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Ecuador Goes Bananas: Incremental Technological Change and Forest Loss

Sven Wunder

1. Introduction[1]

Ecuador is a traditional primary commodity producer and latecomer to economic development. Throughout the 19th century the country relied on cocoa exports. But cocoa declined irreversibly in the 1920s, due to diseases and competition from other suppliers. Two decades later, favourable natural and social conditions helped the country convert bananas into its new lead export and to become the world's largest banana producer in 1954, an expansion that continued until the mid-1960s.

Ecuador has three regions: the coastal lowlands, the highlands and the Amazon lowlands. Only the coast grows bananas for export, where they compete for land with pasture, cocoa, sugar, coffee, rice and other crops and forest. Before humans arrived, forests covered an estimated 90–94% of the country's land area (Cabarle *et al.*, 1989). In 1951, their share was still almost 75%, while crops covered only 4.5%. The coast's entire cultivated area was only 501,021 ha (CEPAL, 1954: 43–48). In this context, the 100,000–150,000 ha of bananas that existed in the early 1960s represented a sizeable portion of the agricultural area. Overall, the expansion of banana production may have augmented the area of coastal agriculture by 20–30%. The area converted to bananas amounted to only 0.5–0.8% of Ecuador's huge forest cover in 1951, but it contributed notably to broader social processes, which eventually reduced the coastal region's forest cover to 33.4% in 1995 (Wunder, 2000). As Larrea (1987: 30) says:

> It is difficult to find a case in the history of the international banana economy where the expansion of the crop produced such ample demographic and migratory effects as in the case of the Ecuadorean coast during 1948–1965. The rapid expansion of production shifted the region's agricultural frontier outwards, until it contained the majority of the area currently under cultivation.
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> (Author's translation from the Spanish)

The demand for cultivated land and pasture accounts for most deforestation in Ecuador. More than 90% of the deforested areas ends up as pasture, but a large portion of that had already been harvested for timber and used for crops before being converted to grasslands (Wunder, 2000). Forest loss data are unreliable, but it is likely that deforestation in Ecuador rose to between 180,000 ha and 240,000 ha year^{-1} in the mid-1970s. Most forest clearing occurs in the two lowland regions. Estimates of current forest cover range between 11 and 15 million ha, so yearly deforestation rates are between 1.2% and 2.2%.[2]

In assessing how banana production and technologies have affected deforestation, one must distinguish between direct and indirect impacts. During the postwar period, the amount of forested land directly cleared for banana plantations fluctuated heavily and varied from one region to the next. Technological change greatly influenced this process. New varieties and other changes in production and transport technology determined the shifting requirements for, and changing production centres of, banana plantations. Three factors proved vital in setting dynamic comparative advantage: water, soil quality and access to markets (Sylva, 1987: 116–122).

At the same time, banana production indirectly affected deforestation in many complex ways. Bananas were pivotal to the entire economy's growth and transformation. They demanded great amounts of labour and provided the taxes to finance the expansion of railways, roads and credit. They changed the balance of power between political classes and geographical regions and they altered the role of the Ecuadorean state and its institutions (Larrea, 1987; Striffler, 1997).

Against this background, the relevant counterfactual questions – 'how much forest would have been lost without the banana boom?' and 'how much forest would have been lost applying different banana production technologies?' – are very hard to answer. Both questions require speculative judgements on alternative regional and product development options over a period of five decades, and their respective indirect land-use impacts.[3] However, based on sector-wide analyses of banana production (CIDA, 1965; Larrea, 1987), case-studies of banana-led coastal colonization (Brownrigg, 1981; Striffler, 1997) and comparisons with other commodity booms (cocoa and oil) (Wunder, 2000), we conclude that road construction and labour migration encapsulate the banana expansion's main indirect effects on land use. Hence, our discussion of indirect impacts focuses on these two aspects, both of which led to important asymmetries in land-use changes between banana booms and busts.

Sections 2, 3 and 4 analyse three periods in the postwar development of the Ecuadorean banana sector. For each period, an initial subsection describes market and production trends. A subsection on technologies and the regional distribution of banana production follows. Then come a characterization of the indirect impacts and a summary. Section 5 compares the banana technology, production and market characteristics in the three periods, and section 6 the corresponding deforestation impacts. Section 7 discusses the theoretical and policy implications.

2. 'Banana Fever' (1946–1966)

2.1. Markets and production

Several factors facilitated the rapid rise of Ecuadorean banana exports after the Second World War. First and foremost, global demand rose steadily, mainly centred in the US market. Secondly, the country's Central American competitors faced severe problems with 'Panama disease' and other diseases, as well as periodic devastation of their plantations by cyclones. Ecuador's abundant, disease-free, fertile soils, which had sufficient water and were less exposed to tropical storms, gave it a comparative advantage. This helped convince multinationals like United Fruit and Standard Fruit to buy large areas to establish their own banana plantations, as well as providing capital and technical assistance to Ecuadorean banana-growers (Striffler, 1997).

At the time, Ecuador was still suffering from the decline of cocoa. Coastal farmers were diversifying into cattle, sugar and cotton and were searching for ways to reduce production costs (CEPAL, 1954: 52). Underutilized former cocoa plantations, low rural wages and a devalued currency all provided excellent incentives for establishing new lines of production. The government of Galo Plaza (1948–1952) favoured banana producers by expanding the road network and giving them subsidized credit (Sylva, 1987; Acosta, 1997: 92). These advantages outweighed Ecuador's disadvantages, such as its undeveloped port and road infrastructure (CEPAL, 1954: 82) and technological backwardness and its greater distance from the US and European markets, compared with Central America (Larrea, 1987: 47).

The only statistics available prior to 1955 refer to the number of banana racemes exported. From 112,973 in 1920, these rose significantly to 1,181,710 in 1930 and 1,874,595 in 1940. They declined during the war to 693,551 in 1945, but then grew exponentially to 2,686,870 in 1947, 16,755,066 in 1952 and 23,874,310 in 1955 (Riofrío, 1995: 11). From 1945 to 1951, prices rose fourfold and this greatly stimulated production (CEPAL, 1954: 170).

2.2. Technology and regional distribution

'Gros Michel' was the dominant commercial banana variety around the world. Its main advantages were its size and physical robustness. It was simple to plant, maintain, harvest and transport and did not damage easily. This helped it expand widely, both geographically and in terms of the types of farmers that grew it. The requirements for banana production that largely determined their spatial distribution were (Hernández and Witter, 1996; Rios, 1996): (i) fertile, deep, nutrient-rich soils, preferably with loose texture, pH 5.5–7.5; (ii) humid tropical to subtropical temperatures (optimal around 30°C); (iii) abundant, regular availability of water and good drainage; and (iv) access to ports.

Many urban middle-class entrepreneurs invested in land to participate in the boom. The owners of large haciendas, traditionally dedicated to cocoa and cattle ranching, allocated part of their land to bananas. Peasants migrated from highland provinces, cleared forest to gain land rights and planted bananas. Everybody could grow bananas. There were no significant technological or financial barriers to entry (Striffler, 1997: 43). Hence, the impact was much more far-reaching than the cocoa boom, which had been concentrated on haciendas in the Guayas river basin, a fertile lowland area north of Guayaquil.

Two contemporary analyses at the regional and farm level (CEPAL, 1954; CIDA,1965) give us a detailed vision of the process through which bananas penetrated the rural economy. The first banana plantations were established near navigable rivers – the main transport arteries in the absence of roads. These plantations were often located in or near the old cocoa haciendas in Guayas (see Fig. 10.1). There, bananas constituted one additional element within diversified production systems, which also included sugar, rice, oil crops and cattle. Within this area, one could find both haciendas of over 1000 ha and small to medium-sized lots (CIDA, 1965: 382–392). The area's main advantages for producing bananas were its good soils and accessibility. Its key drawbacks were its deficient rainfall and poor drainage (CEPAL, 1954).

The western Andean foothills, which descend towards the coastal plain, offered the best natural conditions for cultivating bananas. This area offered rich soils and regular abundant rainfall and its hilly topography provided natural drainage. The road network gradually expanded and made new areas of production accessible, especially in the hilly parts of the provinces of Los Ríos and El Oro and, to a lesser extent, in the lower parts of the highland provinces. Migrant farmers colonized and deforested most of these areas, typically claiming a homestead of 50 ha, of which they dedicated up to 30 ha to bananas. Unlike in Guayas province, most of these small- and medium-scale producers established banana monocultures (CEPAL, 1954: 166–169).

Bananas are extremely perishable and cannot withstand more than 5 weeks between harvesting and consumption (López, 1988: 17). Nevertheless, the 'Gros Michel' variety was so robust that, even in places with no direct access to roads, farmers could transport unwashed and unpacked racemes by

mule, on shaky trucks and in canoes navigating untamed rivers. When prices were high, the radius of economically feasible cultivation expanded (Sylva, 1987: 118). In the Andean foothills, banana cultivation and deforestation were directly linked. A Comisión Económica para América Latina y Caribe (CEPAL) report from the period noted that with 'the conquest of idle lands in all the hilly zones of the coast, which offered excellent conditions for the new product . . . forests were felled and old gardens destroyed to plant bananas' (CEPAL, 1954: 170, translation from Spanish by the author).

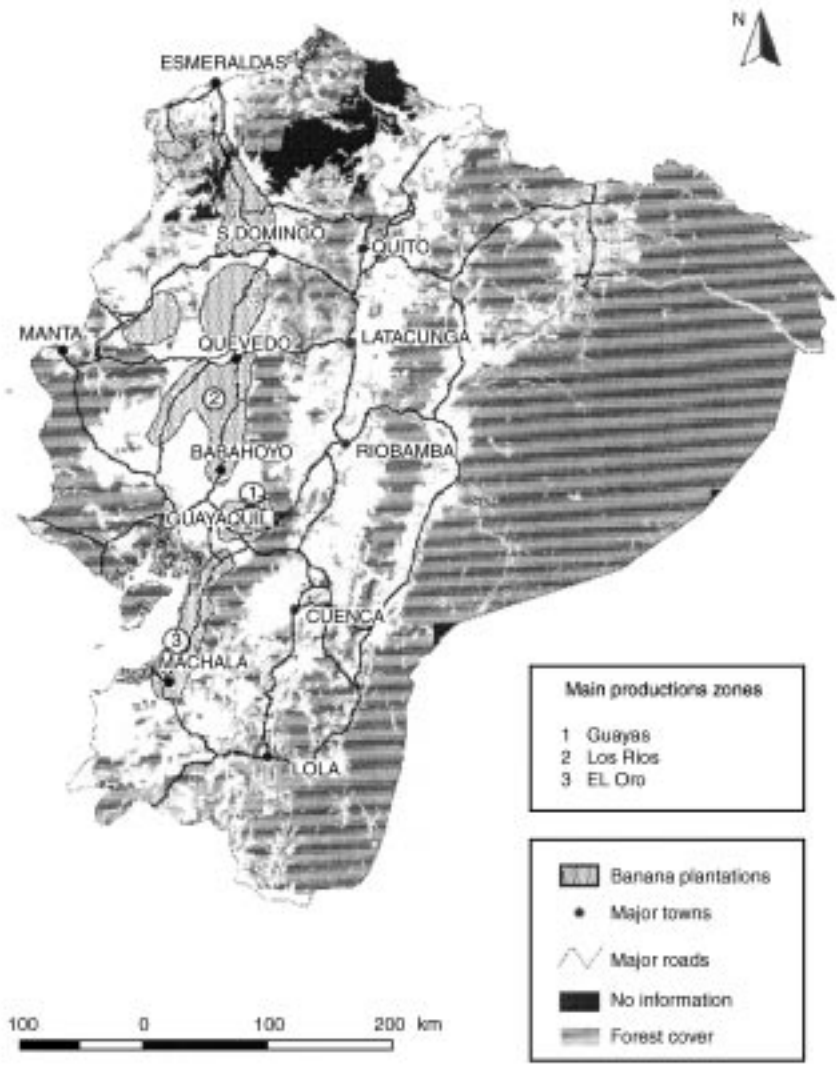

Fig. 10.1. Historical banana plantation zones and current forest cover. (Sources: Wunder, 1999; UPEB, 1990.)

Besides the 'old' (Guayas plains) and 'new' (foothills of Los Ríos and El Oro provinces) production zones, banana cultivation gradually expanded into more marginal production areas with poorer soils, in response to high prices. Already in 1948, the multinational Fruit Trading Corporation had established plantations near the northern port of Esmeraldas (Sylva, 1987: 116). Bananas also expanded into the drier parts of El Oro province. To grow bananas in that area, producers had to both irrigate and drain excess water and the soils were generally less fertile than in Los Ríos and Guayas. The region's only advantage was that it was near the port of Bolívar. In the El Oro lowlands, growers used land particularly extensively. Another report by CEPAL refers to banana cultivation there as 'a bad habit that encroaches on all kinds of soils' (CIDA, 1965: 396).

After banana cultivation depleted the soils, in most cases the growers put the land into pasture and moved their bananas elsewhere, creating a 'semi-migratory production system' (Striffler, 1997: 41), which required access to large areas. On some haciendas in the El Oro lowlands, sharecroppers cleared land for bananas and then abandoned it after several years. Before moving on, the landowners required that they leave the land planted in pasture (CIDA, 1965: 402). One report talks about 'the predatory effect of continued banana cultivation' in reference to El Oro's land-consuming production system, in which farmers grew bananas without fertilizers or drainage infrastructure and constantly shifted the location of their plantations (CIDA, 1965: 414), a practice highly conducive to deforestation. By the end of the period, frequent attacks of Panama disease would lead growers to move out even further, triggering land races with homesteading peasants, who often encroached on the multinationals' banana plantations (Striffler, 1997: 89–136).

2.3. Indirect impacts

Bananas' impact on forests was not restricted to their direct effects. The 'banana fever' epoch also had conspicuous indirect effects. Natural population growth on the coast could not satisfy the mounting demand for wage labour stemming from the rapidly rising production of the highly labour-intensive crop. The growers demanded massive quantities of unskilled labour and paid good salaries, especially the multinationals. Partially in response, over 250,000 people migrated to the coast during the 1950s (Striffler, 1997: 60). The Canadian International Development Agency (CIDA, 1965: 395) mentions that in El Oro 'banana cultivation powerfully influenced the development of the province, increasing the cultivated area and favouring in-migration from the Republic's interior, especially the [highland] provinces of Azuay and Loja' (translated from Spanish by the author).

Since the new production areas were still poorly integrated into the market economy, food crops were largely grown on-farm. Even on one of the largest and most specialized plantations, Tenguel, between the Guayas and El

Oro provinces, workers recall that the plantation produced 'nearly everything, from sugar to cattle, to basic food crops such as yucca and plantains as well as a wide range of fruits' (Striffler, 1997: 34). In all probability, feeding so many workers with locally grown foods sharply exacerbated the demand for land associated with banana cultivation.

By no means all migrants became banana-growers or workers. Many followed other livelihood strategies. For instance, Brownrigg (1981) describes a group of rural–rural migrants who moved from Loja to the El Oro foothills and basically retained the diversified farming systems they practised previously. But these groups' efforts could never have succeeded so much were it not for the growing urban food markets, wage-labour opportunities and other possibilities the banana boom offered. Banana incomes stimulated the transport, construction and service sectors, creating regional development booms in mid-sized coastal towns, such as Naranjal, Machala, Quevedo and Babahoya (Striffler, 1997: 58).

The infrastructure built by the state or banana producers to bring new areas into the plantation economy were key in fomenting other economic activities as well (Striffler, 1997: 59, 239). In several cases in the Guayas and El Oro provinces, the colonization of marginal, hillside areas depended directly on the construction or extension of an existing road or railway designed to promote banana production. Taxes paid by banana producers allowed the state to increase its presence in these newly colonized areas (Striffler, 1997: 56). This helped push the forest frontier forward.

2.4. Summary

Extremely land-extensive technologies (low capital intensity, low yields) characterized the early 'banana fever' period (1945–1966). The rustic nature and technological simplicity of the 'Gros Michel' variety made it possible to grow bananas throughout the coastal lowlands, even in areas far from ports, allowing production to expand widely, both geographically and socially. The growing demand for land led landowners to convert former cocoa plantations and other previously cultivated areas to bananas. But large areas of forest were also converted to banana plantations, especially on the fertile Andean slopes. With their high rainfall, natural drainage and abundant virgin land, these areas provided a perfect setting for a simple banana production system, based on nutrient mining and low investment. Banana production areas frequently shifted, continuously opening up new areas of forest. The technology required a lot of labour, supplied by immigrants from the highlands, attracted by high wages. The banana trade justified an extension of the road and rail networks, which opened up new areas for forest clearing. During this period, production led to substantial deforestation, both directly (land-extensive, shifting banana plantations) and indirectly (immigration, road construction).

3. Stagnation, Variety Shift and Intensification (1967–1985)

3.1. Markets and production

With the spread of banana plantations to marginal soils in the late 1960s, extensive expansion reached its limit. A shift in external conditions changed that. Between 1957 and 1965, Central American producers successfully replaced the 'Gros Michel' by the new, more productive 'Cavendish' variety (López, 1988). Over the next 10 years, mechanization and shifts between 'Cavendish' subvarieties further improved the Central Americans' technology.[4] Central American producers, particularly the multinationals, developed and adopted technology much faster than in Ecuador, where medium-scale domestic growers continued to dominate production. These producers adopted technology more slowly due to financial constraints and their limited know-how. Thus, Ecuador did not shift from 'Gros Michel' to 'Cavendish' until the late 1960s and early 1970s (Larrea, 1987: 57; Ríos, 1996).

The shift from 'Gros Michel' to 'Cavendish' in Central America doubled that region's yields and almost tripled the volume the main producers exported in 6 years (1965–1971). Ecuador's disease- and cyclone-free production environment ceased to give it a major natural comparative advantage, since the new variety made these factors less important (Larrea, 1987: 56–58). During the boom, banana workers had earned continuously higher wages as growers sought aggressively to attract labour (Acosta, 1997: 83). This drove up production costs and eventually proved unsustainable. Banana workers' real wages started to gradually decline, especially after 1969 (Larrea, 1987: 60–61). From 1973 to 1983, the oil boom caused an overvalued exchange rate, which hampered the expansion of agricultural exports in general (Wunder, 1997). The loss of Ecuador's natural comparative advantage, combined with lagging technology and an overvalued exchange rate, kept its banana exports stagnant for a decade. Ecuador came to hold a 'second-class status as a reserve supplier' (Striffler, 1997: 175). Multinationals stopped producing directly and established contract farming arrangements with domestic producers. The crisis, together with the gradual adoption of more land-intensive technologies, sharply reduced the amount of land devoted to banana cultivation in Ecuador, as shown in Fig. 10.2.

A note is in order here regarding Ecuador's banana-area statistics. The National Banana Programme (PNB) annually records the area devoted to bananas for export, while periodic agricultural censuses register the total area with bananas. In theory, the two sources should differ only with respect to the small amount of bananas produced for the domestic market. In practice, the PNB figures include only areas covered by that programme, which must fulfil certain quality standards. Thus, they underestimate the area of bananas produced for export. Census data include banana areas with low planting densities, interplanted with other crops or even abandoned, so they exaggerate the area. For instance, Fig. 10.2 documents the sharp rise in cultivated area

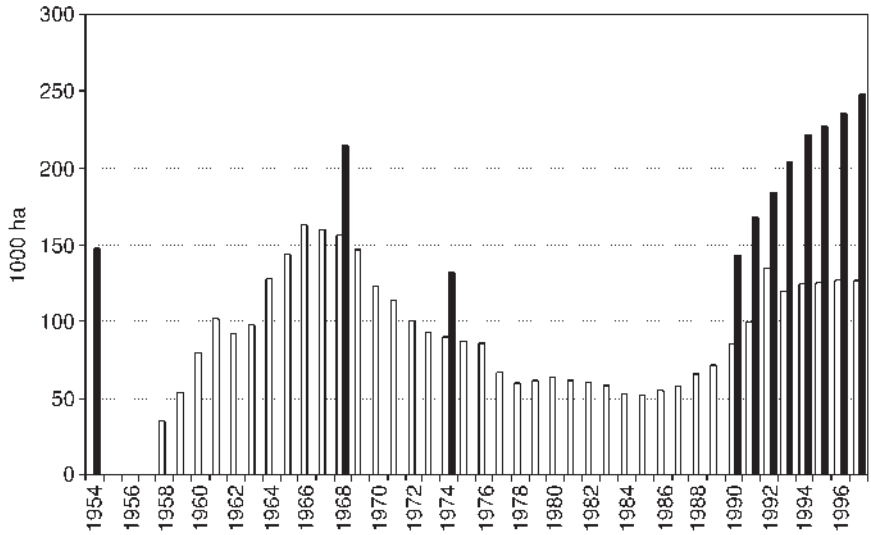

Fig. 10.2. Cultivated area of bananas in Ecuador, 1958–1997 (ha) (from Larrea, 1987; Riofrío, 1995, 1997; MAG, 1998). □, PNB data; ■, 1954 census data.

from the 1950s to 1964, but the PNB data (light-shaded columns) clearly underestimate exports for the late 1950s, since the programme had just begun to sign up producers at the time.[5] At the same time, the 1954 census figure (dark-shaded column) of almost 150,000 ha clearly exaggerates export production, seeing that CEPAL (1954: 167) estimated that the banana export area in 1951 was only 30,530 ha.

Stagnant exports and the adoption of land-saving technologies precipitated a dramatic and continuous fall in the area devoted to producing bananas for export over two decades, from the peak of 163,773 ha in 1966 to 51,796 ha in 1985. Agricultural census figures show a similar trend, although starting from a higher initial level.

3.2. Technology and regional distribution

The 'Cavendish' variety was resistant to Panama disease and could be planted at a higher density, and its lower plant size made it less susceptible to cyclone damage (Sylva, 1987: 118). Figure 10.3 combines the figures on cultivated area with export production data to estimate the trends in physical yields. After the decline in yields that accompanied the extensive expansion of bananas into marginal lands in the 1960s, the gradual introduction of the 'Cavendish' variety brought a pronounced rise in yields, at least up to 1978. As a result, more or less constant overall production levels during this period required less and less land.

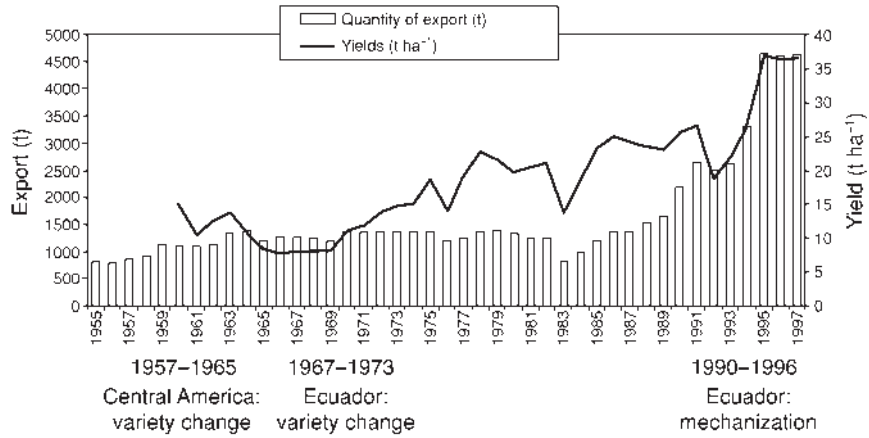

Fig. 10.3. Banana export quantities and per-hectare yields (1955–1997) (from Larrea, 1987; Riofrío, 1995, 1997; MAG, 1998).

This dramatic decline in cultivated area was highly unevenly distributed between producing areas. Table 10.1 shows the evolution of the banana export production areas since 1954 in the five coastal provinces and the lower part of the highland province of Pichincha. In 1954, bananas were still fairly equally distributed among all the coastal provinces. By 1968, this situation had changed. The plantations in the dry and populous province of Manabí receded, while Los Ríos, El Oro and Pichincha increased their participation. Observing Table 10.1, one notes that the regional distribution of banana plantations was markedly unstable and varied sharply from decade to decade. However, by 1983, a clear trend was visible. Banana production had concentrated in three provinces: Los Ríos, Guayas and, in particular, El Oro.[6] Since the 'Cavendish' variety was much more susceptible to transport damage than 'Gros Michel', distance to ports became the deciding factor in where growers located their banana plantations. Excellent access to the small but specialized port of Puerto Bolívar particularly favoured the southern production zone of El Oro. In 1966, 12.1% of Ecuador's banana exports left the country through Puerto Bolívar. Only 4 years later, the share had risen to 50.2%, and in 1978 it peaked at 68% (Larrea, 1987: 238). The country's main port, Guayaquil, which served banana-growers in Guayas and Los Ríos, became a bottleneck. The United Nations Conference on Trade and Development (UNCTAD) figures for 1974 (cited in López, 1988: 20) show that, while Central American ports shipped 10,000–12,000 boxes h^{-1}, Guayaquil only managed to ship 5000 boxes h^{-1}.

3.3. Indirect impacts

Banana production caused more modest indirect deforestation impacts during this period compared with the previous boom. The drop in employment in the

Table 10.1. Geographical distribution of banana plantations, Ecuador, 1954–1983, selected years, six main provinces (ha) (from agricultural census and survey data, cited in Larrea *et al.* (1987: 125) and Riofrío (1997: 300–301)).

Province	1954	%	1968	%	1974	%	1983*	%	1996*	%
Pichincha	8,270	5.62	39,898	18.59	8,278	6.25	163	0.30	282	0.23
Esmeraldas	36,320	24.66	34,100	15.89	19,235	14.52	1,516	2.75	3,583	2.96
Manabí	27,450	18.64	16,947	7.90	20,532	15.50	249	0.45	50	0.04
El Oro	13,610	9.24	46,851	21.83	25,669	19.38	26,240	47.65	42,515	35.14
Guayas	33,450	22.71	29,201	13.61	25,159	19.00	18,438	33.48	38,396	31.74
Los Ríos	28,170	19.13	47,595	22.18	33,568	25.35	8,464	15.37	36,158	29.89
Total production areas†	147,270	100.00	214,592	100.00	132,441	100.00	55,070	100.00	120,984	100.00
Areas registered for export production*	34,141‡		156,876		90,501		58,317		127,140	

*1983, 1996 and national totals, for export areas.
†1954, 1968, 1974: total production areas.
‡1958 figure.

banana sector ended banana-motivated migration, although population growth continued among families that immigrated during the 'banana fever' period. However, just as the cocoa crisis forced producers to diversify, the banana crisis induced farmers to expand their other crops and their cattle ranching, rather than abandoning the areas released from banana production and allowing the forest there to regenerate. Many laid-off banana workers resorted to colonizing adjacent marginal areas for subsistence agriculture. A former United Fruit worker at Tenguel hacienda recalled that:

> Most of us had just been laid off and had ninety days to leave our houses and the hacienda . . . Some talked about going to Guayaquil. No one really had a good idea. Then someone said, 'Why don't we go start working over near the mountains?' Soon after, we went and took a look and decided to struggle for land and form a community.
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> (Cited in Striffler, 1997: 116)

During the oil-boom period, the government used its abundant foreign exchange to construct many roads into areas with primary forests as part of a deliberate strategy of national integration (Wunder, 1997). But outside the El Oro province, where the expansion of 'Cavendish' production required high-quality roads to the port, these investments had little to do with the banana sector. None the less, just as the after-effects of postwar banana-led immigration continued to cause forest loss even after the banana area contracted, the roads built during the banana fever helped failed banana production areas to survive the crisis by diversifying. As Striffler (1997: 237–238) notes for the La Florida area, forest cover did not return symmetrically after the banana boom:

> To a certain extent . . . there was no turning back. Roads were built and lands were cleared. The haciendas retracted but were never again reduced to their 1950s state of near abandonment. Cacao trees and pasture slowly but consistently replaced bananas . . . The zone would remain marginal, but never again unpopulated or uncultivated.

3.4. Summary

Ecuadorean banana production stagnated from the mid-1960s to the mid-1980s. Central American growers successfully boosted their region's production by shifting to the more productive 'Cavendish' variety. This dampened world market prices and reduced Ecuador's market share. From 1975 to 1983, the oil boom led to overvalued exchange rates and rising production costs, which made banana exports even less profitable. In a lagged response to the changes that occurred in Central America, Ecuadorean producers gradually shifted to the 'Cavendish' variety. However, the new variety was more fragile, and growers relocated much of their production to areas close to ports, where transport damage of the more fragile variety could be minimized.

The technological package accompanying the 'Cavendish' variety was less labour-intensive and more intensive in financial capital and know-how. This increasingly excluded small producers, who lacked the conditions necessary to adopt the new technologies. Coastal agriculture diversified, and some labour released from the banana sector cleared forest remnants to produce other crops. On the whole, the land-saving 'Cavendish' variety dramatically reduced the direct deforestation impact from bananas, although the relocation of production to areas near ports promoted forest clearing in certain regions. The indirect impacts of banana-motivated road expansion and migration were also weakened (real wages started to decline), but the previous immigrants continued to multiply, which consolidated coastal settlement.

4. Bonanza and Mechanization (1985–present)

4.1. Markets and production

When the Berlin Wall fell in 1989, the banana became a potent symbol of the East German population's desire to gain access to popular Western consumption goods. More generally, the opening of Eastern European markets helped fuel world demand for bananas. World banana prices rose over 40% in the late 1980s (IMF, 1991: 343), although the European Union imposed trade restrictions that harmed Ecuadorean exports. Furthermore, during the economic crisis of the 1980s, Ecuadorean agricultural exports in general experienced some of the fastest growth in Latin America, encouraged by currency devaluations and other macroeconomic policies that favoured agriculture (Southgate and Whitaker, 1996).

As a result of favourable external demand trends and successful internal adjustment, from the mid-1980s and, above all, in the 1990s, Ecuador experienced a new banana bonanza. Production volumes reached unprecedented levels, except in 1992/93 when climatic fluctuations (El Niño) and fungus attacks (*Sigatoka negra*) caused a momentary decline. Up to 1994, this rise was chiefly achieved by expanding the cultivated area. But, from 1995 on, the growth in area levelled off, and production rose solely as a result of growth in land productivity (Figs 10.1 and 10.2). As explained in the following section, Ecuadorean expansion was associated with the gradual mechanization of banana production, which once again lagged in relation to Central America, where similar changes had been under way since the mid-1970s (López, 1988).

4.2. Technology and regional distribution

The new technological package, which gradually diffused among Ecuadorean producers, included greater chemical input use (fertilizers, insecticides,

fungicides, herbicides), regular aerial fumigation, on-farm funicular transport of harvested racemes, use of plastic bags and other methods to protect and manipulate flower and fruit development, irrigation systems and subterranean drainage installations. The latter two in particular produced an important rise in yields (V. Espinoza, December 1998, personal communication).[7] The timing of investments needed to implement new technologies reflected both 'push' and 'pull' factors. Mechanization and quality improvements are closely linked and, as banana consumers became increasingly accustomed to purchasing larger fruits with unspotted appearances, this put pressure on Ecuadorean producers, who were slow to modernize.

Table 10.2 shows the revolutionary changes in production technology during the 1990s. From 1990 to 1997, the area under 'mechanized production', involving most of the elements of the technological 'package' described above, rose from 20,343 ha (23.9%) to 90,304 ha (71%). 'Semi-mechanized' areas without mechanized irrigation and drainage installations (MAG, n.d.: 9) doubled in extent, while the non-mechanized plantation area fell from 54,856 ha (64.4%) to 13,817 ha (10.9%).

How did these technological changes affect factor demand? Obviously, mechanization significantly increased the capital intensity of production, in terms of both fixed costs (irrigation, drainage and funicular systems) and inputs (chemicals, plastic bags, etc.). Thus, the ratios of capital to output, land and labour rose. The new production methods also reduced the demand for labour per unit of output, and even per unit of land, by modernizing harvest, transport and maintenance. Even so, banana production remained fairly labour-intensive. The exclusive use of unskilled farm labour increasingly gave way to a more specialized labour force that could handle the new management systems. Total demand for farm labour declined, but there were increasing backward linkages to off-farm activities, such as packaging industries and aerial fumigation services. Some analysts predicted that the new technology would reduce the sector's positive multiplier effects on the national economy (Larrea, 1987: 156), but the most recent estimate (1997) demonstrates that bananas still benefit, directly or indirectly, around 1,250,000 people (MAG, 1998: 3).

Improved infrastructure was vital to the new boom. A recent reorganization of Guayaquil's port facilities allowed it to regain efficiency and importance as a banana port (S. Riofrío, December 1998, personal communication.) Producers greatly improved their postharvest treatment of the fruit (washing, packaging, etc.) and off-farm operations (mechanized port embarkation, refrigerated ship transport). Thanks to these innovations, following the extreme geographical concentration of banana production during the period of stagnation, the radius of production widened once again, making closeness to port less important and favouring the return of bananas to Los Ríos and Guayas provinces (see Table 10.1). Other provinces, such as Esmeraldas, Manabí and Pichincha, have lost ground since their soils and climates do not favour specialized, capital-intensive production (Moreno, 1991).

Table 10.2. The diffusion of technological change in Ecuador in the 1990s (ha) (from National Banana Programme (PNB), published in SICA, 1999).

Technological levels	1990	1991	1992	1993	1994	1995	1996	1997
Mechanized	20,343	40,856	50,793	58,462	58,703	68,059	89,741	90,304
Semi-mechanized	9,989	24,322	38,133	35,824	29,156	26,088	23,524	23,005
Unmechanized	54,856	33,941	45,578	46,703	36,557	31,457	14,145	13,817
Total	85,187	99,118	134,504	140,989	124,416	125,604	127,410	127,126
Percentages								
Mechanized	23.9	41.2	37.8	41.5	47.2	54.2	70.4	71.0
Semi-mechanized	11.7	24.5	28.4	25.4	23.4	20.8	18.5	18.1
Unmechanized	64.4	34.2	33.9	33.1	29.4	25.0	10.9	10.9

Mechanization clearly reduced the ratio of cultivated land to output, especially in the last few years. Thus, the boom continued the ongoing trend towards land-saving technologies, which began with the shift to the 'Cavendish' variety. Technology, soil fertility and unit size were strongly correlated. Mechanization has occurred on the best soils and has favoured medium-sized farms, probably because of their greater ability to mobilize the capital and know-how required for the new methods. The smallest and most capital-constrained farmers, who used to cultivate bananas within diversified farm operations, have increasingly turned to other cash crops, such as cocoa or coffee.

4.3. Indirect impacts

The indirect effects on deforestation linked to bananas during the recent boom were even more restricted than during the previous period. The road network in the prime production zones of the southern coast, where mechanized production was concentrated, was already well established when the boom began (Striffler, 1997: 273). Road construction was less pronounced and, as a result of the intensive but fragile character of mechanized 'Cavendish' production, the specific demands from the banana sector were focused more on the improvement of existing roads than on extending the road network. This new pattern of infrastructure development was less likely to contribute to deforestation.

Mechanization generated a labour surplus in the banana sector, which eliminated the incentives for regional immigration. As in the previous period, this surplus labour typically did not return to the rural highlands, where it originally came from. The cities absorbed part of it. Another group shifted into other crops. Many peasant producers, crowded out of bananas by the new technological and capital requirements, went back to producing cocoa (Larrea, 1987; Striffler, 1997: 273). In this way, the indirect impacts of bananas were largely restricted to long-term trends, which had their origins in the early years of 'banana fever' – notably, continued population growth and settlement among the original migrants to the coast.

4.4. Summary

Ecuadorean banana exports experienced a strong revival after the mid-1980s. Exchange rates became less overvalued, international demand grew and the adoption of mechanized technologies again made Ecuador very competitive. The new technologies are highly intensive in capital, know-how and land, but less labour-intensive. Up to the early 1990s, the steady rise in banana exports involved an expansion in cultivated area, but since then growers have achieved unprecedented levels of production without expanding the total area. The incremental adoption of mechanized technologies by Ecuador's

predominantly medium-sized producers made this possible. Improvements in off-farm technologies (packaging, refrigeration) and infrastructure (ports, roads) have again increased the geographical spread of banana production. However, high site-specific on-farm investments in fixed, installed capital (irrigation, drainage and funicular transport systems) have made 'migratory' nutrient-mining technologies unprofitable. The much more intensive and sedentary character of modern banana production has reduced the sector's direct deforestation impact to practically zero. Indirect impacts are now mostly restricted to increasing population, which has its origins in the postwar wave of banana-led migration to the coast.

5. Comparing Production in the Three Periods

Table 10.3 compares the dynamics of the banana sector on the Ecuadorean coast over half a century: the changes in technologies, product and grower characteristics, labour and output markets, the regional distribution of production and the policy environment. First, you have the rapid postwar expansion of simple, labour-intensive and land-extensive production systems into marginal lands. Secondly comes a crisis-cum-adjustment period, during which a shift in banana variety made production more land- and capital-intensive. Thirdly, one observes the recent boom accompanied by mechanization of the plantations, which raised capital and land intensity, but saved labour. Table 10.3 presents how factor intensities (defined in relation to output units) changed during each period. The banana sector went from land-extensive to extremely land-intensive, from migratory to sedentary and from highly labour- to capital-intensive. Technology was initially disembodied, but later embodied into 'packages' during the two latter periods. With increased competition and world market requirements, yields increased and the product and the systems used to produce bananas went from robust and simple to fragile and sophisticated.

Ecuador's growers were much slower to adopt new technologies than their Central American counterparts. In Ecuador, the multinationals withdrew from direct production in the 1960s. Urban investors replaced the smallest farmers, who were pushed out of the banana business, because they lacked the capital and know-how that producing 'Cavendish' bananas required. Medium-scale producers became dominant in Ecuador and technological innovation advanced slowly as a result. Economies of scale may have emerged during this process, but probably more in marketing than in production. Atomized producers generally acted as price takers, but some large trading firms were probably able to influence world prices. *Ceteris paribus*, the growth in Ecuadorean exports lowered prices and thus made farm-level improvements less profitable. Even so, during the last decade, favourable demand trends (e.g. the East European market) and Ecuador's quality advances have sustained the banana boom.

Table 10.3. Changes in the banana sector's production, Ecuador, 1945–1999.

	Period				
	Banana fever		Stagnation and variety shift	Boom and mechanization	
Years	1945–1966		1967–1984	1985–1999	
Main technological change	'Gros Michel' extends to marginal lands		Adoption of high-yield 'Cavendish' variety	Drainage, irrigation, chemical inputs, etc.	
Factor intensity	Level	Trend	Trend	Trend	Level
L/Y (labour intensity)	High	0	–	––	Medium
K/Y (capital intensity)	Low	0	+	++	High
(Installed K)/Y	Nil	0	+	+++	High
H/Y (land intensity)	High	+	–	––	Low
Production type	Extensive Shifting plantations		Semi-intensive Shifting plantations	Intensive Sedentary plantations	
Product type	Low yield, robust		High yield, fragile	High yield, fragile	
Technology	Disembodied		Embodied	Embodied	
Off-farm technology	Rudimentary transport		Improved port handling systems	Improved packaging Refrigeration in ships	
Main producers	All types of farmers		Medium-sized farms Urban investors	Medium-sized farms Urban investors	
Producers' adoption of new technologies	Negligible		Lagged, gradual	Lagged, gradual	

Export markets	Rising demand	Saturation	Rising demand
Main factors of comparative advantage	1. Rainfall, drainage 2. Soils, transport distance	1.Transport distance 2. Soils, rainfall, drainage	1. Soils 2. Transport, rainfall
Regional concentration: leading provinces*	Low: Los Ríos, Esmer., Pich., El Oro, Guayas	High: El Oro, Guayas, Los Ríos	Medium: El Oro, Guayas, Los Ríos
Favoured production zones	1. Hilly frontier 2. Old cocoa farms	Areas near ports and roads	Prime agricultural areas
Labour-market constraints and population	Labour shortages High wages Seasonal migration Low population density	Demand saturation Falling real wages Seasonal migration Medium population density	Demand saturation Wage differentiation Seasonal migration Medium population density
Main policies affecting the banana economy	Credit subsidy (+) Road building (++) Exchange rate (++)	Credit subsidy (+) Road building (+) Exchange rate (––)	Credit subsidy (0) Road building (0) Exchange rate (+)
Direct deforestation impact of bananas	Frontier expansion +++	Bust/reduced area ––	Boom/intensification +/0
Indirect impacts	Roads ++ In-migration ++ Pop. growth +	Roads + In-migration 0 Pop. growth ++	Roads 0 In-migration 0 Pop. growth ++

*By the end of the respective period.
Esmer., Esmeraldas; Pich., Pichincha.

Innovations in transport technology, the unique requirements of each new variety and the geographical distribution of diseases combined to bring about frequent shifts in banana production between regions. Initially, rain-fed production and natural drainage favoured the clearing of hilly frontier areas. Nowadays, irrigation and drainage systems have pushed production towards the more accessible prime agricultural areas with fertile soils. The 'banana fever' spread production equally over large parts of the coast, but disease problems in Esmeraldas province and other producing regions and the demanding transport requirements of the 'Cavendish' variety subsequently concentrated banana production on the southern coast. In 1983, almost half of all production came from El Oro province (see Table 10.2). Improvements in transport technologies and packaging methods facilitated a more even distribution in the 1990s, but the three provinces with the best soil and humidity conditions, El Oro, Guayas and Los Ríos, continued to produce most of the bananas. Even though at any given moment banana plantations only occupied a relatively small area, one must keep in mind that historically fruit production frequently changed location and thus affected land use in much larger areas.

Given the initial very high labour intensity of banana production, labour shortages on the coast severely constrained the expansion of exports in the 1950s. Growers continuously offered high wages to attract both seasonal and permanent workers. Together with the moderately labour-saving technological changes and natural population growth among settlers, this gradually saturated labour demand in the second period. Real wages declined and labour demand in the banana sector became more differentiated. The inflationary pressures from the oil boom and an overvalued exchange rate kept production costs high. However, the economic crisis from the 1980s onwards again turned policies in favour of agro-export interests.

6. Comparing the Impact on Deforestation in the Three Periods

The last two rows in Table 10.3 summarize the direct and indirect deforestation impacts associated with the banana sector in the three periods. The direct impact – new, previously forested areas converted for banana production – varied greatly. The banana area initially expanded sharply, then contracted, then grew moderately and now seems to have halted. Two factors magnified the direct impact beyond what one might expect from the cultivated-area figures – 150,000–250,000 ha, at its peak. The first was the migration of banana production from one location to another during the initial boom. Growers typically mined and degraded the soils and then abandoned the location and moved on. The second involved the repeated relocation of plantations, more related to sudden structural shifts in the requirements of different banana varieties and technological packages. Together, these

two factors explain the historically 'semi-migratory' character of banana production, which critically aggravated its deforestation impact.

Typically, banana production provided the economic justification for the initial clearing of forest. Once the plantations moved on, however, these areas rarely reverted back to forests. Farmers used most abandoned banana areas for other crops or pastures. This created an asymmetry in land-use conversion. The dynamic character, or instability, of the technologies used thus ended up promoting deforestation. Large areas were initially cleared for bananas in the Ecuadorean provinces of Esmeraldas, Manabí and Pichincha, which were later abandoned. Hernández and Witter (1996) report a similar process in Central America.[8]

How much deforestation does banana production directly cause today? In 1997, bananas occupied an area of between 127,126 ha (PNB figures) and 248,350 ha (census figures) and that area shows little or no sign of expanding. Total crop and pasture area in Ecuador in 1997 was 1,878,500 ha and 5,008,000 ha, respectively (SICA, 1999), implying that bananas occupy 7–13% of the area in crops and 2–4% of the total agricultural area. Nobody can predict whether a banana disease or a new variety will cause renewed shifts in the spatial distribution of banana cultivation, but this seems less likely now. The high fixed investments in irrigation, funicular and draining systems make capital-intensive banana production much less mobile than in the past.

Banana production's indirect impacts on deforestation are more difficult to analyse over such a long period, since they necessarily involve difficult judgements about what might have happened without bananas. Clearly, the crop's high labour intensity induced a mass migration to the coast and helped sustain the long-run population growth that established Ecuador as the most densely populated country in South America. Over the long run, population growth is not fully exogenous, but rather responds positively to the income opportunities that trade and development provide. Food demand from the growing population of banana workers and the various local multiplier effects it involved created a demand for land that took an additional toll of forest resources. In addition to these demographic factors, road construction associated with banana production contributed to forest clearing beyond what was needed for bananas alone. However, except for population growth, other indirect deforestation impacts have dampened over time.

To assess the true impact of bananas on land demand, one should compare the land-use intensities of different agricultural products. Table 10.4 presents a tentative attempt in that direction. We used 1997 production (column 2) and harvested area (column 3) figures from the agricultural census to calculate the yields (column 4) of Ecuador's ten most important crops. In terms of harvested biomass, only sugar cane surpasses bananas. We put together farm-gate prices from Guayas province, a banana production area, and prices from other provinces (column 5) to calculate gross income per hectare (column 6).[9] At US$3236 ha^{-1}, bananas generate by far the highest gross income per unit of

Table 10.4. Comparative yields and intensities of land use for main crops, Ecuador, 1997 (from own calculation from SICA, 1999).

Products	Production (metric tonnes)	Harvested area ('000 ha)	Yields (t ha^{-1})	Farm-gate prices (sucres kg^{-1})	Gross income per land unit (US$ ha^{-1})*	Ha to produce US$1000 income	Ranking
Banana[†]	5,750,262	248.35	23.15	559	3236.02	0.309	10
Sugar cane	2,527,215	24.47	103.31	61	1575.87	0.635	8
Rice	992,971	320.20	3.1	939	727.91	1.374	5
African palm	1,357,616	91.05	14.91	374[§]	1394.43	0.717	7
Plantain[†]	894,091	73.88	12.1	314	950.09	1.053	6
Hard maize[‡]	546,448	278.80	1.96	638	312.70	3.198	2
Cotton	23,703	18.23	1.3	1,904	618.95	1.616	4
Potatoes[†]	601,838	66.27	9.08	809[§]	1836.89	0.544	9
Soybeans[‡]	6,750	5.00	1.35	886[‖]	299.10	3.343	1
Cocoa[‡]	89,862	345.62	0.26	5,272	342.77	2.917	3
Total	12,790,756	1,471.87					

*1997 exchange rate US$1 = 3999 sucres; prices Guayas province, unless indicated otherwise.
[†]Fresh fruit/vegetable.
[‡]In dried form.
[§]Farm-gate prices Pichincha province.
[‖]Farm-gate prices Los Ríos province.

land, followed by potatoes (US$1837), sugar cane (US$1576) and African palm (US$1394).

The inverse measure – how many hectares an activity requires to produce a gross income of US$1000 (column 7) – and the corresponding ranking from most to least extensive land use (column 8) make interpretation more straightforward. To generate US$1000, a farmer needs only 0.3 ha of bananas, but 3.3 ha of soybeans, 7.6 ha of wheat and 10.7 ha of coffee. In other words, if farmers decided to transfer US$1000 of gross income from coffee to bananas, they could earn the same amount from 0.3 ha of bananas as they had been earning from 10.7 ha of coffee, leaving 10.4 ha that they could put to other uses, including forest. Although this argument is oversimplified, it does have some validity. If one were to include cattle ranching in the calculations, which accounts for 5 million ha, the differences in land intensity would be even more dramatic. This type of calculation is particularly relevant when farmers are capital- and/or labour-constrained so that forested areas serve as a sort of 'reserve' for future occupation. The figures in Table 10.4 give one a feeling for how important what crop a region specializes in is for explaining the variations in forest loss in different regions. In regard to bananas, they show that, with current technologies, a shift from any of the other crops analysed to bananas would significantly intensify land use, which would tend to reduce deforestation pressures.

Even if banana production currently has almost no direct impact on deforestation, its long-term indirect impacts have been important. Economic historians in Ecuador generally agree that bananas had a much larger impact on the development of the coastal region than cocoa (Benalcázar, 1989; Abril-Ojeda, 1991; Acosta 1997). Ecuadorean banana production remained in the hands of small- to medium-scale national producers (80% of the banana area was in units of less than 30 ha) and technologies remained highly labour-intensive for much longer than in Central America. As a result of the historical sequence of technological change, labour absorption was followed by labour release, land absorption by land release and low capital requirements by high fixed investments. This implies that the labour influx to the coast and subsequent population growth were higher than they would have been without bananas and this additional population eventually cleared more forest on the coast. On the other hand, the rural families that moved to the coast no longer cleared forest in their regions of origin, nor did they move to the Amazon.

Between 1950 and 1962, coastal population grew an impressive 4.11% per year and it continued to rise by 3.48% yearly between 1962 and 1974. The share of the national population living in coastal provinces increased from 40.5% in 1950 to 47.5% in 1962 (Acosta, 1997: 245). Of course, not all lowland colonization was tied to bananas. For instance, the settlement of the Santo Domingo area reflected increasing trade integration with the nearby highlands and the capital Quito (Casagrande *et al.*, 1964; Wood, 1972). None the less, even coastal areas not dominated by bananas benefited from the

associated improvement of the road network and the growth of agricultural markets.

Without wishing to take the analogy too far, it may be relevant here to apply an approach originally developed by Rudel with Horowitz (1993) for Ecuador's Amazon region and to distinguish between forest clearing in large compact forests and the subsequent clearing of forest fragments. The initial banana boom led to agricultural frontier expansion, providing the overriding economic rationale for forest clearing in previously inaccessible areas. The subsequent crisis and diversification periods are more likely to have involved the clearing of forest remnants. In the latter case, incremental factors, such as population growth and domestic market integration, had greater influence. Road building and migrant settlement appear to 'bridge' boom-and-bust periods and to provide asymmetries for land demand and forest conversion. Their occurrence during boom periods has lasting repercussions on forest clearing even during busts.

7. Conclusions

What policy lessons can we derive from the half-century of banana expansion in the coastal region? For the period as a whole, bananas had a catalytic role in promoting coastal deforestation. At first, this was mostly through direct banana frontier expansion. Later, the gradual settlement effects proved to be of key importance. Modest credit subsidies, the large-scale construction and improvement of roads and ports and a devalued exchange rate were probably the most important policies that contributed to the expansion of banana production, though they varied in importance during the different periods. How one evaluates this process depends greatly on the relevant policy objectives. Ecuadorean policy-makers clearly considered deforestation, sustained coastal settlement and integration with the highland economy to be positive contributions to economic development.

Short-run, 'predatory' use of marginal soils for banana production might be seen as an inappropriate land use, but it can equally be seen as an individually rational strategy in a capital-scarce, land-abundant economy. One may conjecture that, had cheap external credits and significant R&D investments been available for banana producers throughout the postwar period, farmers would have adopted new technologies faster, thus accelerating intensification. This probably would have reduced plantation mobility, labour attraction and settlement, and hence coastal deforestation. However, it might also have increased the scale of banana production, since capital constraints greatly impeded further expansion of the crop. On aggregate, the employment and income opportunities bananas provided, combined with their comparatively intensive use of land and labour, would probably lead most observers to conclude that – historically, but even more so today – bananas have played a positive role.

In regard to the theoretical framework and working hypotheses set out prior to the elaboration of this book, the Ecuadorean banana experience provides important lessons. It shows that, in the medium run, the use of labour-intensive technologies may actually increase deforestation if it encourages in-migration and population growth. In a standard economic theory, comparative-static story, adopting labour-intensive technologies with a given factor endowment should reduce deforestation. But, on the Ecuadorean coast, labour pull and demographic adjustment were endogenously determined by changes in the productive sphere, which created a rural proletariat. The long-run impact of greater settler food demand and other multiplier effects actually stimulated deforestation.

Technology intensive in fixed, installed capital (such as mechanized 'Cavendish' production) may reduce deforestation, by making production more stationary. Migratory production systems can have particularly strong deforestation effects, because of asymmetries that keep forests from returning to abandoned production areas. The gradual and unequal diffusion of new banana technologies among farmers confirms the importance of capital constraints, although the adoption of innovations may have been equally constrained by the differential access to know-how, in an increasingly complex production system. These changes tended to crowd out small producers, who were then forced into other products. However, even small producers were market-orientated and clearly responded to pull incentives. Subsistence-orientated, 'full-belly' behaviour played no role (cf. Angelsen *et al.*, Chapter 2, this volume). Banana producers became increasingly integrated into the market economy through improvements in infrastructure, which reinforced deforestation. The initial, simple technologies gave a natural comparative advantage (soils, water) to hilly frontier areas, meaning that conversion of forests was particularly strong in these zones. Here, homesteading rules (land rights as a reward for clearing) provided a strong complementary motivation for deforestation.

More generally, the Ecuadorean case suggests six points that may be relevant in other settings:

1. One needs to distinguish between the direct and indirect deforestation impacts of technological change. In the long run, the latter may be larger than the former.
2. Boom-and-bust export-product cycles lead to asymmetries in forest clearing, whereby forests cleared in the boom do not return in the bust.
3. Technological changes in other supplier regions that compete for the same markets may influence global prices, redistribute market shares and affect land demand and forest conversion pressures.
4. Technologies intensive in fixed, installed capital can make agriculture more stationary, which tends to reduce forest conversion.
5. Off-farm technologies, especially in the transport sector, may greatly affect the regional patterns of land use.

6. Shifts from one agricultural product to another can have a strong impact on deforestation.

Notes

1 I thank the editors and an anonymous referee for useful comments. Funding from the Danish International Development Assistance (Danida) and help from my research assistant, Mr Breno Piectracci is greatly appreciated.
2 Wunder (2000) discusses the various estimates of Ecuadorean forest cover and deforestation in detail.
3 For instance, one may conjecture that, in the absence of a banana boom, highland surplus labour would have caused more deforestation both in their region of origin (the highlands) and in regions that provided alternatives for colonization (the Amazon). But this depends on what other sectors might have been developed in the absence of the banana boom.
4 'Giant Cavendish' increasingly replaced the 'Robusta' ('Valery') variety. The former allows higher planting densities, with larger fruits and less farm labour input per unit of output, but also demands better soils and its higher curvature requires greater packaging efforts. These pros and cons meant that 'Robusta' was not fully replaced, but rather was combined with 'Giant' (López, 1988: 98-100).
5 As late as 1991, the Ministry of Agriculture (MAG, 1994: 2) estimated that about 30,000 ha of export plantations were not registered in the PNB, amounting to an underestimation of about 15%.
6 Bromley (1981: 20) claims that 'Cavendish' had a 'low tolerance to wet, cloudy conditions', which would be an extra benefit in the drier El Oro province. However, other sources do not confirm this. Both varieties seem equally demanding in regard to water management.
7 I am indebted to Victor Espinoza, Guayaquil, for his patient on-site explanations on shifting banana production and marketing methods, during a visit to his plantation between La Troncal and El Triunfo (Guayas province) in December 1998.
8 For example, Panama disease problems led United Fruit to shift its plantations from the Atlantic to the Pacific coast before the Second World War. But in the 1980s, under the name of United Brands, it returned to the Pacific coast (Hernández and Witter, 1996: 172–173).
9 In addition to being a banana area, Guayas province has a diversified agriculture, which allows for substitution between crops. This is important for the interpretation of results. Some crops, however, are exclusively highland crops (e.g. potatoes), so no direct land substitution could occur.

References

Abril-Ojeda, G. (1991) Export booms and development in Ecuador. In: Blomström, M. and Meller, P. (eds) *Diverging Paths: Comparing a Century of Scandinavian and Latin American Economic Development*. Johns Hopkins University Press, Baltimore, pp. 157–179.

Acosta, A. (1997) *Breve Historia Económica del Ecuador*. Corporación Editora Nacional, Quito.

Benalcázar, R.R. (1989) *Análisis del Desarrollo Económico del Ecuador*. Ediciones Banco Central del Ecuador, Quito.

Bromley, R. (1981) The colonisation of humid tropical areas in Ecuador. *Singapore Journal of Tropical Geography* 2(1), 15–26.

Brownrigg, L.A. (1981) Economic and ecological strategies of Lojano migrants to El Oro. In: Whitten, N.E. (ed.) *Cultural Transformation and Ethnicity in Modern Ecuador*. Urbana, Chicago, pp. 303–306.

Cabarle, B.J., Crespi, M., Dodson, C.H., Luzuriaga, C., Rose, D. and Shores, J.N. (1989) *An Assessment of Biological Diversity and Tropical Forests for Ecuador*. USAID, Quito.

Casagrande, J.B., Thompson, S.I. and Young, P.D. (1964) Colonization as a research frontier: the Ecuadorian case. In: Manners, R.A. (ed.) *Process and Pattern in Culture: Essays in Honor of Julian H. Steward*. Aldine, Chicago.

CEPAL (1954) *El Desarrollo Económico del Ecuador*. Naciones Unidas, Mexico.

CIDA (1965) *Tenencia de la Tierra y Desarrollo Socio-económico del Sector Agrícola – Ecuador*, Unión Panamericana and OEA, Washington.

Hernández, C.E. and Witter, S.G. (1996) Evaluating and managing the environmental impact of banana production in Costa Rica: a systems approach. *Ambio* 25(3).

IMF (1991) *International Financial Statistics, Yearbook 1991*. International Monetary Fund, Washington, DC.

Larrea, M.C. (1987) Chapters 1, 2, 3, 6 and 7. In: Larrea, C.M., Espinosa, M. and Sylva, C.P. (eds) *El Banano en el Ecuador*. Bibliotèca de Ciencias Sociales 16, Corporación Editora Nacional, Quito, pp. 9–110, 237–286.

López, J.R. (1988) *La Economía del Banano en Centroamérica*. Colección Universitaria, San José.

MAG (n.d.) *Situación y Pronóstico del Cultivo de Banano en el Ecuador 1980–1991*. PRSA and Ministerio de Agricultura y Ganadería, Quito.

MAG (1994) *Situación y Perspectiva del Cultivo de Banano en el Ecuador 1990–1993*. Proyecto PRSA, Ministerio de Agricultura y Ganadería, Quito.

MAG (1998) *Ecuador Producción Bananera*. Ministerio de Agricultura y Ganadería, Guayaquil.

Moreno, M.C. (1991) *El Fin del Boom Bananero?* Vistazo, Quito.

Riofrío, S. (1995) *Banano en Cifras . . . y Otras Novedades 1995*. Acción Gráfica, Guayaquil.

Riofrío, S. (1997) *J. Banano Ecuatoriano, Perspectives*. Producciones Agropecuarios, Guayaquil.

Ríos, P.R. (1996) Estudio de la estructura y marco regulador del banano. Unpublished consultancy report to the Ministry of Agriculture, Quito.

Rudel, T. with Horowitz, B. (1993) *Tropical Deforestation: Small Farmers and Land Clearing in the Ecuadorian Amazon*. Columbia University Press, New York.

SICA (1999) Proyecto SICA-BIRF/MAG-Ecuador, www.sica.gov.ec.

Southgate, D. and Whitaker, M. (1996) *Economic Progress and the Environment: One Developing Country's Policy Crisis*. Oxford University Press, New York.

Striffler, S. (1997) In the shadows of state and capital: the United Fruit Company and the politics of agricultural restructuring in Ecuador, 1900–1995. PhD thesis, Graduate Faculty of Political and Social Science, New York School for Social Research, New York.

Sylva, C.P. (1987) Los productores de banano. In: Larrea, C.M., Espinosa, M. and Sylva, C.P. (eds) *El Banano en el Ecuador*. Bibliotèca de Ciencias Sociales, Corporación Editora Nacional, Quito, pp. 111–186.

UPEB (1990) *Informe UPEB*. Unión de Países Exportadores de Banana, Panama.

Wood, H.A. (1972) Spontaneous agricultural colonization in Ecuador. *Annals of the Association of American Geographers* 62(4), 599–617.

Wunder, S. (1997) *From Dutch Disease to Deforestation – a Macroeconomic Link? A Case Study from Ecuador*. CDR Working Papers No. 6, Centre for Development Research, Copenhagen.

Wunder, S. (2000) *The Economics of Deforestation: the Example of Ecuador*. St Antony's Series, Macmillan and St Martin's Press, Oxford, London and New York.