Modeling the Effects of a Log Export Ban in Indonesia

Richard G. Dudley

Abstract

Because enforcement of forestry law has become extremely difficult in Indonesia, a ban on export of logs has been suggested as a means of controlling over-harvest and illegal logging. A model of a log export ban can help us visualize its effects on the forestry sector. The model consists of simplified overviews of: the wood processing sector, demand – price feed back loops, forest standing stock and log availability, log harvest capacity, and log exports. It examines important feedbacks that must be understood if the potential costs and benefits of a log export ban are to be properly considered. Although some scenarios can help reduce log harvests to sustainable levels, others encourage expansion of small domestic milling capacity leading to increased log harvests. Excess domestic milling capacity added during a log export ban may continue to operate even after a log export ban is lifted. For a log export ban to be an effective tool in combating over-harvest and illegal harvest, limits must also be placed on possible increases in domestic milling and logging capacity.

Keywords: log export ban, Indonesia, illegal logging, system dynamics modeling

This is a final draft of a paper to be published in 2004 in *System Dynamics Review*.

Richard Dudley can be contacted at rgd6@cornell.edu

Introduction

Indonesia's forestry sector has been in turmoil since the removal of President Soeharto from power in May 1998. A period of weakened legal control followed resulting in substantial increases in illegal logging. The illegal logging situation is well documented (Currey *et al* 2001; Currey and Ruwindrijarto 2000; Newman *et al* 2000), and by late 2000 about 40% of the timber harvest was believed to be illegal (Scotland *et al* 2000). In early 2001, a major decentralization of authority, carried out with minimal planning of local natural resources laws and regulations (see review by Resosudarmo and Dermawan 2001), led to a rapid quasi-legalization and intensification of the serious over-harvest by small and medium scale entrepreneurs.[1]

A wide array of other factors also contribute to deforestation in Indonesia, including: expansion of plantation crops (e.g., palm oil, pulp wood, rubber) (Barr 2001a; Casson 2002); fire, including its use for land clearing (Applegate *et al* 2001); over-harvest on timber concessions (Barr 2001b); and land clearing for agriculture. The illegal and quasi-legal over-logging is occurring within a larger context of many causes of deforestation (Contreras-Hermosilla 2000). Although illegal logging was already a serious problem prior to 1998 (e.g., Mccarthy 2000, 2002), extreme increases in illegal forest activity resulted from causes related to the downfall of President Soeharto and resulting political uncertainty (e.g., see Dudley 2002). The overall situation of Indonesian forests has been discussed in a number of reports (e.g., Aden *et al* 2001; FWI/GFW 2002; Jepson *et al* 2001; Palmer 2001).

Political changes, including decentralization, led to the creation of overlapping jurisdictions and laws which blurred the distinction between legal and illegal logging. This situation reinforced the idea that over-logging might be controlled by limiting demand rather than by attempting to use weakened government agencies to enforce confusing laws. Because they believe many illegal logs are exported, concerned agencies and NGOs suggested a ban on log exports to reduce illegal logging. The initial idea was that after several years the ban would be lifted,[2] having allowed time to control over-logging by other means.

An export ban might appear illogical since illegally cut logs could be exported illegally anyway.[3] However, proponents of a log export ban believe that terminating all raw log exports would make an export ban enforceable, as opposed to a partial ban (e.g., banning export of logs stolen from national parks) which could be easily defeated using phony documentation. A total ban, in theory, would make any log leaving the country illegal.

An export ban might affect domestic processing industries by decreasing raw material (log) costs and decreasing competitiveness through over-protection. Also, employment in the logging and wood processing sectors might decrease – due to a decrease in log harvest, or might increase – due to a stimulation of the domestic wood processing sector. Importantly, if the export ban stimulated local wood processing, this would defeat the utility of a ban in controlling illegal logging. A previous export ban, in the early 1980s, helped the Indonesian processing industry and led to an overall decrease in log harvest. But that occurred during a period of strong governmental control. The usefulness of log export bans as a means of controlling over-logging or of providing in-country benefits is a subject of debate (Arunanondchai 2001; Goodland and Daly 1996; Manurung and Buongiorno 1997).

Participants from industry, government, academia, NGOs, and donor organizations met to discuss these issues in September of 2000.[4] Participants disagreed on 70% of the points discussed, especially those regarding outcomes of a proposed log export ban. Predicting the outcome of actions within such a complex situation without an understandable and agreed upon framework is difficult. This paper presents a framework sufficient to allow meaningful thinking about the use of a log export ban as a means of controlling rampant over-logging.

Modeling Approach

Ideas for this model evolved from related activities (including those reported in Dudley 2002, 2003). These included interviews[5] with institutional stakeholders (government, business, and non-governmental conservation organizations), examination of literature and colleagues' field reports, and follow-up discussions with these and other colleagues. Interest in the log export ban was stimulated by its active consideration by the Indonesian government starting in the latter half of 2001.

Overall Model structure

The model consists of six sectors (Fig. 1): wood processing capacity, domestic demand and log price, log supply and the profitability of logging, profitability and the buildup of logging teams,[6] foreign demand and export price, and the effect of logging on logging costs. Also shown in Fig. 1 is a feedback loop missing from the Indonesian situation and not included in the model: the relation between the amount of forest remaining and management limits on amount of timber cut per year.

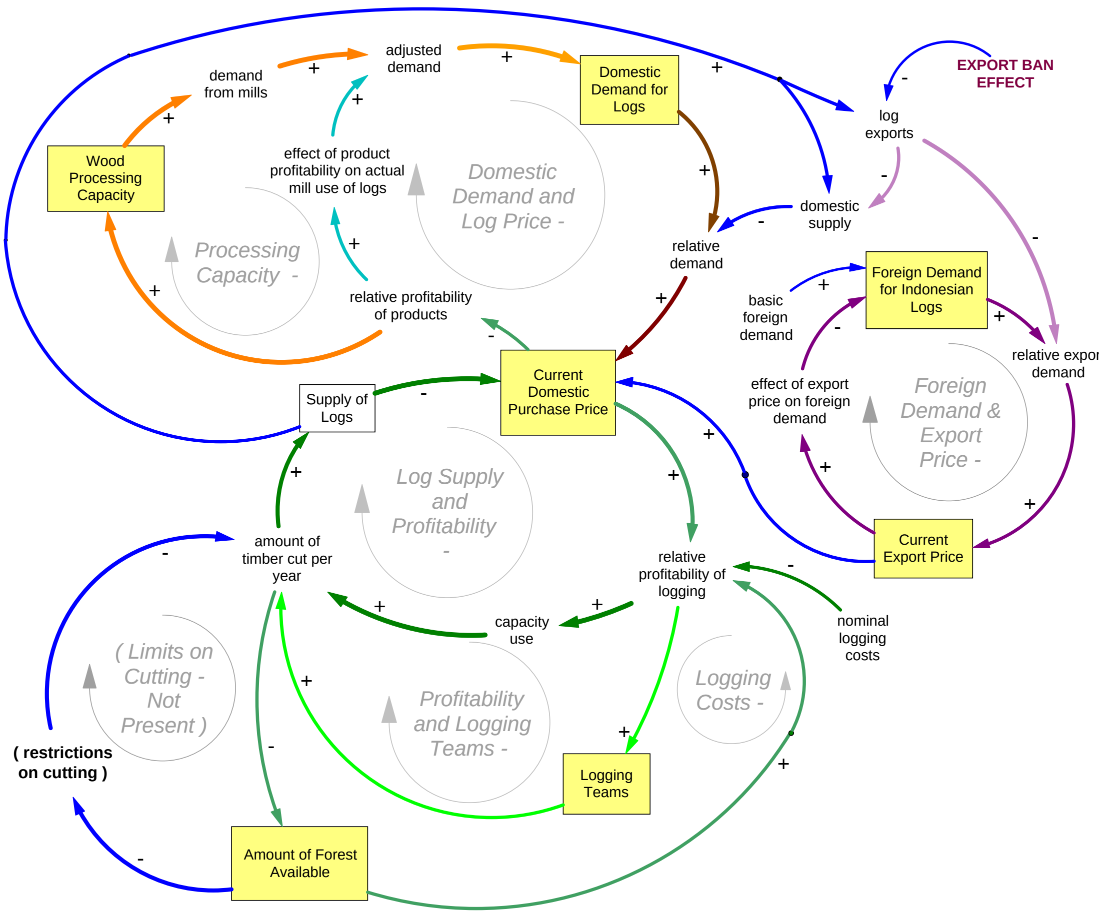


Fig 1. The main sectors of the model

This simplified model considers a one million ha forest with associated processing and harvesting capacity. It is initiated with a stable log harvest of 3 million m^3/year (i.e., 3 m^3/ha/year), half exported and half processed domestically. Log prices are \$50/m^3 with logging cost half of this. The selling price of wood products is set at \$100/m^3 of raw material used, giving an initial profit margin of \$50/m^3. All prices are expressed in terms of generic raw material. For example, prices of wood products are expressed as \$/m^3 of raw material used.

Milling capacity is viewed as small-scale sawmills which can be built and brought on-line within a few to several months, considerably less time than would be needed for plywood or pulp mills. This view is based on several field reports (Casson 2000; Casson and Obidzinski 2001; McCarthy 2000; Obidzinski and Suramenggala 2000; Obidzinski. *et al* 2001; Wadley 2001). An expanded model would include significantly different, parallel, structures for plywood and pulp mills (see Barr 1998, 2001a) .

Wood Processing, Domestic Log Demand and Log Price

Domestic processing capacity affects domestic log demand and, consequently, log price. Relative profitability of wood products depends on log price[7] and determines desired mill capacity which is gradually incorporated into actual wood processing capacity as mills are built, expanded or improved. Older or obsolete mills and equipment are scrapped. Milling capacity creates the log demand from mills. Because wood processing capacity is not always fully used, the demand from the mills is modified by the effect of product profitability on the actual mill use of logs. This, in conjunction with the demand from mills, determines an adjusted demand which gradually influences domestic demand for logs.

A comparison of domestic demand for logs with domestic supply will affect the price the mills would like to pay for their logs. This is one of three primary factors affecting the current domestic log price which in turn will affect the overall profitability of wood products. The other factors are price changes caused by log supply, and price changes caused by foreign demand. A fourth factor, price change caused by alternate sources, acts as a ceiling price on Indonesian logs if log prices escalate drastically.

Logging and Log Supply

Current domestic log purchase price and logging costs directly affect profits from logging. Log contractors weigh potential profitability against some expected profitability of logging. This relative profitability of logging determines whether they believe it desirable to establish more logging teams to cut trees, and also the extent to which they will use existing teams to full capacity. Logging teams, which represent harvesting capacity (m^3/yr), are built up over time and are not immediately disbanded if profitability drops. However, the extent to which teams are used (e.g., capacity utilization) can vary more rapidly as profitability changes. The use of logging teams determines the amount of timber cut each year. This yields a supply of logs which, when compared to typical log supplies in the recent past, provides the second influence on the current domestic log purchase price: the price change caused by log supply.

Foreign Demand and Export Price

Foreign demand for Indonesian logs, when compared to the supply (i.e., log exports) yields a relative export demand which affects current export log price. Changes in current export log price will in turn moderate foreign log demand. Basic foreign demand for Indonesian logs is ultimately created by foreign processing capacity plus the effect of alternate log sources, and is treated exogenously. If Indonesian logs dominate the market then their removal from it via an export ban will have a significant effect on price. On the other hand, if there are many other sources of logs then the effect of a decreased supply from Indonesia would be negligible. In recent years the importance of Indonesian logs has increased as other countries in the region have exhausted their forests and placed limits on logging.

Current export log price is the third factor affecting current domestic log price. However, if the export price is high, but exports are strictly banned, then domestic log price would be only minimally affected. The default modeled impact of export log price on domestic log price, is determined by the fraction of the log supply actually exported. If export volume is high then the effect that export prices have on domestic log price will also be high.

We have no information about decision processes used to determine if logs will be exported or sold domestically. It is assumed to be a function of the ratio of export to domestic log price. Relative amount exported may follow a direct proportional relationship with the export price ratio, however it is more likely that the proportion of exports rises more rapidly than the export price ratio.

Effect of Harvest on Forest Available

The effect of logging on the forest is conceptualized as the effect on an average hectare of forest land. Timber volume changes due to harvesting and regeneration. Regeneration combines creation of new trees, growth, and deaths of trees, and is a fraction of stock volume already on the land as modified by the ratio between it and the maximum standing stock possible. As the forest becomes more densely stocked, regeneration approaches zero and the number of cubic meters per hectare approaches a constant value.

As forests become degraded the lowered availability of trees for harvest will affect logging costs. It is assumed that as harvestable trees become more scarce logging costs rise. This is not necessarily the case, since some harvesting may make access to the forest easier thereby lowering logging costs. It may also be the case, under the current situation, that average logging costs are not yet affected by decreasing forest availability.

A major problem for Indonesian forestry is the conversion of forest land to other uses. This is more likely to occur when the forest is already degraded. In the model, hectares of forest land can optionally be treated as a stock with an outflow dependent on the state of forest degradation. Under the model's sustained yield conditions there is no conversion of forest land, but as over-harvesting causes forest stocking densities to drop there is an increasing rate of forest land conversion.

A Missing Loop – Limits on Cutting

Shown in Figure 1 is a feedback loop, "limits on cutting" which, in reality, does not exist in the current Indonesian situation. In an ideal world, forestry agencies would monitor forest health, and would implement practices, including restrictions on cutting, that would protect the long-term sustainability of the forest. The inability, or unwillingness, of these agencies to do this led the government to attempt to use an export ban as an alternative means of controlling over-harvest.

Model Outcomes

Application of a Log Export Ban for Five Years

If an export ban is instituted, log exports drop and current export price rises causing foreign demand to drop slightly (Fig 2). At first excess supply forces domestic log prices down driving up profitability of wood processing, domestic processing capacity, and domestic demand (Fig 3). Loss of the export market initially causes a substantial drop in the amount of timber cut, but this rises significantly as domestic processing is stimulated by lowered log prices. After about 18 months profitability in the logging sector is back near its normal value (Fig 4).

Effect of Log Export Ban on Export Price and Foreign Demand

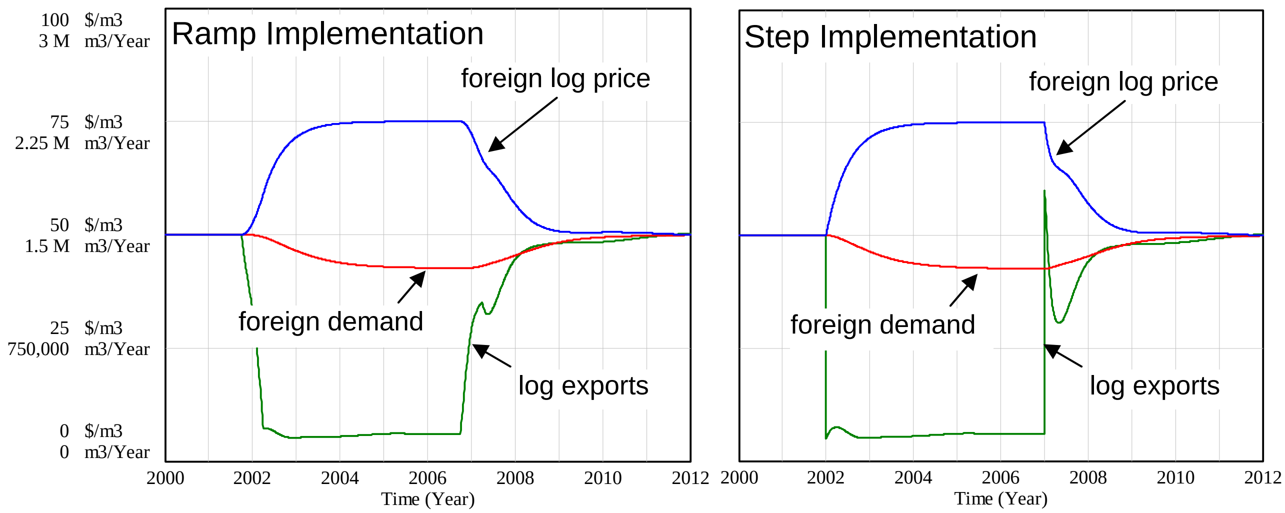


Fig 2. A log export ban removes logs from the foreign market and increases export price which lowers foreign demand. Following the lifting of the ban, log exports gradually return to pre ban levels. If the ban is lifted over a six month period (ramp implementation) exports will return to normal with only minor fluctuations. If the ban is lifted suddenly (step implementation) a spike in log exports will occur due to the sudden attractiveness of the high foreign price. In the following examples an export ban is assumed to be 90% effective with a six month ramp implementation at the start and end of the ban unless stated otherwise.

When the export ban ends gradually (ramp implementation), log exports gradually return to pre-ban levels. If the ban is ended suddenly (step implementation), the lingering high export price and limited supply will cause a temporary surge in exports which will require almost 80% of available logs. In either case the resurgence in export demand coupled with a higher domestic demand, which increased during the ban period, now outstrip supplies. This pushes the domestic price temporarily higher creating a significant but temporary rise in logging profitability which stimulates the re-establishment of logging teams and the cutting of timber. Eventually both export and domestic prices drop again as log supplies increase. Within a few years after the ban the system has largely re-stabilized. However, the log harvest rate during the post-ban period is dependent both on the lag times used and on mill investment strategies as discussed below. Also with expanded harvest, forests very slowly re-stabilize at a lower standing stock causing a very gradual rise in harvesting costs, decline in harvest, and slight rise in log price. As indicated below, other factors can greatly accelerate this decline.

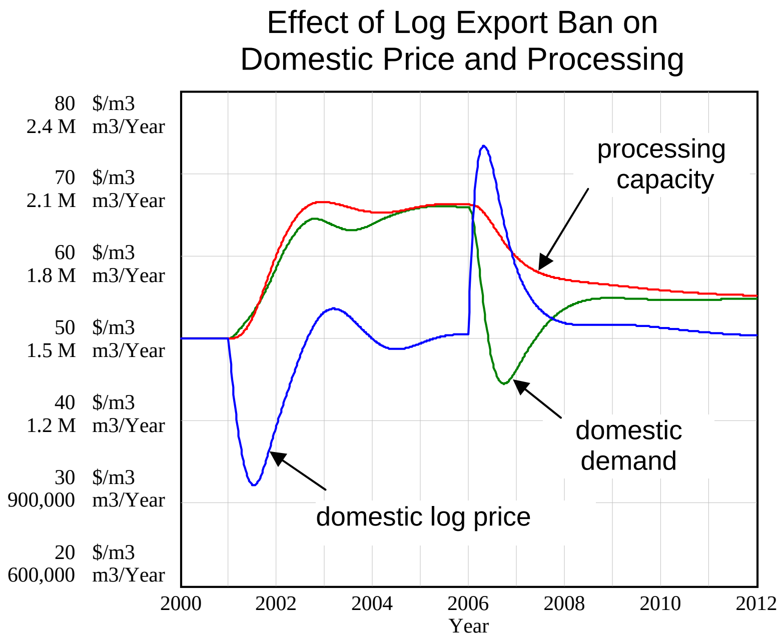


Fig 3. An export ban causes a drop in domestic log price, which stimulates domestic processing capacity. When the ban is lifted log supply is inadequate and domestic prices jump pulling down processing capacity but stimulating log harvest. However, log production recovers quickly lowering log prices, and may maintain an increased domestic processing capacity compared to pre-ban levels.

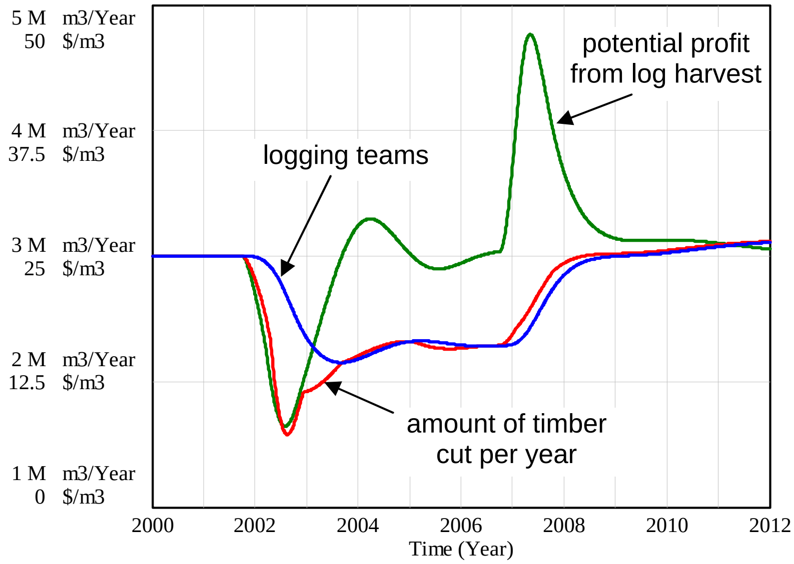


Fig 4. An export ban initially causes a significant drop in timber harvest, which partially recovers as domestic processors take advantage of resulting low log prices. After the ban is lifted the harvest rises to somewhat above pre-ban levels if domestic mill investors follow entrepreneurial behavior. Logging teams refer to the harvest capacity of men and equipment employed in cutting trees.

Variations in Domestic Milling and Logging Investment Response

Investor response to new profit opportunities in domestic wood processing will alter the ultimate outcome of a temporary log export ban. If mill owners aggressively expand operations during periods of high profitability the outcome will be different than if they invest modestly. This question was investigated by examining different shapes for the function describing the effect of relative product profitability on desired mill capacity (Fig 5). While some mill investment strategies lead to lower harvests after a log export ban, others could significantly increase harvest rates. Entrepreneurial mill owners greatly expand operations when profitability rises, and hold on to investments when profitability drops. This entrepreneurial investment strategy would lead to a 10% increase in domestic demand and a 5.5% increase in log harvest about three years after the ban is lifted. In the case of a mild investment strategy little change is made as profitability changes. This strategy would lead, post export ban, to a 4% decrease in domestic demand and a 2% decrease in timber harvested per year (Fig 6 and 7).

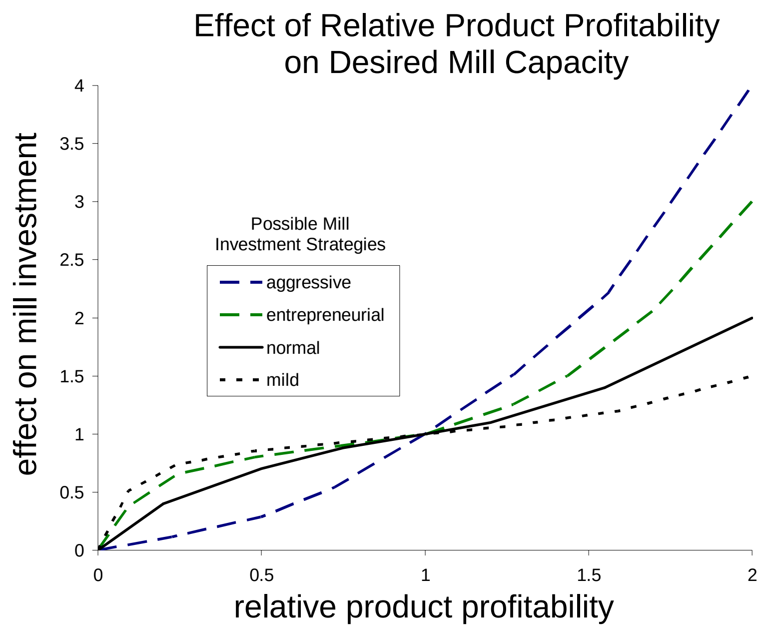


Fig. 5. Possible responses of small scale mill owners to changes in wood processing profitability.

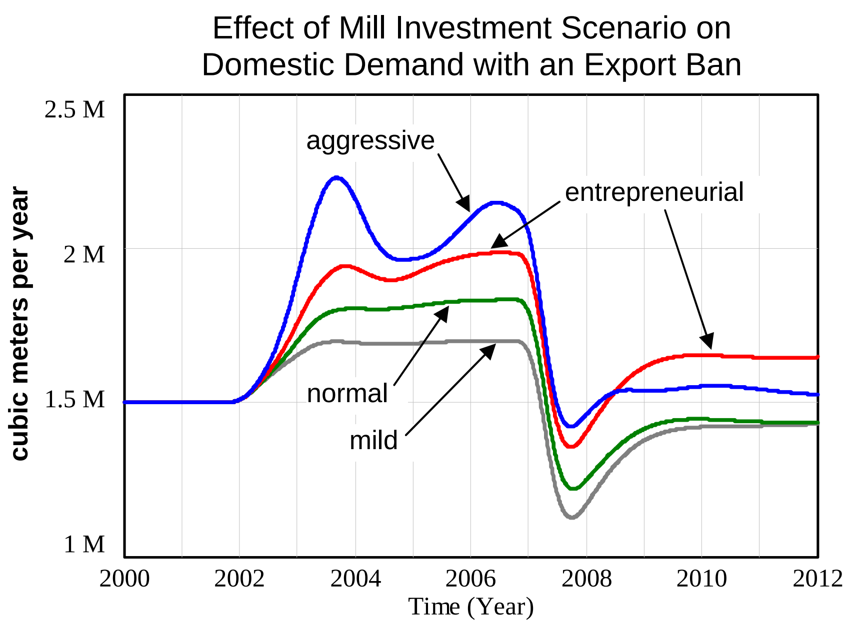


Fig 6. Different mill investment scenarios cause significantly different outcomes of a log export ban. A ban coupled with entrepreneurial investment will result in higher domestic demand after the ban is lifted. Any log ban policy should be coupled with appropriate policies directed at limiting expansion of domestic milling capacity.

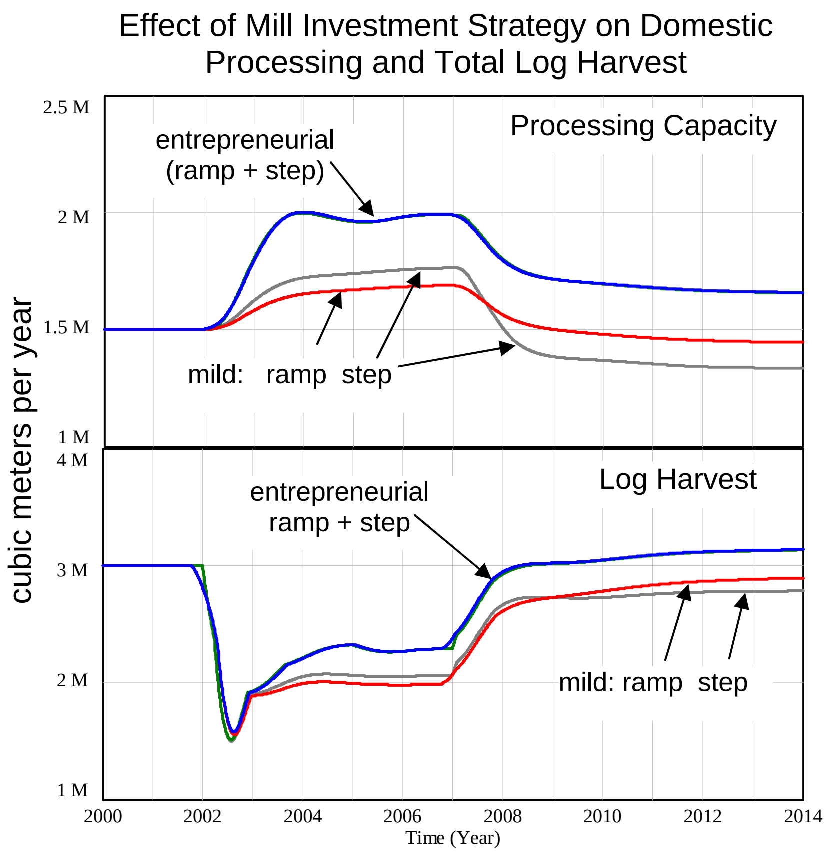


Fig 7. The investment strategy of small mill owners can have significant and lasting effects on domestic processing capacity (upper graph) and log harvest (lower graph) both during an export ban and after the ban is lifted. Entrepreneurial investment will result in a higher domestic processing capacity and somewhat higher log harvest after an export ban is terminated. The way in which a ban is implemented and lifted (ramp or step) makes little difference on the outcome if entrepreneurial investment occurs. With a mild mill investment strategy a step implementation creates a bigger drop in processing capacity because of a spike in export demand that raises log prices promoting export of logs.

The rapidity with which mill investors make decisions also has important effects. If entrepreneurs quickly decide about, and build, new mills, significant increases in domestic capacity and, ultimately, the amount of logging, will occur. With an entrepreneurial investment strategy and shortened, but realistic, response times for investments, post export ban log harvest will increase to 9% above baseline. This change is maintained by a 17% increase in domestic processing capacity coupled with a 4.5% increase in log exports. Short response times coupled with a mild investment strategy could decrease post ban log harvest by 3%, due to a 5% decrease in domestic capacity and a 2% decrease in exports.

In general a sudden (step) implementation of an export ban results in patterns very similar to the gradual (ramp) implementation. Also, bans of less effectiveness (e.g., 50% effective) yield similar but milder effects compared to a 90% effective ban.

The rapidity of investment in logging teams is another problem area for Indonesian forestry making the relation between potential logging profits and investment in logging teams very important. A relatively entrepreneurial logging team investment approach coupled with the entrepreneurial milling investments (as above) results in a post log ban, 13% increase in log harvest to supply a 25% increase in domestic demand and a 6% increase in exports.[9]

The above examples reveal that there is no guarantee that a temporary log export ban will reduce harvest pressure on forests. The outcome is dependent, at least in part, on the response of domestic mill owners and logging entrepreneurs to temporary changes in log supplies and log prices, which can be caused by an export ban.

Possible Effects on Employment

Employment in the forestry sector will be less during a log export ban, but the post ban effect is dependent on the longer term effects on domestic milling capacity. Using the likely scenario of entrepreneurial investment in mills, and assuming that wood from our hypothetical forest is cut and milled by relatively small scale operations, milling employment would rise almost 30% during a 5 year ban, but would remain only about 10% higher than pre-ban levels after the ban was lifted. However logging employment would drop by roughly 24% during the ban and, post ban, would return to about 5% above pre ban levels. Combined employment would drop about 13% during the ban returning to about 6% above pre ban levels after the ban is lifted. Of course in the long run, with over logging occurring, the whole system will collapse, drastically reducing all employment in the forest sector.

Changes in Export Demand

If export demand is gradually rising, as is probably the case in Indonesia,[10] then overall demand increases and log export price gradually rises. Higher export price forces the domestic log price higher diminishing the opportunities for milling profits and lowering both domestic processing capacity and log demand. Nevertheless, a log export ban instituted during a period of rising demand has an effect similar to that described above:

under reasonable assumptions domestic log demand is stimulated. After the ban is lifted this probably results in a higher domestic processing capacity and a higher overall harvest than would occur without a ban.

Over-harvest and Illegal Logging

A full examination of illegal logging requires different models designed to examine a range of social, economic, legal and political issues (e.g., Dudley 2003). One of these issues is the fact that illegal logging lowers the costs of log harvest.[11] One simple examination of the response of the system to illegal logging can be tested by lowering logging costs by 15% over a five year period. This creates a positive feedback effect which dominates the system, raising profits of logging operations, stimulating the harvest of more logs, lowering the price of logs, making both wood processing and log exports more profitable.

More realistically over-logging was already occurring when illegal logging became widespread. Such over logging can be approximated by doubling the harvest per hectare[12] in addition to lowering logging costs as above. This scenario (Fig. 8) results in increasing over logging until the forest is depleted. A log ban does not control this trend and would most likely merely stimulate a higher level of logging and a slightly more rapid, but slightly delayed, collapse. Even this dismal view is probably overly optimistic.

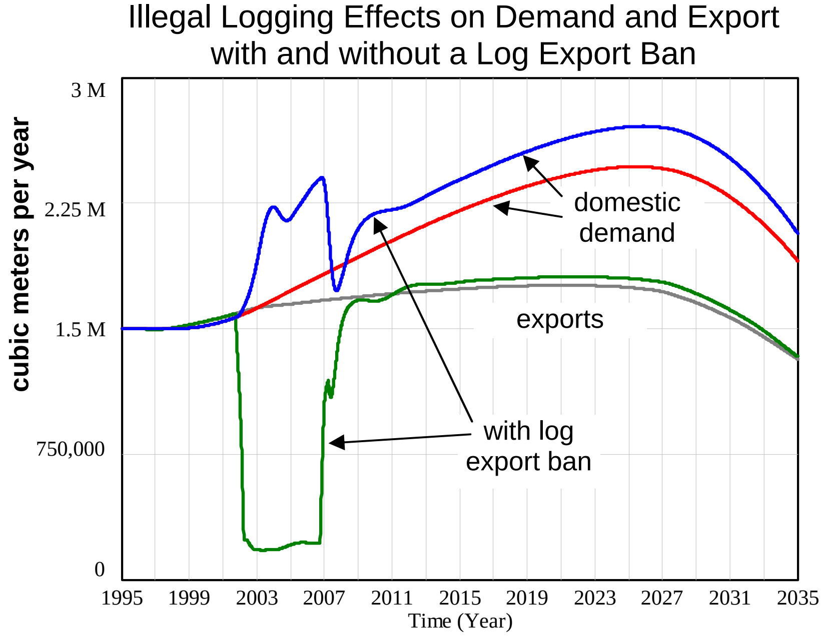


Fig 8. A situation similar to that in current day Indonesia includes logging at an unsustainably high rate coupled with the lowering of logging costs due to illegality. In this case a temporary log export ban would likely raise domestic demand and exports unless limits were placed on domestic processing capacity.

In fact, if we assume that degraded forest lands are converted to other uses, then the situation is more like that illustrated by the left-most curves in Figure 9. Conversion of forest not only removes forest from production but also places more harvest pressure on the remaining forest, thereby degrading it faster and making it more susceptible to conversion.

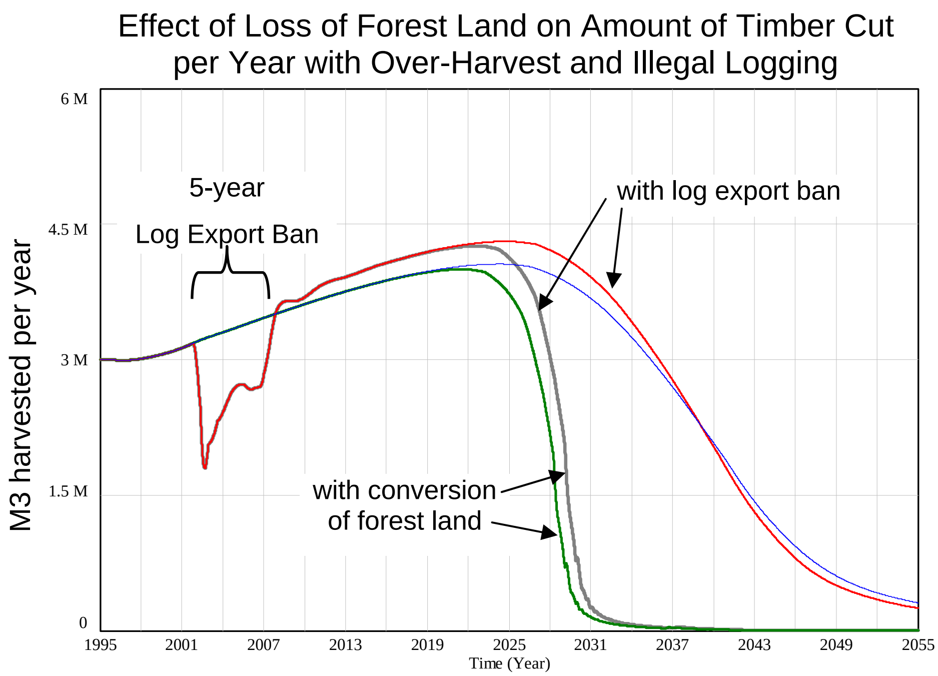


Figure 9. The conversion of forest land to other uses hastens the collapse of the timber industry. In general terms, if illegal logging and over-harvest are common, as in this example, a five year export ban will have little influence on the overall outcome whether or not conversion of forest land is considered. If conversion of forest land is likely as forests are degraded, then the whole system will collapse much more rapidly.

Discussion

The model allows a general examination of interlinked relationships between demand and price, harvesting capacity, milling capacity and other factors. Although the exact nature of these relationships is not accurately known, the model provides a reasonable framework for discussing the effects of a log export ban. This model also helps define questions remaining for a more detailed examination of export ban costs and benefits.

The model indicates that different responses by mill owners to changes in log prices can result in very different outcomes. The likely scenario of entrepreneurial investment by small mill owners makes a temporary log ban less beneficial for forest protection than no ban except that during the export ban harvests will be lowered. Negative post-ban effects are increased if there is similar entrepreneurial behavior in logging team investment. Importantly, some policymakers supporting a log export ban believe this view and hope that a ban will help the local wood processing industry by lowering log prices and allowing expansion of domestic milling capacity as happened in the past.[13] If the purpose of a log export ban is to stimulate local industry, then the conservation rationale for such a ban, prevention of over-harvest, is not valid. Manurung (1997) found that Indonesia's earlier export ban did limit overall log harvest, but that ban was long term, not temporary. Also that ban was instrumental in creating low log prices which stimulated a significant overcapacity in the processing sector, in comparison to the sustainable harvest of logs, which is partly to blame for today's problems. Detail regarding the expected response of investors to any log export ban, as well as any government policies that might stimulate, or control, mill investment, should be examined carefully.

A long term log export ban would limit harvest as long as the ban is in effect, but the decrease in harvest will be less than the amount of banned exports because of expansion of domestic processing. As above, any investigation of a long term ban would have to examine more closely the intentions and probable responses of the domestic processing industry as well as the long term effects of any expanded domestic processing capacity and related export of finished products.

The model is a simplified view of the Indonesian situation. In reality there are many interactions between large scale mills and logging operations, pulp mills, plantations, and small scale logging and milling operations. Similarly, there are many types of trees, some very valuable, some not, as well as a large variety of wood products. It may be beneficial to examine some of these issues in an expanded model. The model also represents a reality in which no forest policy feedback directly links the predicted long-term availability of trees to timber harvests. Feedback occurs only as timber becomes increasingly scarce. This is the sad reality of Indonesia's forest industry.

In late 2001 the Indonesian government instituted a log export ban. However, its implementation has been very weak and its effectiveness in stopping exports poor. It is certainly conceivable that an effective log export ban, coupled with strong regulation of domestic milling capacity, could assist in controlling over logging, but neither of these actions is likely under current conditions.

A log export ban attempts to limit harvest by limiting (export) demand for logs. Even if enforced this might have only limited effectiveness. Lost foreign demand can be replaced by demand from domestic mills which can then export wood products. The real challenge is to limit log harvesting so that harvests are balanced by production of trees in the forest. Growth of trees needs to become the limiting factor of the overall system.

Finding solutions to the Indonesian over-logging problem will be difficult. Overcapacity already exists, and virtually any scenario that adequately protects forest resources for future generations will necessarily limit forest based employment and income in the present. Consistent with current decentralization efforts one approach that might assist in the search for solutions would be regional and national initiatives to investigate future scenarios for the timber industry similar to that developed for northeastern North America by Jones *et al*

(2002). Although the current situation makes this type of cooperative approach difficult, there is certainly an awareness of the problem at national, regional and local levels, and there are numerous local, national and international agencies and NGOs with a genuine interest in solving this problem. Hopefully the current political climate will stabilize, allowing meaningful strategic forest planning for Indonesia, a country with some of the world's richest forest resources.

Acknowledgements

Some of the work reported here was carried out while the author was working as a consultant with the Center for International Forestry Research in Bogor, Indonesia. Many people provided helpful advice and discussion during this work including: Joyotee Smith, Krystof Obidzinski, Carol J. Pierce Colfer, Patrice Levang, Herry Purnomo, Doddy Sukadri, Subarudi, Agus Purnomo, Agus Setyarso, Graham Applegate, and Eva Wollenberg. Two anonymous reviewers and the editors of the special issue also provided useful suggestions.

Notes:

1. In the current Indonesian forestry context what is illegal cannot clearly be distinguished from what is legal. One example is the corrupt creation of laws allowing local officials to participate in what had previously been illegal timber harvests. For this reason controls on log demand rather than enforcement of confusing logging laws was being suggested.

2. The reason for consideration of a temporary, rather than a permanent, export ban was the need to maintain compliance with international trade agreements.

3. Indeed this is exactly what happened. In 2001, the Indonesian government instituted a log export ban. However, its implementation has been very weak and effectiveness in stopping exports poor.

4. Roundtable on Log Export Ban. 27 September 2000. World Bank Office, Jakarta. (meeting summary).

5. Interviews were related to illegal logging, and related research priorities, but did not specifically address modeling efforts except in a few cases where there was an interest in such modeling.

6. The term, logging team, refers to groups of forest workers with equipment usually camped in the forest for periods of many weeks. Within the model this is the equivalent of logging capacity, the amount that can be harvested per unit time, and is measured in m^3/yr.

7. Other factors affecting wood product profitability are treated exogenously. This implies that the market for wood products is very strong and that all products produced can be absorbed into the market without any major effect on pricing. A more detailed model could include wood product demand and pricing relationships.

9. Unless stated otherwise, examples assume a ‘normal’ logging team investment and an ‘entrepreneurial’ milling investment strategy.

10. Several countries in the region have placed a moratorium on logging. Here I use a ramp-up of foreign demand by 150,000 m^3 per year, which is 10% of the original foreign demand, for 10 years.

11. It is important to stress that any factors that increase logging profitability, in the absence of limits on logging, will lead to over-harvest.

12. Various reports indicate that log harvest exceeds sustainable supply by 30 to 50%.

13. In the early 1980s, Indonesia successfully implemented a log export ban which greatly helped the domestic processing industry. By 1990, Indonesia was a major player in the international wood products trade. However, that business empire was centrally controlled by a small political elite, which had almost absolute power to enforce export regulations and to control domestic processing capacity, which it did.

Literature Cited

Aden J, Dore G, Vincent J, Walton. T. 2001. *Indonesia: Environment and natural resource management in a time of transition*, World Bank, Washington, D. C.

Applegate G, Chokkalingam U, Suyanto. 2001. *The underlying causes and impacts of fires in South-East Asia - final report*, Center for International Forestry Research (CIFOR), International Centre for Research in Agroforestry (ICRAF), Bogor Indonesia

Arunanondchai M. 2001. *Can Indonesia gain from log export barriers? Warwick Economic Research Papers 619*, Department of Economics, University of Warwick, Warwick, United Kingdom

Barr CM. 1998. Bob Hasan, the rise of APKINDO, and the shifting dynamics of control in Indonesia’s timber sector. *Indonesia*, Cornell University Modern Indonesia Project, **65**: 1-36.

------. 2001a. Profits on paper: The political-economy of fiber, finance, and debt in Indonesia’s pulp and paper industries. In *Banking on sustainability: A critical assessment of structural adjustment in Indonesia’s forest and estate crop industries*. Barr CM (ed) Center for International Forestry Research: Bogor, Indonesia and World Wide Fund for Nature-International, Macroeconomics Program Office: Washington D.C.

------. 2001b. Will HPH reform lead to sustainable forest management?: Questioning the assumptions of the "sustainable logging" paradigm in Indonesia. In *Which way forward? Forests, policy and people in Indonesia*. Colfer CJP, Resosudarmo IAP (eds). Resources for the Future: Washington, D.C.

Casson A. 2000. *Illegal tropical timber trade in central Kalimantan, Indonesia*, CIFOR, Bogor, Indonesia

------. 2002. A forest of palms: The political economy of Indonesia's oil palm sub-sector and the fate of the forest. In *Which way forward?: People, forests, and policymaking in Indonesia*. Colfer CJP, Resosudarmo IAP (eds). Resources for the Future Press: Washington, DC.

Casson A, Obidzinski K. 2001. *From new order to regional autonomy: Shifting dynamics of 'illegal logging' in Kalimantan, Indonesia*. Presented at Resource Management in Asia-Pacific Conference on Resource Tenure, Forest Management and Conflict Resolution: Perspectives from Borneo and New Guinea, Australian National University, Canberra

Contreras-Hermosilla A. 2000. *The underlying causes of forest decline. Occasional Paper No. 30*, Center for International Forestry Research, Bogor, Indonesia

Currey D, Doherty F, Lawson S, Newman J, Ruwindrijarto A. 2001. *Timber trafficking: Illegal logging in Indonesia, South-East Asia and international consumption of illegally sourced timber*, Environmental Investigation Agency & Telepak Indonesia, Bogor, Indonesia

Currey D, Ruwindrijarto A. 2000. *Illegal logging in Tanjung Puting National Park, an update to the final cut report*, Environmental Investigation Agency and Telapak Indonesia, Bogor, Indonesia

Dudley RG. 2002. Dynamics of illegal logging in Indonesia. In *Which way forward? Forests, people and policymaking in Indonesia*. Colfer CJP, Resosudarmo IAP (eds). Resources for the Future: Washington, D. C. 358 - 382.

------. 2004. A system dynamics examination of the willingness of villagers to engage in illegal logging. *Journal of Sustainable Forestry* **19**(3+4): (forthcoming).

FWI/GFW. 2002. *The state of the forest: Indonesia*, Forest Watch Indonesia/Global Forest Watch, Bogor, Indonesia / Washington D. C.

Goodland R, Daly H. 1996. If tropical log export bans are so perverse, why are there so many? *Ecological Economics* **18**(3): 189-196.

Jepson P, Jarvie JK, MacKinnon K, Monk KA. 2001. The end for Indonesia's lowland forests? *Science* **292**(5518): 859-861.

Jones A, Seville D, Meadows D. 2002. Resource sustainability in commodity systems: The sawmill industry in the northern forest. *System Dynamics Review* **18**(2): 171-204.

Manurung EGT, Buongiorno J. 1997. Effects of the ban on tropical log exports on the forestry sector of Indonesia. *Journal of World Forest Resource Management* **8**(1): 21-49.

McCarthy JF. 2000. *"Wild logging": The rise and fall of logging networks and biodiversity conservation projects on Sumatra's rainforest frontier. Occasional Paper No. 31*, Center for International Forestry Research, Bogor, Indonesia

------. 2002. Turning in circles: District governance, illegal logging, and environmental decline in Sumatra, Indonesia. *Society and Natural Resources* **15**: 867-886.

Newman J, Ruwindrijarto A, Curry D. 2000. *The final cut: Illegal logging in Indonesia's orangutan parks*, Environmental Investigation Agency and Telapak Indonesia, Bogor, Indonesia

Obidzinski K, Suramenggala I. 2000. *Illegal logging in Indonesia - a contextual approach to the problem*, Center for International Forestry Research, Bogor, Indonesia

Obidzinski K, Suramenggala I, Levang P. 2001. L'exploition forestière illégale en Indonésie: Un inquiétant processus de légalization (Illegal logging in Indonesia: A disturbing legalization trend). *Bois et Forêts des Tropique* **270**(4): 85-97.

Palmer CE. 2001. *The extent and causes of illegal logging: An analysis of the major cause of tropical deforestation in Indonesia*. Economics Department University College

London and Centre for Social and Economic Research on the Global Environment, University College London and University of East Anglia: London. 33 pp.

Resosudarmo IAP, Dermawan A. 2001. Forests and regional autonomy: The challenge of sharing the profits and pains. In *Which way forward? Forests, people and policymaking in Indonesia*. Colfer CJP, Resosudarmo IAP (eds). Resources for the Future: Washington, D. C. 325-357.

Scotland N, Smith J, Lisa H, Hiller M, Jarvis B, *et al*. 2000. *Indonesia country paper on illegal logging*. Presented at World Bank-WWF Workshop on Control of Illegal Logging in East Asia, Jakarta

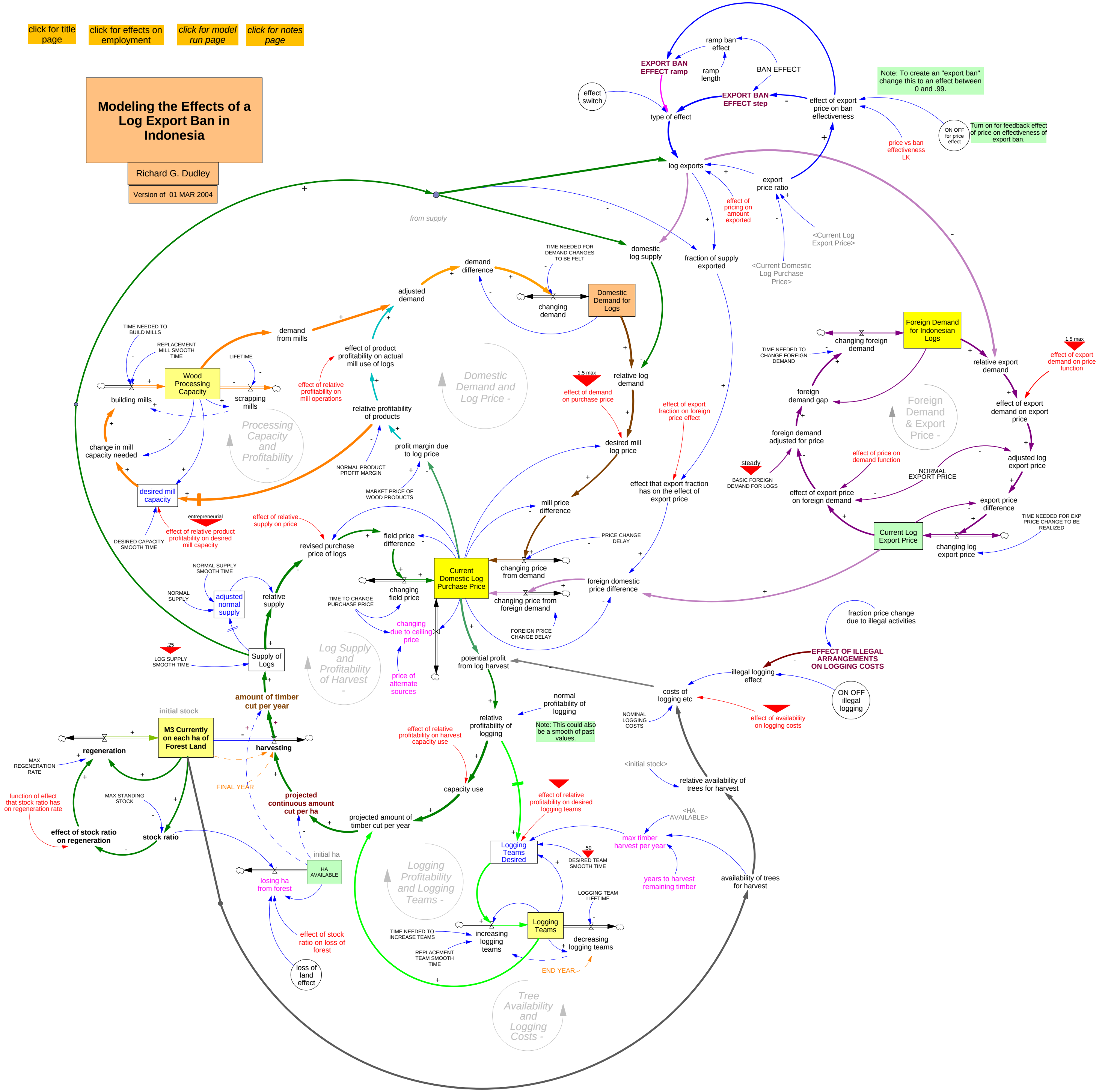
Wadley RL. 2001. *Histories of natural resource use and control in West Kalimantan, Indonesia: Danau Sentarum National Park and its vicinity (1800-2000). A report for the CIFOR project "Local People, Devolution, and Adaptive Collaborative Management,"* Center for International Forestry Research, Bogor, Indonesia

click for title page | click for effects on employment | click for model run page | click for notes page

Modeling the Effects of a Log Export Ban in Indonesia

Richard G. Dudley

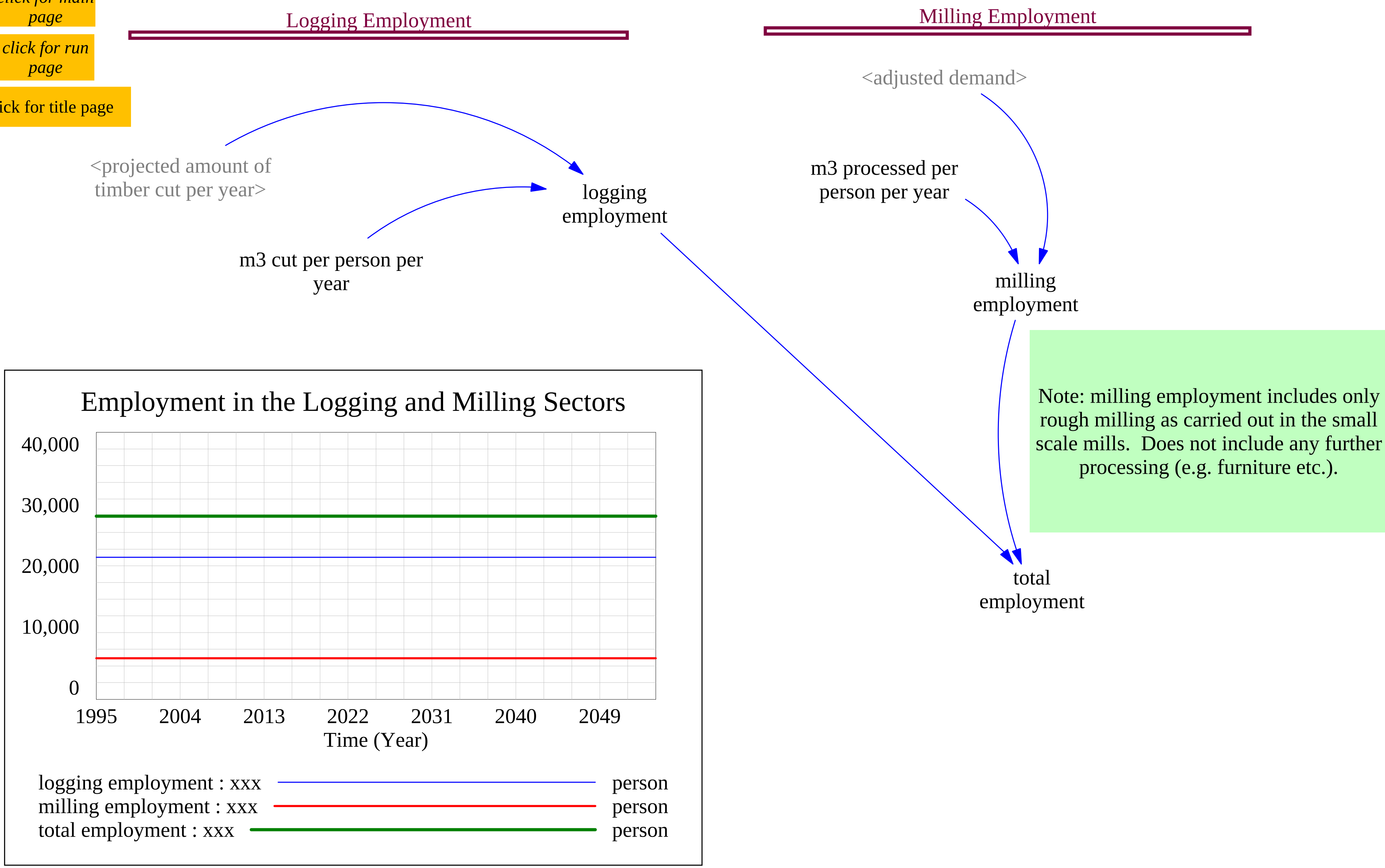
Version of 01 MAR 2004



click for main page

click for run page

click for title page



(001) adjusted demand=
demand from mills*effect of product profitability on actual mill use of logs
Units: m3/Year
Current demand for logs by mills as modified by other factors

(002) adjusted log export price=
NORMAL EXPORT PRICE*effect of export demand on export price
Units: $/m3
Export price after adjustment for changes in demand

(003) adjusted normal supply=
SMOOTHI(Supply of Logs, NORMAL SUPPLY SMOOTH TIME, NORMAL SUPPLY
)
Units: m3/Year
Typical supply levels over the past few years

(004) amount of timber cut per year=
HA AVAILABLE*harvesting
Units: m3/Year
The actual harvest given the per ha harvest and the number of ha of forest available

(005) availability of trees for harvest=
M3 Currently on each ha of Forest Land
Units: m3/ha
Measure of the total availability of trees for harvest

(006) BAN EFFECT=
0
Units: Dmnl
0=no effect, numbers between 0 and .99 allow pecentage effectiveness of a log export ban.

(007) BASIC FOREIGN DEMAND FOR LOGS=
1.5e+006
Units: m3/Year
Overall foreign demand for Indonesian logs.
Note: for alternate add + RAMP(150000, 1998, 2008)

(008) building mills=

max(0,(change in mill capacity needed/TIME NEEDED TO BUILD MILLS
) + SMOOTH(scrapping mills, REPLACEMENT MILL SMOOTH TIME))
Units: m3/Year/Year
Rate at which new capacity is added.

(009) capacity use=
effect of relative profitability on harvest capacity use(relative profitability of logging
)
Units: Dmnl
Fraction of harvesting capacity that is actually used.

(010) change in mill capacity needed=
desired mill capacity-Wood Processing Capacity
Units: m3/Year
Amount of capacity which needs to be added to create the desired capacity.

(011) changing demand=
demand difference/TIME NEEDED FOR DEMAND CHANGES TO BE FELT
Units: m3/(Year*Year)
change in the demand for logs for domestic use by the processing industry

(012) changing due to ceiling price=
MIN(0,(price of alternate sources-Current Domestic Log Purchase Price
)/TIME TO CHANGE PURCHASE PRICE)
Units: $/(m3*Year)

(013) changing field price=
field price difference/TIME TO CHANGE PURCHASE PRICE
Units: $/(m3*Year)
Changes to domestic purchase price caused by changes in the prices loggers and log sellers would like to have.

(014) changing foreign demand=
foreign demand gap/TIME NEEDED TO CHANGE FOREIGN DEMAND
Units: m3/Year/Year
Changes in the foreign demand for Indonesian logs

(015) changing log export price=

export price difference/TIME NEEDED FOR EXP PRICE CHANGE TO BE REALIZED
Units: $/m3/Year
changes occuring in the export price

(016) changing price from demand=
mill price difference/PRICE CHANGE DELAY
Units: $/(m3*Year)
Changes to domestic purchase price caused by changes in the prices domestic log buyers would like to have.

(017) changing price from foreign demand=
foreign domestic price difference/FOREIGN PRICE CHANGE DELAY
Units: $/(m3*Year)
Changes to domestic purchase price caused by changes in the prices exporters would like to have.

(018) costs of logging etc=
illegal logging effect*NOMINAL LOGGING COSTS*effect of availability on logging costs
(1/relative availability of trees for harvest
)
Units: $/m3
Given costs of carrying out logging

(019) Current Domestic Log Purchase Price= INTEG (
changing field price+changing price from demand+changing price from foreign demand
+changing due to ceiling price,
50)
Units: $/m3
Current price paid per cubic meter for logs

(020) Current Log Export Price= INTEG (
changing log export price,
NORMAL EXPORT PRICE)
Units: $/m3
The price currently paid for exported logs

(021) decreasing logging teams=
max(Logging Teams/END YEAR, Logging Teams/LOGGING TEAM LIFETIME
)
Units: m3/(Year*Year)

Rate at which timber harvesting capacity
decreases.

(022) demand difference=
adjusted demand-Domestic Demand for Logs
Units: m3/Year
Change needed in demand to match desired demand.

(023) demand from mills=
Wood Processing Capacity
Units: m3/Year
The demand for logs created by processing mills

(024) DESIRED CAPACITY SMOOTH TIME=
0.5
Units: Year
Time over with the effect of changing
profitability is taken into account.

(025) desired mill capacity=
SMOOTH(Wood Processing Capacity*effect of relative product
profitability on desired mill capacity
(relative profitability of products
), DESIRED CAPACITY SMOOTH TIME)
Units: m3/Year
Amount of capacity needed.

(026) desired mill log price=
Current Domestic Log Purchase Price*effect of demand on purchase price
(relative log demand)
Units: $/m3
Price the mills expect to pay for logs based on
their need to provide the mills with logs

(027) DESIRED TEAM SMOOTH TIME=
0.5
Units: Year
Smooth time for figuring the needed logging team
size.

(028) Domestic Demand for Logs= INTEG (
changing demand,
demand from mills)
Units: m3/Year
Current demand for logs

(029) domestic log supply=
Supply of Logs-log exports
Units: m3/Year
Supply of logs reaching the domestic market

(030) effect of availability on logging costs(
[(0,0)-(10,8)],(0,0.9),(1,1),(1.345,1.08),(2,1.2),(2.87059
,1.53737),(4.08,2.05),(5.15294,2.61922),(6.51765,3.78648),(
7.45882,4.21352),(8.70588,4.3274),(10,4.38434))
Units: Dmnl
A graphical function describing the relationship between the timber availability ratio and the effect on logging costs. Not that the in put is the inverse of the typically used normalized input. \!Original availability divided by current availability\!effect on logging costs

(031) effect of demand on purchase price(
[(0,0)-(6,4)],(0,0),(0.141176,0.149466),(0.5,0.636),(1,1),
(1.544,1.246),(2.512,1.427),(5,1.5))
Units: Dmnl
Graphical relationship of the effect that demand from the mills has on the price of logs which they buy\!relative demand from mills\!\!effect on purchase price mills wish to pay

(032) effect of export demand on export price=
effect of export demand on price function(relative export demand
)
Units: Dmnl
The effect that the relative demand for exported logs has on the price of exported logs.

(033) effect of export demand on price function(
[(0,0)-(6,4)],(0,0),(0.141176,0.149466),(0.5,0.6),(1,1),(1.49647
,1.2669),(2.32941,1.39502),(6,1.5))
Units: Dmnl
A graphical function describing the effect that relative demand will have on the price of exported logs \!relative export demand\!effect on export price Dmnl

(034) effect of export fraction on foreign price effect=
1
Units: Dmnl
Function showing the effect the fraction exported

has on the effect that export price will have on domestic price. As a starting point this is assumed to be directly proportional to the fraction of logs exported.

(035) effect of export price on ban effectiveness=
IF THEN ELSE(ON OFF for price effect=1, price vs ban effectiveness LK (export price ratio), 1)
Units: Dmnl
If export price becomes high in relation to the domestic price then the ban becomes less effective as people find ways to avoid it. This feedback loop allows for this effect when the switch is on.

(036) effect of export price on foreign demand=
effect of price on demand function(Current Log Export Price /NORMAL EXPORT PRICE)
Units: Dmnl
The effect that the export price has on foreign demand

(037) EFFECT OF ILLEGAL ARRANGEMENTS ON LOGGING COSTS=
1+RAMP(fraction price change due to illegal activities, 1997 , 2002)
Units: Dmnl
Fractional effect of illegal arrangements on logging costs. Normally illegal arrangements will lower logging costs.

(038) effect of price on demand function(
[(0,0)-(8,6)],(0,5),(0.150588,3.58719),(0.32,2.60498),(0.508235 ,1.75089),(0.724706,1.28114),(1,1),(1.48706,0.854093),(1.99529 ,0.768683),(3,0.5),(5,0.1),(6,0))
Units: Dmnl
A graphical function describing the effect that relative export price will have on foreign log demand \!export price/ normal export price\!Effect on Foreign Demand Dmnl

(039) effect of pricing on amount exported(
[(0,0)-(3,1)],(0,0),(0.272941,0.0213523),(0.585882,0.124555),(0.811765,0.298932),(1,0.5),(1.21412,0.679715),(1.36941,0.754448),(1.58824,0.811388),(1.95529,0.871886),(2.43529,0.918149), (3,0.95))
Units: Dmnl

A graphical function which describes the relationship between export price ratio and the proportion of logs exported \!export price ratio\!proportion of logs exported Dmnl

(040) effect of product profitability on actual mill use of logs
=
effect of relative profitability on mill operations(relative profitability of products
)
Units: Dmnl

Effect that profitability of wood product manufacture has on demand for wood at existing mills. If profitability of manufacturing wood products drops then demand will also drop. If profitability increases, then demand will increase, but is limited by the capacity of the mills.

(041) effect of relative product profitability on desired mill capacity
(
[(0,0)-(2,4)],(0,0),(0.09412,0.379),(0.2447,0.654),(0.48,0.8
),(0.7435,0.9),(1,1),(1.271,1.253),(1.435,1.5),(1.697,2.059
),(2,3))
Units: Dmnl

A graphical relationship showing how changes in the profitability of wood products might affect the desire for more capacity.\!\!relative profitability\! XnormalX

(042) effect of relative profitability on desired logging teams
(
[(0,0)-(6,6)],(0,0),(0.508235,0.597865),(1,1),(1.69412,1.42349
),(2.44235,1.85765),(3.34588,2.26335),(4.50353,2.66904),(6,
3))
Units: Dmnl

Relation showing how profitability of logging causes increases in the number of logging teams needed. \!relative profitability\!effect on capacity increase Dmnl

(043) effect of relative profitability on harvest capacity use
(
[(0,0)-(4,2)],(0,0),(0.220183,0.464912),(0.5,0.8),(1,1),(1.5
,1.05),(3,1.1))
Units: Dmnl

Function providing the fraction of harvesting
capacity used at each level of
profitability.\!relative profitability\!effect on
harvest capacity use Dmnl

(044) effect of relative profitability on mill operations(
[(0,0)-(2,2)],(0,0),(0.235294,0.128114),(0.5,0.42),(0.649412
,0.640569),(0.809412,0.839858),(1,1),(1.19529,1.08185),(1.5
,1.1),(2,1.1))
Units: Dmnl

A graphical relationship of the effect of wood
product profitability on the use of milling
capacity. For example lowered product
profitability might lower mill operations and
thus lower demand for logs.   \!relative
profitability\!effect on mill use of logs

(045) effect of relative supply on price(
[(0,0)-(10,2)],(0,1.1),(0.376471,1.03915),(1,1),(2.63529,0.882562
),(4.89412,0.768683),(7.38824,0.669039),(10,0.6))
Units: Dmnl

effect of the amount of logs available on the
price for which they are sold\!relative
supply\!effect on log price

(046) effect of stock ratio on loss of forest(
[(0,0)-(0.6,1)],(0,1),(0.00988235,0.701068),(0.0211765,0.587189
),(0.0494118,0.462633),(0.0974118,0.348754),(0.172235,0.224199
),(0.223059,0.174377),(0.282353,0.131673),(0.389647,0.0569395
),(0.5,0))
Units: 1/Year

Lookup function showing the relation between the
density of forest cover and the rate at which
forested land is converted to other uses. As
forest cover is lost the fraction converted will
increase \!stock ratio\!fractional annual loss

(047) effect of stock ratio on regeneration=
function of effect that stock ratio has on regeneration rate
(stock ratio)
Units: Dmnl

As the forest grows the existing forest starts to
limit the regeneration rate.   This is the output
of a graphical function... where the input is the
stock ratio.

(048) effect switch=
0
Units: Dmnl
Switch to allow change to step or ramp effect.
Value of 1 is the step implementation.

(049) effect that export fraction has on the effect of export price
=
effect of export fraction on foreign price effect*fraction of supply exported
Units: Dmnl
The actual amount of foreign exports will have an impact on how important the export price is in determining the domestic log price.

(050) END YEAR=
1
Units: Year

(051) EXPORT BAN EFFECT ramp=
1+RAMP((-ramp ban effect*effect of export price on ban effectiveness
), 2001.75,2002.25) + RAMP((ramp ban effect*effect of export price on ban effectiveness
), 2006.75,2007.25)
Units: Dmnl
The effect that an export ban will have on exports 0 is fully effective..... 1 is no effect. Note fully effective is not possible .... creates zero values in calculations in current formulation. To create export ban effect for five years use the value: 1+step(-0.99, 15) + step(0.99, 20)

(052) EXPORT BAN EFFECT step=
1+step(-BAN EFFECT*effect of export price on ban effectiveness
, 2002) + step(BAN EFFECT*effect of export price on ban effectiveness
, 2007)
Units: Dmnl
The effect that an export ban will have on exports 0 is fully effective..... 1 is no effect. Note fully effective is not possible .... creates zero values in calculations in current formulation. To create export ban effect for five years use the value: 1+step(-0.99, 15) + step(0.99, 20)

(053) export price difference=
adjusted log export price-Current Log Export Price
Units: $/m3
The difference between the adjusted export price and the current export price. This difference is gradually absorbed into the current export price.

(054) export price ratio=
Current Log Export Price/Current Domestic Log Purchase Price
Units: Dmnl
a comparison of the current export price to the current domestic price

(055) field price difference=
revised purchase price of logs-Current Domestic Log Purchase Price
Units: $/m3
difference between the price that suppliers of domestic logs want after accounting for log supply and the current domestic purchase price

(056) FINAL TIME = 2055
Units: Year
The final time for the simulation.

(057) FINAL YEAR=
1
Units: Year

(058) foreign demand adjusted for price=
BASIC FOREIGN DEMAND FOR LOGS*effect of export price on foreign demand
Units: m3/Year
foreign demand after the effect of price change is taken into account

(059) Foreign Demand for Indonesian Logs= INTEG (
+changing foreign demand,
BASIC FOREIGN DEMAND FOR LOGS)
Units: m3/Year

(060) foreign demand gap=
foreign demand adjusted for price-Foreign Demand for Indonesian Logs
Units: m3/Year
Difference between the revised foreign demand and the current foreign demand

(061) foreign domestic price difference=
(Current Log Export Price-Current Domestic Log Purchase Price
)*effect that export fraction has on the effect of export price
Units: $/m3
The difference between current price and export
price modified by the fractionof logs exported.
For example, if exports are very low then the
export price will have little effect.

(062) FOREIGN PRICE CHANGE DELAY=
0.25
Units: Year

(063) fraction of supply exported=
log exports/Supply of Logs
Units: Dmnl
Fraction of logs that are actually exported

(064) fraction price change due to illegal activities=
0
Units: 1/Year
fractional change in logging costs due to
illegality per year during ramp down for x years.
For esample -0.03 would be a yearly decrease of
three percent. The default number of years is 5
starting in 1998.

(065) function of effect that stock ratio has on regeneration rate
(
[(0,0)-(1,1)],(0,1),(0.134557,0.97807),(0.223242,0.95614),
(0.327217,0.925439),(0.431193,0.855263),(0.538226,0.719298)
,(0.605505,0.52193),(0.669725,0.346491),(0.779817,0.166667)
,(0.868502,0.0789474),(1,0),(1.1315,-0.0526316))
Units: Dmnl
\!stock ratio\!effect on regeneration

(066) HA AVAILABLE= INTEG (
-losing ha from forest,
initial ha)
Units: ha
Total hactares of forest land available for
harvest

(067) harvesting=
MIN(M3 Currently on each ha of Forest Land/FINAL YEAR,projected
continuous amount cut per ha

)
Units: m3/ha/Year
Timber actually cut given the desited cut and the actual limitations.

(068) illegal logging effect=
IF THEN ELSE(ON OFF illegal logging=1, EFFECT OF ILLEGAL ARRANGEMENTS ON LOGGING COSTS
, 1)
Units: Dmnl

(069) increasing logging teams=
max(0, (((Logging Teams Desired-Logging Teams)/TIME NEEDED TO INCREASE TEAMS
)+SMOOTH(decreasing logging teams, REPLACEMENT TEAM SMOOTH TIME
)))
Units: m3/Year/Year
Rate at which logging capacity increases.

(070) initial ha=
1e+006
Units: ha

(071) initial stock=
220.76
Units: m3/ha
The initial standing stock in a forest.

(072) INITIAL TIME = 1995
Units: Year
The initial time for the simulation.

(073) LIFETIME=
5
Units: Year
Average lifetime of capacity.

(074) log exports=
Supply of Logs*effect of pricing on amount exported(export price ratio
)*type of effect
Units: m3/Year
Amount of logs exported.

(075) LOG SUPPLY SMOOTH TIME=
0.25

Units: Year
smooth time for determining the current supply of logs

(076) logging employment=
projected amount of timber cut per year/m3 cut per person per year
Units: person
numbers of workers needed for log harvest at a given point in time

(077) LOGGING TEAM LIFETIME=
0.5
Units: Year
Typical lifetime of given units of logging capacity.

(078) Logging Teams= INTEG (
+increasing logging teams-decreasing logging teams,
NORMAL SUPPLY)
Units: m3/Year
Current number of logging teams (logging capacity) This includes personnel, chain saws and other equipment.

(079) Logging Teams Desired=
SMOOTH(MIN(max timber harvest per year, Logging Teams*effect of relative profitability on desired logging teams
(relative profitability of logging))
, DESIRED TEAM SMOOTH TIME)
Units: m3/Year
The number of logging teams (capacity) needed, given the current level of profitability.

(080) losing ha from forest=
loss of land effect*HA AVAILABLE*effect of stock ratio on loss of forest
(stock ratio)
Units: ha/Year
Rate that forest land is lost by conversion to other uses.

(081) loss of land effect=
0
Units: Dmnl
Effect to turn on and off the effect of losing forest land to non-forest uses. Default 0 is no

loss of forest land when forest gets degraded.

(082) M3 Currently on each ha of Forest Land= INTEG (
+regeneration-harvesting,
initial stock)
Units: m3/ha
Amount of harvestable wood currently on the land
in question.

(083) m3 cut per person per year=
141
Units: m3/person/Year
Harvest per person per year. Based on data from
Obidzinski

(084) m3 processed per person per year=
244
Units: m3/person/Year
Amount of wood processed by one mill worker per
year based on data from Obidzinski.

(085) MARKET PRICE OF WOOD PRODUCTS=
100
Units: $/m3
Current price of wood products in terms of $/m3
of raw material. Assumed here that prices are
rlatively stable.... wood products can be
exported.

(086) MAX REGENERATION RATE=
0.03
Units: 1/Year
The fastest fractional rate at which the forest
can add useable biomass.

(087) MAX STANDING STOCK=
350
Units: m3/ha
Highest standing stock possible

(088) max timber harvest per year=
(availability of trees for harvest*HA AVAILABLE)/years to harvest
remaining timber
Units: m3/Year
Harvest rate if all timber were to be harvested
without regard for profitability

(089) mill price difference=
(desired mill log price)-Current Domestic Log Purchase Price
Units: $/m3
Difference between the current price and the desired price that mills want to pay.

(090) milling employment=
adjusted demand/m3 processed per person per year
Units: person

(091) NOMINAL LOGGING COSTS=
25
Units: $/m3
TYPICAL LOGGING COSTS

(092) NORMAL EXPORT PRICE=
50
Units: $/m3
The typical price paid for indonesian logs when they are exported.

(093) NORMAL PRODUCT PROFIT MARGIN=
50
Units: $/m3
An arbitrary standard for profitability based on m3 of raw material.

(094) normal profitability of logging=
25
Units: $/m3

(095) NORMAL SUPPLY=
3e+006
Units: m3/Year

(096) NORMAL SUPPLY SMOOTH TIME=
5
Units: Year
Number of years taken into account when determining what is considered a normal supply of logs

(097) ON OFF for price effect=
0
Units: Dmnl

This switch turns on the feedback effect of export price on ban effectiveness. Zero is the default (off) value.

(098) ON OFF illegal logging=
0
Units: Dmnl
A value of 1 turns on the illegal logging effect. Note that fraction price change due to illegal logging must also be activated.

(099) potential profit from log harvest=
Current Domestic Log Purchase Price-costs of logging etc
Units: $/m3
Calculated potential profit from logging

(100) PRICE CHANGE DELAY=
0.25
Units: Year
Time needed for prices to reflect actual changes in desired price.

(101) price of alternate sources=
250
Units: $/m3

(102) price vs ban effectiveness LK(
[(0,0)-(3,1)],(0,1),(1,1),(1.49647,0.907473),(1.87765,0.782918
),(2.20941,0.651246),(2.61882,0.437722),(3,0.2))
Units: Dmnl
look up to determine the effect of price on ban effectiveness. Also controlled by an on/off switch. \!export price ratio\!effect on ban effectivenessDmnl

(103) profit margin due to log price=
MARKET PRICE OF WOOD PRODUCTS-Current Domestic Log Purchase Price
Units: $/m3

(104) projected amount of timber cut per year=
Logging Teams*capacity use
Units: m3/Year
The amount of timber cut each year is dependent on both the logging capacity (logging teams) and on the fraction of that capacity which is used,

but will ultimately be limited by timber
availability.

(105) projected continuous amount cut per ha=
projected amount of timber cut per year/HA AVAILABLE
Units: m3/ha/Year
The per ha cut given the size of the forest available for cutting, but ultimately this will be limited by actual timber availability.

(106) ramp ban effect=
BAN EFFECT/ramp length
Units: 1/Year
ban effect (slope) for ramp input.

(107) ramp length=
0.5
Units: Year
Years overwhich ban would occur if ramped.

(108) regeneration=
M3 Currently on each ha of Forest Land*effect of stock ratio on regeneration
*MAX REGENERATION RATE
Units: m3/(Year*ha)
Wood being added to trees in a forest.

(109) relative availability of trees for harvest=
availability of trees for harvest/initial stock
Units: Dmnl
Measure of the total availability of trees for harvest

(110) relative export demand=
Foreign Demand for Indonesian Logs/log exports
Units: Dmnl

(111) relative log demand=
(Domestic Demand for Logs)/domestic log supply
Units: Dmnl
Comparison of total log demand to current log supply.

(112) relative profitability of logging=
potential profit from log harvest/normal profitability of logging
Units: Dmnl

The profitability of timber harvest compared to
normal timber harvest profitability

(113) relative profitability of products=
profit margin due to log price/NORMAL PRODUCT PROFIT MARGIN
Units: Dmnl
Profitability of wood products compared to an
arbitrary standard profitability.

(114) relative supply=
Supply of Logs/adjusted normal supply
Units: Dmnl
The relative abundance of logs on the market.

(115) REPLACEMENT MILL SMOOTH TIME=
1
Units: Year
Averaging time for determing amount of
replacement mills.

(116) REPLACEMENT TEAM SMOOTH TIME=
1
Units: Year
Time over which team repalcement needs are
averaged

(117) revised purchase price of logs=
Current Domestic Log Purchase Price*effect of relative supply on price
(relative supply)
Units: $/m3
The price timber suppliers expect for logs
after the effect of existing log supply is taken
into account.

(118) SAVEPER = 0.0625
Units: Year
The frequency with which output is stored.

(119) scrapping mills=
Wood Processing Capacity/LIFETIME
Units: m3/(Year*Year)
Rate at which capacity wears out or is retired.

(120) stock ratio=
M3 Currently on each ha of Forest Land/MAX STANDING STOCK
Units: Dmnl

Ratio of current forest to maximum possible
standing stock.

(121) Supply of Logs=
SMOOTH(amount of timber cut per year, LOG SUPPLY SMOOTH
TIME
)
Units: m3/Year
Supply of logs coming out of the forest

(122) TIME NEEDED FOR DEMAND CHANGES TO BE FELT=
0.5
Units: Year
Changes in demand for wood do not have an instant
effect on the log market. This is the time it
takes for these changes to be absorbed into the
system.

(123) TIME NEEDED FOR EXP PRICE CHANGE TO BE REALIZED=
0.5
Units: Year
time needed for changes in log export price to be
absorbed into the system.

(124) TIME NEEDED TO BUILD MILLS=
0.5
Units: Year
Average time needed to install or build capacity

(125) TIME NEEDED TO CHANGE FOREIGN DEMAND=
0.75
Units: Year
time needed for changes in demand to be realized

(126) TIME NEEDED TO INCREASE TEAMS=
0.5
Units: Year
Typical time needed to increase logging capacity

(127) TIME STEP = 0.0078125
Units: Year
The time step for the simulation.

(128) TIME TO CHANGE PURCHASE PRICE=
0.25
Units: Year

Average time needed for changes in supply to become apparent.... including transport of logs to the mills.

(129) total amount of timber=
HA AVAILABLE*M3 Currently on each ha of Forest Land
Units: m3

(130) total employment=
logging employment+milling employment
Units: person

(131) type of effect=
IF THEN ELSE(effect switch=1, EXPORT BAN EFFECT step, EXPORT BAN EFFECT ramp
)
Units: Dmnl
Part of switch to change from step to ramp implementation of a ban

(132) Wood Processing Capacity= INTEG (
building mills-scrapping mills,
domestic log supply)
Units: m3/Year
Amount of wood processing facilities such as saw mills. It may be necessary to have different models for different aspects of the industry..... saw mills, papermills, plywood mills.

(133) years to harvest remaining timber=
5
Units: Year
Expected years needed to harvest all remaining timber if that were the goal. At some point logging bosses will realize that timber is limited and will avoid over hiring logging teams. Logging teams will be limited by perceived available timber rather than only by potential profits.