# Rent Capture and the Feasibility of Tropical Forest Management

***Jeffrey R. Vincent***

## I. INTRODUCTION

Most naturally regenerated tropical forests are government-owned and administered (Lanly 1982). Timber from these forests is sold to concessionaires—firms holding harvesting rights—at charges established by government agencies, not by markets. The most common charges are royalties, which are assessed on logs extracted from the forest, not on standing trees (Gray 1983). Royalties are usually quite uniform across species and sites. Hence, they do not reflect variations in timber quality and extraction (harvest and delivery) costs.

Gillis (1980) was among the first to call attention to the failure of royalty systems to capture the potential resource rent of tropical forests. He pointed out several negative impacts of this mispricing: reduced government revenues, overexpansion of the forestry sector, and increased logging damage. Quantitative estimates of such impacts during 1979–83 for several tropical regions were recently presented by Repetto and Gillis (1988). Estimates of the percentage of rent captured by royalties range from 11.4 percent for the Philippines (Boado 1988) and 33.2 percent in Indonesia (Gillis 1988a) to 82.8 percent in the Malaysian state of Sabah (Gillis 1988b).

This paper analyzes how the inefficiency of tropical timber royalty systems affects the feasibility of tropical forest management. Although technical, silvicultural obstacles to tropical forest management are daunting (Masson 1983; Wyatt-Smith 1987b), recent reviews suggest that they are not as insurmountable as commonly supposed (Schmidt 1987; Wyatt-Smith 1987a). Instead, economic factors are increasingly recognized as major determinants of management success or failure. This paper argues that distorted price signals from inefficient royalty systems give an unduly negative indication of the potential financial returns to forest management.

The paper has two major objectives: first, to estimate the discrepancy between royalties and resource rent in Malaysia during 1966–85, and second, to use a benefit-cost framework to analyze the impacts of this discrepancy on the feasibility of tropical forest management. The estimates of rent capture are the first available for the entire nation of Malaysia, which is the world's major producer and exporter of tropical hardwood logs, and they provide a useful comparison to those by Repetto and Gillis (1988) for other nations. More important is the finding that tropical forest management is feasible in many cases even if nontimber benefits are excluded, as long as timber is valued by resource rent instead of royalties.

## II. ROYALTY SYSTEMS IN MALAYSIA

Malaysia is composed of three regions—Peninsular Malaysia, Sabah, and Sarawak—which are distinct in terms of forest resources, industries, and policies (Vincent 1988a). Although charges on timber vary

Assistant Professor, Resource Economics, Department of Forestry, Michigan State University.

The author thanks Larry Leefers and an anonymous referee for helpful comments. Support from Yale University's Tropical Resources Institute and the Michigan Agricultural Experiment Station is gratefully acknowledged. This article is Journal Article No. 13165 of the Michigan Agricultural Experiment Station.

*Land Economics* Vol. 66. No. 2, May 1990
0023-7639/00/-0001 $1.50/0

among the regions, the most significant charge in each region is the royalty assessed on extracted logs. Royalties are essentially undifferentiated: timber species are aggregated into a small number of groups, and all species in a given group are assessed an identical royalty.

The following sections describe royalty systems in each region as of 1985. The descriptions are based on information provided by the Forestry Departments of the three regions during fieldwork in 1987 and 1989.

*Peninsular Malaysia*

Species in Peninsular Malaysia are aggregated into five groups. Royalties for most groups are similar across the eleven states of the region. Although royalties are ostensibly based on 10 percent of current log price, only five of the states have updated their royalties since 1972 (Anonymous 1986). The average royalty for 1966–85 was M$10.40 per cubic meter, only 8.6 percent of the average log price, M$121.09 per cubic meter. These values and those given below are weighted by annual harvest volumes and are in Malaysian dollars (M$1 = U.S. $0.46 in 1980) at 1980 price levels.

*Sabah*

Species in Sabah are aggregated into nine groups. Royalties are based on average F.O.B. log export prices for each group. For logs processed domestically, royalties are set equal to 10 percent of current F.O.B. price. For exported logs, royalties are determined by formulas of the following type:

$$r = \phi(p - \theta), \quad [1]$$

where $r$ is the royalty, $p$ is F.O.B. log export price, and $\phi$ and $\theta$ are parameters. The value of $\phi$ ranges from 0.6 to 0.8. $\theta$ is intended to represent average extraction costs in Sabah. Values of $\theta$ equal to M$42, 63, 65, and 67 were all in use in 1985.[1] If $\theta$ were equal to actual (not average) extraction costs, then the royalty would equal the true stumpage value only if $\phi$ equaled 1.

The average royalty for 1966–85, M$42.86 per cubic meter, was substantially higher than in Peninsular Malaysia. It represented 32.3 percent of average log price, M$132.72 per cubic meter.

*Sarawak*

Species in Sarawak are aggregated into five groups. Royalties are set administratively and updated infrequently. For example, the 1985 royalties had been in effect since December 1982. As in Sabah, lower royalties are assessed on logs that are processed domestically. The reduction is 50 percent of the full royalty. Royalties are not adjusted for distance or other factors affecting extraction costs. The average royalty for 1966–85 was M$11.08 per cubic meter, only 11.1 percent of average log price, M$99.95 per cubic meter.

*Other Charges*

Each region assesses a number of other charges on timber that are, for the most part, minor compared to royalties. Those that are essentially undifferentiated and are assessed on extracted logs were included in the average royalty values given above. In addition to log-based charges, the states in Peninsular Malaysia assess a "premium" that is assessed on the area of forest under contract. The average premium during 1966–85 was equivalent to an additional charge of M$4.30 per cubic meter of extracted logs. This amount was not included in the average royalty for Peninsular Malaysia given above.

Each region has also collected revenue

[1] Since July 1983, concessionaires in Sabah have been reimbursed an amount that increases with the haul distance from forest to mill or port. Although this might bring differences in royalties between sites in line with differences in stumpage values, the fact that $\phi$ is less than 1 prevents the absolute levels of royalties and stumpage values from corresponding.

from log export duties. This has never been a significant source of revenue in Peninsular Malaysia, which began restricting the export of logs in the early 1970s and imposed a log export embargo in 1985. Even though Sabah is a major log exporter, its 15 percent export duty is an insignificant source of revenue because it is levied on only one hardwood species. In Sarawak, however, export duties—10 percent in 1985—were the source of half as much revenue during 1966–85 as were royalties.

## III. ROYALTIES AND RESOURCE RENT

Undifferentiated, log-based royalty systems like those in Malaysia influence concessionaires' harvesting behavior in such a way that potential resource rent on a given site is captured partly by the government via royalty revenue, partly by the concessionaire via excess profits, and partly by no one as timber left on the site (Gillis 1980). This section presents an analytical framework for studying these three rent components. This framework is the basis of the empirical approach used to estimate rent capture in Malaysia.

### *Stumpage Value and Resource Rent*

The resource rent, or stumpage value ($s_i$) of a standing tree is equal to the volume of timber in the tree ($v_i$) times the difference between the price ($p_i$) that concessionaires receive when they sell logs to a mill or exporter and the extraction costs ($c_i$) for those logs:

$$s_i \equiv v_i(p_i - c_i), \qquad [2]$$

where $i$ is an index for individual trees ($i = 1, \ldots, I^*$); $c_i$ represents total cost per log; that is, it includes fixed costs and normal profit margins. A site's potential resource rent ($S$) is found by aggregating the stumpage value of all trees on the site:

$$S \equiv \sum_{i=1}^{I^*} s_i$$

$$= \sum_{i=1}^{I^*} v_i p_i - \sum_{i=1}^{I^*} v_i c_i. \qquad [3]$$

For simplicity of exposition, let us assume that variation in log prices can be ignored:

$$p_i = p \;\forall\, i.$$

This implies that differences in stumpage values result only from differences in extraction costs. If we distinguish between marginal costs ($MC_i$) and total fixed costs ($FC$), and if we define total timber volume ($V^*$) on the site as

$$V^* \equiv \sum_{i=1}^{I^*} v_i,$$

then we obtain:

$$S = pV^* - \sum_{i=1}^{I^*} v_i MC_i - FC. \qquad [4]$$

These concepts are presented diagrammatically in Figure 1. The horizontal axis gives cumulative timber volume. Increases in harvest volume are associated with higher marginal extraction costs. The area between the marginal cost curve and the price line represents the sum of potential rent plus fixed costs. The site earns a positive rent only if fixed costs do not account for this entire area.

### *Royalties and Rent Capture*

A royalty system is economically efficient if it captures the full value of the potential resource rent. Equation [2] suggests that this is possible only if royalties are differentiated on an individual tree basis, so that $r_i = s_i$. In Malaysia, however, and in most other tropical countries for that matter, the simple, undifferentiated royalty

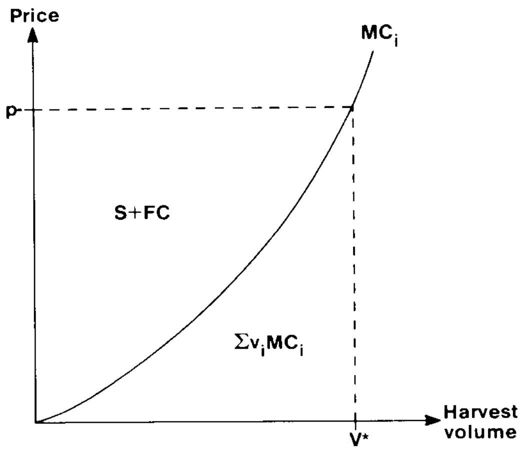


FIGURE 1
EXTRACTION COSTS AND RESOURCE RENT
$p$ = price of log delivered to mill or dock, $V^*$ = total merchantable timber volume, $MC_i$ = marginal extraction cost for logs from tree $i$, $v_i$ = timber volume in tree $i$, $S$ = potential resource rent, $FC$ = fixed costs of extraction.

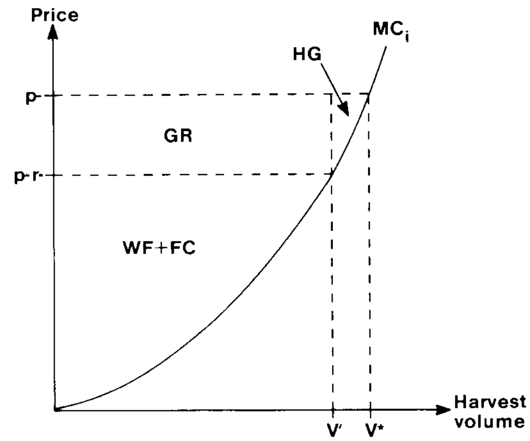


FIGURE 2
UNDIFFERENTIATED ROYALTY AND RENT CAPTURE
$GR$ = government revenue, $HG$ = high-grading loss, $WF$ = windfall profit, $V'$ = actual harvest volume. $GR + HG + WF = S$ in Figure 1.

system ($r$, not $r_i$) results in $r < s_i$ for some trees and $r > s_i$ for others. In the former case, the concessionaire reaps "windfall" profits (Gillis 1980). In the latter case, the log-basis of royalties permits concessionaires to avoid the excessive timber charges by simply leaving trees, felled or standing, on the site. Gillis (1980) has termed this behavior "high-grading."

Figure 2 displays how an undifferentiated royalty causes potential rent to be split among three components: government revenue ($GR$), windfall profits ($WF$), and high-grading ($HG$). A profit-maximizing concessionaire will not harvest trees for which marginal cost exceeds marginal revenue. Marginal revenue is equal to the net log price, $p - r$. Rather than harvesting all timber on the site, $V^*$, the concessionaire harvests only up to $V'$, the point where $MC_i = p - r$. The government collects revenue, $GR$, only on $V'$, since royalties are assessed on extracted logs. The $V^* - V'$ volume that is not extracted has rent value equal to $HG$, the high-grading component. The size of the concessionaire's windfall, $WF$, depends on the size of its fixed costs, $FC$. Note that an undifferentiated royalty causes an unavoidable trade-off between $WF$ and $HG$: as $r$ increases, $HG$ increases, and as $r$ decreases, $WF$ increases.

Using the notation of equation [4], these rent components may be expressed as follows:

1. $GR = rV'$ [5a]

2. $WF = (p - r)V' - \sum_{i=1}^{I'} v_i MC_i - FC$ [5b]

3. $HG = p(V^* - V') - \sum_{i=I'}^{I^*} v_i MC_i.$ [5c]

The sum of these three components equals $S$ in equation [4]. Thus, we have fully accounted for the potential rent of the site.

It is important to realize that $HG$ as given by equation [5c] represents "high-grading" in a strict sense. It does not include logging damage caused by either careless logging methods or "cut out and get out" behavior resulting from concession contracts of too short or uncertain tenure. The substantial potential rent that might be lost due to these causes is excluded from equation [5c].

*Estimating Rent Components*

The individual tree data required to implement equation [5a–c] do not exist for Malaysia, or for any other tropical country for that matter. Available data are essentially limited to aggregate, annual data on royalty revenue and the value and quantity of logs (sometimes with species detail) exported or sold domestically. Data on extraction costs are especially meager; time series have not been compiled for any region. Hence, while *GR* is known, direct calculation of *WF* and *HG* is not possible.

An indirect approach to estimating rent components was necessary. The approach relied on specifying an aggregate marginal cost curve for logging. Details of this approach, and a comparison to Repetto and Gillis's (1988) approach, are presented in the Appendix. The rent components were calculated separately for each Malaysian region using annual data for 1966–85.

## III. RENT CAPTURE IN MALAYSIA

The estimates of 1966–85 totals for *GR*, *WF*, *HG*, and *S* in Peninsular Malaysia, Sabah, and Sarawak are presented in Table 1. Values of *GR* exclude—hence, values of *WF* implicitly include—export duties.[2] Refer to note "c" of the table for values of *GR* inclusive of duties.

*Base Case*

The base case assumes a value of 3.0 for the elasticity ($\beta$) of the marginal cost curve for logging. The largest potential rent occurred in Sabah, followed by Peninsular Malaysia and Sarawak. This ranking reflects not only the log price differences noted earlier, but also differences in harvest levels: the 20-year harvest total for Sabah was 16.7 percent greater than in Peninsular Malaysia, and 46.3 percent greater than in Sarawak. Year-by-year estimates (not shown) indicated that potential rent rose greatly during the sample period in all three regions, due to both rising log prices and rising harvest levels.

The ranking of *GR* among the three regions was the same as for potential rent. This was a consequence of both relative harvest levels and relative royalty levels: as noted earlier, royalties (plus premiums in Peninsular Malaysia) were largest in Sabah and smallest in Sarawak. In no region did *GR* account for more than half of potential rent: it was 46.2 percent in Sabah, 21.8 percent in Peninsular Malaysia, and 18.4 percent in Sarawak.

The remaining rent was captured almost entirely by *WF*. This is not surprising: the low royalty levels suggest that concessionaires were rarely overcharged for timber, which implies that *HG* should be small. The *WF*/*GR* ratios were 1.1 in Sabah, 3.6 in Peninsular Malaysia, and 4.4 in Sarawak. These ratios are of comparable magnitude to those reported by Gillis (1988a) for Indonesia (2.0) and Boado (1988) for the Philippines (7.8). In Malaysia, as elsewhere in the tropics, forest exploitation has been characterized by a tremendous transfer of wealth from the public sector to private concessionaires.[3]

*Comparison to Gillis's Estimates for Sabah*

Table 2 compares Gillis's (1988b) estimates of *WF* in Sabah during 1979–83 to those in this study. For comparability, his estimates have been adjusted to include an amount equivalent to payments of export duties, and this study's estimates have been converted to nominal U.S.$. Both sets

[2] It is not clear whether revenue from export duties should be treated as captured resource rent. Gillis (1980) and Repetto and Gillis (1988) treat it as such. However, duties could be imposed even if resource rent were completely captured by the royalty system, as long as exporters were able to pass the duty onto importers in the form of higher prices. As Burns (1986) has noted, export duties are "hardly an obvious measure of the value of standing timber."

[3] The concessionaire may be a governmental organization in some cases. For example, the Sabah Foundation has the largest concession in Sabah, and a long-term lease to go with it. As a result, *WF* is essentially captured by the effective land owner. It is perhaps not surprising then that the Foundation has among the most ambitious plans for sustained forest management in Malaysia.

TABLE 1
RENT CAPTURE IN MALAYSIA

| β[b] | Region | Rent component[a] | | | |
|---|---|---|---|---|---|
| | | *GR*[c] | *WF* | *HG* | *S* |
| | | Billion M$(1980)[d] | | | |
| 3.0 | Peninsular Malaysia | 2.41 | 8.59 | 0.03 | 11.03 |
| | Sabah | 8.19 | 8.80 | 0.72 | 17.72 |
| | Sarawak | 1.34 | 5.92 | 0.03 | 7.29 |
| 1.5 | Peninsular Malaysia | 2.41 | 3.29 | 0.06 | 5.75 |
| | Sabah | 8.19 | 3.78 | 1.54 | 13.51 |
| | Sarawak | 1.34 | 3.01 | 0.07 | 4.42 |
| 4.5 | Peninsular Malaysia | 2.41 | 11.00 | 0.02 | 13.43 |
| | Sabah | 8.19 | 11.09 | 0.47 | 19.75 |
| | Sarawak | 1.34 | 7.24 | 0.02 | 8.60 |

[a]Totals for 1966–85, in real terms (1980 price levels). *GR* = government revenue, *WF* = windfall profits, *HG* = high-grading, *S* = potential rent (= *GR* + *WF* + *HG*).
[b]β = elasticity of the marginal cost curve for logging.
[c]Excludes revenue from export duties on logs. If export duties are included, *GR* (in billion M$) becomes 2.58 for Peninsular Malaysia, 8.37 for Sabah, and 2.02 for Sarawak. *WF* should be reduced accordingly.
[d]M$1.00 = U.S.$0.46 in 1980.

of estimates predict values of *WF* in the hundred-million dollar range. Gillis's estimates, however, are substantially lower for all five years. The estimates are closest in 1979 and 1982, and even then his are about 50 percent lower.

What is the source of this discrepancy? Gillis's estimates could be biased downwards due to overstating average extraction costs, perhaps because his estimates of extraction costs are based on Indonesian, not Sabah, data. On the other hand, the estimates in this study could be biased upwards due to understating fixed costs or overstating the marginal cost curve elasticity.[4] Determining which study's estimates are closer to the truth would require more reliable, complete data on extraction costs than are available. Until such data become available, significant imprecision in rent estimates is unavoidable.

TABLE 2
WINDFALL PROFITS IN SABAH

| Year | This study | Gillis (1988b) |
|---|---|---|
| | Million U.S.$[a] | |
| 1979 | 289 | 148 |
| 1980 | 217 | 69 |
| 1981 | 317 | 90 |
| 1982 | 335 | 153 |
| 1983 | 305 | 21 |
| 5-year sum: | 1,464 | 481 |

[a]In nominal terms.

*Sensitivity Analysis*

Table 1 includes estimates of rent components for alternative (50-percent smaller, 50-percent larger) values of β. The effects of changing β were predictable: higher values of β were associated with higher estimates of *WF* and lower estimates of *HG*. The changes in *WF* were the most dramatic. Nevertheless, the results show a degree of robustness in that the absolute magnitudes of the three rent components were affected more than their relative magnitudes. In particular, *GR* remained less than half of potential rent in all cases except β = 1.5 for Sabah.

[4]Using a value of 1.5 instead of 3.0 for β yielded an estimate of the 1979–83 sum of *WF* that was very similar to Gillis's estimate. Estimates for individual years still showed substantial differences, however.

## IV. FEASIBILITY OF TROPICAL FOREST MANAGEMENT

The low rates of rent capture for Malaysia suggest that purported economic obstacles to tropical forest management may, to a certain extent, be illusory: inefficient royalty systems lead to reduced revenue generation, creating the false impression that alternative land uses are more productive. Quantifying the impacts of this artificial bias against tropical forest management is the concern of the remainder of this paper.

### *A Tropical Forest Management Example*

The best-known work on the economics of tropical forest management is probably that of Leslie (1977, 1987a, 1987b). Leslie argues that tropical forest management is generally infeasible on a financial basis but may frequently be feasible on an economic basis that includes nonmarket, nontimber benefits. The natural forest management example given in Leslie (1987b) provides a useful context for reexamining the issue of financial feasibility in light of the evidence on low rates of rent capture.

"Natural" forest management refers to systems that rely on natural regeneration to produce the next stand of trees.[5] In Leslie's example, the forest is harvested on a rotation of sixty years, and the complete timber crop is removed at this time. That is, the system is monocyclic. Establishment costs for activities related to regeneration range from U.S.$20 to U.S.$100 per hectare, while annual maintenance costs range from U.S.$0.5 to U.S.$1.5 per hectare. Costs are assumed to remain constant in real terms.

Physical yields at harvest range from 30 to 120 cubic meters per hectare in Leslie's example. The upper limit here is unusually high: average log yields in Peninsular Malaysia, Sabah, and Sarawak were 31, 48, and 51 cubic meters per hectare during 1966–85, and these were for harvests from predominantly old-growth forests, which tend to have higher yields than second-growth forests. An upper limit of 60 cubic meters per hectare for second-growth forests seems more reasonable.

Leslie assumed that royalties would range from U.S.$6 to U.S.$20 per cubic meter. This range corresponds closely to the range in average 1966–85 royalties among the three Malaysian regions: Peninsular Malaysia = U.S.$4.78 per cubic meter, Sarawak = U.S.$5.10, and Sabah = U.S.$19.72 (conversions based on 1980 exchange rates). According to Leslie, "socially valued stumpage rates" might be 20 percent higher than royalties. Results in Table 1 indicate that true timber values, in a financial sense, are much higher: in the base case, the ratio of potential rent to government revenue for Malaysia as a whole was 3.0—a 200, not 20 percent, undervaluation.

Leslie also assumed that timber values would remain constant in real terms. Historically, however, stumpage values in many parts of the world have risen at rates greater than inflation (Manthy 1978). These trends are expected to continue (Dykstra and Kallio 1987; Binkley and Vincent 1988). During 1966–85, real prices of tropical hardwood logs in Malaysia rose at average annual rates ranging from 2.0 percent in Peninsular Malaysia and 2.5 percent in Sarawak to 3.7 percent in Sabah. It is doubtful that real extraction costs have increased as quickly, and so real stumpage values have probably increased as well.

These considerations led to the formulation of three distinct cases, distinguished by the value assigned timber. In the first case, which corresponds most closely to Leslie's original analysis, timber was valued by royalties ranging from U.S.$4.78 to U.S.$19.72 per cubic meter, which is the range of the historical averages for the three Malaysian regions. In the second case, timber was valued by approximate stumpage values, which ranged from U.S.$21.84 to U.S.$42.60 per cubic meter. This is the range of imputed values for the three Malaysian regions based on *S/GR* ratios in Table 1. The third case was the same as the second, except that stumpage values were

[5] Enrichment planting of indigenous species is sometimes considered natural management (Nwoboshi 1987).

TABLE 3
FINANCIAL FEASIBILITY OF TROPICAL FOREST MANAGEMENT

| Case[a] | Scenario[b] | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|
| | | Net present value[c] (U.S.$ per hectare) | | | |
| First | High $C$, low $Y$, low $r$ | −134 | −125 | −120 | −116 |
| | High $C$, high $Y$, low $r$ | −119 | −121 | −118 | −116 |
| | High $C$, low $Y$, high $r$ | −87 | −111 | −115 | −115 |
| | High $C$, high $Y$, high $r$ | −25 | −93 | −109 | −113 |
| | Low $C$, low $Y$, low $r$ | −20 | −25 | −26 | −25 |
| | Low $C$, high $Y$, low $r$ | −5 | −20 | −24 | −25 |
| | Low $C$, low $Y$, high $r$ | 27 | −11 | −21 | −24 |
| | Low $C$, high $Y$, high $r$ | 89 | 8 | −15 | −22 |
| Second | High $C$, low $Y$, low $r$ | −81 | −109 | −115 | −115 |
| | High $C$, high $Y$, low $r$ | −12 | −89 | −108 | −113 |
| | High $C$, low $Y$, high $r$ | −15 | −90 | −109 | −113 |
| | High $C$, high $Y$, high $r$ | 119 | −50 | −96 | −108 |
| | Low $C$, low $Y$, low $r$ | 34 | −9 | −20 | −23 |
| | Low $C$, high $Y$, low $r$ | 103 | 12 | −14 | −21 |
| | Low $C$, low $Y$, high $r$ | 99 | 10 | −14 | −21 |
| | Low $C$, high $Y$, high $r$ | 233 | 50 | −1 | −17 |
| Third | High $C$, low $Y$, low $r$ | 76 | −62 | −100 | −110 |
| | High $C$, high $Y$, low $r$ | 302 | 5 | −78 | −103 |
| | High $C$, low $Y$, high $r$ | 291 | 1 | −79 | −103 |
| | High $C$, high $Y$, high $r$ | 731 | 133 | −38 | −89 |
| | Low $C$, low $Y$, low $r$ | 191 | 38 | −6 | −18 |
| | Low $C$, high $Y$, low $r$ | 417 | 105 | 16 | −11 |
| | Low $C$, low $Y$, high $r$ | 405 | 102 | 15 | −12 |
| | Low $C$, high $Y$, high $r$ | 846 | 233 | 57 | 2 |

[a] First case: timber valued by royalties, constant in real terms. Second case: timber valued by stumpage value, constant in real terms. Third case: timber valued by stumpage value, rising in real terms at 2.0 percent per year.

[b] $C$ = cost, $Y$ = yield, $r$ = timber value. All values are in U.S.$, in real terms. Low $C$: establishment costs of $20 per hectare and annual costs of $0.5 per hectare. High $C$: establishment costs of $100 per hectare and annual costs of $1.5 per hectare. Low $Y$: harvest volume of 30 cubic meters per hectare. High $Y$: harvest volume of 60 cubic meters per hectare. Low $r$: royalty of $4.78 per cubic meter in first case; stumpage value of $21.84 per cubic meter in second and third cases. High $r$: royalty of $19.72 per cubic meter in first case; stumpage value of $42.60 per cubic meter in second and third cases.

[c] Based on management in perpetuity ("soil expectation value") for 60-year rotation. The boxes highlight positive NPVs.

assumed to increase at an annual real rate of 2.0 percent. This rate is equal to the minimum rate of log price increase during 1966–85 among the three Malaysian regions.

*Financial Analysis*

Table 3 presents net present values (NPVs) for financial analysis of the three cases.[6] NPVs are based on management in perpetuity (infinite rotations) and thus may be interpreted as soil expectation values.

In the first case, NPVs were positive in only three out of thirty-two cases. All three cases involved low cost/high royalty combinations and discount rates no greater than 6 percent. In the second case, financial performance improved markedly: NPVs were

[6] A referee pointed out that referring to the analysis of Cases 2 and 3 as "financial" might be confusing, since actual timber prices (royalties) are replaced by shadow values that approximate stumpage prices. I use this terminology to emphasize that only timber values are included in the analysis.

positive in eight cases. Some of the cases included high cost or low royalty combinations. The maximum discount rate for feasibility remained 6 percent.

In the third case, NPVs were positive in more than half, nineteen, of the cases. At least one of each cost/yield/royalty combination was financially feasible, and feasibility occurred at discount rates up to 10 percent. The impact of the royalty/rent discrepancy is indicated by the fact that feasibility occurred in only nine cases when timber values were based on royalties, instead of stumpage values, rising at 2.0 percent per year. Results of this analysis are not shown.

## V. DISCUSSION

Results of the analysis of rent capture in Malaysia reaffirm Repetto and Gillis's (1988) finding that royalty systems drastically undervalue tropical timber. Results of the financial analysis of natural forest management indicate that simply correcting for this undervaluation leads to management being feasible in a wide variety of cases. Feasibility occurs more frequently at lower discount rates, which is not surprising given the long period between establishment and harvest under monocyclic timber management. Polycyclic systems, in which smaller, selective harvests are made more frequently, are increasingly being recommended by tropical silviculturalists (Schmidt 1987; Tang 1987). Financial performance of these systems would be expected to be even better than that of the monocyclic example used in this paper, since positive cash flows occur sooner.

As Leslie (1987a, 1987b) points out, an economic analysis that accounts for nontimber as well as timber values is the conceptually superior framework for evaluating tropical forest management. Recent work by Peters et al. (1989) indicates that the value of produce collected from Amazonian rainforests and sold in local markets can be substantial in particular areas. However, many nontimber values of tropical forests, such as biodiversity, are difficult to quantify due to the absence of both biological and economic data (Ashton and Panayotou 1988; Wilson 1988). Moreover, compared to financial benefits captured directly by the government, policymakers are less likely to give credence to nonmarket benefits that are estimated using valuation techniques (for example, contingent valuation) that are still in many respects experimental, or to benefits reaped largely outside of tropical countries.

Incorporating nontimber values into the analysis in this paper would strengthen the conclusion that tropical forest management is feasible in many circumstances. Of course, feasibility in either financial or economic senses does not necessarily imply that forest management is the highest and best use of tropical lands. Although several NPVs in the second and third cases in Table 3 are positive, many are barely so. Alternative land uses might have higher NPVs. For example, NPVs in Sedjo's (1983) base case assessment of plantation forestry in several developing countries are significantly larger than those in Table 3. This study should not be interpreted as a blanket proclamation in favor of natural management of tropical forests in all places at all times.

Revision of royalty systems to approximate stumpage values more closely would make the potential returns to forest management more apparent and would enhance government revenue collection. Revision is called for in reports on royalty systems in Sabah (UNDP/FAO 1980) and Sarawak (UNDP/FAO 1981), and reviews of systems in Peninsular Malaysia are currently underway. Development of better data on log extraction costs will be crucial to these efforts, as well as to further research on the effects of timber pricing on tropical forest management.

## APPENDIX

Repetto and Gillis (1988) estimated $WF$ as follows:

$$WF = (\bar{p} - \bar{r} - \bar{c}) * V',$$

where $\bar{p}$ is average log price, $\bar{r}$ is average royalty, and $\bar{c}$ is average extraction cost. If the averages are volume-weighted and if $\bar{c}$ includes fixed costs, then this expression is equivalent to equation [5b]. A problem with this approach is the lack of a large and varied enough sample of data on extraction costs to permit reliable estimation of $\bar{c}$. Available data are usually based on engineering studies of new equipment, not on measurement of actual extraction costs, for a small sample of sites (see, e.g., Buenaflor and Heinrich 1980; and Marn, Vel, and Hui 1982).

The present study used a different approach: an explicit specification of the marginal cost curve for log extraction was assumed, and total fixed costs in a given year were assumed to be approximately proportional to total variable costs in that year. Under these assumptions, equation [5b–c] may be rewritten as follows:

$$WF = (\bar{p} - \bar{r})V' - (1 + \sigma)\int_0^{V'} MC(x)\,dx$$

$$HG = \bar{p}(V^* - V') - \int_{V'}^{V^*} MC(x)\,dx,$$

where $\sigma$ represents the ratio between total fixed and total variable costs.

The marginal cost curve, $MC(x)$, is a short-run curve: variables other than harvest volume are assumed to be fixed in a given year. The functional form chosen for the curve was a specification used by Binkley and Dykstra (1987) for timber supply in the IIASA Global Trade Model for forest products:

$$MC_t = \mu_t V_t^{\beta},$$

where $t$ is a time subscript; $\mu_t$ is a parameter that varies over time due to changes in other variables affecting extraction costs, such as site and industry characteristics; and $\beta$, the elasticity of the cost curve, is assumed to be a constant parameter. If $\beta$ is known, then the value of $\mu_t$ can be determined by inserting $V_t'$ and setting $MC$ equal to $\bar{p}_t - \bar{r}_t$ (the marginal cost at $V_t'$). Once $\mu_t$ is determined, the potential harvest level, $V_t^*$, can be determined by setting $MC$ equal to $\bar{p}_t$.

The baseline estimate of $\beta$ was 3.0, the value used by Binkley and Dykstra (1987) for Southeast Asia. The analysis was repeated using values 50 percent smaller (1.5) and 50 percent larger (4.5). This range encompasses the values estimated by Vincent (1987, 1988b) for Malaysia as a whole, 2.70 and 1.57 respectively. Cardellichio et al. (1988) reported substantially lower estimates, 0.453 for East Malaysia (Sabah and Sarawak combined) and 1.09 for Peninsular Malaysia, but these estimates were probably biased downwards due to the exclusion of capital stock from estimated equations.

The ratio of total fixed to total variable costs, $\sigma$, was calculated using data for 1979–81 reported by Chung (1984), supplemented by data in Apandi (1973), and Apandi and Sudrajat (1976). Calculated values varied little during 1979–81, supporting the assumption that $\sigma$ can be treated as a constant. $\sigma$ was set equal to 0.95 for Peninsular Malaysia and Sabah and 0.80 for Sarawak. Differences were due to differing proportions of swamp and hill logging among the regions.

Data on harvests, prices, and royalties were drawn primarily from Forestry Department Peninsular Malaysia (1979, 1986), Forest Department Sarawak (1986), and records provided by the Forest Department Sabah. Harvest volume was given by total removals of tropical hardwood logs, measured in cubic meters. Log price was represented by export unit value (net of export duties) in Sabah and Sarawak for all years and in Peninsular Malaysia during 1966–70. In Peninsular Malaysia during 1971–85, log price was given by the average annual price of logs sold domestically. Royalties were determined by dividing the sum of government revenue from log-based charges by harvest volume. The premium in Peninsular Malaysia was treated as an additional fixed-cost term subtracted from the right-hand side of equation [5b]. Prices and royalties were in Malaysian dollars at 1980 price levels.

## References

Anonymous. 1986. "In Defense of Selangor New Royalty Rates on Logs." *Forest Sector Review* 2(1):20–21. Kuala Lumpur, Malaysia: Forestry Department Peninsular Malaysia.

Apandi Mangundikoro. 1973. "A Cost Analysis on Logging Operation in Kalimantan." *Laporan No. 22*. Bogor, Indonesia: Lembaga Penelitian Hasil Hutan.

Apandi Mangundikoro, and Sudrajat Suriarahardja. 1976. "A Production Cost Analysis of Logging Enterprises in Riau." *Laporan No. 69*. Bogor, Indonesia: Lembaga Penelitian Hasil Hutan.

Ashton, Peter, and Theodore Panayotou. 1988. *The Case for Multiple-Use Management of Tropical Hardwood Forests*. Report prepared for the International Tropical Timber Organi-

zation. Cambridge: Harvard Institute for International Development.
Binkley, Clark S., and Dykstra, Dennis. 1987. "Timber Supply." In *The Global Forest Sector: An Analytical Perspective*, ed. Markku Kallio, Dennis Dykstra, and Clark S. Binkley. Chichester, UK: John Wiley & Sons.
Binkley, Clark S., and Jeffrey R. Vincent. 1988. "Timber Prices in the U.S. South: Past Trends and Outlook for the Future." *Southern Journal of Applied Forestry* 12(1):15–18.
Boado, Eufresina L. 1988. "Incentive Policies and Forest Use in the Philippines." In *Public Policies and the Misuse of Forest Resources*, ed. Robert Repetto and Malcolm Gillis. Cambridge: Cambridge University Press.
Buenaflor, V., and R. Heinrich. 1980. "FMC Tracked Skidder Logging Study in Indonesia." *FO:INS/78/054, Working Paper No. 7*. Rome: Food and Agriculture Organization of the United Nations.
Burns, David. 1986. "Runway and Treadmill Deforestation." *IUCN/IIED Tropical Forest Policy Paper No. 2*. Cambridge, UK: IUCN Publications Service.
Cardellichio, Peter A., Yeo Chang Youn, Clark S. Binkley, Jeffrey R. Vincent, and Darius M. Adams. 1988. "An Economic Analysis of Short-run Timber Supply Around the Globe." *CINTRAFOR Working Paper No. 18*. Seattle: University of Washington, College of Forest Resources.
Chung Kueh Shin. 1984. "Costs of Logging in Hill and Swamp Forests of Sarawak: 1979, 1980 & 1981." Unpublished manuscript. Kuching, Malaysia: Forest Department Sarawak.
Dykstra, Dennis P., and Markku Kallio. 1987. "Base Scenario." In *The Global Forest Sector: An Analytical Perspective*, ed. Markku Kallio, Dennis Dykstra, and Clark S. Binkley. Chichester, UK: John Wiley & Sons.
Forest Department Sarawak. 1986. *Forestry Statistics 1985*. Kuching, Malaysia: Forest Department Sarawak.
Forestry Department Peninsular Malaysia. 1979. *Forest Statistics Peninsular Malaysia: 1971–78*. Kuala Lumpur, Malaysia: Forestry Department Peninsular Malaysia.
———. 1986. *Forest Statistics Peninsular Malaysia: 1979–85*. Kuala Lumpur, Malaysia: Forestry Department Peninsular Malaysia.
Gillis, Malcolm. 1980. "Fiscal and Financial Issues in Tropical Hardwood Concessions." *Development Discussion Paper No. 110*. Cambridge: Harvard Institute for International Development.
———. 1988a. "Indonesia: Public Policies, Resource Management, and the Tropical Forest." In *Public Policies and the Misuse of Forest Resources*, ed. Robert Repetto and Malcolm Gillis. Cambridge: Cambridge University Press.
———. 1988b. "Malaysia: Public Policies and the Tropical Forest." In *Public Policies and the Misuse of Forest Resources*, ed. Robert Repetto and Malcolm Gillis. Cambridge: Cambridge University Press.
Gray, John W. 1983. "Forest Revenue Systems in Developing Countries." *Forestry Paper 43*. Rome: Food and Agriculture Organization of the United Nations.
Lanly, Jean-Paul. 1982. "Tropical Forest Resources." *Forestry Paper 30*. Rome: Food and Agriculture Organization of the United Nations.
Leslie, A. J. 1977. "Where Contradictory Theory and Practice Co-exist." *Unasylva* 29 (115):2–17, 40.
———. 1987a. "The Economic Feasibility of Natural Management of Tropical Moist Forests." In *Natural Management of Tropical Moist Forests*, ed. François Mergen and Jeffrey R. Vincent. New Haven: Yale University, School of Forestry and Environmental Studies.
———. 1987b. "A Second Look at the Economics of Natural Management Systems in Tropical Mixed Forests." *Unasylva* 39(155):46–58.
Manthy, Robert S. 1978. *Natural Resource Commodities 1870–1973: Prices, Output, Consumption, and Employment*. Baltimore: Johns Hopkins University Press.
Marn, H. M., E. Vel, and D. C. K. Hui. 1982. "Further Cost Studies in Harvesting the Mixed Dipterocarp Forests of Sarawak, Including FMC Skidder Operation." *FO:MAL/76/008, Field Document No. 8*. Rome: Food and Agriculture Organization of the United Nations.
Masson, J. L. 1983. "Management of Tropical Mixed Forests: Preliminary Assessment of Present Status." *FO:MISC/83/17*. Rome: Food and Agriculture Organization of the United Nations.
Nwoboshi, L. Chelunor. 1987. "Regeneration Success of Natural Management, Enrichment Planting, and Plantations of Native Species in West Africa." In *Natural Management of Tropical Moist Forests*, ed. François Mergen and Jeffrey R. Vincent. New Haven: Yale University, School of Forestry and Environmental Studies.
Peters, Charles M., Alwyn H. Gentry, and Robert O. Mendelsohn. 1989. "Valuation of

an Amazonian Rainforest." *Nature* 339:655–56.
Repetto, Robert, and Malcolm Gillis. 1988. *Public Policies and the Misuse of Forest Resources*. Cambridge: Cambridge University Press.
Schmidt, R. 1987. "Tropical Rain Forest Management." *Unasylva* 39(156):2–17.
Sedjo, Roger A. 1983. *The Comparative Economics of Plantation Forestry*. Washington, DC: Resources for the Future.
Tang Hon Tat. 1987. "Problems and Strategies for Regenerating Dipterocarp Forests in Malaysia." In *Natural Management of Tropical Moist Forests*, ed. François Mergen and Jeffrey R. Vincent. New Haven: Yale University, School of Forestry and Environmental Studies.
UNDP/FAO. 1980. "Sabah Timber Industry: Royalty Appraisal and Market Study." *FO: DP/MAL/77/016, Terminal Report*. Rome: FAO.
———. 1981. "A Royalty System for the Hill Mixed Dipterocarp Forest of Sarawak." Kuching, Sarawak: Forest Department.
Vincent, Jeffrey R. 1987. "Modeling Japan-South Seas Trade in Forest Products." *General Technical Report PNW-GTR-210*. Portland, OR: U.S.D.A. Forest Service, Pacific Northwest Research Station.
———. 1988a. "Malaysia: Key Player in International Trade." *Journal of Forestry* 86(12):32–35.
———. 1988b. "Optimal Tariffs on Resource-Based Intermediate and Final Goods." Ph.D. diss., Yale University.
Wilson, Edward O., ed. 1988. *Biodiversity*. Washington, DC: National Academy Press.
Wyatt-Smith, John. 1987a. "The Management of Tropical Moist Forest for the Sustained Production of Timber: Some Issues." *IUCN/IIED Tropical Forest Policy Paper No. 4*. Cambridge, UK: IUCN Publications Service.
———. 1987b. "Problems and Prospects for Natural Management of Tropical Moist Forests." In *Natural Management of Tropical Moist Forests*, ed. François Mergen and Jeffrey R. Vincent. New Haven: Yale University, School of Forestry and Environmental Studies.