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TRADITIONAL ANDEAN AGRICULTURE AND CHANGING PROCESSES IN THE ZENTA RIVER BASIN, SALTA, NORTHWESTERN ARGENTINA

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ABSTRACT: Hilgert, N. I. & Gil, G. E. 2005. Tradicional andean agriculture and changing processes in the Zenta River basin, Salta, northwestern Argentina. *Darwiniana* 43(1-4): 30-43.

In this paper we analyze the altitudinal use of the environment in the traditional agricultural practices of an Andean rural community of Salta Province, Argentina. At present, families that used to move periodically among different settlements are gradually turning to be sedentary. This process has resulted in the weakening of the vertical use of the environment, the concentration of agricultural activities into a sole altitudinal level, the loss of some cultigens proper of abandoned areas and in the increase in the pressure of use in permanent locations. Even though ancestral agricultural practices are still in use in the community under study, changes are negatively influencing their preservation.

Keywords: Andean agriculture, Argentina, Cloud forest, Farming systems.

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Se analiza el uso altitudinal del ambiente en relación a prácticas agrícolas tradicionales, en una comunidad rural de la provincia de Salta, Argentina. En el presente, las familias que solían trasladarse periódicamente entre diferentes puestos están tornándose sedentarias paulatinamente. Este proceso está ocasionando cambios tales como la disminución de la importancia del uso vertical del ambiente, la concentración de las actividades agrícolas en un solo nivel altitudinal, la pérdida de algunos cultígenos debido al abandono de las áreas apropiadas para su producción y el incremento de la presión de uso en las empleadas de forma permanente. Aunque las prácticas agrícolas ancestrales aún se observan en la comunidad estudiada, están ocurriendo cambios que influencian negativamente su preservación.

Palabras clave: Agricultura andina, Argentina, Bosque nublado, Sistema agrícola.

INTRODUCTION

For traditional agricultural societies, Schmidt (1951) described four types of productive practices: gardening, shifting, irrigation and terrace cultivation. The first two are still present in the Andean cloud forests. In the high lands cultivation is carried out in permanent small plots while shifting agriculture is used in slopes in the medium and low sectors of the area, where woodlands and forests are located (Brown et al., inédito).

According to Watters (1971), the agriculture of the region falls within the traditional type; it is completely incorporated into the culture of the inhabitants and it has been practiced since remote times. Small plots and primitive technologies are also used: wooden plows, oxen, manual harvest, seed recycling, etc. The output is used mainly for household consumption, and only as a secondary resource some surplus is bartered for other products (Reboratti, 1995). The economy of the region is supplemented with paid work, via temporary or permanent jobs, occasional meager monetary aid provided by the State and raising of

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cattle or sheep and, to a lesser extent, goats and horses. These herds demand a periodical migration of animals in search of foraging places. The combination of agriculture in different altitudinal belts and the movement of herds among them constitute, in fact, the utilization of the natural resources of all levels. This altitudinal use is actually a typical characteristic of several mountain societies, i.e. Andean and Asian peasant cultures, (Murra, 1975; Camino, 1982; Zimmerer, 1995; Altieri, 1996; Grôtzbach & Stadel, 1997; Mitchell & Brown, 2002).

Gradual changes are taking place in the traditional management systems in the Andean World (Knapp, 1994; Zimmerer, 1995; Mitchell & Brown, 2002, for example). Near the study area, Ventura reported evidence of the supplementary utilization of different belts as from 1300-1470 AD (Ventura, 2001). It was proposed that the economy of the communities suffered changes with the arrival of European cattle; a new system for the utilization of pastures had to be implemented according to the demands of the introduced species; crops in terraces and irrigated fields were gradually and almost totally abandoned, and changed by temporary crops in the mountain slopes, a practice that gave rise to a point of no return towards shifting agriculture (Reboratti, 1995). In order to face this irreversible trend, it is mandatory to study Andean animal husbandry and peasant agriculture in the Andean valleys (Rabey, 1993). Systems of production and adaptative strategies are very familiar to the people of the region, but their basic and applied characteristics are otherwise scarcely known.

In other parts of Latin America the productive system established in the region from colonial times is called "constelación latifundio-minifundio" (small farmlands into a large property). This agrarian type is characterized by the asymmetric functional relationship between a latifundia and a group of peasants that, living in it, establish a rent or partnership system. In this way, the farm controls the population income within its limits through the management of the profit of the lands rights (Reboratti, 1995).

Wood & Lenné (1999) suggested that local knowledge and culture can be considered as integral parts of agricultural biodiversity, because it is the agricultural activity of people which affects this biodiversity. In this regard, we here describe how traditional agriculture is related to the vertical use of the environment in the southern Andean montane forests according to local people's practices, memories and testimonies. Our first objective is to describe the current ways in which local people use plant resources related to agricultural practices in the area and the changes in this kind of activities which have occurred according to local people perception. Our second objective is to analyse the ethnobotanical species –Taxon- diversity related to traditional agriculture, including alpha diversity (species richness within each altitudinal level), beta diversity (species turnover between altitudinal levels), and gamma diversity of the mountainous landscape.

These results are part of a larger undertaking in which the ethnobotany of the domestic environment was analyzed (Hilgert, 1998).

STUDY AREA

The study area is located on the west of the department of Orán, province of Salta, Argentina. It comprises a part of the Zenta River basin covering a surface of 1290 km^2. From the western limit, at 4,000 m elev., to the eastern limit, at 400 m elev., there is a distance of 75 km (Del Castillo, inédito). The climate is continental tropical, with warm, rainy summers and cold, dry winters. The annual mean temperature ranges between 14 ºC to 26.5 ºC. The annual mean rainfall varies from 700 to 1400 mm. The rainy season goes from November to March. There is a dry period in the rest of the year with a low rainfall, which represents 15% of the total annual one (Bianchi & Yañez, 1992).

The vegetation of the area corresponds to the "Yungas" biogeographic province, which is the southernmost distribution of the tropical Andean Montane forests (Cabrera & Willink, 1980). The composition and floristic elements of these units have been described by Cabrera (1976) and Hueck (1978). The different ecological layers correspond to the elevation belts locally known as *monte* (Pedemontane Forest - 400 to 700 m elev.-), *valle* (Montane Forest - 700 to 1500 m elev.-) and *cerro* (Montane Cloud Forest -1500 to 3000 m elev.-) (Sturzenegger, 1982; Brown et al. 2001).

The present population is Andean with strong Spanish influence and speak only Spanish, al-

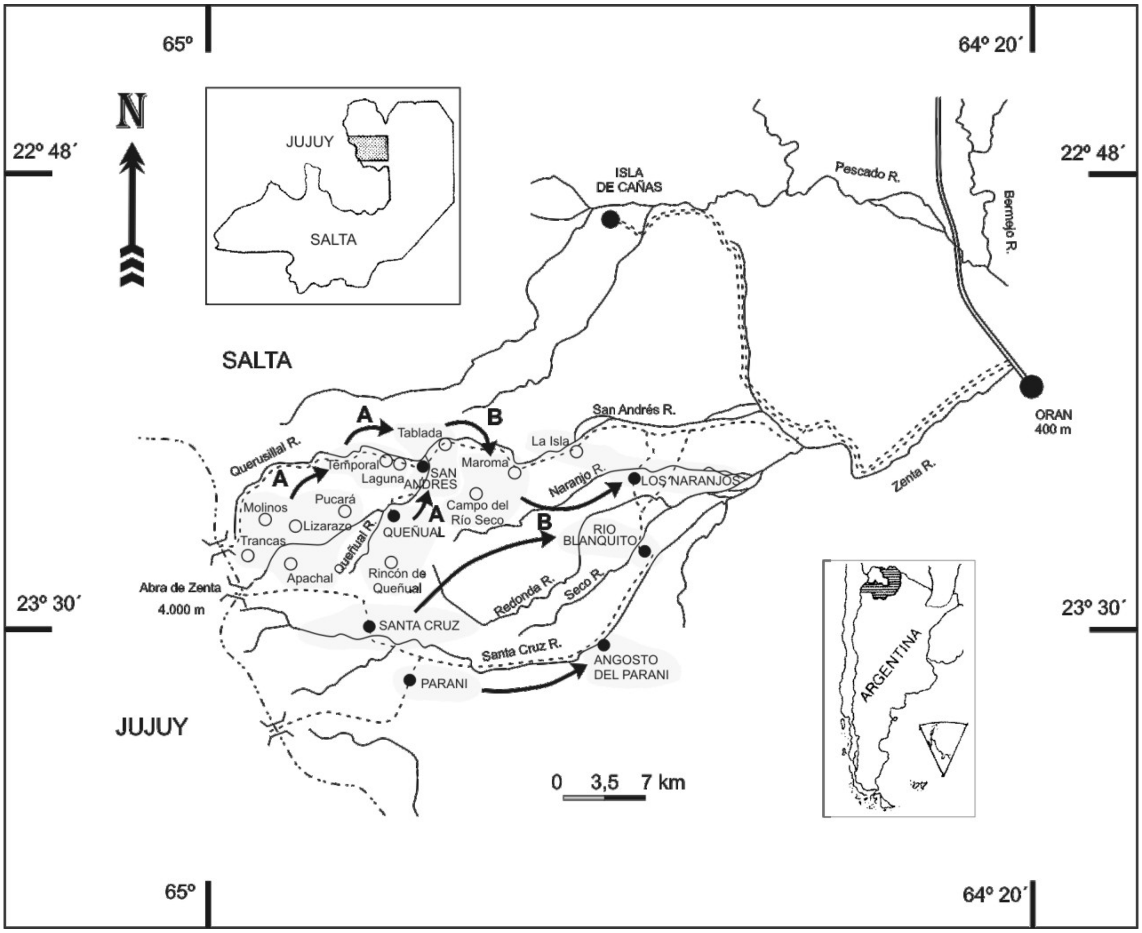

Fig. 1.- Studied area: ————— Pedestrian walk or horseshoe; = = = = Dirty road; ====== National route. Temporary migration patterns: (A) from the *cerro* area to one of the *valle* townships, (B) from the *valle* area to the *monte* settlements.

though many Quechuan expressions are found in their speech. The population comprised approximately 186 family groups and 1300 inhabitants (INDEC, 1997), all of them being farmers. Access to these villages is difficult due to their geographic isolation. There are only five important settlements in the area: Río Blanquito, Los Naranjos, San Andrés, Santa Cruz and Queñual (the last three are presently in regression) (Figure 1).

In the three environments described above, a large number of the families occupy temporary settlements *(puestos)* where they live part of the year. Each family performs productive tasks independently, except those that demand considerable exertion, in which case they rely on their neighbours for help. This communal activity is called *minga*.

METHODS

The information was gathered during five field trips from January 1996 to March 1997. The analysis unit was the family, so, central tendency measures were estimated with cultivated species per family data. A special point was made on current agricultural practices and the changes which occurred in them according to the informant's memories and testimonies; in this study only the edible species associated to agricultural activities were considered. Interviews were conducted with those who consented to taking part in this work, 91 families (49% out of the total). During visits, different semi-structured specially prepared surveys were used as guidelines. Plants were collected with the informants. The material was deposited at the herbarium of Museo de Ciencias Naturales de Salta, Universidad Nacional de Salta (MCNS).

Species diversity can be analyzed in three main components. Whittaker (1972; 1977) proposed alpha diversity to mean the species richness of a particular habitat that is considered to be homogeneous; beta diversity, the degree of replacement of species among different habitats in a landscape (turnover rate); and gamma diversity, the species richness of the entire landscape, as a result of both the alpha and the beta diversities. Alpha diversity can be expressed with species richness, an *ad hoc* index, parametric or non-parametric estimators, or an index based in proportional abundance (Magurran, 1988; Colwell & Coddington, 1994). Beta diversity is measured using a similarity index and an *ad hoc* index (Magurran, 1988; Colwell & Coddington, 1994; Koleff et al., 2003). Finally, gamma diversity is expressed as a relationship between alpha and beta components (Moreno, 2000). Several of these quantitative diversity measures are currently being applied in ethnobotany (Begossi, 1996; Hanazaki et al., 2000; Ladio & Lozada, 2003).

In this work we computed the following complementary measures of alpha diversity for cultivated species in each vegetation belt: Richness (S), inverse of Simpson's index and Chao 1 estimator. For this, we used Biodiversity Professional Beta (McAleece, 1997) and EstimateS (Colwell, 2000) software. The Shannon-Wiener's index was compared between belts using a t-student test (Magurran, 1988). These measures were selected because they are the most precise, they allow comparisons and they are in agreement to the kind of data. S is the most direct and simplest expression of alpha diversity for well known taxa with defined space and time. Although it is N dependent, the sampling differences are saved using species accumulation curves, being these data more profitable than rarefaction curves (Moreno, 2000) which were suggested by Begossi (1996). These functions describe the curve obtained from the relationship between the sampling effort and the detected species, which, according with the model, reach a plateau or asymptote in the total value of the species from a defined area. These curves can be used for study groups with a finite number of elements, which are not detectable in a single sampling. The species accumulation curves obtained from our data were fitted to three basic models: logarithmic, lineal dependence and Clench equation using non linear regressions with Statistica (StatSoft Inc., 1998) to estimate the total number of expected species in each habitat. The records mentioned in interviews per species data were fitted to different structure models (geometric series, log series, log normal and broken stick) using Chi square or Kolmogorov-Smirnoff tests (Moreno, 2000), with Biodiversity Professional Beta (Mc Aleece, 1997) and Anacom (De la Cruz, 1994) software. To evaluate complementarity between belts, the inverse of Simpson's similarity index (N-independent) and the Whittaker's turnover index (Moreno, 2000; Sánchez & López, 1988) were used. Finally, to compare the gamma diversity of the different combinations observed in the habitat under different uses, potential combinations, the Schluter and Ricklef's measure, which is based in species richness and based in Simpson's index measures (Moreno, 2000), was calculated.

The proportion of families using each habitat was used as a measure of the community importance for gamma measure based on Simpson's index. Biodiversity integrity index (BI) was created to evaluate the biodiversity conservation status of an area unit and was applied in studies focussed on the response of biodiversity of ants to different conservation degrees of vegetation (Majer & Beeston, 1996). This index is the product between the number of species, for a particular element of the landscape, and the percentage of this area. BI = Ó A*P , where A refers to the area percentage that is occupied by the landscape unit and P refers to the detected species proportion of that unit regarding to the original community which is assigned 1.0, if 100% of the landscape area was pristine, then BI = 100 * 1.0 = 100. The difference between 100 and the obtained value is a measure, shown in percentage, of the biodiversity integrity loss (Majer & Beeston, 1996). However, we propose to also use BI to evaluate the conservation status of biodiversity use. For this we think that the conservation of use is reflected in which species and landscape units are used. Furthermore, we measure the change from a previous stage that does not need to be the original stage.

In this case, the previous situation is based on the information from semi-structured interviews about the use of the different habitats, where all

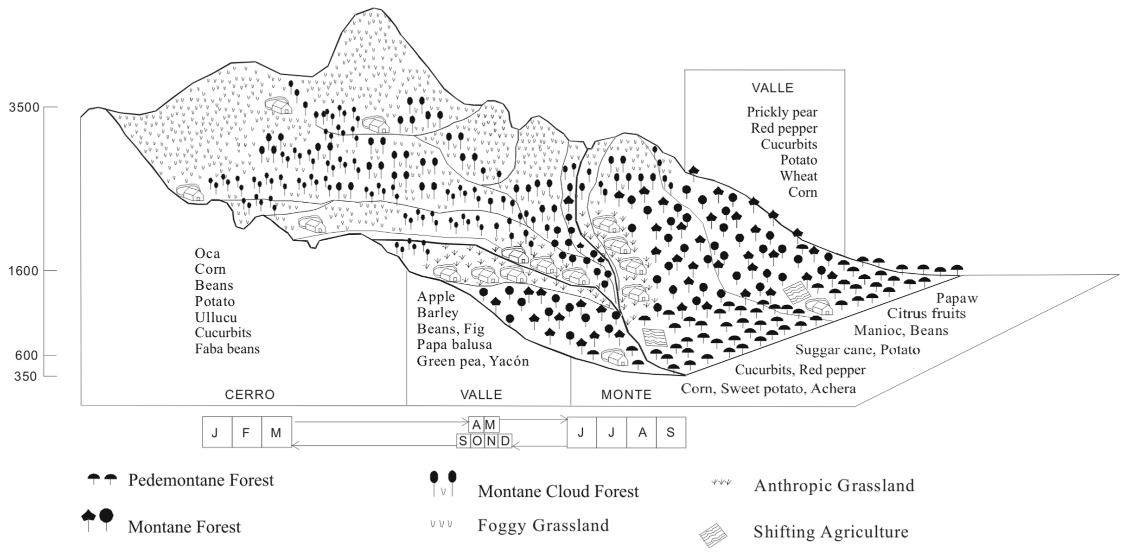

Fig. 2.- Main crops by belts.

families had recently used the three belts. Information on the time elapsed since some of the belts were abandoned was little accurate. However, all the abandonments occurred during the adults' life within the nuclear families. Average age of the informants was 59 (range: 80-32). To apply BI in this case, we are more interested in measuring the status of conservation of use in the studied community instead the environmental conservation status on a land area. Therefore, we applied the percentage of families using each belt combination instead of the habitat coverage, which was proposed in the original formula. In each observed combination of belts, the proportion of used species was calculated with regards to those species previously used (assigned value = 1.0). We point out that this new perspective for the application of BI can be applied as long as there were available data on a previous situation of the pattern of use and a differential use of the space by the community.

RESULTS

Current use of resources in the area

The analysis of the agricultural practices showed a coexistence of two different methods. On one hand in the *valle* and *cerro*, permanent plots are used; they are cultivated every other year (i.e. cultivated one year, left to lie fallow the next year and used again the following year, etc.). On the other hand, in the lowlands (*monte*), permanent plots in level sectors and slopes are used; slopes are cultivated using the method known as shifting agriculture where the same plot is used for three consecutive years and then left to fallow for a long period (approximately ten years).

Main uses of the land by belts (Figure 2)

In the *cerro*, the dwellings are located on ample, level sectors - valleys - along riverbeds and are limited by high mountain ranges. These areas have natural foggy grasslands with small woods of *Polylepis* spp. In the most humid ravines, from 3 to 7 houses, which generally belong to related families, are found in the different valleys.

Until the 1980s, the *valle* was the belt with the longest-lasting settlement period along the year. A settlement pattern concentrated near the confluence of rivers with wide plain sectors where the dominant vegetation is grasslands within a matrix of clouded temperate forests. Some places with scattered settlements, probably associated to streams or foraging sites, are also observed. In this belt, permanent crop fields are used and fruit orchards are common. Until the 1940s, a great part of the available alluvial terraces was also used, tacitly divided among neighbours and cultivated communally. To cultivate them, the "co-owners" gathered and collectively worked the part assigned to each one. At that time the *minga* was a common practice between neighbours.

In the *monte*, some families live scattered in the forest and others concentrate in two villages settled during the 80s (Los Naranjos and Río Blanquito). These dwellings are located on level ground, near water courses. Plots are prepared near the houses in small fields, and larger plots for shifting agriculture are prepared at a distance, on the mountain slopes. In level places fruit gardens can be observed.

The total area used per family is approximately 8 hectares, about 2.5 of which are effectively used each year. The former comprises about 6 plots, two in each altitudinal belt. The plots for cultivation are divided into: garden, vegetable garden, corrals, fruit gardens and shifting cultivation.

Garden: it is close to the house and surrounded by a fence. Ornamental plants and citrus trees are cultivated. The garden is a place beloved by the house women, who tend it with loving care. The greater number of species it displays, the greater pride owners show for them.

Vegetable garden: this is the place where vegetables used for household consumption are grown. It is located near the corrals adjoining the house or in a separate plot, but always at hand. According to tradition, certain crops are produced in the vegetable garden because they are to be used at different phenological phases [i.e. *Zea mays*, beans (*Phaseolus vulgaris*)]; some vegetables introduced during the last 15 years like lettuce (*Cichorium endivia*, *Lactuca sativa*) and radish (*Raphanus sativus*) are also found.

Corrals: these enclosures are found in dwellings in the *cerro* and *valle*. Each family usually owns two corrals located on the outskirts of the property. They are used in rotation, one for agriculture and one for the enclosure of sheep at night. The herd enclosure has different functions: a- allows the farmers to collect the excrements to add them to the furrow together with the seeds at the time of ploughing, b- with the accumulation of the dung the soil is duly matured avoiding depletion, and finally c- it protects herds from predators.

Shifting cultivation: This type of plot is found in the *monte*. It can be located on gentle or steep slopes on the mountainside. The plots are not used permanently; thus, a new one is cleared every two or three years and the one previously used is left to rest for ten to fifteen years. This traditional handling aims at avoiding the lixiviation of bare, ploughed soil. In the shifting land, cutting is carried out in autumn. Cutting is made with axes, saws and/or chain saws. If there are very large trees and their wood is valuable, they are removed from the plot, while middle branches are selected to build fences, and the remainder is left to dry for several months and then piled up and burned.

Fruit gardens: in the *monte*, there are orchards especially of citrus fruits (*Citrus sinensis, Citrus limon, Citrus aurantifolia*). They are located under the canopy of the forest (some 20 to 30 meters high) which protects fruit trees from the sun and frosts. Sometimes the orchards are located near the dwellings, on a land that has been completely deforested. This is also observed in the *valle*, where *Malus domestica, Ficus carica* and *Opuntia ficus-indica* are also produced.

Fences and Technology

Fences: except for the communal terraces, all the plots used for agriculture have some kind of fencing. In the high and middle belts, the most widespread practice is the building of walls about 27 inch (approximately 70 cm) high, made of piled-up stones locally called "pircas". They are very sturdy structures, usually with only one opening that is closed with wooden bars. Even when the building of this type of fences is a slow, heavy task, they are preferred because of their durability. In places where the use of the land is more sporadic, or in the *monte*, where stones are not easily found, fences are built using woven branches. To build them the timber cut down during land clearing is used, thorny branches are usually placed on the outside and top of the fences as an additional safety measure.

Technology: in plain terrain, wooden plows drawn by oxen are generally used in farming.

A communal tractor has been used regularly for about 8 years in the *monte*. It is possible that the use of the plow draft by oxen is decreasing and that it is gradually being replaced by the tractor in the terrains where it can be used. The “palo cavador”, which is a very primitive tool with a sharp pointed extreme used to make the holes in the soil, is used to plow in the slopes.

Importance of the vertical use of the environment in traditional agriculture

The inhabitants identify two successive periods in the course of one year: the warm, rainy season, and the cold, dry one; the activities carried out during these periods are related to these climate variations.

Forty percent (40%) of the interviewed families still maintain transhumance as their lifestyle. Thirty percent (30%) stated that they go on cultivating in the *cerro* but without moving the whole family to the area; the families stay in the *monte* and only the members in charge of the crops in the fields go and stay there regularly. The rest of families have abandoned the *cerro* and *valle* and have crops only in the *monte.*

A simplified pattern of the people’s temporary migrations could be traced as follows (Figure 1 and 2): from the *cerro* area they go down, in May, to one of the *valle* villages (A). From there, they descend to the *monte* in early June and settle in the new village (Los Naranjos) or in a dispersed fashion in different locations (B). They stay there during winter until mid September when they come back to the *valle* until mid December and they go back up to the *cerro* in January. In this way they complete a yearly itinerant cycle. On the other hand, the inhabitants of Santa Cruz and Paraní (the transition between *cerro* and *valle)* make only one journey, to the *monte* belts (Río Blanquito and Angosto del Paraní, respectively).

Production features

With regard to the volume of crop production in the *cerro*, the most important crops are potatoes and maize. There are also a considerable number of crops that are only produced in the highlands, such as the oca (*Oxalis tuberosa*) and the ullucu (*Ullucus tuberosus*). These crops are used for bartering with neighbouring populations of Jujuy or with the inhabitants who stay in the *valle* or in the *monte* all year round.

Until the 1990s, the largest part of the agricultural production was concentrated in the *valle*, probably because the climate there is milder and because it is the place where people spend most of the year. Fruits such as the prickly pear (*Opuntia ficus-indica*), fig (*Ficus carica*), apple (*Malus domestica*), are exclusively produced in this belt.

The *monte* has become important as agricultural land in the last 20 years. In the beginning only citrus were produced and there were family orchards near the dwellings. As from the early 1990s many families settled down permanently and in a concentrated fashion, and built dwellings with basic facilities replacing the former precarious constructions of temporary use. This belt has also become more important due to problems with land rights and ownership. In fact, the permanent occupation of these lands was a local strategy to gain these rights in face of the threat of eviction and destruction of the low lands temporary dwellings. This new location pattern affected the use of the other belts. As a consequence, the population rate decreased in the *cerro;* although most people still go up to the *cerro* to work the land, whole families do not remain there for long periods.

We found significant changes occurred in the use of the *valle* and the *monte.* In the *valle* a large depopulation and occasional abandonment of farming sites can be noticed. In these cases, at least 12 species exclusively produced in this environment have ceased to be part of the people’s diet (Table 1). Although the change is not so significant in the *cerro* yet, it is gradually losing importance as an agricultural belt, which may indicate an abandonment of the site in the near future. Taking into account the total number of species cultivated in these two belts, we estimated that at least 21 regularly consumed crops were under risk of disappearing (Table 1).

In the *monte* important changes have also been taking place. This environment has turned from being the least used for agriculture to be almost the only one in use at present. This change has resulted in an increase in the surface used for this purpose and a decrease in the plots resting periods derived from the need for concentrating a production that can ensure the subsistence in a sole environment. The increase on this surface has not been measured yet.

Table 1.- Species list. Abreviaturas: C, cultivated; Ce, cerro; M, monte; NA, native andean; OW, old world; PE, pre european; S, sylvicole; V, valle.

Vernacular name (Species, FAMILY)	Management	Used Belt			Species Origin
Acelga (*Beta vulgaris* L. var. *cicla* L., CHENOPODIACEAE)	C	M	V		OW
Achera (*Canna edulis* Ker-Gawl, CANNACEAE)	C	M	V		NA
Achicoria (*Cichorium intybus* L., ASTERACEAE)	C	M	V		OW
Achoscha (*Cyclanthera pedata* (L.) Schard., CUCURBITACEAE)	C		V		NA
Ají amarillo, vainilla, bola de gallo, ají huevito de gallo (*Capsicum frutescens* L., SOLANACEAE)	C	M	V		PE
Ají picante (*Capsicum baccatum* L., SOLANACEAE)	C	M			PE
Ají ulupica o urpica (*Capsicum eximium* A.T. Hunziker, SOLANACEAE)	C	M	V		NA
Ajo (*Allium sativum* L., LILIACEAE)	C	M	V		OW
Albahaca (*Ocimun basilicum* L., LAMIACEAE)	C	M	V	Ce	OW
Anco (*Cucurbita moschata* Duch., CUCURBITACEAE)	C		V	Ce	PE
Angolino (not identified, CUCURBITACEAE)	C		V	Ce	PE
Anís (*Tagetes pusilla* H. B. K., ASTERACEAE)	S	M			NA
Anís (*Peperomia blanda* (Jacq.) H.B.K., PIPERACEAE)	C	M			NA
Apache (*Trichocereus thelegonoides* (Speg.) Britton et Rose, CACTACEAE)	C			Ce	NA
Apio (*Apium graveolens* L., APIACEAE)	C	M	V		OW
Arveja (*Pisum sativum* L., FABACEAE)	C		V	Ce	OW
Caña de azúcar (*Saccharum officinarum* L., POACEAE)	C	M	V	Ce	OW
Banana (*Musa* x *acuminata* L., MUSACEAE)	C	M			OW
Batata (*Ipomoea batatas* (L.) Poir., CONVOLVULACEAE)	C	M	V		NA
Cayote (*Cucurbita ficifolia* Bouché, CUCURBITACEAE)	C		V	Ce	NA
Cebada (*Hordeum vulgare* L., POACEAE)	C			Ce	OW
Cebolla (*Allium cepa* L., LILIACEAE)	C	M	V		OW
Ciruelo (*Prunus domestica* L., ROSACEAE)	C		V		OW
Corianito (not identified, CUCURBITACEAE)	C		V	Ce	OW
Durazno (*Prunus persica* (L.) Batsch., ROSACEAE)	C	M	V		OW
Espinaca (*Spinacia oleracea* L., CHENOPODIACEAE)	C	M	V		OW
Guayabo del monte (Psidium sp. L., MYRTACEAE)	C	M			NA
Haba (*Vicia faba* L., FABACEAE)	C		V	Ce	OW
Higo (*Ficus carica* L., MORACEAE)	C		V		OW
Kiwi (*Actinidia chinensis* Planch., ACTINIDIACEAE)	C		V		OW
Laurel (*Laurus nobilis* L., LAURACEAE)	C	M			OW
Lechuga (*Cichorium endivia* L., ASTERACEAE)	C	M	V	Ce	OW
Lechuga (*Lactuca sativa* L., ASTERACEAE)	C	M	V	Ce	OW
Lima (*Citrus aurantifolia* (Christm.) Sw., RUTACEAE)	C	M			OW
Limón (*Citrus limon* (L.) Burm., RUTACEAE)	C	M			OW
Maíz sauceño (*Zea mays* L. ssp. *mays* chiriguano x capia blanco, POACEAE)	C	M			PE
Maíz amarillo chico, bola, amarillo duro o amarillo previador (*Zea mays* L. ssp. *mays* var. *chaucha*, POACEAE)	C		V	Ce	PE
Maíz amarillo duro (*Zea mays* L. ssp. *mays* var. *chiriguano* x *morocho*, POACEAE)	C	M			PE
Maíz amarillo mediano (*Zea mays* L. ssp. *mays* var. *amarillo chico x capia blanco*, POACEAE)	C			Ce	PE
Maíz blanco (*Zea mays* L. ssp. *mays* var. *orgullo cuarentón x capia*, POACEAE)	C			Ce	PE
Maíz blanco del cerro (*Zea mays* L. ssp. *mays capia blanco*, POACEAE)	C			Ce	PE
Maíz blanco, capia (*Zea mays* L. ssp. *mays* var. *capia x morocho*, POACEAE)	C		V		PE
Maíz capia (*Zea mays* L. ssp. *mays* var. *harinoso*, POACEAE)	C			Ce	PE
Maíz colorado (*Zea mays* L. ssp. *mays* var. *capia x amarillo*, POACEAE)	C	M			PE
Maíz chaucha (*Zea mays* L. ssp. *mays* var. *pisingallo* (fasciado), POACEAE)	C		V	Ce	PE
Maíz garrapata (*Zea mays* L. ssp. *mays* var. *pisingallo*, POACEAE)	C		V		PE
Maíz oke (*Zea mays* L. ssp. *mays* var. *azul*, POACEAE)	C	M			PE
Maíz oquecho (*Zea mays* L. ssp. *mays* var. *garrapata x amarillo chico*, POACEAE)	C			Ce	PE
Maíz Perla (*Zea mays* L. ssp. *mays 8 rayas*, POACEAE)	C			Ce	PE
Maíz pisancallo, pisin o pisincho (*Zea mays* L. ssp. *mays* var. *pisingallo x capia*, POACEAE)	C	M			PE
Maíz pisankallo (*Zea mays* L. ssp. *Mays* var. *morocho*, POACEAE)	C		V	Ce	PE

Table 1.- (Continuación)

Vernacular name (Species, FAMILY)	Management	Used Belt			Species Origin
Mandioca (*Manihot esculenta* Crantz , EUPHORBIACEAE)	C	M			PE
Maní (*Arachis hypogaea* L., FABACEAE)	C	M			PE
Manzana (*Malus domestica* Borkh., ROSACEAE)	C		V		OW
Membrillo (*Cydonia oblonga* Mill., ROSACEAE)	C	M	V		OW
Mirasol (*Helianthus annuus* L., ASTERACEAE)	C		V		PE
Naranja (*Citrus sinensis* (L.) Osbeck., RUTACEAE)	C	M			OW
Naranja agria (*Citrus aurantium* L., RUTACEAE)	C	M	V		OW
Oca (*Oxalis tuberosa* Molina, OXALIDACEAE)	C			Ce	NA
Orégano (*Origanum x applii* (Domin) Boros, LAMIACEAE)	C	M	V	Ce	OW
Palta (*Persea americana* Miller, LAURACEAE)	C	M			PE
Papa (*Solanum tuberosum* L. ssp. *andigena*, SOLANACEAE)	C		V	Ce	NA
Papa baya (*Solanum tuberosum* L. ssp. *andigena x papa baya*, SOLANACEAE)	C		V		NA
Papa collareja (*Solanum tuberosum* L. ssp. *andigena*, SOLANACEAE)	C			Ce	NA
Papa granada (*Solanum tuberosum* L. ssp. *andigena x colorada*, SOLANACEAE)	C			Ce	NA
Papa guareña (*Solanum tuberosum* L. ssp. *andigena*, SOLANACEAE)	C			Ce	NA
Papa morada (*Solanum tuberosum* L. ssp. *andigena x tuni morada*, SOLANACEAE)	C		V	Ce	NA
Papa morada chata (*Solanum tuberosum* L. ssp. *andigena x tuni*, SOLANACEAE)	C			Ce	NA
Papa morada ojosa o morada del cerro (*Solanum tuberosum* L. ssp. *andigena* var. *bolivianum* f. *willa-pala*, SOLANACEAE)	C			Ce	NA
Papa overa (*Solanum tuberosum* L. ssp. *andigena*, SOLANACEAE)	C			Ce	NA
Papa rosada (*Solanum tuberosum* L. ssp. *andigena x papa baya*, SOLANACEAE)	C			Ce	NA
Papa verde (*Ullucus tuberosus* Lozano, BASSELACEAE)	C			Ce	NA
Papaya (*Carica papaya* L., CARICACEAE)	C	M			PE
Pera (*Pyrus communis* L., ROSACEAE)	C		V		OW
Perejil (*Petroselinum crispum* (Mill.) A.W. Hill, APIACEAE)	C	M	V	Ce	OW
Pimentón, pimiento (*Capsicum annuum* L., SOLANACEAE)	C	M	V	Ce	PE
Pomelo (*Citrus paradisi* Macf., RUTACEAE)	C	M			OW
Poroto haba (*Canavalia gladiata* (Jacq.) DC., FABACEAE)	C	M			OW
Poroto moradito, overito, rosadito, blanco, negro guillador (*Phaseolus vulgaris* L. var. *vulgaris* L., FABACEAE)	C		V		NA
Quinoa (*Chenopodium quinoa* Willd., Ch. sp., CHENOPODIACEAE)	C			Ce	NA
Rabanito (*Raphanus sativus* L., BRASSICACEAE)	C	M	V		OW
Remolacha (*Beta vulgaris* L. var. *rapacea* (Koch) Aellen., CHENOPODIACEAE)	C	M			OW
Repollo (*Brassica oleracea* L., BRASSICACEAE)	C	M			OW
Sandía (*Citrullus lanatus* Schrad., CUCURBITACEAE)	C	M	V		OW
Suico (*Tagetes terniflora* H.B.K., ASTERACEAE)	S		V	Ce	NA
Tomate (*Lycopersicum esculentum* Mill., SOLANACEAE)	C	M			PE
Tomate de monte (*Cyphomandra betaceae* (Cav.) Sendt., SOLANACEAE)	C	M	V		NA
Trigo (*Triticum aestivum* L., POACEAE)	C		V	Ce	OW
Tuna (*Opuntia ficus-indica* (L.) Mill., CACTACEAE)	C		V		PE
Yacón (*Smallanthus sonchifolius* (Popp. et Endl.) Robinson, ASTERACEAE)	C		V		PE
Zanahoria (*Daucus carota* L. var. *sativa* DC., APIACEAE)	C		V		OW
Zapallo (*Cucurbita maxima* Duch., CUCURBITACEAE)	C	M	V	Ce	PE

Table 2.- Alpha Diversity.

Alpha Diversity	**VALLE**	**MONTE**	**CERRO**
Observed species	59	62	50
Expected species (species accumulation curves, Clench model)	65.02	69.6	54.55
Chao1	59	62	50,04
% observed from expected	90,74%	89,08%	91,66%
Shannon-Wiener's index	3,767	3,877	3,290
Simpson's Diversity (1/D)	39,48	45,43	22,71
Structure	Broken stick (Chi sq. no sig.)	Broken stick (Chi sq. no sig.)	Log series (D Kol. no sig.)

Ethnobotanical species diversity related to traditional agriculture

We have found 72 edible species that are cultivated; some of them include one or more subespecific categories, making a total of 96 taxons. Of these, 94 taxons are cultivated and 2 receive silvicultural treatment as proposed by (Casas 2001) (Table 1). In fact, *Tagetes pusilla* and *.T terniflora* are tolerated and *Peperomia blanda* is induced. From now on we will use the term "species" to refer to the species themselves and to the sub-especific taxons found.

In the *cerro*, the total number of species was 47 (30% of which are exclusive of this belt); in the *valle*, 45 species (27% exclusive) and in the *monte*, 58 (40% exclusive). The average number of species cultivated by each family is thirty five (35) and the standard deviation is twelve point five (S=12.5); 10 is the lowest number of cultivated species registered for one family and 61 the highest. There are several similar modes, 28, 37 and 40; the median is 32.

Several varieties of potatoes (*Solanum tuberosum* ssp. *andigena*) are cultivated in each environment, 5 varieties in the *cerro*, 2 in the *valle*, and 2 in the *monte;* as for maize (*Zea mays* ssp. *mays*), 5 varieties in the *cerro*, 4 in *cerro* and *valle*, and 2 in the valle and 5 in the *monte*. Some of these varieties are used in a specific way. For example, some maize varieties are cultivated to feed domestic fowl and dogs, others are used to prepare traditional dishes while others are produced to be sold or bartered.

The biodiversity integrity index used to evaluate the conservation status of biodiversity use takes a value of 86.25 % in the present situation. This value would be 100% if all the families used the three belts, 88.54% if the all families used *cerro* and *monte*, and 65.63% if all the families used only *monte*.

Alpha diversity measures for each belt are shown in Table 2, where the decreasing order, *monte, valle, cerro* is maintained, and all differences between Shannon-Wiener´s index are significant. The richness estimator (Chao 1) coincides with the one observed in this study. Species accumulation curves fitted to Clench model and predicted 4 to 7 more species for each belt. Therefore, in this study, 89 to 91 % of the expected species were found. This narrow percentage range permits direct comparisons between the richness of different environments. The *valle* and *monte* datum structure fitted to a broken stick model, whereas *cerro* fitted to a log series model.

The beta diversity between vegetation belts is detailed in Table 3. The highest species turnover occurs between *monte* and *cerro*, and then continues with different intermediate orders according to the index, and finally *valle* and *cerro* + *monte*.

The comparison among different used habitat combinations, with gamma diversity measures, revealed that the use of the three belts set is the most diverse, whereas with regard to lost habitats, this measure is reduced (Table 4).

Table 3.- Beta Diversity.

Beta Diversity	**C+M**	**V+C**	**MONTE**	**CERRO**
1-Simpson's index/100				
VALLE	0,18		0,37	0,28
MONTE		0,37		0,47
V+M				0,23
Whittaker's index				
VALLE	1,34		1,40	1,39
MONTE		1,43		1,57
V+M				1,48
C: Cerro, V: Valle, M: Monte				

Table 4.- Gamma Diversity.

Gamma Diversity	**C+V+M**	**C+M**	**M**
Schluter-Ricklefs' index	96,00	93,18	63,00
S based index	83,90	77,43	63,00
Simpson based index (actual)	0,99		
BI (actual = 86.25 %)	100,00%	88,54%	65,63%
C: Cerro, V: Valle, M: Monte			

DISCUSSION

With regard to the farming system, some techniques observed in the area have already been described. Alternating the use of the corrals for agricultural and herding activities has been mentioned for other Andean communities by Parodi (1935), Aznar (1968), Camino (1982) and Mitchell & Brown (2002).

According to Lauer (1993), the permanent settlements in the tropical Andes are located in the high lands while middle and low lands are of supplementary use. In the community under study, however, this pattern was not observed, as settlements were located (at least until few years ago) in the middle lands (the *valle*). According to Prudkin (inédito) (cited in Ventura 1995) this is due to the fact that in this belt humidity and temperatures are higher than in the *cerro.* Ventura (2001) suggests as hypothesis an antropic origin for the existence of the part of the present day *valle* grasslands. These grasslands could have resulted because, since the occupation of the yungas, the woody plains may have served as agricultural fields which required less labour than those in higher and drier sites.

The vertical use of the environment, as well as the preparation and handling of its cultivated holdings could be interpreted as ancient cultural practices, according to that suggested by Ventura (2001), and traditional practices if "traditional" is regarded as something that has been an integrated part of a culture for more than one generation (Pieroni & Quave 2005).

Mishkin (1946), Aznar (1968) and Sturzenegger (1982) have described the different types of *mingas* as well as the significance of the ritual and symbolic life for Andean people; these authors also state that these practices were common in the past. Zimmerer (1995) and Mitchell & Brown (2002) have mentioned the same system as reciprocal labor exchange or *ayni*.

If the cultivated species in the different belts used for agriculture are taken into account, there is a strong agreement with that recorded by Lauer (1993), Altieri (1996) and Bastien (1998) for Andean groups. A parallel comparison can be made between the *cerro* and the belt of temperate tuber plants (+ cereals) of the Callawaya, the *valle* resembles their cereal belt and the *monte* the upper Yungas (Lauer, 1993). Nevertheless, the altitudes at which these similar agricultural systems are carried out in the community under this study are always lower, possibly due to its more southern location.

However, these patterns of utilization are not exclusive of the Andean environment, an example being given in the description made by Uhlig & Kreutzmann (1995) of the Himalayan *Staffeln,* a kind of agricultural production pattern that has already disappeared but which was significantly similar to that observed in our study.

In relation to the technology used in the area, Sturzenegger (1982) has mentioned a kind of hand plow with a small metal plowshare, drawn by mules, that has now disappeared. The use of the "palo cavador" coincides with that cited by Ramadori (1995) for rural communities located farther north in the same environment. The use of this tool added to the fact that this is a subsistence practice makes it possible to consider the *monte* agricultural pattern within traditional shifting agriculture (Watters, 1971).

In relation to the changes registered in the area according to the discourse of the informants there is a coincidence with Reboratti (1995), who has explained that in the mid 20th century, the land owners began the exploitation of the *monte* for timber, and intended to confine the local dwellers to the high lands. As a response, the settlers pressed to maintain the use of all the altitudinal belts, consequently permanent settlements arose in the forest (the monte was a belt under the threat of being looted), and this caused an almost total abandonment of the *valle*. From a diversity analysis point of view, the *valle* is the less complementary belt (Table 3), although we do not mean that this effect is searched for. In other words, it adds the smallest number of exclusive cultivated plants and taking into account all the possible combinations, the pair of belts whose use was more preserved, is the one which has lost less global diversity (gamma) with respect to the total use.

Analysing each vegetation belt datum structure, according to Moreno (2000), broken stick is the most equitable (diverse) distribution. This occurs in *valle* and *monte,* where the number of families using each species is randomly distributed. This similarity in structure and species (Table 3) is perhaps the result from people who now live permanently in the *monte* but cultivate some species they cultivated in the *valle* before. This more (equitable) diversity could be caused by 100% and 70% of families using *monte* and *valle* respectively. The transitional stage (abandonment of the *valle* and permanence in the *cerro*) observed during the study may result in the absence or difficulty in finding a pattern in the use of different species. But the *cerro* structure (log series) is less equitable, because a small quantity of species is cultivated by all the families, and the majority of species are used by a small number of families.

We have two hypotheses for this. One is that many species reduce their frequency because the permanence of people that use the *cerro* is shorter now, consequently, plants which need periodical care or are for diary consumption (i.e. some potatoes and corn varieties; oca; quinoa) are disappearing from the family diet. The other hypothesis is that the *cerro* is very important for cattle, and that cultivation there is a secondary activity, with few important species.

According to Ventura & Belardi (2001) these changes started around 1984. In this study, the changes described are not related to modifications in the accessibility and road construction, which occurred later, and which constitute two decisive elements for Uhlig & Kreutzmann (1995) and Allan (1986) when analysing the reason for changes in mountain communities. Consequently, based on our data, the previous biodiversity use suffered a reduction of nearly 14%, and would cause a loss of nearly 34% if all families used only the *monte* (this belt has the present largest proportional use).

In many families, women are responsible for the high levels of agricultural biodiversity, due to their work in home gardens (Cromwell et al., 1999). Therefore, it may be informative to perform gender analysis to understand the cognitive and cultural factors which are affecting the dynamics of agricultural management in a given community or family.

We conclude that conservation efforts should be made in order to maintain traditional uses associated to altitudinal levels, and thus maintaining high landscape diversity. To this end, it would be necessary to implement measures that protect this kind of use, initially at local level and then at the national level. As Cromwell et al. (1999) have suggested, at local level these measures may include practices which intend to promote the cultivation of local varieties and minor crops and to preserve the local genetic pool in situ, i.e. with community seed banks.

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