J. Ethnobiol. 6(1):169-204 Summer 1986

SECTORAL FALLOWING SYSTEMS IN THE CENTRAL ANDES

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ABSTRACT.—Sectoral fallowing systems from 51 communities (Fig. 1) in highland Peru and Bolivia have been examined, focusing on altitudinal and latitudinal variation in these systems. In these instances of communal management of cropping patterns and fallowing, a significant proportion of lands is left fallow. This practice has been studied for implications related to maintenance of soil quality and reduction of pathogen impacts. Recent changes in several systems are noted. Comparison with other Andean patterns of culture and social organization reveal similarities with the present study area.

INTRODUCTION

Many peasants in the Andean highlands practice a complex pattern of crop and pasture management called sectoral fallowing systems. These systems, found in a large number of communities[1] distributed over a wide territory, are of interest to ethnobiologists for several reasons. They show that human knowledge and use of plants and animals can lead to the coordination of behavior of many individuals. They also demonstrate the complex interaction of human populations and the environments in which they live. Since there are a large number of these systems, they are particularly well-suited to statistical analysis.

Anthropologists who specialize in the Andean region have been drawn to study these systems, not only because they are an important aspect of economic organization in the region, but also because they appear to exemplify important forces which shape peasant life there. Some writers select an adaptationist perspective, viewing human activity as constrained by the difficulties of extracting resources from fragile and unproductive mountain ecosystems. Others emphasize the cultural continuities between earlier periods and the present, and see in agriculture and pastoralism, as in other areas of activity, underlying Andean patterns of thought and belief. Still others stress the importance of political economy, of the ways in which peasants and pastoralists, as one class in a dependent, stratified society, cope with the pressures from elites, governments and markets.

This article examines these sectoral fallowing systems in detail. It describes the basic features of these systems and analyzes the variation among the systems. The evidence provides general support for the adaptationist view of these systems, but also indicates the significance of Andean cultural patterns. It does not directly address the political economy perspective, neither confirming or challenging it. The evidence hints at recent shifts in these systems associated with population increases and commercialization of agriculture, but the lack of quantitative information does not permit a detailed exploration of these important links.

SECTORAL FALLOWING SYSTEMS: DEFINITIONS

Early ethnographic accounts of rural Andean life comment on community-wide management of cycles of planting and fallowing (Bandelier 1910:83, 85), but it has only been recently that these systems of land use have been described in detail. The account of this system by Matos Mar (1964) is one of the earliest full ones. The community of Paracaos in the province of Canta, department of Lima in the central Peruvian highlands may be taken as typical (Table 1). The 163 households which make up this community have access to some irrigated plots, which are cultivated each year, and to natural pastures. In addition, they have 929 hectares of land which they cultivate in some years and let lie fallow in others. These lands are divided into ten sectors. Most households own plots in all of the sectors. These households plant potatoes in their plots in a given sector in one year. In the next year, those who wish to do so plant other Andean tubers (oca,

TABLE 1.—*Cultivation cycle of sectoral fallowing systems in Paracaos (Degregori and Golte 1973:44-45).*

	YEAR				
Name of Sector	1958	1959	1960	1961	1962
Huayatama	pasture	pasture	pasture	pasture	pasture
Cushurumachay	pasture	pasture	pasture	pasture	pasture
Shujuncha	min. tubers[1]	pasture	pasture	pasture	pasture
Chuyochacra	potatoes	min. tubers	pasture	pasture	pasture
Acopuquio	pasture	potatoes	min. tubers	pasture	pasture
Ayal and Ushtuna	pasture	pasture	potatoes	min. tubers	pasture
Tamburhuasi	pasture	pasture	pasture	potatoes	min. tubers
Liuli and Mitaysinsan	pasture	pasture	pasture	pasture	potatoes
Sinsanchacra	pasture	pasture	pasture	pasture	pasture
Milacancha	pasture	pasture	pasture	pasture	pasture

Name of Sector	1963	1964	1965	1966	1967
Huayatama	pasture	pasture	potatoes	min. tubers	pasture
Cushurumachay	pasture	pasture	pasture	potatoes	min. tubers
Shujuncha	pasture	pasture	pasture	pasture	potatoes
Chuyochacra	pasture	pasture	pasture	pasture	pasture
Acopuquio	pasture	pasture	pasture	pasture	pasture
Ayal and Ushtuna	pasture	pasture	pasture	pasture	pasture
Tamburhuasi	pasture	pasture	pasture	pasture	pasture
Liuli and Mitaysinsan	min. tubers	pasture	pasture	pasture	pasture
Sinsanchacra	potatoes	min. tubers	pasture	pasture	pasture
Milacancha	pasture	potatoes	min. tubers	pasture	pasture

[1]minor tubers are olluco, oca, mashua

Oxalis crenata; ollucu, *Ullucus tuberosa*; and mashua, *Tropaeolom tuberosum)* in the same plots, although others choose not to plant in this second year. All of them let these plots lie fallow for the next eight years. Although individuals in the community recognize the boundaries and ownership of the plots, households have exclusive rights to use their plots only during the years when they are planted. During the fallow years, the plots are used as pasture by all the members of the community. The plots in all of the sectors pass through the same sequence of uses. However, the timing is staggered, so that no two sectors begin the sequence in the same year. When a particular sector is about to be cultivated after eight years of fallow, the community authorities indicate the day when agricultural activities will begin; they also ratify the ownership of particular households, and can redistribute plots which are abandoned or left vacant by owners who died without leaving heirs.

Other sectoral fallowing systems vary in the details of the crops which are grown, the length of the cycle, and the nature of the communal control, but they share with Paracaos a number of imporant features. (1) Each of the sectoral fallowing systems is a land-use system which consists of a set of lands associated with a set of households; (2) The set of lands are divided into a number *n* of sectors. The lands which make up each sector are contiguous; (3) All households own plots in most or all sectors. Most or all households own plots in all sectors; (4) There is a sequence of *n* year-long uses for the lands. Some of these uses consist of the planting of a specific annual crop or small number of annual crops. The set of crops may differ among the successive cropping uses out of the total set of uses. The other uses are fallowing, combined with grazing. All the fallowing uses occur after all the planting uses; (5) All *n* sectors pass through the same sequence of *n* year-long uses. In any given year, one and only one sector will have each cropping use, and the number of sectors which are fallowed is equal to the number of fallowing uses in the *n* year cycle; (6) When a sector is used for planting, each household has access and usufruct rights to its plot or plots in that sector; (7) When a sector is used for fallowing and grazing, all households have access and grazing rights to the entire sector; and (8) This land use pattern is maintained and enforced by institutionalized means.

These systems have awakened the interest of a number of anthropologists and geographers. They seem large in their spatial, temporal and social scale. Many specialists, accustomed to thinking of peasants as competitive and uncooperative, are surprised by this coordination of activity. How widespread are sectoral fallowing systems? How may their presence and distribution be explained? Along what dimensions do the sectoral fallowing systems differ from one another? Are there any regularities in their patterning? As in other areas of human activity in the Andes, several lines of explanation may be presented. The sectoral fallowing systems could be seen as adaptations to mountain environments, as a historical product of the political economy, or as an expression of underlying cultural patterns. These explanations could be integrated in a variety of fashions.

METHODS

Literature reviews conducted independently by the two authors (Custred and Orlove 1974, Campbell and Godoy in press) showed several types of sources: some detailed ethnographic studies of single sectoral fallowing systems, brief references to sectoral fallowing systems throughout the Andes, and a few studies of changes within sectoral fallowing systems in particular regions. We also sent a questionnaire to 119 anthropologists and geographers who have conducted research in the Andes. We received 27 replies. There were some instances of incomplete or missing information in both published materials and completed questionnaires. Our sample of 51 communities (Appendix 1) is thus not random. We hope that it represents a fairly complete presentation of available research on communities with sectoral fallowing systems.

There are several basic variables which we consider in detail and which are summarized in Table 2; though simple, they have not been fully distinguished in earlier writings. The cropping and fallowing cycle in any given system is as many years long as there are sectors in the system, since each sector must pass through every year of the cycle and since no two sectors are at the same point in the cycle in any given year. Thus the number of sectors which are in fallow at any given time is the same as the number of years which each sector lies fallow. We will discuss in particular the following variables: the number of years which each sector lies fallow, which we call "number of fallow years" and the number of years in which each sector is cropped, which we call the "number of crop years". The sum of these two variables is the number of years in the cycle, identical to the number of sectors in the system; we refer to it as "number of sectors". The ratio of the number of fallow years to the number of sectors is called the "fallow ratio". Because of the great importance of tuber crops, particularly the potato, in Andean agriculture, we constructed several measures.

The "number of tuber years" refers to the number of years in the cycle in which tuber crops are grown exclusively or predominantly. This definition raises certain measurement problems. If we counted only years in which tuber crops were grown

TABLE 2.—Summary of variables utilized in this study.

Description	Value	Name
Basic features:		
Number of tuber years	T	TUBERYR
Number of other (non-tuber) crop years	O	OTHCRPYR
Number of fallow years	F	FALLYR
Number of crop years	T + O	CROPYR
Number of non-tuber years	O + F	NOTUBYR
Number of sectors	T + O + F	NUMSECTS
Percentage of time in fallow	F/(T + O + F)	FLRATIO
Percentage of time not in tuber cultivation	(O + F)/(T + O + F)	NOTBRAT
Tuber years as percentage of crop years	T/(T + O)	TUBINDX
Other features:		
Mean elevation of plots in sectoral fallowing system		ELVSFS
Community elevation		ELVCOM
Number of sectoral fallowing systems associated with a specific community		NUMSFS

exclusively, we would have to reject cases in which a few other crops were occasionally interspersed in a sector otherwise planted with tubers. However, we did not wish to include cases where tubers accounted only for a small proportion of the crops which were planted in a specific year. In practice, this problem turned out not to be difficult; most sources described the cropping patterns in sufficient detail to permit the coding of years in which both tubers and other crops were grown as tuber years or non-tuber crop years.

The sum of the number of fallow years and the number of years in which crops other than tubers were grown is called the "number of non-tuber years". The ratio of the number of non-tuber years to the number of sectors is called, somewhat awkwardly, the "non-tuber ratio"; the ratio of the number of tuber years to the number of crop years is called the "tuber index". The tuber index ranges from 0.25, in the cases in which tubers account for only one of the four cropping years, to 1.0, when only tubers are grown.

In addition we sought to establish the mean elevation of plots within the sectoral fallowing systems; for this purpose, we used the much more readily available average of the highest and the lowest elevations within the sectoral fallowing system. To establish the elevation of the community, we took the elevation of the central settlement, if there was one, or the average elevation of the permanent dwellings, if there was not. These variables are respectively called "system elevation" and "community elevation".

The examination of the data revealed three difficulties which might be termed the multiple-system problem, the zero-fallowing problem, and the multiple-community problem. They are all illustrated by the community of Irpa Chico, in the province of Ingavi, department of La Paz, Bolivia. A recent monograph about this community offers one of the best descriptions of land use systems anywhere in the Andean highlands (Carter and Mamani 1982). The inhabitants on this community distinguish between the *sayaña*, a plot held by an individual or a household which can be used for grazing, cultivation or house construction; each household may decide independently on the use to which it will put each *sayaña* plot. An *aynuqa*[2], by contrast, is a set of communally controlled lands managed as a sectoral fallowing system. Local community authorities retain considerable discretionary powers in reallocating plots within these *aynuqa* to poor families. With a total of 513 households and 3109 hectares of land in the *aynuqa*, the land-population ratio for these lands is close to that in Paracaos. The total number of plots within the *aynuqa* exceeds 11,000. In Irpa Chico, unlike Paracaos and many other communities, there are several sectoral fallowing systems or *aynuqa* rather than just one. Carter and Mamani suggest that there are eight *aynuqa* within the community. The multiple-system problem consists in the necessity of deciding whether to consider each of the *aynuqa* as a distinct system. If all the *aynuqa* had the same sequence of planting anf fallowing, they might easily be considered to be a single sectoral fallowing system in which the sectors were non-contiguous. For example, if eight different *aynuqa* all went through a sequence of one year of potatoes, one of barley and six of fallow, then they could be considered to be a single sectoral fallowing system in which the plots in each sector were dispersed among sub-sectors rather than being placed contiguously. However, there are at least six different sequences (op. cit. 87-88). Some of these resemble other sectoral fallowing systems; in one, for instance, three years of cultivation, first of potatoes, then of quinoa *(Chenopodium quinoa)* and finally of barley, are followed by three fallow years. However, in other systems there are no fallow years at all. In one *aynuqa*, two years of potatoes are followed by four of barley, after which potatoes are planted once again. This zero-fallowing problem presents a dilemma: if the cases of zero-fallowing are excluded, then an artificial distinction is imposed between *aynuqa* which the local population all calls by a single term and manages by the same rules; their inclusion, though, seems to contradict the basic character of the vast majority of sectoral fallowing systems—the alternation of planting and fallowing.

Finally, the multi-community problem is presented by cases in which members of more than one community own plots within a single sectoral fallowing system. In Irpa Chico, each of the *aynuqa* are associated with a specific sub-community, which Carter and Mamani term *zona* or zones. Although Irpa Chico as a community shows a high degree of endogamy, there is also a fair degre of endogamy within the zones. Most households own the majority of the plots in the *aynuqa* associated with their zone, although many of them own plots in other *aynuqa* as well. If Irpa Chico did not possess other strong communal organizations, each specific zone might be considered to be a distinct community. There are several other cases, all within Bolivia, where there is some ambiguity over the question of whether the term "community" should be assigned to a larger, more inclusive social unit, which might manage several sectoral fallowing systems, or to a smaller, more exclusive one with a single system (Albó 1972, Buechler 1980, Campbell and Godoy in press). Their absence in Peru might be attributed to the policy of the Peruvian government of granting official recognition to communities; to receive such a title, a community must indicate precisely its boundaries and its component households. Their presence in Bolivia may also reflect a stronger continuity with the multi-level Andean *ayllu* form of organization (Platt 1982a). Because we both had field experience in the specific regions for which this multi-community problem appeared (Orlove in the Lake Titicaca area, Godoy in the northern portion of the department of Potosí), we believed that we could reasonably assign the limits to communities. It is quite possible that this multi-community problem appears in other areas, but has not been adequately documented.

The more troubling zero-fallowing problem appears to be less frequent than the multiple-system problem. After some reflection, we decided to exclude the zero-fallowing cases, in part because they proved to be very difficult to detect; Irpa Chico is the single instance in the literature in which we could be certain that plots in zero-fallowing systems were managed sectorally, rather than at the level of the individual household, although other sources suggest that it may occur elsewhere (Painter 1981). There appear to be many such non-sectoral zero-fallowing cases of potato cultivation on unirrigated land and of intensive maize cultivation on irrigated land.

The second justication for excluding zero-fallowing cases was the sense of Carter and Mamani's informants that such systems were recent and atypical, to be explained as the unfortunate consequence of land fragmentation. It thus seemed appropriate to consider such cases as former sectoral fallowing systems which would no longer be classified as such. Even this hedge did not completely eliminate the difficulty, because there were some cases in which fallowing was neither clearly present nor clearly absent. The island of Amantaní in the Peruvian portion of Lake Titicaca, with a four-sector system, is one such ambiguous case. When a particular sector is first cultivated, it is called *papasuyu* or 'potato-sector', since potatoes are the exclusive crop. The next three years, known as *oqasuyu* or 'oca sector', *siwarasuyu* or 'barley sector' and *uywasuyu* or 'livestock sector', reflect the dominant crops of the second and third years and the grazing on fallow in the fourth. Other crops, principally quinoa and broad beans *(Vicia faba)*, are also grown in the *oqasuyu*. In recent years, some households have grown broad beans in the *uywasuyu*; in the 1980-81 agricultural year, one of the authors [Orlove] observed such plots dispersed among the fallow fields. Since they covered much less than half of the area of the sector, and since local peasants still referred to the sector as *uywasuyu* rather than *awasuyu* ['broad bean sector'], it seemed appropriate to consider it as fallow.

The multiple-system problem was addressed by keeping distinct records for each of the systems, if a community controlled more than one. The analysis focusses on communities, for two reasons: the research upon which this study is based was conducted at the level of communities rather than of sectoral fallowing systems, and there are some communities in which sectoral fallowing systems have been identified but in which the precise number of such systems is unknown. Most communities had only one system, but some had several. Of the total of 51 communities for which some information was available, 13 lacked sufficient information to establish precisely the number of sectoral fallowing systems. For the 38 communities with sufficient data, there were 55 sectoral fallowing systems. If analysis were conducted on one system per community, the systems from multi-system communities might be underrepresented in the sample; however, if the analysis were based on the total sample of systems, then the systems from multi-system communities might be overrepresented. This problem was far less intractible, since the analysis could be conducted both ways, and in fact gave similar results. The difference between single-system and multiple-system communities are slight, and the systems in both types of communities are similar. These topics are discussed in greater detail in the next section.

RESULTS

Distribution.—As earlier reports have indicated, the sectoral fallowing systems are restricted to a band in the central Andes (Table 3). They are found in central and southern Peru and in western Bolivia, ranging from 10° 20'.S to 18° 50' S. Of the 51 cases, the elevations of the plots in the sectoral fallowing systems are available for 31; these range from 2400 to 4200 meters above sea level. The range of the average elevations of plots in the different sectoral fallowing systems is smaller, from 3000 to 4100 m. The rainfall, reported for 15 of the 51 cases, varies from 300 to 1270 mm/yr; excluding the highest and lowest figures, which may be suspect, reduces the range to 500 to 1100 mm/yr.

At higher elevations, crop production is limited to small plots of potatoes, predominantly the bitter varieties which are processed by freeze-drying into a product called *chuño*; the natural and cultivated grasslands in these areas support livestock. Fallowing is more extensive and is not managed communally. The fields at lower elevations are often irrigated. They are usually cropped yearly, in a more intensive agricultural regime. Other crops such as maize are more common, though some potato cultivation is also found. Fallowing in these zones is also not managed on a sectoral basis. Aridity seems to limit sectoral fallowing systems in the south, where fields are more often irrigated or fallowed on a non-communal basis. The factors which restrict sectoral fallowing systems to the north are less clear. Heavier precipitation and warmer temperatures affect soils and vegetation, favoring the formation of sod, quite different from the bunch grasses which characterize the main zone of sectoral fallowing systems. The management of this sod is relatively little known; shorter fallowing periods might be needed, for instance, or the greater labor requirements to prepare fallow fields might not be as well suited to sectoral fallowing systems. The apparent absence of sectoral fallowing systems north of 10° S. may also be the result of underreporting. Fewer anthropologists and geographers have worked there. Much of the published research, particularly for the northern Peruvian highlands, provides little detailed information on the spatial and temporal patterning of cropping, fallowing and grazing, although some sources clearly document the existence of non-sectoral fallowing systems (Brush 1977). The absence of these systems in Ecuador appears to be less in doubt.

This distribution places the sectoral fallowing systems well within the limits of cultivation of the potato, the most important crop in these systems. However, it is not quite appropriate to equate the sectoral fallowing system with potato cultivation, since Andean peasants at latitutdes outside the range of sectoral fallowing systems in northern Peru (Brush 1977), Ecuador (Knapp 1984) and southern Bolivia (Rasnake 1982) grow potatoes on plots that are fallowed. Other crops that are grown in sectoral fallowing systems, such as barley, quinoa, and broad beans, are also more widely distributed than

TABLE 3.—*Some Dimenstions of Sectoral Fallowing Systems.*

	S Latitude[1]	W Longitude[1]	Mean Annual Rainfall (mm)	ELVCOM (m)	ELVSFS (m)	CROPYR	FALLYR	NUMSECTS	FLRATIO	TUBERYR	NOTUBYR	NOTBRAT	TUBINDX	NUMSFS
Number of cases with data	48	49	15	43	31	44	43	42	42	41	39	39	41	38
Number of cases without data	3	2	36	8	20	7	8	9	9	10	12	12	10	13
Mean	14.34	71.70	728	3537	3725	2.602	5.24	7.91	0.640	1.463	6.70	0.8032	0.591	1.447
Median	14.25	71.50	725	3675	3800	3.000	5.00	7.00	0.631	1.500	6.00	0.8182	0.500	1.000
Trimmed mean[2]	14.33	71.72	719	3554	3753	2.612	5.11	7.85	0.643	1.459	6.62	0.8086	0.588	1.353
Standard Deviation	2.03	2.90	242	331	281	0.946	2.57	2.76	0.139	0.479	2.55	0.0837	0.246	0.724
Maximum Value	18.70	77.00	1270	3950	4098	4.000	13.00	15.00	0.867	2.000	13.00	0.9167	1.000	4.000
Minimum Value	10.40	66.10	300	2700	3000	1.000	1.00	2.00	0.333	1.000	2.50	0.6000	0.250	1.000
Third Quartile	15.63	73.35	850	3800	3910	3.000	7.00	10.00	0.766	2.000	9.00	0.8571	0.733	2.000
First Quartile	13.33	69.80	562	3200	3583	2.000	3.00	6.00	0.571	1.000	5.00	0.7500	0.333	1.000

[1]Latitudes and longitudes are stated in degrees and hundredths of degrees.
[2]The trimmed consists of the mean of the population from which the 5% ot cases with the highest values and the 5% with the lowest values have been eliminated.

these systems. We wish to stress that fallowing is found in many parts of the Andes where sectoral fallowing systems are absent.

Other Features.—A number of specialists on the Andes have emphasized the importance of the potato in agriculture in that region (Brush *et al.* 1981). In particular, potatoes are associated with agriculture at high elevations; in lower areas, maize is a major crop. Special frost-tolerant bitter varieties of potatoes are adapted to elevations too high for other crops. We were therefore surprised to find a slight negative relation[3] between the tuber index and the elevation of the community; we had expected a strong positive relation. In other words, potatoes account for a slightly higher proportion of the crops in communities at lower elevations.

TUBINDX = 2.04 — 0.000413 ELVCOM ($n = 37$, $t^{35} = -3.81$, corrected $R^2 = 27.3\%$). No significant correlation was found between the tuber index and the elevation of the sectoral fallowing system. An examination of the cropping sequences in Appendix 1 suggests that the importance of grains, particularly barley and quinoa, at high elevations may account for this unexpected result; it should be remembered that communities manage sectoral fallowing systems jointly with other crop lands at higher and lower elevations, so that cropping patterns within sectoral fallowing systems may be influenced by the availability of lands outside them. We also note that tuber indices decrease with distance from the equator:

TUBINDX = 1.24 - 0.0461 LATD ($n = 40$, $t_{38} = -2.68$, corrected $R^2 = 13.7\%$). The Mann-Whitney U Test finds the difference between the median tuber indices for Peru and Bolivia, 0.6 and 0.417, respectively, to be significantly different from Zero at the 0.05 level.

Another aspect of the sectoral fallowing systems remains to be discussed: the case of multiple systems. Of the 51 cases, sufficient data were available for 38 of them to determine the number of sectoral fallowing systems. There was one system in 25 cases, two systems in 10 cases, three systems in 2 cases, and there was also one case of a four-system community. In most communities with multiple systems, each system is located at a specific elevation. Camino *et al.* offer one of the best descriptions of such a community, Cuyo-cuyo in the province of Sandia in the Peruvian department of Puno (1981). In the highest system, the *luki manda* from 3800 to 4100 meters above sea level, a sector is first planted with special frost-resistant varieties of potatoes, called *luki* in Quechua and *papa amarga* ('bitter potato') in Spanish, which are used for the preparation of freeze-dried potatoes or *chuño*; the sector then remains in fallow for five years. In the *uray manda* from 3200 to 3800 meters, in the first year potatoes are planted, in the second oca, olluco and mashua, in the third oca, ulluco and mashua, and in some cases a few rows of broad beans, and in the fourth broad beans and some barley; the four crop years are followed by two years of fallow. The *manda del anexo* from 3200 to 32400 meters is located at some distance from the other two systems; it also follows a sequence of one year of potatoes, one of oca and four of fallow, although a number of other crops, including olluco, mashua and broad beans, may be included in both years. There is an association between the elevation of the community and the number of sectoral fallowing systems. The equation is:

NUMSFS = 4.36 - 0.000815 ELVCOM ($n = 35$, $t_{33} = -2.30$, corrected $R^2 = 11.2\%$). A Mann-Whitney U Test does not find significant at an 0.05 level the difference of the median elevations for single-system and multiple-system communities, which are 3720 meters and 3500 meters, respectively. This relation reflects the fact, discussed later in more detail, that the sectoral fallowing systems tend to be located higher than the community of peasants who cultivate plots in them. Since most multiple systems consist of systems more or less stacked vertically, the lower communities have more room in which to place these systems. The principal exceptions to these vertical arrangements are several multiple-system communities in the Lake Titicaca basin which, like Irpa Chico, utilize distinct systems in locations whose differences, such as soil fertility, do not depend on large variations in elevation, in addition, the relative flatness of the Lake Titicaca basin impedes the downward drainage of cold air and create significant differences in the risk of frost between flat areas and adjacent slopes which are less than 100 meters higher in elevation.

We examined the different systems within multiple-system communities, and did not find significant correlations between elevation and the other features of such systems. In addition, Wilcoxon Signed-ranks Tests showed no significant differences between dimensions (number of sectors, number of crop years, tuber index, etc.), systems in single-system communities and multiple-system communities. On the basis of these results, we conducted our statistical analysis by taking the mean values of the systems in the multiple-system communities. Since 65.8% of the communities for which data were available had only one system, we did not believe that we were reducing variability by using means.

Adaptationist Hypotheses: Claims.—The adaptationist claims for the presence and distribution of sectoral fallowing systems have been stated on several occasions. Such claims tend to rest on rather loose notions of adaptation rather than on more rigorous extensions of biological concepts. Adaptations are seen as means by which populations draw resources from their environments while maintaining long-term productivity and by which they avoid the hazards present in their environments. One adaptationist discussion of sectoral fallowing systems states that fallowing, in combination with deposition of dung by animals grazed on fallow sectors, "is essential to the regeneration of the land" (Guillet 1981:144). Another article claims that these systems permit the "maintenance of soil fertility and removal of crop pathogens" (Brush and Guillet 1985:26). It is argued that Andean soils tend to be low in nutrients, that cultivation removes nutrients from the soils, and that fallowing must be maintained to prevent degradation of the soils.

Fallowing and Soil Management.—These adaptationist claims address issues that are more complicated than they might appear to be. Agriculture can lead to decreasing nutrient levels in the soil, because crop plants directly consume nutrients and because tillage can increase microbial activity which can lower nutrient levels and impair the physical structure of soils. However, fallowing does not necessarily restore nutrients to the soil, although it may do so, if nitrogen-fixing plants are cultivated or occur naturally. Fallowing may also increase the organic content of the soil, if atmospheric carbon fixed in photosynthesis during fallow returns to the soil; however, crop plants derive the bulk of their carbon from carbon dioxide in the atmosphere rather than from the soil. Fallowing nonetheless appears to present several advantages in the case of Andean agriculture. First, by reducing the proportion of the time when the soil is stripped of its plant cover, fallowing protects soil against some of the dangers of nutrient leaching and erosion that accompany agriculture. Second, fallowing may allow some soil nutrients to be redistributed in a fashion that makes them more avilable to crop plants. The deep-rooted perennial grasses which grow during fallow years reach to lower levels of the soil than annual crop plants do; they may draw nutrients from these lower levels and, when reincorporated into the soil during the preparation of fallow fields for planting, increase the concentration of these nutrients in the upper layers of the soil. Third, there may be agronomic benefits from the increase in organic matter which occurs as plants grow during fallow and then are partially or fully reincorporated into the soil; in particular, the physical structure of the soil may improve, enhancing its water-holding potential and favoring root growth. Fourth, the use of fallow land for grazing may also improve the soil. There may be a net transfer of nutrients to the fallow fields as animals grazed on both fallow fields and on permanent pasture (often located adjacent to and above the sectoral fallowing systems) deposit dung on the fields; it should be noted, however, that the dung is often not deposited evenly throughout the fields, so that grazing in some areas might still lead to a loss of nutrients. (It is also possible, though unlikely, that the presence of grazing animals damages soils because of compaction.) Finally, fallowing may enhance the moisture content of the soil; this is its principal advantage in other regions of the world. It is noteworthy that a textbook, *Soils and Soil Fertility*, places its discussion of fallowing in the chapter on water management, rather than in any of the chapters on nutrients (Thompson and Troeh 1978). It is quite possible, though, that the addition of fertilizer to soils may enhance soil fertility more than fallowing does.

The relation between elevation and soil fertility is complex and mediated by several variables. Temperature is the most important of these, since it affects the rate of plant growth, the rate at which microorganisms convert nutrients such as nitrogen, phosphorus and sulfur found in organic matter in the soil into forms available for plants, and the rate of oxidation, which breaks down organic matter, and may therefore reduce the quality of the physical structure. At low temperatures, below about 5°C, biological activity in the soil is reduced to very low levels or stops entirely, so that the organic content of the soil does not increase and its physical structure does not improve (Price 1981:235). Higher temperatures cause organic compounds to oxidize and break down; at temperatures above about 25°C, this loss overtakes the formation of organic matter, and soil fertility declines. The meximum rate of accumulation of organic matter occurs between these extremes.

These rates, however, are influenced by soil moisture. Biological activity proceeds more slowly in very dry soils, reducing the decompositon of organic matter and the conversion of nutrients into forms available to plants. However, excessive moisture also reduces the oxidative decompositon of organic matter and the release of nutrients into the soil; it may also lead to the leaching of nutrients which are already present. As with temperature, there is an ideal range of moisture, somewhere on the wet rather than dry extreme.

There is thus no universal direct relation between elevation and soil fertility. Price (1983:248) states "soils in the humid tropics . . . generally improve with elevation (up to a certain point)," and offers as an example the contrast between the heavily leached soils commonly found in tropical lowlands and the more fertile soils in adjacent highland zones at intermediate altitudes. This difference is due primarily to the lower temperatures at higher elevations. In the case of the relatively high altitude regions where sectoral fallowing systems are found, however, it seems that soil fertility is lower at higher elevations because of low temperatures which slow the growth of bunch grasses and which impede decomposition of organic matter. It thus seems that sectoral fallowing systems are generally beneficial to Andean soils, because they assure a certain length of fallow period; it might also be important for fallow periods to be longer at higher elevations.

Fallowing and Pest Management.—The relation between fallowing and the reduction of losses due to nematode attacks is also somewhat unclear. The round cyst nematodes (*Globodera rostochiensis* and *Globodera pallida*) attack potato roots, reducing the ability of the plant to absorb water and nutrients (Evans *et al.* 1975). Losses increase with greater nematode density; in some cases, virtually no potatoes can be harvested. At one stage in the nematode's life cycle, the female nematode produces eggs which she retains within her body. When the female dies, her cuticle becomes a dark hard layer, forming a cyst inside which the eggs can survive for as long as 20 years (Hooker 1981:96). Nonetheless, nematode populations increase most rapidly when their populations are large and when food supplies are abundant; limitation of their food supply may lead their populations to decline *(op cit.*:95). They are favored by moist cool soil conditions. Hooker states that "(w)hen nematode densities are high, rotation with potatoes grown once in five years is necessary to assure profitable potato yields. Resistant potato cultivars in rotation with susceptible cultivars and nonhosts considerably reduce the required length of rotation." *(op cit.*:96). This source does not provide a definitive fallow period necessary to prevent damage, since Andean peasants might well be able to subsist on potato yields which Western experts would not consider "profitable," and because many native cultivars may be resistant.

The number of non-tuber years is a better measure of the effect of particular sectoral fallowing system on the nematodes than the number of fallow years, since the effect on nematodes of a year in which grain and legume crops are grown is more likely to resemble that of a fallow year than that of a tuber year. It seems likely that a non-sectoral form of fallowing, in which the fallowing cycles of individual plots are not coordinated, would be less effective than sectoral forms, since plots adjacent to an area where nematode-infested potatoes remain at risk for several years. It would be more common in non-sectoral systems to find the planting of potatoes in plots adjacent to areas where potatoes had been planted in the previous year; in such plot, there is a risk that nematodes remaining from the previous year would disperse from the adjacent area to attack the new potato crop.

Other Claims.—In addition, sectoral fallowing systems have been considered to be adaptations in other ways. By grouping together a large number of plots that will be cultivated in a given year, they reduce the total perimeter of these plots which border on fallow land, thus reducing the frequency with which domesticated animals enter the plots and damage crops. This feature reduces the amount of labor which a household must allocate to the supervision of its animals (Mayer 1979:71). Skar's study (1982) of the Peruvian community of Matapuquio, in the province of Andahuaylas, department of Apurimac, shows the importance of limiting livestock damage. When an animal breaks into a plot in a sector currently under cultivation, the owner of the animal pays compensation to the owner of the plot; if the same animal were to damage crops in a plot that had been planted in a sector which was currently in the fallow portion of the cycle, no such payment is required. As a member of the community stated, "If you sow the other fields (in fallow sectors) then the animals will just come and eat it and no one is responsible for it." (1982:82) In addition, herders take particular care to keep animals away from cultivated sectors.

This juxtaposition of plots also permits the more experienced and knowledgeable members of the community to have a large role in making decisions about the timing of agricultural activities (Custred and Orlove 1974). If the plots were scattered, it would be more difficult for all members of community to obtain their advice.

Adaptationist Hypotheses: Results.—These adaptationist claims are generally supported by the fact that sectoral fallowing systems are located at higher elevations than areas of continuous cropping, where the maintenance of soil fertility is more problematic, and that they are associated with the cultivation of tubers, the crops most sensitive to round cyst nematodes. A more detailed examination of these systems does not support these claims unequivocally, however. The adaptationist claims refer to related but distinct aspects of the system. The fertility argument generally supposted that a significant proportion of the land will lie fallow at any moment, and usually does not address the question of how many years any one sector must remain without being cultivated. The pathogen argument, by contrast, states that each sector must remain out of tuber cultivation for a certain number of years, and usually does not address the question of what proportion of the time the sectors will remain without tuber cultivation.

The typical features of sectoral fallowing systems offer some support of the general claims. The mean fallow ratio in the 42 cases for which information is available is 0.640, a figure which seems high enough to permit the maintenance of the nutrient levels and the physical structure of the soil. One recent source makes the adaptationist claim that in sectoral fallowing systems "more land is left fallow than is being cultivated at any one time." (Guillet 1981:143-144). A use of the Wilcoxon Signed-ranks Test permits a non-parametric test of the hypothesis that mean fallow ratios are greater than or equal to 0.5; parametric tests, which require fallow ratios to be distributed normally, are less appropriate. This hypothesis is supported at the $p<.005$ level. However, 9 out of 42 cases have fallow ratios of 0.5 or less. Although these cases are part of a population whose mean is significantly greater than 0.5, they do not conform to Guillet's claim. In the 39 cases for which information is available, the average number of non-tuber years is 6.70 and 35 or 89.7% have at least 4 non-tuber years, probably enough to reduce pathogen populations (Hooker 1981:96). The hypothesis that the mean number of non-tuber years is greater than 4 is supported by the Wilcoxon Signed-ranks Test at the $p < .001$ level; nonetheless, 4 out of 39 cases or 10.3% had fewer than 4 non-tuber years.

These claims would be difficult to test definitively, since levels of soil nutrients and pathogen populations vary continuously, without sharp breaks at particular fallow or number of non-tuber years. The data do seem, though, both to support the claims and to indicate the existence of cases which challenge them. A second difficulty in definitively testing these claims lies in the fact that the same level of nutrient increase might be reached by different fallow ratios in different communities; a similar problem exists for pathogen protection. This issue could be addressed by examining variation by elevation. Since the benefits of fallowing accrue more slowly with an increase of elevation, because the colder temperatures at higher elevations reduce plant growth and microorganism activity, the fertility claim would suggest that the fallow ratio would increase the elevation. These relations do not hold; there is no significant relation between this feature of sectoral fallowing systems and elevation, whether measured by elevation of community ($n = 37$) or, more accurately but with a smaller sample, by average elevation of plots in the sectoral fallowing systems ($n = 26$). One might expect that more southerly communities, where average temperatures are lower and frost are more common, to require higher fallow ratios in order to achieve levels of soil fertility similar to those at equivalent elevations further north. In fact, the fallow ratio decreases with distance from the equator:

FLRATIO = 0.979 - 0.0236 LATD ($n=40$, $t_{38}=-2.12$, corrected $R_2=8.2\%$). Since Bolivia lies generally further south than Peru, this difference could also be associated with the nation in which communities are located. The Mann-Whitney U Test comes close to finding a significant difference between the median fallow ratios, 0.571 in Bolivia and 0.652 in Peru; it assigns a p-value of 0.052. The lower fallow ratios in Bolivia might in part reflect the dominance of the Lake Titicaca region, where some fallow ratios are low, in the sample of communities from that country; the overall relation of fallow ratio with latitude is more puzzling.

Similarly, it should be noted that the number of crop years is positively associated with latitude:

CROPYR = 0.006 + 0.0186 LATD ($n=42$, $t_{40}=2.80$, corrected $R^2=14.3\%$), and that the differences for the median values for Bolivia and Peru, 3.5 and 2.5 respectively, is significant at the level of $p < 0.005$. There is no significant relation between number of sectors and latitude or nation. Noting the following relations:

$$\text{FLRATIO} = (\text{NUMSECTS} - \text{CROPYR})/\text{NUMSECTS}$$

$$\text{CROPYR} = \text{NUMSECTS} - (\text{NUMSECTS}*\text{FLRATIO}),$$

it is reasonable that one has a negative and the other a positive relation with latitude.

It seems even more difficult to construct reasonable hypotheses for the influence of elevation or latitude on the nematode-reducing effects of fallowing. We did note an association between the number of non-tuber years and the elevation of the sectoral fallowing systems:

NOTUBYR = -8.09 + 0.00394 ELVSFS ($n = 25$, $t_{23} = 2.05$, corrected $R_2 = 11.7\%$).

The relationof the number of non-tuber years and the elevation of the community was weaker. Contrarily, we found a strong relation between non-tuber ratio and community elevation, though not with system elevation:

NOTBRAT = 0.422 + 0.000109 ELVCOM ($n = 35$, $t_{33} = 2.63$, corrected $R_2 = 14.8\%$).

These relations generally indicate an increase in non-tuber years and ratios with elevation.

Agricultural Intensification and Sectoral Fallowing Systems.—This examination of the adaptationist hypotheses led to another set of considerations. The adaptationist position might have been more strongly supported in the past than it is at present. Because of the extensive changes in highland Andean agriculture, it seems possible that some sectoral fallowing systems have been altered in certain ways. In this view, these weaknesses in the adaptationist position could be explained by the presence of forces which have shifted sectoral fallowing systems from a greater to a lesser degree of adaptation. In other words, it might be possible to accept the adaptationist position even though there are some cases which do not support it; to do so, one would need to find some means to distinguish between the systems for which it would hold and those for which it would not. One promising argument could be called the intensificationist position, since the reduction of fallow ratios resembles what Boserup (1965) calls agricultural intensification, and parallels her classification of agricultural systems. Population pressure and commercialization of agriculture have been identified as causes which might lead to more intensive land use within agricultural systems in general and sectoral fallowing systems in particular, reducing fallow ratios and the number of fallow years. Three sources which diachronically examine sectoral fallowing systems support these arguments. Godoy (1984) describes sectoral fallowing systems in the northern portion of the department of Potosí, Bolivia, in which the total number of sectors has been maintained, but each sector is cultivated for an increasing number of years and left in fallow for a correspondingly shorter period. He attributes this decline in fallow ratios, as well as the intensification in lands not cultivated by sectoral fallowing systems, to population increase; he also suggests that taxation placed additional demands on the yields of a finite land base. Mayer's (1979) studies of the Mantaro Valley in the department of Junín show not only that fallow ratios declined, but also that strong pressures for commercialization led to a breakdown of the coordination of fallowing and planting by different households, so that sectoral fallowing systems no longer exist. The previously-mentioned study by Carter and Mamani offers a detailed description of changes in the sectoral fallowing systems or *aynuqa* in one Bolivian community. In some cases, the number of years in the cycle is retained, but households cultivate crops in years that were formerly allocated to fallowing, much as some residents of Amantaní do. To follow the earlier terminology, the number of sectors in such cases remains unchanged, but a fallow year is replaced by a crop year. In other instances, an entire sector is taken out of the cycle and converted into private household plots, known locally as *sayaña*, so that the number of crop years remains the same but the number of fallow years is reduced by one. In either case, the fallow ratio declines; in some instances, when the number of fallow years falls to zero, the lands are no longer considered to be sectoral fallowing systems. Anecdotal information also provides evidence for this decrease in fallow ratios: an entire sector may be removed from the system by appropriation by a landlord (Orlove 1976) or by other communities (Godoy 1984). Since the number of sectors is reduced, the number of years in the cycle must decline as well. It seems that the number of crop years remains the same and the number of fallow years is reduced, lowering the fallow ratio.

These pressures are documented by the sources already mentioned but not by the set of 51 cases. Information is scarce on the population variables; for example, none of the 51 cases have information on population density at the community level, and population densities at the next higher administrative level, of the district in Peru and canton in Bolivia, would be a poor substitute. Few cases had information on such possible measures of commercialization as distance to markets or presence of metal roofs. Fallow ratios and the number of fallow years also are not significantly related to other, less reliable measures of commercialization, such as the distance to the nearest town or official recognition of community. The 51 cases do offer some indirect support. There is a significant positive relation between the number of sectors and fallow ratio in sectoral fallowing systems.

FLRATIO = 0.426 + 0.0271 NUMSECTS ($n = 42$, $t_{40} = 4.04$, corrected $R^2 = 27.2\%$). The fact that there are few systems with a high number of sectors and a low fallow ratio suggest the generality of the following sequence: a system might start with a large number of sectors and a high fallow ratio. Demographic and commercial pressure might lead to a decrease in the number of fallow years and a corresponding increase in the number of crop years, leading to a decline in fallow ratio. After a certain point, the entire number of sectors might be halved and the area of each sector doubled (Mayer 1979:67-70). This possibility, though, is quite speculative. It should be stressed that the previously-mentioned areas where fallowing has declined are subject to high rates of population increase, increased sale of crops, or both of these influences. Fallowing may well be maintained in communities where populations have remained relatively steady, due to lower fertility, to higher mortality, or to higher out-migration, and where commercialization of agriculture has been less, due to acceptance by peasants of low cash incomes or to the earning of income through migratory wage labor.

This uneven support of the adaptationist position and the difficulty of directly testing the intensificationist position still leaves open the possibility that demographic or economic pressures have altered some features of the sectoral fallowing systems. It would therefore be useful to examine features of these systems which are less prone to these pressures, to search for regularities in them, and then to try to explain them. There are two such features: the relative elevations of the communities and the systems, and the sequencing of crops.

It would seem fairly likely that the former would change less than other features such as fallow ratios. A community might expand the sectors somewhat, add crop years and delete fallow years, or might lose sectors to haciendas, but it is less likely that the community or the sectoral fallowing system would be relocated entirely. The latter feature also displays certain regularities, for reasons that are less immediately evident.

In the case of the former, two variables, system elevation and community elevation, were compared. These variables are closely related:

ELVSFS = 2117 + 0.464 ELVCOM ($n = 27$, $t_{25} = 3.27$, corrected $R^2 = 27.2\%$). The system elevation is generally greater than community elevation. The mean difference between the system elevation and the community elevation is 229 meters; the Mann-Whitney U Test supports the hypothesis that this mean is greater than zero at the $p < .01$ level. The mean difference between system elevation and community elevation is unequal to the difference between the mean system elevation and the mean community elevation because of the different sample sizes for the two variables. There are several reasons for locations of communities at lower elevations: the importance of proximity to irrigated lands lying below the sectoral fallowing systems, the importance of deep river valleys in shaping transportation networks, the need for access to water. In some cases, this location also reflects the sixteenth-century Spanish policy of forcibly resettling Andean populations in nucleated settlements called *reducciones*, which were often at lower elevations than the fields.

The crop sequences also show strong regularities. Commercial crops such as onions, cabbage and carrots are absent; such crops tend to be grown in lower zones, where warmer temperatures and more abundant irrigation water encourage investment in such crops. Conversely, subsistence crops dominate. More specifically, root crops have a position of unique importance. In 7 of 41 cases, only tubers are cultivated. In the remaining 34 cases, potatoes are always the first crop grown. In 11 cases, information is insufficient to determine precise crop sequenes. In the cases where there are several years of exclusive or mixed tuber cultivation, these years occur before the others in the cycle. To test the hypothesis that this pattern did not occur by chance, one could take the number of tuber years and the number of non-tuber crop years for each community and assume that the communities selected the order of tuber and non-tuber years at random. There is a probability of less than .001 that all 34 communities would place all tuber years before all non-tuber crop years.

This sequence of crops reflects the great importance of potatoes in Andean diets. They grow well over a wide range of environmental conditions (Gade 1975). Potatoes offer high yields, whether measured by unit area or by labor (Painter 1981; Brush *et al.* 1981). they account for a large proportion of the calories and protein which local peasants consume (Orlove 1986). In addition, they store well. It could be argued along adaptationist lines that Andean cultivators plant potatoes in the beginning of the cycle, because the levels of nutrients in the soil are highest at that time. If the concern was solely to provide potato crops with high levels of nutrients, though, they might be planted after, rather than before, nitrogen-fixing crops, such as the native tarwi *(Lupinus mutabilis)* and the introduced broad bean.

A second adaptationist perspective suggests that tubers are planted before grains and legumes because the harvesting of tubers destroys the pattern of furrows in the field, while the harvest of the other crops does not (Orlove 1977a). The purported advantage of this arrangement is that the furrows facilitate drainage of water in the rainy season, thus reducing erosion and permitting the earlier return of wild grasses. The evidence for this argument is anecdotal, and in any case this effect would be unlikely to hold with equal significance in the wide variety of degrees of slope and of soil structure in the regions where sectoral fallowing systems are found.

Culturalist Hypotheses.—Where adaptationists would view the needs and preferences of peasants as unproblematic consequences of environmental, technological and demographic causes, culturalists would seek to explore the origins and ramifications of these needs and preferences. In the instance of the priority given to the potato, a culturalist argument holds some plausibility. Andean peasants, it could be said, plant potatoes first because it seems right to them to do so. In this view, potatoes have a value which transcends their agronomic or nutritional significance. This culturalist argument is supported by the importance of potato-planting ceremonies in some regions with sectoral fallowing systems (Barstow 1979). Although the ritual emphasis on maize in the Andes is widely acknowledged to be greater than on potatoes (Murra 1960), potatoes hold a greater importance than the other crops with which they alternate in the sectoral fallowing system. No other crop would be as appropriate for the rituals that in many cases form an integral part of the preparation of a sector after it has completed its fallow years.

There are other cases where Andean cultural patterns structure fallowing cycles. As previously mentioned, in Paracaos, potatoes are planted in the first crop year, known as *turno* (Degregori and Golte 1973); the second year, known as *lana* or *yana*, the minor tubers are grown, and a smaller proportion of the plots are planted. The term *yana* has great significance in the Andes; it refers to the second, and lesser, or two elements which form a complementary duality (Platt 1978).

This correspondence might suggest that a certain number of sectors represents the cultural ideal; one might expect an even number of sectors, granted the importance of dualism in Andean culture. Although the link between cultural pattern and observable behavior need not be direct, this view nonetheless is not supported by the empirical evidence. The proportion of even values of the number of sectors, the number of crop years and the number of fallow years is not significantly different from the proportion of odd values, and in some areas where Andean traditions are held to be particularly strong, there are odd numbers of sectors; the Jukumani in northern Potosí, with a seven-sector system, are a case in point.

The culturalist perspective may account for particular details, but its greatest significance is its accounting for relative smoothness with which sectoral fallowing systems operate. This view resembles Bourdieu's discussion of culture as habitus, which he defines as "systems of durable, transposable dispositions" (1977:72; Ortner 1984). Three features of sectoral fallowing system which are common in the Andes are boundedness, universal participation and rotational turns. The existence of well-bounded communities, all of whose members participate in many activities, is reflected in a number of spheres: other communal patterns of resource management, such as pasture and irrigation water (Brush and Guillet 1985); the importance of assemblies in which all resident households and no outsiders have a vote (Alberti and Mayer 1974); collective work projects such as road and school construction, in which all resident households must contribute equally in labor and in materials (Brush and Guillet 1985); and the well-known ritual complex of the annual cycle of fiestas (Isbell 1978; Rasnake 1982). Many aspects of Andean organization show similar patterns of the division of a whole into equal parts, and the assignment of these parts on a rotational basis (Albó 1974). Common examples include the rotation of political and ritual offices on a yearly basis among the sections of a community (Rasnake 1982) and the rotation of political offices among villages in multi-community systems (Albó 1972). The management of irrigation water, in which water rights are assigned sequentially to a number of component households, is another example of this pattern of rotational turns (Mitchell 1976). This instance also reflects the boundedness and universal participation in the limitations on use of water by outsiders and in the ritualized annual cleaning of irrigation canals, in which all households participate. An unusual example of rotational turns may be found in bands of musicians who play panpipes at fiestas around Lake Titicaca; Buechler (1980:55) reports that these instruments "are always played in pairs with successive notes alternating between them." Two recent studies examine the division of space into a set of equal parts from this culturalist perspective (Wachtel 1982; Urton 1984). these instances render plausible the potential culturalist argument, that Andean peasants manage sectoral fallowing systems well because they have had experience with organizing themselves on such a basis in other areas of activity, and find this basis fair and reasonable.[4]

Political Economic Hypotheses.—Writers who emphasize political economy view these forms of organization somewhat differently. They argue that the tight internal governance and great emphasis on ritual in Andean communities are to be understood primarily as responses to pressures from external elites which seek to control peasant land and labor (Wolf 1982:145-149). In this sense, the sectoral fallowing system serves to mark large extensions of land as being equally under the protection of a set of households. In plots managed by households, it would be more difficult to protect them against encroachment from others. Although only 7 sources report the extent of sectoral fallowing systems, the average number of households, about 350, may well represent a balance between the advantages of small size (easy management) and large size (protection against outsiders). Similarly, it could be argued that sectoral fallowing systems are well-suited to regions like the Andes, where seasonal migration encourages peasants to manage their plots in a highly predictable manner. In fact, the areas where sectoral fallowing systems are now found correspond loosely to the provinces from which in the colonial period *mita* workers were sent to Huancavelica and Potosí, though this spatial overlap is far from precise. Nonetheless, this emphasis on political economy is not directly supported by the case material. Many such systems are found in areas where there is relatively little pressure from outsiders on peasant lands and where there is relatively little outmigration. Though political economy in general has influenced Andean agriculture strongly (Orlove 1977b), sectoral fallowing systems do not seem to provide evidence for this view.

SUMMARY

There are certain regularities among sectoral fallowing systems. They are found within specific altitudinal and latitudinal limits. They may serve to maintain soil fertility, to reduce nematode damage to potato crops, and to facilitate a mixed agropastoral economy. Specific diachronic information from selected localities indicates that fallowing decreases with population increase and with commercialization; since such demographic and economic data are available for only a few communities, it was not possible to examine these relations by a statistical analysis of a large number of sectoral fallowing systems. The sectoral fallowing systems also correspond to other social and cultural patterns in the Andes; this link may help explain their relatively smooth functioning.

ACKNOWLEDGMENTS

The authors would like to thank the many colleagues who gave generously of their time in filling out questionnaires. We also wish to acknowledge the useful comments which we received from several colleagues, particularly Stephen Brush, Michael Singer and Karl Zimmerer. We greatly appreciate Neil Willits' valuable advice on the use of several statistical tests, Thomas Turrentine's diligent efforts in tracking down a number of sources which were difficult to obtain and in coding these sources and the questionnaires, Aileen Tsai's prompt entry of the data, Rod Thompson's helpful assistance in guiding a notive through the complexities of packaged statistical programs, and Sharon Lynch's patient and careful transformation of numerous drafts into a final manuscript. Maria Dudzak prepared the map. The authors are responsible for any errors of fact or interpretation which may remain in the article.

NOTES

[1]In many parts of the Andes households can be unambiguously associated with a local set of households whose lands are continguous and whose members participate in institutionalized economic, political and religious activities. The term "community" is a common and convenient label for such groups. It is important to mention, though not to dwell upon, the major debates among Andean specialists over the meaning and appropriate use of this term: to what extent do communities reflect Andean cultural principles and patterns of social organization; to what extent are current community structures the product of interaction with imperial and national states; to what extent are patterns of community organization a spontaneous outgrowth of adaptation to environments; in what ways do communities interrelate with other patterns of local-level social organization (Guillet 1978; Guillet and Brush 1985; Murra 1984; Salomon 1982; Yambert 1980).

[2]The transcription of Quechua and Aymara terms is not fully standardized. We have adopted the spelling of the source which we cite most frequently. The same term also appears in published sources as *aynoca* and, less frequently, *aynoqa*.

[3]We do not offer exact p values for the acceptance or rejection of the relations, since a precise t-test is inappropriate. The variations are not normally distributed, and the necessary condition for equality of variance is not met. Nonetheless, we have included regressions for which t-ratios are greater than 2.0, since such levels seem to indicate some importance.

[4]We have deliberately avoided a discussion of the origins of sectoral fallowing systems, in part because they are so difficult to detect in both the archaeological record and historical sources. Their conformity with Andean patterns of organization suggests an Andean origin, although there are similar patterns of organization in Spain (Fernandez 1981, Espinoza 1981).

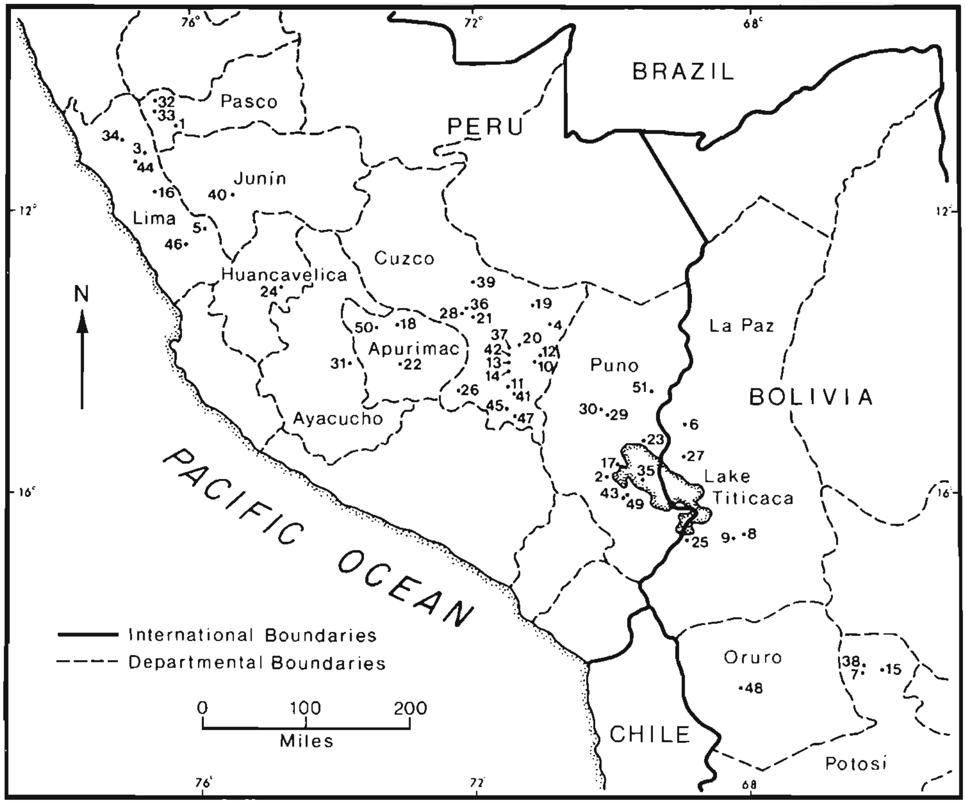

FIG. 1. Locations of communities studied. See text and appendix 1.

APPENDIX 1.—Communities with sectoral fallowing systems.

Name of Community	Depart- ment	Country	°S Lati- tude	°W Longi- tude	Elevation of Com- munity (meters	Total No. of SFS per Com- munity	Average Elevation of SFS (meters)
Paucartambo (Andrews 1963)	Pasco	Peru	10° 40′	76° 20′	3044	1	N/A
Paucarcolla (Bourricaud 1967)	Puno	Peru	15° 40′	70° 10′	3830	1	N/A
Santa Lucía de Pacaraos (Degregori & Golte 1973)	Lima	Peru	11° 15′	76° 40′	3200	1	3425
Marcapata (Yamamoto 1982)	Cuzco	Peru	13° 30′	70° 55′	3100	3	3300
Same							3850
Same							4100
Miraflores/ Laraos (Mayer and Fonseca 1979)	Lima	Peru	12° 20′	75° 50′	3000	1	3500
Kaata (Bastian 1978)	La Paz	Bolivia	15° 0′	69° 0′	3500	1	4100
Jukumani (Godoy 1982)	Potosí	Bolivia	18° 35′	66° 25′	N/A	1	3750
Jesús de Machaca (Vellard 1963)	La Paz	Bolivia	16° 35′	68° 5′	3800	1	3800
Irpa Chico (Carter & Mamani 1982)	La Paz	Bolivia	16° 40′	68° 20′	3800	2	N/A

No. of Years Fallow[1]	No. of Years Culti-vated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
4	1	5	80%	Potatoes	Fallow	Fallow	Fallow	Fallow
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	2	10	80%	Potatoes	Oca Mashua Olluco	Fallow	Fallow	Fallow
3	2	5	60%	Potatoes	Oca Olluco Mashua	Fallow	Fallow	Fallow
3	2	5	60%	Potatoes	Oca Olluco Mashua	Fallow	Fallow	Fallow
1	1	2	50%	Bitter Potatoes	Fallow	Bitter Potatoes	Fallow	Bitter Potatoes
7	3	10	70%	Potatoes	Oca Mashua Olluco	Barley	Fallow	Fallow
5	3	8	63%	Potatoes	Oca	Barley	Fallow	Fallow
3	4	7	43%	Potatoes	Oca	Wheat	Barley	Fallow
3	4	7	43%	Potatoes	Quinoa Cañihua	Cañihua	Barley	Fallow
3	3	6	50%	Potatoes	Quinoa	Barley	Fallow	Fallow

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

APPENDIX 1. Communities with sectoral fallowing systems. (continued)

Name of Community	Depart- ment	Country	°S Lati- tude	°W Longi- tude	Elevation of Com- munity (meters)	Total No. of SFS per Com- munity	Average Elevation of SFS (meters)
							N/A
Santa Bárbara (Orlove & Custred 1974)	Cuzco	Peru	14° 10′	71° 10′	N/A	1	N/A
Quehue (Orlove & Custred 1974)	Cuzco	Peru	14°	71°	3675	2	N/A
							N/A
Pata Anza (Orlove & Custred)	Cuzco	Peru	14°	71°	N/A	1	N/A
Pampa Marca (Orlove & Custred)	Cuzco	Peru	14° 5′	71° 30′	3829	1	N/A
Mosocllacta (Orlove & Custred)	Cuzco	Peru	14° 10′	71° 30′	3815	1	N/A
Laymis (Harris 1982)	Potosí	Bolivia	18° 30′	66° 15′	N/A	1	3900
San Pedro de Casta (Gelles 85 Question.)	Lima	Peru	11° 45′	76° 35′	3168	1	3000
Rinconada (Chaquilla 85 Question.)	Puno	Peru	15° 45′	69° 55′	3820	2	4050
Same							3820

No. of Years Fallow[1]	No. of Years Culti-vated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
3	3	6	50%	Potatoes Ocas Mashua	Habas Arvejas Quinoa	Barley	Fallow	fallow
10	3	13	76%	Potatoes	Olluco Oca Habas	Barley Habas Quinoa Cañihua	Fallow	Fallow
8	1	9	88%	Potatoes	Fallow	Fallow	Fallow	Fallow
7	2	9	77%	Potatoes	Barley	Fallow	Fallow	Fallow
6	3	9	67%	Potatoes	Oca Olluco Habas	Barley Habas Quinoa Cañihua	Fallow	Fallow
3	3	6	50%	Potatoes	Barley Olluco Quinoa	Barley Olluco Quinoa	Fallow	Fallow
4	3	7	57%	Potatoes	Barley	Habas	Fallow	Fallow
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	2	4	50%	Potatoes	Arvejas Habas	Fallow	Fallow	Potatoes
3-5	3	8	63%	Potatoes	Potatoes	Oca Olluco	Fallow	Fallow
5	2	7	71%	Potatoes	Barley	Fallow	Fallow	Fallow

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

APPENDIX 1. Communities with sectoral fallowing systems. (continued)

Name of Community	Depart- ment	Country	°S Lati- tude	°W Longi- tude	Elevation of Com- munity (meters)	Total No. of SFS per Com- munity	Average Elevation of SFS (meters)
Matapuquio (Skar 1982)	Apu- rimac	Peru	13° 35′	73° 10′	3000	1	3750
Ch'eqec (Webster 85 Question.) (Pseudonym)	Cuzco	Peru	13° 20′	71° 10′	3300	3	3950
Same							3550
Same							2650
Usi (McCorkle 85 Question.) (Pseudonym)	Cuzco	Peru	13° 45′	75° 30′	3700	2	3750
Same							3750
Chinchero (Núñez del Prado 1949)	Cuzco	Peru	13° 25′	72° 0′	N/A	1	N/A
Caraybamba (Fujii/Tomoeda 1981)	Apu- rimac	Peru	14° 10′	73° 5′	3140	1	3750
Chanajari (Collins 85 Question.)	Puno	Peru	20°	30°	3740	1	N/A
Huallay Grande (Bradby 85 Question.)	Huan- cave- lica	Peru	12° 55′	45°	3600	1	3900
Chiripa (Browman 85 Question.)	La Paz	Bolivia	16° 30′	69° 0′	3835	1	3910
Alccavitoria (Custred 1974)	Cuzco	Peru	14° 30′	72° 20′	N/A	1	3800

No. of Years Fallow[1]	No. of Years Culti-vated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
5-8	4	12	66%	Potatoes	Oca Olluco	Habas	Wheat	Fallow
9	1	10	90%	Potatoes	Fallow	Fallow	Fallow	Fallow
5	1	6	83%	Potatoes	Fallow	Fallow	Fallow	Fallow
2	1	3	66%	Maize	Fallow	Fallow	Maize	Fallow
3	2	5	60%	Potatoes	Barley Habas	Fallow	Fallow	Fallow
3	2	5	60%	Potatoes	Barley Habas	Fallow	Fallow	Fallow
4	3	7	57%	Potatoes	Olluco Ocu	Barley Habas	Fallow	Fallow
13	2	15	87%	Potatoes Olluco Ocas	Volunteer Potatoes	Fallow	Fallow	Fallow
7	4	11	64%	Potatoes	Ollucos Ocas	Habas	Barley	Fallow
6	1	7	86%	Potatoes	Fallow	Fallow	Fallow	Fallow
4	3	N/A	N/A	Potatoes	Barley Wheat Quinoa Cañihua	Habas Tarni	Fallow	Fallow
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

APPENDIX 1. Communities with sectoral fallowing systems. (continued)

Name of Community	Depart-ment	Country	°S Lati-tude	°W Longi-tude	Elevation of Com-munity (meters)	Total No. of SFS per Com-munity	Average Elevation of SFS (meters)
Ambaná (Aguirre 1980)	La Paz	Bolivia	15° 25′	69° 0′	3800	2	3700
Same							4500
Rumipata (Pseudonym) (Guillet 1979)	Cuzco	Peru	N/A	N/A	3100+	1	3500
San Jose′ (Jacobsen 1982)	Puno	Peru	14° 50′	70° 5′	3800	1	N/A
Llaulli (Jacobsen 1982)	Puno	Peru	14° 50′	70° 5′	3800	1	N/A
Soras (Turpaud & Murrugarra 1966)	Aya-cucho	Peru	14° 5′	73° 35′	3433	1	3400
Tangor (Mayer 1979)	Pasco	Peru	10° 25′	76° 25′	2700	1	N/A
Yacan (Fonseca 1972)	Pasco	Peru	10° 30′	76° 30′	3667	1	3780
Yancao (Galdo & Martínez 1966)	Lima	Peru	11° 0′	77° 0′	N/A	2	N/A
							N/A
Taquile (Matos Mar 1957)	Puno	Peru	15° 40′	69° 35′	3830	1	N/A

No. of Years Fallow[1]	No. of Years Cultivated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
5	5	10	50%	Potatoes	Ocas	Habas Peas	Barley	Oats
10	3	13	77%	Potatoes	Ocas	Oats	Fallow	Fallow
4	3	7	57%	N/A	N/A	N/A	Fallow	Fallow
2	4	6	33%	Potatoes	Barley Oats Quinoa Ocas Habas	Repeat	Opt. Repeat	Fallow
5	N/A	6	83%	N/A	Fallow	Fallow	Fallow	Fallow
4	3	7	57%	Potatoes	Ocas Ollucos Mashua Habas	Barley	Opt. Repeat	Fallow
7	5	12	58%	Potatoes	Ocas	Trigo	N/A	N/A
5	3	8	63%	Potatoes	Oca Olluco Mashua Quinoa	Barley Habas	Fallow	Fallow
4	3	7	57%	Potatoes	Ollucos Ocas	Barley	Fallow	Fallow
2	1	3	66%	Bitter Potatoes	Fallow	Fallow	Bitter Potatoes	Fallow
N/A	N/A	6	N/A	N/A	N/A	N/A	N/A	N/A

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

APPENDIX 1. Communities with sectoral fallowing systems. (continued)

Name of Community	Depart-ment	Country	°S Lati-tude	°W Longi-tude	Elevation of Com-munity (meters)	Total No. of SFS per Com-munity	Average Elevation of SFS (meters)
Tukiwasi (Pseudonym) (Guillet 1974)	Cuzco	Peru	N/A	N/A	3100	1	3304
Moccoraise (Gade 1975)	Cuzco	Peru	13° 55′	71° 30′	3500	1	N/A
Macha (Platt 1982)	Potosí	Bolivia	18° 30′	66° 20′	N/A	1	3850
Yucay. (Fiorante Molinie 1982)	Cuzco	Peru	13° 0′	72° 0′	2930	1	N/A
Mantaro Valley eastside (Mayer 1979)	Junín	Peru	11° 45′	73° 20′	N/A	2	4100
2nd Mayer							3750
Surimana (Orlove 1976)	Cuzco	Peru	14° 30′	71° 25′	3586	2	3700
							N/A
Pomacanchi (Gade 85 Question.)	Cuzco	Peru	14° 0′	71° 30′	3700	1	3825
Ichu (Bourricaud 1967)	Puno	Peru	16° 0′	69° 50′	3830	1	N/A
Huayapampa (Fuenzalida 1968)	Lima	Peru	11° 20′	76° 50′	3047	2	3275
Same							N/A

No. of Years Fallow[1]	No. of Years Culti- vated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
1	1	2	50%	Potatoes Ocas Quinoa Habas	Fallow	Repeat	Fallow	Repeat
7	4	11	64%	Potatoes	N/A	N/A	N/A	Fallow
7	4	11	64%	Potatoes	Oca	Quinoa	Barley	Fallow
N/A	N/A	9	N/A	Potatoes	N/A	N/A	N/A	N/A
10	2	12	83%	Potatoes	Barley Oats	Fallow	Fallow	Fallow
4	3	7	57%	Potatoes	Oca Ollucos	Wheat Barley	Opt Repeat	Fallow
5	3	8	63%	Potatoes	Barley	Habas	Fallow	Fallow
7	2	9	77%	Potatoes	Barley	Fallow	Fallow	Fallow
2	3	5	40%	Potatoes	Barley	Habas	Fallow	Fallow
2	3	5	40%	Potatoes	Barley Oats	Quinoa	Fallow	Fallow
3	3	6	50%	Potatoes	Olluco Oca	Wheat Barley	Fallow	Fallow
5	2	7	71%	Tuber	Tubers	Fallow	Fallow	Fallow

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

APPENDIX 1. Communities with sectoral fallowing systems. (continued)

Name of Community	Depart-ment	Country	°S Lati-tude	°W Longi-tude	Elevation of Com-munity (meters)	Total No. of SFS per Com-munity	Average Elevation of SFS (meters)
Huayhuahuasi (Orlove 1977)	Cuzco	Peru	14° 40′	71° 30′	3950	1	N/A
Huancaire (Soler 1964)	Lima	Peru	12° 25′	76° 10′	3200	1	N/A
Pampahuarca (Orlove 1977)	Cuzco	Peru	14° 50′	71° 25′	3900	1	4100
Escara (Prescott 1974)	Oruro	Bolivia	18° 40′	68° 10′	N/A	1	N/A
Acora (Tshopik 1946)	Puno	Peru	16° 0′	69° 50′	3861	2	N/A
							N/A
Uripa (Fonseca & Murrugarra 1966)	Apu-rimac	Peru	13° 35′	73° 25′	2903		3675
Cuyo Cuyo (Camino 1978)	Puno	Peru	14° 30′	69° 30′	3450	3	3950
							3500
							3300

No. of Years Fallow[1]	No. of Years Culti-vated	Total No. of Sectors	% of Years Fallow	Crops in 1st Year	Crops in 2nd Year	Crops in 3rd Year	Crops in 4th Year	Crops in 5th Year
10	2	12	83%	Potatoes	Cañihua	Fallow	Fallow	Fallow
N/A	N/A	6	N/A	Potatoes	N/A	N/A	N/A	N/A
9	2	11	82%	Potatoes	Quinoa Cañihua	Fallow	Fallow	Fallow
N/A	3	N/A	N/A	N/A	N/A	N/A	Fallow	Fallow
3	2	5	60%	Potatoes	Quinoa Barley	Fallow	Fallow	Fallow
10	2	12	83%	Potatoes	Cañihua	Fallow	Fallow	Fallow
N/A	N/A	N/A	N/A	Potatoes	Fallow	Fallow	Fallow	Fallow
5	1	6	83%	Bitter Potatoes	Fallow	Fallow	Fallow	Fallow
2	4	6	33%	Potatoes Mashua	Oca Olluco Mashua Habas	Habas Barley	Fallow	
4	2	6	66%	Potatoes	Oca Malle Lisas Mashua Yacon Rachacha	Fallow	Fallow	Fallow

[1]In some instances, some plats will be cultivated in the first fallow years. Note discussion in text.

Additional cases of sectoral fallowing systems were recently reported by Dr. Xavier Albo for the department of Cochabamba, Bolivia, at locations generally above 3000 meters in elevation and between 17° S. and 18° S., 65° 30′ W. and 67° W. Local Quechua names for these systems include *ayanuga, ayta, muyu* and *manta.*

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