

Market Incorporation, Agricultural Change, and Sustainability Among the Machiguenga Indians of the Peruvian Amazon

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By marshaling empirical data from five Machiguenga communities studied over 20 years, this paper disputes two common assumptions about the behavior of indigenous peoples in the face of increasing commercialization. First, many Amazonian researchers suggest that the social and ecological deterioration confronting native populations results from externally-imposed political, legal and market structures that compel local groups to pursue short-term, unstable economic strategies. Second, these structural explanations are combined with the increasing recognition that indigenous peoples possess a substantial agroecological knowledge to suggest that, if indigenous people receive control of adequate land and resources, they will implement their traditional knowledge in conservative resource management practices. In contrast to these assumptions, this analysis shows that the Machiguenga are not compelled by external forces (such as land tenure, migration policies or economic trends), but instead are active enthusiastic participants seeking to engage the market in order to acquire western goods. Further, despite highly adaptive traditional subsistence patterns and a vast agroecological knowledge, households and communities facing increasing degrees of market integration are progressively altering their traditional cropping strategies, planting practices, labor allocation and land use patterns toward a greater emphasis on commodity crop production and domesticated animal breeding. This increasing concentration on income generating activities subverts the environmentally-friendly nature of traditional productive practices and creates a socially, economically, and ecologically unsustainable system.

KEY WORDS: commercialization; deforestation; sustainability; Machiguenga; markets.

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INTRODUCTION

Many Amazonian researchers insist that the social, economic, and ecological deterioration confronting indigenous peoples results from the inexorable process of capitalist market expansion. Indigenous peoples seem compelled by externally-imposed political, social, legal, and economic structures to pursue short-term, unsustainable economic strategies that inevitably lead to escalating rates of environmental destruction, malnutrition, economic dislocation, and social inequity (e.g., Clay, 1992; Hecht, 1992; Durham, 1995). Governmental policies relating to land tenure, resource access, and colonization, often viewed as the tools of conspiring politicians, industrialists, multilateral aid organizations and transnational capital, often stand as the proximate cause of these problems. Undoubtedly these factors, and combinations thereof, do provide valuable insights into the plight of indigenous peoples. But too much emphasis on these exogenous factors has neglected the degree to which indigenous peoples, who are increasingly gaining access to land and environmental resources, actively and enthusiastically engage the market by making economic decisions intended to expand commercial participation.

Accompanying such structural explanations, development researchers, responding to commercialization and the ineffective—often disastrous—imposition of Western agricultural models, emphasize the importance of researching and deploying the vast storehouse of time-tested indigenous cultural knowledge to solve the problems of tropical land and resource management (Richards, 1985; Eden and Andrade, 1987; Bunyard, 1989; Posey, 1993, 1985). By combining explanations related to land and resource access with the revalued emphasis on indigenous agroecological knowledge, many assume that if indigenous people receive control of adequate land and environmental resources they will implement their traditional knowledge in conservative and sustainable management practices (Bodley, 1990, p. 2; Redford, 1991, p. 47; Padoch and Pinedo-Vasques, 1993, p. 10). However, other researchers have shown that indigenous groups are not consciously conservationists, but that at low population pressure they employ technologies and food procurement strategies to meet simple needs, which inherently conserve land and resources (Johnson, 1989; Wilken, 1989). Because much of this cultural knowledge is integrated and retained implicitly in behaviors, beliefs, and world views, rather than the cause-effect form typical of western science,²

²This not to say that indigenous groups never understand things in this manner. Much of their knowledge is produced through experimentation and empiricism, but behaviors and beliefs related to the often gradual, sometimes imperceptible, process of environmental degradation tend to manifest themselves implicitly in ideas and practices adapted over generations.

some indigenous groups may find their old ways or traditional practices inapplicable, or difficult to apply under the radically altered circumstances of global commercialization (Behrens, 1989). The value of such indigenous knowledge and the effectiveness of its related practices cannot be underestimated. However, native groups possessing title and access to significant land and environmental resources, but also desiring increased access to market goods and facing the potential for greater market participation, do readily pursue destructive courses of resource mismanagement, despite their vast cultural knowledge of sustainable productive practices (see Hammond *et al.*, 1995, for an analysis of a market-oriented change in swidden-fallow management among the Ticuna).

Among the Machiguenga Indians of the Lower Urubamba region, the increasing availability of commodity markets combines with an escalating desire for market goods to rapidly transform traditional patterns of subsistence and resource use into a highly unsustainable mixture of commodity and subsistence production. The Machiguenga's desire for income to buy such things as wristwatches, shotguns, pocket knives, cooking oil, antibiotics, and blue jeans (the list goes on and on) leads them to expand and intensify commodity production, while simultaneously seeking ways to gain greater market access.³ Household and community economic decisions, intended to raise surplus production by altering traditional practices, have produced an economically, socially, and ecologically unsustainable system.

The first part of this discussion demonstrates through both survey data and individual voices, the Machiguenga's interest and drive in pursuing market contact, expanding production, and pushing for acculturative changes (roads, electricity, plumbing, etc.—none of which presently exist in the region). In the second part, I describe and analyze the social, economic, and ecological impact of the Machiguenga's efforts to increase commodity production and market participation. By contrasting communities which, because of geographical or temporal differences, have experienced differing degrees of market incorporation, my analysis reveals how the commercialization process progressively alters settlement patterns, labor allocation, resource consumption, and land use. The analysis and projection of these trends suggests a rapidly deteriorating degree of sustainability.⁴

³Along with commodity crop production and domesticated animal breeding, many Machiguenga have also begun participating in wage labor and cottage craft. Currently, the impact of these activities, in terms of time and money, remains small and is therefore neglected in this paper.

⁴Systems are rarely "sustainable" or "unsustainable"; the less sustainable the system, the more rapidly current trends are leading to system failure, and the more extreme the changes or actions necessary to avert failure.

BACKGROUND

The Machiguenga are an Arawakan-speaking people inhabiting the lower and upper regions of the Urubamba river and its tributaries, Manu National Park, and the Madre De Dios region of southeastern Peru (see Fig. 1). Traditionally Machiguengas live in scattered single family units or small extended family hamlets that subsist on a combination of hunting, fishing, gathering, and horticulture. Crops cultivated in slash and burn gardens supply most of the Machiguenga's caloric intake. These small polycropped plots, maintained for only a few years, produce primarily sweet manioc, maize, bananas (depending on the region), as well as other minor crops (Camino, 1979; Johnson, 1983, 1989; Baksh, 1985, 1984; Johnson and Baksh, 1987).

Currently Machiguenga communities span a spectrum of productive systems ranging from those still practicing traditional lifeways in Manu Park and regions of the Upper Picha to those wage laborers who experience near constant market contact in the Catholic Missions of the Upper Urubamba. Understanding the present situation of these diverse communities, and particularly the independent farming communities Shimaa, Camisea, Mayapo, Camaná, and Nuevo Mundo (those examined herein), requires examining the historical forces which preceded land entitlements and the rapid commercialization of this region.

Market Contact with Incan Empire

The Machiguenga have maintained exchange relations with highland groups at least as far back as the Incan Empire. In exchange for metal tools, Montaña Indians exported coca leaves, feathers, animal skins, hardwoods, monkeys, pineapples, medicinal plants, vegetable dyes, and spices. Missionaries report finding Incan bronze axes in regions long inhabited by various Machiguenga groups. In fact, the Machiguenga cannot recollect ever fabricating stone tools, suggesting a long history of exchange with more complex societies (O. Johnson, 1978, p. 32). Note however, these limited exchanges do not begin to compare with the global market's seemingly infinite quantity of trade goods and limitless demand for certain commodities.

The Rubber Boom

During the rubber boom, a period spanning approximately 1870-1912, slaving raids led by Machiguenga-born headmen working for local rubber patrons captured entire families and drove hundreds of Machiguenga into the remote headwater regions of the Urubamba's tributaries (Camino,

1979, p. 138). Hundreds, possibly thousands, of Machiguenga were enslaved and forced into latex extraction labor during this period; most eventually died of infectious diseases, mistreatment, or malnutrition (Davis, 1994, p. 81). Only in the last 35 years have families begun re-inhabiting the more accessible areas that lie along major waterways. Some traditional Machiguenga still retreat at the sight of individuals wearing Western clothes.

Shock waves from the rubber boom would be felt by the Machiguenga for decades after 1912. Filling the void left in the wake of the rubber patrons' departure, the Dominican Catholic Order began establishing missions. These Catholic missions initiated the process of sedentizing and educating the Machiguenga that the Summer Institute of Linguistics would eventually come to dominate (O. Johnson, 1978; Camino, 1979; Rosengren, 1987).

The Summer Institute of Linguistics

Undeniably the Summer Institute of Linguistics' program of community creation, proselytization (or Bible translation), and bilingual education shaped the initial stages of the commercialization process experienced by most Machiguenga. In the late 1940s, SIL began aggregating families who wanted increased access to Western medicine and Western technology into small community clusters. Soon, the institute's missionary-linguists began translating the New Testament and encouraging cash crop production, animal husbandry, and cottage craft (making of traditional native goods for sale; in Larson and Davis, 1981, p. 349; Davis, 1994, pp. 90-95).

In 1952, with the Peruvian government's permission, SIL began establishing bilingual schools in its newly created native communities throughout Peru (Larson and Davis, 1981, p. 1). A training center for native teachers was established at SIL's home base in Yarina Cocha, where specially selected native community members receive instruction and training in a variety of subjects including Spanish, mathematics, history, and religion. Returning teachers receive a salary and do more than simply teach elementary subjects; they encourage the use of Spanish, promote the planting of cash crops and production for market, and supply a continuous income source for potential wage labor opportunities.

Shift Toward Community Life and Market Contact

The introduction of Western medicine and the clustering of families around access to western goods in SIL-created communities have produced substantial rates of population aggregation and growth. Prior to the introduction of Western medicine, SIL's missionary-linguists report finding that, on average, a woman could expect to bear ten children, only three of which

Table I. Population Growth from 1980 to 1994 in Two Communities

Community	Pop. 1980 ^a	Pop. 1994 ^b	Total (%) Δ	Rate (%) Δ /yr
Camaná	267	370	38.6	2.35 ^c
Mayapo	170	263	54.7	3.19 ^d

^aData on Camaná are from Michael Baksh's 1980 census; Mayapo data are from Carlos Rios, a school teacher and the founder of Mayapo.

^bData on Camaná are from Camaná's president, as reported in July 1994. Mayapo data are based on a community census taken by the community leader in May 1994.

^cAt this rate, the population will double in 30 years.

^dAt this rate, the population will double in 22 years.

would survive to adulthood (age 15). Twenty years later, immunizations, treatments for tuberculosis, medicine for malaria, and antibiotics have reversed this statistic. Now only three out of ten children die before age 15 (Davis, 1994, p. 91). Reductions in infant mortality have combined with continuous immigrations of Machiguenga families previously living in traditional lifeways to generate substantial population growth rates. Table I shows the population expansion from 1980 to 1994 for two communities discussed later. Obviously such growth rates make any system unsustainable in the long term; however, these overall growth rates should level off as the pool of potential immigrants declines—there will be fewer and fewer traditional families left to immigrate into communities.

Separating the influence of immigration from the effects of increased infant survival rate on population growth is impossible with available data. However, the trend toward community life, with increasing degrees of market contact, is unmistakable. Estimates of the total Machiguenga population range between 10,000 and 12,000. Censuses taken in 1990 indicate that over 10,000 Machiguenga reside in communities experiencing varying levels of market contact, rather than in the traditional scatter of hamlets and single family groupings. Less than 2000 Machiguenga continue to maintain traditional living patterns. Villages like Shimaá have experienced tremendous growth rates (from both aggregation and changes in birth/death ratio) in the last 20 years. From 1972 to 1990, Shimaá grew from 110 people to 564—a growth rate per year of 9.53% (Chavez, 1991).

INDIGENOUS ENTREPRENEURS

The intent of this section is not to unravel the complex set of reasons why such a large and rising proportion of Machiguenga desire ever-increasing access to Western goods, but seeks only to demonstrate that many Machiguenga are active and eager participants in the commercialization process now occurring along the Lower Urubamba.

The Machiguenga provide an excellent case study for understanding how native groups incorporate into larger regional, national, and international economies, when not overtly forced by structural factors (land tenure, plantation patrons, etc.) or compelled by obvious needs (food, medicine). During the early 1970s the Peruvian government began granting land titles ranging from 1489 to 3874 ha to a number of Machiguenga communities including Shimaa, Camisea, Mayapo, Nuevo Mundo, and Camaná. Communities were eligible for 10 ha per permanent resident over the age of five. In addition to these titled lands, the Machiguenga are permitted to use the larger "reserve areas," between 10,000 and 30,000 ha, surrounding their communities. Families can avoid market contact by remaining in these large "reserve areas," or by retreating deep into the confines of the Massachusetts-sized Manu National Park. Many Machiguenga do live in remote areas both in and outside the Park, and effectively avoid market contact. Market activities, commodity production, and the use of shotguns remain restricted within the Park (all "nontraditional" activities are restricted), although some communities located along the perimeter of Manu are increasingly demanding policy revisions regarding access to markets and technology.⁵ Most Machiguengas (10 out of 12), however, choose to live in communities and seek at least some degree of market interaction.

Earlier anthropological studies of the Machiguenga reveal a growing interest in Western goods and modernization. In 1972, as the Machiguenga of Shimaa were initially experiencing some limited market contacts, Johnson (1978, p. 57) reports that after examining his Swiss Army knife several Machiguenga men asked how they could get one. He describes their interest not as a "craving," but as a willingness, "to make a serious effort to get it or something similar." In 1980, residents of Camaná, when asked by Baksh (1984) what they wanted out of life in the upcoming years, replied that they wanted "to advance" or "progress." Baksh also supplies a five-item list of "aspects of life for which the Machiguenga maintain and express strong preference." Item five reads, "they want large amounts of a variety of Western implements and other goods that they perceive would allow them to live more comfortably" (Baksh, 1984, p. 450). This kind of interest continues into the present as many Machiguenga communities experience rising degrees of market contact.

Today, in the communities of the Lower Urubamba, Machiguenga interest in western goods becomes obvious almost immediately. In every community, I was barraged with requests to buy my Swiss Army knife, my camera, my baseball cap, my shoes, etc.; teenage boys were constantly asking how much my things cost and where I got them. At the same time,

⁵These border communities want to abolish restrictions on shotgun use, chain saws, and cattle ranching, while remaining protected from colonization, oil prospecting, and tourism.

people began trying to sell me native goods such as clothing (*cushmas*), bracelets, net bags, snake skins, and jaguar pelts.

In 40 interviews, farmers from five different Machiguenga communities consistently say that they grow cash crops to get money. When asked why they want money, 39 out of 40 responded that they want it to buy things they need. Of these 39, 33 went on to list several items, including: machetes, axes, salt, athletic shorts, rubber boots, wristwatches, radios, kitchen knives, etc. The one farmer who did not want "to buy things," said he needed money to pay for his son's education as an agronomist in Quillabamba. Many of the interviewees went on to add that they could make more money if they were not being cheated by the river traders, who presently are their primary connection to local markets (both buying and selling).

In three of the villages I visited, community leaders, seeking to expand market participation, presented me with two unsolicited, manually-typed proposals for funding to buy large boats with Johnson outboard motors for transporting crops to market. They requested that I attempt to find an organization in the U.S. to help them. The introduction to one of the proposals reads:

The agricultural production of our communities is little valued economically in our zone. In contrast, the prices of foreign products are between double and triple of that which they are in the Capital. The local products cost a third or a fourth of the price that is paid in the Capital. The products that can be commercialized are: cacao, coffee, beef, fish, beans, peanuts, etc. At this time there is a great need for salt, ham, kerosene, tools and medicines, etc.

The desire for Western goods, and modernization in general, often combines with an awareness of their situation vis-à-vis the surrounding society to produce both anger and frustration. While I was discussing transportation arrangements with Puerto Huallana's community president, Timateo, a Machiguenga farmer, approached us and began shouting at me (Machiguenga rarely shout). The following excerpt from Timateo's speech illustrates his desire for western goods as well as his frustration at their rate of "advancement":

we have no tin roofs for our houses, no mosquito nets, no shotguns; there is no electricity or roads; we have no radio, no medicines for our children. I spend everyday in my *chacra*. I have bags of cacao, but it's rotting because sometimes the river traders do not come and we have no boat to take it to Quillabamba. Do you have a radio? [meaning a two-way radio? I respond no] Then you are like us, we have no way to communicate with Yarina, Quillabamba, or Sepahua.

Obviously Timateo strongly wants many western goods and is willing to work hard to get them, but he feels his efforts go unrewarded, thwarted by circumstances beyond his control.

Matias, the 25-year-old bilingual school teacher and president of the Machiguenga's economic cooperative, explained to me that community

members work hard because they hope to modernize. He believes that with just a little financial assistance the Machiguenga could make great strides toward modernization. He explained to me the need for community development aid:

[We need] a project so that we can help ourselves in the community, even if it only contributes to some of us, because the community has hopes. But there is no support [financial aid], practically nothing. They [the community members] work much for themselves and want to excel [stand out]. We have little. There is nothing. We are lowly Three months ago we had a meeting in Quillabamba in order to plan a project. We have made the project enough that it is going to make a water purification installation. It is going to make a hospital and a big pharmacy. Now there is nothing. Then the community will have electricity.

Besides actively seeking development aid, Matias administers a 13 community economic cooperative, teaches school, and organizes collaborative labor within his own community to monocrop cacao and raise cattle. He, and his multitude of supporters, aggressively engage commercialization in variety of ways.

Finally Gustavo, a 28-year-old farmer and student, explained that things are different now and Machiguenga can no longer live as they once did:

. . . the situation of the Machiguenga who live here in the community, as practically all live, does not conform to that of our ancestors Our ancestors lived, fished and carried their chickens in order to travel from one place to another and in order to meet with other groups. But now the situation of the community is different, different. The community is tranquil and practically no one is able to continue the old ways. Some live here; students leave for more studies; others go from here to breed cattle; they want to be plantation [ranch] owners. They want to be whatever they can, but they don't conform to the situation of the ancestors. This is the what the Machiguenga want now.

He eloquently describes a view expressed by many older students (usually males in their twenties). These literate, bilingual young people are searching for new ways to live in a world that has changed so rapidly during their lifetime. Old ways and traditional culture no longer seem as relevant, and often fail to provide answers to new questions and new desires.

COMMODITY CROP PRODUCTION, DOMESTICATED ANIMALS, AND SUSTAINABILITY

By comparing five Machiguenga communities at differing degrees of market incorporation, I describe and analyze the transformation of traditional productive patterns in response to increasing commercialization. First, I explain the conceptualization and quantification of market incorporation, as a measure of the degree of commercialization, among Machiguenga communities and households. I then present an analysis of commercialization's consequences on

crop production which focuses on variations in garden size, travel time, cropping pattern, fertilizer use, and the re-allocation of household labor among communities experiencing varying degrees of market incorporation. In the subsequent section I discuss the impact of shifts toward animal husbandry, with particular emphasis on community cattle projects. Finally, I conclude by assessing the long-term social, economic, and ecological sustainability of the emerging productive systems. Concentrating on how households and communities are altering their traditional patterns sheds light on the interaction of forces shaping future development.

Market Incorporation

Throughout this discussion I rely on the concept of market incorporation to describe and quantify the degree to which both households and communities participate in the market economy. Quantifying the concept of market incorporation is necessary in order to compare communities at different geographical and temporal locations, and experiencing differing degrees of market interaction. Ideally, such a measure would include the details (items in transaction, cash exchanged, etc.) and frequency of every market transaction over a long period of time. This task would certainly be possible in a single Machiguenga community, but nearly impossible for several communities over the same period.⁶ Consequently I have chosen to measure "market incorporation" (MI) by surveying the number and kind of western possessions owned by each household and calculating composite scores for each household based on the market values of selected items. This measure will be valid to the extent that households which possess a greater variety of western goods also maintain a higher degree of market integration. Aggregate numbers for communities are generated by averaging household scores.

Community Market Incorporation

Community development accelerates the spiral of market participation and dependence through the progressive acquisition of capital technologies, which continuously require such things as replacement parts, gasoline, oil, etc. This process perpetuates the need to generate more income. Communities with higher market incorporation scores have more community-owned capital technology. For example, the community of Nuevo Mundo, receiving a market incorporation score of 730, maintains a generator, tractor, and lumber processor, while Camisea, with a score of 545, operates

⁶Data taken in successive periods would be distorted by changes in market activity over time. My data indicate that even at their most frequent, river traders visit Machiguenga villages no more than twice per week.

only a rice processor and a large saw; finally Mayapo, scoring a low 323, has no capital technology. Aggregate community evaluations could have incorporated the presence of community-owned capital technology, but these items were intentionally left out because the income produced by these technologies eventually shows up in the form of Western goods, which were already inventoried and accounted for in the original calculation.

Second, communities with a higher *MI* index had more market transactions during my stay. In 2 weeks, Nuevo Mundo (*MI* = 730) received three visits from river traders and did an absolute value of 58 *soles* worth of commercial transaction.⁷ During the preceding 2-week period, Camisea (*MI* = 545) received one visit from traders and transacted 34 *soles* worth of commerce. Mayapo was not visited during my stay there.

Lastly, the index is not sensitive to reasonable changes in inventory items or assigned market values. The nominal ranking of, and to a large degree the proportional differences between market incorporation scores of different communities, do not depend on the specifics of the calculation. Changing the items (Western household goods) selected for the calculations, or adjusting the market value of different items (within the range of real market values recorded for each item), does not significantly alter the results for tests of 15 or more items (Table II lists items used in test procedures and the final item list). In tests with fewer than 15 items, distortions begin to appear in household rankings as single expensive items dominated some household scores and the resolution among household *MI* scores diminished. With more than 15 items, households that received high scores in one test calculation continued to receive high scores in variations of that test calculation. Shifts in household ranking within a given community did not exceed 20% for all reasonable test modifications (meaning tests with at least 15 items). Communities' nominal ranking never varied and yielded a maximum variation in proportionality differences of only 18%. Many of the items inventoried were used in the *MI* calculation because either they were extremely rare and made little or no difference, or the available data were not entirely complete for all households.

All test modifications of the index methodology used only market values from the range created by prices elicited from different informants and my price surveys of local markets. With few exceptions, most informants were very aware of current prices and my informant price data matched closely with market surveys.⁸ Consequently, the final analysis uses all prices from my market price surveys.

⁷Calculations simply sum the absolute value of exchanges made by all participants.

⁸All items came from three possible market sources: the river traders, Quillabamba, or Pucallpu (Pucallpu is about 220 miles north of this region, in the central Peruvian Amazon). I surveyed markets in both towns and two different groups of river traders for comparison to my informant reports. Although Sepahua is the closest market, Machiguenga do not like to buy from there because of the high prices.

**Table II. Market Incorporation Index
Items**

Items used in market incorporation calculation	Other items inventoried
salt	canned foods
soap	pots
detergent	machete
tin roof	boat motor
mosquito netting	noodles
western clothes	gasoline
batteries	big fishnet
carpentry tools	bucket
kerosene	fishhooks
fish-line	ax
small fishnet	
watch	
radio (one-way)	
cooking oil	
rubber boots	
wheelbarrow	
sewing machine	
flashlight	
sugar	
shotgun shells	
western medicines	
shotgun	
chainsaw	

Household *MI* scores were tabulated by adding up the cost of each item possessed by that household. After some analytical experimentation, I decided that all items would simply be counted as either present or absent, rather than incorporating a count or quantity measure for each item. I tested several methods of including item counts, but none made any significant changes in the nominal ranking of the household or community market incorporation scores. However, including all or nearly all item counts does slightly exaggerate the differences (increases the average difference by 10% to 20%) between the cluster of more highly market incorporated households and the less incorporated cluster of households—see later discussion. For most items, households possessed only one of each, and for some things like sugar, salt, and noodles, I had no quantity measurements to compare with my counts of other items, such as pots, machetes, or fishhooks. Hence, the final method omits items which varied in number among households and excludes quantity measures from the calculations.

Because all communities have similar cultural backgrounds, geography (their position on the river system) explains most of the variation in market incorporation found among the 1994 communities. The less remote the community, the greater the market incorporation. Nuevo Mundo lies along the widest section of the Urubamba near the missionary town, and closest market, of Sepahua. Frequently traders will make runs along the Urubamba between Sepahua and the Catholic mission of Kirigeti, which lies a couple of hours past Nuevo Mundo. River traders conveniently stop at the Machiguenga communities of Nuevo Luz and Nuevo Mundo, as well as the colony of Nuevo Vida, enroute to Kirigeti. Camisea lies beyond Kirigeti, with no other large communities along the Urubamba within an hour's travel. Only when traders are willing to travel from Sepahua, along the length of the Urubamba river, through the dangerous rapids of the Pongo de Mainique to the town of Quillabamba, does Camisea receive visits from river traders.

Some remote Machiguenga communities, residing on tributaries of the Urubamba, experience only infrequent or seasonal market contact because of the time and difficulty in traveling to them. To reach the communities of the Upper Picha River traders must use small, low horsepower engines in order to navigate their shallow waters (particularly in the dry season), rather than the 75+ horsepower engines used in cruising the Urubamba River. Puerto Huallana lies between 4-6 hours up the Picha river. River traders rarely venture up the treacherous Picha to visit (trade with) the communities of Puerto Huallana, Mayapo, and Camaná. Mayapo is 3 hours past Puerto Huallana and Camaná lies another 5 hours past Mayapo, on the Parotori river. Most of the Parotori is unnavigable by motorized canoe during the dry season. River traders choosing this destination must push their canoes by hand for most of the 5-hr trip upriver from Mayapo.

Household Market Incorporation

Most of the impact from commercialization, in terms of land usage, agricultural practices, and labor allocation, results from variations in economic decision-making patterns at the household level. Households make decisions which affect their degree of market integration. A breakdown of market incorporation from the community level reveals two distinct modes used by households in economic decision making. The bimodal distributions of market incorporation from all three communities, found in Figs. 2, 3, and 4, suggests that individual households choose either to maintain a low level of market integration, allowing only replacement of their machetes, axes, and pots, or embark on an aggressive process of increasing income

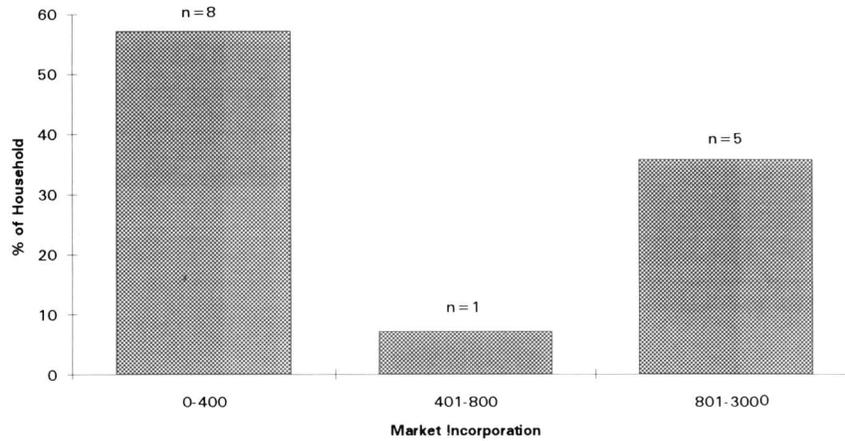


Fig. 2. Histogram of market incorporation scores for 14 households (representing 34% of households) in Nuevo Mundo.

generation. These figures, one for each community, divide the households sampled into three groups of market incorporation scores.⁹ They illustrate that households do not cluster around community averages (which are always contained in the middle grouping), but instead spread away from the average to create two clusters, one high, one low. These distributions reveal that not everyone is seeking, or at least succeeding in, expansion of their market interaction.¹⁰ Apparently, for whatever reason, the development of disparate degrees of market incorporation, which may represent incipient class division, arise as part of the commercialization process.

⁹Note, the bin divisions on Fig. 2 do not match those of Figs. 3 and 4. Because the actual numerical values of the bin demarcations do not, in and of themselves, mean anything, I selected demarcation values appearing in gaps between clusters of data points. If Fig. 2 is re-plotted using the bins found in Figs. 3 and 4, the bimodal nature of the data presentation is preserved (though not as exaggerated); however, 3 data points just above $MI = 300$ slip into the center bin and 1 data point just above $MI = 700$ slips into the highest valued range. I intentionally avoided allowing bin demarcations to divide data clusters, consequently I moved the center bin demarcations to higher "gap" values.

¹⁰With the exception of school teachers, Machiguenga have equal access to resources, language training (Spanish), and information. Further, only a few individuals (2 or 3) in each community have specialized skills (e.g., carpentry or medical knowledge) and these few individuals cannot account for the substantial differences in market incorporation. I argue that the differences in market incorporation at the household level result primarily from differences in desires and goals. Also, it is certainly possible that differences exist due to individual ability or proficiency (at shared skills), but these differences cannot account for the extreme disparity in market incorporation between modes. Such differences would produce a continuum, not a bimodality. Differences in ability, however, could explain variations between households within a mode.

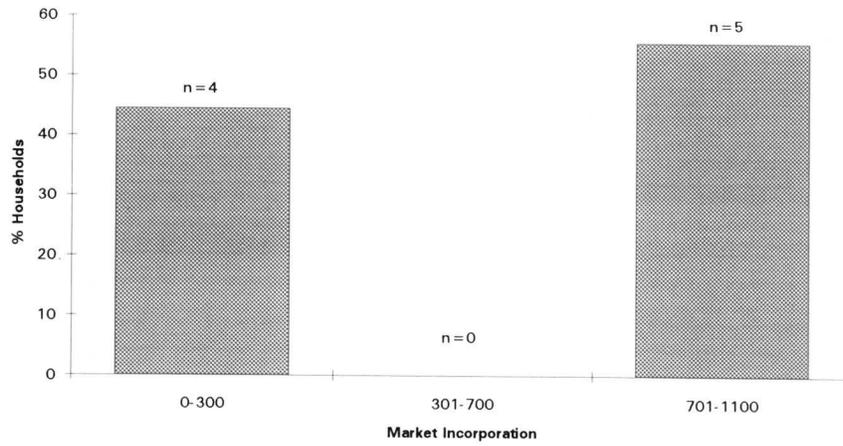


Fig. 3. Histogram of market incorporation scores for nine households (25% of households) in Camisea.

Crop Production

Commercialization alters traditional Machiguenga agricultural practices and land-use patterns. Land usage expands and intensifies as crop selection shifts, garden size expands, time under cultivation increases, deforestation accelerates, and fertilizers are used. As communities experience

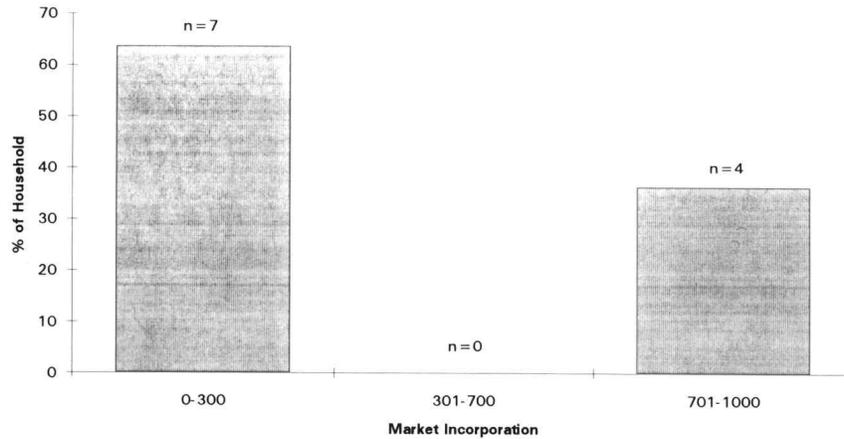


Fig. 4. Histogram of market incorporation scores for 11 households (30% of households) in Mayapo.

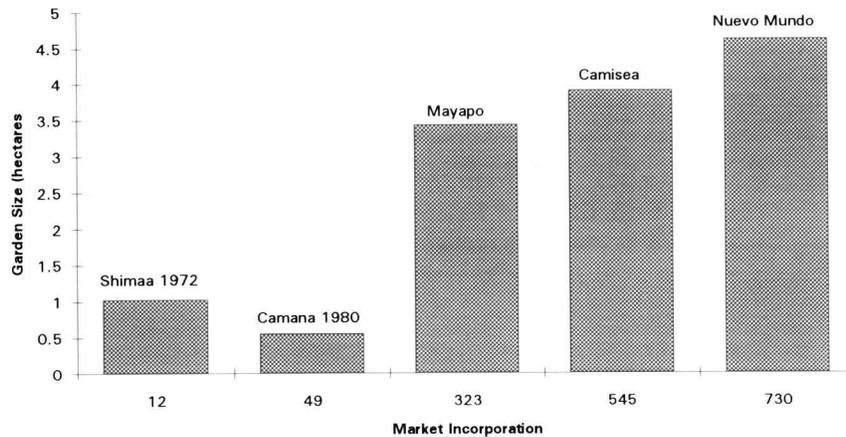


Fig. 5. Comparison of average garden sizes for five communities (Shimaá data from Johnson, personal communication, and Camaná data from Baksh, 1984).

increasing degrees of market incorporation the average garden size per household rises from a subsistence size of approximately 0.55 ha to a maximum of 4.6 ha.¹¹ Figure 5 compares five Machiguenga communities experiencing differing degrees of market contact to illustrate the variation in average garden size. A comparison of the three communities studied in 1994 (which includes 37% of households in Nuevo Mundo, 39% of Camisea, and 38% of Mayapo) shows that garden size increases by 35% from 3.4 (± 1.2 —the standard deviation) to 4.6 (± 2.7) ha as market incorporation rises from 323 in Mayapo to 730 in Nuevo Mundo. Garden size shows a 15% increase, from 3.4 to 3.9 (± 1.7) ha between Mayapo ($MI = 323$) and Camisea ($MI = 545$). A one-tailed *t*-test with unequal variances yields a *p*-value of 0.19 for the comparison of Camisea and Mayapo, and a *p*-value of 0.07 for the comparison Nuevo Mundo and Mayapo.¹²

Households in Shimaá (1972 study) and Camana (1979 study), involved primarily in subsistence-oriented production, show substantially smaller gardens than those of more commercialized communities. Households in Shimaá (1972), with an estimated community market incorporation of 12, cultivate an average of only 1.03 (± 1.6) ha of land. This average for the 14 households of Shimaá may be deceptively high as the school teacher

¹¹Here “garden size” indicates the average land under production per household. Comparisons are based on community averages, but community gardens are not included in calculation.

¹²All *p*-values were determined based on a one-tail *t*-test because I expected that communities with higher market incorporation scores would cut larger gardens and travel longer distances to their gardens. The null hypothesis assumes that more commercialized communities have garden sizes and travel times less than or equal to less commercialized communities. The alternative hypothesis, then, concurs with my expectations.

alone was cultivating 6.18 ha. As the only cash cropper, the school teacher, employing the labor of the community members, maintained over 10 times the average amount of land under cultivation if we remove him from the average,¹³ which gives an average size of 0.6 ha per household (± 0.51). These subsistence gardens compare closely to the 0.55 ha per household (± 0.23) found by Michael Baksh among Machiguenga Camaná ($MI \approx 49$) during 1979 and 1980.¹⁴ Comparing data from Nuevo Mundo and Camaná shows that households in Nuevo Mundo, with an average garden size of 4.6 ha, maintain 8.4 times more land under cultivation than the 0.55 ha gardens of Camaná (p -value = 0.001). Even comparing the 1980 situation in Camaná, or the 1972 situation in Shimaa, with the least market-incorporated community of 1994 reveals the substantial impact of expanding commodity production. Mayapo cultivates at least 5.5 times as much land as Shimaa or Camaná. Even if one includes the cash-cropping school teacher of Shimaa, Mayapo still maintains 3.3 times more cultivated land than Shimaa did in 1972 (for Mayapo/Shimaa p -value = $7.6E-5$).

Expanding garden size for cash cropping and animal feed, while aggregating once scattered populations, increases, over time, the average travel time from village to garden. The three primary factors influencing travel time are population size, duration of occupation (how long the community has remained in a particular spot) and rate of land consumption—all of which are linked to the process of market incorporation. Figure 6 shows the effect of varying degrees of market incorporation on the average travel time to new gardens, and reveals that Shimaa, which in 1972 had little or no sustained market contact, has the shortest travel time of only 4.9 (± 7.2) min. This time is assumed to be representative of a traditional Machiguenga hamlet. Camaná, which in 1980 had also little or no market interaction, shows the next shortest travel time of 14.8 (± 9.0) min. Because both Shimaa and Camaná show little market interaction and had remained in the same location for about 4 years at their respective times of study, the difference in average travel time (a 175% increase between

¹³Although school teachers are included in calculations of 1994 communities, this point remains significant because the Shimaa teacher's gardens were so large in comparison to other members of the community. School teachers in the 1994 communities maintain gardens approximately the same size as the average household. Note however, that the school teacher's gardens did contribute to feeding some families in Shimaa that maintained only small gardens.

¹⁴These estimates of approximately 0.6 ha of land for subsistence agriculture remain roughly consistent with Camino's findings in the Machiguenga community of Monte Carmelo in 1976, as well as that found for other Amazonian groups (e.g., the Kuikuru, Carneiro, 1983, p. 75). Of course the details of subsistence garden size depend on a number of ecological and cultural factors. Such things as the productivity of local soils, the availability of foraged foods, and the degree of surplus food desired (for security) vary from region to region, and between cultural groups.

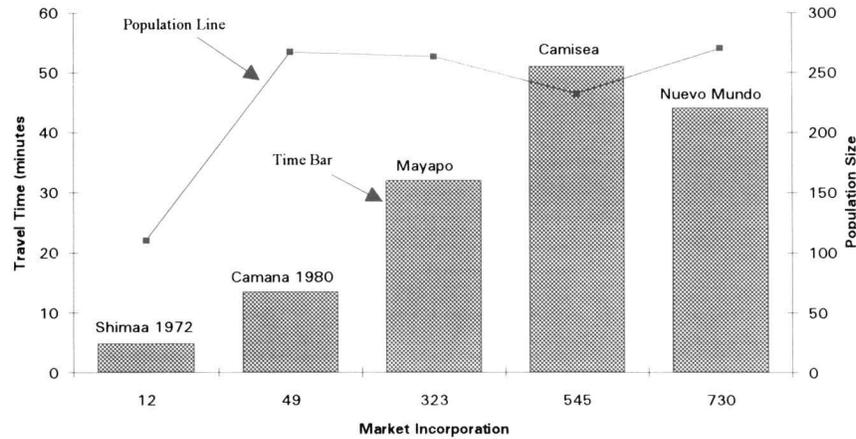


Fig. 6. Comparison of average travel time to gardens and population size in five communities (Shimaá data from Johnson, personal communication, and Camaná data from Baksh, 1984).

Shimaá and Camaná) results primarily from differences in community size. In 1972 Shimaá had only 110 individuals in 14 households, while in 1980, Camaná had 267 individuals spread among 42 households.

Settlement size alone, however, cannot account for the vast differences in travel time between communities of similar size: Camaná's population of 267 had an average travel time of 14.8 minutes, while Mayapo's population of 263 shows an average time of 34 (± 45.1) min (an increase of 151% with p -value = 0.04); Camisea, with only 232 people, requires the longest travel time of 51 (± 55.7) min—an increase of 278% over Camaná (p -value = 0.001) and 50% over Mayapo (p -value = 0.125). Comparison of Nuevo Mundo (44 \pm 47.3 min) and Mayapo, both founded in 1974 with nearly identical population sizes, shows a difference of 10 min yielding an increase of 29% (which, as we will see is a minimum difference yielding p -value = 0.24). Undeniably, rising degrees of market incorporation indicating greater commercialization contribute to progressively increasing travel time from community to garden as households seek to expand their commodity crop production.

If commercialization has the effect of increasing the travel time from community to garden, then Nuevo Mundo should have a longer traveling time than Camisea; yet, Fig. 6 indicates the opposite—that Camisea has a longer travel time than Nuevo Mundo. This unexpected deviation exposes one of the most significant effects of the commercialization process: the creation of a bilocal residence pattern. The difference between the average travel time in Nuevo Mundo and Camisea arises from a bias inherent in the Nuevo Mundo data. Travel time data come from a combination of interviews with farmers and actual travel time to gardens. But, because potential interviewees were found in the community, and as it turns out, many

families stay in second residences located in their gardens for 3, 4, or sometimes 5 days a week (usually returning on the weekend for church and soccer), the data differentially incorporate those who, because their gardens are close to the community, tend to remain in the village. Nightly surveys reveal that only 40% of the total households in the community spend Monday through Thursday night in Nuevo Mundo. The remaining sleep in their garden houses. The primary reason given by farmers for this bilocal residence pattern is the long travel time required to commute from village to garden—it seems that it is not worth traveling more than approximately 60 min to one's garden.

Assuming this trend continues, which it should unless there is a massive leap in agricultural intensification, most families will maintain bilocal residence patterns. Communities will be nearly empty during the week, except for school children and households involved in other projects (like house construction). Family life will be drastically altered as school-age children are forced to live with those few who can remain in the community.¹⁵ Families will lose valuable labor as children will need to live near school. Knowledge and cultural information, ranging from agricultural practices to ritual songs, will disappear as children lose essential time with their parents. Community projects demanding cooperative labor will become increasingly difficult, as potential laborers will be spread over most of the region during the week. Kinship ties may begin to break down as nuclear families scatter and households become increasingly market dependent.

Households seeking greater market integration have not only increased the amount of land under cultivation, but have also intensified cultivation by extending cropping periods (the number of years of active use) and altering their traditional planting approach. Traditionally the Machiguenga rely on a system of swidden agriculture in which clearing, burning, planting, harvesting, and abandonment all occurs within a 3-year period, followed by fallow periods of at least 20 years. Initially, these horticulturists intercrop maize and manioc, which account for 85% of plants found in first-year gardens, with a scattering of other crops (e.g., pineapple, bananas, papaya, yams, beans, pigeon peas, etc.). Maize is generally not planted after the second year. By the end of the third year, gardens enter an initial stage of abandonment in which weeding stops, but some harvesting continues. Usually within a year or two after the initial abandonment all cultigens are exhausted and harvesting stops completely (Johnson, 1983; Baksh, 1984; Kaplan and Kopischke, 1992).

¹⁵Children ages 0–7 stay with their parents; ages 7–11 attend primary school in Nuevo Mundo, and some ages 11–19 may choose to attend secondary school in Nuevo Luz, where they live during the week and some weekends. Primary school children usually stay with grandparents, uncles, aunts, or some other kin during school weeks.

Currently, among the communities of Nuevo Mundo, Camisea, and Mayapo, Machiguenga households have modified their traditional crop production strategy in hopes of increasing income-generating production. Although a great deal of individual variation exists among household planting strategies, the following pattern consistently emerges. Sweet manioc is always planted first; sometimes maize is immediately intercropped, otherwise it is planted later during that first year. Manioc is replanted continuously, while annual maize planting stops after the second year; much of the variation in cropping patterns comes after the initial planting of maize and manioc when farmers may intercrop sugar cane, rice, beans, peanuts, bananas, achiote, cotton, papaya, guava, etc. In the third year, rather than abandoning the garden, farmers continue harvesting and weeding; cacao and coffee trees largely replace maize. Manioc harvesting slows as farmers reduce replanting; increasing attention is given to cash crops such as rice, beans, and peanuts. Harvesting and weeding continues until crops no longer produce—about 5 years. Usually, after reaching maturity, cacao and coffee produce for two or three years; however sometimes they may never produce any fruit. Consequently nearly half of the current land under cultivation contains coffee or cacao trees, while large amounts of fallow land remain covered with nonproductive cacao and coffee trees. Recently farmers have increasingly shifted their production emphasis from a combination of coffee and cacao to mostly cacao. The reason for this, according to farmers, is that cacao's market value remains stable, while coffee's market price seems to fluctuate somewhat erratically.¹⁶

Decisions made by river traders, as to the profitability of certain commodities, directly influence cropping patterns of Machiguenga households. In the more remote communities of the Upper Picha, river traders have recently begun refusing to buy crops other than cacao, coffee, and sugarcane. These traders maintain that cash crops such as peanuts, beans, and rice do not bring sufficient recompense to compensate for their travel expenses. The unfortunate consequence of this is that Machiguenga farmers are then driven to produce pure commodity crops, which unlike beans, peanuts, and rice, have almost no nutritional value if they cannot be sold. Typically cash crops which cannot be sold, whether because of infrequent market access or radical market fluctuations (common in the Peruvian economy), are consumed locally and can provide important dietary additions, especially in these regions facing the rapid depletion of the faunal

¹⁶Interestingly Machiguenga farmers' impressions concur with statistical data on world market fluctuations. During the late 1980s and early 1990s, the price of coffee was less stable than cacao, and Peru has experienced an almost continuous decline in coffee prices since 1986 (UNCTAD Commodity Year Book, 1993).

foods so critical to the nutrient balance of the traditional Machiguenga diet (Johnson and Behrens, 1982; Baksh, 1985).

Despite the fervor to develop and the allure of money and market goods, the Machiguenga of the Lower Urubamba continue to maintain the traditional pattern of planting manioc and maize first (Johnson and Baksh, 1987). However, gradually, farmers are exploring more intensive agricultural practices to increase production and generate income. In Camisea ($MI = 545$) four farmers, in addition to their own family gardens, have decided to combine their efforts and clear a single large garden (6 ha) in order to monocrop cacao trees. Matías, the leader, feels that using cooperative labor to monocrop cacao and dividing the profits equally among the contributors is the most effective means to generate income. He further explains that planting annual crops first reduces the length and abundance of the cacao harvest. Similarly, four families in Nuevo Mundo ($MI = 730$) have also been regularly monocropping maize for three years.

Monocropping in tropical soils, particularly the acidic inceptisols found along the Lower Urubamba (already low in nitrogen and phosphorous; Cespedes, 1987), can create substantial ecological problems. Monocropping tends to deplete certain nutrients more rapidly than the intercropping of traditional agriculture. Note that, unlike some other Amazonian groups, the Machiguenga practice "true" polycropping. Farmers systematically intercrop different species over the entire garden, rather than grouping like species as in other swidden systems. Monocropping also dramatically increases a crop's susceptibility to diseases and insect pests. In Brazil, for example, cacao growers have suffered crop losses as high as 80% from the fungal disease "witches broom" (*Crinipellis pernicioso*; in Milliken, 1992). Finally, growing only a single crop deviates from the successional-like regrowth common to many swidden systems, thus both reducing the system's inherent biodiversity and depleting the forest's regenerative abilities.

Farmers in Mayapo, attempting to reduce commuting time to their gardens, report that recent attempts to cultivate secondary succession plots, abandoned only 10–15 years ago, have largely failed. These reports indicate that these plots can produce manioc, but fail to yield fruits for maize, cacao, and usually for bananas. Soil tests for nitrogen, phosphorous, and potassium in these fields show low, but typical, amounts of nitrogen and phosphorous, and high amounts of potassium. However, the unusually acidic pH of 4.0 (5.5 is average for virgin jungle in this region), potentially indicating an aluminum toxicity problem common to this region, may prevent the production of more sensitive crops.¹⁷ Efforts to reduce traditional fallow

¹⁷Based on soil testing carried out by the researcher during July and August 1994. Maize requires pH levels between 5 and 8. Cacao and coffee require levels between 5.5 and 8 (Landon, 1984).

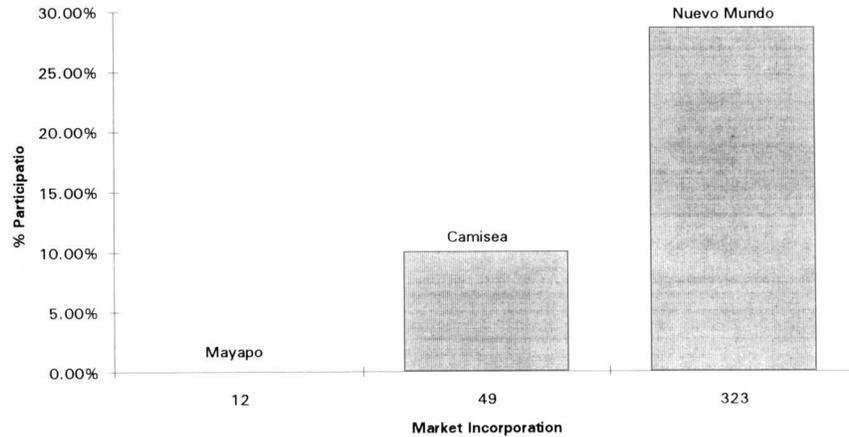


Fig. 7. Fertilizer usage in three communities.

lengths below 15 years, without the use of chemical fertilizers, have resulted in limited or nonexistent yields.

The desire to intensify land usage in order to produce for the market has provided the impetus for the use of *organic* fertilizer—market incorporation has driven the increasing use of fertilizer. Figure 7 shows the variation in the use of manure to fertilize gardens. Note that, although Mayapo presently has no cattle (they all died, mysteriously), and thus no manure, farmers claim that even when they had cattle no one employed manure fertilizer. When asked why they did not use *chemical* fertilizer some farmers replied that they had considered it, but simply could not afford it. Other farmers did not know about chemical fertilizer, or felt they did not need it.

Allocation of Labor

As households seek to generate greater amounts of income they are allocating more labor to agricultural production. Table III compares the number of hours spent weekly on agriculture for Shimaa (1972), Camisea, Nuevo Mundo, Camaná (1980), and Mayapo. Households in Nuevo Mundo and Camisea, the communities with the highest degrees of market contact, use nearly all available daylight hours for agriculture. Males spend approximately 58 hr per week on agriculture and related activities (including travel time to gardens). They depart at about 6 AM for their gardens and return at about 5 PM, Monday through Friday. Females in Nuevo Mundo spend approximately 46 hr per week in agricultural production, they too usually leave early, but are more likely to return sooner or spend the day working around

Table III. The Allocation of Agricultural Labor

Community	Market incorpr.	Males hr/week	Females hr/week	Total hr/week
Nuevo Mundo	730	58 ± 3.0	46 ± 2.1	104
Camisea	545	58 ± 3.0	40 ± 2.2	98
Mayapo	323	46 ± 2.6	12 ± 1.7	58
Camaná	49	9.5 ^a	5.9	15.4
Shimaa	12	26 ^a	7.3	33.3

^aConfidence limits are unavailable for Shimaa and Camaná.

the house (feeding animals, making clothing, etc.). On Saturdays, many males will tend their gardens for part of the day, approximately 3–4 hr; the remainder of the day is spent hunting, fishing, doing household chores, or in leisure activities. On Sundays, no one goes to their gardens; people (especially women) do household chores, hunt, fish, attend church, and always play soccer. With the exception of Saturday afternoon and Sunday, which are reserved for necessary chores and leisure, the Machiguenga households of Camisea and Nuevo Mundo have allocated nearly all of their time to agricultural production, the vast majority of which is cash cropping. Increasing production in these communities, by allocating more labor to productive activities, is virtually impossible without removing children from school, because most households have already fully deployed all available adult labor.

Mayapo follows a similar, but less intensive pattern of labor allocation. Males spend about 46 hr per week on agriculture, while women spend significantly less time, approximately 12 hr per week (Monday through Friday). Here males leave early, usually by 6 AM, but in contrast to Camisea and Nuevo Mundo, they return earlier, often by 3 PM. Men are also more likely to spend the day hunting, fishing, hanging around the house, or in some leisure activity than men in Camisea or Nuevo Mundo. No one works in their gardens on Saturday or Sunday. Weekends involve resting, hunting, fishing, chatting, religious services, and soccer.¹⁸

In direct contrast to the communities of Nuevo Mundo, Camisea, and Mayapo, the men and women of Shimaa and Camaná spent much less time in agricultural labor. Men in Camaná (1980) allocate only 9.5 hr per week to crop production, compared to 6 times that amount (58 hr) in Camisea and Nuevo Mundo. Similarly women spend less than 6 hr per week in agriculture, while women in Nuevo Mundo provide 46 hr/week. In Shimaa

¹⁸Both fishing and hunting trips are more frequent and successful in Mayapo than in Nuevo Mundo or Camisea. Seventy-one percent of meals in Mayapo contain fish or game ($n = 14$), while Camisea and Nuevo Mundo meals have fish or game only 43% of the time ($n = 35$).

(1972) men spend about 26 hr/week on agriculture,¹⁹ less than half that of Nuevo Mundo, while women contribute less than a fifth of the agricultural labor of women in Nuevo Mundo. Clearly, the Machiguenga households of 1994 have chosen to reallocate their labor towards agricultural commodity crop production, and away from hunting, gathering, fishing, and leisure.

Methodologically, the calculation of time allocated to labor for male and female adults in Nuevo Mundo, Mayapo, and Camisea involved data gathered through communitywide activity surveys and evening interviews on the day's activities. At approximately 8 AM, noon, and 3 PM on most days, surveys of the entire community record the activities of those around their houses, based on observations. In Nuevo Mundo and Camisea, because most people were not home, inquiries were made with those who were home as to the whereabouts of other household members. In Mayapo, selected houses received inquiry as to the whereabouts of other household members. Between 4:30 PM and 6 PM, as most people returned from their gardens, families (in this case male heads of households) not interviewed earlier that day, were selected and interviewed about their day's activities.

General questions about daily activities were only intended to estimate the approximate time spent in agricultural activities. I asked individuals what they did that day and when they returned from working (unless I already knew through observation). Usually men said they worked in the *chacras* (gardens) all day, and returned at about 5 PM. Often I would ask the men if their wives also worked in their gardens and when they returned. Both interviews and observations confirmed that nearly everyone departs between 5:30 AM and 6:30 AM.²⁰

Domesticated Animals

The Machiguenga view domesticated animals as an important source of additional income. All families in Nuevo Mundo, Camisea, and most in Mayapo, have at least a couple of chickens; many have 20 or 30. Households also keep ducks, guinea pigs, and turkeys. Nuevo Mundo and Camisea have community-owned cattle which are sold for community reve-

¹⁹Baksh, 1984, provides two reasons to explain why Shimaa and Camaná differ so significantly in their allocation of agricultural labor. First, households in Shimaa manage risk by producing more calories than they need, while in Camaná households manage risk by relying on the strong social cohesion of their large community. Second, Camaná lies in a previously uninhabited area rich with fish, game, and faunal foods, while Shimaa exists in a long inhabited region with limited fish, game, and faunal resources.

²⁰Although I probably relied more heavily on interviews for labor allocation data than Johnson (Shimaa) or Baksh (Camaná), both of them did rely on secondary informant reports for individuals not in the immediate vicinity of the community. The minor methodological variation certainly cannot account for the vast differences in the amount of time devoted to agricultural labor among these communities.

Table IV. Market Incorporation and Cattle

Community	Market Incrop.	No. of cows	Area cleared (ht)
Nuevo Mundo	730	40	30
Camisea	545	20	25
Mayapo	323	0 ^a	10
Camaná 1979	49	2	3.36
Shimaa 1972	12	0	0

^aIndicates the community had cows but they died.

nue. Despite the dwindling frequency of game (reported), Machiguenga families never eat their domesticated animals; these animals, chickens for example, have a value of 10–12 *soles* (\$4.75 to \$5.71) per animal and are considered too valuable to be eaten.

Despite several failures, Machiguenga leaders believe that cattle raising is an important and potentially profitable community enterprise. Matías Ríos, a bilingual school teacher and the president of the Machiguenga economic cooperative, states, “the most important one [community business] is the cattle ranch because it’s the most profitable.” Community leaders in Puerto Huallana, Camaná, and Mayapo expressed regrets at the deaths of all their cattle, and a hope that they will be able to buy more. José Vargas, a bilingual school teacher in Mayapo, intends to raise cattle himself in lieu of maintaining a garden.

The accessibility of river traders with large boats, the availability of animal medicines, and the funds to buy those medicines, limits a community’s ability to successfully raise cattle. Table IV shows that communities with greater market contact have been more successful at cattle breeding. In the late 1960s several Machiguenga communities, including Mayapo, Camaná, Puerto Huallana, Camisea, and Nuevo Mundo, were given cows as part of the Heifer Project administered by the Summer Institute of Linguistics. All the cows in Camaná, Mayapo, and Puerto Huallana had died by the time of the 1994 study,²¹ while Camisea and Nuevo Mundo, possessing access to markets necessary to generate the cash essential to buy medicines, continue to expand their herds.

Maintaining cattle creates a number of social, economic, and ecological problems for Machiguenga communities. Ecologically, cattle herding in the Amazon can produce serious environmental consequences. Toledo and Serrao (1982) show that under “traditional management” (in contrast to “rational management”) soil fertility drops rapidly from a high just after burning to below that necessary for crops within one year, and into a degraded state, below the natural level of soil fertility for the area, after 5 years. Because of the successional differences between swidden systems and cattle pastures,

²¹Actually Puerto Huallana still has one sickly cow who continues to hang on.

pastures require at least twice the fallow time to regenerate an equal amount of biomass as swidden systems (even nontraditional swidden systems). Of course, the success of post-fallow land reuse, for both pasture and agriculture, relies on the reaccumulation of biomass during fallows. Without sufficient biomass, burning and subsequent decay cannot release sufficient nutrients and organic matter in these otherwise poor soils (Loker, 1993). Loker suggests that over the long term, this process of land degradation transforms farms into "green deserts," containing only small, stunted secondary vegetation and possessing little productive potential.

Raising cattle in the tropics, particularly with limited technology and experience, creates some significant challenges. Cattle are highly susceptible to bacterial infections. Communities require access to antibiotics and the knowledge to use them. Camisea and Nuevo Mundo maintain a small stock of cattle medicines to treat their herds, while Puerto Huallana, Mayapo, and Camaná (where all the cows died) never had any medicines or the cash to purchase them. Furthermore, cows can also die from eating poisonous plants, pit viper bites, and consuming mineral salts. People in Camaná claim several of their cows died from eating barbasco (a poisonous plant used in fishing). Sometimes pastures, even newly cut ones, lack the nutrients to maintain cattle. Several people in Puerto Huallana believe their cows died from malnutrition caused by a "bad pasture."

As demonstrated in the next section, cattle require huge amounts of pasture land. Clearing these lands demands a large amount of community labor, which if the cows should suddenly die from any of the multiplicity of potential causes, represents a significant investment loss. Particularly as the bilocal residence pattern develops, and households begin living farther and farther apart, many community members may decide that their labor is better applied elsewhere.

Deforestation and Sustainability

Efforts to increase the amount of land under cultivation combine with the belief that shortened fallow lengths drastically reduce agricultural productivity to produce escalating rates of deforestation and political-ecological insustainability. The most commercialized Machiguenga farmers now cultivate over eight times the amount of land their forbearers did only 20 years ago. Nuevo Mundo's 45 households presently cut approximately 83 new ha of crop land per year, mostly from primary forest. Assuming a conservative population growth rate of 2% per year,²² and a fallow time of 15

²²Other Machiguenga communities have shown larger population growth rates. For the years 1980-1994, Table I shows rates of 2.35% and 3.19% for Camaná and Mayapo, respectively.

years, in 40 years Nuevo Mundo will have cut down almost 4000 ha of primary forest for crops alone (not to mention the constant process of recycling 15-year-old fallows). If the effect of cutting new pasture for Nuevo Mundo's 40 cattle is included in the calculation,²³ assuming the herd grows at only 1% per year, the community will deforest an additional 605 ha for a total of 4600 ha for both cattle and crops (see the Appendix for the deforestation model).

Presently, Nuevo Mundo holds title to 1,651.66 ha of land around their community; the government allows them access to another 10,621 ha surrounding their titled land, provided nobody else wants it. Including estimates of land use since Nuevo Mundo's founding in 1974, based on a linear expansion from traditional land use patterns (see λ calculation in the Appendix), the Machiguenga will have consumed the total amount of land originally allocated to them within seven years; within 21 years they will have put more than double that amount into production. After 80 years, assuming the government does not seize the land for other uses and the Machiguenga continue to fail in their drive to modernize, all of the titled and "reserved" lands will be deforested.

In reality none of these projections will come to pass. Innovative, organized, and highly motivated Machiguenga farmers, seeking to increase their income, will soon devise better ways to get their crops to market, allowing them to invest in chain saws, tractors, and chemical fertilizers. Deforestation rates will surely dwarf those projected. Simultaneously, the Peruvian government, in order to support a nearby gas extraction project, has told the Machiguenga that any lands not under cultivation in 1995 are eligible to be taken for the settling of colonists. So, as the Machiguenga increase their rate of land consumption for both production and defense (cultivated land will not be taken), the government, through colonization policies, will be reducing the amount of "reserved" land accessible to the Machiguenga. The present trajectory of Machiguenga land use indicates a collision course with political plans for regional industrialization and colonization. Future land disputes are inevitable.

Restrictions on land and resource access cannot be used to explain the substantial changes that have occurred in Machiguenga productive activities. In the last 25 years, Machiguenga communities have had free access to large areas of land, ranging in size from 12,273 ha to 29,277 ha. Yet, despite a vast cultural knowledge of a highly adaptive and arguably stable productive system, many Machiguenga households have increasingly altered their economic activities to engage expanding markets. Researchers and

²³Assumes a carrying capacity of 1.04 animals unit per hectare is adequate for 7 years (i.e., every cow needs a new hectare every 7 years). Carrying capacity for pastures under traditional technology assuming appropriate grazing (not over grazing) from Hecht *et al.*, 1988.

development planners cannot assume that, when faced with new circumstances including increasing access to global markets, indigenous peoples will continue to employ traditional highly sustainable means of production. From the Machiguenga perspective, the market possesses a near limitless variety of goods (that families may desire), and a seemingly unlimited demand for some commodities. Scholars have long touted the adaptiveness, stability, and ecologically-friendly nature of Amazonian swidden agricultural systems, but swidden agriculture is not in itself highly stable and non-destructive; only certain (traditional, meaning time-tested) ways of doing swidden agriculture possess these merits, other ways can be highly destructive and entirely unstable. Transformations of traditional Machiguenga productive activities, resulting from the ongoing process of commercialization, reduces the social, economic, and ecological sustainability of this socioeconomic system. Current political decisions related to land access, colonization, and resource extraction function only to accelerate change processes already underway.

Population pressure cannot explain the changes in productive activities. Current population densities range from an extreme of 2.2 persons/km² to a low of 1.19 persons/km², with an average of 1.5 persons/km² among the communities of Mayapo, Nuevo Mundo, Camisea, Puerto Huallana, and Camaná. Regardless of disputes about Amazonian carrying capacities, these densities are low by any standard, unless households are seeking to expand production to take advantage of the unquenchable thirst of world markets.

As community life begins to break down in Nuevo Mundo and Camisea, households can no longer increase production by allocating more time to agriculture. After only 20 years of continuous market contact, families now deploy nearly all their available productive time to agriculture. As a result, farmers, having already considerably expanded agricultural land use, are actively seeking both more intensive production approaches and alternative strategies to generate income. Despite a once highly adaptive set of cultural practices and a vast agroecological knowledge, some failed intensification experiments have already produced highly degraded fields, capable of only very slow regeneration. Current attempts at monocropping, cattle raising, and fertilizer use will continue to cause ecological deterioration and economic failure. Some attempts however will succeed, at least economically. Household members are pursuing alternative strategies as women and students are increasingly turning to cottage craft (the manufacturing and selling of native crafts) and wage labor to generate income with a frequency that increases with rising market incorporation. As colonization and gas extraction activities begin to complete with Machiguenga farmers for land and resources, families will be increasingly forced either back into traditional patterns or headlong into alternative income produc-

ing activities. The reality is however, as Gustavo tells us, “practically no one is able to continue the old ways”; very few Machiguenga will be prepared to “go back.”

CONCLUSIONS

Commercialization must be analyzed as an interactive process in which households, communities, and emerging social or ethnic groups are actively changing their traditional beliefs and behaviors in confronting—sometimes engaging, sometimes resisting, and usually both—the expansion of regional and global markets. Attempts to explain and/or improve the plight of indigenous groups must incorporate an understanding of how and why households are altering their traditional decision making patterns, as well as the social, economic, and ecological impacts of those changes. Specifically, researchers cannot assume that indigenous people, when faced with dynamic new circumstances, will be able to, or will want to apply their traditional agroecological knowledge and practices in sustainable land management. Only when the internal dynamics of cultural change (why some ideas proliferate in some groups and different ideas spread in other groups) which affect micro-level decision-making processes are examined in light of macro-level political economic factors (land tenure, resource access, etc.) can we more fully understand the change processes now occurring among indigenous populations. Further research should focus on combining a theoretical understanding of cultural change with the political ecological emphasis on linking levels of social, ecological, and economic analysis.

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APPENDIX. DEFORESTATION MODEL

This simple model deploys the present land use data from Nuevo Mundo with reasonable population growth rates for humans and cattle.

	Symbol	1994 Data
Nuevo Mundo Data:		
Human population:	P	271
Number of households:	η	45
Average family size:	z	6
Average amount of land cut per year per household	λ	1.8 ha
Cattle population	C	40
Assumed Data		
Human population growth rate	α	2% per year (lower than that for other Machiguenga communities)
Cattle population growth rate	β	1% per year (very conservative)
Hectares per cow for 7 years	δ	1.04 (from Hecht <i>et al.</i> , 1988)

Recursions

Equations are iterated every year based on previous year (t always equals 1 year). The subscript "old" indicate the value of the parameter from the previous year.

Population growth (P)

Humans $P_{new} = P_{old} + P_{old} * \alpha * t$; which translates in an increase in η .

Cows $C_{new} = C_{old} + C_{old} * \beta * t$;

Land consumed for crops (D)

$$D_{new} = D_{old} + \lambda * \eta * t - D(\text{current year}-15);$$

$D(\text{current year}-15)$ accounts for secondary growth brought back into production after a 15-year fallow.

λ values from 1974 (founding year of Nuevo Mundo) to 1994 are assumed to change linearly from the traditional value 0.22 ha per year to there current value of 1.8 ha per year.

Land consumed for cattle (Q)

$$Q = C_{new} * \delta + Q(\text{current year}-7);$$

$Q(\text{current year}-7)$ accounts for need to replace land after 7 years.

Total land deforested (TLD)

$$TLD = D + Q.$$

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