Land use in the Andean region of Ecuador

From inventory to analysis

Pierre Gondard

The land use inventory is a suitable method of approach for understanding an area's current situation, but it runs the risk of fixing knowledge at a given moment. The desire to follow evolutionary patterns and to understand dynamics leads to it being overtaken. The accent in this article on land use in the Andean region of Ecuador is placed above all on heuristic complementarity with the social and agronomic sciences which hold the keys to understanding the principal evolutions taking place.

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The prime defects of 'classical' land use surveys such as those of the British Land Utilization Survey were, first, that they were carried out at a large scale, thus requiring considerable (in many cases largely unpaid) labour and, second, that they were static overviews unsupported by any formal means of monitoring change. It was the realization of these defects, together with the impracticability of using labour-intensive survey methods in often remote and barely settled regions, that led Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) to undertake the development and successive refinement of methods of land resources inventory of which land use surveys were part. Elsewhere similar cost-effective methods were evolved – in the US by the Department of Agriculture working from the standpoint of soil conservation, and in Canada (during the 1950s) with the objective of rural zone planning backed by legal sanctions. Subsequently, via inter-American organizations, land inventories were similarly developed in South America: ONERN in Pêru, 1962; COPLANARH in Venezuela, 1968; CETENAL in Mexico; RADAM in Brazil, 1970; ERTS Bolivia in Bolivia, 1974; and PRONAREG, founded in Ecuador in 1973. In Ecuador the 'National Programme of Agricultural Regionalization' is but one part of an inventory of renewable natural resources undertaken by the Ministry of Agriculture and Livestock in 1973–74.[1]

Ecuador's inventory shares a number of characteristics with those of other countries which have undertaken wide-ranging national inventories. A particular characteristic is the importance accorded to the physical environment as the prime object of study. Second, in terms of method, data are acquired through aerial photography and photo interpretation and the results are then expressed by cartographic techniques. These two fundamental characteristics are both found in the land use inventory of the Andean region of Ecuador.

It is, however, important to underline one of the survey's great weaknesses, which in fact is intrinsic to the genre itself. The inventory has a tendency to solidify an image of reality on paper, when in reality

[1]This inventory is supported by the French government through ORSTOM, the government's organization for overseas scientific and technical research.

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the countryside is in perpetual transformation. Is it possible to represent an evolving landscape, when we see only its current form?

Land use survey

Four factors appeared essential to the Ecuadorean land use survey as they were true determinants of land use type: slope, precipitation, fine-grained volcanic materials and a form of human exploitation characterized by little concern for environmental consequences, the result of which is soil erosion. Paradoxically, the population density, although important, received less attention. The greatest densities can be found in the maize-growing zone or in the barley–potato zone and since these are generally occupied by Indians there is a correlation with size of holding which has already been taken into account.

The survey was made both effective and rapid – it was necessary to work quickly to cover the 80 000 km^2 area – by focusing on those factors most easy to observe in the landscape. This implied important methodological choices in the use of air photo coverage. The direct identification of crop patterns, still less the cultural associations on the aerial photographs, were not possible due to inadequacies of scale (between 1:45 000 and 1:70 000), variation in the dates (season and year) of photographs, and the differing flight lines. Instead, research focused on the images of the determining factors mentioned above. Their analysis permitted the delimitation of physiographically homogeneous areas which at first sight appeared to be homogeneous in land use. It should be noted that the soil characteristics were not examined directly. Formed on relatively homogeneous parent materials of volcanic origin, their spatial variation is linked to local differences in climate, derived largely from elevation, which was already taken into account as the first major factor of variation in land use.

Map series

A series of maps resulted from the land use inventory. The first series, at the scale of 1:50 000, comprises 128 sheets which cover all but the unutilized lands of the exterior slopes of the Andes. In this map series the determining factors are emphasized in order of importance and regrouped as a function of the percentage of the occupied land in each class. The provenance of these results is the ground survey which verifies or corrects the details of photo interpretation and records the agricultural patterns of the homogeneous zones. Thus the maps do not bear upon a particular point in space but translate into cartographic form the overall situation in each zone.

These maps reflect the terrain with quite considerable precision and in recent years they have been of much use in planning projects or agricultural developments which have been undertaken in Ecuador. They have been used in the creation of irrigation zones, the opening up of new roads, in drainage basin planning and in organization and production. They constitute a key document in field study. This inventory-based map series served as the direct source for two further series.

The second series of thematic maps is on a scale of 1:200 000, and is reworked from the basic data on the 1:50 000 maps. Each map emphasizes one of the determining factors or a single land use, so there

are maps of erosion, irrigation, large holdings, a map of utilized land in contrast to areas in natural vegetation, and finally a map for each major crop – maize, wheat, grassland, coffee, etc. The study area is covered in 11 sheets and for each sheet there are some 15 thematic maps depending upon the crops present. These maps were prepared to correspond to the immediate needs of the Ministry of Agriculture, which has a very segmented organizational structure with, for example, separate programmes for coffee, bananas, cereals, and forests.

The third cartographic series is also on the scale of 1:200 000 and this is the series in which land use types are emphasized. From the scientific and geographical points of view this map series is the most interesting, and acts as a forum for interdisciplinary analyses. The demographer Daniel Delaunay was involved in the analysis of population change in terms of the pattern of the most representative types of land use. Early discussions with the survey group sociologist or economist had shown co-workers the choice that is available in this zonation for the initiation of spot enquiries.[2] (A map of general land use in the Andean region of Ecuador is shown in Figure 1.)

Proposals for new land uses (maps of suitability or of potential) prepared by agronomists of the Ministry are predominantly based upon the data collected on the physical environment, together with knowledge of the present land use and the determining factors already discussed – in particular the influence of farm-plot dimension or technical management, and the social approach to problems.

Of the three cartographic series, the map of land use types and vegetated landscapes is the most rich; it is a synthesis of observations on the physical environment as used by man. To gain insight into the elements mapped at the 1:50 000 scale and the functioning of the types presented, new surveys and consequently further research have been necessary. Thus have premisses of the definition and cartography of agricultural production systems been tackled.

Capturing land use change

The cartographic representation of present land use that resulted from national inventories has a strongly marked static character. How can one capture and explain the movement which perpetually transforms systems of production when cartography only produces a picture of a given moment?

Dynamism can be seen in particular agricultural production systems, and it is important that they be shown as such on the maps. These type of maps endeavour to encompass the major changes. Analysis of maps of particular systems permitted the identification of zones with fringes of forest clearance and underline the great stages in the colonization of new lands because they are both visible in the landscape and observable on aerial photographs. That is a start, but is not fully satisfying. How can the underlying mechanisms of land use change be shown?

Are the mechanisms of land use change due to economic driving factors, such as prices on international and national markets? Or is it a question of dynamism engendered by demographic growth, the impact of political leadership, the status quo, or agrarian reform, or agrarian reform combined with the colonization of new lands or the subsidy of certain products? It is not possible to map these phenomena directly because their consequences can only be seen via the spatial transforma-

[2]This point has been taken up in another paper, 'Du paysage à la planification', in a collective work from Laboratory 96 of CRNS and ORSTOM, *A Travers Champs, Agronomes et Géographes*, éditions de l'ORMSTOM, Collection Séminaires et Colloques, Paris, France, 1985, pp 265–288.

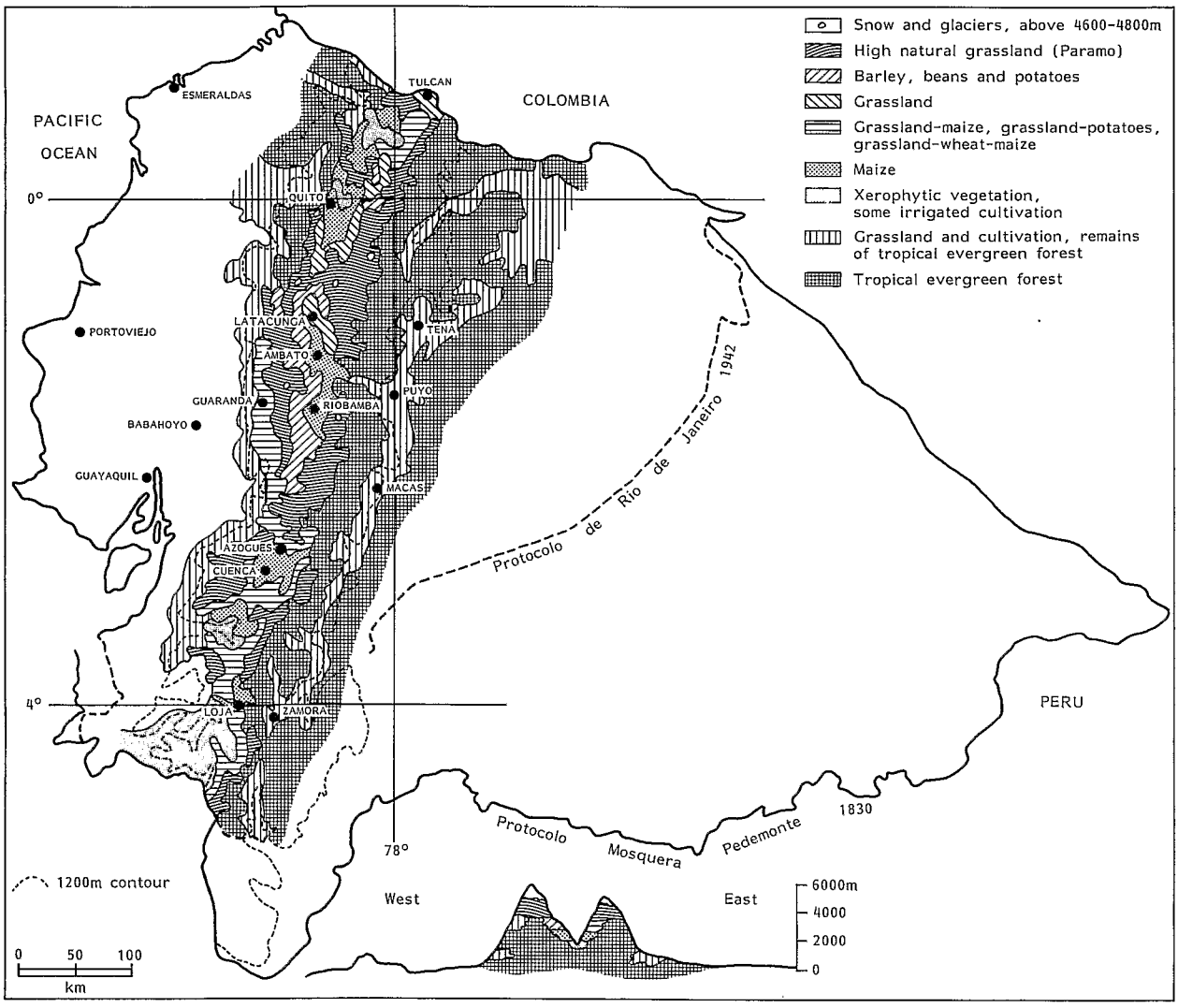

Figure 1. General land use map of the Andean region of Ecuador.

Notes: Land use in the Andes of Ecuador can be described in a very general theoretical way as a pattern of concentric rings of terraces rising on either side of low valleys within the Andes, with a hot, dry climate. The accompanying map shows the variations of this scheme from one valley to another.

The first level, at the bottom of the valleys, can only be cultivated with irrigation. Only flat or slightly sloping surfaces can be used. Extension of irrigated areas is limited by the mountainous relief. Because of the lack of any significant subsidence, there is no first level in Ambato, Riobamba or Cuenca. North-east of Quito it is reduced to a number of 'oases'. At Ibarra (to the west of Loja, south-west of Cuenca) the traditional main crop is sugar cane, which has difficulty competing with the large plantations on the coast. Low, open, thorny plant formations cover the uncultivated land. These become thickets and Acacia forests where the soil is deeper and vegetation is preserved. The area south-west of Loja is covered with a vast dry Ceiba forest.

The second level corresponds to the tier of high-altitude maize, a crop that largely dominates on the small properties of the middle valleys. Population densities of more than 200/km^2 are frequent (south of Ibarra). National demand has led to a rapid increase in the number of orchards of temperate fruits (apples, pears, peaches, etc, at Ambato) and in market gardening (at Riobamba and to the south of Quito). Land reform has accelerated the parcelling out of the *latifundia*. On large and medium properties, dairy farming is carried out on irrigated artificial meadows (Tulcan, south of Quito, Latacunga). Quickset hedges of *Eucalyptus globulus* characterize this landscape of mixed woodland and pasture land. In most of the valleys, except in the central zone, the amount of maize grown decreases above 2800 m, a fringe of meadows on large estates appears, and there is a patchwork of meadows and crop growth on small properties: meadow and maize at Cuenca, a warmer zone; meadow and potatoes at Tulcan, a colder zone; meadow and wheat at Guaranda, a zone with a *mestizo* population. These zones are generally wetter, with a lower population density, and have only recently been occupied or reoccupied. Here pioneering is accompanied by the most vigorous clearing of the only remaining woody vegetation within the Andes. In the driest areas, maize monoculture rises to an altitude of 3100–3200 m.

The third level corresponds to mountain farming systems with crop rotation based mainly on barley, beans and potatoes. This level extends from 3100–3200 m to 3600 m, and sometimes to 3900–4000 m (to the west of Latacunga), but only on the western cordillera of the large central basins and in several isolated areas to the north of Quito. The population is almost exclusively Indian. The landscape is open, without trees, and the fields form a regular and dense patchwork on the very steep slopes. The last traces of woody vegetation disappeared some time ago. The upper limit is constantly modified by strong population pressure, and also by the release of some land by agrarian reform. There is active clearing of the lower fringes of the paramo (natural high-altitude meadows).

The fourth level consists of the high meadows of the paramo, the largest of which are in the central Andes. Here, extensive sheep raising is carried out. Vast plantations of *Pinus* (*patula* and *radiata*) are now being developed. Above 4600–4800 m this level is characterized by large volcanic structures with glaciers. *The outer slopes* of the north-western and eastern Andes are still mostly covered by dense evergreen forest. Elsewhere, pasture land occupies an ever-increasing area. The most extensive clearing operations are localized on the western slopes and the Amazonian piedmont, along the main highways. This generalized deforestation is resulting in active and severe erosion, with alarming consequences for future land use.

tion of the agricultural landscape. Another example is the profound impact that the recent decline of the petroleum industry has had on agriculture. Cartography is the preferred method of expression in the study of land use, but in its present form it is more than a little static in nature.[3] Because of this fundamental limitation, the cartography of present land use generally falls into one of the two following classes – maps of land use in the strict sense and maps of the evolution of land use.[4]

Transformations of land use in Ecuador

Certain tendencies in land use change can be identified throughout the region, and this is the point of departure for a new consideration which demands another mode of inquiry centred upon collaboration with the social sciences.

Pioneer fringes

Pioneer fringes occur in Ecuador where the edges of great plant formations, until recently little touched by agricultural activity, are being nibbled away at an increasing rate. This type of fringe area develops in two main locations: (1) the dense evergreen forest where people are descending into the plains and Andean foothills; and (2) in high-altitude grasslands, where there is an ascent into the cordilleras. Whereas the first process is quite common in tropical areas of South America, the second seems most exceptional because the highland environment is now more usually the object of abandonment than reconquest. Numerous examples can be given in Ecuador of this general expansion of the inhabited world at the expense of the saltus or of the selva.

Earlier studies have shown that in the 15th century the inhabited areas of the northern Andean region in Ecuador were probably more extensive than at present. Thus there has been a regression, and now a period of expansion has once again arrived. This could explain the spatial variation of the population: there was a decline during the colonial period and pacification, with settlement of the indigenes in large regroupment villages; this was then followed by contraction on the ground followed by growth to the present day. The population of Ecuador has grown from 6.8 million in 1974 to more than 8.5 million in 1982. Between 1962 and 1974 growth was even faster, at 3.3% annually. Thus, despite real technical advance, the pressure upon land became more marked. Where holdings were particularly small, emigration towards the towns or other lands occurred. Movement to new lands, however, is possible only where accessible reserves exist.

Accessibility cannot be discussed merely in terms of physical factors. Although the role of Amazonia in Brazil or of the opening up of routeways for petroleum development in the north-east of Ecuador[5] is undeniable in the development of the regions concerned, it is also necessary to take into account legal accessibility. Forested lands may be considered 'open lands', *tierras baldias*, of which the state may – in the manner of colonial concessions – give away rights of ownership whilst ignoring the rights of Indian communities for whom the best of the reserves have been agreed. Thus accessibility is also rooted in the law of colonization. This has simultaneously legalized and provoked a movement towards the foothills, a movement which had existed earlier but was numerically of little importance.

[3]The development of information science (cartography and computer-assisted graphics) opens new perspectives for research, not only because of the possibilities of data storage and treatment, but also because of the evolution of cartographic support which no longer needs to be printed on paper. Magnetic tapes and cathode-ray screens give much greater flexibility in the continuous dynamics of evolution and in simulation.

[4]Of particular note is Pierre Brunet, 'Map of change in French rural space, 1950–80', a paper presented at the International Geographical Congress, Paris, 1984.

[5]Henri Barral, *Informe Sobre la Colonizaciòn en la Provincia del Napo y las Transformaciones en las Sociedades Indigenas,* MAG-ORSTOM, Quito, Ecuador, 1978.

The rise of settlement towards the mountains and in the inter-Andean couloir derive equally from population growth. Here the agrarian reform law forms the legal basis of accessibility. The wide expanses of high-altitude grasslands, the *paramo*, used as very extensive grazing lands by the haciendas, have been cut up, divided and assigned privately to the peasants in the form of cooperatives. The land use transformation is immediate – almost total clearance of the land and widespread, immediate ploughing. Cultivation replaces herding. Thus the high-altitude system of cultivation, based upon the rotation of potatoes, beans and barley with subsidiary sheep and goat rearing, is extended.

In the older systems, the main purpose of flocks was to provide wool and also to transfer fertility from the grasslands at higher levels to the ploughlands. The association between herding and cropping is less carefully articulated in the new system, for it appears less necessary. Soil fertility is important and spectacular yields are achieved in the initial years of cultivation. Such yields trigger an acceleration in its wake. These pioneer systems are, in a manner of speaking, 'mining' systems since they succeed by the extraction of reserves accumulated by the natural environment.[6]

Afforestation

Over the last 12 years the afforested area has grown very rapidly and thousands of hectares have radically changed their land use. Some of these lands were 'sterile' and eroded; others have been transformed from high-altitude grasslands and sometimes even from cereal cultivation to forestry. Much of the interest in forestry has come from large landowners who wish, by means of a stable form of land use, to assure their properties against the risks of the agrarian reform. Interest also derives from small farmers who plant trees on the margins of fields and along the roads to form wooded thickets, as well as from Indians who replant newly abandoned and eroded slopes. Environmental pressure groups have developed which are concerned with the promotion and stimulation of afforestation. The combination of these interested parties has created a strong movement. However, while they reinforce each other, they do not rule out the cutting of mature forests and the woodland or scrub formations which as yet remain spared in nooks and crannies of the Andes.

Is the issue truly that of reafforestation or better still 're-creation of forest' ['reforestation'] as the Spanish terminology has it? Single-variety forests of *Eucalyptus globulus* or of pine (generally *Pinus radiata* with *P. patula* on the red soils of the southern Andes) replace the high-altitude formations, comprised of a variety of species, which are not possible to reproduce artificially and above all are less advantageous to exploit. The swing, moreover, is not from natural forest to planted forest but rather from natural forest to cultivation. It is consequently lands despoiled of their soil by inappropriate cultivation practices that are afforested, at least in the high temperate zone. On colder terrain afforestation is carried out on high-altitude grasslands which are thus withdrawn from stock-rearing or agrarian reform and, in the medium term, from cultivation.

There is a serious need to assess the wider pattern of each of these land uses. The first element in such a comparison would be the natural (or, as in Peru, improved) high-altitude grasslands. Such lands can support extensive stock rearing (or semi-intensive, if improved) and

[6]A brief remark needs to be made concerning the altitudinal limit of cultivation. Although it cannot be identical in all places because of local climatic variation, it has been seen to have risen in those areas where it was already high. It now reaches 3700–3800 m in several regions and even exceeds these limits in several places.

they ensure a reserve of moisture. Oldeman has compared them to a sponge in their role in accumulating moisture and regulating shortfalls. The second element is the forest. Its function as a hydrological regulator in the temperate environment is largely acknowledged; but what is its role in tropical uplands in terms of radiation, potential evapotranspiration, etc? Its presence excludes stock rearing, but what is its future for lumber, as fuelwood, as pulpwood or in land stabilization? Finally, agriculture is the third element in a regional comparison. Is the system one of peasant-based polycultures or plantation? Are soils being degraded because of 'mining' of mineral constituents, or does the system result in conservation? Towards which of the three major usages – pastoral, silvicultural or cultivation – should planning be oriented?

Dairying

A further major land use change has been brought about by the development of dairying, now a general phenomenon in the Andes of Ecuador. It began on haciendas at the beginning of the century[7] and has not been dissociated from them despite growth of the urban population, changes in life styles and dietary patterns which accord an important place to milk products, or by the agrarian reform. As they rid themselves of marginal lands, the haciendas undertook a profound technical revolution. This was marked by a relative or total abandonment of cultivation in favour of dairying, the development of which was supported by significant capital input. The increase in demand has given weight to the dairying lobby which has laid claim to price increases in order to recoup their investments and to ensure a good margin of profit for producers. Between 1973 and 1982 the price of milk at the point of production rose from two *sucres* per litre to eight.[8]

Faced with stability in prices of other agricultural products, small farmers have also begun to promote dairying. This movement has not yet been studied. However, it does not provoke a spectacular reorientation for it is done without the heavy equipment of the large properties. The purchase by the haciendas of half-bred Holsteins to improve or replace the indigenous breeds, and the use of appropriate veterinary medicines are amongst the major technical innovations. Stock rearing is tied to the consumption of crop by-products, eg maize stalks, but these are no longer sufficient to support the growing number of animals. Grasslands have been extended to the detriment of ploughland as there is a general diminution in the production of wheat, cereals and legumes. With wheat, other factors equally come into play.

The decline of grain lands

The diminution in areas sown to wheat has been particularly marked during the 1970s. The area sown fell from 99 000 ha in 1968 to 27 000 ha by 1979, and 90% of national consumption was covered by imports. What caused this abrupt fall? The first consideration is the profit margins of producers; these have fallen. The state fixes the selling price each year but the costs of production – fertilizer prices in particular – have grown more rapidly. The shortfall is explained by the political decision to keep the price of flour at a relatively low level, below the cost on the international market. Certain of the millers were able to purchase the total national wheat production, but even though this gave higher returns than that on the international market it was poorly remunerated. Other pertinent reasons appear in the extension of

[7]Oswaldo Barskey and Gustavo Cosse, *Tecnologia y Cambio Social – Las Haciendas Lecheras del Ecuador*, FLACSO, Quito, Ecuador, 1981.

[8]Over the same period the US dollar rose from 25 to 39 *sucres*.

pastures to support dairy development, or in the expansion (and thus the competition) of barley (which is destined for brewing).

These lines of research have not been followed further. Nevertheless, field work has shown a relative persistence, or at least a minimal diminution, in grain lands in the northern Ecuadorian Andes. How is this persistence justified? A rapid survey amongst wheat growers and workers in the Ministry of Agriculture's cereals programme provides two probably complementary answers. On the one hand there was the powerful attraction of the black market directed towards Colombia where the price of wheat was much higher due to differences in exchange rates of the two currencies. The buyer would come right to the producer's field to lift the grain and pay significantly above the local price. On the other hand the relative maintenance of wheat is also explained, paradoxically, by the cultivation system in the region, which gives preference to potatoes. Highly remunerative, though fertilizer-intensive, potatoes receive heavy doses of fertilizer which still benefit the grain crop in the following year within the context of crop rotation. The manuring of wheat, which appears to producers in other regions as a major handicap, is here not considered a constraint since interest in wheat remains supported by the appeal of a neighbouring market.

In 1984 the decision to double the production price of wheat set sowings free and an expansion of the area under wheat was observed. It is still necessary to re-emphasize the difference between the large enterprises which respond very rapidly to market influences and the small holdings on which the response is slower.

Conclusion

The present land use inventory in the Ecuadorian Andes has had to be adapted to particular conditions of the physical and human environment. The survey was able to present results with greater precision than is usual in similar studies. Nevertheless it was a static study, although it served to underline the difficulty of accounting for evolutionary situations in an inventory. Maps, based upon remote sensing, were the chosen instrument for the inventory, although they can give no more than a picture of a given moment.

The understanding of changes is more complex, for here a great many factors are involved. In this situation the inquiry is the preferred instrument. There is a great complementarity between land use zonation, which delimits space affected by the same phenomenon, eg forest clearance, and the inquiry which explains it. This multidisciplinary inquiry – encompassing agronomic, demographic, social, economic, legal and political factors – gives the land use inventory its full dimensions. In the examples which have been given here, the multiplicity of the causes of land use change have been emphasized. Perhaps their deep roots in the past have been masked by the considerable attention given to the present. The transformation of some haciendas into agroindustrial complexes followed the adaption of latifundios at the end of the last century and was related to the opening of the Sierra railway. The mountain region is becoming spatially less fragmented. National settlement now is spreading to the coastal plain where the cocoa boom is in full swing. The novelty today is the beginning of spatial integration of the Amazonian region which up to this point had been marginal. The study of local land use changes thus returns to the society which creates them and transforms its habitat.

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