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Financing environmental services: the Costa Rican experience and its implications

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Abstract

Costa Rica's pioneering environmental services program seeks to maintain socially optimal forest cover by compensating landowners for the external benefits provided by their forests. The National Forestry Fund proposes to sell carbon sequestration services to the world market and hydrological services to the domestic market. Revenues from these sales, together with tax revenue, is used to finance environmental service provision through landholder incentives for forest maintenance. The mechanics of these programs are discussed, along with implications for the design and implementation of similar programs.

Keywords: Environmental services; Deforestation; Carbon sequestration; Forestry policy

1. Introduction and background

1.1. Purpose of this paper

This paper provides a snapshot of the experiment in progress: Costa Rica's pioneering initiative to achieve environmental goals by creating markets for the environmental benefits of forests. That initiative takes a proposition from theoretical economics — that forests would be better maintained if forest owners were compensated for all the services they provide — and puts it to work in the real world. In doing so, Costa Rica is blazing a trail into a previously undisturbed jungle of policy issues. This paper describes the practical issues that Costa Rica has faced, the 'nuts and bolts' mechanics of how it has approached those issues, and the challenges that remain, both for Costa Rica and for would-be emulators.

1.2. Decades of deforestation

More than half of Costa Rica was covered by forest in 1950. Forest cover declined rapidly over

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the following decades, falling to 29% by 1986. Agriculture, and especially pasture, replaced the forest. Conversion was driven by rapid expansion of the road system, cheap credit for cattle, and land titling laws that rewarded deforestation (Peuker, 1992). Preliminary results from a new study based on satellite images (CCT-CIEDES-CI/FONAFIFO, 1998) show that areas covered by forest in 1986 were converted over to non-forest over the following decade at an annual rate of approximately 1.1%. However, in the areas under protection by 1997 — constituting approximately half the 1986 forest cover — the gross rate of forest loss was substantially lower, indicating both the success of the protected area system and continued high rates of forest loss on private lands.[1]

1.3. Forest values and services

Why do we care about deforestation on private lands? After all, in many (though not all) cases conversion occurs on reasonably good soils, results in sustainable, relatively high-value agriculture, and yields a one-time harvest of valuable timber. Examining private returns at discount rates ranging from 4 to 35%, Kishor and Constantino (1993) find that the returns to conversion always exceed the returns to sustainable forest management, regardless of whether domestic or border prices are used for evaluation.

The concern, as several studies elaborated in the early 1990s, is that private decisions to convert forests fail to account for the value of the services that those forests provide to others, both in Costa Rica and abroad. Because those external benefits don't enter the landholder's cost–benefit calculus, the social costs of deforestation exceed the private gains, and too much forest is converted or degraded from a social standpoint.

1.4. The new forestry law and approach

In principle, then, socially optimum levels of forest cover could be maintained if there were mechanisms to allow national and international beneficiaries to compensate landholders for the benefits they produce. In 1996, Costa Rica adopted a new forestry law (Law no. 7575), which explicitly recognizes four external environmental services of forests:[2]

- carbon fixation;
- hydrological services;
- biodiversity protection; and
- provision of scenic beauty.

The law permits landholders to be compensated for providing these services. Implementing rules for the new law were adopted in 1997.[3] At the same time, Costa Rica moved aggressively to participate in the emerging world of Activities Implemented Jointly/Joint Implementation (Dutschske and Michaelowa, 1997; OCIC (Costa Rican Office on Joint Implementation), 1997) — a system whereby developed-country investors finance developing-country activities that reduce atmospheric greenhouse gas (GHG) levels. The establishment of SINAC (the system of national conservation areas, under the Ministry of Environment and Energy) in 1995 resulted in a unified but decentralized system for administering protected forest areas and coordinating conservation activities on a regional basis. Thus, by the end of 1997, a novel set of institutions was in place to

[1] These gross deforestation figures do not include forest degradation due to unsustainable logging. In addition, the gross area of deforestation was partially counterbalanced by regrowth and plantation establishment equivalent to approximately three-quarters of the deforested area. While this regrowth can provide valuable environmental and economic services, it is not equivalent, especially in biodiversity value, to lost primary forest.

[2] See Castro and Tattenbach (1997) for a comprehensive policymakers' account of the development and implementation of the new forestry policies.

[3] See No. 26141-H-MINAE, *La Gaceta No 133,* 11 July 1997 MINAE (1997a); Resolucion No 947-MINAE-SINAC-FONAFIFO, *La Gaceta No. 176*, 12 September 1997 MINAE (1997b)

mediate the creation of markets for the forest's environmental services.

2. The private provision of environmental services

Costa Rica's new approach to forestry delinks the provision of environmental services from the financing of these services. The government acts as an intermediary in the sale of services. It sells forest services such as carbon sequestration and watershed protection to domestic and international buyers. Funds from these sales — and from a fuel tax — are used to finance service provision. Some services are provided directly by the government, from national parks and other public lands. However, the most innovative part of the system is the provision of services by private landholders under contract.

This section describes the mechanisms, principles, and issues underlying the private provision of environmental services in Costa Rica. The following section discusses how these services are consolidated and on-sold.

2.1. Nature and terms of contracted activities

The payment for forestry environmental services program (FESP) currently provides incentives for three types of actions by landholders: reforestation, sustainable management of forests, and forest preservation. There are also provisions for a fourth, forest regeneration. In many ways the program is similar to the US Conservation Reserve Program, which contracts with farmers to revegetate erosion-prone croplands and pastures, and riparian buffer strips (USDA, 1997a).

Total incentive payments (disbursed over a 5-year period) are from 50 000 colones/ha for forest protection or natural regeneration, 80 225 for sustainable forest management, and 120 000 for plantation establishment.[4] In all cases the payments are made over a 5-year period. In return, the landholders cede their carbon and other environmental service rights to FONAFIFO for 5 years. Afterwards, they are presumably free to renegotiate the prices, or sell the rights to other parties. However, they promise to manage or protect the forest for a period of 20 years (15 in the case of reforestation). This obligation is noted in the public land register and applies to future purchasers of the land. The landholder must establish a management plan for the property, which becomes an integral part of the contract. The contract does not specify an explicit penalty for non-compliance.

The pricing structure should be viewed as an initial trial, and is subject to later revision as FONAFIFO and SINAC assess the response. For instance, the incentive payment for natural forest management probably would not, by itself, dissuade a landholder from 'mining' the forest and converting to agriculture. Given that the new Forestry Law strictly forbids forest conversion and requires that all production forests be placed under an approved management plan, the incentive payment for management may be a rough approximation to the opportunity costs of sustainable vs. 'business as usual' logging — taking into account the legal risks of the latter. The higher price for forest management compared to protection seems at first glance counterintuitive, as well, since forest management offers greater revenues and probably lesser environmental benefits. However, the up-front costs of preparing a management plan are greater for management, as compared to protection. In addition, the protection contract may appeal to, or be directed to, landholders whose forest is unsuitable for sustained management due to terrain, location, or prior extraction of salable wood. Finally, the incentive for forest regeneration is about the same order of magnitude as the rental price for pasture, reported by Castro and Tattenbach (1997) to be approximately US$20–$30/ha in the Central Cordillera region.

2.2. Area under contract

The FESP supersedes earlier incentive programs, which provided tax deductions (since 1979), loans, and tradable tax credits (since 1986) for

[4]At this writing (Jan 99), the exchange rate is approximately 270 colones/ US dollar.

reforestation. A cumulative area of 145 000 ha has received incentives for plantations under these programs (Castro Salazar, 1998). Forest conservation incentives were actually initiated in 1995, before the formal inauguration of the FESP program.

The FESP program formally started in 1997. In that year, $14 million in payments were allocated to 79 000 ha of forest protection, 10 000 ha of forest management and 6500 ha of reforestation (Castro Salazar, 1998). Allocations for 1997 prioritized forest protection (CPB), in part because El Nino conditions were thought to jeopardize reforestation efforts. The median or typical size of protection contract is probably approximately 80–100 ha. Contracts for reforestation tend to be for smaller properties.

There is substantial excess demand for participation in the programs; the formal waiting list may be in excess of 70 000 ha. As a result, the local conservation area offices of SINAC must prioritize applications. The regulations offer a broad list of criteria for prioritization, including hydrological importance, presence of significant species, location near an existing protected area, identification as a priority area in the GRUAS report (MINAE, 1996), carbon sequestration potential, and others. The list is probably too broad to provide much guidance without further clarification.

2.3. Transactions costs: participant processing, monitoring, and enforcement

A program such as the FESP necessarily involves substantial transactions costs, on the part of both participants and the government. These costs have a high fixed component, making participation relatively more expensive for smallholders. Applicants to the program, for instance, must provide legal documentation of title and draw up a detailed management plan. Plans for forest management are expensive, but cheaper per hectare for larger properties. The official minimum[5] rate is 12 029 colones/ha for a 20-ha plan, and 6874 for a 200-ha plan. Plans for strict protection are much simpler and less expensive — which may be a factor in attracting applicants to this program rather than to forest management.

The FESP program achieves its goals only if participants comply with contract terms. This requires a system of monitoring and enforcement. Currently, prime responsibility for monitoring belongs to each participant's supervising forester (who drew up the property's management plan). By law, the forester is recognized as having 'public faith', similar to a notary public, and therefore serves as a kind of third-party certifier. There is as yet no formal system for auditing foresters' reports; questions have been raised in the past about the integrity of some foresters (Peuker, 1992, p. 15). In addition, the precise criteria for determining compliance have not been specified. Compliance will be much more difficult to define and verify in the case of forest management and forest preservation contracts than it has been, historically, for reforestation contracts.

Since the landholders' contract does not specify an explicit penalty for non-compliance, the only possible response to an offense is to file a civil lawsuit for breach of contract. In the past, prosecution for environmental offenses has been a slow, difficult process, in which only a fraction of offenders were actually brought to sentence. An alternative mechanism, the conservation easement, has been used in the KLINKI AIJ/JI project. Conservation easements are legal agreements, inscribed in the public land registry, which restrict land use of one property for the benefit of another (Mack, n.d.). An advantage of the conservation easement, for enforcement purposes, is that the beneficiary of an easement can secure an immediate injunction in case of a violation of the easement terms.

2.4. Intermediaries to reduce transactions costs for small holdings

One way to reduce transactions costs for smallholders is to create local organizations which

[5] In practice, charges are often more, and sometimes less, than the minimum rates sanctioned by the foresters' professional association.

intermediate between the government and the landholders, in effect bundling and 'wholesaling' collections of individual projects. FUNDECOR (the Foundation for the Development of the Central Volcanic Range) is probably the most prominent of a number of NGOs which have spontaneously adopted this role. FUNDECOR currently has enrolled 371 clients with 22 000 ha in incentive programs. Seven thousand hectares are enrolled under the FESP and the remainder under the earlier reforestation incentive schemes. While many of the protection and management clients are large, the reforestation clients often have 5 ha or fewer under plantation.

FUNDECOR provides a variety of services for its clients. It handles all the paperwork related to application for FESP payments. This is particularly important for poorer, less well educated clients who have difficulty with the paperwork. FUNDECOR serves as supervising forester for the projects, drawing up management plans, monitoring client performance, and providing technical assistance.

Local intermediaries such as FUNDECOR can reduce transactions costs if — as seems plausible — they have lower monitoring and administrative costs than distant government agencies, and can realize economies of scale in dealing with neighboring clients. At the same time, reputational considerations for the intermediary organization can help to insure the integrity of the monitoring process.

3. Financing environmental services: carbon offsets

3.1. Introduction and background

This section describes a major potential funding source for environmental services: the sale of Certified (or Certifiable) Tradable Offsets (CTOs). CTOs — a Costa Rican invention — are externally certified reductions in net carbon emissions. CTOs are created through project activities that sequester carbon or avert carbon emissions.

CTOs have value for buyers who want to offset their own GHG emissions, either as a voluntary contribution to environmental improvement or in order to meet legal or regulatory limits on net emissions. While there is already a nascent market for such offsets, the major potential demand arises from the Kyoto Protocol to the UNFCCC. Through the Clean Development Mechanism, the Protocol authorizes the creation of certified emissions reductions through activities in developing countries, requires that these activities benefit the host countries, and allows developed (Annex I) countries to acquire the emissions reductions and apply them towards meeting national GHG emissions limits. Costa Rican CTOs appear very close in spirit to the protocol's certified emissions reductions. Whether they, or other forestry-related offsets, will be creditable under the Kyoto Protocol remains to be determined.

Costa Rica plans to create and market CTOs through three large 'umbrella' projects. Two are already underway: the Protected Areas Project (PAP), which creates CTOS through the addition of lands to the nation's protected area system. The Private Forestry Project (PFP) will create offsets based on the FESP contracts described in the previous section. A third project will sponsor energy-related activities.

This section summarizes the mechanics of the forestry offset projects and discusses implementation issues.

3.2. The projects

Because Costa Rica's traditions and constitution strongly emphasize private property rights, there has long been uncertainty about the degree of forest protection afforded to properties located in protected areas, but not legally registered as belonging to the national park system. The Protected Areas Project (PAP) addresses this problem by placing 555 052 ha of land in protected areas under firm legal ownership of the State, in National Park or Biological Reserve status. This is accomplished through outright purchase of private lands, and through a variety of legal procedures and surveying activities necessary to regularize and transfer title from ownership by NGOs, parastatals, and other government agencies. Approximately 10% of the area in question is privately owned, and 16% is owned by NGOs. The project will spend $44 million on land consolidation, $92 million to set up a trust fund to support protected area operations, and $21 million on indirect costs (Castro and Tattenbach, 1997).

The PAP claims to produce carbon offsets in two ways (Costa Rican Ministry of Environment and Energy, 1997). First, it claims to avert the release of 11 100 756 tons of carbon by preventing deforestation of 422 800 ha of forested lands. Second, by stimulating secondary regrowth on 107 698 ha of pastures and in existing secondary forest, the PAP claims sequestration of an additional 4 572 136 tons.

The Private Forestry Project (PFP) will be similar to the PAP. However, the offsets will be based on averted deforestation and induced reforestation or regeneration on private lands. These actions will be accomplished by funneling PFP offset revenues through the FESP program. The PFP will be challenging because it will involve setting baselines for, and monitoring the actions of, thousands of private landholders, many with small properties. Baseline and monitoring design is still underway. The ultimate scope of the project has not been precisely determined, but it could encompass more than 700 000 ha.

3.3. Baseline determination

Carbon offsets (in any emissions reduction project) are defined as the difference between observed carbon emissions (or sequestration) and the *baseline,* business-as-usual level in the absence of the project. The reliance on the hypothetical baseline is what makes the offset a peculiar commodity. Clearly the 'true' baseline is unknowable, but the integrity of the market for offsets depends on the application of unbiased yet affordable techniques for estimating baselines (Chomitz, 1998).

No standardized protocols have been adopted for forestry or other offsets. The baseline problem is particularly tricky for forestry because of the need to project land use behavior decades into the future. The Costa Rican projects are among the first attempts to establish forestry offset baselines over large areas.

For the Protected Areas Project, there are two sets of baselines: the baseline rate of deforestation in areas of primary forest, and of regrowth in pasture and secondary forest areas. The baseline deforestation rate is based on extrapolation of past deforestation trends. It uses satellite imagery to compute deforestation rates over the period 1979–1992, for a 10-km buffer zone *outside* each of the national parks. These rates were then imputed to areas *inside* the national parks, with ad hoc adjustments for different tenure statuses. Rates are differentiated between parks. Deforestation rates are used to calculate carbon emissions rates using standardized assumptions about carbon densities of forests in different ecological zones. The baseline reforestation rate — net carbon accumulation in secondary forest and pasture — is assumed to be zero.

These baseline estimates were made before the calculation of cover changes over the period 1986–1997 by a FONAFIFO-sponsored study. Those updated results suggest very low gross deforestation rates for national parks, and spontaneous regrowth of pasture in some parts of the country. This could result in recalculation of future baselines; the self-insurance arrangement (see below) sets aside a 'buffer' of excess offsets to allow for errors in the calculation of past baselines. It could, however, be argued that legal challenges to the forestry law's prohibition of deforestation could result in future deforestation and reforestation rates that are more similar to the rates outside the parks. This points to unresolved issues in deforestation-based offset projects: the degree to which baselines should be adjusted ex post to reflect new information, policy changes, or other conditions that might affect forest clearance or regrowth rates.

3.3.1. Leakage

'Leakage' occurs when carbon offsets in project areas are vitiated by emissions outside (Brown et al., 1997). This could happen, for instance, if squatters evicted from the project were diverted to privately-owned forests in other areas. It could also occur through general-equilibrium market effects. If the project reduces the amount of wood sold on the market, regional wood prices could rise, spurring increased demand for wood. Some of this might be satisfied from sustainable plantations, with no long-term net emissions of carbon, but some might come from increased deforestation at forest margins elsewhere in the region. Similarly, if the project reduces the number of cattle, it may slightly boost the regional price of beef. This may induce a rebound in supply, part of which might come from induced deforestation outside the project boundaries, though part might come from intensified production on developed lands. The PAP assumes that the degree of leakage is small.

3.4. Performance risk and offset buffers

In the PAP, offset sales are contracts for future deliveries of offsets. The buyer pays for 20 years of offsets in advance, and receives 20 coupons for annual redemption of offsets. In the absence of some form of insurance, this kind of sale would expose the buyer to numerous risks. What if the pasture fails to regenerate? What if deforestation continues to take place? What if a natural disaster destroys part of the forest?

The Costa Rican CTO scheme innovates by self-insuring against performance risk. It does so by producing more offsets than it promises to sell. The remainder is kept in a 'buffer' against performance risk. For instance, approximately 21% of the offsets produced in the initial year of the project are permanently reserved as insurance against challenges to the baseline. One-quarter of offsets produced from pasture regeneration in the dry, heavily grazed Guanacaste and Palo Verde regions, are reserved as insurance against failure of regeneration. In all, approximately half of the 3.56 million tons of offsets produced in the project's first year will be placed in the buffer.

4. Other sources of financing for environmental services

4.1. Fuel tax

Currently, the main source of funding for the FESP is not carbon, but a dedicated tax on fuel sales. One-third of this tax, that is 5% of fuel sales, is earmarked to forestry through FONAFIFO. In practice, fiscal constraints have led to an appropriation of 1.8 billion colones for this purpose in 1997, with expectations that the annual appropriations will double over the next 5 years.

4.2. Watershed services

There is great interest in Costa Rica in quantifying and creating markets for the watershed services provided by forests. Potential services include sediment prevention and regulation of runoff and streamflows. Potential beneficiaries or customers include hydroelectric power stations, and urban water consumers. Discussions are underway to attach a water quality charge for consumers, and use the proceeds to finance watershed protection.

So far the most concrete effort along these lines is an arrangement negotiated with Energía Global, a private electricity provider. Energía Global operates two small run-of-the-river hydroelectric facilities with a total capacity of 31 MW drawing on watersheds with a total area of 5806 ha. The company has offered landowners in its watersheds $10/ha year to maintain or restore forest cover on their plots. The payments will be transferred through FUNDECOR to FONAFIFO and will be used to finance payments under the FESP. Payment levels will be the same as for properties outside the watersheds; however, these properties will be prioritized for early inclusion in the FESP.

The company's rationale for this investment is that maintenance of forest cover smoothes streamflows. These powerplants have tiny reservoirs, able to store only 5 hours of water. Output, and revenue, are maximized if streamflow is maintained at the plant's maximum capacity. A forested catchment may temporarily store rainfall, releasing it gradually. Rain in a denuded watershed, on the other hand, may run off immediately, resulting in greater variability of streamflow. When streamflow exceeds the plant's capacity for more than 5 hours, the excess water must be spilled. Each lost cubic meter of water translates approximately to a lost kilowatt hour of output, or approximately US $0.065 in lost revenue[6] (with price depending on time of day and year). While no in-depth hydrologic analysis has been performed, the company's investment will pay off if it succeeds in capturing an extra 460 000 m^3/year for generation.

Sedimentation prevention is another hydrological benefit of forest protection of potential interest to Costa Rica, which is heavily dependent on hydropower. However, the potential economic benefits are inversely related to the size of the reservoirs' dead storage areas, which in some cases is very large (Aylward et al., 1998). Sedimentation may also impose costs on the provision of drinking water to urban centers. Sánchez-Azofeifa (1996) demonstrates a negative relation between forest cover and sediment flows across watersheds, but finds no upward trend in national sediment production for the period 1970–1991, despite considerable deforestation. This may reflect shortcomings in the data, or it may reflect very long periods of sediment transport.

It is widely thought that forest protection helps to boost dry season flows. If so, this would provide substantial economic benefits to consumers of both electricity and water. However, decades of hydrological studies caution against uncritically accepting the conventional wisdom that forests are like sponges, soaking up water in the wet season and slowly releasing it in the dry season. (See the review in Chomitz and Kumari, 1998).

Deforestation has multiple, conflicting effects on water yield. While it does reduce infiltration of water into the ground, it also reduces water loss due to evapotranspiration — the process whereby trees pump water out of the ground and transpire it to the atmosphere. Deforestation may also affect local climate by changing local heat absorption and wind interception patterns. The net effect on water yield of changes in infiltration, transpiration, and microclimate could be positive or negative and will be sensitive to local conditions.

[6]Calculated from data kindly supplied by Michael Skelly, Energa Global.

Aylward et al. (1998) analyze the potential impacts of reforestation in the Río Chiquita watershed, which is part of the Arenal watershed feeding Costa Rica's largest hydroelectric facility. Aylward et al. (1998) find that reforestation of the denuded parts of this watershed would reduce sedimentation, but that it would also reduce water yield. The net effect is that the net present value of hydrological services is $200–$1400 *higher* for pasture than for forest, except in cloud forest areas where trees help to 'harvest' passing moisture. This echoes empirical findings by Vincent et al. (1995) who find that reforestation of a Thai watershed with thirsty pine trees substantially reduced dry season flows.

In sum, hydrological processes are extremely complex and sometimes counterintuitive. Careful analysis is required if hydrological services are to be properly defined and marketed. Such analysis may yield more specific means of providing hydrological services than an undifferentiated prescription of forest protection or reforestation. For instance, it may be that replanting of denuded slopes can be 'fine-tuned' to maximize water yield while reducing sedimentation, or that maintenance of forest cover near streams has a much higher sediment-reducing effect than in other areas.

4.3. Other services

The Forestry Law explicitly recognizes two other environmental services: provision of scenic views, and protection of biodiversity. There are no immediate plans to use these services as sources of finance under the FESP.

5. The policy frontier: efficiency and equity in the pursuit of multiple goals

5.1. New challenges

As a pioneering effort, Costa Rica's environmental services program raises challenging new issues in policy and implementation. How should payments be set? Should they be uniform or differentiated? Should participants be selected through an auction scheme or according to predetermined criteria? Is it more important to recruit smallholders or largeholders? How can a baseline be defined for the Private Forestry Program? Should there be government monopsony in services, or a competitive market? In order to answer these questions, it is useful to work through the goals, constraints, and options that Costa Rica (and its potential emulators) face.

5.2. Goals

The FESP attempts to satisfy three distinct goals:

- to produce the socially optimal level of carbon sequestration and hydrological services;
- to conserve biodiversity; and
- to boost smallholder incomes.

These goals are related but not coincident. Achieving optimum carbon storage and hydrological services probably helps biodiversity preservation, but doesn't guarantee it. Biodiversity is not perfectly correlated with carbon. Moreover, some lowland forests on good soils might have agricultural value that outweighs their carbon value — but not their biodiversity value. Similarly, fragmented smallholder properties may be less important for biodiversity than large holdings. Given limited resources, there may be tradeoffs among the goals. In addition, multiple instruments may be required to address multiple goals efficiently.

5.3. Constraints

The scope of FESP is constrained by available finance. Currently, the major source of finance for FESP is the fuel tax. Additional revenues are hoped for from the sales of carbon offsets and watershed services. A major constraint is that biodiversity conservation currently yields no revenue, except as a byproduct of carbon storage or hydrological maintenance.

A second constraint is the need to structure payments in an equitable fashion. A problem here is that one can imagine several mutually inconsistent ways to define equity. Many in Costa Rica believe that equity entails equal payments per hectare to participants, even if this means that some service-providing landowners are unable to participate because of budget constraints. An alternative view of equity is that all landowners who provide services should be recompensed to some degree, and that landowners who provide more services should get higher payments.

A third constraint is that imposed by the additionality requirement for offset sales. Consider three forest owners. A's forest is inaccessible and cannot be economically exploited. It is at no risk of being converted or degraded. B's forest can be economically exploited, but B prefers to keep it undisturbed, so it too is at no risk. C's forest is exploitable; C refrains from exploiting it only as long as he receives an incentive payment. Which of the owners is providing carbon sequestration services?

Arguably, all are providing services. From a strict interpretation, however, only C is clearly providing real, additional emissions reductions. As a result, A and B's services cannot be financed through offset sales, even though this seems particularly unfair for B, a kind of reverse moral hazard. (To avoid moral hazard in defining offsets it might be desirable to reward individuals and nations that refrain from deforesting areas which are profitable to convert.)[7]

Finally, it is crucial to recognize that properties differ dramatically in the mix and quantity of services that they provide, and in their costs of participation. Above-ground carbon densities vary from near 0 in pasture to 300 tons/ha in primary lowland rainforest. Deforestation risks (and hence salable offsets) systematically vary from negligible to high, depending on local agroclimatic conditions, enforcement efforts, access costs, and landowner characteristics. The level of watershed services provided by a property will depend a great deal on the property's slope, the erodibility of its soil, and its proximity to a waterway used for power generation or drinking water supply.

[7] For an in-depth discussion of the issues involved in establishing baselines and additionality, see Chomitz (1998).

The value of properties for biodiversity preservation will vary greatly depending on the presence of endemic species, the proximity to threatened areas of habitat, and many other considerations. For instance, in Costa Rica as in many areas of Central America, some fauna seasonally migrate from highlands to lowlands. Their ability to do so is severely threatened by the conversion of mid-slope areas (Guindon, 1996). Preservation of forest fragments in these mid-slope areas is therefore particularly crucial.

Small properties are likely to differ systematically from large properties in participation costs and environmental and social benefits. As discussed earlier, it is generally more expensive to recruit and monitor smaller properties, boosting the cost of supplying environmental services. We might hypothesize that biodiversity benefits will generally be lower for small properties. Forests on these properties are probably smaller and more fragmented, less likely to support viable wildlife populations and more subject to edge effects and disturbances.[8] On the other hand, it is possible that smallholders are more likely to clear forests than largeholders, which would mean that maintenance of forest cover on smaller properties provides more carbon offsets per hectare compared to the baseline situation.

5.4. Policy and implementation options

Here we present a step-by-step outline of the choices that must be made by a country seeking to implement an environmental services payment scheme such as Costa Rica's.

5.4.1. Definition of rights and services

It is worth reflecting for a moment on the definition of environmental services. These services arise from the implicit assignment of landholder rights to take actions that result in carbon dioxide emissions and in downslope sediment and runoff impacts. Landowners provide services by refraining from these actions. This contrasts with the 'polluter pays principle', often used to allocate responsibility for environmental impacts. For instance, we typically grant households the right to clean air and water, and may auction off pollution permits, in limited quantity, to industrial firms. As Coase (1960) has taught us, either approach is potentially workable; the choice depends on distributional considerations (who pays?) and on transactions costs (how difficult is it to negotiate and gather the payments?). Costa Rica's definition of environmental services is defensible, but may not be appropriate for all countries. For instance, a country with large frontier areas may choose to determine what proportion of the forest is acceptable for conversion, based on the national interest, and after setting aside areas important for biodiversity. Conversion permits for the appropriate number of hectares would then be sold. Deforestation of that area would constitute a national baseline. Carbon offsets could be generated by buying, and retiring, conversion permits.

5.4.2. Monopsony and service bundling

In principle, landowners could 'unbundle' the carbon, watershed, scenic view, and biodiversity services of their properties, and sell each service in different markets. In practice, FONAFIFO acts as a monopsonist, purchasing all the landowner's services and reselling them on foreign (CTO) and domestic (watershed) markets.

There are practical and strategic advantages to maintaining a monopsonistic arrangement. In practical terms, purchase of watershed services is naturally monopsonistic, since there will tend to be a single hydropower or utility consumer in a watershed. There are also practical advantages to consolidating all carbon offset sales under a single seller, since it facilitates baseline definition and monitoring. The strategic advantage is that, as a monopsonist, the government can appropriate some of the rents associated with the offsets, and use this revenue to secure the biodiversity services for which no markets exist.

5.5. Pricing

If a decision is made in favor of monopsony, then a pricing strategy must be defined. A basic

[8]The value of a small fragment may of course be very high if it contains the last surviving exemplars of some species or community.

choice is between fixed and differentiated prices. Fixed prices have the advantage of simplicity, and the appearance of equity. They are easy to administer, and for this reason the FESP program quite sensibly adopted this initial approach. However, if the prices are set high enough to generate excess demand for participation, then some kind of prioritization process has to be set up, and some would-be participants must be turned away. Transparency and equity in pricing are therefore accompanied by complexity in the process of allocating incentives among claimants.

Fixed prices are also potentially fiscally and socially inefficient. Applying the framework of Babcock et al. (1997). Fig. 1 plots properties according to each property's potential supply of carbon offsets in tons per hectare, and to the property's supply price in dollars per hectare. Suppose for the moment we are only interested in the carbon content of properties. If the slope of the diagonal line represents the current price of offsets, in dollars per ton, then any property below the diagonal line can supply offsets competitively. Properties above the line cannot. At the fixed incentive price, properties in the vertically shaded region decline to participate, even though they could supply carbon cheaply. These might be, for instance, areas of primary forest on good soils. On the other hand, properties in the horizontally shaded region are eager to participate, but would receive payments higher than the value of the carbon they provide — if not screened out. Such properties might, for instance, include forested areas on inaccessible high slopes.

This problem of inefficiency may be particularly likely in the case of watershed services. The watershed services provided by a property will be quite sensitive to the property's position in the watershed. Quite possibly the most valuable properties for sedimentation prevention will be those on the riverbanks, as these are the most likely and direct sources of sediment. They may also be the properties with the highest opportunity costs, because of favorable access and good alluvial soils. A fixed-price payment strategy may fail to enroll these properties. In a different setting, Parks and Schorr (1997) make an analogous argument: that limits on payment levels by the

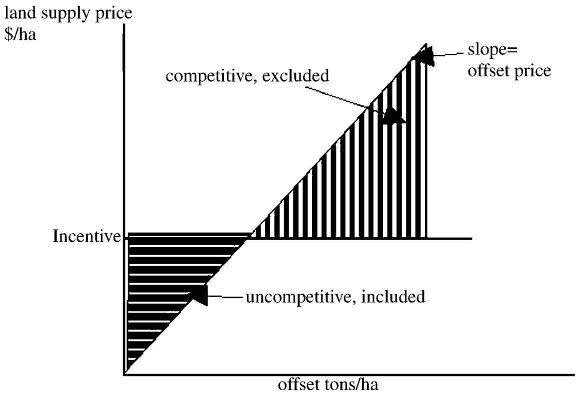

Fig. 1. Plot of properties according to each property's potential supply of carbon effects and to the property's supply price in $/ha.

Conservation Reserve Program result in foregone opportunities to secure environmental amenities in metropolitan areas, where land values are high.

The alternative, differentiated pricing, has advantages and disadvantages of its own. It would be possible under differentiated pricing to compensate each property for the bundle of services it provides. Taken to the limit, this would require a system for assigning monetary value to biodiversity resources. The scheme would achieve social efficiency, but would not yield revenues for the implementing agency, and might be difficult to finance. The price-setting mechanism might be contentious.

A different way of discriminating among properties would be to hold a reverse auction. The financing agency could announce its budget and ask for bids from property holders to place their properties under protection. The agency could simply finance the lowest bids up to its budget, or it could apply prioritization criteria.

5.6. Prioritization

In the end, some kind of prioritization strategy will be necessary regardless of which pricing strategy is chosen. This is because biodiversity values are difficult to monetize and because the biodiversity importance of a collection of properties is not the simple sum of the importance of each individual property. Biodiversity preservation requires both representation of different species or habitats, and ensuring minimum habitat sizes and contiguity. These are global features of a landscape plan, and cannot be handled by a completely decentralized or market-oriented approach.

There may be some lessons from the US Conservation Reserve Program, which has refined its priority-setting system over time. Currently the program uses a scoring system, the Environmental Benefits Index (USDA, 1997b), which calculates a weighted sum of various benefits (water quality, air quality, biodiversity) and cost.

5.7. Conclusions and a suggested approach

Because of the additionality requirement for carbon offset sales, and limited sources of other funds, not everyone can be compensated for all the environmental services they provide. Fixed-rate payment systems may be seen as inequitable by those excluded from participation, or by those providing more services. Differentiated payment systems may be seen as inequitable by those receiving lower payments.

Perhaps the fundamental choice faced by FONAFIFO or its equivalent elsewhere is whether to pass all carbon offset or watershed service rents through to landowners, or to retain some rents in order to finance biodiversity preservation, income redistribution, or other social goals. If some rents are to be retained and redistributed, then it is useful to assemble a framework to guide price-setting and prioritization.

Such a framework will rely heavily on spatial data about properties, since both supply price and environmental services depend on location. It will have the following elements:

1. A model that predicts land use as a function of a property's location and characteristics, and of the incentive payment offered. Such a model is in any case necessary in order to establish the baseline against which carbon offsets are reckoned.
2. A worked-out set of relative priorities among the provision of carbon and watershed services, the preservation of biodiversity, and income redistribution towards smallholders.
3. Maps showing the value, across the landscape, of different areas for carbon storage and watershed impact.
4. A biodiversity objective function which assigns a score to a particular landscape configuration based on the degree to which it satisfies ecosystem representation and viability goals.

With these things in hand, it would be possible to simulate the effect of alternative payment and prioritization schemes on carbon offset generation, watershed service production, environmental services payments by type of landowner, government revenues, and biodiversity. This 'test-bed' would encourage clarity in the definition of goals and permit the development of simple, implementable strategies to reach those goals.

While these are not easy tasks, much of the ground work has been done and much of the requisite information is in existence. A rough-and-ready compilation of spatially explicit land use change trends, hydrological features, and biodiversity conservation priorities would go a long way towards providing useful rules of thumb. A more refined approach to land use modeling and to biodiversity information gathering would require more effort. However, the expense of creating this framework has to be weighed against the possible revenues — for Costa Rica, potentially in the hundreds of millions of dollars — from producing carbon offsets in the most cost-efficient manner.

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