Property Rights and Tropical Deforestation

Robert Mendelsohn


Stable URL: http://links.jstor.org/sici?sici=0030-7653%28199410%292%3A46%3C750%3APRATD%3E2.0.CO%3B2-G

*Oxford Economic Papers* is currently published by Oxford University Press.

Your use of the JSTOR archive indicates your acceptance of JSTOR’s Terms and Conditions of Use, available at http://www.jstor.org/about/terms.html. JSTOR’s Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at http://www.jstor.org/journals/oup.html.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is an independent not-for-profit organization dedicated to creating and preserving a digital archive of scholarly journals. For more information regarding JSTOR, please contact support@jstor.org.
PROPERTY RIGHTS AND TROPICAL DEFORESTATION

By ROBERT MENDELSONH

Yale School of Forestry and Environmental Studies, New Haven, CT 06511, USA

1. Introduction

The fact that the world's tropical forests are shrinking is unmistakable. Although anthropogenic deforestation in temperate forests has come and gone over the last millennium, the rate of tropical deforestation has reached an historic high in the post World War II development boom. In the Amazon alone, the area deforested since WWII reached the size of France by 1980.

Although it is clear that current deforestation rates in the tropics impose large ecological impacts on tropical ecosystems, it is not clear whether or not the deforestation is an efficient economic activity. Deforestation can be efficient. For example, the deforestation which occurred in the temperate zone over the last two centuries converted an over-mature forested ecosystem into a much more productive landscape. With the rising demand for agricultural land, tropical deforestation could also be viewed as an adjustment process whereby tropical countries are moving from natural forests to more productive landscapes. Further, the improvement in transportation technology over the last century has made most of the world's natural forests economically accessible to timber harvesting. Most of this natural forest stock is economically overmature and ripe for harvest. Optimal control models (see Lyon and Sedjo 1983; Brazee and Mendelsohn 1990) of over-mature forests recommend that the older trees should be mined and the forest converted to younger stands. This mining process should end only when prices are high enough (timber is scarce enough) that the return from sustainable forestry justifies planting and sustainably managing new forest. Deforestation may be both desirable and efficient.

However, it is also plausible that a great deal of the deforestation now taking place is economically wasteful. Specifically, there are three market failures pertaining to tropical forest lands which could result in excessive destruction of forests: badly designed concessionaire agreements; subsidies for alternative land uses which destroy forests; and lack of adequate property rights. The first two of these issues have received substantial attention in recent years (see Binswanger 1987; Browder 1988; Gillis and Repetto 1988; Mahar 1989). Tropical countries have begun to take steps to curb these excesses and deforestation rates have slowed recently.

However, in many parts of the world, poorly-defined property rights may still be encouraging wasteful deforestation. The purpose of this paper is to explore how incomplete property rights may contribute to deforestation and
how this problem could be curbed. Problems with property rights have long been identified in the literature. The ‘tragedy of the commons’ results in people underinvesting in capital or land held jointly. However, the specific problems of settling a frontier and squatting on public lands have not been addressed formally. The models demonstrate that even minor flaws in the creation and enforcement of property rights can result in widespread destruction of forests. In Section 2, a model is developed of rent dissipation through excessive private defense of property rights. In Section 3, a model of long-term investment is developed which demonstrates that even relatively low probabilities of losing control of one’s lands are sufficient to discourage investment into long-lived assets such as forests. The paper concludes with observations concerning how to arrest the problems associated with poorly defined property rights.

2. A model of the frontier

Binswanger (1987), Browder (1988), and Mahar (1989) all identify a serious limitation in the Brazilian method of granting property rights in the frontier; colonists can only be granted title if they remove substantial forest cover from the land. These restrictions are actually commonplace, emanating from a desire to eliminate ‘speculators’ and frequently native citizens, in favor of ‘true settlers’ who are expected to ‘improve’ the wilderness. For example, improvement restrictions were required in American frontier development; settlers had to build cabins and clear lands to gain title (see Cronon 1983). In this section, we develop a formal model of frontier behavior in order to understand the consequence of these restrictions.

The model explores the behavior of colonists as they first come to control unclaimed lands. At first glance, these colonists should become wealthy as they gain title to lands for free. In fact, many never do. Further, it is not clear that societies always prosper as a result of their expansion into new frontiers.

Suppose there is a port of access into the frontier, with the frontier surrounding this port on all sides. Suppose that land in this frontier could produce $Z$ units of output sustainably (without declining over time). Suppose that units of $Z$ could sell at price $P_z$ at the port but to get there require transportation expenditures $T \cdot d$ where $d$ is distance from the port. The social value of a unit of land will be equal to the present value of profits

$$V(d) = (P_z \cdot Z - T \cdot d)/r$$

(1)

where $r$ is the discount rate. The value of land decreases with distance from the port ($\Delta V/\Delta d < 0$) because of increasing transportation cost. Development will stretch from the port until the value of the further most hectare is zero ($V(d_{max}) = 0$). At each distance, there will be an equal-valued ring of land of size $2\pi d$.

Suppose that property rights over the new frontier have not yet been defined. In order to secure land, each person must invest resources, $x_i$ per hectare, in defending or creating his property right. For example, the colonist might have
to build fences or cabins or cut down and burn forest land. Suppose that individual \(i\) can purchase private protection with a single purchase of \(x_i\) at a constant cost of \(c\) per unit. Of course, some defensive expenditures must be made over a long period of time in which case one would have to calculate the present value of these expenditures.

How much land any single frontiersman can obtain is limited by competition with other potential settlers. Suppose that each settler’s share of each ring of land (\(2\pi d\) hectares) depends on the amount of \(x\) that person invests relative to the amount of \(x\) spent by the entire group. Each person’s share of the ring is proportional to his share of \(\Sigma x_k\), the total property protection effort expended by everyone in the ring. The profit function \(W(d)\) per hectare for each individual is

\[
W(d) = (P_z * Z - T * d) * x_i / (r * \Sigma x_k) - C * x_i
\]  
(2)

Differentiating \(W(d)\) with respect to \(x_i\) and setting the result to zero yields the following first order condition

\[
[(P_z * Z - T * d) / r] * [((\Sigma x_k - x_i) / (\Sigma x_k)) - C * \Sigma x_k = 0
\]  
(3)

If there are many competing colonists, the expression in the second bracket on the lefthand side will go to 1 and (3) will simplify to

\[
(P_z * Z - T * d) / r - C * \Sigma x_k = 0
\]  
(3’)

In this limiting case, individual maximizing behavior will lead competing colonists to spend as much money creating their property rights as the land is worth. Development will be physically sustainable but society will reap zero net benefits. Colonists will just cover their costs as they dissipate the value of the fronter resource on an expensive property right acquisition program.

Even with a relatively small number of colonists, a surprisingly large fraction of the potential value of the land will be dissipated. For example, using (3) and assuming that there are five equal colonists, the colonists would spend 80% of the value of the resource privately defending their property values. Unless an efficient social program is established which allocates and protects property rights, the frontier resource will largely be wasted.

Note that because the value of land close to the port is higher, the above model predicts that settlers will spend even larger amounts in these nearby lands defending their rights. Frontier communities appear to have addressed this problem. By jointly establishing local order in towns (ports), the settlers can avoid these highly wasteful property struggles. More remote locations, however, remain largely unprotected. Frontier societies often cannot afford to establish order in these less-populated areas because of the high cost and low land value. More remote areas are more likely to suffer from the waste described in this model.
3. A model of squatters

Feder et al. (1988) provide a detailed account of landowners in Thailand, contrasting the behavior of farmers with and without title. Landowners with title made more agricultural improvements than those without. The authors argue that title is important because it gains access to credit. However, even with better credit access, forest squatters are likely to make less long-term investment. Without title, owners must live with at least a small probability that they will be evicted. Even small probabilities of losing one’s land make long-lived assets such as forests unattractive compared to less sustainable activities which yield more immediate returns.

Suppose a tropical forest can sustainably withstand light harvests of $Q$ units of wood every $t$ years. Although sustainable tropical forestry is not frequently practised, silviculturalists have identical sustainable harvesting practices for tropical forests (see Sharma 1992). Suppose that the wood, $Q$, taken out in these harvests has a stumpage price of $P_q$. Starting with a mature forest, the present value of this future stream of intermittent revenue is

$$V_f(t) = P_q Q(t)/(1 - e^{-rt})$$  \hspace{1cm} (4)

Alternatively, the forest could be used to sustain a constant annual flow of non-timber forest products (NTFP’s) such as fruit, latex, rattan, grazing, or medicine (Peters et al. 1989; or Balick and Mendelsohn 1992). In this case, the present value of the forest would be

$$V_{mf} = P_{mf} Q_{mf}/r$$  \hspace{1cm} (5)

As long as the present value of the forest exceeds the present value of alternative land uses, the forest should be protected by the landowner.

Suppose an alternative land use was a destructive agricultural process with decaying physical output; i.e. the agricultural productivity decayed at an exponential rate, $\alpha$. The present value of the alternative land use would be

$$V_a = \int_0^\infty (P_z Z e^{-zt} e^{-rt}) dt = P_z Z/(t + \alpha)$$  \hspace{1cm} (6)

For the forest land uses to dominate the nonsustainable use, $V_f$ or $V_{mf} > V_a$. The longer the rotations (the greater $t$) and the periods between timber harvests, the larger must be the revenue from each harvest for timber to remain competitive as a land use. The more decadent the nonsustainable use (the greater $\alpha$) the larger must be the initial payoff from the destructive use in order to engage in the farming alternative.

Let us now explore the impact of insecure land tenure. Suppose that there is a small chance each year, $\lambda$, that the squatter will be evicted from the land. Upon eviction, the squatter loses all future income from the land. The present value of timber forestry is now

$$EV_f(t) = P_q Q(t) + P_q Q(t) e^{-rt}(1 - \lambda)^t + P_q Q(t) e^{-2rt}(1 - \lambda)^{2t} + \cdots$$

$$+ P_q Q(t) e^{-urt}(1 - \lambda)^{rt} + \cdots$$
Defining $e^{-\delta t} = (1 - \lambda)^t$, it follows that $\delta = -\log(1 - \lambda)$. As long as $\lambda$ is a function between 0 and 1, $\delta$ is a positive number. Making the substitution into the present value calculation reveals

$$EV_f(t) = P_qQ(t) + P_qQ(t) e^{-(\delta + r)\tau} + P_qQ(t) e^{-2(\delta + r)\tau} + \ldots$$

which can be simplified to

$$EV_f(t) = P_qQ(t)/(1 - e^{-(\delta + r)\tau}) \quad (7)$$

The higher the eviction rate, the smaller the value of forest land.

The value of sustained harvest of NTFP’s is also affected by eviction factor $\delta$, the present value falls to

$$V_{mf} = P_{mf}Q_{mf}/(r + \delta) \quad (8)$$

With the probability of eviction, the present value of the more destructive land use is

$$V_d = \int_0^\infty (P_z Z e^{-x_1} e^{-x_1} e^{-x_2}) dt = P_z Z/(r + \alpha + \delta)$$

Let us now compare sustainable forest practices against destructive agricultural alternatives. With positive eviction rates, the present value of all streams of revenue fall in value. However, the value of sustainable resources which have larger future rewards tend to fall more rapidly than unsustainable activities. In order to illustrate this point, we compare the present value of different land uses with alternative eviction rates. For clarity of exposition, we set the present values of all land uses equal for the zero eviction case. We then introduce eviction rates of between 0.02 and 0.10. The results are displayed in Table 1.

Eviction rates reduce the present value of sustainable forest uses relative to destructive agricultural practices. For example, with 8% eviction rate, the value

<table>
<thead>
<tr>
<th>Eviction rate ($\lambda$)</th>
<th>Timber</th>
<th>Minor forest products</th>
<th>$\alpha = 0.1$</th>
<th>$\alpha = 0.2$</th>
<th>$\alpha = 0.3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>0.02</td>
<td>0.836</td>
<td>0.714</td>
<td>0.874</td>
<td>0.922</td>
<td>0.944</td>
</tr>
<tr>
<td>0.04</td>
<td>0.767</td>
<td>0.556</td>
<td>0.774</td>
<td>0.855</td>
<td>0.893</td>
</tr>
<tr>
<td>0.06</td>
<td>0.733</td>
<td>0.450</td>
<td>0.694</td>
<td>0.795</td>
<td>0.846</td>
</tr>
<tr>
<td>0.08</td>
<td>0.717</td>
<td>0.379</td>
<td>0.627</td>
<td>0.742</td>
<td>0.803</td>
</tr>
<tr>
<td>0.10</td>
<td>0.708</td>
<td>0.323</td>
<td>0.571</td>
<td>0.696</td>
<td>0.763</td>
</tr>
</tbody>
</table>

* The figures have been normalized to 1 so that all five land-use activities would have equal value in a world with secure tenure. A real interest rate of 0.05 has been assumed throughout.
of NTFP collection falls to below 50% of some of the more destructive land uses. Even with relatively low eviction rates of just 2%, the value of NTFP collection can fall to 77% of more destructive activities. Even low rates of eviction make destructive land use choices relatively more attractive than sustainable choices. Insecure property rights lead a society to wastefully destroy their forests.¹

4. Conclusion

This paper identifies reasons why wasteful deforestation may be caused by poorly-defined property rights. In the first model, colonists can obtain property rights through private defense expenditures. In this case, real resources are lost in an effort to secure property rights. As with common property resources, the effort allocated to the acquisition of property rights can equal the value of the resource. A large fraction of the value of the natural resources can be dissipated.

In the second model, we examine the land use choice of squatters subject to low rates of eviction. Even small rates of eviction discourage squatters from maintaining productive forests. The possibility of eviction leads squatters to choose short-term destructive land uses with lower present values. The squatters are rational given the property right system in which they find themselves, but with full rights they would have preserved more forest.

Permitting landless squatters temporary rights on public land may be a politically expedient mechanism for land reform. Unfortunately, without guaranteeing long-term control to squatters, this type of progress discourages sustainable land uses and leads to the destruction of natural assets. In the long run, the society will deplete its resources without enjoying their full benefits, leaving the country even poorer than it was before.

In order to correct these problems, property rights must be secured in an efficient and prompt manner. For example, property rights to well-defined parcels of land could be sold in financial markets rather than requiring land ‘improvements’. People will then bid for the property right, allowing a transfer of resources from the successful bidder to the government. Although purchase of public lands is sometimes viewed as unfair because it leads to wealthier people controlling frontier land, it also leads to substantial wealth transfers from richer individuals to the government. To counterbalance remaining equity impacts, some portion of the collected funds from land sales could be allocated to poor people so they can also buy land.

An alternative approach is to give the land to citizens without requiring improvements. For example, one could engage in a lottery where every one had an equal chance of winning land. This would yield a more random allocation of land resources to people.

An efficient property rights system requires an extensive surveying project.

¹ With mature forests, evictions benefit timber relative to minor forest products because a higher fraction of revenue can be collected immediately with timber.
It is important that the resulting parcels be designed with the optimal size of the best land use in mind. The development of the United States is quite helpful as an illustration. In the plains, the land was divided into 100-acre rectangles, each of which was ideal for supporting a family on a farm. When it came time to survey the more arid West, the identically-shaped parcels could not support a family. Western development consequently proceeded in a far more destructive manner with substantial acrimony.

In the case of tropical forests, the optimal size of a parcel is still unknown. If it is to be used for grazing, the size should be quite large. However, alternative land uses which depend on natural forests or agroforestry may be optimal at smaller sizes of perhaps 100–200 hectares. Care should be taken to fit the local geography, climate, and soils so that the parcels can be used efficiently to support at least one family.

Finally, grandiose claims that strong property rights will stop all deforestation, guarantee sustainability, secure immense wealth, and control externalities such as watershed effects, biological conservation, or global warming cannot be made. Strong rights will only end one source of wasteful behavior. Ultimately deforestation will only stop when the remaining forests are more valuable than alternative uses, as is clear in the history of temperate forests in Europe and North America. Landowners will engage in sustainable management only if and when it is profitable. Low quality lands, because of their soils, climate, or access, will remain low-valued even when managed efficiently. Externalities will remain unabated without government controls. Secure property rights do not guarantee long-term well-being, but they do make an important contribution towards encouraging the prudent management of the world’s scarce resources.

REFERENCES


