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INTRODUCTION

Tropical deforestation has become the subject of considerable debate and concern. Experts disagree over how quickly tree-covered land near the equator is being cleared (Lanly, 1982) and deforestation's impacts on global climate (Detwiler and Hall, 1988). By contrast, the claim that land clearing threatens the world's stock of "biological information" is less controversial. Tropical forests' high biological diversity is indisputable; although they cover less than 10 percent of the Earth's land surface, they contain approximately half the world's plant and animal species (Wilson, 1988).

Concern over the impacts of tropical deforestation in Africa, Asia, and Latin America has begun to stimulate analysis of national policies conditioning human interaction with natural environments in the developing world. World Bank economists have found that subsidies and tax breaks encourage land clearing in the Brazilian Amazon (Binswanger, 1989; Mahar, 1989). In addition, the argument is made that rural development policies pursued in a number of countries displace the rural poor, who tend to resettle in environmentally fragile hinterlands (Blaikie, 1985). To date, however, investigation of the social context of deforestation has not included much analysis of the tenurial incentives at work along expanding agricultural frontiers. This is a serious omission since, as Bromley and Cernea (1989) point out, tangible environmental problems in developing countries are often a manifestation of underlying institutional crisis.

This paper addresses that crisis, tropical deforestation in Ecuador serving as a case study. To begin, the tenure regime facing those who live in or use tree-covered land in that country is described. Next, four specific institutional incentives for deforestation in Ecuador and other Latin American countries are examined. First, the waste and misuse of forest resources is,

in part, a classic open access problem. Second, stipulating that deforestation is a prerequisite for land tenure sets in motion a cycle of excessive land clearing and erosive farming. Third, bureaucratically induced tenure insecurity further diminishes private incentives to conserve natural resources. Fourth, formal property law in Latin America induces the demise of indigenous common property regimes, which have long provided a framework for sustainable agriculture and forest conservation.

Based on an examination of these four institutional incentives, we conclude this paper with a discussion of policy reforms needed to ensure the conservation of Latin America's tropical forests.

THE TENURIAL ENVIRONMENT IN ECUADOR

It is appropriate to begin an overview of any Latin American country's institutional regime by recognizing that the state makes extensive claims on the natural environment. In Ecuador, for example, subsurface resources are government property. With passage of the 1972 Water Law, all water resources were nationalized. Coastal wetlands are "national patrimonies." Similarly, most of the country's tree-covered land is designated as "forest patrimony" or national parks.

These claims far outstrip the government's capacity to manage resources or even to ensure that its claims are honored by the public at large. Weak management of Ecuador's public forests is a case in point. No rangers work in the 2,000,000 HA of forest patrimony delimited in the northwestern and northeastern parts of the country (MAG, 1987) and, as of 1987, a mere two administrators, 25 technicians, and 119 permanent and seasonal rangers had been assigned to the 2,100,000 HA of parks in continental Ecuador (DINAF,

1988).

A marked discrepancy between public sector claims on resources and the government's capacity to control access to "its properties" can bring about what Hardin (1968) calls a "tragedy of the commons." Recognizing the potential for open access problems, Ecuador's government allows individuals and firms to acquire public lands. However, ecosystem destruction is typically a prerequisite for private tenure. Private parties interested in forest management, for example, cannot acquire legal interests in tree-covered land, timber concessions having been banned in 1982. Instead, the Ecuadorian Institute for Agrarian Reform and Colonization (IERAC) has only adjudicated a claim for private tenure in a frontier parcel if at least half of that parcel had been cleared.

By no means does deforestation win an agricultural colonist formal tenure quickly. IERAC requires a long time, often years, to adjudicate claims for formal property rights. Delays are explained in part by administrative constraints. IERAC's record-keeping system is extremely cumbersome and the agency did not acquire its first computer until the late 1980s. In addition, the complexity of formal property law draws out the adjudication process. As Seligson (1984) points out, IERAC is obliged to execute ten separate procedures during the course of settling a tenure claim.

To complete a description of institutional conditions in Ecuador's tropical forests, one must consider the impacts of formal property law on the country's indigenous inhabitants. Those impacts have been the subject of a great deal of anthropological research. Macdonald (1981) reports, for example, that the periodic fallowing scheme long practiced by the Amerindian community of Pasu Urcu, in eastern Ecuador, was abandoned during the 1970s

after IERAC agents informed the community that fallow lands could be claimed by agricultural colonists, who were 50 KM away at the time. This and other case studies suggest that Amerindians respond to tenurial incentives much as do agricultural colonists. As a result, indigenous resource management regimes are discarded.

Ecuador's property rights regime is entirely representative of institutional conditions throughout Latin America. In every country with extensive tropical forests, the public sector's claims on tree-covered land far outstrip its ability to manage or to control resources. Accordingly, open access problems are chronic. Throughout the region, deforestation is a prerequisite for formal tenure. Agricultural colonists in the Brazilian Amazon, for example, obtain title in a forested parcel only by clearing a large part of it (Mahar, 1989). By the same token, tenure insecurity is a problem in most of Latin America. IERAC's time-consuming adjudication procedures are followed throughout the region by counterpart agencies established in the early 1960s under the auspices of the Alliance for Progress, as de Soto (1989) has documented vividly in a case study undertaken in Lima, Peru. Finally, suppression of indigenous groups' tenurial arrangements is the norm in many Latin American countries.

In the sections that follow, we describe how each of these elements of the institutional order in Latin America contributes to depletive human interaction with the natural environment.

OPEN ACCESS PROBLEMS

Four specific institutional incentives for deforestation are relevant to much of Latin America. The first of these is the problem of "open access."

The distinction between "open access" and "common property" is a celebrated one in the resource economics literature, although one continually finds confusion between the concepts at the level of both theory and policy. As Ciriacy-Wantrup and Bishop (1975) clearly show, common property (res communes in Roman law) and open access (res nullius) are two quite different structures of property rights.

Often, what appears to the outside observer to be open access may involve tacit cooperation by individual users according to a complex set of rules specifying rights of joint use. This is common property. Empirically, it is crucial to distinguish between open access and common property if appropriate policy is to be formulated. Problems of open access arise from unrestricted entry, whereas problems of common property result from tension in the structure of joint use rights adopted by a particular village or group. These tensions may arise from a variety of complex causes, including population pressure, changes in technology, climate, or political forces. Too often, these causes have been confused, and the problem ascribed simply to the "Tragedy of the Commons," in which the misuse of resources is attributed to the institution of common property itself.

A fundamental issue in much of the developing world is the degree to which resource mismanagement has actually been caused by common property arrangements. In the Sahel and southern Africa, for example, serious misuse of resources has been alleged to be the direct result of traditional common property institutions (see Hitchcock, 1981; Picardi and Seifert, 1976; Glantz, 1977). In response, Western economic consultants and planners have called for the imposition of private property rights (Johnson, 1972; Picardi, 1974). Similarly motivated private property schemes have been attempted throughout

the developing world. Many, perhaps most, have failed to stop overuse, and in many cases may have contributed to even more rapid degradation of resources and increased inequality in already unequal distributions of wealth. Not unlike the European experience with enclosure, lands formerly held in common are often transferred to individuals (such as high-ranking government bureaucrats) who can exercise influence in the allocation of use rights. These individuals have then failed to manage these resources effectively. Despite this record, such policies are often supported by those who argue on theoretical grounds that individual incentives inevitably lead common property to be mismanaged. Modern economists often refer to this as the "free rider" problem. When applied to resource management, the free rider problem leads to the conclusions that common property is not a viable institutional alternative.

Yet common property may be as viable as private property on grounds of both efficiency and equity. Rather than representing an atavistic arrangement of rights which inevitably results in inefficient resource use, much value may lie in existing common property institutions, as well as in new institutional arrangements with common property characteristics. In many cases, these institutions are well adapted to the particular resource constraints facing villages and groups in developing countries. In this sense they relate to work on institutional constraints and innovation developed by Hayami and Ruttan (1985).

In Ecuador and throughout Latin America, state claims of property rights are unenforceable and essentially meaningless. Furthermore, by undercutting legitimate systems of common property, such claims lead to a system of open access, to which the only apparent solution is often argued to be

"privatization." The result is that the possible advantages of common property management are lost in the shuffle.

THE CYCLE OF EXCESSIVE LAND CLEARING AND EXCESSIVE SOIL EROSION

To avoid open access problems of the type described in the preceding section, the governments of Ecuador and other Latin American countries routinely transfer natural resources to private parties. The legal tradition governing this transfer dates to the early days of the colonial era, the first European settlers in the Andes having been ceded "idle" lands (tierras baldias) only when they proposed to use those lands for crop or livestock production. This tradition is deeply imbedded in formal as well as informal property law. IERAC and counterpart agencies in neighboring countries have required that idle forests be converted into "productive" cropland or pasture before recognizing private rights in a colonized parcel. At the same time, agricultural use rights are the central feature of informal tenure regimes throughout Latin America.

Vesting private tenure in those who convert tropical forests into agricultural land serves powerful political and economic interests. The establishment of "live frontiers" is viewed in many countries as a way to strengthen a nation's territorial claims in the Amazon Basin and other remote areas (Landau, 1980). In addition, the migration of the rural poor to the frontier tends to vent social pressures that can lead to political conflict (Blaikie, 1985). However, where land clearing is a prerequisite for property rights, a cycle of excessive clearing and soil depletion tends to be set in motion.

The institutional underpinnings of this cycle can be clarified with the

aid of a model, developed by Southgate (1990), that describes the opportunity costs of inputs allocated to deforestation and soil conservation (N_D and N_C , respectively) as well as the returns to those same inputs. Opportunity costs, W , are an increasing function of the sum of N_D and N_C :

$$W = W [N_D + N_C] \quad W' > 0 . \quad (1)$$

The returns to land clearing, R_D , comprise the present value of crops grown on newly deforested land less the discounted opportunity cost of agricultural inputs employed on that same land. In general, those returns are an increasing and concave function of the extent of deforestation, which can be represented as N_D divided by the inputs needed to clear a unit of land, d :

$$R_D = R_D [N_D/d] \quad R_D' > 0 \quad R_D'' < 0 . \quad (2)$$

The returns to erosion control, R_C , comprise two parts. The first is the present value of additional crop production that comes about because a higher level of soil quality is maintained. The second part is the present value of any persisting reduction in crop production costs. Each element of R_C is an increasing and concave function of the area where erosion control measures are being applied, which can be represented as N_C divided by the inputs needed to control erosion from a unit of land, c :

$$R_C = R_C [N_C/c] \quad R_C' > 0 \quad R_C'' < 0 . \quad (3)$$

Since agricultural colonists are preempted from capturing non-agricultural rents (e.g., the net returns to forest management), they try to maximize the present value of additional crop production associated both with soil conservation and land clearing less the opportunity costs of those two activities. This is accomplished by satisfying two first order conditions:

$$W' = R_C'/c \text{ and} \quad (4)$$

$$W' = R_D'/d . \quad (5)$$

Equation (4) indicates that a settler should increase inputs allocated to erosion control, N_C , up to the point where N_C 's marginal opportunity cost, W' , equals the marginal returns of those same inputs: R_C'/c . A similar rule, expressed in equation (5), governs a colonist's decisions regarding N_D .

The inefficiency of the second guideline, equation (5), is obvious. When the tenure regime prevents individuals from capturing non-agricultural rents, agriculture's extensive margin is found where agricultural rents equal zero. By contrast, the agricultural frontier is found where agricultural rents equal non-agricultural rents whenever settlers are in a position to take into account the returns and costs associated with non-agricultural land uses.

As settlers respond to institutional incentives by allocating too many inputs to land clearing, a second inefficiency arises. With N_D set too high, inputs' current scarcity value rises. This, in turn, discourages erosion control. The linkage between N_C and N_D is appreciated by referring to a four quadrant diagram (Figure 1), the northeastern and southwestern quadrants of which show R_C'/c and R_D'/d , respectively. Also indicated in the southwestern quadrant is the difference between R_D'/d and the marginal rental value of tree-covered land, C/d . The marginal opportunity cost of inputs currently allocated to soil conservation and land clearing, W' , is shown in the northwestern quadrant and the sum of N_C^* and N_D^* is represented in the southeastern quadrant. Note that, if the tenure regime were to change so that farmers could internalize the marginal rental value of tree-covered land, not only would inputs allocated to deforestation decline, from N_D^* to N_D^* , but the associated decrease in wages would induce an increase in conservation effort, from N_C^* to N_C^* .

The cycle of excessive deforestation and insufficient erosion control that is set in motion by a frontier tenure regime is not necessarily decelerated by a change in non-institutional incentives. Lower interest rates or higher commodity prices, for example, enhance both the present value of crops grown on deforested land and the present value of additional crop production associated with erosion control. These impacts are represented by outward displacement of the two functions, R_C'/c and R_D'/d , shown in the northeastern and southwestern quadrants, respectively, of Figure 1. Responding to this shift in incentives, settlers allocate more labor to soil conservation as well as to deforestation.

Whether N_C^* and N_D^* rise or fall in response to increased timber prices depends entirely on the tenure regime. If non-agricultural rents (value C in the model) can be captured, then the price increase discourages land clearing, N_D . As a result, the current opportunity cost of labor falls, which in turn causes N_C to rise. Under a frontier tenure regime, by contrast, settlers selling logs removed from land to be used for agricultural production treat timber values as a negative argument of land clearing costs. Consequently, an increase in those values enhances R_D/d , both absolutely and relative to R_C/c . As illustrated in Figure 2, this accelerates deforestation and discourages soil conservation.

RESOURCE DEVELOPMENT AND BUREAUCRATICALLY INDUCED TENURE INSECURITY

Legal traditions governing the transfer of tierras baldias to private parties are not the only way that property rights are attenuated in Latin America. Bureaucratically induced tenure insecurity is also chronic

throughout the region. Furthermore, just as a cycle of excessive deforestation and insufficient erosion control arises where agricultural use rights are a major feature of the institutional order, insecure property rights contribute to depletive human interaction with the natural environment.

In part, tenure insecurity discourages resource conservation by reducing the chances that current land users will capture the long term benefits of resource conservation. A typical situation arises when a farmer has doubts about when or if his application for formal tenure will be accepted. At least for the time being, that farmer will not adopt erosion control measures, for example, that enhance crop yields only after the passage of several years.

Insecure property rights also contribute to resource degradation by impeding access to formal credit. In most Latin American countries, public sector development banks loan money only to those farmers whose land has been adjudicated. Private banks, of course, do not accept non-adjudicated land as collateral. Denied access to formal credit, farmers without clear title to their land must rely on informal credit markets, in which interest rates are considerably higher. This discourages the adoption of conservation measures (e.g., a switch to agroforestry) that carry short term costs.

The results of empirical research carried out in a number of developing countries bolster the argument that insecure property rights influence decisions regarding the use and management of natural resources. Feder et al. (1988) have found a clear statistical relationship between the strength of farmers' formal property rights and their willingness to invest in land improvements. In Latin America, Southgate et al. (forthcoming) have identified a statistically significant linkage between deforestation and tenure insecurity in eastern Ecuador's Amazonian lowlands. The latter finding

bears out the claim that agricultural colonists safeguard their tenuous legal claims on land by using it continuously for crop and livestock production (Rudel, 1983).

The problem of insecure property rights is chronic for Latin America's small farmers. That same group also tends to be concentrated on environmentally fragile lands. Accordingly, enhancing tenure security is an essential element of strategies to the region's renewable natural resources.

THE DEMISE OF INDIGENOUS TENURE REGIMES

Tenure insecurity is not a problem only for recent migrants to the agricultural frontier. The property rights of indigenous forest dwellers are also in jeopardy. As a result, the latter group is encouraged to participate in the destruction of the habitat from which it has traditionally drawn sustenance.

The assault on forest dwellers' tenure is often direct. The creation of parks and military zones and other forms of resource nationalization renders irrelevant the structure of rights and duties previously developed by the local community. Similarly, recognizing private land claims while ignoring communal claims, as several Latin American governments have done from time to time, assures the demise of common property, which is the predominant form of tenure in Latin America's tropical forests. Because it has tended to obfuscate the distinction between open access resources and common properties, the economic literature addressing the tragedy of the commons has legitimized this policy approach.

More subtle forms of pressure are often applied against forest dwellers' communal property arrangements. In many countries, registering a communal

claim requires more time, money, or legal expertise than registering an individual claim. This is an important drawback for indigenous groups, which have limited financial means as well as restricted access to legal services. In addition, when governments state that land uses characteristic of communal tenure regimes are "non-tenurable," those regimes tend to break down. From an individual's standpoint, for example, the net benefits of observing following norms are seriously diminished by laws, such as those that exist in much of Latin America, that make land "improvement" a prerequisite for formal tenure. Because improvement has, in practice, been equated with deforestation, forsaking encroachment on a fallow parcel carries the risk that someone else will assert an individual claim on that same parcel. Anthropological case studies, like the one carried out by Macdonald (1981), show that indigenous forest dwellers respond to this risk by forsaking traditional common property arrangements and becoming agents of deforestation.

A variant of a model first developed by Schelling (1973) can be used to understand this response. Described in that model are the benefits for an individual of cooperating in a collective resource management scheme as well as the private benefits of defecting from the scheme. The former equal the individual's share of total net returns of the scheme captured by the cooperating coalition. Generally, the private benefits of cooperating increase as the size of the coalition increases. The benefits for an individual of defecting, which are also a positive function of the number of agents who join the cooperating coalition, consist of part or all of the benefits of the collective scheme not captured by the coalition along with other net returns of individual action.

If the private benefits of defecting exceed the private benefits of

cooperating regardless of the size of the cooperating coalition (i.e., if defection is a universally dominant strategy), the game is a multi-person prisoner's dilemma. In such a game, individuals must be coerced into adhering to a mutually beneficial collective arrangement. Another possibility is depicted in Figure 3, which describes the benefits to one individual of cooperating or defecting in a strategically interdependent game with $n + 1$ players. If a "minimum coalition" of n^* or more players is assembled in that game, then other individuals will freely choose to cooperate as well.

Setting deforestation as a prerequisite for property rights reduces the private benefits of cooperating in traditional collective resource management schemes. Within the context of the model, this event is represented by downward displacement of the curve relating private benefits of cooperation to the size of the cooperating coalition (see Figure 4). If those benefits fall, stronger forms of coercion must be used to make individuals observe group rules. Alternatively, it becomes more difficult to raise within a group the minimum coalition needed to bring about universal voluntary agreement in collective schemes. As illustrated in Figure 4, a decline in the private benefits of cooperating results in an increase (from n^* to n^{**}) in the size of the minimum coalition needed to effect a collective management scheme.

SUMMARY AND CONCLUSIONS

Institutional reform is always a politically charged undertaking. Ideologues of the right, who have supreme confidence in the workings of the marketplace, argue that all natural resources should be divided among private holdings, the owners of which can be expected to develop their properties efficiently. They distrust any deviation from a perfectly comprehensive

regime of private tenure, expecting that a tragedy of the commons will arise wherever a resource is not privately owned. At the same time, ideologues of the left doubt that market exchange of private interests in natural resources can ever result in their being used wisely. Only government, they reason, is capable of developing resources efficiently.

Neither perspective should be neglected. Most societies are very comfortable with the idea of dividing agricultural land, for example, among private holdings. Provided nonpoint pollution associated with agricultural production does not result in major downstream costs, there is no strong reason for government to interfere in private decisions regarding the use, management, or exchange of agricultural holdings. By contrast, some resources (e.g., the air we breathe) cannot be divided among private holdings. Government must take primary responsibility for the conservation of such resources.

Of course, the dogmatic right is loathe to acknowledge instances in which tenurial arrangements favored by the left are suitable. Similarly, it is difficult to convince the rigid left that decisions regarding the use and management of many resources are best left to individual property owners heeding price signals generated in unregulated, competitive markets. Furthermore, both extremes share an ideological blindspot. As Hayami (1988) points out, neither the left nor the right has been prepared to admit the value of "intermediate" tenurial arrangements: the institutions communities around the world have long used to deal with "local externalities."

Local externalities are a universal feature of agriculture and natural resource development. For example, one farmer's water use is bound to have a direct effect on the welfare of his neighbors just as his welfare is greatly

affected by their water use. Economists are only now beginning to recognize that game theory and other models can be used to explain why an individual agent facing such a situation finds that his or her personal welfare is enhanced by voluntarily cooperating in collective institutional arrangements (e.g., a village level water rationing scheme) developed to address local externality problems (Schelling, 1973; Axelrod, 1984).

As a consequence of growing interest in such arrangements, however, the "menu" of tenurial solutions to third world environmental problems is being expanded. It has always included the policy prescriptions of the right (i.e., strengthening or establishing private property rights) as well as those of the left (i.e., increasing public sector control of resources). Intermediate approaches (i.e., reenforcing the institutions communities have long used to resolve local externality problems) are now generally accepted as being worthy of consideration as well.

More than anything else, applying the menu of tenurial solutions to resource degradation problems requires hard-headed economic objectivity. That is, all costs and advantages of different tenurial approaches to any particular environmental issue must be carefully assessed. For example, before deciding to draw on the strengths of a regime of private property rights, the costs of establishing and administering such a regime, which can be considerable (Runge, 1986), need to be investigated. Similarly, heavy reliance on community-level arrangements is a suitable approach to environmental policy only when local externalities are truly important. Finally, even when the impacts of resource degradation are broadly distributed, government action is called for only if expected improvements in environmental quality compare favorably to the costs of that action.

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Figure 1: Land Clearing and Erosion Control under Alternative Tenure Regimes

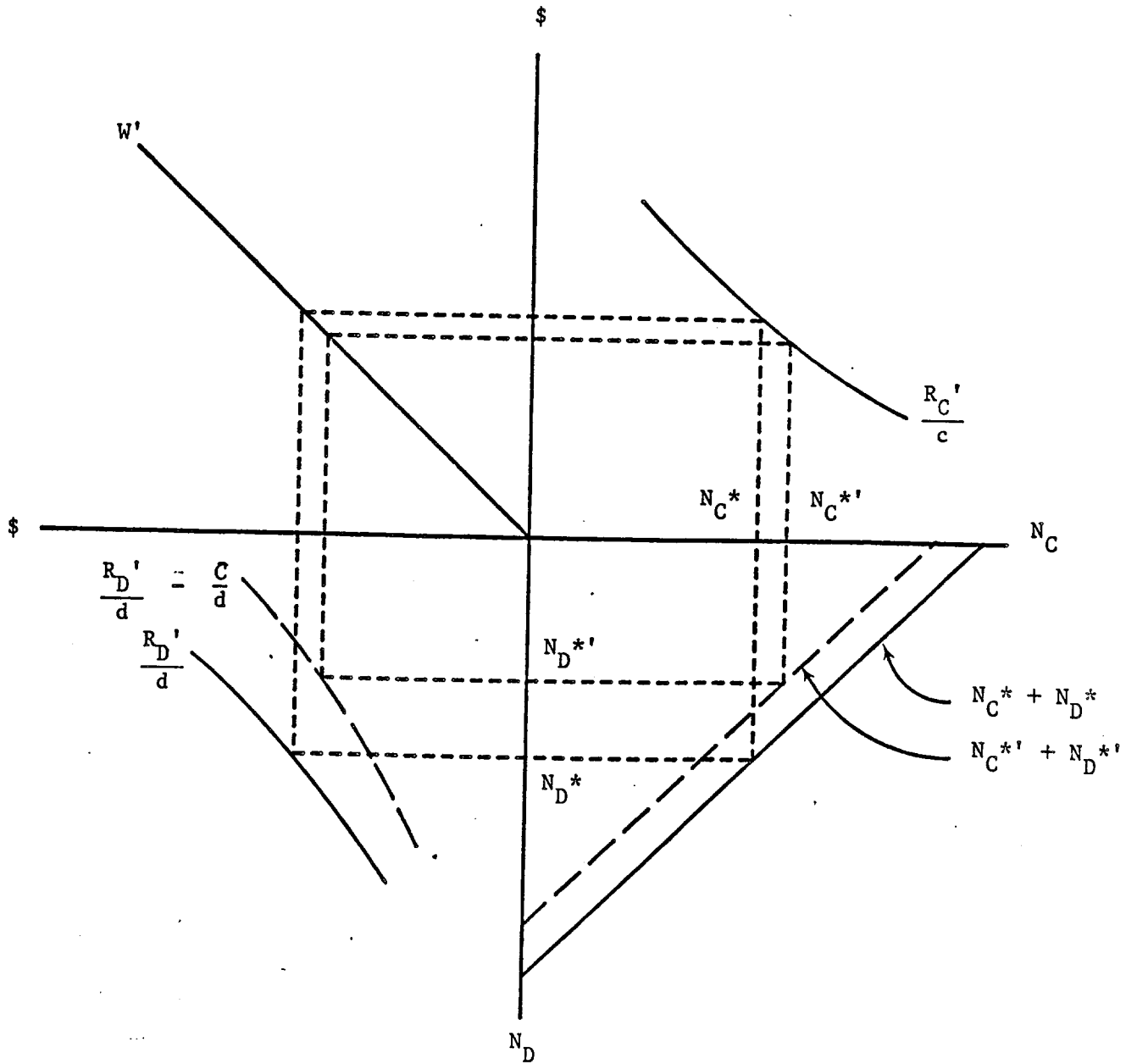


Figure 2: Impacts on Land Clearing and Erosion Control of Enhancing the Returns to Agricultural Colonization

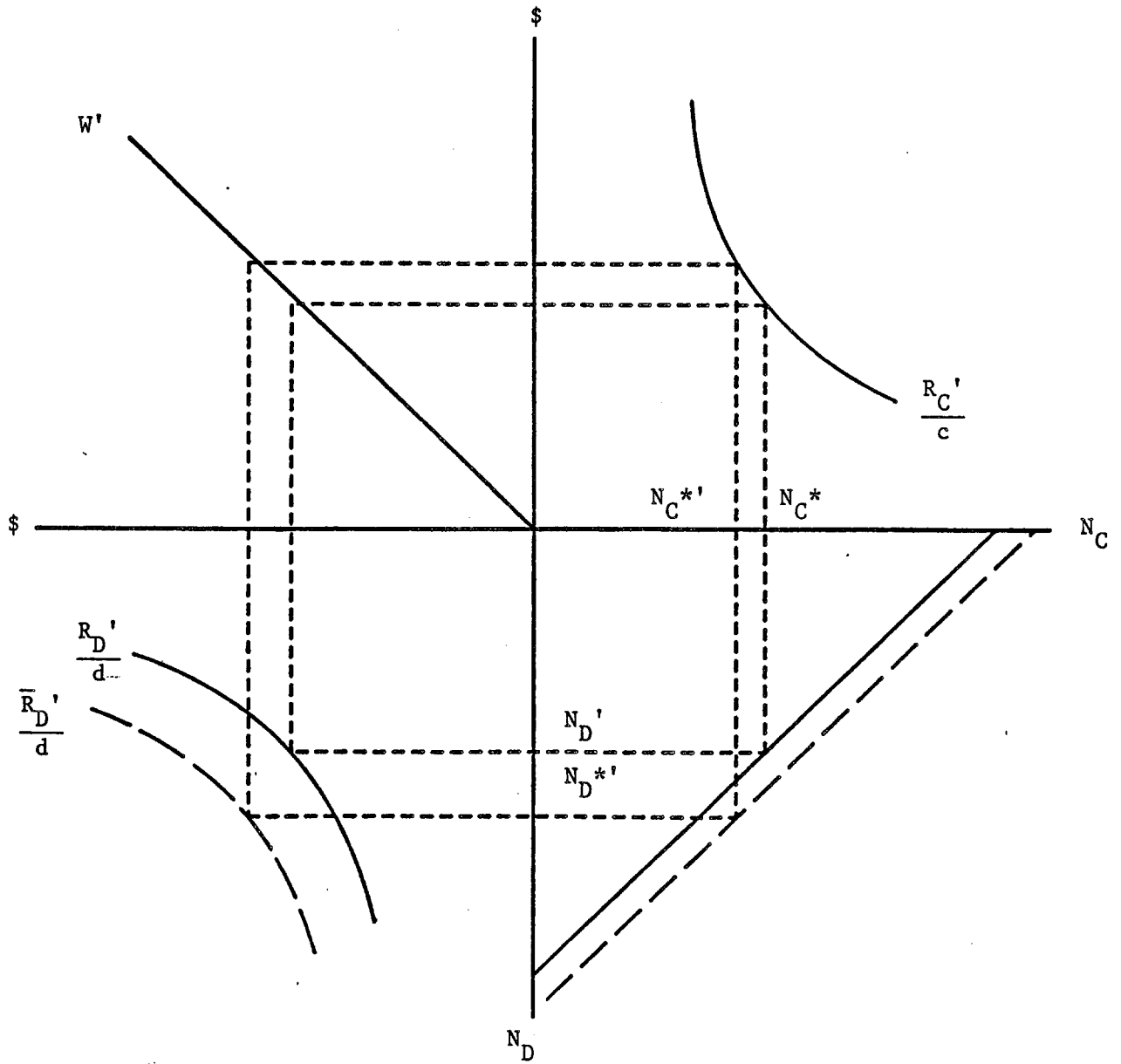


Figure 3: Returns to an Individual Player in a Strategically Interdependent Multi-Person Game

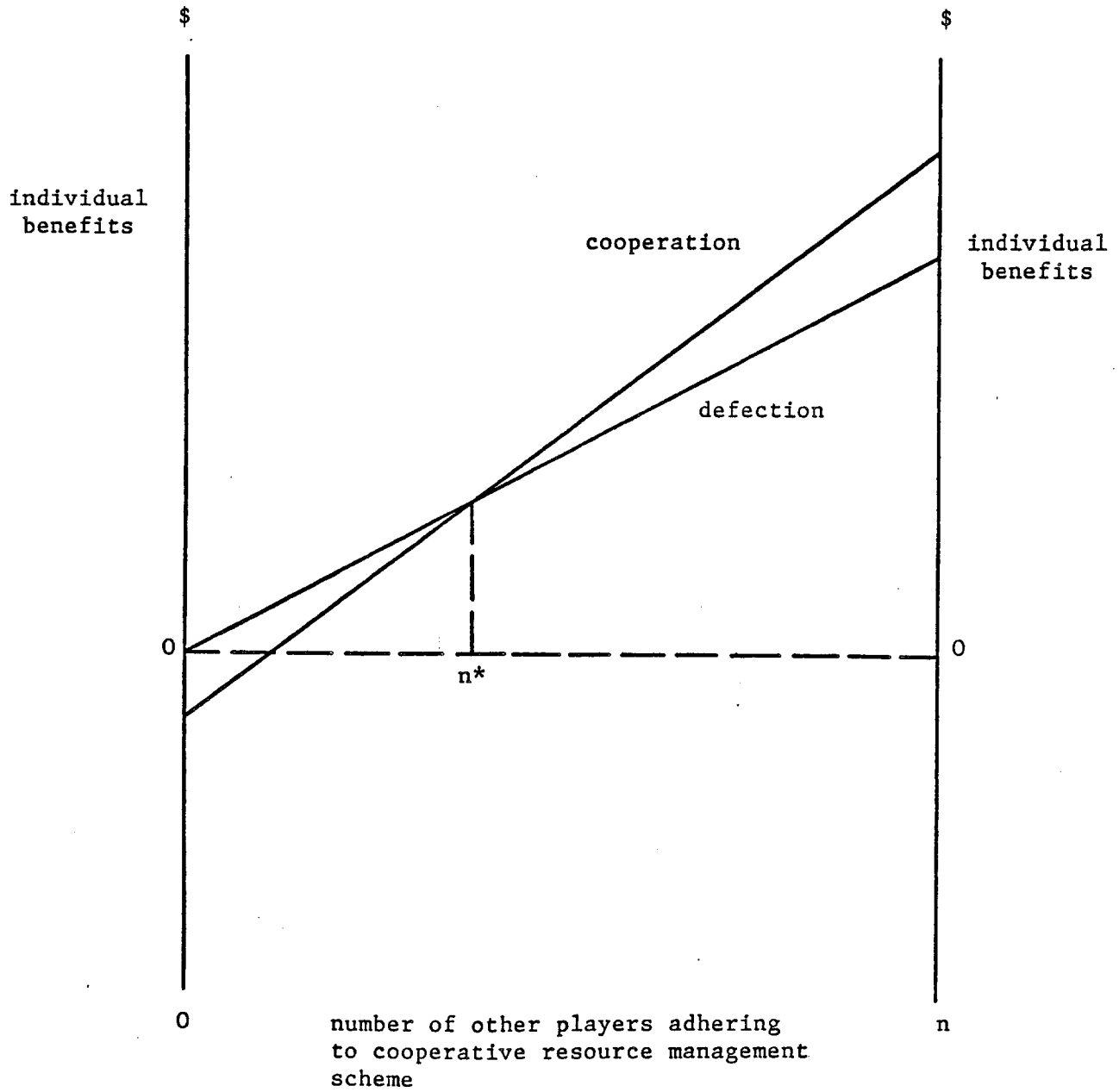


Figure 4: The Impacts of Pressure Exerted against a Cooperative Regime

