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ETHNOECOLOGY, BIODIVERSITY, AND MODERNIZATION IN ANDEAN POTATO AGRICULTURE

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ABSTRACT.—Genetic erosion of traditional crops (landraces) has been predicted as a consequence of technological modernization and social change in centers of crop domestication and diversity. This paper discusses the impact of these changes on traditional potato diversity in the Andes of Peru. Comparative research between two valleys suggests that Andean farmers have maintained potato landraces, even as they adopt modern agricultural inputs. The emphasis on diversity in the ethnoecology of potatoes is explored as an explanation of this pattern. Consumption factors are particularly important in farmer conservation of biological diversity in potatoes.

RESUMEN.—La erosión genética de cultivos tradicionales (variedades criollas) had sido predicha como una consecuencia de la modernización tecnológica y el cambio social en los centros de domesticación y diversidad de plantas cultivadas. Este trabajo discute el impacto de estos cambios sobre la diversidad tradicional de papas en los Andes del Perú. La investigación comparativa entre dos valles sugiere que los campesinos andinos han mantenido las variedades criollas de la papa, aun al adoptar insumos agrícolas modernos. Se explora el énfasis sobre la diversidad en la etnoecología de las papas como una explicación de este patrón. Los factores relacionados con el consumo son particularmente importantes en la conservación de la diversidad biológica de las papas por parte de los campesinos.

RÉSUMÉ.—L'érosion génetique de cultures traditionnelles (espèces locales) a été considérée conséquence de la modernisation technologique et des changements sociaux dans les centres de domestication et de diversité de cultures. Cette note examine l'effet de ces changements sur la diversité des espèces locales de pommes de terre dans les Andes du Pérou. Une étude comparative entre deux vallés mettent en évidence que les paysans andins ont preservé les espèces locales meme si ils adoptent des varietés nouvelles. Les paysans soulignent l'importance de conserver la diversité des espèces locales. Les differents usages de la pomme de terre sont particulierement importants dans la conservation biologique.

Profusion of crop diversity has long been a puzzle, and in recent times it has become a conservation issue. De Candolle (1882) and subsequently Vavilov (1926) noted that interspecific and infraspecific variation of crop species is not evenly distributed, that hyperdiversity in the form of numerous locally named varieties or landraces occurs in certain areas, and that these areas are the most likely centers of crop domestication. Vavilov emphasized the importance of centers of diversity as pools of genetic resources for crop improvement. Many agricultural scientists who are familiar with centers of crop diversity argue that the great profusion of species and genotypes is endangered by technical progress, social change, and environmental factors (Hawkes 1983). Yet, we have only a rudimentary understanding of how specific cultural traditions maintain and influence crop populations in centers of crop origin and evolution. Poor understanding of the ecology of crop diversity weakens our ability to assess the danger of genetic erosion and to plan effective conservation programs.

This paper questions whether the loss of biodiversity under conditions of agricultural modernization is as likely or widespread as purported. It examines the case of potatoes (*Solanum* spp.) in the Andes of Peru, the cradle of potato domestication and evolution. The paper begins with a general review of the ethnoecology of Andean potato agriculture. It then presents data on two Andean valleys that have different histories of agricultural modernization. It argues that diversity persists in peasant agriculture even after intensification and commercialization. While ecological and utilitarian factors are often cited as paramount in the maintenance of diversity (e.g., Clawson 1985), this paper concludes that these factors can only partially explain the practice of Andean farmers to conserve high levels of potato diversity.

One obstacle to understanding crop diversity has been that variation is at the infraspecific level. Burtt's advice on treating infraspecific variation is stark: "the best thing to do with a muck-heap is to leave it undisturbed so that it quietly rots down. In course of time the *Code of Nomenclature* will no doubt accept it as disposable refuse" (Burtt 1970:238). Bulmer (1970) notes that a similar aversion seems to prevail among ethnobiologists. Nevertheless, there are several good reasons for grappling with the ethnobiological treatment of plant varieties, especially of crops. The infraspecific level is common to many ethnobotanical systems (Atran 1987; Berlin 1976; Dougherty 1978), and elaborate varietal classification is conspicuous in some folk systems. Variety identification becomes more significant with industrialization and implementation of intellectual property rights. Perhaps most importantly, the variety level is a primary unit in the management of agricultural ecosystems by farmers around the world. Several case studies reveal the merits of drawing a more explicit connection between ethnobiology and farmer decision making in agriculture (e.g., Johnson 1974; Richards 1985). These studies reflect Bulmer's (1974) point that one of ethnobiology's principal goals is to understand how the determination of biological species relates humans to the biological dimension, a point that has been reiterated in the recent emphasis on "indigenous knowledge systems" (Brokensha et al. 1980).

INTRODUCTION: ETHNOECOLOGY OF ANDEAN POTATOES

Bertonio's (1612) dictionary of the Aymara language mentions some of the many names applied to the vast diversity of potatoes found in the central Andes. Contemporary Andean farmers still use some of the same terms. While it is unlikely that the varieties currently grown are biologically the same as those grown 400 years ago, there is continuity in Andean ethnobiology. Many ethnobiologists and geneticists have come to believe that the biological diversity of Andean farming systems is endangered by contemporary trends, particularly the diffusion of new potato varieties (Ochoa 1975). The loss of biodiversity threatens the continuity of Andean agriculture that has withstood the upheaval of European conquest and colonization.

Two dominant approaches stand out for understanding cultural adaptation by Andean people to their high mountain environment. One focuses on the indigenous knowledge of Andean people, especially the identification and use of local plants, animals, and production zones, emphasizing the diversity of biological resources that are used (Franquemont et al. 1990; Gade 1975; Tapia Núñez and Flores Ochoa 1984). The other approach, referred to here as the cultural ecology model, focuses on the social mechanisms that determine the management of a heterogeneous landscape and provision social units from the household to the state (Murra 1975). The cultural ecology model emphasizes complementarity as one of the organizing principles of Andean society. The complementarity principle refers to the control and use of ecologically distinct, spatially separated production zones by single ethnic groups. This idea was originally articulated by Murra (1975) as "verticality." Thomas's (1973) work on energy flow showed that multiple zones were better able to provide sufficient energy than single zones, and Golte's (1980) research suggests that multiple zone use smooths out labor demand, thus making labor more efficient and productive than is possible within a single zone.

A prerequisite of complementary land use is an inventory of crops that are suited to the different physical conditions of the land: soils, temperatures, moisture, and evapotranspiration regimes. Describing the Vilcanota Valley of Peru, Gade (1975) found 36 species of Andean domesticates. The single most important Andean cultigen is the potato, and diversity within this crop in the Andes is greater than for any other crop grown there. Originally domesticated from tuber-bearing members of the Solanaceae family by Andean pastoralists, the potato has coevolved in the Andean environment for at least 6,000 years (Pickersgill and Heiser 1978). Potatoes are grown throughout most of the crop zones of the Andes, but they predominate in the upper zones, between 3,000 m and 4,000 m above sea level, and in some areas they provide up to 70% of the calories (Ferroni 1979). Eight different species and subspecies among four polyploid groups (diploid $2n=24$ to pentaploid $5n=60$) are cultivated. Some of these species (e.g., tetraploid, *Solanum tuberosum* subsp. *andigena*) are cosmopolitan, while others (e.g., *S. ajanhuiri*) are very localized in their distribution. Some 5,000 morphologically distinct varieties have been identified by the International Potato Center, out of more than 13,000 Andean accessions (Huamán 1986). Over 100 varieties may be found in a single valley and a dozen or more distinct varieties are kept by a typical farming household.

Indigenous knowledge and diversity.—Andean potato nomenclature was first described by LaBarre (1947) for the Aymara of Bolivia, and folk taxonomies have since been described for Quechua and Spanish speaking peasants of Peru (Brunel 1975; Brush et al. 1981; Zimmerer 1991a). Following LaBarre, recent descriptions of Andean folk classification find three or four taxonomic levels for potatoes: genus, species, variety, and subvariety. Four criteria are important in potato classification: ecology (cultivated/wild/weedy; production zone), use (edible; for boiling; for freeze drying), plant and tuber phenotype, and degree of polytypy (number of subclasses). The similarities of potato nomenclature across languages and types of production systems are notable. Both terms and taxonomy found in contemporary nomenclature are also evident in Bertonio's (1612) Aymara dictionary. In both the seventeenth and twentieth centuries, Andean potato farmers distinguish potatoes by tuber phenotype, ecology, and use.

Table 1 presents a schematic diagram of a folk taxonomy of potatoes from the central and southern highlands of Peru. At the genus level, the *Solanum* tuber group ***(papa)*** is distinguished from other Andean tubers such as *Oxalis tuberosa* and *Tropaeolum tuberosum*. At the species level, domesticated, wild, and weedy types are demarcated ***(mikhuna papa, atoq papa, araq papa)***, and frost resistant, high altitude, bitter types ***(haya papa)*** with high glycoalkaloid content are differentiated from mid-altitude types without bitter compounds ***(miski papa)***. Table 2 compares the different folk species according to the four criteria mentioned above.

TABLE 1.—Schematic diagram of Andean taxonomy of potatoes (Cusco Quechua).

Taxonomic Level	Term(s)								
Genus				*Papa*					
Species	*atoq papa*	*araq papa*			*mikhuna papa*		*haya papa*		
Variety			*qompis*		*runtus*	*ruk'i*		*waña*	
Subvariety		*alqa qompis*		*yuraq qompis*				*yuraq waña*	*yana waña*

Varieties are primarily distinguished according to tuber characteristics, such as tuber shape (oval, spherical, flat, long), the configuration of the tuber's "eyes" (depth, number, location, color), skin color and pattern (white to deep purple, solid color, multicolored), and flesh color and color pattern (solid, ringed, white to deep purple). In rare cases, nontuber characteristics such as stem or flower color distinguish varieties. Tuber characteristics are highly subject to somatic variation and to environmental influences. The relationship between tuber characteristics and plant genotype is not well understood.

The final level of Andean potato taxonomy is the subvariety, where the only contrast is between tuber colors. Black ***(yana)*** and white ***(yuraq)*** subvarieties are frequent, and variegated skin color is labeled ***alga***. Skin coloration varies continuously and is transitory in some varieties, and the subvariety label is often understood to be unstable. In other cases, however, subvarieties are stable and biologically distinct. ***Yuraq waña*** and ***yana waña*** are the two stable variants of a single species, *S.* x *curtilobum*.

TABLE 2.—Characteristics of folk species of Andean potatoes (Cusco Quechua).

Folk Species	Ecology	Use	Phenotype	Polytypy
mikhuna papa	broad adaptability; mid-altitudes, 2,500–3,700	boiling; soups; frying	nonbitter tubers; highly variable	very high
haya papa	frost resistant; high altitude, 3,700–4,100	processing by freeze-drying; ***chuño***	bitter tubers	low
araq papa	weedy species; low-medium altitudes, 2,500–3,200	boiling; soups	nonbitter	low
atoq papa	wild species; all altitudes	not used	small tubers	none

Potatoes in two lowest taxanomic levels are grouped into named categories that constitute intermediate ranking rather than separate taxa. Table 3 presents a description of six intermediate ranks that are common in the central Andes. These intermediate ranks are labeled and usually group several varieties and subvarieties by a single criterion, such as use or ecology. One grouping distinguishes potatoes with a high water content ***(uno papa*** or ***kal'wi papa)*** that are suitable for soups or frying from varieties with high dry matter ***(haku papa)*** that are preferred for boiling or steaming. Farmers also contrast modern potato varieties that have been introduced since 1950 with local or "native" varieties. Modern varieties (Spanish: *papa mejorada)* are light skinned, white fleshed, smooth, and generally larger than local varieties that are described as ***chalo. Chalo*** is used by both Quechua and Aymara speakers to describe mixed collections of potatoes with many colors and shapes. The word appears in Bertonio's (1612) Aymara dictionary ***(cchalu),*** suggesting that Andean farmers distinguished mixed collections long before the appearance of modern varieties.

The rich Andean nomenclature for potatoes is *prima facie* evidence for great diversity, and diversity at the species and infraspecific levels has been well documented for the Andes (e.g., Hawkes and Hjerting 1989). However, very little is known about the actual distribution of diversity either within or between regions or how diversity is affected by changes in agriculture. The measurement of genetic diversity and its distribution in Andean potato agriculture is confounded by the complexity within the group of cultivated *Solanums* and by the great number of phenotypes and genotypes at the variety level. Somatic variation, introgression between cultivated and wild species, and hybridization within cultivated

TABLE 3.—Intermediate folk categories at variety level in Andean potato classification (Cusco Quechua).

Category	Distinguishing Criteria	Description	Contrast
wayk'u papa	use	dry/mealy potatoes for boiling or roasting	to *unu papa*
unu papa	use	watery potatoes for frying and soups	to *wayk'u papa*
k'usi papa	use	nonbitter tubers for freeze-drying *(chuño)*	to *wayk'u papa*
miska papa	ecology	fast growing; for short season *(maway tarpuy)*	to unnamed category for long season *(hatun tarpuy)*
chaqro/chalo	phenotype	mixed colors and shapes	to unnamed category for modern varieties (white potatoes)

species also pose problems for measuring diversity. Geneticists who work with the crop have preferred to work at the ploidy or species levels rather than at the variety level (Hawkes and Hjerting 1989). However, recent advances in biochemical characterization of potatoes (Quiros et al. 1990) may help overcome some of the obstacles to biological assessment of diversity. These measures rely on isozymes, and they focus on characteristics that are far less variable or environmentally determined than plant descriptors such as tuber shape.

While varietal naming is a centerpiece of the Andean folk classification of potatoes geneticists have long believed that this system is not a reliable gauge of diversity for two reasons. First, the folk system is based on tuber characteristics that are only partially relevant to the biological systematics of the crop. Second, Andean farmers are believed to overclassify diversity (Hawkes 1947), a practice that is exemplified by the use of several names in a single community for a single type of potato and by the habit of changing names for such purposes as marketing. There is no evidence of a single, master list of names that farmers know or agree on, although they are aware of synonymy.

The individualistic, localized, and transitory nature of potato names would thus seem to limit them as a general tool for measuring diversity. Nevertheless, Quiros et al. (1990) found that there is a high degree of correspondence between farmer segregation and identification of tubers and biochemical (isozyme) profiles of tubers that reflect genotype differences. The isozyme analysis is particularly relevant here, since one would not expect any degree of correspondence between a folk taxonomy largely based on one criterion (tuber characteristics) and biochemical identity based on characters that are invisible to Andean farmers. Households are the primary management unit of selection of potato varieties and the primary unit for maintaining diversity. Assessment of the amount of diversity kept by different households is therefor essential to an oveall understanding of diversity in the agricultural system, and this assessment can rely on farmer identification. Thus, research on diversity can draw directly on folk classification, as long as the unit of analysis is the household.

Cultural ecology of potato agriculture.—Isbell (1978) reports that households in Ayacucho, Peru, initially receive gifts of seed potatoes from the couple's parents, but afterwards they are generally on their own in selecting and maintaining varieties. This pattern pertains both north and south of the Ayacucho area. Additional varieties are acquired through trade, purchase, gifts, and wages in kind. Women play an especially important role in the identification and selection of varieties, and women are involved in every stage of potato production: seed selection, production, harvest, storage, processing, and cooking. The key role of women has been described in Ecuador (Weismantel 1988), Peru (Allen 1988), and Bolivia (Johnsson 1986). Men acknowledge women's superiority in plant knowledge and defer to them when questions arise about potato identification.

The Andean potato crop, both within villages and across regions, includes a few cosmopolitan varieties that are cultivated by virtually every household and many varieties that are cultivated by only a few households. Cosmopolitan varieties include ***huayro*** in central and southern Peru, ***qompis*** in southern Peru, and ***imilla*** in southern Peru and Bolivia. Approximately half of the total varieties in a household's inventory are these common varieties, but only a small percentage of a region's varieties are common (Zimmerer 1988). Common varieties include both native and modern ones that are kept for different purposes; the native ones because of their culinary and commercial value and the modern ones because of their yield and acceptance in the market. Improved and native commercial varieties are often grown as monocrops in single fields or blocks within fields, and they may account for 70–90% of the area planted in potatoes in many places (Mayer 1979). The prevalence of certain native and improved varieties means that most of the diversity can be kept in only a small portion of the farm, where modern and selected varieties are not grown. This pattern is facilitated by the fragmentation of Andean landscapes, by complementary land use by single households and villages, and by the practice of cultivating numerous fields in the same year.

The ethnographic literature provides strong evidence that consumption is critically important in maintaining diversity. Virtually every study of potato selection refers to the importance of subtle yet elaborate contrast in taste, color, and texture of Andean tubers (Johns 1990; Johnsson 1986). Carter and Mamani (1982) note that certain varieties are prized for special meals, the most favored also being the most delicate and least productive. Brush (1977) describes certain varieties that are saved for gifts. Johnsson's (1986) study in Bolivia discusses the importance of potatoes and potato diversity to the cultural identity of the Aymara.

His emphasis reflects Carter and Mamani's (1982:98) account of the Mauca family's pride and prestige in possessing seed of many rare potato varieties. The contribution of potato diversity to Andean identity and prestige is echoed by Weismantel's (1988) study of Zumbagua, Ecuador. Potatoes are not a primary staple for most Zumbaguan families, but they retain prestige. Serving meals without European introductions such as barley and fava beans is a privilege of more affluent families. This contradicts the popular and Eurocentric notion that potatoes are always judged to be inferior food to cereals.

Intuitive logic asserts that diversity also exists because it is adaptive, leading to more stable production in the face of great environmental heterogeneity and abundant pests and pathogens. Brush (1977) and Carter and Mamani (1982) report that farmers recognize specific agronomic characteristics in certain varieties, such as resistance to disease or insects. While diversity may endow an adaptive or ecological advantage to subsistence farmers without other means to control disease or limit the effects of poor weather, this advantage is not particularly evident in potato names at the variety level. One exception occurs within the bitter species ***(haya papa)*** where more frost resistant varieties ***(ruki,*** *Solanum juzepczuki)* are contrasted with less frost resistant varieties ***(waña,*** *S.* x *curtilobum)*. However, within the nonbitter folk species ***(miski papa),*** where diversity is greatest, there are exceptionally few widely shared names that refer to tubers with special resistance to insects, disease, or poor weather.

It is possible that a more diverse collection of potatoes performs better than a less diverse one as it is moved over the heterogeneous landscape. However, this superior performance must ultimately be traced to the performance of specific varieties at certain places and under particular conditions. We might expect diversity to be retained because certain varieties perform best at certain locations that vary by soils, water availability, temperature, and so forth.

One-to-one relationships between particular varieties and environmental conditions, such as soils, insect predation, or disease, have rarely been reported or evaluated (Hawkes and Hjerting 1989). Strong resistance to disease, insects, and drought is rare in domesticated potatoes, although some resistance is found within the predominant subspecies of the Andean region *(Solanum tuberosum* subsp. *andigena)* (Hawkes and Hjerting 1989). While the ethnobiology of insects and crop diseases of the Andes has not been specifically studied, the observations of agronomists indicate that a folk classification of six insect species that attack potatoes exists (Universidad Nacional San Cristobal de Huamanga 1983). Plant disease taxonomy is the least developed of the folk systems. Andean farmers gloss several diseases under the Spanish term *rancha* (late blight), but they do not recognize several major pathogens, such as nematodes and viruses. Knowledge of soils has been documented (McCamant 1986), but no single matrix seems to exist that maps potato varieties onto soil types.

The widely practiced sectoral rotation of fields (Orlove and Godoy 1986) is especially problematic to an ecological interpretation of diversity. This practice results in the yearly movement of the potato crop between fields in different parts of the community's territory. If ecological advantage of potato diversity results from fitting genotype to location, then this advantage would seem to be eliminated by the practices of frequent field rotation and the practice of growing diverse collections of potatoes together, instead of placing each variety in its special niche and keeping it there. Andean farmers do not emphasize site-specific adaptation in their nomenclature or management of potatoes, and agronomic trials suggest that most individual potato varieties perform equally well over a broad range of altitudes (Zimmerer 1991b). While the contrast at the folk species level between nonbitter, mid-altitude types ***(miska papa)*** and bitter, high altitude, types ***(haya papa)*** is salient on several axes (production zone, relative hardiness, processing, and consumption), the contrast between varieties is based primarily on tuber phenotype. Potato farmers report that the most diverse, native varieties are also the least resistant to disease, insects, and the effects of poor weather.

Diversity may have a very long-term advantage that is not specifically recognized in Andean folk biology or immediately apparent in the short-term. Long-term stability of potato production may be enhanced by having a large repertoire of genotypes, some of which have particular advantage as environmental conditions, pests, and pathogens change over time. Under different conditions, varieties that are now rare may become advantageous, and thus prevalent. A large repertoire may seem superfluous in the short run, but it allows farmers to adjust to new conditions, including market demand.

Loss of diversity.—Andean agriculture has never been a static system, and cultivators have long been able to accommodate new technology such as European crops and animals. However, the pace of change appears to have accelerated during this century. Market penetration, migration, population growth, political reform, and new technology are now ubiquitous. Integration of local communities into larger political and economic systems has been present since pre-Hispanic times, but this integration has changed both qualitatively and quantitatively in the twentieth century, with the spread of capitalism, through increased population, and the expansion of state power, roads, and mass communication. The Peruvian population almost tripled between 1950 and 1990, from 7.6 million to 21.9 million (Urban and Trueblood 1990). Rural areas have experienced far less growth because of emigration to urban areas, but demographic pressures are felt everywhere, as market systems have expanded and rural hinterlands have been more closely incorporated into national economics. The presence of centralized state power has increased through means such as agrarian reform, education, and regional development. Andean production is now characterized as much by commoditization and the acquisition of new technology as by complementarity and community regulation. Virtually every household now uses not only some Old World crops and animals but also agricultural chemicals and improved Andean crop varieties.

Modern potato varieties were first released in Peru in the early 1950s, and they are now found in virtually every village in the highlands. These varieties were specifically bred to be higher yielding, better able to utilize fertilizer, and resistant to specific stresses such as disease or drought. Their adoption is directly encouraged by agricultural extension and credit policies of the government and indirectly by such factors as population increase or a farmer's wish to produce a larger surplus for the market. Two impacts of the diffusion of modern crop varieties in the Andes have been reported: increased productivity (Horton 1984) and loss of potato diversity (Ochoa 1975).

The concept of genetic erosion in farming systems is based on somewhat simplistic biogeography. Adopting modern crop varieties decreases the area that is planted to the traditional and more diverse varieties. Shrinking the area devoted to native crops should logically reduce diversity, just as the size of islands is directly related to biological diversity (McArthur and Wilson 1967). The basic flaw with this logic is that it assumes that farmer behavior towards traditional crops remains unchanged as improved crops are adopted. The biogeographic view of genetic erosion does not account for cultural, economic, and environmental buffers in agricultural systems that might protect diversity. Environmental heterogeneity, agronomic risk limit, market factors, and cultural factors are likely to limit the substitution of one or two varieties for the dozens that have evolved locally. The remainder of this paper will examine whether this conservation has occurred in Andean potato agriculture in two highland valleys of Peru.

METHODS

The impact on traditional crop diversity of the adoption of new varieties and agricultural intensification should ideally be studied in a historic framework by following the fate of diverse native crops as these changes occur over time. By all accounts, modern potatoes spread rapidly throughout the highlands after 1950. Unfortunately, we have neither biological nor socio-economic benchmarks from a period before the diffusion of these varieties. The oldest systematic and preserved collections of native potatoes date only to the early 1970s, and our information on agricultural practices before 1950 is scanty and superficial. Without these historic benchmarks, comparison among regions, villages, and households is a valuable way to estimate the impact on diversity of such factors as commercialization of agriculture or the adoption of modern potato varieties. With this comparison in mind, research was undertaken in two valleys in eastern Peru. These valleys were chosen both because of their similarities and differences.

Study sites.—Reconnaissance in 1978 indicated that studying valleys in Peru's central and southern highlands would provide contrasting records of agricultural modernization and commercialization. Peasant villages in the central highlands were known to have a longer record of the adoption of modern technology and greater integration into regional and national commercial networks. Reconnaissance in 1978 and 1984 suggested that the Tulumayo Valley, 50 km east of Huancayo in central Peru, was representative of areas with records of great potato diversity that had undergone extensive modernization and commercialization. Paucartambo Valley, 50 km east of Cusco in southern Peru, was representative of diverse farming systems that had experienced less modernization and commercialization. The Tulumayo and Paucartambo valleys are like many others along the eastern Andean escarpment. They share the traditions of complementary land use and community control mentioned above. Rolling upland pastures descend into steep and narrow valleys where crops are produced on slopes that have been landscaped into terrace-like fields by generations of farmers. In each valley, "peasant communities,'' or corporate villages, control agro-pastoral production over a large altitude range with different production zones. Each valley has some communities that existed independently and others that were part of *haciendas* before the agrarian reform of 1969-1970. The community provides the modern framework of complementary land use, but households make most of the in-field decisions, such as which crop and variety to plant. Production is destined both for home consumption and for the market, and each valley is located four hours by all-weather road from a major urban center, Huancayo or Cusco.

The Tulumayo and Paucartambo valleys are also alike in their emphasis on potato production and in the organization of potato production. Potatoes are the predominant crop, accounting for 54% of the cultivated land in Tulumayo and 47% in Paucartambo. In both valleys, households cultivate numerous small plots across production zones that are differentiated according to altitude, crops, agricultural calendar, intensity of land use, and degree of community control. Each valley produces both bitter and nonbitter varieties; each divides mid-altitude production into a lower, short cycle ***(maway tarpuy)*** and a higher, long cycle ***(hatun tarpuy);*** each relies on sectoral fallow and the simultaneous cultivation of different plots by the same household. Finally, both the Tulumayo and the Paucartambo valleys share regional fame as places where particularly high levels of diversity are found. These two valleys show a pattern that is familiar to agricultural systems in cradle areas of crop evolution and diversity. Small islands of traditional agriculture remain in a sea of more uniform, commercial agriculture based on the use of modern crop varieties and high energy inputs.

The major differences between the two valleys have to do with ethnicity, degree of commercialization of potato agriculture, and the history of adoption of modern potato varieties. A generation ago, the people of the Tulumayo were Quechua speakers, but today Spanish is the most widely spoken language. Labor migration from this valley to the mining industry in central Peru has been a significant force in shaping local cultural identity during this century (Long and Roberts 1984; Mallon 1983). Tulumayo people identify themselves as *mestizos*, and they are explicit about the cultural differences between themselves and Quechua-speaking people who live south of the Mantaro Valley. Quechua is the predominant language of Paucartambo, where ethnic identity is Indian (Allen 1988). Paucartambo has not experienced such a singular integrating force as massive labor migration to mines. Its integration into the regional economy of southern Peru has been through the *hacienda* system and through periodic migration to Cusco and to commercial farms in the lowlands. This integration has not produced the fundamental shift in ethnic identity experienced in the central highlands. Differences in potato agriculture between the two valleys can be seen by comparing three types of potatoes: improved varieties, native commercial varieties, and mixed native varieties. These types are salient to the farmers in the study in terms of classification and management.

Sample and survey strategies.—The object of studying the Tulumayo and Paucartambo valleys was to model the impact on traditional potato diversity of the adoption of improved potato varieties by comparing households and valleys. The Tulumayo and Paucartambo valleys are each heterogeneous in similar ways.

Different production systems are distributed according to altitude, and these vary by agricultural intensity, community control, crop, and crop variety. Different areas in each valley are more readily accessible to the principal town, the local nexus between peasant communities and regional market and administrative systems. We assumed that better access to the principal town lowered transportation costs and made more available modern technological inputs, including information and new potato varieties. The complexity of potato agriculture in the Andes, heterogeneity within each valley, and differences between valleys were issues in determining a research design. These issues were addressed by surveying in several villages within each valley, by sampling a reasonably large number of households, and by focusing on three categories of potato varieties: improved, native commercial, and mixed native.

The first step in surveying was to select villages for sampling, and this was done by reconnaissance in November 1984. Potato producing villages were selected using two criteria: altitude and distance (travel time) to each valley's administrative center. Villages were chosen in each valley at three altitudes: high (village at >3,500 m), middle (village at 3,000–3,500 m), and low (village at <3,000 m). The distances from the administrative center varied by the existence and quality of roads. In the Tulumayo Valley, 14 villages were surveyed. The closest of these to Comas, the economic and administrative center of the Tulumayo Valley, was 30 minutes by car, and the most distant was three hours over a road that had opened in 1984, the year our fieldwork began. In Paucartambo, 10 villages were surveyed. The closest to the town of Paucartambo was 30 minutes by car, and the most distant was four hours by foot.

The researchers contacted the elected officials of each village or peasant community to explain the research, obtain permission, and select the sample. Peasant communities in Peru keep membership lists of their inhabitants. A short questionnaire was prepared to gather information from the elected officials about the village inhabitants, using the membership list as the base. The village officials were asked to estimate age of the household head, marital status, family size, educational background, extent of land holdings, off farm employment, and socio-economic status of each member of the community. This information was then used to select a sample of households for the main survey. The objective was to include households of different socio-economic status in a survey of between 15 and 20 households in each village. A total of 154 surveys were conducted in the Tulumayo Valley and 204 in Paucartambo.

The main survey instrument was applied between January and July, 1985, in the Tulumayo Valley and between January and September, 1986, in the Paucartambo Valley. The survey instrument included questions on household characteristics and farming practices and the use of the production from each cultivated parcel. Questions about fallow land were also asked. We gathered information about each of the three general types of potatoes, improved, native commercial, and mixed native, such as how seed was acquired and how often, and advantages and disadvantages of the types. Finally, an inventory of varieties was made by drawing a random lot of 100 tubers from the potatoes stored in the farmer's house. These tubers were then sorted by the farmer into varieties that he recognized, and three to six tubers of each variety were requested for analysis and conservation in the collections of the International Potato Center and the University of Cusco. In the early stages of interviewing, it became apparent that we would not be able to conduct an inventory of the entire sample of households that were being surveyed, because of difficulties of logistics and gaining access to the farm's store of potatoes. Our solution was to revisit a smaller number of households that were chosen randomly from the larger sample after completion of the survey. In the Tulumayo Valley we obtained inventories from 87 households, and in Paucartambu we completed 85 inventories.

The survey took approximately one and a half hours to complete. A survey team of five interviewers was employed in each valley. One surveyor worked in both valleys. The surveyors had university training in anthropology, economics, and agronomy. More than half of each team had previous fieldwork and survey experience. Team members lived in villages for one to three months while conducting the survey. Besides the survey on potato varieties and farming practices, the surveyors made ethnographic notes on each of the households that they surveyed. In addition to the variety survey, the research team also produced a land use map of each valley and completed a detailed study of the economics of peasant potato agriculture (Mayer and Glave 1990).

A principal object of the survey on potato varieties was to compare the extent and treatment of three different types of potatoes, improved, native commercial, and mixed native. Improved potatoes are bred for their adaptability to a wide range of Andean environments. They are planted in both of the production zones for nonbitter potatoes, although they are more common in the lower one *(maway tarpuy)*. They are usually smooth and white skinned and somewhat higher in water content than native potatoes. Improved varieties are especially important for commercial production, and they represent a large proportion of all potatoes sold (78% in Tulumayo and 62% in Paucartambo). The native commercial varieties are local varieties that have been intensively selected and are grown in monocultures for the market. They are regarded as excellent eating potatoes by farmers and urban consumers alike. They have moderately deep eyes, colored skin, and cream colored flesh with a high percentage dry matter. These are varieties that are grown by virtually every household. They are well known to merchants and urban consumers, and commercial demand has led farmers to plant them in uniform fields that are managed much like fields of improved varieties. Mixed native varieties are the prime source of diversity in Andean potatoes. Their tubers are usually small and come in many shapes and colors, inside and out, a characteristic that is captured in the label ***chalo***. These mixed native varieties have tubers with many different degrees of dryness and different flavors. They are planted as random collections in the high zone ***(hatun tarpuy)***. Production from mixed native collections is sold, but they are not subject to the same selection pressures as the specifically commercial varieties. These collections are planted by almost every household in the two valleys but in only a small portion of the total land of Tulumayo farms.

RESULTS AND DISCUSSION

Comparison between the two valleys and among the three types of potatoes reveals a number of predictable contrasts but some intriguing surprises. Table 4

TABLE 4.—Potato distribution in the Tulumayo and Paucartambo valleys. Values are percentages of potato types by zone.

	Tulumayo Valley (n = 154)			Paucartambo Valley (n = 204)		
	Improved	Native Commer.	Native Mixed	Improved	Native Commer.	Native Mixed
Hatun Tarpuy (Long Season Zone)	23	75	89	28	10	98
Maway Tarpuy (Short Season Zones)	77	25	11	72	90	2
Total	100	100	100	100	100	100

shows the distribution of different potato types according to the weight of seed reported by farmers in the survey. The important contrast here is between improved and mixed types in the two production zones. Predictably, improved varieties are grown primarily in the lower zones that are farmed more intensively throughout the central Andes for commercial purposes (e.g., Mayer and Fonseca 1979). Native types, especially mixed varieties, are concentrated in the high zone where agriculture is less intensive and community control more direct. Another striking contrast between the two valleys is the location of native commercial varieties. In the Tulumayo Valley, these are primarily grown in the high zone ***(hatun tarpuy)*** while in Paucartambo, they are grown mostly in the lower zone ***(maway tarpuy)***. In both valleys, the lower zone is dedicated to commercial production of the high-yielding improved and high-value native commercial varieties, to take advantage of high off-season prices. The difference in location of native commercial varieties reflects the fact that Paucartambo farmers plant another commercial crop, barley, in the upper zone. Native commercial types are less important in Paucartambo than in Tulumayo.

Table 5 presents data on the percentage of potato area planted in the three types and the use of the entire potato crop for sale and consumption for each valley. These figures refer to the total seed planted and harvest weight of potatoes as estimated by farmers. Eighty-nine percent of the Tulumayo Valley's potato area is planted to the more commercial types, in comparison to only 39% of the Paucartambo Valley. This contrast suggests that potato production in the Tulumayo Valley is more commercially specialized. Improved types comprise the bulk of potatoes that are sold in each valley. In Paucartambo the consumption of mixed native potatoes is considerably higher, reflecting their greater area there than in Tulumayo.

Table 6 presents data on potato use (sale, consumed, saved for seed) of each of the three types of potatoes. The data in Table 6 show that improved potatoes

TABLE 5.—Potato farming systems in Tulumayo and Paucartambo valleys. Values are percentages of potato types.

	Tulumayo Valley (n = 154)				Paucartambo Valley (n = 204)			
	Improved	Native Commer.	Native Mixed	Total	Improved	Native Commer.	Native Mixed	Total
Area in potatoes	59	30	11	100	31	8	61	100
Percentage of potatoes sold	78	20	2	100	62	7	31	100
Percentage of potatoes consumed	41	37	22	100	30	8	62	100

are primarily grown for sale in both valleys, but the data also reveal that relatively high percentages of the mixed native varieties are also sold. The data presented in Tables 4–6 suggest that variation in use is continuous rather than discrete. Farmers in both valleys grow different varieties and mixes of varieties in separate fields, but the production from all fields is used for both consumption and sale. Comparing Tables 5 and 6 indicates that no simple division can be made between production for sale of improved potatoes versus production for use of mixed native potatoes. The consumption of native potatoes is higher in Paucartambo, but so is their sale, since modern potatoes represent a smaller proportion of all potatoes produced.

The variation of diversity, management level, and commercialization between fields of different varieties and combinations of varieties is continuous. Tulumayo and Paucartambo farmers do not create, conceive of, or manage fields according to a matrix of discrete types: low input or high input, commercial or subsistence.

TABLE 6.—Potato use by type in Tulumayo and Paucartambo valleys. Values are percentages of potato types.

	Tulumayo Valley (n = 154)			Paucartambo Valley (n = 204)		
	Improved	Native Commer.	Native Mixed	Improved	Native Commer.	Native Mixed
Percentage sold	80	62	45	64	50	25
Percentage consumed	9	26	43	20	39	55
Percentage saved for seed	11	12	12	16	11	20
Total	100	100	100	100	100	100

The continuous gradation of management, selection, and use allows ample opportunity for different mixes of local and outside inputs, enabling the conservation of traditional varieties and production technology throughout the system.

Keeping diversity.—The social framework of Andean agriculture is experiencing fundamental changes: incorporation of local communities into larger regional systems (especially markets), demographic growth, development of economic and technological infrastructure, and political and social restructuring of Andean society through land reform. It has been common to assume that such changes will bring about the rapid decline of diversity, as ''traditional'' agriculture is replaced by a ''modern'' system (Hawkes 1983).

Improved potatoes came into the Tulumayo Valley almost as soon as they were released in 1950, but they did not appear in Paucartambo until 1960. Tulumayo farmers average almost twice as many years as their Paucartambo counterparts in producing these varieties (Table 7), and this longer period of adoption is reflected in the higher percentage of potato area in the Tulumayo Valley that is planted with improved varieties. Tulumayo suggests a glimpse of the path of agricultural change that Paucartambo may follow, as measured by agricultural

TABLE 7.—Technology adoption and potato diversity.

	Tulumayo Valley	Paucartambo Valley
Average number years using improved varieties[1]	13.9	7.8
Year of first introduction of improved varieties[1]	1950	1960
Percentage of farmers who have ever planted improved varieties[2]	95.8	79.0
Cumulative number of improved varieties planted since introduction[2]	16	7
Percentage of farms using purchased fertilizer[2]	97.9	85.8
Percentage of farms using pesticides[2]	95.7	77.2
Average number of native varieties per farm[1]	12.8	9.6

[1]n = 87 for Tulumayo and 85 for Paucartambo

[2]n = 154 for Tulumayo and 204 for Paucartambo

intensification, commercialization, and adoption of new technology. If we accept the model that the diversity of traditional crops will be adversely affected by the increased use of modern technology—in particular, seed varieties and increased integration into the market—then a comparison between the two valleys may give us some idea about the fate of native potatoes.

On a biogeographical basis, we may expect crop diversity to decrease as commercial and more intensive agriculture relying on modern potato varieties takes hold over a larger and larger portion of the two valleys. Table 5 showed that fields of mixed native varieties represented only 11% of the Tulumayo's potato area. These fields are small islands of diversity, surrounded by biologically more uniform fields. The size of these islands of traditional, mixed potatoes is critical to conserving diversity. In Paucartambo, mixed native fields comprise 61% of the potato area. Biogeographically, we should thus expect Tulumayo to have much less diversity than the southern valley. In fact, the average number of varieties per household in the Tulumayo Valley is 12.8, compared to 9.6 varieties per household in Paucartambo. Table 7 sets this comparison in the context of adoption of improved varieties, illustrating the idea that the farmers of Paucartambo are at an earlier stage in the adoption process of improved potato varieties. It also suggests that diversity of native potatoes remains, even after adoption becomes virtually complete, as long as some area is planted to native potatoes.

Tulumayo's higher average number of potato varieties per household may result from its history of having greater diversity than Paucartambo before the introduction of modern varieties. However, the southern valley is regarded by most potato biologists to be within the region of greatest diversity in Peru (Hawkes 1983). Nevertheless, Tulumayo's higher average underlines the point that modernization has not eliminated diversity. Statistical modeling indicates that the loss of diversity resulting from technology adoption may be asymptotic after an initial period of genetic erosion (Brush et al. 1992). The loss of diversity is neither simply described nor linear. Social reproduction in the Andes is best understood as a syncretic process whereby local and exogenous elements are continually combined (Allen 1988). Likewise, agricultural change in the Andes is not a dichotomous process of the replacement of older technology, but one whereby indigenous and imported technologies are combined into a single mosaic. Thus, fields of modern potato varieties are managed within the sectoral fallow system, and fields of mixed native potato varieties are rotated with European crops, e.g., barley and fava beans. Potato production in these two Andean valleys is not a dual system of production for use with native technology and production for sale with modern technology. Virtually every potato field has elements of indigenous and outside technology, and production of all types of potatoes is used both for consumption and for sale.

Table 8 outlines the major reasons that favor and discourage native and improved potatoes in relation to three factors: consumption, commercialization, and production. This table suggests the complexity of determining the advantages and disadvantages of producing either type. It also shows that there is no single axis on which to select the two types. Cultural identity, culinary quality, risk, yield, and commercial demand interact in the decision. Andean farmers are accustomed to wrestling with complexity of this nature, and they long ago learned that production and use decisions are not simple dichotomies.

TABLE 8.—Selection criteria for native and improved potato varieties.

	Factors Favoring Selection		Factors Discouraging Selection	
	Native Varieties	Improved Varieties	Native Varieties	Improved Varieties
Consumption factors	good tasting; valued for gifts	lower unit cost	higher unit costs	inferior taste; less suitable for usual cuisine; larger tubers require more fuel
Commercial factors	higher market value; high exchange value	more profitable (good benefit/ cost ratio)	low yield under traditional management	low market value; limited local market
Production factors	don't need new seed; seed readily available	good short-term resistance to specific risks	less resistance to specific risks	new seed required

Native potatoes are universally acknowledged to be culinarily superior to modern varieties. The first measure for judging taste in both valleys is how a particular variety tastes when cooked in the *watia*, a simple oven constructed of rocks or sod in the field at harvest time. Varieties are also evaluated by how well they taste after boiling or steaming. Give the problems of synonymy, agreement among people on the identity of different tubers, and individual taste differences, no single native variety represents a culinary standard for other potato varieties. The varieties that come closest to this status are the cosmopolitan, native commercial ones that are found in virtually every household, such as ***huayro*** in the central highlands and ***qompis*** in the south. However, I have been frequently told by informants that rare native varieties are equal or superior to these commercial native varieties.

Native potatoes are preferred as a class because they are drier than the improved varieties, which are thought of as insipid and watery ***(uno papa)*** and suitable for frying or for soups but not for standard boiling. Ritual meals and celebrations and meals for guests emphasize native potatoes. Weismantel (1988) writes that potatoes occupy a primary place in the system of culinary signs and metaphors that comprise Quichua identity in Ecuador. She observes that "White" guests are served meals in which potatoes are minor complements to chicken and rice, while "Indian" guests are served guinea pig and potatoes. Native varieties are favored gift items and are used to strengthen social ties, and some reports refer to them as "gift potatoes" (Spanish: *papas de regalo)* (Mayer 1979). Native potatoes are often expected as part of wages and during reciprocal labor exchange when meals are served. In the extremely tight labor market of Andean agriculture, the offer of ***wayk'u papa*** as partial payment is a good way to guarantee a supply of workers at critical times. These potatoes likewise are attractive to distant trading partners who bring meat and wool from the *puna* to exchange for potatoes. There is large and active market for all varieties of potatoes between the two valleys and the regional urban and commercial centers, but the internal market for potatoes within the valleys is small and not well developed. Individual households do not trade, barter, or sell significant amounts of potatoes with their neighbors. Farmers speak of the desire to be self sufficient in the different kinds of potatoes. Thus keeping mixed native potatoes is seen as an option that is preferable to specializing in one type and relying on a market to supply mixed types.

While judged to be culinarily superior, native varieties are perceived as agronomically inferior to the modern ones. Native varieties are lower yielding and more susceptible to the major diseases and environmental risks affecting potato production. Table 4 showed that in both the Tulumayo and Paucartambo valleys improved potatoes are concentrated in the lower, ***maway*** zone. This zone is less subject to frost than the higher zone, but it is more susceptible to some of the most severe threats in Andean potato production: aphids, viruses, drought, and especially late blight *(Phythphtora infestans)*. Zimmerer (1988) points out that modern potato varieties have completely eliminated native varieties in the lower zones of the Paucartambo Valley.

Modern potato varieties depend on regular supplies of fresh seed tubers, since farmers change the seed for these varieties after two or three years. The seed for native varieties is kept for many years, and it is renewed by rotation between fields at different altitudes. Seventy-two percent of the Tulumayo farmers and 79% of the Paucartambo farmers in the sample reported that they never changed native potato seed. Sixteen percent of Tulumayo farmers and 49% of Paucartambo farmers said they never changed improved potato seed. Large farms that are more commercial or farmers with more capital may thus be more able to plant modern varieties than capital-poor farmers. On the other hand, native potatoes are marketed at premium prices, and a household may broaden its economic strategy by producing them for market. This is evident in the large percentage of land devoted to native commercial varieties in each valley.

While Table 8 and the preceding discussion explain the persistence of native potatoes, the question "why so much diversity" remains unanswered. This puzzle cannot be cracked by direct inquiry, because the question "why do you grow so many types of potatoes?" is a silly and nonsensical question to Andean farmers. Informants were surprised and baffled by the question. From their point of view, diversity is natural and a given of the Andean ecosystem, rather than something strange or unusual to be explained. They manage one of the most heterogeneous and complex agroecosystems in the world, and diversity within a single crop and within a single field is a logical corollary of the variety of the world around them. From this perspective, the question of diversity may only be asked indirectly by examining why farmers don't eliminate diversity in favor of a single type of potato, improved or native. This question is less absurd to Andean farmers, but it asks them to speculate about something which they don't usually do.

Farmers in the Tulumayo and Paucartambo valleys have not eliminated diversity because they don't perceive any advantage to doing it and because there are advantages to keeping their mixed collections of native potatoes. Improved varieties don't taste very good, so they are not likely candidates to replace native varieties, and no single native variety meets everyone's criteria for best taste or best for exchange, gifts, or sale. Diversity is a pleasure in its own right when sitting down before a bowl of potatoes as the primary food at a meal. It is common for people to eat 20 to 30 potatoes at a single meal, and it is much more interesting if every other potato is a different variety. Diversity is akin to a condiment, like hot peppers, making meals more interesting. Naming often provides for word games that enliven meals. Some names are clearly evoked by the tuber's characteristics: pink, flat, and oval (cow's tongue, ***wacapahallum***), cylindrical with eyes clustered at one end (cat's nose, ***mishpasingu***), or a mottled, rounded oval (condor egg, ***condor runtu***). Other names evoke places, perhaps where the variety originated (e.g., ***Curimarca***). This nomenclature is rich in Andean wit, irony, and iconoclasm. We find such folk varieties as "priest's ear" ***(kurapalingling)***, as seen through the confessional screen; another is "dog's vomit" or "dog's stomach" ***(alcapapanzan)*** in Quechua, glossed to "Peruvian flag" in Spanish.

When queried about replacing mixed native varieties with improved, higher yielding ones or selected native types, farmers point to two things that encourage diversity. First, there is no need to make such a simplifying replacement in the diverse Andean landscape. They cultivate potatoes in several fields each year, and in an Andean variant of agricultural involution, they always find space and time for a few native potatoes. Farmers of the Tulumayo valley have reduced this to a very small portion of their fields, but they maintain a high amount of diversity on this small portion. Enough potatoes are produced to satisfy local needs, and the market is often saturated with potatoes during the main harvest. They complain that they lose money on the potatoes that they do sell (Mayer and Glave 1990). Thus there is no incentive to squeeze out the small fields of native potatoes for food or commerce.

Second, the collections of mixed native potatoes are perceived as a resource by farmers who are economically marginalized. Mixed native potatoes are associated with traditional Andean agriculture and culture by subsistence and commercial farmers, by Quechua and *mestizo* farmers, and by urban consumers. Native potatoes are grown in the most marginal of areas by marginalized farmers. Like other material elements of Andean culture, such as weaving, their value has been inverted in the Andean kaleidoscope (Isabell 1978), that at once depreciates and values items of traditional culture. Products of a humiliated group, native potatoes command premium prices in regional markets, such as Cusco and Huancayo, where they have been elevated to the status of an artisan crop. Within farming communities, native potatoes are also appreciated, perhaps as much for their cultural significance as for their superior flavor. They are favored gift items, and in a rural economy that is increasingly short of labor, they are used as added incentives by landowners to attract workers.

Wholesale merchants who purchase native potatoes have a narrow concept of diversity and prefer the one or two varieties that have won widespread appeal and recognition. However, the flow of diverse native potatoes to urban markets is sufficient to bring new native varieties to the attention of consumers and merchants alike. Periodic "booms" in demand for specific varieties are sufficiently common to be an incentive for farmers to keep diversity as a source of seed. The spread of the ***huayro*** variety from the central highlands to the Cusco region and the local appearance of ***olones*** (Franquemont et al. 1990) fit this pattern. The difficulty in multiplying seed rapidly and ambiguity in folk taxonomy are reasons farmers prefer to keep their own inventory of varieties rather than relying on exchange or the market place.

CONCLUSION

This paper has explored the persistence of diversity in Andean potato agriculture. The ethnobiology of the potato crop emphasizes diversity at the infraspecific or variety level. Andean categories such as production zones ***(maway tarpuy*** and ***hatun tarpuy)*** and types of potato (dry, ***miski papa***; watery, ***uno papa***; boiling, ***wayk'u papa)*** all contribute to this emphasis. This case study is representative of several others on the maintenance of traditional crops in centers of agricultural origins in the face of economic and technological change in agriculture (Boster 1985; Brush et al. 1988; Dennis 1987; Richards 1985). These studies document the resilience of traditional crops, like the cultures that have produced and nurtured them.

We might imagine two alternative futures for traditional Andean potatoes from the above analysis. On the one hand, there might be a gradual encroachment of improved and uniform native varieties under the inexorable pressures of population growth and incorporation into regional market systems. The impact of this encroachment is to shrink the area devoted to mixed native varieties, and this impact is evident in the comparison between the Tulumayo and Paucartambo valleys. The small area of mixed native potatoes with its tremendous diversity may be the last remnant of a waning agricultural system, whose replacement is already present. Ultimately, the area of native potatoes might shrink to nothing, thus completing the biological transformation of Andean agriculture that began with the European conquest 500 years ago. On the other hand, the continued presence of traditional potato area and diversity may be interpreted as biological evidence of the tenacity of Andean cultural elements in the technological polyculture that has existed since the European conquest.

Assuming that market incorporation, demographic growth, and technological innovation will continue and increase, the replacement hypothesis is plausible. However, the persistence of diversity in the Tulumayo Valley, at even a higher level per household than in Paucartambo, suggests that the Andean tradition of diversity will survive. The disappearance of traditional crops and of diversity has been predicted by theorists of very different persuasions (e.g., Hawkes 1983;

Fowler and Mooney 1990). Like the predicted demise of peasants, the eclipse of diversity is confounded by the complexity of the tropical world and by the actions of the inheritors of ancient farming traditions. Maintaining crop diversity echoes the survival of Latin American peasantry in the face of major structural change (de Janvry et al. 1989). Many factors dampen the predicted erosion of traditional potatoes in the two valleys described here. While the pressures of the adoption of modern varieties, market penetration, and population increase are significant, so too are cultural, economic, and environmental factors that buffer their impact. There is no single axis on which to chart the fate of these genetic resources as farming systems change. What seems to be predictable is that farmers will continue to be active agents in conserving the material base of their Andean agricultural legacy.

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BOOK REVIEW

Plants for People. Anna Lewington. New York: Oxford University Press, 1990. Pp. vii, 232. $40.00 (hardbound). ISBN 0-19-520840-4.

With the welcome proliferation of economic botany courses in junior colleges and extension courses, there is a need for nontechnical books. *Plants for People* in many ways answers this need. With its friendly, conversational language its presentation succeeds in reaching the nontechnical reader yet it offers reliable data necessary for a broad understanding of people's dependence upon useful plants. There is, in addition, much material that frequently will be of value to the trained botanist who undertakes to teach economic botany but whose specialties in the plant sciences may be unrelated to mankind's utilitarian interests in the world's vegetation.

The book is organized into seven sections:

1. Starting the Day (soaps and cosmetics in general). An interesting technique is seen in the discussion of cosmetic color: a cosmetician painting a girl's lips on one page and a South American Indian whose face is completely painted with achiote on the next page. This kind of fascinating comparative illustrative presentation is common in the book and is used very effectively.
2. Keeping Us Covered. This section concerns primarily fiber, dyeing and printing, and various parts of clothing.
3. From First Foods to Fast Foods discusses an interesting variety of material which can be taken into the stomach, from our major food plants to Amazonian cow trees, coffee and tea, plant foods for different peoples (rain forest and desert dwellers), and ending with future foods.
4. House and Home—Plants that Protect Us. This section concerns various wood, thatch, rattan and sundry stems for furniture and wickerware, linoleum, bamboo, and even plant materials used in rain forest dwellings.
5. Your Very Good Health—Plants that Cure Us treats many species valuable for a wide spectrum of ills and discusses plants from the family medicine chest, medicines in the hospital, and the rain forest pharmacy.
6. Getting Around—Plants that Transport Us spans a broad consideration from rubber in its numerous uses, tree trunks and reeds for boats and canoes, construction of docks, and plants for future fuel.
7. Recreation—Plants that Entertain Us includes paper for words and pictures, papyrus, wood pulp, plants for inks and dyes, the camera and plants, and plants in musical instruments.

This list is far from a complete enumeration of the incredible types of employment that the Plant Kingdom offers and that are discussed in these seven sec-