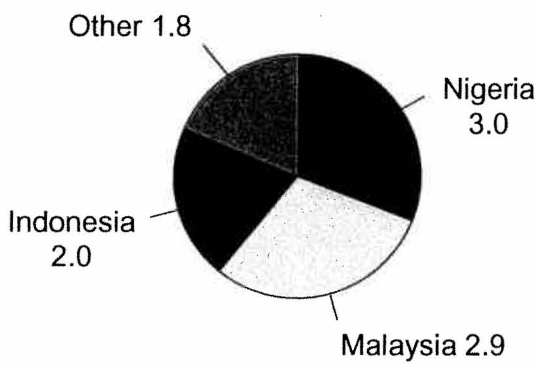
Palm Oil *Elaeis guineensis* and *E. oleifera*

Production	
Area Under Cultivation	9.7 million ha
Global Production	118.5 million MT (Fruit) 17.7 million MT (Oil)
Average Productivity	12,224 kg/ha (Fruit) 1,844 kg/ha (Oil)
Producer Price	$81 per MT
Producer Production Value	$9,560 million
International Trade	
Share of World Production	49%
Exports	8.7 million MT
Average Price	$456 per MT
Value	$3,969 million
Principal Producing Countries/Blocs (by weight)	Malaysia, Indonesia, Nigeria, Thailand, Colombia, Côte d'Ivoire, Ecuador
Principal Exporting Countries/Blocs	Indonesia, Malaysia
Principal Importing Countries/Blocs	European Union, India, China, Pakistan, Japan, Singapore, Egypt, Bangladesh
Major Environmental Impacts	Habitat conversion, particularly tropical forests Soil erosion and degradation Threats to key species Effluents from processing
Potential to Improve	High Land use planning and zoning can reduce many impacts BMPs are known Investors and buyers are interested in reducing the impact of production BMP-based certification programs are in development

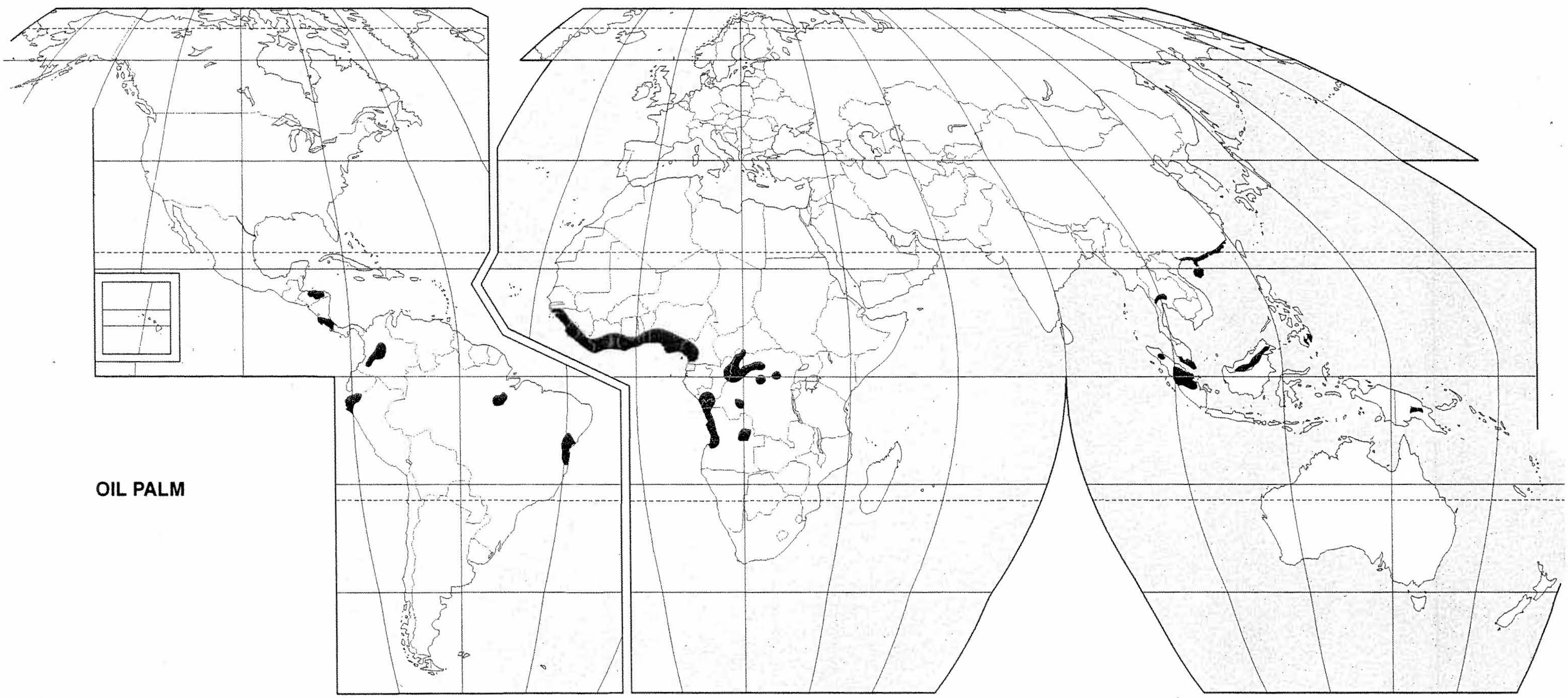
Source: FAO 2002. All data for 2000.

Oil Palm

Area in Production (MMha)



OIL PALM



Main areas of production

Chapter 9

Palm Oil

Overview

Cultivation of vegetable oil crops has increased faster than any other major type of food or industrial agricultural crop in the past forty years. Likewise, per capita human consumption of vegetable oils has increased more rapidly during the past thirty years than any other food. Economic growth is certainly one reason that more consumers, particularly in China and India, can afford to purchase more vegetable oils. However, this trend also suggests that more people prefer to have a higher percentage of their food prepared with vegetable oils.

While trailing soybeans, canola (rapeseed), and sunflower in area cultivated, by 2000 palm oil was the vegetable oil most produced and traded internationally by volume (FAO 2002). Palm oil (both crude palm oil and palm kernel oil) accounted for 40 percent of all vegetable oils traded, against 21 percent for soybean oil in 1999.

Palm oil can be separated into a wide range of distinct oils with different properties that can be used in a variety of products which, in the past, contained animal or other vegetable oils. Palm oil is used as a cooking oil; is the main ingredient for most margarine; is the base for most liquid detergents, soaps, and shampoos; and, in its most dense form, serves as the base for lipstick, waxes, and polishes. It is even used to reduce friction during the manufacture of steel.

Oil palm cultivation is expanding more rapidly than almost any other agricultural commodity. Cultivation originated in West Africa, where oil palm trees were originally interplanted in traditional agricultural production systems along with other annual and perennial crops. Production was for subsistence or trade within the region. By 1961 trade in palm oil had increased substantially, and Nigeria had 74 percent of the world's plantations (FAO 2002). By the early 1970s monocrop plantations of oil palm had increased dramatically in Malaysia and Indonesia. By 2000, Malaysia and Indonesia accounted for just over half of the world's total plantation area, and Nigeria accounted for just over 30 percent. Production is expanding into Southeast Asia, Oceania, and South and Central America, with dramatic consequences for biodiversity.

Producing Countries

The main oil palm producing countries in 2000 were Nigeria (3.0 million hectares under cultivation), Malaysia (2.9 million hectares), and Indonesia (2.0 million hectares). It should be noted that the estimates of land planted to oil palm, especially in Indonesia, vary considerably. The figures used here are those reported by the government to the Food and Agriculture Organization of the United Nations and used in their FAOSTAT statistics database. Other sources, used later in this chapter to provide specific details or insights, put the figure for planted land in Indonesia much higher. In any case, these three countries account for more than 81 percent of all land planted to oil palm and an equal percentage of total production. However, Malaysia and Indonesia account for 80 percent of all palm oil traded internationally. In 2001 Malaysia alone produced 50 percent of the world's palm oil and captured about 61 percent of total trade. In 1999 only 8.3 percent of the palm oil produced in Malaysia was used domestically, as compared to 47 percent in Indonesia and 100 percent in Nigeria (FAO 2002).

While oil palm cultivation has spread to several places in Latin America, a majority of the world's production has shifted to Asia and the Pacific. Generally higher per-hectare yields, government initiatives and support, intensive farming practices, selective breeding, and lower labor costs in the Asia/Pacific region have pushed production to that area. In fact, oil palm production in Asia and the Pacific is undertaken almost to the exclusion of any other oilseed. Low production costs resulting from increasing productivity and increases in area planted to the crop are an additional spur to production in the region. Indonesia and Malaysia are the most cost-efficient countries in the world for establishing and running palm oil plantations. This is due to the high yields, year-round harvesting, low labor costs, favorable climate, and good soils (Casson 2000).

Crop breeding since the 1960s has resulted in a trebling of average yields globally. Costa Rica has the highest average yield in the world with more than three times the global average. Nicaragua and Colombia produce just over and under, respectively, twice the global averages (FAO 2002). These yields are due to the development of hybrids by crossing American oil palm (*Elaeis oleifera)* with African oil palm (*E. guineensis*). Such hybrids are more compact and produce more bunches per tree per year. As a result, they are able to produce more than double the average yields of other varieties.

Box 9.1 shows the main oil palm producers in Indonesia. These companies are large, diversified, and each has corporate ties to a number of other companies and commodities. In addition to those companies actually producing palm oil, at least in Indonesia, it appears that the financial sector (particularly Dutch and, to a lesser extent, American banks) plays an important role in the expansion of the industry. In 1997 the ten largest Indonesian oil palm conglomerates owned 2.9 million hectares of land, with 723,000 hectares already planted. The area planted represented 45 percent of Indonesian palm oil plantations in 1997 (Casson 2000).

Box 9.1 Indonesian Oil Palm Producers

1. Astra Agro Lestari. 27 oil palm plantations in Kalimantan, Sumatra, and Sulawesi; 176,000 hectares as of 1996; planned expansion to 260,000 hectares by 2000; small farms produce 40 percent of Astra's output.
2. Salim Group. Indonesia's largest conglomerate (the group consists of 450 companies); 240,000 hectares in 1995; planned expansion to 400,000 in Sumatra, Kalimantan, Sulawesi, and Riau Islands.
3. Sinar Mas Group/PT SMART. 64,000 hectares in Sumatra and Kalimantan; 40,000 hectares in production; whole or partial interest in 25 plantations.
4. Raja Garuda Mas Group. From 1995–97 it invested U.S.$491 million to increase expansion of its plantation area of 363,000 hectares.
5. Barito Pacific. In joint venture with Astra Group (see above) owns several palm oil plantations.
6. Bakrie Brothers. 88,000 hectares in Sumatra; plans to expand another 88,000 hectares in Kalimantan.
7. PT Perkebunan Nusantara. Largest state-owned plantation company in Indonesia with some 30 percent of country's oil palm production; 14 subsidiaries and 97 plantations located throughout the country with 130,000 hectares of oil palm.
8. SOCFIN (Société Financiere des Caoutchoucs). Franco-Belgian holding company with oil palm plantations in Malaysia and Sumatra. Partially owned by the Bollore Group; also has oil palm interests in Cameroon; developed first oil palm plantations in Indonesia and has nearly 40,000 hectares.
9. PT PP London Sumatra (LonSum). 54,000 hectares of oil palm and rubber in north Sumatra; developing 75,000 hectares of oil palm in East Kalimantan and 10,000 hectares of oil palm in South Sumatra. Also developing small-scale oil palm estates.
10. SIPEF (Belgium capital). Brussels-based multinational with investments in oil palm as well as other agricultural plantation crops Major supplier of palm oil to the United Kingdom, Germany, and Belgium. 25,030 hectares of oil palm; second largest foreign-owned group in Indonesia.
11. Cargill Indonesia. Investing $45 million in first oil palm plantation and mill in South Sumatra under the name of Hindoli. Planted 1 million oil palm trees and helped small farmers plant an additional 2.4 million.

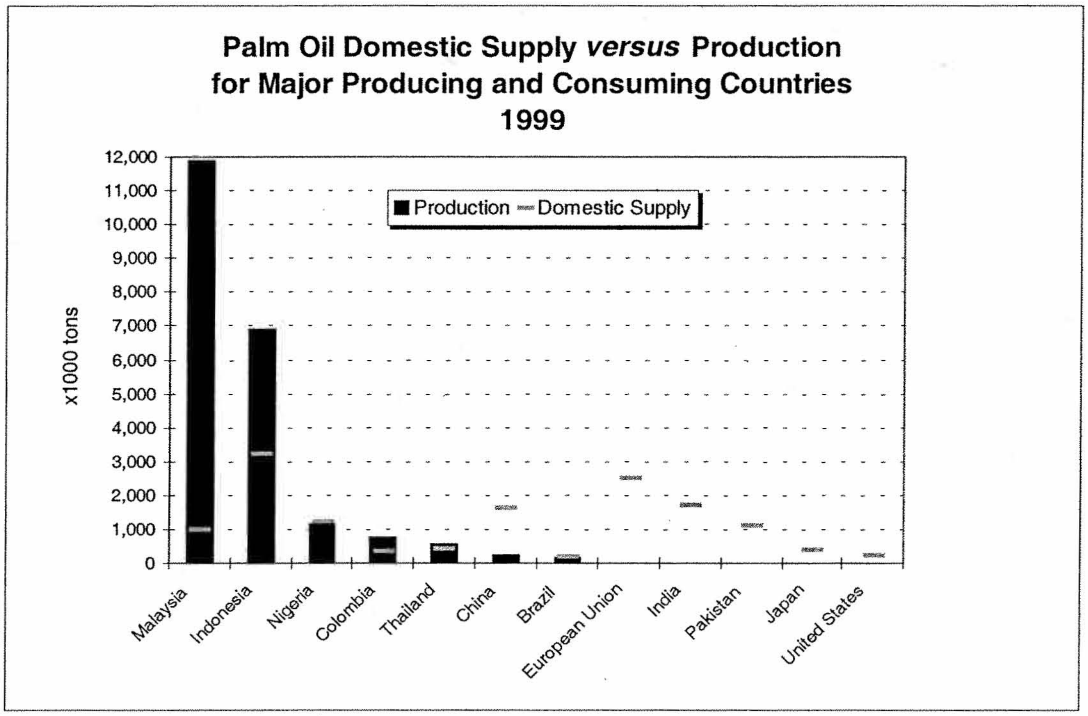
Source: Wakker 1998.

Consuming Countries

Indonesia is the largest palm oil consumer in the world and the fifth largest consumer of all vegetable oils. The world's largest palm oil importers are the European Union (26.4 percent of global imports), India (23.5 percent), China (9.8 percent), Pakistan (7.1 percent), and Japan (3 percent). In India, China, and Pakistan, palm oil is used primarily in food preparation and for cooking. In the European Union, Japan, and the United States, palm oil is used primarily for nonfood purposes. Within Europe the main importers are the Netherlands (7 percent of global imports), the United Kingdom (3 percent), and Germany (3 percent) (FAO 2002).

The chart in Figure 9.1 indicates the difference between the levels of palm oil production and consumption in the main palm oil producing and consuming countries. Nigeria, Thailand, and Brazil produce most of their own palm oil and do not export significant quantities. Malaysia, on the other hand, exports more than 90 percent of its production.

Figure 9.1



Source: WWF Forest Conversion Initiative (n.d.)

The main traded products from oil palm plantations are crude palm oil (CPO), which is extracted from the tissues surrounding the kernel (the mesocarp), and palm kernel oil (PKO) extracted from the kernel. PKO is more highly saturated than CPO, but both can be separated during the refining process into different types of oils with different properties. (Like petroleum, the different nature of the various fractions of palm oil is due to different lengths of the chains of carbon atoms that make up each fraction.) CPO and PKO are refined into bleached deodorized palm oil and olein—the raw materials for cooking oil, margarine, vegetable shortening, ice cream, and other foodstuffs. A third refinery product, stearin, is used for soap production. In addition to food products, large quantities of CPO are used by the steel industry to lubricate and prevent surface corrosion during the cold rolling of steel plate. Cosmetics (including lipsticks, hand creams, liquid soaps, and shampoos) and candles are also produced from CPO and PKO.

In Africa and Brazil the unrefined CPO with a slightly yellowish color is preferred for cooking over more highly refined palm oil or other varieties of vegetable oil. This oil has a distinct flavor that is very much associated with different styles of cooking. The undeodorized and less refined oil also has a much higher content of vitamins A and E and is therefore healthier for the consumer.

Production Systems

Palm oil was first produced in West Africa, where it is still an important source of oil in the diet. It dominates traditional cooking in West Africa as well as in Brazil and other countries where large numbers of slaves originating from West Africa were transported. Traditionally, oil palm was planted in household slash-and-burn gardens that were allowed to revert back to forest cover after one or two years of crop production. Planting oil palm in these areas created agroforestry systems that were harvested over several decades. The trees' fruit also attracted game that was hunted as a source of protein. Since machinery was not available in the past, the oily seeds were pounded and then boiled in water. The oil was skimmed from the surface of the water and stored for later use. Since it was not deodorized, this oil had a strong flavor and for that reason was not considered a viable alternative food product or ingredient in most export markets. More recently, ways have been developed to deodorize palm oil, and this has opened up its markets considerably.

Outside of its native habitat in West Africa, oil palm is mostly grown in plantations in Asia and Latin America. In Southeast Asia these plantations are usually established as monocultures in concessions ranging in size from 4 square kilometers (400 hectares) to 729 square kilometers (72,900 hectares). During the creation of plantations, most standing vegetation is removed by cutting, mechanical clearing, and/or burning. After clearing, the land is usually planted in a grid pattern with little regard to topography. In some instances, logging companies receive permits for cutting, and then subsidiary companies apply for permits to be allowed to clear the "severely degraded" forests to plant oil palm. Oil palm plantations can produce a positive cash flow in only eight years. Logging companies have positive cash flows in even less time, but high grading or clearcutting operations cannot undertake a second cut for fifty years or more.

Oil palm seedlings are planted in fields after about one year of growth in a nursery. They tend to be planted on grids of 8 meters by 8 meters with 143 trees in each hectare. The palms start to flower in two and a half to three years and continue producing from three to as much as forty or fifty years. New technology is changing this picture, however. Tissue culture decreases the time required to produce young plants in nurseries. In addition, improved varieties are more productive but shorter lived. In the past, trees were most productive until twenty-five to thirty years. The newer varieties tend to be most productive for only fifteen to twenty years. The new, shorter-lived varieties do not grow as tall and, consequently, are easier and cheaper to harvest.

The land needs to be carefully prepared for planting and maintained afterwards. It is prepared by plowing the soil and weeding, either mechanically or with herbicides. Fertilizer is very important to obtain the current high yields of palm oil production. The cost of fertilizer constitutes about 40 to 60 percent of the total maintenance cost, or 15 to 20 percent of the total production cost of the palm oil seeds (Syamsulbahri 1996).

Increasingly, producers plant leguminous cover crops to supply nitrogen for the trees, reducing the need for purchased fertilizers. This can occur until the branches of the palms extend to form a canopy, which creates too much shade for the legumes to grow well. Cash crops can also be planted under or between the trees until the palm trees begin to form a closed canopy. An area 2.5 meters in diameter immediately around the trunk of the tree is kept clear of vegetation. This is where the fertilizers are applied in order to be most efficiently taken up by the trees.

When created in isolation or when the first oil palm plantation in a region is being established, a large area is involved. The investment for building the factory to make palm oil is sufficiently large and the capacity of the factories is high enough to warrant large plantings. Once an oil processing factory is established in an area, plantings can be much smaller for those producers who sell their seeds to the factory rather than processing them on their farms. In the past, there was no small-scale crusher/expeller that allowed small farmers to add value to their produce or that allowed for smaller and more environmentally benign plantings. However, in the past fifteen years smaller crushers/expellers have been developed that can efficiently process the kernel production of some 400 to 1,000 hectares, a typical output for a group of small farmers. Such expellers allow producers to convert their seeds into crude unrefined and unbleached CPO and PKO. These small mills are in place in Costa Rica and Ecuador, where the oil palm plantations are smaller and scattered more in the countryside and do not (at least in Costa Rica) constitute large plantations of thousands of hectares (Panfilo Tabora, personal communication).

Most oil palm plantations in Malaysia are in peninsular areas. They have been established through either direct forest habitat conversion or the conversion of former rubber estates. At this time, oil palm plantations are expanding rapidly in East Malaysia (Sabah and Sarawak). This is likely to be where any expansion of oil palm plantings in Malaysia will take place in the future, but even here land suitable for plantations is getting scarce.

In the 1990s, due to rising land and labor prices in their country, Malaysian palm oil companies began to invest abroad, particularly in nearby Indonesia. In all, some fifty Malaysian companies have established joint ventures with Indonesian plantation companies as well as with companies in Cambodia, Thailand, Papua New Guinea, and the Solomon Islands. Table 9.1 compares the 1997 costs of producing CPO in Colombia, Côte d'Ivoire, Indonesia, Malaysia, and Nigeria with global averages. From this table it is clear that Indonesia, and to a lesser extent Malaysia, are the low cost producers. This is true because of the productivity of labor relative to its cost. It is also interesting that the costs of establishing plantations in Nigeria are three times as much as anywhere else in the world. It is not clear if this is due to the cost of land, the cost of doing business in the country, the cost of labor, or a combination of the above.

Table 9.1 A Comparison of Production Costs for Crude Palm Oil, 1997
(in U.S. dollars per metric ton)

	Colombia	Côte d'Ivoire	Indonesia	Malaysia	Nigeria	World Average
Establishment	71.2	69.5	64.3	60.7	224.5	72.1
Cultivation	91.2	136.1	72.5	75.7	113.7	79.3
Harvest/ transportation	78.9	33.8	40.2	45.1	90.7	47.3
Milling costs	106.1	105.3	82.6	98.3	130.7	96.6
Kernel milling costs	6.9	7.7	7.2	7.6	8.2	7.5
Kernel oil and meal credits*	-58.2	-54.0	-60.0	-61.9	-65.6	-61.5
Total	296.1	298.4	206.2	225.5	502.2	241.6

Source: PT Purimas Sasmita 1998, as cited in Casson 2000 and LaFranchi 2000.
*Kernel oil and meal are products from milling and have been included in this calculation as a credit (income) back to the system.

Table 9.2 breaks down the costs of production in Indonesia and calculates the share of each toward the overall cost of production. The two main costs are depreciation and fertilizer (47 percent of total costs) followed by harvesting and overhead (25 percent of total costs). What the table does not show, however, is the financial impact on a processing plant of buying product from independent growers, or what price would be paid. Since this is a common practice, it is likely that independent growers are used to lower a plant's fixed costs per unit of production. In effect, this subsidizes on-farm production while providing independent growers with markets. The price paid to independent growers is probably improved when there are more buyers in an area to increase competition.

Table 9.2 Costs of Palm Oil Production (Excluding Milling) in Indonesia, 1997

Operation	Cost (U.S.$/MT)	Percentage of Total Costs
Harvesting	24.29	13
Maintenance	18.78	10
Fertilizer	38.74	21
Transportation	12.00	7
Processing	19.35	11
Overhead	22.00	12
Depreciation	47.00	26
Total	182.16	100

Source: Voituriez 2001.

In Indonesia, from 1967–1997 oil palm was one of the fastest growing subsectors of the economy. During this time the area planted increased twenty-fold, and there was a 12 percent average annual increase in crude palm oil production. Through 1988 the Indonesian government estates were the largest palm oil producers. In 1989 private estates surpassed production on government estates, and in 1991 small-farm production surpassed that from government estates as well.

By 1997 government estates accounted for 449,000 of the 2.2 million hectares of oil palm in Indonesia, small farms made up some 813,000 hectares, and private companies held the rest (Casson 2000). Many of the private company holdings were still immature, which means that their production will increase and they will dominate total production and trade figures even more in the future. In 1997 the ten largest Indonesian palm oil conglomerates held over 2,900,000 hectares of oil palm concessions, of which some 723,000 hectares were planted (Casson 2000).

Oil palm has by far the largest area in estates for all crops in Indonesia. The area of oil palm plantations increased to 2.4 million hectares at the beginning of 1998, and plans were underway to establish another 1.5 million hectares by the end of that year. Many of the forest fires in late 1997 were started by plantation companies that wanted to speed up the "conversion" of tropical forests to plant oil palm. For example, of the 176 companies accused of forest burning, 133 were oil palm plantation companies (Lebbin 2000).

More conservative estimates suggest that the area planted to oil palm in Indonesia may double by 2005 (Lebbin 2000). With concessions of 5.5 million hectares already granted by 1997, the projection of doubling current planting levels is quite realistic. In addition, another 40 million hectares of forested land in Indonesia's outer islands have been slated by the government as available for conversion to cash-crop production. In 1998 there were fifty foreign investment projects (80 percent of which were in collaboration with Malaysian companies) with plans to establish 900,000 hectares of oil palm through an overall investment valued at U.S.$3 billion. By mid-1998 only 600,000 hectares had been established.

In Indonesia oil palm production increased more than tenfold from 1975 to 1994—from 397,000 metric tons to 4 million metric tons. This rate of increase is likely to continue as more trees reach maturity. By the end of 1997 only two-thirds of the planted area had matured and was productive; one-third was still too immature to produce oil. It takes three to four years for oil palm to begin to produce. This means that about 800,000 hectares had been planted after the 1993–94 planting period. If demand is relatively constant, the more recently planted areas will increase production substantially as they mature and reduce prices accordingly.

Oil palm can be planted on degraded land, but plantations are normally established directly on newly cleared forest lands. In some cases, logging forests appears to provide the capital for establishing oil palm plantations. In other instances, oil palm concessions are obtained by logging companies that never intend to plant oil palm. Instead they want to log the areas without having to pay the fees to operate a logging concession. Oil palm plantations are often established subsequently on these degraded lands as well as in other forests that may have been selectively cut by illegal logging operations. These factors appear to be related in many individual cases, but a clear connection between logging for timber or pulp and the establishment of oil palm plantations has not been established at this time.

Processing

Palm seeds spoil within forty-eight hours of harvest. Consequently, they must be processed quickly. Given the condition of roads in most producing areas, they cannot be transported great distances. One of the reasons that so many of the oil palm plantings are in large plantations is the size of the fixed investment formerly required for processing plants, particularly those in use in Asia. In the past, processing plants were on a scale that required as much as 30,000 to 40,000 hectares of trees to support them. Today the newer mills being constructed are competitive with only 10,000 to 15,000 hectares of trees, and in many instances most of these plantings are managed by small producers and not the milling company itself. Good roads, of course, would extend the radius from which processing plants could draw their product.

In parts of the Americas, smaller crushers/expellers have been adapted for processing oil palm, and these require as little as 400 hectares of trees to operate competitively. These processing plants have a payback period of approximately nine years. The crushers/expellers can produce crude oil, which is stable and can be transported much longer distances for refining (hydrogenation) and bleaching. Smaller mills of this type are currently in operation in Costa Rica and Ecuador.

Large-scale producers who purchase considerable quantities of labor and machinery make very little money if they only grow oil palm seeds for sale. Small producers, by contrast, who do not need machinery and who rely primarily on family labor, can generate profits selling their oil palm seeds to processors. Consequently, a system has evolved in Asia in which larger companies encourage small producers to plant oil palm and produce seeds because the companies can then rely on them for part of the volume they need to make their processing plants viable economically. These large mills, however, have traditionally had a monopoly on the areas where they buy the oil seeds.

Similarly, the limiting factors in oil palm plantation development in Latin American countries such as Ecuador, Colombia, and even Brazil have traditionally been the high cost of the fixed investment in processing plant technology and the high cost of labor. Smaller mills have been developed, but many companies still operate the older larger units and cannot replace them without losing money. In addition, the cost of labor in most parts of Latin America is much higher than in Asia. This remains an issue for most producers who want to expand production beyond sales into local markets.

Palm fruit bunches yield a number of different products. Yields of various products from one hectare of oil palm trees are detailed below in Table 9.3. Of the marketable products, crude palm oil and palm kernel oil represent about 25.3 percent of the weight of palm bunches brought to the processing plant. Palm kernel meal, the substance that remains when the oil has been removed from the kernel, comprises some 3.7 percent of total weight, and can also be sold for animal feed. The remaining by-products are waste. These include the empty palm bunches (21.1 percent of total weight) and water (about 50 percent of total weight). More efficient companies produce less waste (e.g. they are able to extract a higher proportion of oil and meal than less efficient companies) and turn much of the waste into marketable by-products. They also take the empty palm bunches back to the field where they are used as mulch and reduce the use of some inputs. In general, however, the issue of how to dispose of waste (especially the water) in ways that cause the fewest impacts has not been adequately addressed. Incidentally, palm oil companies are not the only ones that haven't found good ways to solve this problem. The issue of waste water is also a major issue in olive oil and wine grape production.

Table 9.3 Yields from One Hectare of Oil Palm Trees

Average yield from fruit	19.0 MT of fruit
Crude Palm oil from fruit pulp	4.2 MT CPO (22.1% by weight)
Oil from palm kernel	0.6 MT PKO (3.2% by weight)
Palm kernel meal	0.7 MT meal (3.7% by weight)
Empty palm bunches	4.0 MT palm bunches (21.1% by weight)
Water lost during processing	± 9.5 MT water (50% by weight)

Source: Blix and Mattson 1998, Cederberg 1998, and Tengnas and Sveden 2002.

Even after the CPO and PKO are extracted from the palm fruits considerable processing is still required to produce consumer products. Table 9.4 lists some of the companies that are involved in turning palm oil into various types of consumer products in Germany. A striking thing about the table is the number of easily recognized transnational corporations that are involved in the different products.

Table 9.4 Germany's Oil Palm Industry

Oil refiners	Meister Markenwerke, Noblee & Thorl, Walter Rauh Nuesser Ol und Fett, and Deutsche Cargill
Chemical products	AKZO Nobel, Henkel Material Wirtschaft
Foodstuffs	Dr. Oetker, Maylip Nahrungsmittel
Refining food and nonfood products	Unilever
Food	Nestlé
Cosmetics and detergents	Colgate-Palmolive, Procter & Gamble, L'Oreal, Johnson & Johnson, Beiersdorf, Unilever/Lever GmbH, and Avon

Source: Wakker 1998.

Substitutes

Palm oil is a ready substitute for other vegetable oils for cooking (e.g. soybean, corn, canola, and cottonseed oils) depending on price and availability. It is also a substitute for cocoa butter and coconut oil for most personal care and cosmetic products. Hydrogenated palm oil can be substituted for animal fats in many foods to reduce dependence on animal fat and increase product stability and shelf life. Animal fat is expensive to produce, and the volume of production has remained stable while overall demand has increased. Palm oil, by contrast, is increasing in volume produced and decreasing dramatically in price. According to palm oil processors, however, they could continue to make good profits even if the international price of palm oil were to decline by half.

One substitute for palm oil that deserves special mention is soybean oil. As described in the chapter on soybeans, this oil is a byproduct of soybean meal, which is increasing in demand as a source of protein in animal feeds and as a substitute for fishmeal in both aquaculture and animal feeds. The demand for soybean meal is driving an increase in the production of soybean oil as a by-product, which in turn adversely affects the price for both soybean and palm oils.

Market Chain

There is some evidence that the palm oil market is becoming more vertically integrated, as traders and processors are extending their influence into production itself. This will probably continue to happen so long as there are relatively few risks associated with producing the oilseed. When this vertical integration happens, the larger companies will concentrate more on milling and refining the oil and dominating exports, imports, and distribution of uniform oil products that perform the same in different formulations and that can as a result be readily substituted for one another.

There is also some evidence that the recent consolidation of the manufacturing and retail of food and personal care products may extend vertically into the distribution and refining areas. Unilever's operations, for example, tend to run the full gamut up to but not including retail, although they recently sold their oil palm plantations so they are not now directly involved in production. Cargill's operations tend to run the gamut from production to refining the oil for use in manufacturing finished products without getting involved in the manufacturing sphere. The Nestlé corporation refines the oil and uses it to manufacture finished retail products. For example, Nestlé's canned condensed milk manufactured in its Malaysian operations contains some 25 percent palm oil as do nondairy creamer and other products. Other markets in the United States and Europe are less forgiving both about non-dairy items being sold as dairy and about overall fat content in general.

Globalization and consumer scrutiny have pushed companies to provide, and consequently to demand, more transparency with regard to their products as well as the ingredients they use. European grocery store chains want to be able to understand and defend the social and environmental impacts of the ingredients in the products they sell. This trend towards accountability for both product quality and production practices has enabled larger companies to influence the entire market chain, including segments of it in which they do not invest directly. A palm oil roundtable in Europe, initiated by WWF, currently includes food processors such as Unilever and grocery store chains such as Migros and COOP in Switzerland.

Market Trends

Though the average annual world prices for CPO and PKO have fluctuated considerably, overall the price of palm oil has fallen from U.S.$1,102 per metric ton in 1960 to $307 per metric ton in 2000, a decline of more than 72 percent (FAO 2002). The decline is due to increased yields and improved extraction rates, subsidized marketing, and a substantial increase in competition from other vegetable oils.

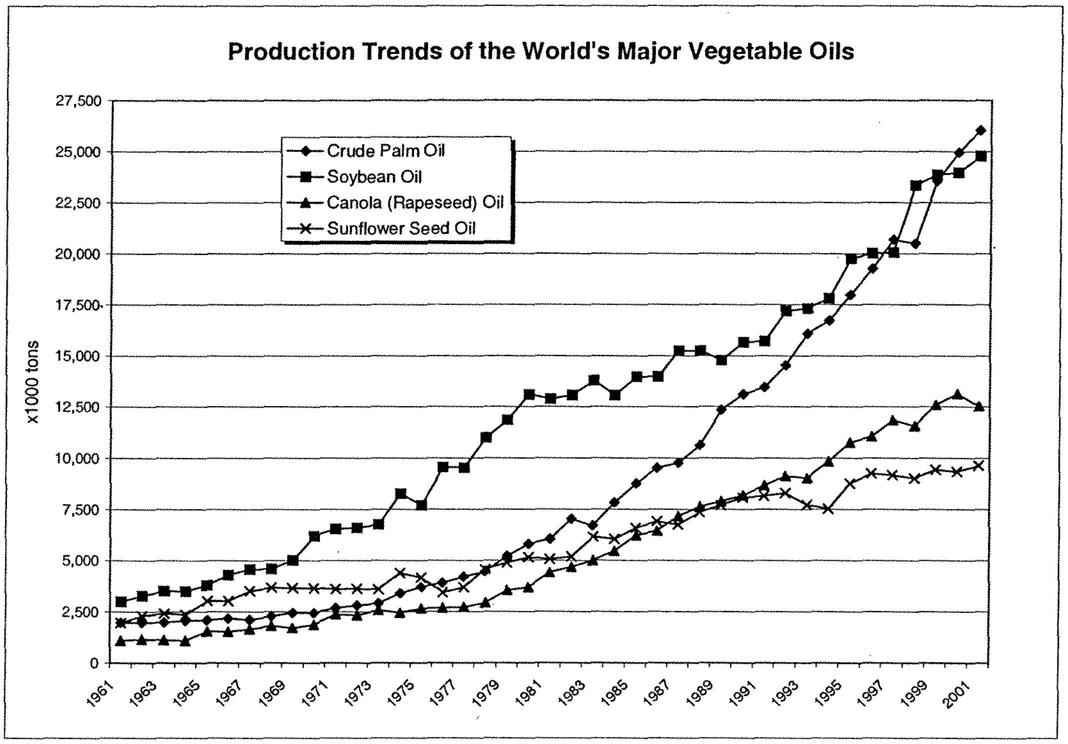
Production is coming on line faster than most analysts expected. Also, when trees come into production, they stay in production for longer than any other vegetable oil plant (other than olive trees). Prices reflect the overall increase in production, as shown in 1999 when oil palm prices declined by 30 percent. Falling palm oil prices are likely to be exacerbated by plentiful and increasing supplies. New plantings in Indonesia will not even come into production for another three or four years and not into full production until later still. The situation of increasing amounts of oil on world markets and declining prices will be further exacerbated because Indonesia recently cut its taxes on palm oil exports by 30 percent.

In addition to Indonesia, Malaysia also has large palm oil surpluses. Malaysia is trying to increase its overall market share by gaining access to India and China. It is doing this by allowing palm oil deliveries on credit. This too will affect markets and may establish a trend in which producers from countries with less working capital will find it hard to remain competitive.

Prices being equal, buyers (at least in the United States) tend to prefer soybean to palm oil for cooking and food products. This preference has been created by the U.S. soybean industry's rather dubious campaign to paint palm oil (usually described as "tropical oils") as being less healthy than soybean oil. As long as this preference holds, the price of palm oil will be lower than the price for soybean oil. The palm oil industry will have to lower its prices to compete with soybean and canola (rapeseed) oil to regain market share (Casson 2000).

Palm oil is increasingly competitive in the vegetable oils market. Figure 9.2 compares the relative annual production of four vegetable oils: CPO, soybean, canola (rapeseed), and sunflower. Most analysts believe that demand for vegetable oils and meal will continue to increase and that, despite growing competition from other oils, palm oil (CPO and PKO combined) will continue to dominate the oil market with soybeans dominating the meal market. After several decades of similar growth curves, it now appears that canola and sunflower oil are no longer competitive with palm oil and soybean oil.

Figure 9.2



Source: WWF Forest Conservation Initiative (n.d.)

Palm oil consumption is predicted to increase by 10 million metric tons between 1996 and 2005. It is already the most-consumed oil in the world. By 1999, 53 percent of palm oil was used for food or food products. The amount of palm oil used in nonfood products such as soaps, cosmetics, candles, and lubricants is expected to increase as well. Besides being price-competitive and exhibiting good performance, palm oil products (unlike animal products) are accepted by people of all religions. While there is strong competition between vegetable oils and petrochemical products, the current awareness of environmental issues and the increasing preference for environmentally friendly products suggests that the use of renewable, vegetable-based products will increase.

Demand for vegetable oils has increased particularly rapidly in Europe. While the European Union has long been a major importer of palm oil, future demand for palm oil is likely to be driven by China, India, and Pakistan due to increased economic growth and consumer purchasing power in those countries (USDA 2000).

The demand for CPO is projected to increase by 42 percent from 1998 levels by the year 2020. Production is projected to reach 40.5 million metric tons per year by the end of the same period (Oil World 1999). In short, CPO production is projected to more than double while demand is projected to increase by less than half. If these projections hold, the price of palm oil will decline considerably in the next two decades.

Financial crises are likely to affect oil palm production and consumption. The overall impact of the recent Southeast Asian financial crisis, however, is not clear. The crisis appears to have stimulated production increases in 1997–1998 from 5.3 million metric tons to 6.9 million metric tons. Through 1998 profit margins were quite high. For example, one company—PT Astro Agro Lestari—announced a 200 percent increase in net profits from 1997 to 1998. In addition, smuggling in Indonesia also affected prices. Some 15 percent of Indonesia's palm oil was smuggled out of the country in 1998 (when the government taxed exports and the rupiah had been devalued). This pushed world prices down (Casson 2000) because the smuggled oil was dumped onto the world market at below market rates.

The situation, however, made palm oil much more expensive in countries that were affected by the crisis. Currency fluctuations clearly affect the market for palm oil. India, China, and Pakistan are some of the largest buyers of palm oil. If the Chinese currency is devalued for any reason, it is likely that demand in that country will be reduced considerably. Similarly, if the economies of India and Pakistan are disrupted for any reason, their demand will fall as well.

The Southeast Asian financial crisis led to a 59 percent increase in palm oil exports in 1998 as producers and governments alike attempted to generate hard currency earnings at the expense of local consumption. This caused local prices to soar and large tracts of forest to be rapidly converted for oil palm plantations.

To counter the increased cost of palm oil for local consumers, the Indonesian government increased the export tax from 40 percent to 60 percent of export value. This slowed the growth of the industry. In 1999 the government estimated that only 177,000 hectares of oil palm would be planted. However, with the 2000 announcement that the export tax would be reduced, the government gave the industry a green light for renewed expansion.

The oil palm industry, for its part, is poised to expand, at least in Indonesia. The share value of companies has stabilized since the financial crisis. Planting targets are increasing. Most importantly, the government has lowered interest rates and changed regulations to encourage the expansion of the industry. Furthermore, joint ventures and marketing cooperation between Indonesian and Malaysian producers will allow them to maintain the price of palm oil and increase their dominant share of the world vegetable oil market at the same time. In Indonesia the government is encouraging oil palm development in the eastern islands (e.g. Kalimantan and Irian Jaya), but the industry is more interested in developing palm oil plantations in Sumatra. The bottom line, however, is that all these factors spell the end of any forests where expansion takes place.

At some point between 2012 and 2015 Indonesia is projected to overtake Malaysia as the leading palm oil producer in the world. Indonesia has been planting oil palm for some time, with the highest planting rates in the 1990s. In the early 1990s Indonesia planted up to 200,000 hectares of oil palm per year. Immediately after the economic crisis in 1997 and 1998 the planting rate slowed to 40,000 to 60,000 hectares per year, but it then began to pick up and by 2000 had increased beyond the rates for the first half of the 1990s. If the market continues to increase and if acceptable profits can be made even at lower prices, the planting rate is certain to increase even more.

Environmental Impacts of Production

The main environmental problems from oil palm production are habitat conversion, threats to critical habitat for endangered species, use of poisons to control rats, and pollution from processing wastes.

Most of the world's oil palm trees are grown on a few islands in Malaysia and Indonesia. These islands have the most biodiverse tropical forests found on Earth. What is particularly striking about oil palm is that it is so much more productive, per hectare, than any other vegetable oil. Given the extraordinary productivity of oil palm trees, it should have been very easy to maintain representative areas of biodiversity within areas of production and to ensure that corridors were maintained that would allow larger animals (especially elephants, rhinoceroses, and tigers) to move between larger parks and protected areas. This did not happen. Now that prices have declined so much, it should be possible to retire the unproductive, unprofitable plantation areas and return them to a more natural state to maintain biodiversity (or at least connect protected areas) and restore ecosystem functions. There has been great reluctance to do this, to date, even though it makes economic sense.

Habitat Conversion

In Africa oil palm has been a subsistence crop for generations. As such it tends to be an agroforestry crop that is interplanted with other cash and subsistence crops. In most cases, this type of production does not have a large impact on biodiversity. More recently the establishment of vast monocrop oil palm plantations in Asia and Latin America, as well as in West Africa itself, threatens vast tracts of tropical forests with high conservation value.

Nowhere is this problem of forest conversion more acute than in Indonesia. In Indonesia, even though there are 20 million hectares of abandoned agricultural land appropriate for the establishment of oil palm plantations, this land is not being planted. Instead, in the 1990s concessions for plantations were granted mostly in forests. Planters feel that it is more expensive to plant in grasslands or in degraded areas because they will have to add so much more chemical fertilizer. The cost of clearing forests is subsidized from the sale of timber from concession areas. Some oil palm production plantations were converted from other uses such as former rubber plantations whose production is now less valuable than in the past. However, it is mostly primary forests that are being converted. Being relatively easy to clear, peat forest areas are one of the main areas of conversion. They were the sites of many of the forest fires in Indonesia in the late 1990s. Peat forests are even less suitable for conversion to plantations than other tropical forests. Peat forests have very high water tables so often palm oil plantings have to be made on elevated pedestals that prevent the roots from being in standing water. As a consequence, many trees fall over for lack of support. If an entire peat forest area is cleared, then the area can dry out so that palm oil production is more successful.

The Malaysian government has successfully lobbied for rubber plantations to be classified as "forest" by the FAO. Such areas are classified as part of the "permanent forest estate," which obfuscates the amount of natural, biodiverse forest that is actually left in the country. There is a chance that the same case might be made for oil palm plantations in the future. Once land is classed as "forest," developers can continue to convert more biodiverse natural forests to monocrop plantations without it ever showing up in any statistical sources. This would have a major impact on biodiversity wherever such crops as oil palm trees are planted. In addition, however, the people who would be lured to the forests as oil palm workers and harvesters would tend to have an additional impact on biodiversity through killing or harvesting other species.

There is a direct relationship between the growth of oil palm estates and deforestation in Malaysia and Indonesia. In the Kinabatangan watershed area of Sabah, Malaysia, large areas of previously logged forests have been converted into oil palm estates. In Indonesia oil palm plantations have also been created illegally within a number of different protected areas (see Table 9.5). Habitat conversion from natural forests to oil palm plantations has been shown to have a devastating impact not only on the tropical forests with the most species of trees per hectare but on other plant and animal species as well. For example, there are nearly eighty mammal species found in Malaysia's primary forests, just over thirty in disturbed forests, and only eleven or twelve in oil palm plantations (Wakker 1998). Similar species reductions occur for insects, birds, reptiles, and most important of all for soil microorganisms.

Table 9.5
A Sample of Indonesian Parks and Reserves Affected by Oil Palm Plantations

Location	Status	Area	Year	Observation
Gunung Leuser	National Park	200 ha	1994	
Siberut	Buffer Zone of World and Heritage Biosphere Reserve	70,000 ha	1997	
Bukit Tigapuluh	National Park	12,000 ha	1998	347 families forced off their land inside the park by oil palm company
			1998	2 oil palm companies
Kalimantan	Intended for conservation		1998	21 oil palm estate companies operating in forests intended for conservation
Inhu	Protection Forests	1,500 ha	1998	
Bukit Barisan Selatan	National Park			Encroachment by oil palm companies reported
Kerinci Seblat	National Park			Encroachment reported on two sides

Source: Lebbin 2000.

Burning and Air Pollution

The establishment of oil palm plantations in Indonesia and to some extent Malaysia has been cited as the major cause of the air pollution that affected many non-producing areas of Southeast Asia including Singapore and other cities in 1997. The smoke was so bad that airports were closed for days at a time. Once started, many of the fires in peat forests burned uncontrolled both underground and above ground for months. A recent letter published in *Nature* presented research that suggested that the 1997 fires were one of the main sources of CO_2 emissions globally in a year that had more emissions than any other on record since record keeping started in 1957 (Page et al. 2002). The authors estimate that the Indonesian fires released 0.81 to 2.57 gigatons of carbon into the atmosphere. This represents 13–40 percent of the mean annual global carbon emissions from fossil fuels. While this practice of burning has since been outlawed in Malaysia and Indonesia, it is still common in other parts of the world where plantation establishment is now occurring.

Threats to Critical Habitat for Endangered Species

Of all the agricultural commodities described in this book, oil palm poses the most significant threats to the widest range of endangered megafauna. These include the Asian elephant, the Sumatran rhinoceros, and the tiger. It is rare that these three very different species are found in one place, yet they coexist in peninsular Malaysia and Sumatra in precisely those areas where oil palm plantations are expanding. In addition the orangutan, tapir, sun bear, and other primate and bird species are affected by the expansion of oil palm plantations in tropical forests. With all these species, the primary issues are the incompatible conversion and use of the habitat and the elimination of wildlife corridors between areas of genetic diversity. Rhinoceroses and tigers will not be found in the types of disturbed areas that are created in oil palm plantations.

Elephants are a slightly different story. While elephants are affected by forest clearing, they are willing to inhabit disturbed areas and even oil palm plantations. As a consequence, they are considered a nuisance by plantation managers. Elephants like to eat the tender new shoots on oil palms as well as the oil-rich palm seeds if they can get to them. Thus, they not only "eat the profits" but also damage the trees doing it. In some areas elephants have destroyed 20 percent or more of plantations as large as 5,000 hectares. As a consequence, in areas of known elephant populations deep trenches are dug surrounding entire plantations to prevent elephants from entering the farms and destroying the crops. To be effective, these have to be maintained regularly. In other cases elephants are fenced out with electric fences and barbed wire. Still, elephants often find ways into the plantations. In many instances they walk up unprotected rivers and streams. The conflicts are not always benign, either for the elephants or the workers. In at least one instance, an elephant killed a plantation manager. It is not known how many elephants have been killed over conflicts in oil palm plantations.

Soil Erosion

Traditional practices used to establish oil palm plantations can lead to considerable soil erosion. Erosion occurs during forest clearing and plantation establishment phase when the soil is left uncovered. However, erosion has been accentuated by planting trees in rows up and down hillsides rather than on contours around them, by not properly siting or constructing infrastructure such as roads, and by establishing plantations and infrastructure on slopes of more than 15 degrees.

Erosion can also be encouraged when clearing is not undertaken properly in the establishment of plantations. As late as 2001 in the Riau Province of Sumatra in Indonesia, fallen trees were bulldozed into piles that went straight up and down the hillsides (as opposed to contour rows). Such practices tend to funnel the water into channels and thereby increase soil erosion.

It is expensive for plantations and local governments to correct problems caused by erosion. Eroded areas require more fertilizer and other inputs including repair of roads and other infrastructure. Municipalities have additional expenses in terms of road maintenance but also from increased flooding and the removal of silt deposits as well as the dredging of rivers and ports. In addition, there is some indication that the impacts of soil sediments on local fisheries cause municipalities to lose tax revenues.

Use of Pesticides

Rats are the most common mammals found within oil palm plantations. Rats are attracted to the plantations because they feed on the oil palm seeds. They flourish there because all of their natural predators are removed during the initial forest clearing. Traditionally, snakes and other potential predators are systematically eliminated if they make any attempt to recolonize the oil palm plantations.

Once established, rats are very difficult to remove from plantations. In the past oil palm plantation managers used poisons indiscriminately to eliminate them. This indiscriminate use also poisoned other animals that were attempting recolonize the plantations. Today, more enlightened companies raise and release owls and other predators to control rats on the plantations. They also instruct workers not to kill pythons and other snakes that eat rats.

The use of other pesticides on plantations is rather minimal, with a few notable exceptions. For example, the *Oryctes rhinoceros* beetle, Ganoderma, stem rot, other beetles and even bagworms can require treatment. Some herbicides are still used, however, particularly when plantations are being established. Once the trees grow and produce a canopy that shades the ground, the use of herbicides is greatly reduced.

Use of Fertilizers

Palm oil production requires less fertilizer per unit of output than other oilseed crops. However, it could require even less. The constant removal of nutrients from the plantations in the form of fruit bunches requires fertilizer inputs so that production does not decline over time. For that reason the standard nutrients nitrogen, phosphorus, and potassium, plus other trace elements, are applied regularly to oil palm trees. A number of factors affect the amount of any type of fertilizer that is applied to oil palm plantations. The key variables include the amount or type of ground cover, the slope of the land cleared for the plantation, and whether the empty fruit bunches or other organic matter are used to mulch the area where fertilizers are applied. If these factors are not addressed then more agrochemical inputs will be required because those used will tend to leach out of the plantation and into freshwater systems.

Better Management Practices

There are several effective strategies to reduce the problems caused by oil palm plantations. Given the rate of expansion of the industry and its impact on key ecosystems and species, it is important to make a concerted effort to engage the industry and independent researchers to identify and adopt cost-effective strategies to reduce the overall impact of the industry. In all likelihood successful strategies will need to address many different issues and the concerns of a wide range of stakeholders.

The decision-makers regarding the expansion of oil palm plantations include both company and government personnel. Increasingly, regional governments control permitting and concession agreements. The viability of proposed oil palm operations is, of course, also influenced by other players such as buyers, lenders, investors, and even local communities. Successful strategies to influence the establishment of oil palm plantations should understand the constraints of each of these players. Most damage from oil palm plantations results from where they are located. If expansion can be limited to appropriate sites, many of the problems common to the industry could be eliminated.

An important conservation strategy for oil palm will be to assist with the development of industry investment screens that would encourage investments in more sustainable palm oil businesses (e.g. those that incorporate some of the better management practices or BMPs described below). This is important because expanding and running palm oil businesses requires considerable capital. For example, all major Dutch banks have oil palm investments in Indonesia. Plantations that are well sited and have adopted practices that increase their efficiency, reduce their input use, reduce their waste, and create valuable by-products from waste are less risky investments. Approaching investors about ways to reduce their risks could be a useful point of departure. The same risk-reducing rationale would be of interest to those who insure palm oil companies. Poorly managed operations are more likely to have conflicts with neighbors, or increased liability as a result of flooding or fires.

Another effective conservation strategy will be to work with large-scale, sympathetic vegetable oil purchasers to employ the same type of BMP-based screens as have been developed for investors and insurers as conditions for their purchases. These screens could become conditions of letter-of-credit purchase orders. This approach would signal to producers that buyers are interested in purchasing palm oil, but only that which is produced in a more sustainable way. Unilever, Migros, and Ecover are companies that have already expressed interest in this approach and are trying to do it by themselves. It would be less expensive and more credible if a wider range of stakeholders developed appropriate BMP-based screens for general use.

Some of the specific management practices that need to be identified, analyzed, and discussed with producers and others as part of the development of an overall strategy for reducing the impact of oil palm plantations and increasing their economic viability are discussed below. The list, however, is not intended to be exhaustive.

Use Land Use Planning to Protect Critical Areas

Areas identified as critical habitat for endangered species and areas of exceptional biodiversity need some form of protection. Setting aside preserves is not sufficient, especially since palm oil production is already encroaching onto some of these supposedly protected areas. More effective zoning, land use planning, and enforcement on the ground will be the cornerstone of successful strategies to reduce environmental damage from oil palm cultivation. However, the devil will be in the details of plans refined and implemented on specific sites. Plans should include setting aside areas of high biodiversity as well as those that are important for the maintenance of ecosystem functions (particularly along rivers and on steep slopes). Forest restoration could also be considered in subsequent replanting cycles depending on prior poor productivity, declining prices, or soil erosion.

Any conservation strategy to address the expansion of oil palm plantations will require an initial mapping of existing plantations showing ecological and species priority areas as overlays, as well as concessions that have already been granted but not yet developed. This information is essential for any type of land use planning and zoning; it is also a useful starting point for engaging the industry as well as government officials. At the conclusion of this exercise, it would be possible to identify the most important areas that should be protected either due to their importance as biodiversity preserves or as corridors for the movement of key species. This would force those interested in conservation to identify areas that are not key for protection and that could be used for oil palm or other appropriate development.

Zoning is, of course, not only an exercise to be done at the larger landscape or ecosystem level. It can also be usefully undertaken on a single plantation. In this case, it is important to identify minimal-size, viable forest fragments of biological significance within oil palm concessions. This information should then be reviewed with owners and managers to identify the most appropriate options for developing forest corridors within their plantations or connecting them to other intact forest areas in order to mitigate the development impacts of oil palm plantations.

Enlightened palm oil producers might even be convinced to allow Sumatran rhinoceroses to be introduced to unplanted areas of a plantation, with appropriate measures to prevent worker injuries and poaching. Stray rhinoceroses that have wandered out of protected areas could be used to stock such areas. Prior to this, however, basic research would be needed on local vegetation characteristics and food availability. If successful, rhinoceroses bred on such plantations could be used to restock reserves or other areas. Without advocating captive breeding, the vastness of palm oil plantations plus the intermittent availability of "stray" rhinoceroses and the clear failure of other projects already holding rhinoceroses in captivity make such an experiment worth considering. If undertaken appropriately, this could generate another stream of income for palm oil plantations.

Not all zoning needs to be done by government. Estate owners or even associations of small holders can zone their own lands to reduce their impacts and improve their profitability. A few oil palm producers are beginning to understand that fighting rivers and steep slopes actually lowers their overall production because they spend most of their time focusing on the least productive areas instead of the most fertile ones. The traditional strategy, in effect, was to bring the production levels of the problem areas up to the average. The new strategy is quite different. By leaving (or zoning) such areas (e.g.

riparian areas or steep slopes) for wildlife corridors and watershed and stream protection, producers actually increase their net profits because they focus their attention not on the problems but on raising the average production on most of their plantings. But this shift in thinking, and the record keeping that would support it, has not happened on most farms.

Make the Economic Case that Supports Conservation

Conservationists need to make the case that supporting wildlife and protecting the environment also make economic sense, and they need to address producer concerns in any conservation effort. The elimination of wildlife corridors has a number of direct costs, only some of which are environmental. The environmental costs in terms of biodiversity loss, loss of ecosystem functions, and degradation of downstream environments are quite high but hard to quantify. What is clear, however, is that plantation managers are increasing their own costs by not taking such factors into account. There are a number of examples, including the following:

- How much does it cost to build and maintain long stretches of five-wire electric fences, or to dig and maintain long stretches of trenches up to 2 meters deep to keep elephants out of oil palm plantations?
- How much does it cost (in lost production time and money) to replant areas after elephants have come in and eaten the trees because there is no other food in the area?
- How much does it cost to replant areas along streams where the oil palm trees were killed because of flooding caused by stripping the native vegetation that once protected watersheds and stream banks?
- Given the current low prices for palm oil, is it cost-effective to tend, harvest, and care for plantings on steep slopes where production is poor, erosion is severe, fertilizer requirements are high, and roads are constantly washed out?

In some areas, these costs are incurred on a regular basis. They have literally become a cost of doing business.

Most producers do not separate out the costs of farming different parts of their plantations. They aggregate their data. As a consequence, they do not know when it is cheaper to leave native vegetation in riparian areas than to plant them over and over. They do not know at what degree of slope it stops making sense to farm, because the overall expenses are included in gross figures but are nonetheless dragging down the profitability of the entire operation.

Encourage Planting of Oil Palm on Degraded Lands

Oil palm plantations can be established on former pastures or degraded agricultural lands. Whether it makes sense to do so depends on how the cost of rehabilitating these areas compares to the cost of establishing plantations in natural forests. In many places the sale of timber and pulpwood subsidizes the expense of clearing forested areas for plantation establishment. However, payments for environmental services might tilt the balance in favor of rehabilitating degraded lands instead. For example, rehabilitation of degraded lands may offer significant carbon sequestration potential. Oil palm plantations are reported to sequester as much as 15 metric tons of carbon per hectare per year. If such plantations can be established without destroying forest or releasing carbon already in the soil, then 15 metric tons of carbon per hectare per year is a significant contribution toward reducing global emissions. Countries with carbon-reduction commitments under the Kyoto Protocol, for example, or companies that have made voluntary commitments to reduce or offset their greenhouse gas emissions, have shown interest in "buying" the ecosystem service of carbon sequestration. At current global prices of U.S.$4 to $6 per metric ton of carbon, this could result in a $60 to $90 per-hectare income stream for farmers. However, much more research is required to insure that the carbon would remain sequestered when the plantations are replanted (World Rainforest Movement 2001).

In Malaysia there are attempts to integrate other crops (such as food crops, cocoa trees, or coconut palms) with plantations of oil palm as well as livestock such as cattle, deer, sheep, and buffalo. These practices should be evaluated as possible ways to diversify producer income while reducing environmental impacts. For example, the manure from livestock is an excellent source of nitrogen, which could be used to reduce the amount of purchased nitrogen fertilizer.

Promote Conversion to Smaller Mills

It is now possible to purchase smaller mills that have sufficient capacity to process palm oil from production areas of 400 to 1,000 hectares. These mills can process the production from several small farms, instead of the huge plantations required to supply the older, larger mills. Converting to smaller mills would minimize widespread deforestation and the conversion of natural habitat to monoculture. As a consequence, such processing plants could help to promote more diversity and polyculture production within a region of oil palm production. This is not currently the norm, however. Buyers could target their purchases from smaller mills as a form of corporate social responsibility. However, given the large quantities of bulk transport it would be hard to segregate the product. The question is whether smaller mills could compete with larger ones if small farmers were owners or equity holders of such mills. It is possible that international donors could help set up such mills as part of poverty reduction programs.

Maintain Soil Fertility

Many practices could minimize soil erosion and prevent soil degradation. During planting or replanting all vegetation to be cleared should be windrowed (banked into ridges), leaving only a narrow cleared planting avenue. There should be no burning; instead, the windrowed materials should be constructed along the contour of the land to slow the flow of runoff (rather than up and down hillsides, which does nothing to discourage erosion). During clearing and replanting, the period of time that the soil is exposed without ground cover should be minimized. While trees are still small, cover crops should be grown to reduce erosion while building up organic matter levels in soil through leaf and plant litter. All fronds removed during crop harvesting or pruning can be cut in two and used to cover the ground between the palm rows.

Terraces should be constructed on slopes that are subject to erosion. The economics of farming steep slopes should be evaluated on a regular basis to determine which areas are cleared for planting to begin with or replanted over time. On slopes, leaf matter left from trimming the palm trees to harvest the fruit should be used to reinforce terraces or to otherwise create erosion barriers on contours. Silt pits could be constructed along roads and in fields to trap eroded soil carried in runoff.

Careful siting of infrastructure can also help maintain soil fertility. For example, well-chosen harvesting path locations as well as improved design and construction reduces erosion, standing water, and rutting. It tends to be cheaper to build roads, culverts, terraces, and paths one time correctly than to repair them continuously over the decades.

Ongoing soil management is also important. The soil should be protected during all activities associated with production. Tractors and trailers, if used, should be the appropriate size for soil type to minimize soil compaction. Tires should be inflated appropriately and double tires should be used if possible. On very soft or easily compacted soils draft animals, wheelbarrows, or even cable systems should be used to bring inputs into the fields and carry out harvested fruit bunches. Cable systems are expensive, however. Studies in Costa Rica show that cable systems (similar to those used for bananas) can cost half as much as the entire costs for establishing palm oil plantations (Panfilo Tabora, personal communication).

Soft grasses and ferns should be encouraged under older palms that cast too much shade for traditional cover crops. Clean cultivation should be discouraged. There should be no blanket spraying of herbicides, and only less toxic herbicides should be used (Benbrook et al. n.d.). Organic matter should be kept on the surface to reduce unwanted plant growth and to keep sprays from making direct contact with the soil.

Some soils are not appropriate for oil palm plantations. For example, coastal wetlands with soils containing large amounts of sulfur and iron sulfide often develop into what are known as acid sulfate soils when they are drained for planting. Acid sulfate soils have extreme levels of soil acidity (pH values as low as 2) that require vast quantities of lime before they can support plants such as oil palm. These soils also require more ongoing management (including careful selection of fertilizers) to maintain adequate levels of fertility. Another issue is what will happen to the former oil palm areas if cultivation ceases for any reason, and who is then responsible for rehabilitating the areas.

Reduce Fertilizer Use

Oil palm trees require some form of fertilization to produce yields that are viable economically. Ideally, added fertilizers should never exceed the amounts of nutrients exported in the harvested product plus what erodes, leaches, or volatilizes annually or when replanted. Producers should be encouraged to evaluate the types of fertilizers used in order to assess ways to increase the efficiency and reduce the environmental impacts of their use. This would allow for the identification of specific application practices or the timing of applications that should be encouraged, as well as those that should be discouraged or even banned. For example, any techniques that reduce surface runoff will reduce leaching of nutrients, which in turn minimizes contamination of surface and groundwater with nitrogen and phosphorus. To complement this, nitrogen-fixing legumes should be included in cover crops to reduce the need for purchased nitrogen fertilizers.

Another way to greatly reduce the use of nutrient inputs is through nutrient recycling, particularly from production of waste and/or by-products. One of the main categories of waste on oil palm plantations is the empty fruit bunches remaining after processing. Every 25 metric tons of full fruit bunches yields 16 metric tons of empty fruit branches. This can be returned to the fields. If applied at 6 metric tons per hectare per year, given average yields, eventually it can return half of the nutrients originally harvested in the bunches once it decomposes. To the extent that it is feasible financially, this waste should be spread around the trees throughout the plantation. One of the larger plantations focuses this material on the 2-meter radius around the trees. A problem with recycling this material is that many of the mills return it to their own land rather than to the lands of those who sell seed to them. Thus, this is an issue of cost and ownership.

The other main waste product that should be recycled is the palm oil mill effluent. This is one of the most difficult wastes to handle as it is in liquid form and the temptation is simply to release it into the environment. It too, should be applied back to the fields, as it makes an excellent soil additive.

Trunks of mature trees that have been cut to allow replanting should be recycled more effectively. They contain up to 1,000 kilograms per hectare of potassium. Windrowing the trunks gives a slow breakdown of the material. This is the best way to release the nutrients. Chipping or shredding releases all the nutrients within two to three years, and unless the chips are spread over a much larger area than the replanted area, the nutrients released would exceed the uptake capacity of the new trees. One other important factor that has to do with the best way to recycle trunks is whether they are diseased or whether there is disease in the area. If pests are a problem in the area, then it may be best to chip, pulverize or grind the trunks to reduce the time over which the nutrients are available to pests.

Empty fruit branches and trunks can be chipped and used as mulch if they are free of diseases. When used in circles around mature trees, the mulch can reduce herbicide requirements, but it may be a less efficient way to recycle nutrients than when spread over a larger area. For young trees, biodegradable mulch sheets can also reduce herbicide use.

There are three areas where improvements could reduce fertilizer use. First, to avoid overapplication of potassium, palm oil mill effluent and empty fruit branches should not be applied to the same areas. Second, there is evidence that nitrogen may be lost if palm oil mill effluent is stored for long periods in effluent ponds. If so, the raw effluent should be recycled directly on the fields as soon as possible after processing. In any case, the sludge from effluent ponds should be applied to fields that are low in organic matter. And third, increased monitoring is needed to understand better nutrient use, storage, and loss.

Composting residues from oil mills and using them as mulch are seen as effective ways to maintain or build soil nutrients. Empty fruit bunches have also been used successfully in a joint Finnish/Indonesian project to produce paper. These efforts should be evaluated and, to the extent that they are appropriate, should be encouraged. Studies have also shown that the production of edible mushrooms is also a financially viable possibility.

Oil palm trees regularly lose branches as they grow, which creates waste on the ground beneath the trees. In addition, empty fruit bunches from oil palm mills must be disposed of; they are generally burned or converted into mulch. All in all, the weight and volume of waste far exceeds the commercially viable products produced from palm oil seeds. In addition, overly mature trees (twenty-five years or older) are felled and either left lying on the ground or gathered and burned or chipped. The trunks of trees can also be used for lumber or made into fiberboard. Palm kernel waste is a major raw material, and is processed into cake for animal feed such as food for pigs. Many plantation owners now put most of the processing waste back onto the farm as mulch. There is still considerable potential for preparations of other by-products such as fertilizers.

Use Integrated Pest Management and Biological Controls

Better management practices should include detailed methods for addressing the main pests in each area. Integrated pest management (IPM) should be adopted to ensure that the least harmful method of pest control is used and pesticide application is kept to a minimum. Only pesticides that are approved in the country of production and the country of consumption should be used. In general, the least toxic and least persistent pesticide should be used to address each problem. One way to achieve this is to develop an overall point system in which producers are given a "total pesticide toxicity allowance" to be used for all needs. In general, however, chemicals should be used only as the last resort. The equipment for applying these chemicals should use as little as possible with effective targeting while minimizing drift.

One of the best ways to develop an appropriate IPM system is to undertake a census of the main pests. This should include an understanding of both the pest's life cycle and its natural enemies. The next issue is to understand what levels of infestation cause economic losses. These would be the action thresholds, and no pest control would be required until infestations reach these action thresholds.

Owls are effective predators of rats, the main mammal pest in oil palm plantations. Owl boxes can be established and monitored for occupancy. Snakes can also be introduced or encouraged. If poisons are used, it is important to choose chemicals that are not toxic to predators that may inadvertently consume poisoned rats. Maintaining adequate populations of predators will reduce the need for poisons.

Integrated pest management is already being used by some producers to reduce the use of pesticides. Workers on the Golden Hope Plantations Berhad in Malaysia have been using IPM measures since the early 1980s. They have found that the following IPM measures reduce pests significantly:

- close monitoring of disease and pest infestations allows them to be more easily controlled with or without few chemical inputs;
- planting species that support or attract natural enemies of oil palm pests helps minimize pest problems;
- proper shredding and rapid decomposition of old trees suppress the pest *Oryctes rhinoceros* from breeding;
- use of a biological control, a native baculovirus, to attack *Oryctes rhinoceros* has been proven 80 to 95 percent effective;
- growing thick legume cover crops helps suppress pests from breeding in the debris; and
- encouraging barn owls and snakes helps to reduce rat populations.

It is clear that some of the IPM practices have to be adjusted as other management practices shift. For example, with the zero-burning policies discussed in the following section, additional control measures are needed to keep pests such as beetles and bagworms in check. These and other IPM efforts should be further documented and, as appropriate, shared with other producers and government officials.

In some instances, pesticides will be necessary to insure profitable yields. Producers should be encouraged to evaluate the types of pesticides they use in order to increase the efficiency and reduce the environmental impacts of use. This would allow for the identification of specific chemicals and application practices that should be discouraged or even banned.

Eliminate Burning

Better clearing practices do not involve burning. One way to insure this is to enforce burning regulations. It is equally important, however, to identify and disseminate information about the best ways to clear without burning. The goal should be to help identify what companies should do, not just what they should not do. Since 1989 Good Hope Plantations (1997a) has found that eliminating burning is practical for replanting or new plantings. With this method, useful parts of trees are harvested and the remainder are left on the ground where they can be spread out to provide protective ground cover, or piled into rows to prevent runoff and erosion. More than 30,000 hectares have been planted with this technique. The main issue of concern with zero burning is that it might lead to the infestation of beetle pests and stem rot disease. Plowing, pulverizing debris, or planting legumes minimizes this risk.

The main benefit derived from zero burning in Malaysia is that nutrients tend to be released more slowly during decomposition so that they can be utilized by the new trees. This reduces per hectare inorganic fertilizers needed at the time of planting (e.g. nitrogen by 738 kilograms, phosphorus by 205 kilograms, potassium by 848 kilograms, and magnesium by 487 kilograms). The organic matter also improves the soil. When organic matter is used properly it helps with terracing and the reduction of runoff.

One study found that in 1993 the zero burning technique reduced costs for establishing plantations from 1,070 to 1,415 ringgits (the Malaysian unit of currency) when compared with plantations where burning was used. This is primarily because zero burning reduces the fallow time needed by eliminating the need to dry the cleared forest material for burning. Thus, producers get a portion of a crop that much faster. This method also exposes soil far less than other methods, and it lets replanting occur gradually throughout the year whenever there is sufficient rainfall for the seedlings (Golden Hope Plantations Berhad 1997a).

Encourage the Use of Renewables

When solid wastes from processing palm oil cannot be recycled back to the fields, they can be burned as a source of energy to reduce the amount of nonrenewable energy sources imported to plantations and mills. In addition, solar power or biomass should be explored in lieu of importing fuels from off of the plantations. Whether such alternatives are acceptable often depends on the cost of fuel. Biomass and effluent ponds produce methane, a very potent greenhouse gas, which should be captured and used as a fuel rather than released into the atmosphere. While methane often is not cost-effective as a substitute for diesel within the plantation operation itself, it can substitute for natural gas, especially when bought in small quantities by workers and used for cooking.

Reduce Water Use and Nutrient Loading of Freshwater Bodies

Plantations should irrigate efficiently. In nurseries for palm oil seedlings, drip or perforated tube irrigation systems are preferable to sprinklers. The use of water in processing mills should also be minimized, and every effort should be made to recycle an ever-increasing amount of the water that is used.

Operations should divert rainwater from the factory effluent stream to minimize water treatment requirements and the dilution of nutrient-laden wastewater that requires treatment. Ponds and water catchment areas can be constructed to collect rainwater and reduce the amount of water taken from natural bodies.

Mill effluents should be concentrated and reused. For every metric ton of oil produced 2.5 metric tons of effluent are generated, which have an average biochemical oxygen demand (BOD) of 25,000 parts per million. In Malaysia, the BOD level must be below 100 parts per million before effluent can be legally discharged into streams. However, Golden Hope has found that returning the palm oil mill effluent to the plantations actually saves them in costs for fertilizers (nitrogen, phosphorous, and potassium) while avoiding pollution and pollution taxes. The sludge cake produced when the effluent is allowed to settle can also be used to make biogas or livestock feed. An oil mill processing 60 metric tons of fresh fruit bunches per hour is capable of producing about 20,000 cubic meters of biogas per day, enough to generate about 1,000 kilowatts of electricity. Utilization of biogas, however, is limited because of the low cost of natural gas in Malaysia at this time (Rahman bin Ramli 1996).

The changes in Malaysia's effluent standards for palm oil mill effluents from 1978 to 1984 are shown in Table 9.6. As this history of effluent standards suggests, they can be strengthened over time. However, this is only likely to happen if specific, measurable targets are given and then effective monitoring takes place to ensure that targets are met.

What can also be more effective is not to be to prescriptive, i.e. to set the standards and let the companies find the best way to achieve them.

Table 9.6 Palm Oil Mill Effluent Standards for Watercourse Discharge in Malaysia

Parameter	Standard A 7/1/78–6/30/79	Standard B 7/1/79–6/30/80	Standard C 7/1/80–6/30/81	Standard D 7/1/81–6/30/82	Standard E 7/1/82–21/31/83	Standard F 1/1/84 onward
BOD(ppm)	5,000	2,000	1,000	500	250	100(50)+
COD(ppm)	10,000	4,000	2,000	1,000	--	--
Total solids (mg/l)	4,000	2,500	2,000	1,500	--	--
Suspended solids (mg/l)	1,200	800	600	400	400	400
Oil and grease (mg/l)	150	100	75	50	50	50
Ammoniacal nitrogen (mg/l)	25	15	15	10	150Y	100Y
Total nitrogen	200	100	75	50	300Y	200Y
pH	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0
Temperature (°C)	45	45	45	45	45	45

Source: IPAS Training Center n.d.

+ This additional limit is the arithmetic mean value determined on the basis of a minimum of four samples taken at least once a week for four consecutive weeks.

Y = Value on filtered sample.

Outlook

The consumption of vegetable oils is increasing faster than that of any other major agricultural commodity with the exception of fruit. Production of a whole range of vegetable oils, including palm oil, has expanded even more rapidly as producers have attempted to increase their income from these lucrative markets. As a consequence, the price of vegetable oils has declined rapidly. Palm oil is both very productive and relatively cheap to produce. Palm oil processors insist that they can still make money if the price were to be cut in half again as it has been in the past decade. While palm oil processors may continue to make money, other oilseed producers will not. Sunflower production in Argentina, for example, has declined precipitously in favor of soybeans where at least the value of the soybean meal cushions producers from the glut of palm oil on global markets.

The question is not whether palm oil will remain competitive on global markets. It will. The question is whether palm oil can be produced in ways that are more harmonious with preserving biodiversity and ecosystem functions on the one hand, and on the other, whether production can be undertaken on scales that will benefit the majority of the people who live in rural areas. There is some indication that investors, manufacturers, and retailers, particularly in Europe, are keen to use their influence to see that this happens. If so, what happens with palm oil could be a precursor of what could happen with other agricultural commodities.

Resources

Web Resources

www.cigiar.org/cifor
www.kpu.gov.my:1025/commodities/txpalm.html
www.bdb.co.uk/bdb05.html
www.admworld.com/other.shtml
www.gaexpertise.com/index.htm
www.latin.or.id/palm_oil.htm
www.unilever.com
www.itgldn.freeserve.co.uk
www.l-hendrix.nl/home/page3.htm
www.cbot.com
www.imt-gt/org/other/Indogov.html
www.cargill.com
www.cargill.com/indo.htm
www.arabis.org/arab/arab_plantatn.htm

Additional resources can be obtained by searching on "oil palm" or "palm oil" on the WWF International Intranet:
http://intranet.panda.org/documents/index.cfm

Contacts Within the WWF Network

Matthias Diemer, WWF-Switzerland (matthias.diemer@wwf.ch)
Derk Kuiper, WWF-Netherlands (dkuiper@wwf.nl)
Andrew Ng, WWF-Malaysia (ang@wwf.org.my)
Bella Roscher, WWF-Switzerland (bella.roscher@wwf.ch)

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