca controlled forests and the cultivation and cutting of trees and collected large quantities of fuel as tribute. Archaeological evidence indicates that fuel management may have begun before the Inca conquest of the area.

RESUMEN.—Presentamos evidencia de una larga historia de manejo activo de recursos combustibles por parte de los habitantes de un valle andino alto, relativamente desprovisto de árboles. En este estudio se usan tres tipos de información: datos arqueológicos sobre restos de combustibles recuperados de sitios prehistóricos; documentos indígenas y españoles refiriendo aspectos del uso de combustibles en el siglo XVI; y una encuesta etnográfica sobre el uso actual de combustibles. En el presente los recursos combustibles se manejan mediante el cultivo de árboles, el uso de una gran variedad de combustibles, incluyendo los subproductos de cultivos y rebaños, reglas para la recolección de combustible y procedimientos culinarios que enfatizan su uso frugal. Estas practicas son muy antiguas en la zona; en la época prehispanica el Inca controlaba los bosques y el cultivo y corte de los árboles, y colectaba grandes cantidades de combustible como tributo. La evidencia arqueológica indica que el manejo de combustibles puede haberse iniciado desde antes de la conquista incaica de esta área.

RÉSUMÉ.—Nous présentons les preuves d'une longue durée dans la direction active des resources combustibles chez les habitants d'une vallée des Andes ou on trouve assez peu d'arbres. Cette étude utilise trois categories d'information: les restes archéologiques des combustibles dans des sites préhistoriques, les documents Espagnols et indigénes sur l'utilisation des combustibles au 16 éme

siécle, et une étude ethnographique de l'utilisation contemporain des combustibles. Aujourdhui, les combustibles sont organisés dans la cultivation des arbres, dans l'utilisation d'une grande variété des formes des combustibles comme les restes de la récolte et des troupeaux, dans les réglements pour le receuil des combustibles, et dans les pratiques de la cuisine oú on souligne l'utilisation prudent des combustibles. Ces pratiques ont une grande antiquité dans la region; pendent l'ére pre-Hispanique las Incas controllaient les forêts et la cultivation et le coupage des arbres et ramassaient des grandes quantités des combustibles dans la forme de tribut. Le témoignage de l'archéologie indique que l'organisation des combustibles avait peut-être commencé avant la conquete de la region por les Incas.

INTRODUCTION

In the river valleys of the central Andes, natural fuel resources have long been scarce. The surrounding high plateaus are devoid of trees, and only a few small trees and bushes grow on the cold wet slopes and line the watercourses of the valleys. Yet large populations of people have lived and farmed in these valleys for millennia, periodically supporting such wide-spread phenomena as the Inca empire and Spanish colonialism. How have the people of these valleys managed their fuel resources over the centuries, and how have the valleys continued to support large populations in spite of the scarcity of fuel? In this paper we investigate the long-term history of fuel management in one Andean valley. Studying the dynamics of existing fuel-use systems is a basis for approaching the urgent ecological problem posed by the scarcity of fuel in many areas of the world today.

After an introduction to the Mantaro Valley, we begin with a survey of present-day fuel practices made there in 1985, which reveals that the inhabitants of the valley today manage their fuel by cultivating trees and by using a wide variety of fuel types from different elevational zones. The products of the anthropogenic landscape such as crop residues and animal dung are valuable fuels. Rules govern the collection of different fuel types, and cooking practices reflect sparing fuel use. In the second section, we discuss documents from the sixteenth century showing that many of these management practices are ancient; not only were there tree-planting programs and controls under early Spanish rule, but the evidence indicates that fuel and fuel management was also an important part of pre-Spanish Inca economy and policy. We can go further into the past through the use of archaeological evidence; in the third section of the paper we present a study of fuel remains from archaeological sites in the Mantaro Valley. We believe that the remains reflect Incaic fuel management policy. Furthermore, the pattern characterizing the Inca period is first evident in pre-Incaic times, in the households of Late Intermediate fortified towns of the fourteenth century.

THE MANTARO VALLEY AND ITS PEOPLE

The Mantaro Valley is a high intermontane valley in the modern province of Junín in the central Andes of Peru. The valley floor, bisected by the Mantaro

River, is 3200-3400 m above sea level, and is flanked by two high mountain ranges, the Cordillera Occidental on the west and the Cordillera Central on the east. The valley is about 60 km long and about 4-8 km wide. The data in this paper are mostly from the upper valley near the town of Jauja, including the small Yanamarca Valley to the north (Figs. 1 and 2).

The sharp relief of the area creates a gradient of biological communities. The valley floor receives about 700 mm of rainfall a year, falling mostly from September to March. Average daily temperature ranges from about 10°C to 12°C throughout the year. However, diurnal variation is great, especially in the dry

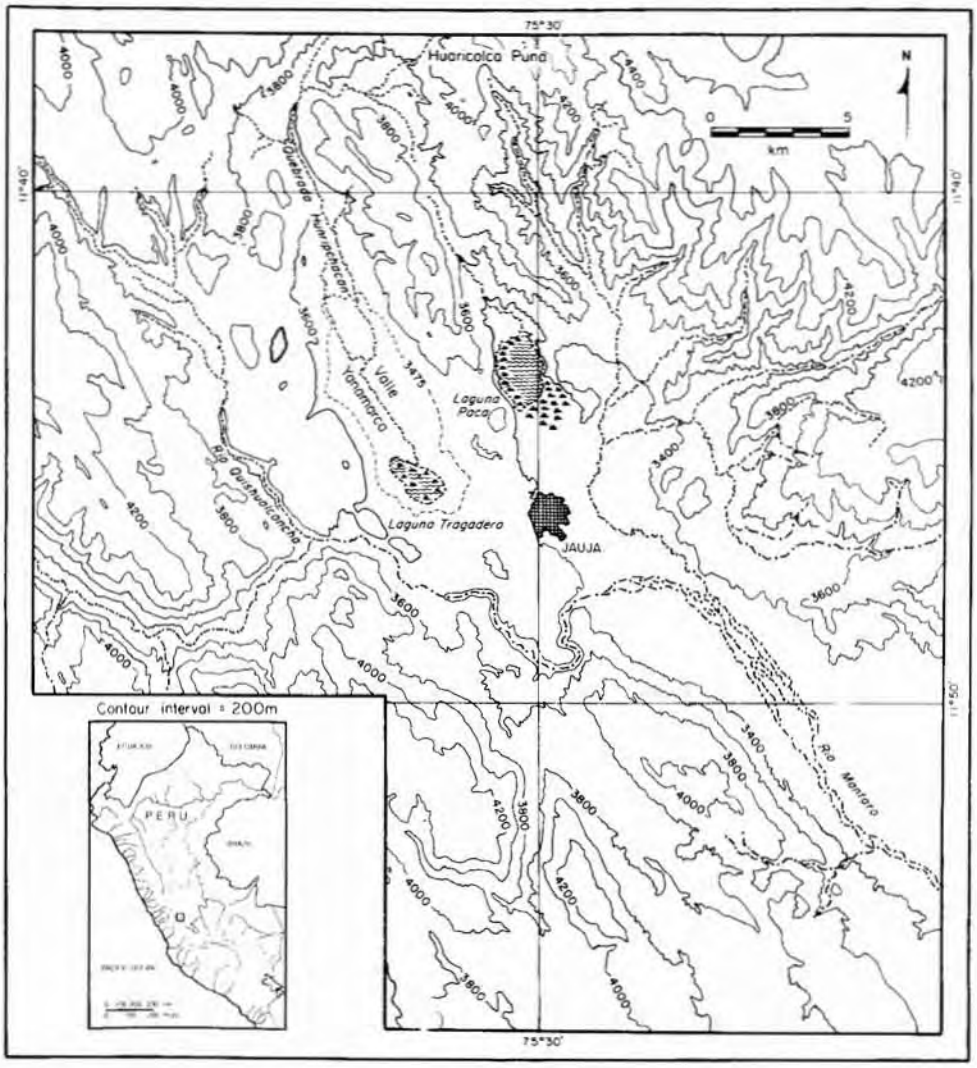

FIG. 1.—Map of the Upper Mantaro River Valley.

FIG. 2.—View across the Yanamarca Valley. Note the scarcity of trees except for cultivated eucalyptus in the valley bottom.

season between May and August when night frosts occur on the valley floor (Hastorf 1983, Mayer 1979). As elevation increases up the slopes of the mountains, conditions become wetter and colder. The modern plant communities will be briefly described, especially in regard to the available sources of fuel, following Gade (1975), Hastorf (1983), Mayer (1979), Tosi (1960), Pulgar Vidal (1967) and Weberbauer (1936, 1945).

The puna. The high cold plateau or puna above the valley (above 4000 m) supports no trees, being covered mostly with grasses, notably ***ichu*** (species of *Stipa* L. and *Festuca* L.). The plants of the puna serve as pasturage or cows, sheep, and camelids. The puna is sparsely populated with the scattered camps and small villages of herders.

The high slopes. The high slopes between 4000 and 3500 m are moist and cold, and are characterized by grassy steppes with scattered shrubs and small trees, mostly ***quinual*** (species of *Polylepis* Ruiz & Pav.) and ***quishuar*** (species of *Buddleja* L.), with some *aliso (Alnus jorulensis* HBK). On protected slopes people grow barley *(Hordeum vulgare* L.), ***tarhui*** *(Lupinus mutabilis* Swett), ***quinoa*** *(Chenopodium quinoa* Willd.), and the tubers ***papa*** *(Solanum tuberosum* L.), ***mashua*** *(Tropaeolum tuberosum* R. & P.), ***oca*** *(Oxalis tuberosa* Molina), and ***ulluco*** *(Ullucus tuberosus* Loz). The lower fields within this zone are step-slope terraces often edged with hedges, and the upper fields tend to be without hedges and have longer periods of fallow. These field systems provide fuel from the hedge shrubs and stalks of the threshed crops, and in higher areas, dung from animals grazing on fallow fields. Many of the peasants of the valley live in nucleated or dispersed villages in this zone.

The valley. The Mantaro River basin, tributary valleys, and lower alluvial slopes (3000-3500 m) comprise a temperate, semiarid zone, with intensive settlement and agriculture. Almost all of this zone is under cultivation, with field of maize, wheat, ***quinoa*** *(Zea mays* L., *Triticum* spp., *Chenopodium* spp.), legumes, fodder crops, fruits and vegetables. Trees grow on the edges of fields and in groves; the most common is the cultivated introduced eucalyptus *(Eucalyptus globulus* Labill). The *guinda* (the introduced cherry *Prunus avium* L.) and the native *aliso,* ***quinual*** and ***quishuar*** are also planted (Adams 1959, Dickinson 1969, Mayer 1979). In waste areas and ravines there is abundant growth of woody shrubs such as ***chilca*** (species of *Baccharis* L.), *retama* (an introduced shrub, *Spartium junceum* L.), and ***pactae*** (species of *Cassia* L.). ***Chaghual*** (the Mesoamerican maguey, *Agave americana* L.) also grows here and is used for fuel.

The ceja de la montaña. Another biological community available to the inhabitants of the valley is the cloud forest or *ceja de la montaña* on the eastern slopes of the Andes, some 30-40 km from Jauja. Here, the warm and humid conditions support a dense forest including species of *Weinmannia* L., *Cedrela* (P. Br.) L., the coniferous *Podocarpus* L'Her., and many other arboreal taxa. The higher slopes are much disturbed, and secondary growth is typically the bamboo-like grass *carrizo (Chusquea serulata* Pilger), shrubs, and small trees typical of higher elevations such as *Alnus jorulensis* and species of *Buddleja* and *Escallonia* Mutis. To the inhabitants of the Mantaro Valley the *ceja* has since prehistoric times been an important source of products of the tropical forest, especially ***coca*** *(Erythroxylum coca* Lam.) (Hastorf 1987).

The landscape of the Mantaro valley has been greatly affected by thousands of years of occupation by herders and farmers. The extent of this effect has been debated; many researchers argue that the Andes were originally forested and have been deforested by human activities (Ansión 1986, Budowski 1968, Cook 1916, Dollfus 1981, Guillet 1985, Venero and Macedo 1983). Investigations of glacial history in the Mantaro have revealed that periodic climatic fluctuations were of sufficient magnitude to change the elevational range of the vegetation zones (Seltzer and Hastorf, in press). It is likely that human and climatic factors have interacted in shaping the landscape. The anthropogenic landscape is probably a very old one, perhaps initiated by increased camelid grazing in the Junín puna by about 1500 B.C. (see Rick 1980).

The inhabitants of the valley today, a population of some 500,000 (Aliaga 1985:7) live in towns, villages, scattered households, or in the provincial capitals of Jauja in the north and Huancayo in the south. Farming is the major occupation in the valley; employment also includes mining, commercial farming, and light industry (Aliaga 1985, Mayer 1979). Spanish is the common language with only a few people still speaking Quechua.

The indigenous ethnic group of the Upper Mantaro Valley are the Wanka, who have been farmers and herders in the area for at least 2500 years. They were known as the Wanka by the Inca who conquered them in A.D. 1460,

and archaeological evidence indicates ethnic continuities far into the past (Hastorf *et al.* 1989).

Archaeological investigations (D'Altroy 1981, Hastorf *et al.* 1989, LeBlanc 1981, Matos and Parsons 1979, Parsons 1976, Parsons and Hastings 1977) have shown that until about A.D. 1300 the people lived in many small settlements scattered across the valley floor and up the sides of the mountains. They herded camelids and grew many of the same crops as today: maize, ***quinoa***, tubers, and lupines. About A.D. 1300 there was a considerable demographic (and presumably social and political) change; population increased and people began to live in fewer, larger towns, often built on hilltops and surrounded by fortifications. This era, evidently one of warfare among several polities in the valley, ended ca. A.D. 1460 when the Wanka were conquered for the Inca Pachacuti by his general Tupac Yupanqui. Under the *pax incaica,* the Wanka were resettled in smaller towns on the valley floor.

At the time of Spanish conquest, the Wanka sided with the Spanish against their Inca overlords, providing the Spanish with labor and supplies. They were again resettled in the 1570's, when the viceroy Francisco de Toledo ordered the *reducciones,* a movement of the people from scattered settlements into colonial towns. Due to the Wanka alliance with the Spanish, the *hacienda* system never took hold in the valley and land stayed largely in the hands of the Wanka people (Aliaga 1985, Espinosa Bravo 1964).

After recovering from the effects of the Spanish conquest and civil wars, the Valley re-established itself as a center of agricultural production and mining. Economic trends in the last centuries have been increasing participation in a cash economy, and a shift in land tenure from a traditional usufructory group use to private ownership (Aliaga 1985, Mayer 1979). The change in economy is such that now in the Mantaro a reasonably steady source of cash is necessary to survival (Mayer 1979).

PRESENT-DAY FUEL USE: FIELD STUDY EVIDENCE

In the 1980s, the Mantaro Valley is still inhabited by Wanka people who are largely farmers and herders. An idea of the present-day pattern of fuel-use was obtained by a series of interviews with people of the valley made by Christine Hastorf and Lynn Sikkink in the summer of 1985. Fifteen interviews were made with people collecting or processing fuel or travelling on the roads in and around the Jauja valley. Questions were asked about types of fuel used, fuel preferences, collection practices, and cooking and hearth use (see Appendix 1). Although the sample of interviews is small, the patterning of the responses (Tables 1 through 3) indicates a general consensus in present practices.

Fuel use and preference.—People were asked what types of fuel they burned and in what proportions. Categories asked about were firewood *(leña),* dung *(guano),* straw *(paja),* cobs *(mazorcas),* and other *(otro)* (Table 1). The categories in the questionnaire are those in common use; at least four additional fuel categories

TABLE 1.—*Responses to questions on kinds of fuel and their relative use.**

Categories	Types	Probable taxon referred to**
Firewood (14)	eucalyptus (13)	(*Eucalyptus globulus* Labill)
	aliso (3)	(*Alnus jorulensis* HBK.)
	quinual (3)	(species of *Polylepis* R. & P.)
	pactae (2)	(species of *Cassia* L.)
	jiljil (1)	(?species of *Berberis* L.)
	chaile (1)	(?)
	taraca (1)	(?*Sambucus peruviana* HBK.)
Dung (13)	cow and sheep (1)	
	cow (1)	
	"of the countryside" (1)	
Straw (11)	"of the fields" (3)	
	"of the mountains" (1)	
	quinoa (1)	(*Chenopodium quinoa* Willd.)
	habas (1)	(*Vicia faba* L.)
Maize Cobs (4)	"sometimes" (3)	
Other (7)	chilca (3)	(species of *Baccharis* L.)
	pactae (2)	(species of *Cassia* L.)
	kerosene (2)	
	retama (1)	(*Spartium junceum* L.)
	tantal (1)	(species of *Citharexylum* (Juss) L.)
	charcoal (1)	

*numbers in parentheses are the number of times a particular category or type was mentioned as being used, out of 15 interviews. Some people did not name particular types of material under a general category; some people named several types. For example, thirteen people said they used dung, but only three defined the kind of dung; some of the seven people who said they used "other" fuels mentioned several types.

**actual plant material was not shown at the time of the interviews; the scientific taxon is that to which the common name generally refers in the area; confirmation can be seen on identified vouchers for the reference collection including common names given by local guides at the time of collection.

emerged from the interviews (see below). In general, people said they used a combination of firewood, dung, and straw for fuel. 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 were seldom mentioned.

Table 1 lists the specific types of fuel mentioned under the general fuel categories. In the category firewood, eucalyptus was mentioned first by almost

TABLE 2.—*Fuel use vs. fuel preference.* *

Rank Order	Firewood	Dung	Straw	Kerosene	Charcoal	Shrubs	Cobs
1	6(9)	6(1)	1(1)	1(1)	(1)		
2	4(2)	4(3)				1(1)	
3		(1)	3			(1)	
4							1

*numbers are the counts of responses of a category in a rank-order; numbers not in parentheses are for *use;* and numbers in parentheses are for *preference,* e.g., six people ranked firewood as the primary fuel used, and nine people ranked it as the primary fuel preferred.

TABLE 3.—*When and where fuel is obtained.* *

Category	When**	Where
eucalyptus	yearly (10)	bought (6) own land (3)
other firewood and shrubs	daily (5) weekly (1) monthly (1)	mountains (2) low slopes (1) ravines (1) valley (1)
dung	daily (10)	fields (5) corrals (5) mountains (2) puna (2) ''anywhere'' (2)
straw	daily (5)	fields (2) ''anywhere'' (2) mountains (1)

*numbers in parentheses are the times that particular response was given (out of fifteen interviews). The number of responses under ''where'' do not necessarily add up to the number under ''when,'' since people sometimes named several places (or none) when asked where they obtained that particular category of fuel.

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

everyone interviewed. Additional types of firewood mentioned by at least two people were *aliso, **quinual,*** and ***pactae***[1]. The dung used is from cows and sheep, although sheep dung is not as suitable and is used less often. Responses in the category straw can be subdivided into two groups of annuals; i) naturally-occurring grasses of the mountains, and ii) crop stalks such as ***quinoa*** and *habas.*

A number of fuels were named under "other." These included two additional categories of material bought in the market, kerosene and charcoal. Also mentioned were woody shrubs such as ***chilca,*** *retama,* and ***pactae.*** Evidently these shrubby types are perceived to be in a category other than *"leña,"* presumably because they have small thin branches. Apparently the category *"leña"* can be subdivided into i) logs or split sections of logs (also called *rajadas de madera)* from the trunks or large branches of trees, and ii) small-diameter sticks or brush from shrubs and bushes. Note that one taxon, ***pactae,*** was mentioned in both these categories (by different people); it is unclear whether they meant different parts of the same plant or whether the categories overlap in some way *(leña* may be an inclusive term).

A second set of questions concerned fuel preferences. People were asked to rank the fuel categories they used in order of use and of preference. Table 2 compares the rank-ordered responses for the categories firewood, dung, straw, kerosene, charcoal, shrubs, and cobs. The table shows that the major difference beween use and preference is that while firewood is the number one *preferred* fuel by most people (dung is given as first choice only once), dung is in fact *used* most often in about half the cases.

Obtaining fuel.—The interviews indicate considerable differences between the main fuel categories in when, where, how, and by whom each is obtained (Table 3). The main fuelwood, eucalyptus, is cultivated, mostly on good land on the valley bottom. Most people obtain eucalyptus wood once a year in the span of a few days, and then store it for the year. One to four trees are bought, cut, and hauled home, or cut on a person's own land. This is primarily a male task. Eucalyptus, for those who can buy or have land to grow it, is a staple fuel in the wet season. To augment this supply shrubby woods are collected daily or weekly (less often in the rainy season) from the hills, lower slopes, and ravines. One woman said she walked three hours everyday to get wood, another reported one to two hours, and another an hour a day. Dung is collected daily in the corrals, fields, on the puna or anywhere it can be found. Four people said dung collection was done mostly in the dry season, because it needs to dry for a week before use (Fig. 3). One person said dung collection took about an hour a day, and another said dung was collected during other errands. Straw or grasses and weedy plants are 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 grass said they went everyday to the hills to collect. At harvest time, all crop straw is saved either for fodder or fuel.

Use of the hearth.—There was little variation in responses to questions about how people used their hearths. Most people said they light their hearths twice a day for cooking, once in the morning and once in the afternoon. One person said it was lit only once a day in the afternoon. The hearth is not generally used to provide warmth, although two people said their fires were going all day. The hearths are most often swept and emptied every morning, the ashes being thrown

FIG. 3.—A woman putting dung to dry on her roof. (Photo courtesy of L. Sikkink)

onto a waste pile (locally called *guano de corral).* These piles are left to compost and are then used for fertilizer (Sikkink 1988). The ashes from the hearth are considered valuable field fertilizer by everyone asked. The pattern mentioned most frequently is that the *guano de corral* pile is taken to the fields once a year at planting time. Potatoes and fava beans are the two crops named that receive the ashes.

Summary and discussion.—A number of points about the nature and use of fuel emerge from the interviews. First, getting fuel in the Mantaro Valley is expensive in time, labor and/or cash, and fuel is used sparingly. For those without sufficient cash, considerable daily labor is expended in getting fuel, mostly by women and children, although men cut eucalyptus and collect fuel when out on other errands. Most people light their hearths only for cooking meals, which are generally soups and stews that can be boiled in a single pot over a small fire. Nor does fuel use end with cooking; the ashes are afterwards used as field fertilizer. Fuel use studies elsewhere in the Peruvian Andes also indicate this sparing use of fuel, but add that at times of feast or fiesta, fuel, as well as food and drink, is used lavishly (Ansión 1986, Skar 1982).

The assemblage of fuels used is varied, including several kinds of wood, kindling, dung, grass, weedy plants and crop residues. This variability is probably related to the relative scarcity of fuel; Skar (1982) found that in Andean communities where fuel is relatively abundant only the preferred fuels, wood and kerosene, were used, while where fuel is scarce people resort to a greater variety.

The categories of fuel used correspond to categories in long use. To the catgories firewood, dung, straw, and cobs, people added charcoal and kerosene, and also made a distinction between logs and sticks, and between grass "of the mountain" and crop straw. These categories, with the exception of kerosene, correspond to those seen in the Mantaro Valley ***quipu*** records from the time of the Spanish conquest and also in sixteenth-century written accounts (see below).

Many of the fuel types used are products of the anthropogenic landscape—cultivated trees or the by-product of crops or domesticated animals. In other words, people produce much of the fuel they use.

The acquisition of fuel in the Mantaro Valley forms a complex pattern with varying seasonal and economic aspects. Fuel collection and use varies throughout the year; daily collection of dung, small sticks, and grass to augment the eucalyptus supply is a dry season pattern. Crop residues also provide additional fuel during the dry season. This indicates that less time but more cash are needed for fuel in the rainy season.

Economic and land-use factors also contribute variability to the fuel pattern. Today's "ideal" Andean fuel, eucalyptus, is a cultivated cash crop available only to those who have cash or land. In the Andes, planted trees are the personal property of those who plant them (Sherbondy 1986). Shrubs and kindling however can be gathered from hills and ravines. Here use rights are traditionally communal, as is firewood land in the Marañon Valley to the north (Brush 1977:77), but with increasing privatization these rights may be curtailed. For example, Skar (1982) found that Peruvian cooperatives controlling land are beginning to demand payment from neighbors for pasturage and wood collected while pasturing; people are indignant about this since they consider collecting wood their right. Dung, straw, and weedy plants are more readily available. In the Jauja region, while only the owners have the rights to dung or straw from their corrals or fields in crop, anyone may collect dung and straw from the communal grazing lands of the upper slopes and the puna, and from fallow fields.

The adoption of eucalyptus has had a major impact on the fuel-use patterns and landscape of the Mantaro Valley. In 1911 and 1920, the first plantings of eucalyptus *(Eucalyptus globulus* Labill.) were made in Muquiyauyo near Jauja (Adams 1959), some 50 years after its introduction to Peru from Australia (Soukup 1980-87:177). Since then, eucalyptus has spread rapidly throughout the valley, replacing the indigenous trees in preference and planting (Dickinson 1969). Eucalyptus first was planted as a dooryard tree and a field border, and fulfilled only local demand, but commercial demand for the wood in the 1940s greatly increased production. Irrigated fields in the best crop land are now solid-planted in eucalyptus (Dickinson 1969). In 1969 the valley contained some 12 million eucalyptus trees (Soukup 1980-87:177). This cash crop is a favorite fuel and has brought fuel into the cash economy.

HISTORIC FUEL USE: DOCUMENTARY EVIDENCE

For a look at fuel use in the Mantaro Valley in the sixteenth century, we turn to the documentary evidence. The first Spanish view of the area comes from

Miguel de Estete, one of the small band that first entered the Mantaro Valley in March 1533, who wrote:

> The town of Xauxa is large and is in a very attractive valley, and the land is temperate; a strong river passes by one part of the town. It is abundant in supplies and herds; it is made in the manner of a town in Spain . . . (Estete 1917 [1532-1533]:96)

The valley was partitioned into three Inca administrative units or ***saya;*** Hatunxauxa at the north end, Lurinhuanca in the central part, and Ananhuanca to the south. Estimates of the valley's population at the time of Spanish entry range from 135,000 (Rowe 1947) to 243,000 (Smith 1970).

Lining the hillslopes behind Jauja and for the length of the valley were thousands of Inca state storehouses, or ***qollqa*** (D'Altroy 1981). These ***qollqa*** contained massive stores of subsistence and luxury goods, and the quantities were recorded by officials on ***quipu,*** a mnemonic system of knotted strings. The Wanka supplied the Spaniards with goods for much of their campaigning, and in 1561, the ***quipu*** records of these supplies were presented by the Wanka leaders for restitution at the *Audiencia de Los Reyes* in Lima. These records have been published by Espinoza Soriano (1971) and discussed by Murra (1975), D'Altroy (1981), and D'Altroy and Hastorf (1984). The contributions from the Wanka included large quantities of fuel, along with other goods such as animals, maize, potatoes, cloth, and ceramics. The ***quipu*** records tell the categories of fuel, the quantities donated, the event occasioning the donation, and by which ***saya*** the material was contributed (Table 4). These records contain several points of interest in regard to fuel-use in the Mantaro Valley at the time of Spanish contact.

First, fuel was a considerable article of tribute, indicating its valuable role in the economy. The contents of the ***qollqa,*** especially the food and fuel, were used to support state personnel, supply labor projects and the military, and for the support of the community (D'Altroy 1981, Morris 1967).

Second, the ***quipu*** reveal the linguistic categories used for fuel. Each string of a ***quipu*** corresponded to a category of goods for tribute. The categories of fuel were always listed together and in the following order: string 28, *leña rajadas;* string 29, *leña menuda;* string 30, *carbón;* string 31, *hierba;* and string 32, *paja* (Murra 1975). These categories in Spanish were those transcribed at the *Audiencia* from the Quechua readings given by the ***quipu*** officials. D'Altroy (1981) translates the categories as "coarse firewood," "fine firewood," "charcoal," "grass," and "straw," respectively. The inclusion of charcoal in the 1533 records indicates that it was an indigenous category (although this has been debated, see Ansión 1986:38), since large quantities were already stored in the Mantaro storehouses at the time of Spanish contact. The existence of a sixteenth century Quechua word for charcoal, ***quillimca*** or ***sansa,*** (Holguin 1952 [1608]:308, 447) is additional evidence for prehispanic charcoal-making in the Andes. Dung is not one of the ***quipu*** categories. Camelid dung may have been a fuel category, but perhaps in household use only.

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Straw (11)	"of the fields" (3)	
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	charcoal (1)	

*numbers in parentheses are the number of times a particular category or type was mentioned as being used, out of 15 interviews. Some people did not name particular types of material under a general category; some people named several types. For example, thirteen people said they used dung, but only three defined the kind of dung; some of the seven people who said they used "other" fuels mentioned several types.

**actual plant material was not shown at the time of the interviews; the scientific taxon is that to which the common name generally refers in the area; confirmation can be seen on identified vouchers for the reference collection including common names given by local guides at the time of collection.

emerged from the interviews (see below). In general, people said they used a combination of firewood, dung, and straw for fuel. 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 were seldom mentioned.

Table 1 lists the specific types of fuel mentioned under the general fuel categories. In the category firewood, eucalyptus was mentioned first by almost

> . . . the first Spanish Town that Francisco Pizarro established was in the tambo of Hatun Xauxa, and they were settled there for two years, and because it seemed to them that there was a lack of firewood in this valley and of irrigation water to make fields and other plantings, they agreed to leave to settle in the valley of Lima ...
>
> (Henestrosa 1965 [1582]:170)

The apparent scarcity of fuel, or at least of wood, in the Mantaro Valley is alluded to again in the report, in a passage that also gives some idea of the landscape and of fuel sources and management at the time:

> . . . in this valley there are not more than two kinds of trees of the countryside; one is aliso *[Alnus jorulensis]* and the other is ***quixuar*** *[Buddleja]*, as it is called by the Indians; and this is planted by hand and brought in from outside for use in their houses and church buildings, so that with effort enough wood can be found for them . . .
>
> (Henestrosa 1965 [1582]:171)

This passage was written 50 years after the conquest and about a decade after a major resettlement. At this time the population was much reduced; the 1582 reports records a population for the Mantaro (an estimated 60,000) of less than

FIG. 4.—Old men and young girls as fuel gatherers (Guaman Poma 1987 [1615]: 190, 218).

FIG. 5.—Firewood and grass as a gift cementing kinship ties (Guaman Poma 1987 [1615]:918).

half what it had been in Inca times (an estimated 135,000)[2] (Henestrosa 1965 [1582]:167). If the people in 1582 had to plant trees and import wood, plausibly they also did in Inca times when the population level was more than twice as high and there were also high tribute demands for wood.

There is evidence indicating that fuel management, especially in the form of tree-planting, was an essential indigenous Andean practice. Sherbondy (1986) discusses the Quechua word ***mallqui,*** meaning a cultivated tree in distinction from trees that grow wild, called ***sacha.*** She points out that the rich terminology in Quechua concerning tree-planting indicates the antiquity of these practices. The following list from Holguin's sixteenth-century Quechua dictionary illuminates those practices:

> ***mallquini*** to plant or transplant.
> ***mallquipani*** to replant.
> ***Ppitticta cassacta mallquipani*** to transport trees to where they are lacking.
> ***Mallquiscca*** something planted.
> ***Mallqui mallqui*** plantation or grove of fruit-bearing trees.
> ***Mallquiçapa muya*** orchard of fruit-bearing trees.
>
> (Holguin 1952 [1560]:224-5)

Tree-planting and forest management seem to have been a concern of the Inca (see further discussion in Ansión 1986, Sherbondy 1986). Pachacuti Yamqui, a native chronicler, wrote this about the 7th Inca Viracocha Inca Yupanqui

> . . . they say that he was very gentle; his occupation was to build houses, and the fortress of Sacssaguaman, and also the fields and the planting of alisos *[Alnus jorulensis]* and other plantings of quishuar *[Buddleja* spp.] and chachacoma *[Escallonia* spp.] and molles *[Schinus molle* L.] . . .
>
> (Pachacuti Yamqui 1950 [1613]:236)

Polo de Ondegardo (1917 [1567]:80) wrote that in areas with a shortage of firewood the Inca set forests aside for himself that were called ***moyas*** of the Inca—the towns within whose boundaries the forests were could use them according to need, but only with order and license from the Inca. Fray de Murua lists among officials appointed by the Inca those who plant and take care of trees ***("malqui camayos"),*** and states that one of the ordinances that the Incas gave to their vassals was that nothing should be harvested from planted or grafted trees until the fourth year (Murua 1964 [ca. 1600]:87, 89). There may also have been a somewhat stronger prohibition issued by the Inca: Guaman Poma (1987 [1615]:179) wrote that an ordinance of the Inca stated that no fruit-tree, woodlot *("madera aomente"*; literally, augmented wood) or straw shall be burnt or cut without proper authority, on pain of death or other punishment.

The documents also reveal aspects of traditional fuel use, including details as to its collection, use in cooking and high value as a resource. Getting firewood was one of the major tasks of life, as this scolding of a lazy person suggests:

> . . . you don't work in your field, you don't watch your llamas, or fetch dung, or firewood or straw, or finish anything, or weave to earn a living, lazy one.
>
> (Guaman Poma 1987[1615]:950)

Collecting fuel (firewood and straw are mentioned) was primarily the task of young girls (ages 8-12) and old men (between about 60 and 80) (Fig. 4). The drawing on the left of Fig. 4 of the old man carrying wood is captioned "the conveying of tribute that serves the chiefs" (Guaman Poma 1987 [1615]:190, 218). In October, in preparation for the rainy season, firewood was cut and piled up and put away for the winter; and straw *("paxa")* was also stored up. In November people also accumulated firewood and piled itup in their houses "for themselves and for their principal people and ***curacas*** [local chiefs] and for the ***mitas*** [labor exchange projects] and for the whole winter" (Guaman Poma (1987 [1615]:1233-7).

The categories of fuel mentioned in these early writings are those that appeared in the ***quipu;*** for example, as in a passage that also shows the Indian duty of providing fuel to the Spanish:

> And thus to the said caciques . . . the Indians are made to betake themselves with their firewood *["leñas"]* and straw *["paxas"]* in the

> mornings; in the afternoons as usual, obedience and law and Christianity. And whoever doesn't do it is punished. And they have to carry dung [*''estiércol''*] and firewood [*''leña''*], straw [*''paxa''*], grass [*''yerua''*] to their house and spin as they walk along the roads.
>
> (Guaman Poma 1987 [1615]:913)

The possession of abundant firewood was a sign of prosperity. Of town mayors it was said ''they have much firewood and straw and many fields'' (Guaman Poma 1987 [1615]:852). In the houses of the Inca, among other objects made of gold and silver such as maize plants, flowers, and birds, were ''heaps and piles of firewood logs, imitating the natural, as if they had been put there for use in the service of the houses'' (Garcilaso de la Vega 1985 [1609-1617:215). Firewood is often equated with food and water in importance as a resource; for example, as in this work of mercy:

> Your fire, Christian, is for God, your water is for God, your firewood is for God and your food is for God . . . Pity the crippled, lost and old Indians who have nothing to eat nor anyone to give them water [and] firewood.
>
> (Guaman Poma 1987 [1615]:914)

Fuel was used like food and other goods in reciprocal social and kin relations: the drawing shown in Figure 5 illustrates that in-laws have a duty to provide for each other; here a man presents a gift of firewood (*''lena''*) and straw (*''paxa''*) to his in-laws on the occasion of a death in the family (Guaman Poma 1987 [1615]:918). Firewood even had a place in the Inca wedding ceremonies; logs of firewood were gilded so that they looked like solid gold (Murua 1964 [ca. 1600]:67). At more typical weddings, Murua (1964 [ca. 1600]:70-71) recounts that the Indians brought the bride gifts of meat, coca, and ''firewood of some roots called ***Urutne*** [?], or if they didn't have that, of *aliso,* made into logs, and if they didn't have any of their own, they requested some from their cacique.'' This suggests i) that the type of wood burned had symbolic significance, and ii) that local leaders had some control over sources of wood.

Domestic fuel use was evidently limited to cooking; meals were cooked twice a day and most food boiled as soups, stews, and *mote* (boiled maize) (Guaman Poma 1987 [1615]:926, Horkheimer 1973). Cooking practices, and hence fuel use, were associated with units of time: ***huc yanuy chica*** was defined as ''one hour which is what it takes to cook a stew,'' (Holguin 1952 [1608]:365).

In contrast to the sparing household use of fuel was its lavish use in ceremony. Some of wood collected as tribute under the Inca went for this purpose; Polo de Ondegardo recounts (1917 [1571]:87-88) that a kind of red firewood was brought to Cuzco from 200 leagues away in the form of carved and decorated logs—these were brought in great quantities to burn in the sacrifices to the Sun and in the fires that burned in the plaza in the presence of the Inca and his mummified ancestors.

It is likely that the Spanish occupation brought about some changes in the traditional pattern of fuel use. The per capita need for fuel probably increased. Padre Cobo commented in 1639 that the Spanish were very wasteful in their use of fuel: he said that a Spanish household will use in a day fuel that would last an Indian household a month (Cobo 1891-1893 [1639]:Vol. 2, Libro 6:6-9). An earlier chronicler, Garcilaso de la Vega (1985 [1609-1617]:345) notes that most of the abundant ***molle*** trees (presumably encouraged or cultivated) near Cuzco were cut down in short order after the Spanish arrived because they made such good charcoal. The Spanish had new uses for fuel that consumed large quantities; in mining, lime and brick kilns, and bread ovens (see Ansión 1986, van Dam 1986), as well as new grazing animals that cleared new areas and prevented the reestablishment of woody growth. The dearth of wood and fuel was quickly felt in areas of high population, and near Lima and Cuzco measures were taken to counteract it. In Lima in 1551 a program of planting trees and ordinances governing the cutting of trees and use of fuel were instituted (Jiménez de la Espada 1965, Vol. 1:123). People who owned land were ordered to plant trees, and penalties were imposed on Spaniards and Indians for making charcoal, cutting or girdling trees, and using large logs in ovens.[3] In 1590 a program was instituted to reforest 60 km of the valley near Cuzco; 2400 trees were planted by the various ***allyu*** (community kin groups) under the direction of the Spanish. Trees of four taxa were planted: *Buddleja, Escallonia, Alnus,* and *Polylepis* (Sherbondy 1986).

In the sixteenth century, as in the twentieth, fuel was a valuable and tended resource in the Andes, as reflected in the cultural practices of tree planting, forest management, its collection as tribute and its social and ceremonial roles. In the Mantaro Valley, we have seen that in the 1580s *Buddleja* was planted and wood was imported from outside the valley. These practices were not limited to post-conquest times; the evidence indicates that tree cultivation, forest management, and wood importation were part of Andean life in Inca times as well. Whether these practices were exclusively Inca policy, or more essentially Andean and therefore likely to predate the Inca conquest in the Mantaro Valley, is a question to be addressed through archaeological evidence.

PREHISTORIC FUEL USE: ARCHAEOLOGICAL EVIDENCE

Archaeological sites in the Mantaro Valley are numerous and range from scattered hamlets of the Early Formative to large nucleated Late Intermediate towns and Inca period villages and administrative installations. The members of the Upper Mantaro Archaeological Research Project have excavated the remains of house compounds at a number of Late Intermediate and Inca period sites as well as earlier deposits at the stratified site of Pancán (Earle *et al.* 1980, 1987; Hastorf *et al.* 1989). From these house contexts we have direct evidence in the form of fuel remains from a thousand years of prehistoric fuel-use. These plant remains have been preserved by charring in antiquity.

During excavation of these sites, soil samples for flotation were systematically collected from each unit and context. The samples analyzed for this study (both

screen and flotation samples of 6 liters of soil) are from the four levels of Pancán, the two earliest of which date to the Early Intermediate (A.D. 450-700) and the two upper to the Middle Horizon and early Late Intermediate (A.D. 700-1300); from seven house compounds of the Late Intermediate Wanka II phase (A.D. 1300-1460); and from five house compounds dating to the Inca period (Wanka III phase, A.D. 1460-1532) (Table 5). Samples were chosen from uncontaminated midden, floor, and hearth contexts from all time periods. Samples from clear cases of catastrophic burning (i.e. burned houses) were excluded from the analysis, since the woody material in these samples may represent construction rather than fuel materials. We are assuming that the types of woody remains recovered most commonly and from wide distribution in middens, floors and ash dumps are most plausibly the result of intentional burning, i.e. fuel use (Smart and Hoffman 1988). Even if the primary use of the material was in manufacture (e.g. discarded tool handles, posts, bedding, mats), their charred condition indicates a secondary use as fuel.

TABLE 5.—*Chronology of Archaeological Fuel Remains.*

Provenience*	N of Samples	Phase	Period	Dates (A.D.)
J2=1,2; J54=2; J74=1,2	74	Wanka III	Inca	1460-1532
J7=2,3,7; J2=4; J41=1,5,6	117	Wanka II	Late Intermediate	1300-1460
J1, Level 1	53	Wanka I	Late Intermediate	1000-1300
J1, Level 2	36	Wanka 0	Middle Horizon	700-1000
J1, Level 3	19	Huacrapukio II	Early Intermediate/ Middle Horizon	450-700
J1, Level 4	28	Huacrapukio II	Early Intermediate	450-700

*site names and components: J1—Pancan (multicomponent HII-W1); J2—Hatunmarca (WII and WIII); J7—Tunanmarca (WII only); J41—Umpamalca (WII only); J54—Marca (WIII only); J74—Chucchus (WIII only).

In all, we analyzed 47 samples from Pancán levels 3 and 4, 89 samples from Pancán levels 1 and 2, 117 from Wanka II contexts, and 74 from Wanka III (a total of 327 samples). A total of 7996 woody fragments were recovered from the 327 samples, and 3670 of these were examined. The fuel remains from the Pancán site were analyzed by Greenlee (1988), the later material by S. Johannessen.

The procedures followed in the identification of the woody material are described by Pearsall (1989:155-165). All woody and stem materials were removed from the samples, which also included abundant food remains (Lennstrom 1988). A maximum of 20 fragments (some samples contained fewer than 20 fragments) were randomly selected for examination from the total fragments over 2 mm in

size. The remains fell into three general categories: "wood" (mature wood with growth ring pattern clearly distinguishable); "stem" (immature dicotyledonous wood, twig or stem); and "grass" (monocotyledonous stem, i.e. from grasses, rushes, etc.). The monocot and dicot stem fragments were predominantly complete cross-sections of small diameter (≤ 0.5cm). These two categories were not further identifiable. The mature wood fragments were compared to specimens in a reference collection of charred wood from 88 taxa of common Andean trees and shrubs.[4] The internal anatomy of the fragments was examined under 10X-70X magnification in transverse, radial, and tangential section, and details of the size and arrangement of the vessels, rays, and parenchyma were drawn and described (Core *et al.* 1979, Panshin and de Zeeuw 1970). One-to-one comparisons were made of the archaeological fragments to charred specimens in the reference collection.

In addition to wood, stem, and grass fragments, dung and maize cob remains present in some samples may represent fuel sources. The dung of grazing animals is an important source of fuel in the Andes (Winterhalder *et al.* 1974), but it is scarce in the Mantaro samples. This could be due to poor preservation of this material; however, in the earlier Pachamachay site (ca. 2000 B.C. to A.D. 500) just north of the Mantaro in the Junín puna, charred dung remains were commonly recovered from flotation samples (Pearsall 1980:211). Thus camelid dung may not have been a primary fuel source in the Mantaro Valley sites, although it was apparently more heavily used on the nearby puna in earlier times. Maize cobs, an occasional fuel in the present-day Mantaro, are represented in the samples in the form of charred cupules. We cannot, however, be certain whether they were charred accidentally as by-products of food preparation (they were generally found with maize kernels) or intentionally as fuel.

To examine how fuel-use may have changed in the thousand years covered by the samples, we first look at shifts in the general composition of the samples, i.e. in the relative proportions of mature wood, small dicot stem, and monocot stem. The proportions of the various categories are by no means assumed to reflect the proportions in which the fuel categories were actually used, given an unknown preservational bias; that is, that various types of plant remains have different chances of being preserved through charring (Smart and Hoffman 1988). However, given that the preservational properties of each plant type remains constant, and that contexts and conditions were fairly stable from site to site, we can propose that in a comparison of the assemblages from several sites or time periods, major proportional changes reflect shifts in depositional behavior (Asch and Asch 1988, Miller 1988).

Figure 6a shows the proportions of the total fragments recovered from each time period that are "wood" (mature wood), "grass" (monocot stem), and "stem" (dicot stem). The figure shows that while mature wood is the dominant category in the samples in all time periods, the proportions of stem and grass vary. The ratios (Fig. 6b) of stem and grass fragments to wood fragments show an increased relative proportion of stem and grass throughout the Pancán sequence until almost half of the remains from Pancán levels 1 and 2 are stem

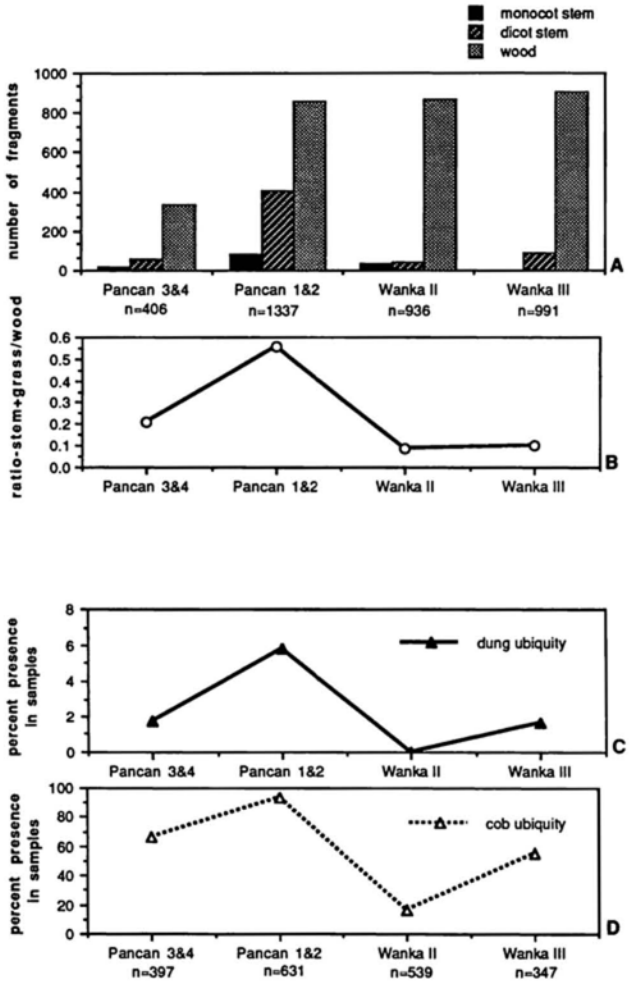

FIG. 6.—Trends in archaeological fuel categories. 6a) the relative proportions of the categories mature wood, stem, and grass (by count) and 6b) the changing ratio of stem and grass to wood (by count). The lower graphs show similar trends in the ubiquities of dung (6c) and cob fragments (6d).

and grass pieces. The trend reverses abruptly in Late Intermediate and Inca times when the samples are composed almost entirely of mature wood fragments. Figure 6c and 6d show that ubiquities (percentage presence in samples) of dung and maize cobs, other possible fuel sources, follow the trend of the relative proportion of grass and stem—rising through the Pancan sequence and dropping steeply in the Late Intermediate.

We suggest the data indicate that the people living at the Pancán site resorted increasingly to the use of twigs, stems, grasses, dung, and cobs for fuel. Several lines of evidence from the Pancán site indicate that the nature of the agricultural system was changing throughout its occupation; maize remains for example increased in ubiquity from about 30% to 95% (Lennstrom 1988), and hoes from 4% to 51% in ubiquity (Russell 1988). The increasing land clearance implied by these data may have lessened the availability of mature trees and promoted greater use of less favored fuel types. The reversal of this trend in the Late Intermediate may reflect new fuel management techniques associated with shifting patterns of land use and land tenure accompanying the major demographic and political changes apparent at about A.D. 1300 (see page 66). These new techniques apparently increased the supply of mature wood which is (at least today) a favored fuel.

Changes occur not only in the relative proportions of woody materials, but in the composition of the mature wood itself. The wood assemblages from all time periods were extremely diverse, with as many as 40 taxa represented in material from a single time period. Table 6 gives the ubiquities (percentage of

TABLE 6.—*Ubiquities of twelve major archaeological wood taxa.**

Taxon	Pancán 3&4 (n=47)	Pancán 1&2 (n=89)	Wanka II (n=117)	Wanka III (n=74)
Type U	0%	0%	0%	9%
Colletia	0%	0%	3%	18%
Cedrela	0%	0%	4%	11%
Buddleja	0%	0%	3%	27%
Type OO	17%	11%	4%	7%
Polylepis	9%	17%	7%	19%
Cassia	9%	5%	8%	12%
Type B	4%	24%	12%	12%
Type VVV	11%	8%	0%	0%
Type BBB	11%	10%	0%	0%
Type LLL	11%	23%	0%	0%
Type FFF	4%	16%	0%	0%

*Ubiquities are the percentage of the samples analyzed from that level in which the taxon was present.

samples in which a taxon was present) (Pearsall 1989, Popper 1988) of the 12 taxa most often present in samples (i.e. those with the highest ubiquities). Four of these taxa (presently unidentified) occur only in the earlier time periods, being completely absent in Wanka II and III. Four other taxa are relatively common in all time periods. Two of these are unidentified, and two have been identified as *Polylepis* sp. and *Cassia* sp. These are common Andean fuel woods and are still used in the Mantaro Valley (see Table 1). A third group of taxa occur only in the two later time periods. Three of these taxa first appear infrequently in Wanka II samples and then more commonly in Wanka III. These are *Colletia* sp., a spiny bush; *Buddleja* sp., a tree of the high elevations, and *Cedrela* sp., a tall tree typical of the *ceja* forest of the eastern Andes. Also appearing only in Wanka II and Wanka III contexts (although not among the common types listed in the table) is *Chusquea* sp., a bamboo-like monocot also typical of the *ceja* area. While most of the identified taxa are typical constituents of the high intermontane Andean vegetation, *Cedrela* and *Chusquea* grow in the warmer humid environs of the eastern Andean slopes (Weberbauer 1936, 1945), and their presence in the Mantaro indicates their importation. Importation of plant products from the eastern slopes in pre-Inca times is further evidenced by the presence of coca in Wanka II contexts (Hastorf 1987).

In sum, the fuel remains reveal both changes and continuities over a period of a thousand years. The fuel assemblages from all time periods are diverse, including many wood taxa, grass, twigs, dung and cobs. The overall composition, however, shifts as the proportion of mature wood decreases slowly through Wanka I and then increases abruptly in Wanka II (late Late Intermediate). Several of the wood taxa (some still common fuels today) are relatively common throughout the record. Others are present only in the earlier time periods, to be replaced by new taxa in the Late Intermediate and Inca periods. *Buddleja,* although a local taxon, does not appear in the record until Late Intermediate times and subsequently becomes the most common taxon in the remains from Inca period households. *Buddleja* is one of the types of planted trees mentioned in early texts. Wood of two additional taxa appearing first in the Late Intermediate were probable imports from the eastern slopes of the Andes. We believe that these data indicate that tree cultivation, forest management, and wood importation were practiced in the Mantaro Valley not only in Inca times, but in the late Late Intermediate by indigenous Wanka people at least a century before establishment of the Inca empire.

DISCUSSION AND CONCLUSIONS: CHANGE AND CONTINUITY IN FUEL-USE

In this history, created from three different types of data, we have seen significant continuities in an ancient pattern of fuel management in an environment with limited naturally-occuring fuels. The pattern since the sixteenth century includes use of a wide variety of fuels, production and management of fuel by tree-cultivation, rules governing fuel collection, use of the by-products of

domesticated animals and crops, sparing use of fuel in cooking practices, and a cultural perception of fuel as a resource as valuable as food and water.

In the Mantaro the prehispanic system under the Inca evidently could produce large surpluses of fuel, if the Wanka were able to stock the storehouses for the seventy years of Inca rule with the amounts of fuel that were there in 1533. The Wanka under Inca rule may have managed their fuel supply in part by growing trees. Archaeological data show in Inca times an increase in the occurrence of several wood taxa, especially in *Buddleja,* which documentary evidence indicates was one of the taxa cultivated by the Inca. It was also a commonly cultivated tree in the late sixteenth century, and in fact is still planted today. Archaeological evidence indicates that the pattern may have been pre-Incaic-*Buddleja* first becomes common with the increased wood use of the Late Intermediate. The Late Intermediate also yields (in the presence of *Cedrela* and *Chusquea*) the first evidence of the importation of wood from the *ceja.*

The archaeological evidence has demonstrated that the pattern of a varied fuel assemblage dates at least from the beginning of the record in A.D. 500. The first evidence of fuel management comes with the major demographic, political and social changes of the Late Intermediate in about A.D. 1300. At this time a relatively greater use of mature wood, and the appearance of one taxon that may have been cultivated and of two that were imported, implies an increased degree of fuel management.

The pattern established by late Late Intermediate times and amplified under the Inca has continued up to the present. Fuel and wood are still mostly produced; by growing trees, by using crop and herd by-products, and by importation from the *ceja.* The categories of fuel have not changed significantly since pre-Spanish times, as shown by the concurrence of the Inca period ***quipu*** categories and the distinctions made by present-day Spanish-speaking inhabitants of the valley. Fuel has long had a high value and an association with prosperity; this was explicit in 16th century documents and in the economic distinctions in fuel use today. Sparing everyday use, as opposed to lavish use in ceremony or fiesta, is another aspect of the long-term pattern also indicating the cultural value of fuel. Control over wood and fuel resources has been an important tool in the hands of those in power; first perhaps the Wanka leaders of the Late Intermediate, then seen in the Inca and later the Spanish ordinances, and presently the land-owners and cooperatives who control access to fuel.

There have been changes in the long-term pattern of fuel management, but many seem to be substitutions rather than structural changes: eucalyptus replaces indigenous cultivated trees, cow dung replaces llama dung, wheat straw replaces quinoa straw. A more basic change is being wrought by the cash economy and land privatization. The value of fuel no longer comes from the time spent gathering it, as appears to have been the case in the 16th century, but from its new place as a commodity in a cash economy. The traditional practice of tree-planting, now almost exclusively eucalyptus at the expense of the indigenous trees, serves the urban market rather than the needs of the local people. The web

of factors affecting fuel use and management has now expanded to include the international economy.

The history of fuel-use in the Mantaro has not been one in which the Wanka people have had a passive role—they have managed their landscape as well as adjusted to its changes, probably from the earliest inhabitants. Here the long-term pattern has been the tending, management, cultivation, and production of fuel resources. The Wanka people have long since actively defined their fuel resources as an integral part of their cultural ecology.

NOTES

Notes on the text. The taxonomy used follows Soukup (second edition, 1980-87). The authority is given with the first mention of the taxon. The orthography uses bold italics for Quechua words, and italics for Spanish words and the scientific names of the taxa. Translations from the Spanish sources were made by the first author with the help of Richard Omana.

[1]It is curious that no one mentions ***molle*** *(Schinus molle).* In the Vilcanota area, Gade (1975:84) lists ***molle*** after eucalyptus as the next most important fuelwood. Yet in the Mantaro Valley we have no evidence of its use presently or prehistorically, although it grows in the area today. It may be that ***molle*** is too useful and respected a tree to be used as fuel; many early writers (e.g., Cobo 1891-93, Vol. 2:84-86) comment on the respect ***molle*** received as a provider of medicines and of berries for chicha. This respect evidently continues—today ***molle*** leaves are traded into the high Andes of Bolivia for use in baking harvest celebratory bread and in weddings (Guillermo Delgado *pers. comm.*).

[2]These population estimates are based on the number of *"tributarios"* given for the three Mantaro Valley ***saya*** in Henestrosa's 1582 report. He reports 12,000 *tributarios* and says that in Inca times there were 27,000. Plausibly *tributarios* are also heads of household; an estimated five additional family members were added for each household (Rowe 1947).

[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 fields. 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 100 azotes, whatever his master desires; and for a second offense 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).

[4]The University of Minnesota Archaeobotanical Laboratory reference collection was compiled by Dr. Christine A. Hastorf in the years 1977 to 1985. Vouchers were identified by Dra. Emma Cerrate of the Museo de Xavier Prado, Lima. The collection includes wood specimens from 60 taxa of common Andean woody plants. The wood of an additional

28 Andean taxa was examined at the Forest Products Laboratory in Madison, Wisconsin, with the kind assistance of Dr. Regis Miller.

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APPENDIX 1. Questionnaire used in fuel-use interviews.

1) *Que quema en su fogón? y que tipo?* (What do you burn in your hearth? And what type?)
   leña? guano? paja? mazorcas? otro?
   (firewood? dung? straw? cobs? other?)

2) *Qual usa con la mas frecuencia?* (RANK FREQUENCY) (Which do you use most frequently?

3) *Donde va para recoger éstas cosas?* (Where do you go to collect these things?)

4) *Cuantas veces va para recoger éstas cosas?* (How often do you go to collect these things?)
   diariamente? cada semana? cada estación?
   (daily? each week? each season?)

5) *De las cosas que usa en el fogón, cuales son las mas preferidas?* (RANK PREFERENCE) (Of those things you use in the hearth, which are most preferred?)

6) *Cuántas veces incendia el fogón cada día?* (How often do you light the hearth every day?)

7) *Vacía el fogón?* (Do you empty the hearth?)

8) *Dónde se bota el contenido del fogón?* (Where do you throw the contents of the hearth?)

9) *Se usa la ceniza del fogón para algo mas? Sirve para algo?* (Are the ashes from the hearth used for anything?)