THEORETICAL APPROACHES TO UNDERSTANDING FOREST GOVERNANCE

Full model is available from the author.

A System Dynamics Examination of the Willingness of Villagers to Engage in Illegal Logging

Richard G. Dudley

email address: rgd6@cornell.edu

SUMMARY. Much of the work of illegal logging in Indonesia is carried out by villagers. Several factors determine villagers' willingness to

Richard G. Dudley is a fisheries and natural resources consultant. During 2002-2003 he was a visiting fellow at Cornell University (~~E-mail: drrdudley@compuserve.com~~).

Much of the work reported here was carried out while he was working as a consultant with the Center for International Forestry Research in Bogor, Indonesia. Among the many people who provided advice and discussion during this work were: Joyotee Smith, Krystof Obidzinski, Carol Colfer, Patrice Levang, Herry Purnomo, Doddy Sukadri, Subarudi, Agus Purnomo, Agus Setyarso, Graham Applegate, and Eva Wolenberg.

Modeling used Vensim software available from Ventana Systems, Inc., 60 Jacob Gates Road, Harvard, MA 01451 USA (E-mail: vensim@vensim.com) (Web site: http://www.vensim.com).

[Haworth co-indexing entry note]: "A System Dynamics Examination of the Willingness of Villagers to Engage in Illegal Logging." Dudley, Richard G. Co-published simultaneously in *Journal of Sustainable Forestry* (The Haworth Press, Inc.) Vol. 19, No. 1/2/3, 2004, pp. 31-53; and: *Illegal Logging in the Tropics: Strategies for Cutting Crime* (ed: Ramsay M. Ravenel, Ilmi M. E. Granoff, and Carrie Magee) The Haworth Press, Inc., 2004, pp. 31-53. Single or multiple copies of this article are available for a fee from The Haworth Document Delivery Service [1-800-HAWORTH, 9:00 a.m. - 5:00 p.m. (EST). E-mail address: docdelivery@haworthpress.com].

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Digital Object Identifier: 10.1300/J091v19n01_03

participate in such activities. Chief among these are: (1) the need for income, (2) the fact that other villagers (and non-villagers) are already illegally logging, and (3) the realization of loss of community control over traditional forest areas. These factors form the basis of feedback loops, which trap villagers in illegal logging systems, which will likely result in the disappearance of a major source of livelihood. Ideas for system dynamics model structure were obtained from field reports and interviews with stakeholders. These ideas were examined using causal loop diagrams to represent different views of illegal logging. One village level view was formulated as a quantified system dynamics model using Vensim software. The model allows examination of scenarios, which might alter system behavior. The model is a tool for understanding consequences of various proposed strategies to control illegal logging. These strategies include enforcement of laws, strengthening of community rights, the prevention of outside labor in local forests, and the provision of alternate sources of income. This is part of a larger effort to describe and analyze illegal logging using system dynamics modeling.

KEYWORDS. System dynamics modeling, illegal logging, Indonesia, villagers

INTRODUCTION

The decline of Indonesian forests is well documented. In 1997 and 1998, during the first phases of Indonesia's economic crisis, between 3 8 and 50% of Indonesian timber harvest was unaccounted for in official statistics (Palmer, 2001; Scotland et al., 2000). Illegal logging was thought to account for a large portion of this shortfall. Prior to 1997 Indonesian forests were disappearing at the rate of almost 1.6 million ha per year, equivalent to an annual decline of 1.5% (World Bank, 2001). Annual rate of decline was more rapid within Sumatra (2.8%) and Kalimantan (1.9%). Several reports indicate significant increases in illegal logging since 1998 (e.g., McCarthy, 2000; Obidzinski and Suramenggala, 2000; Casson, 2000), so the rate of forest loss has presumably increased considerably.

The nature of illegal logging activity has rapidly changed. Prior to 1998, much of the "illegality" was confined to large scale timber operations owned by a well-connected business and political elite. To a significant extent these operations were technically legal because laws and regulations establishing

them were created and used by the same elites. Some small-scale illegal logging took place as local people tried to gain access to traditional lands that were within the extensive forest concessions granted to powerful business and government interests. These attempts were suppressed by military and police who had ties to concession holders.

After the fall of President Soeharto in 1998, the situation changed dramatically. Large scale concession holders, timber tycoons, and their political backers no longer had the political power to control what happened in the provinces. The effect of this failure of central government was magnified by an official, and inevitable, move toward decentralization during 2000 and 2001, which was backed by foreign donors.

A two-step change occurred. First, from 1998 to 2000, there was an explosion of illegal logging at the local level whereby entrepreneurs came in to cut trees illegally, often making deals directly with villagers and village heads. Second, by early 2000 newly empowered local governments started to assert their new authority. They created laws to permit local logging concessions. These new laws allowed local officials and entrepreneurs to create corrupt business arrangements more easily. Many local communities saw this as a challenge and an opportunity. They claimed blocks of land as traditional forest, requesting approval from local government, which then allowed them to also make deals directly with entrepreneurs. Using this approach, traditional lands can even be claimed inside established protected areas and forest concessions. Sustained yield forest management has little to do with this type of quasi-legal over-exploitation. In any case, modern forestry expertise is largely non-existent at the local level (see Obidzinski et al., 2001; Casson and Obidzinski, 2001).

When we consider the involvement of villagers in illegal logging we need to consider the above context. Villagers live in a world of uncertain laws, with the knowledge that existing laws have always been manipulated by powerful individuals for their own ends. Laws have little meaning if they are widely ignored and un-enforced. Nevertheless, the emergence of local, as opposed to centralized, political power makes the use of local and traditional laws a seemingly attractive option for natural resource management. To use such an approach effectively, a better understanding of the involvement of local people in illegal logging is needed.

The purpose of the research reported here is to develop a conceptual model of village level aspects of illegal logging that explains basic causal relationships leading to villagers' willingness to engage in illegal and/or destructive activities that appear to be against their own long term interests. A system dynamics model of this sort can be considered a theory about how a system works, and why it produces particular results. It can then be used to gain in-

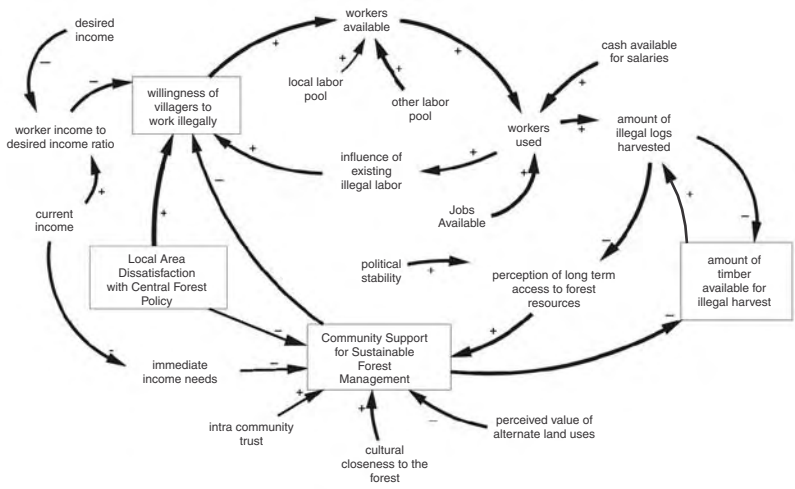
sights into the workings of the actual system. The theory can also be compared to reality and modified as better information is obtained.

This paper represents part of a larger effort to develop system dynamics models of various aspects of illegal logging (e.g., Dudley, 2002).

METHODS

Data and information used as the basis for model building were obtained from field reports (e.g., Casson, 2000; McCarthy, 2000; Obidzinski and Suramenggala, 2000; Obidzinski et al., 2001; and Wadley, 2001) and interviews with various stakeholders. Several qualitative conceptual models, from different stakeholder perspectives, were earlier formulated as causal loop diagrams (see Dudley 2001 for details). Subsequently, some of these conceptual models were used as the basis for quantified system dynamics models. The model presented here is based on one of those conceptual models (Figure 1) that deals with one aspect of the local area view of illegal logging. Other local area aspects include the views of entrepreneurs, and the relationship between entrepreneurs and local officials. The conceptual model was used as the basis for construction of a system dynamics model. See Sterman (2000) for a discussion of the system dynamics modeling approach.

FIGURE 1. Conceptual framework for modeling was based on this diagram from Dudley (2001) which describes factors affecting villagers' perception of illegal logging.



Figures presented herein are of two types: causal loop diagrams and parts of the actual model. The loop diagrams (Figures 1 and 7) show only major causal relationships and do not specifically show flows. The other figures illustrate parts of the actual model. The following conventions are used in labeling model components: stocks (sometimes called state variables or levels) are capitalized and are enclosed in boxes, flows are shown as hollow arrows with a valve and are labeled in lowercase. Auxiliary variables are also in lowercase. Constants are shown in all uppercase. Arrows are illustrated with a plus (+) or a minus (−) to indicate the general trend of the relationship between the two connected variables. A plus indicates a change in the same direction. That is, if X increases then Y also increases if this relationship is taken by itself. A minus indicates a change in the opposite direction. The actual relationship is described by the model equations. In general thicker arrows were used to illustrate more important relationships. When used in the text, names of model components are italicized.

MODEL STRUCTURE

The model describes a theoretical group of small communities with a total labor pool of 1,000 villagers available for logging work. The communities have 5,000 ha of well-forested traditional land holding 200 m^3 of merchantable timber per ha. Normal harvests from this forest start at about 5,000 m^3 per year (i.e., 1.0 $m^3\ ha^{-1}$), which is calculated as a fixed fraction of available timber. The model also assumes a baseline illegal harvest of 1,400 m^3 per year for a total annual harvest of 6,400 m^3 (1.2 $m^3\ ha^{-1}$), a reasonable sustainable harvest from these forests (see, for example, Bruenig 1996, p. 173). This creates an income of $143 per village forest laborer per year ($125 from normal logging and $1 from illegal logging). It is assumed that, initially, one percent of villagers engage in illegal logging. Villagers have other income sources so that the total annual income for members of the above labor pool averages $1,800.

The model consists of 5 interacting feedback loops that describe the following relationships:

1. An increase in need for money increases villagers' willingness to work illegally.
2. As more villagers work illegally they influence others to work illegally.
3. As the amount of forest still intact decreases, community support for sustainable management gradually declines. This increases willingness of villagers to work illegally.
4. As community support for sustainable management declines the amount of forest made available to entrepreneurs for exploitation increases, raising entrepreneurs' desire and ability to provide illegal salaries.
5. As the forest eventually disappears the funds from entrepreneurs decline, and jobs from logging also disappear.

Loop 1: Need for Income Forces Villagers to Work Illegally

According to the model, if villagers have adequate income then they have no need to work illegally. If their income level drops for any reason their willingness to participate in illegal logging will rise, other things being equal, and this *willingness based on income need* can be viewed as a function of the ratio of income to desired income, called the *desired income ratio*. The *desired income ratio* could also change if *desired income* changes. This might happen, for example, if villagers became aware of new desirable consumer goods, or if school fees were increased.

If the income needs of villagers increase, for example, the *current willingness of villagers to work illegally* will gradually increase as well. If this happens then some villagers will start earning illegal income. This, in turn, will raise the income of the villagers as a whole. It is assumed that the money is shared with other villagers so the average income of villagers seeking work is raised even when only some participate in illegal activities. For example, food may be purchased from neighbors. Eventually, the *desired income ratio* is raised enough so that willingness does not rise any further unless disturbed by some other factor. This is a negative feedback, or stabilizing, loop (Figure 2).

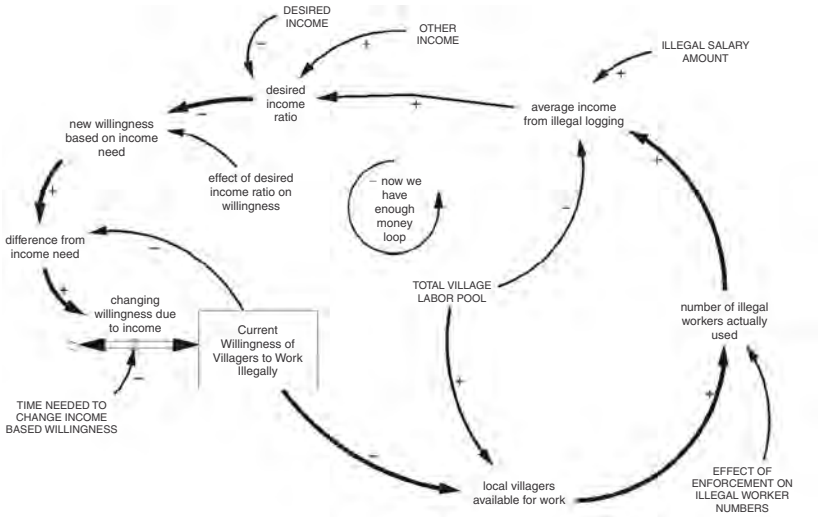
Loop 2: Illegal Workers Create More Illegal Workers

As illegal workers (villagers or outsiders) become more common they have a significant influence on others to participate in illegal logging. This creates a positive feedback that can spiral out of control in the absence of other controlling factors. If the *current willingness of villagers to work illegally* increases, then the number of *local villagers available for work* increases. If illegal work is available and enforcement of laws is weak then the *number of illegal workers actually used* for labor will increase, and will include both villagers and outside workers if they are available. It is likely that in any village there are some *people normally working illegally* and other villagers are accustomed to this. However, at some point the *number of illegal workers actually used* rises above the normal number. As this *illegal worker ratio* increases it causes an increase in the willingness of villagers to work illegally as indicated in Figure 3. This is a positive, or reinforcing, feedback loop, which will lead to all villagers participating in illegal logging if no other factors influenced the outcome.

Loop 3: Disappearing Forest Decreases Community Support for Good Forest Management

As forests disappear in relation to what villagers see as *normal forest cover*, there will be a weakening of the community's *strength of perception of long*

FIGURE 2. One factor affecting the willingness of villagers to work illegally is the need for income. This is a negative feedback, or stabilizing, loop, forming part of the model. As income from illegal logging rises the willingness stabilizes. While enforcement can limit illegal workers, it will also prevent the rise of income levels so the willingness to work illegally will remain high. For clarity some model components have been omitted in this view.

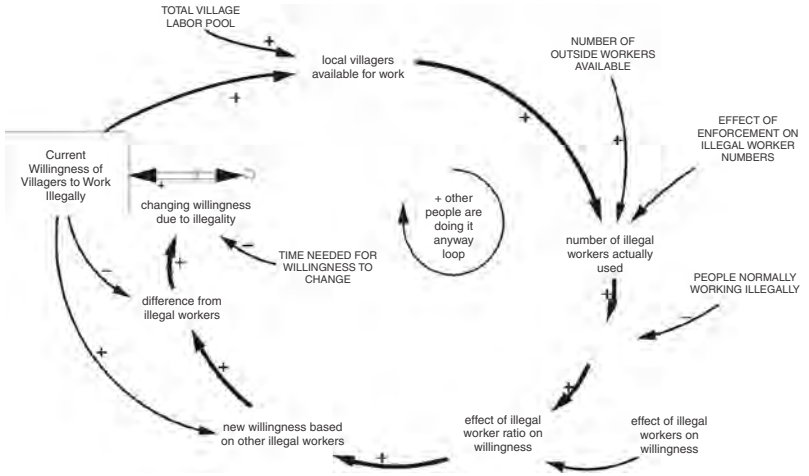


term access to resources. As a community's sense of control over these resources dwindles, *community support for sustainable forest management* also decreases. If *community support for sustainable forest management* is strong then community norms, local customs and rules tend to discourage villagers from working on illegal timber operations. If *community support for sustainable forest management* weakens, then, other things being equal, the *current willingness of villagers to work illegally* will increase, causing a further increase in illegal logging and a decrease in forest cover. If no other factors come into play, this positive feedback loop will spiral out of control as forest cover disappears (Figure 4).

Loop 4: Decreasing Community Support Makes More Forest Available for Illegal Operations

Decreasing *community support for sustainable forest management* causes an overall weakening of traditional community control over its lands. If that happens, community leaders may become more willing to make illegal or cor-

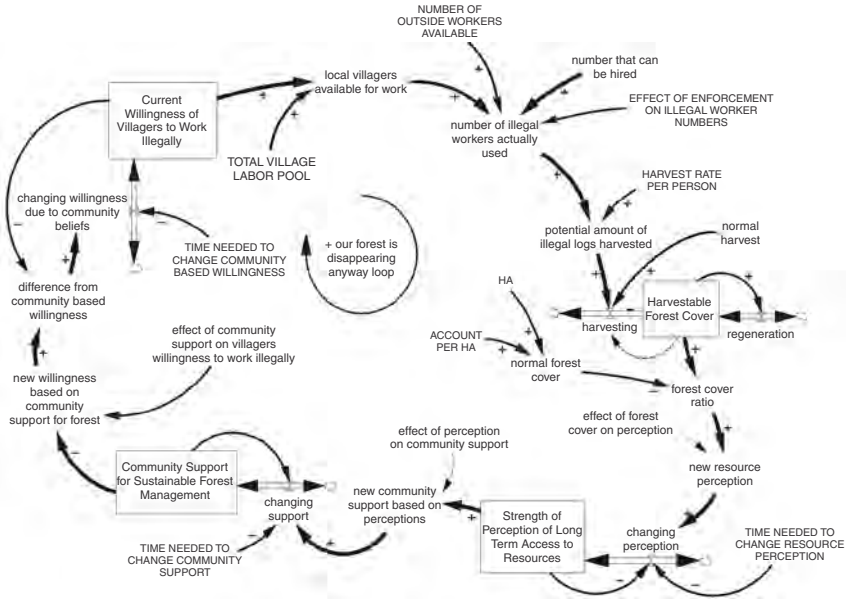
FIGURE 3. A positive feedback loop which illustrates the effect that existing illegal workers have on the willingness of villagers to work illegally. As villagers realize that others are carrying out illegal logging, they gradually lose remaining inhibitions to do so. Over time illegal logging becomes the normal thing to do if other forces do not act on the system. For clarity some model components have been omitted in this view.



rupt arrangements with outsiders, or outsiders may become more willing to ignore community rules and regulations that are no longer considered important by community members. As a consequence, the amount of community lands available for illegal or inappropriate exploitation will increase or decrease depending on the direction of change in *community support for sustainable forest management*. If more community lands are believed to be open for exploitation, and the risks are considered acceptable by entrepreneurs, then they will provide operating capital for equipment, salaries and other needs. Workers will be hired and more illegal logging will occur, further degrading *community support for sustainable forest management* (Figure 5).

The *fraction of forest that can be logged illegally* also depends on the *strength of community rights* under the legal system (Figure 5). In some cases, community rights have been eroded as new laws give rights to other government authorities (e.g., see McCarthy, 2000). As presented here, *strength of community rights* is a constant (which can be manipulated by the model user), but other model formulations are possible. For example, we may wish to assume that as *community support for sustainable forest management* decreases, the legal support for such control would also change after some delay. That is, there is a distinction between the actual legal backing for community rights

FIGURE 4. The effect of changes in *forest cover* on *community support for sustainable forest management* and, therefore, also on the willingness of villagers to work illegally. If forests disappear a community's perception of its access to resources weakens, weakening community support for long term management approaches. This, in turn, tends to weaken or remove community sanctions or restrictions on villagers working illegally. For clarity some model components have been omitted in this view.

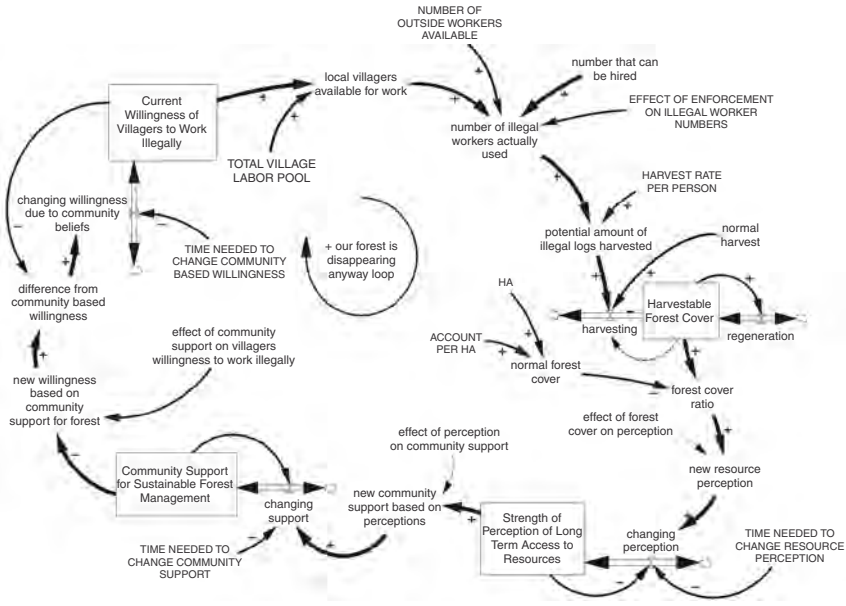


and the desire to apply those rights to manage and control logging activities on community lands.

Loop 5: Disappearing Forests Cause Disappearing Jobs

Harvest from the forest provides jobs. If forest cover becomes degraded not only will sustained yield forest productivity decline, but the temporary benefits of over-harvest will also disappear. While significant *harvestable forest cover* remains there is a large *potential illegal harvest* based on the *fraction of forest that can be logged illegally*. Eventually, *harvesting* becomes self limiting: as over-harvest occurs potential illegal harvest will decline if no other factors interfere. Unfortunately, this self limitation does not stop over-harvest. It merely decreases the rate at which timber is removed. Forest cover will gradually approach zero as will forest related jobs (Figure 5, upper loop). It is impor-

FIGURE 5. Two additional feedback loops make up the remainder of the model. The lower loop (which includes most of the upper loop) illustrates how weakening *community support for sustainable forest management* can lead to increasing illegal log harvest. As community support drops, the community is more likely to allow lands to be accessed by questionable operators. Operators see the weakening community control in terms of larger *potential illegal log harvest*, and thus are willing to risk larger amounts of money in the necessary investments. This is a positive feedback loop whereby decreases in forest cover lead to lower community support for good forest management leading to more illegal operations leading to more illegal harvest. Note that *community support for sustainable forest management* also affects the *willingness of villagers to work illegally* (see Figure 4). The upper loop is a negative feedback loop reflecting the idea that loss of *forest cover* will eventually limit the *harvesting* of timber.



tant to remember that illegal harvest is not necessarily over-harvest, and legal harvest is not necessarily sustainable.

One minor difficulty arises in the selection of a simple approach for depicting the forest that is being harvested. It is not my intention here to provide a detailed forest vegetation model, but the approach used should reflect the ability of the forest to regenerate (grow and reproduce), and *regeneration* should be somewhat higher at intermediate stand densities. I have chosen a biomass approach that disregards stems per ha, size of the trees, and species composition

(Figure 6). This is not to say these components lack importance, but that such a level of detail is not necessary to describe the illegal logging dynamics discussed here.

The Full Model–Additional Comments

The full model incorporates all of the above feedback loops, which are interlinked as illustrated, in simplified form, in Figure 7. A complete model diagram and equations are presented at the end of the document.

MODEL OUTCOMES

Presented here are some model outcomes that might be expected if an increase in illegal logging initially started in response to significant drops in income levels of rural communities. A drop of 50% in income over a two year period (1997-1998) was used as a triggering mechanism. To accomplish this,

FIGURE 6. Harvestable forest is described by a simple biomass model. Net gain (*regeneration*) of harvestable forest biomass is a fraction of existing biomass. When forest cover is very low that fraction is highest (equal to *max regen rate*). As harvestable forest cover increases, stock ratio increases, and because of the shape of the regeneration function (*rgn function*) the *effect of stock on regeneration* lowers *regeneration*. *Regeneration* reaches is zero if *harvestable forest cover* equals or exceeds *max per ha*.

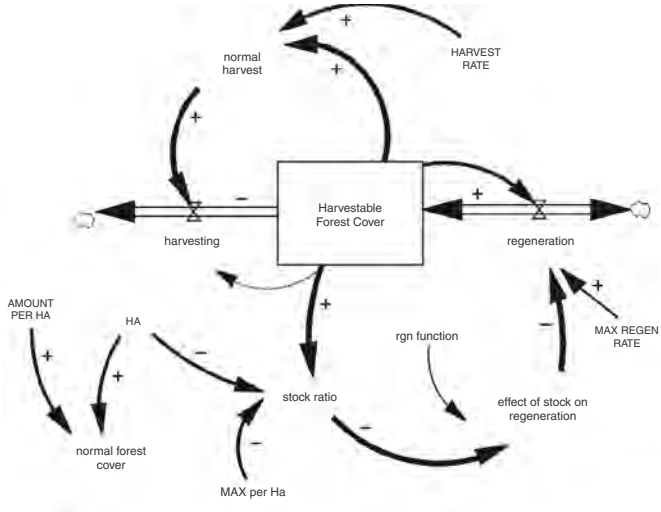
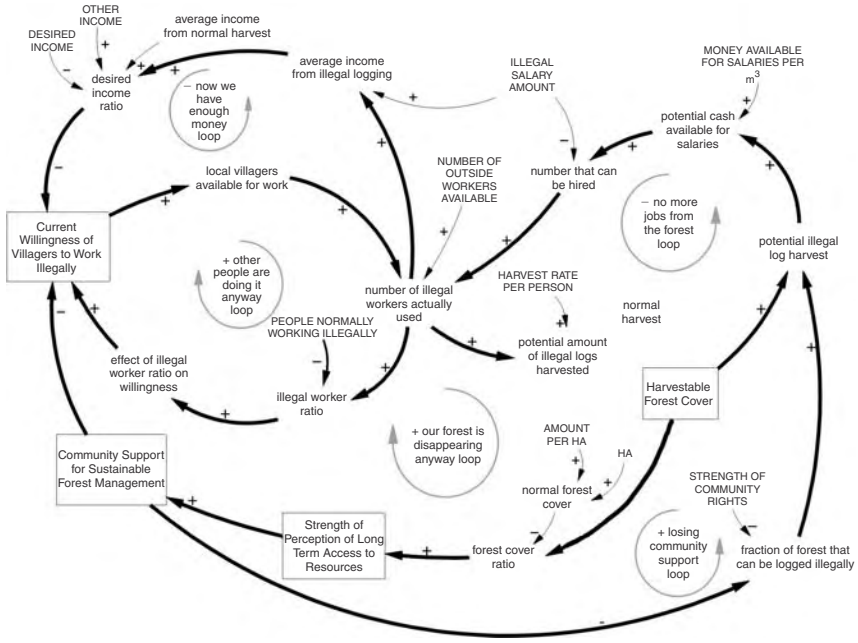


FIGURE 7. The full model is shown here as a causal loop diagram. All five major feedback loops are represented in general form. A detailed model diagram, and model equations, are presented at the end of the paper.

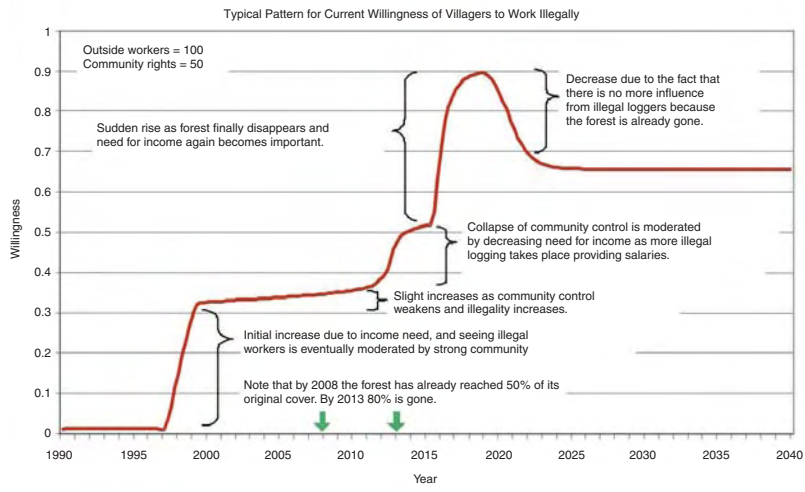


other income was decreased with a ramp function at a rate of $450 per year over the two years. The model was started in approximate equilibrium with the sum of income sources equaling the annual *desired income* of $1,800. This represents the effects of the Asian monetary crisis of those years. Primary factors examined for their effect on illegal logging were *number of outside workers available*, *strength of community rights*, and *effect of enforcement on illegal worker numbers*.

General Pattern of Willingness to Work Illegally

A typical response of villagers' willingness to engage in illegal logging is illustrated in Figure 8. Here we see three phases of willingness while forest still exists. First, willingness rises rapidly as incomes drop and people become willing to work illegally. During this period, as more people work illegally the willingness of others to work illegally also increases. At the same time *community support for sustainable forest management* remains strong and, as income needs are partially satisfied, is able to limit a further rise of willingness.

FIGURE 8. This figure represents the general pattern, over time, of villagers' willingness to engage in illegal logging. The triggering even during 1997-98 is a 50% drop in income. There is a rapid rise in willingness in response to income need, but this need is addressed somewhat as income rises. During this same period the existence of illegal workers stimulates more illegal workers. After this first growth in willingness ends in late 1999 it remains relatively stable because of residual community desire for long term management. By the end of this period forests are largely gone and remaining community control collapses. By the end of this second period incomes have jumped again and willingness starts to stabilize at a higher level. Near the end of this period income from the forest is depleted and willingness due to income need rises rapidly but no additional income is forthcoming. Eventually willingness drops as illegal logging disappears due to the disappearance of the forest.



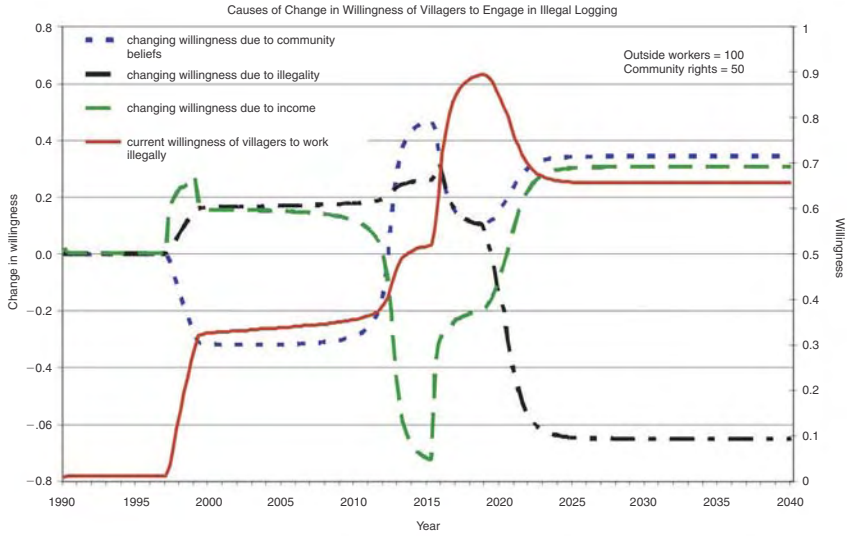
After this period of rapid increase, willingness increases more slowly. During this period, the effects of *community support for sustainable forest management* almost balance the effects of income need and other workers' illegality. Overall, willingness rises only slightly. Even so, the effect on the forest is extreme because the willingness to work illegally remains between 0.3 and 0.4; over 30% of villagers in the labor pool are willing to work illegally. These villagers, plus outside workers, are hired by entrepreneurs. By 2008 (in the scenario shown) 50% of the forest is gone, and by 2013 it has been reduced to 0% of its original amount.

Toward the end of the previous phase the strength of *community support for sustainable forest management* collapses as communities finally realize that the forest is disappearing anyway, regardless of their efforts. This causes a

third phase where willingness jumps again. This jump is reinforced by the effect of illegal workers as more illegal workers take to the field. However, this period of increase is short-lived because it also increases income flowing into the village. Increased income limits further increases in willingness as income levels approach the desired income level causing willingness to remain at just above 0.5. At the end of this phase the forest is essentially gone, but further changes in willingness occur.

Following the disappearance of the forest income levels drop precipitously causing a large jump in willingness to work illegally. However, there is no forest left to cut. Willingness jumps to over 0.9 but then drops as illegal loggers, and the idea of illegal logging, disappear along with other forest related jobs (Figure 8 and Figure 9).

FIGURE 9. This figure details the changes in willingness illustrated in the previous figure. Here the left-hand axis gives the change in willingness. Three sources of changes are shown. When the sum of these three is zero willingness (right-hand axis) will not change. When the sum is positive willingness will rise and when negative willingness will decline. We can think of the dotted or dashed lines above zero as pulling willingness up and those that are negative as pulling willingness down. *Changing willingness due to community beliefs* refers to changes caused by strength of community support for sustainable forest management. *Changing willingness due to illegality* refers to the effect of other illegal workers, and *changing willingness due to income* refers to the effect of income need.



The Effect of Outside Workers

Not all illegal logging is done by villagers themselves. Some is carried out by migrants who move to forested areas specifically to find such jobs. As the number of outsiders increases, the forest disappears faster (Figure 10). Outsiders take illegal jobs that locals don't want, but their presence also influences locals to start working illegally (Figure 11). An increase in *the number of outside workers available* causes an increase in *harvesting* because there are more outside workers and also because more villagers are influenced to work illegally.

In addition, outside workers take salaries that would ultimately go to locals. Assuming that little money paid to outsiders is spent locally, the overall amount of money reaching villagers is lower if more outside workers are present. However, shortly prior to the collapse of illegal logging, villagers actually bring slightly higher amounts of money into the village when more outsiders are present. This is because more of the available village labor force is stimulated to work illegally under those conditions creating a peak in illegal incomes that precedes the collapse (Figure 12).

Effect of the Strength of Community Rights

Strong community rights can limit the amount of forest that illegal entrepreneurs can log. If entrepreneurs expect to have difficulty making illegal ar-

FIGURE 10. Influence of outside workers on forest disappearance. Outside workers work illegally and also influence villagers to work illegally. In addition, outsiders absorb some of the cash that would otherwise have gone to villagers.

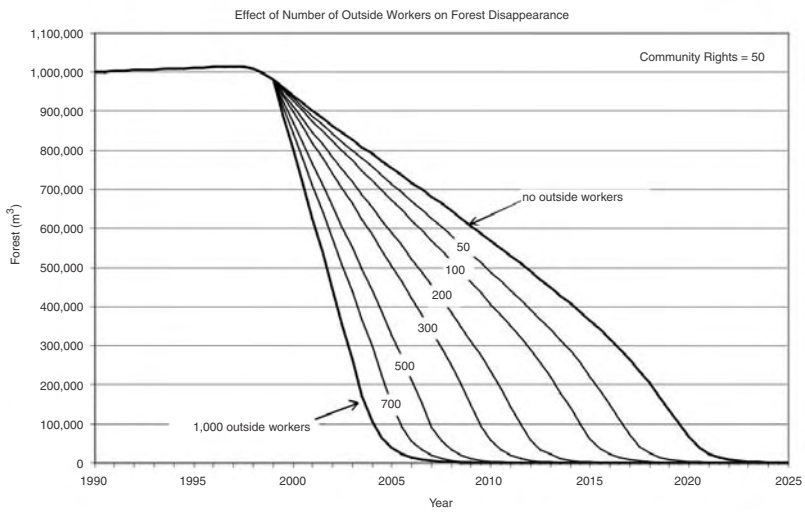


FIGURE 11. The effect of outside illegal workers on villagers' willingness to engage in illegal activities. Outside workers stimulate more villagers to participate in illegal logging earlier than they would in the absence of outsiders.

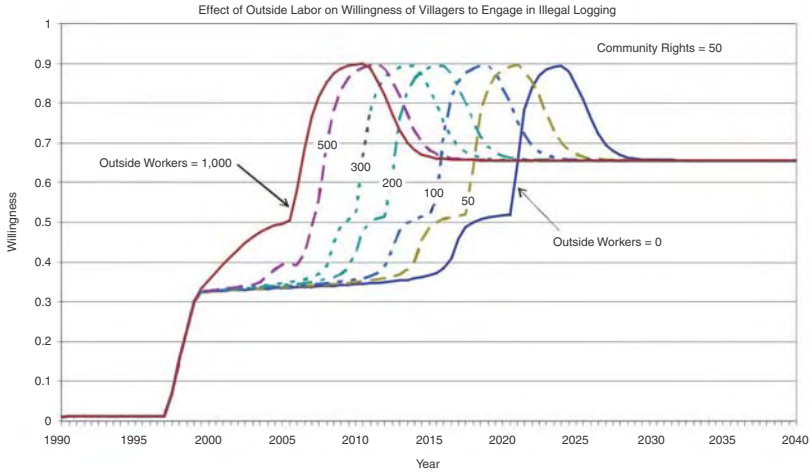
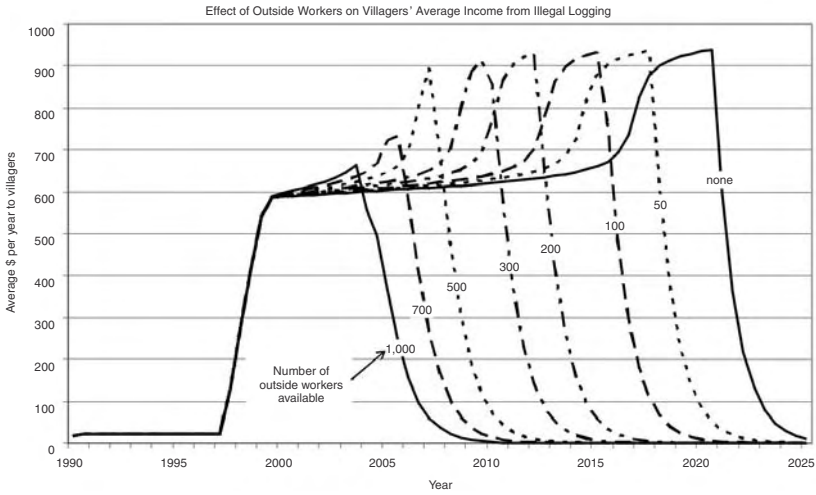


FIGURE 12. Average salary flowing to the village labor pool under situations with different numbers of outside workers. Ultimately, the more outside workers there are the less money goes to village workers. (The area under each curve can be considered the average amount earned per labor pool member.)

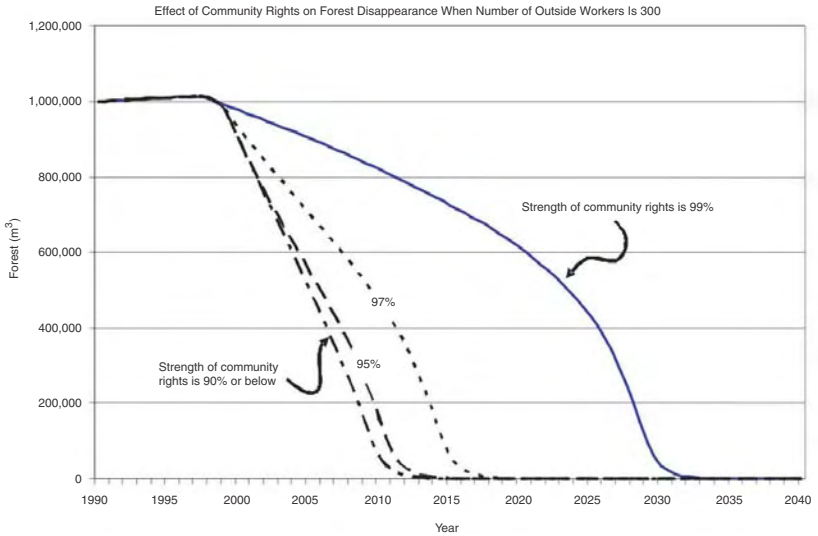


rangements to get logs then they will be less willing to invest in illegal operations. When community rights are strong we would expect to see less illegal logging, assuming that communities want to maintain a long term management approach.

Two problems tend to counteract the role that community rights can play in preventing illegal logging. Firstly, unless rights are very strong there is always some fraction of the forest that can be logged illegally. As that forest is logged community resolve will weaken allowing a larger fraction to be logged. Secondly, logging is to some extent limited by worker availability. If labor is limited then illegal entrepreneurs will be satisfied to use what labor is available on that portion of the forest not currently under community protection. In cases where labor is limited, the effects of moderate levels of community rights may not be noticeable.

Because there is a fairly large amount of forest available to be cut, community rights do not have a significant impact unless the strength of community control is high. For example, if *strength of community rights* is only 50% then entrepreneurs can work on harvesting the remaining 50% until community resolve weakens (Figure 13).

FIGURE 13. The strength of community rights can have a strong effect on forest integrity, but this effect is dependent on the proportion of outside workers available and has little effect if rights are not reasonably strong. Community rights which protect only a small portion of forest are irrelevant from the entrepreneurs' point of view since they can merely harvest other areas of the forest until community resolve weakens.



If community rights are weak but the number of workers is limited, then the number of workers available will limit entrepreneurs' operations. Consequently, if *number of outside workers available* is high then *strength of community rights* plays a bigger role (compare Figure 13 and Figure 14).

Enforcement

If enforcement is feasible it can have a major effect on forest protection. This is especially true if *strength of community rights* is weak and the *number of outside workers available* is high. That is, under conditions where illegal logging is most likely to occur enforcement is most likely to have a positive effect. Figure 15 illustrates this situation with 1,000 outside workers and 50% community control. At low levels of enforcement the forest disappears quickly, but at higher levels the disappearance is delayed considerably. Preventing villagers from working illegally prevents their income needs from being satisfied, which raises their willingness to work illegally. On the other hand, by maintaining forest cover enforcement tends to reinforce community support for long-term management. (Factors limiting the effectiveness of enforcement present an excellent subject for another model.)

Under the conditions of the model, enforcement did not significantly lower the effect that other illegal workers in the forest had on willingness. This is be-

FIGURE 14. If the number of outside workers is high then the effect of community rights will be more important because labor to harvest available forest is less limiting.

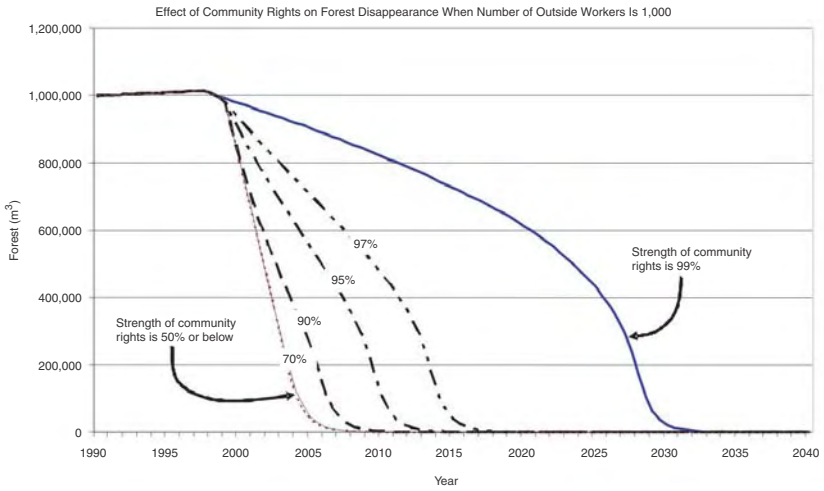
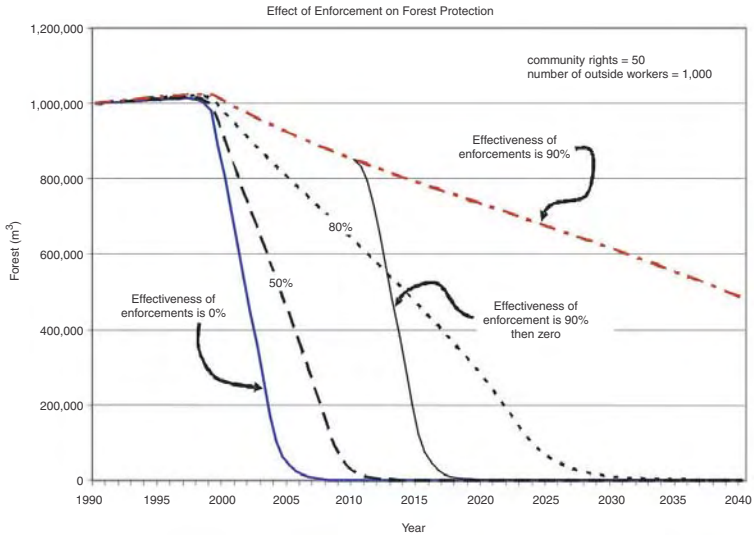


FIGURE 15. Enforcement has a major effect on protecting forest, especially if community rights are weak and the number of outside workers is high. However, with strong enforcement, villagers' willingness to engage in illegal activities due to income need remains high. Thus, if enforcement is suddenly weakened (as illustrated here in year 2010) then illegal activities will rapidly increase.



cause for most model conditions used (especially with 1,000 outsiders), regardless of enforcement effectiveness, there were always more illegal workers than the number of *people normally working illegally.* This situation tends to raise willingness. Even in a case with no outsiders, unless enforcement is very strong, enough illegal workers will be working (initially due to income need) that other workers will be influenced to want to join the ranks of illegal workers. This is, of course, dependent on how easily villagers are so influenced. Note that willingness to work illegally, by itself, does not necessarily mean the villagers work illegally. Both availability of salary money and enforcement affect whether a willing villager will actually work illegally.

DISCUSSION

The Model and the Real World? What Is Missing?

In considering the usefulness of the modeling process we need to consider if the model is good enough for its intended purpose. That is, can this model

help to explain basic causal relationships leading to villagers' willingness to engage in illegal logging? The model represents one attempt to describe and investigate these causal relationships. It simultaneously considers five feedback relationships connecting villagers' willingness to work illegally, their need for income, the availability of forest to support that income, the communities' role in good forest management, and illegal entrepreneurs' role in hiring villagers.

Within limitations the model does help to elucidate these relationships. We see more clearly that although income levels are raised by illegal logging, other factors also serve to stimulate additional willingness to work illegally even when income levels are already reasonably high. As forests disappear, willingness increases even further because community support for long-term management disappears as well. In examining the model, we are stimulated to consider other elements not included in the model's current structure. Some aspects of illegal logging at the village level are not specifically addressed by the model. Would addition of such factors improve the model, or would they merely make the model more confusing and harder to understand?

We may wonder, for example, if the amount that villagers consider as *desired income* might also rise as incomes from illegal logging rise. If this were the case, then as income expectations rose, it would be harder for *desired income* to be matched by actual income, and illegal logging levels would grow more rapidly. Also, the model includes no additional sources of income that might emerge as forests disappear. One example might be labor income from work on mono-crop plantations–typically oil palm in Indonesia. Alternate income sources would tend to lower the need for illegal employment, especially if these alternate sources grew as forests declined.

In the model, communities' views of long term forest management remain strong until the forest is obviously disappearing. In the real world, community views may be influenced, for example, by possibilities for other uses of community land such as plantation development. Most probably, as the value of alternate land uses rises, the communities' desire for long term forest management would weaken more rapidly.

In the model, forest disappearance does not generate more concern for forest protection, and this seems to agree with reality, at least in practical terms. That is, there is not a resurgence of meaningful community desire to protect forest resources as they disappear. We might use the model to help us consider possible changes to this portion of the real world system. As forest cover disappears, is there a feedback mechanism whereby the desire to protect and rehabilitate forest can be strengthened? Are communities willing to merely accept conversion of forest to non-forest, or can new mechanisms stimulate the desire for long-term forest management? Can such mechanisms be self-reinforcing?

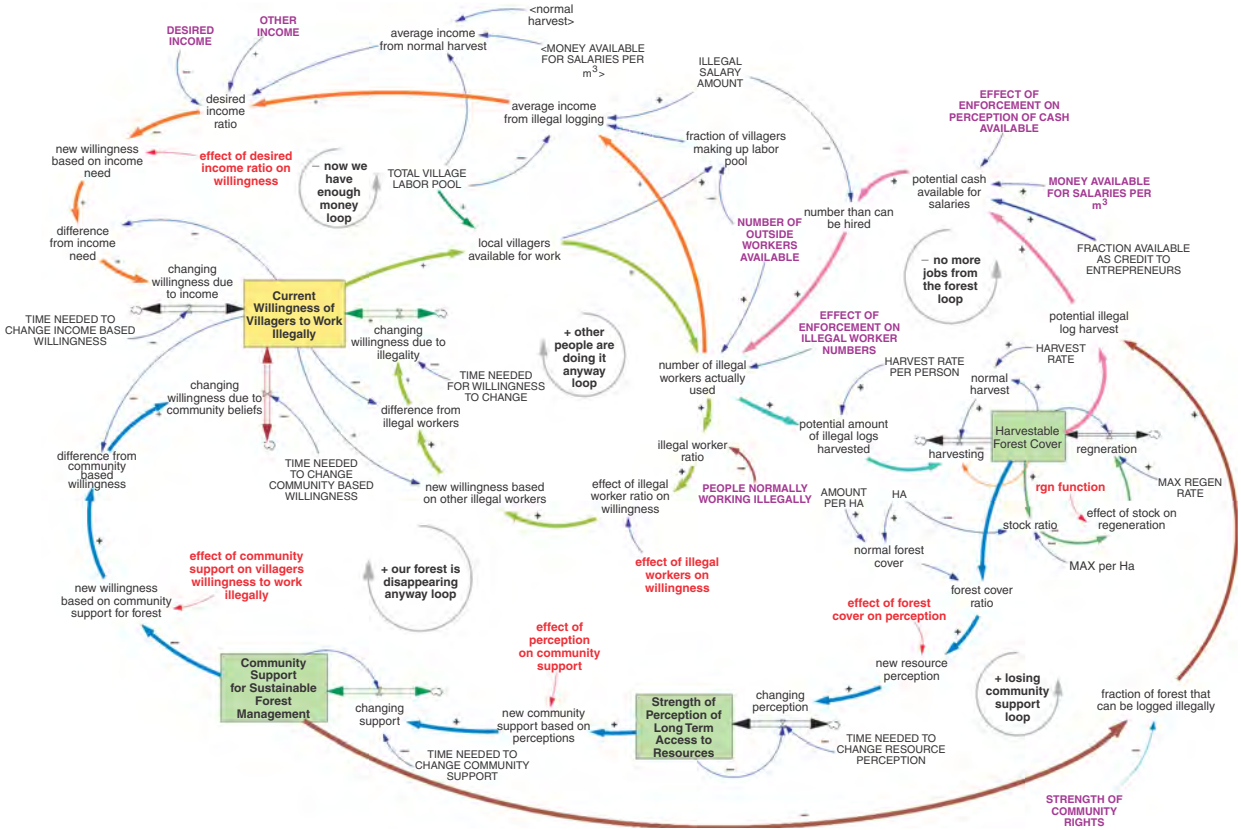
Except for competition for timber, the model does not examine specific relationships between legal and illegal logging. Where laws and regulations limit access to forest, increases in illegal logging from those same forests will remove future timber harvest originally destined for the legal operators. The model reflects this case. If, however, illegal logging is carried out in protected areas, for example, legal and illegal operations would not be in competition for timber. The model also does not reflect the situation whereby cheaper illegal timber and timber products provide competition for legally produced items. This is a subject for a related modeling effort.

Once illegal logging starts, its development in a given area seems to accelerate. This acceleration may be partly related to competition among illegal entrepreneurs and their corrupt colleagues in local government. In such an environment, those who can tend to scramble for resources creating a gold rush mentality. The urgency created by such activity would create additional pressures on communities, and community leaders may be bribed or tricked into illegal agreements. This would clearly hasten the spread of illegal logging. The model does not address such competition. Entrepreneurs in the model are motivated only by money available in standing timber, and there is no direct influence of entrepreneurial desires on weakening community resolve.

Although the model examines the role of outside workers, it is assumed that outsiders and villagers share work in proportion to their numbers in the labor pool. It is also assumed that money paid to villagers remains among villagers, and that paid to outsiders leaves the area. What proportion of outsiders become de facto villagers? Some of their money may stay within the communities and provide income for others. In the model the number of outsiders is determined externally. It is possible to allow the number to be determined by demand for labor. In this case labor would be less limiting and illegal logging would proceed more quickly.

The preceding paragraphs present a number of areas where the model may be inadequate or unfinished. However, the correction of these weaknesses could make the model less understandable and less able to provide insights. The purpose of the model is to provide a framework for thinking about illegal logging at the local level. It is not intended that this model will provide detailed management strategies. However, it can be used as a first step to examine larger, as well as more detailed, issues. Such examination can expose those secondary issues that might provide avenues for modification, not only to the model itself, but more importantly to the real illegal logging system that is our ultimate target.

MODEL 1. Willingness of Villagers to Engage in Illegal Logging



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