FINANCING ENVIRONMENTAL SERVICES:

THE COSTA RICAN EXPERIENCE AND ITS IMPLICATIONS

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1. INTRODUCTION AND BACKGROUND

PURPOSE OF THIS PAPER

This paper provides a snapshot of a fascinating, rapidly evolving 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.

The paper begins with a brief description of the background to the new policies. For a more comprehensive account, the reader is referred to Castro and Tattenbach (1997), which this paper seeks to complement and update.

DECADES OF DEFORESTATION

More than half of Costa Rica was covered by forest in 1950. Forest cover declined rapidly over 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 nonforest over the following decade at an annual rate of about 1.1%. However, in the areas under protection by 1997 – constituting about 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. The deforestation rates do not reflect forest degradation due to unsustainable logging.

In terms of overall land cover, the gross area of deforestation was partially counterbalanced by regrowth equivalent to about three-quarters of the deforested area[1]. Some of this regrowth may represent the establishment of plantations; some of it may reflect spontaneous regeneration of abandoned pasture on poor terrain, especially in the Pacific slopes. While this regrowth can provide valuable environmental and economic services, it is not equivalent, especially in biodiversity value, to lost primary forest.

In sum, the expansion and strengthening of the country's protected area system has been important in arresting the loss of forest. Outside those areas, however, deforestation and forest degradation has proceeded rapidly, resulting in an increasingly fragmented forest landscape.

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[1] Young plantations and recent regrowth will not be included in the calculation.

FOREST VALUES AND SERVICES

Why do we care about deforestation? 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. At low discount rates, conversion to fast-growing plantations dominates lower-yielding natural forest management. At higher discount rates, the landholder's greatest profit is obtained simply by clear-cutting the forest.

The concern, as several studies elaborated in the early 1990's, is that private decisions to convert forests fail to account for the value of the services that those forests provide to others. 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.

Valuing forest benefits

A catalog of these external services includes the following:

Biodiversity --The potential loss of biodiversity has probably been the largest source of concern surrounding deforestation in Costa Rica. Despite its small size, Costa Rica is very rich in biodiversity, containing an estimated 4% of the world's species. Much of this biodiversity, however, is not represented in protected areas and is therefore at risk (MINAE, 1996).

It is extraordinarily difficult to assign a monetary value to biodiversity, which has instrumental and intrinsic values. The intrinsic values include the "existence value" or notional willingness-to-pay for preservation by the world's population, present and future. The instrumental values include both ecotourism (see below) and bioprospecting opportunities. Per-hectare values of bioprospecting rights have been argued to be low (at most $2, likely much less), because of the overlap among plots in the biochemicals they harbor.(Simpson and Sedjo 1996; Simpson 1997). In aggregate, however, the bioprospecting value of Costa Rica's forests may be substantial because of the country's ability to provide good logistics, a stable legal and institutional environment, and ancillary information that increases the chance of finding a valuable biochemical (see Rausser and Small 1997, Artuso 1998).

Carbon sequestration -- Carbon sequestration services are the largest monetizable component of forest services. By refraining from deforestation, or by promoting plantations and secondary regrowth, the Costa Rican landholder reduces atmospheric concentrations of carbon dioxide, and thereby reduces the economic impacts of global climate change. Rough estimates of either the net present value of damages associated with the release of a ton of carbon have ranged from $5 to $40; one estimate puts the likely price of tradable carbon emissions permits in 2010 at a minimum of $35/ton carbon if demand is unrestricted[2] (Ellerman, Jacoby and Decaux 1998). The sequestration value of standing forests depends on the density of those forests; in Costa Rica, carbon density in above-ground biomass in primary forests has been estimated to range in from 170 to 300 tons/hectare. (SGS, 1997)

Watershed protection -- Loss of forest cover can result in erosion and consequent sedimentation of streams and rivers. Sedimentation reduces the quality of drinking water, and may damage fisheries. (see Reid, forthcoming). Siltation also penalizes hydroelectric power generation by reducing the effective size of reservoirs, and by damaging equipment. Loss of forest cover can also result in 'peaky' response of streamflow to rainfall. This increases the risk of flooding, and results in the loss of potential electricity generation at run-of-river hydroelectric plants, as the excess water is spilled-over and lost for energy generation purposes. Under some circumstances, it is conceivable that deforestation could reduce dry season flows, but the hydrological relationships are quite complex and site-specific, and the contrary effect has often been observed (Chomitz and Kumari 1998; Vincent *et al* 1995).

Ecotourism and scenic values: Forests are an attraction of growing importance to Costa Rica's large tourist industry. The annual number of visitors to the national parks has ranged from 500,000 to 600,000[3] in recent years (SINAC, 1997). A 1991 survey of ecotourists found that most came to Costa Rica specifically to visit protected areas, and that their average total in-country expenditure was about $1100 (Aylward *et al.* 1991). Forested properties also provide scenic vistas to neighboring properties, an economic benefit potentially capitalized in land values.

Valuation exercises

Some of these benefits accrue at the local level (watershed protection), some at the national level (ecotourism, scenic values), and some at the global level ('existence value' for biodiversity, carbon sequestration). Attempts have been made to estimate these values, at both the aggregate and per-hectare level. (Kishor and Constantino 1993; Carranza *et al.* 1996) This is a difficult exercise precisely because there have been no markets for these services, and many of the underlying biophysical and economic parameters are poorly understood. It is also important to note that values may differ between plots. The results of Kishor and Constantino (1993, p.19) are summarized below. A clear result of these rough exercises, however, is that carbon values are quite large and potentially dominate other monetizable values, with hydrological values and ecotourism as runners-up.

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[2] Based on fully efficient global trading including the Clean Development Mechanism. Constraints on rapid development of supply suggest that prices could be higher. On the other hand, this projection does not allow for offsets from forestry activities, or from gases other than carbon dioxide.

[3] This is the sum of admissions to individual parks and probably incorporates substantial double-counting of individuals who visited several parks.

Environmental service	**annual value/ha of service (US$, 1993)**
Carbon sequestration	$120 (@$20/ton)
Ecotourism	$ 12 - $25
Hydroelectric power protection	$ 10- $20
Other hydrological benefits	$ 7 - $17
Existence and option values	$ 13- $32
Pharmaceuticals from bioprospecting	$ 0.15

Internalizing the externalities

Forest preservation by a Costa Rican landholder benefits the world by providing carbon sequestration and by preserving biodiversity. It benefits other Costa Ricans by providing hydrological services and ecotourism revenues. In principle, then, socially optimum levels of forest cover could be maintained if only there were mechanisms to allow national and international beneficiaries to compensate landholders for the benefits they produce. In the early 1990's such mechanisms seemed to be speculative hopes, at best. By 1997, they had been created.

THE NEW FORESTRY LAW AND APPROACH

The mid 1990's saw a remarkable set of institutional innovations in Costa Rican forestry. In 1996, Costa Rica adopted a new forestry law (Law no. 7575), which explicitly recognizes four environmental services of forests:

- carbon fixation
- hydrological services
- biodiversity protection
- 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[4]. These defined sources of financing (including a dedicated fuel tax), and rules for disbursing, environmental services payments. Funds were to be channeled through the National Forestry Fund (FONAFIFO), which had been established in 1991 to handle an earlier generation of incentives for reforestation.

At the same time, Costa Rica had moved aggressively to participate in the emerging world of Activities Implemented Jointly/Joint Implementation – a system whereby developed-country investors finance developing-country activities that reduce atmospheric greenhouse gas (GHG) levels. In 1994, Costa Rica become the first

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

developing country to establish an AIJ/JI agreement. OCIC, the Costa Rican joint implementation office, was set up in 1996 to coordinate AIJ/JI activities. By October 1997, Costa Rica hosted nine UNFCCC-approved projects, five in energy and four in land use. (OCIC, 1997). (See Dutschke and Michaelowa, 1997, for a description of some of these projects).

These activities took on heightened importance with the adoption of the Kyoto Protocol to the UNFCCC in December 1997. The Protocol provides for the creation of a Clean Development Mechanism. This permits developing countries to benefit by producing GHG emissions reductions which can be applied by the developed countries for credit against their own emissions limits. This potentially allows Costa Rica to sell carbon sequestration services to the developed world. However, at this writing there is not yet consensus on whether forest-based offsets will be creditable under the Clean Development Mechanism.

Meanwhile, 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 mediate the creation of markets for the forest's environmental services. These are described in the next section.

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 the services. 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.

NATURE AND TERMS OF CONTRACTED ACTIVITIES

The payment for forestry environmental services program (FESP) currently reimburses 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 U.S. Conservation Reserve Program, which contracts with farmers to revegetate erosion-prone croplands and pastures, and riparian buffer strips. (USDA 1997).

The payment levels and eligible areas for these contracts are summarized in the table below. In all cases the payments are made over a five year period. In return, the landholders cede their carbon and other environmental service rights to FONAFIFO for five 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 noncompliance.

Activity	Current name of instrument	Min. area	Max.area	Total payment (colones) per ha over 5 yrs	annual disbursement schedule
Reforestation	Certificado de Abono Forestal (CAF)	1	--	120,000	50%, 20%,15%,10%, 5%
Reforestation (by organizations of small producers)	Certificado de Abono Forestal Adelantado (CAFA)	1	10	120,000	50%, 20%,15%,10% ,5%
Natural forest management	Certificado de Abono Forestal para Manejo del Bosque Natural (CAFMA)	2	300	80,225	50%, 20%, 10%,10%,10%
Forest regeneration	--	2	300	50,000	20% annually
Forest protection	Certificado de Proteccion del Bosque (CPB)	2	300	50,000	20% annually

(Note: exchange rate approximately 250 colones/US$, March 1998)

The pricing structure should be viewed as an initial trial, and is subject to later revision as FONAFIFO and SINAC assess the response. Currently, the reforestation incentives appear generous, since financial analyses find reforestation to be preferable to alternative land uses such as pasture. However, high discount rates and risk aversion among smallholders may discourage plantation investment. 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 versus '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 about US $20 to $30/hectare in the Central Cordillera region.

AREA UNDER CONTRACT

The FESP supersedes earlier incentive programs which provided tax deductions (since 1979), loans, and tradable tax credits (since 1986) for reforestation. In fact, the CAF and CAFA originated with the latter program. A cumulative area of 145,000 ha has received incentives for plantations under these programs (Castro 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 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 around 80 to 100 hectares. 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 hectares. 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.

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/hectare for a 20-hectare plan, 9256 for a 50-hectare plan, and 6874 for a 200-hectare 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. The forester is required to inspect the property at least twice a year; incentive payments are made upon receipt of a positive report. Foresters generally charge their clients a fixed proportion of their incentive payments for this service, though there would again seem to be economies of scale in monitoring larger properties. 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 noncompliance, 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.

INTERMEDIARIES TO REDUCE TRANSACTIONS COSTS FOR SMALL HOLDINGS

While the costs of including small properties in the FESP are relatively high, the benefits may also be high. These properties may be at greater risk of deforestation because of their owners' lower income, high discount rates, and lack of alternatives. On income distribution grounds, too, it is desirable to include small holders in the program.

One way to reduce transactions costs is to create local organizations which 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 NGO's

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

which have spontaneously adopted this role. FUNDECOR currently has enrolled 371 clients with 22,000 hectares in incentive programs. Seven thousands 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 five hectares 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, and draws up management plans. In some cases it draws up consolidated management plans for adjacent properties, taking advantage of economies of scale. It also monitors the performance of its clients, up to four times a year in the case of protection contracts. It provides technical assistance in reforestation projects, and provides favorable finance for acquisition of seedlings. And, with financing from the IFC, it is experimenting with advance purchases of wood, where it provides an annual flow of financing to landholders in exchange for rights to future harvests.

Local intermediaries such as FUNDECOR can realize economies of scale in organizing, managing, and monitoring smallholder clients. At the same time, reputational considerations and organizational norms help to insure the integrity of the monitoring process.

3. FINANCING ENVIRONMENTAL SERVICES: CARBON OFFSETS

INTRODUCTION AND BACKGROUND

This section describes the major potential funding source for environmental services: the sale of Certified (or Certifiable) Tradable Offsets (CTOs). (Other funding sources are described in the following section.)

CTOs – a Costa Rican invention – are externally certified reductions in net carbon emissions. CTOs are created through project activities which sequester carbon or avert carbon emissions. The offset amount, in tons, is the difference between the actual carbon emissions and the baseline emissions – that is, those that would have been emitted in the absence of the project.

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. Funds from the sale of CTOs will be deposited in a Specific Fund for the Conservation and Development of Greenhouse Gas Sinks and Deposits, and then can be transferred to FONAFIFO to finance further activities.

This section describes the mechanics of the PAP, since that is the most advanced, and discusses implications for full implementation of the PFP.

THE PROTECTED AREAS PROJECT

As in many Latin American countries, formal protected areas in Costa Rica comprise lands under a range of different tenurial statuses, public and private. Because Costa Rica's traditions and constitution strongly emphasize private property rights, there has long been uncertainty about the degree of actual protection afforded to properties in protected areas that are not securely registered as part of the national parks. While the 1996 Forestry Law states that land use change is not permitted in *any* forest-covered land, similar laws have been subject to evasion and to legal challenge in the past.

The Protected Areas Project (PAP) addresses this problem by placing 555,052 hectares 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. About 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. First, it claims to avert the release of 11,100,756 tons of carbon by preventing deforestation of 422,800 hectares of forested lands. Second, by stimulating secondary regrowth on 107,698 hectares of pastures and in existing secondary forest, the PAP claims sequestration of an additional 4,572,136 tons. (The small remaining portion of the consolidated area consists of swamps and waterways not at risk for loss or gain of carbon.)

Offset purchasers receive a 20-year stream of offsets. Offsets will be sold in five annual tranches. A complex optimization model was used to program the sequence of project actions. Properties with the highest carbon return per unit of expenditure were programmed for the initial year; offsets generated by consolidating these properties will be used to finance consolidations in subsequent years.

BASELINE DETERMINATION

As in any emissions reductions project, the quantity of reductions depends crucially on the baseline: the projection of what would have happened in the absence of the project. Separate baselines are necessary for deforestation and for regeneration. The key assumption is that in the absence of external project financing, the government would be limited in its ability to prevent deforestation or to encourage regeneration in unconsolidated properties in protected areas.

Deforestation baseline

The baseline for deforestation is derived from satellite data on forest cover. Images for 1979 (from Landsat MSS) and 1992 (Landsat TM) were visually interpreted. Deforestation rates were computed for a 10-km buffer zone *outside* each of the national parks. Because of regional variation, these differ from the nationwide average quoted earlier. (See below.)

Park	*Deforestation rate (arithmetic mean % /year)*
Barbilla Biological Reserve	1.26
Carrara Biological Reserve	0.84
Barra Honda National Park	2.29
Piedras Blancas National Park	1.20
Amistad National Park	3.25
Guanacaste National Park	2.29
Palo Verde	2.29
Rincon de la Viejo National Park	3.25

Source: MINAE (1997a)

These rates were then imputed to areas *inside* the national parks. To allow for the differences in law enforcement between lands with different tenure status, the following *ad hoc* adjustments were made:

Ownership category	*Deforestation rate multiplier*
State land	0
NGO	1/7
Other state institutions	2/7
NGO lands pending procedures	3/7

National Reserves	4/7
In litigation	5/7
Non-defined legal situation	6/7
Private	7/7=1

Source:MINAE (1997)

Thus deforestation on private lands in the PAP is assumed, in the baseline, to take place as deforestation on nearby properties outside protected areas, but deforestation on NGO-held land is assumed to proceed only one-seventh as fast.

These estimates of past trends were made before the calculation of cover changes over the period 1986-1997 by a FONAFIFO-sponsored study. Preliminary results suggest very low gross deforestation rates for national parks. It could however be argued that legal challenges to the forestry law's prohibition on deforestation could result in future deforestation rates that are more similar to the rates outside the parks. In any case, an unresolved issue in deforestation-based offset projects is the degree to which baselines should account for potential changes in commodity prices or policy that might affect forest clearance rates.

Average above-ground carbon densities per hectare were estimated by ecological life zone using forest inventory data from a variety of sources, formulas for relating inventory data (e.g. basal area of trees) to total tree volume, and default parameters for carbon and biomass densities per cubic meter. Below-ground and soil carbon was not considered in the calculation of offsets; a qualitative analysis suggested that this resulted in a conservative bias (i.e. an underestimate of actual offsets).

Baseline carbon emissions rates were calculated as the product of the region-specific deforestation rate, the tenure-specific adjustment factor, and the life-zone specific carbon density.

Regeneration baseline

Secondary forests are assumed to have a carbon density of 50% of the density of primary forests in their lifezone. Pasture is assumed to have a biomass of 10 tons/ha. In the baseline scenario, these biomass levels are assumed to remain constant over time. In fact, there is evidence that in some parts of the country there has been spontaneous regeneration of pasture. The extent and correlates of this regeneration remain to be investigated.

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.

Recalibration of deforestation and regrowth rates

Newly-available data could be used to produce revised, more accurate estimates of past deforestation rates and regrowth rates in project areas, conditional on land tenure status. Past trends, however, may need to be adjusted for current and projected future changes in beef and timber prices, and in forestry law enforcement efforts.

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 the most part, the risks are extremely difficult to predict in any rigorous fashion, and so are quantified subjectively, taking into account the likelihood of the event and the strength of existing precautions.

Some of the buffer offsets are designated as 'permanent' and nonsalable, and insure against irreversible events. For instance, about 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. Buffers against reversible risks are designated as temporary; these offsets are available for eventual sale if the risk does not materialize. An example is loss of secondary forest biomass, subsequently corrected by regrowth. In all, about half of the 3.56 million tons of offsets produced in the project's first year will be placed in the buffer.

The PAP design and offset scheme has been certified by SGS Forestry, an independent, private company. SGS will annually certify realized offsets, based on audits of project monitoring data from remote sensing, ground surveys, and sample plots. Buffers will be adjusted to reflect the difference, positive or negative, between realized and promised offsets.

THE PRIVATE FORESTRY PROJECT

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. Unlike the PAP, which sells 20 year future streams of offsets, the PFP will sell accomplished offsets, a year at a time. The reflects the private landowners' right to periodically renegotiate their carbon sales (though not to change their agreed-on land use).

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. Two hundred thousand tons of uncertified offsets have already been sold. The ultimate scope of the project has not been precisely determined, but it could encompass more than 700,000 hectares.

4. OTHER SOURCES OF FINANCING FOR ENVIRONMENTAL SERVICES

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 five years.

WATERSHED SERVICES

There is great interest in Costa Rica in quantifying and marketizing 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 (approximately 15 MW each) run-of-the-river hydroelectric facilities, Don Pedro (14 MW) and Rio Volcan (17 MW). The watersheds are 2377 and 3429 hectares, respectively. The company has offered landowners in its watersheds $10/hectare/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 five 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 five hours, the excess water must be spilled. Each lost cubic meter of water translates approximately to a lost kWh of output, or about 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 cubic meters per year for generation.

Sedimentation prevention is another potential hydrological benefit of forest protection. This is potentially quite important for Costa Rica because of the country's dependence on larger hydropower plants with sediment-sensitive reservoirs. However, the potential economic benefits depends in part on the size of the reservoirs' dead storage areas, which in some cases is very large (Aylward *et al.* 1998). Sedimentation also imposes costs on the provision of drinking water to San José. 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 provides 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 water, it also reduces water loss due to evapotranspiration – the process whereby trees pump water out of the ground and transpire it to the atmosphere. The net effect is situation-dependent, and hard to predict. Deforestation may also affect local climate by changing local heat absorption and wind interception patterns. Whether these changes increase, decrease, or displace rainfall is difficult to predict and depends on the scale and nature of land use change. The net effect on water yield of changes in infiltration, transpiration, and microclimatic change will be sensitive to local conditions.

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

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

hydroelectric facility. Aylward *et al.* 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 to $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.

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.

5. THE POLICY FRONTIER: EFFICIENCY AND EQUITY IN THE PURSUIT OF MULTIPLE GOALS

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.

GOALS

The FESP attempts to satisfy three distinct goals:

- to produce the socially optimal level of carbon sequestration and hydrological services;

- to conserve biodiversity;
- 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.

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.)

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/hectare 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. 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 recruitment, monitoring, and enforcement costs, and in carbon and biodiversity values. Some hypothesized differences are shown in the table below.

Characteristic	*Small properties*	*Large properties*
recruitment, monitoring costs/hectare	higher	lower
deforestation risk, potential for carbon offsets/hectare	higher	lower (?)
biodiversity value	lower (less viable habitat due to fragmentation, edge effects)	higher

To the extent that these generalizations hold, larger properties are likely to be more cost-effective providers of biodiversity services. Whether or not they are more cost effective providers of carbon offsets depends on how rapidly deforestation risk falls with increasing size of property.

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.

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.

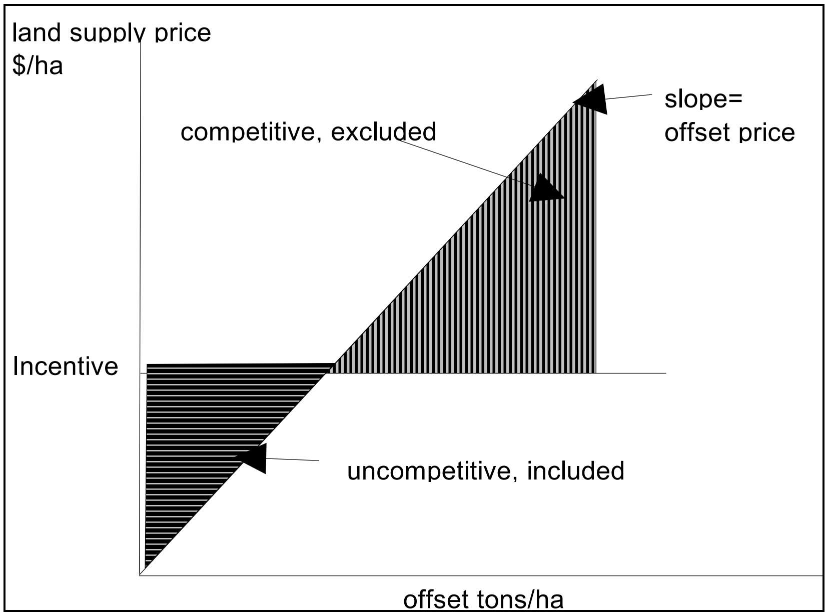
Monopsony and service bundling

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.

Pricing

If a decision is made in favor of monopsony, then a pricing strategy must be defined. A basic 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 an 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, the diagram plots properties according to each property's potential supply of carbon offsets in tons/ha, and to the property's supply price in $/ha. 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 $/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 Schor (1997) make an analogous argument: that limits on payment levels by the 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 (unless there was an administration fee). 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.

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.

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 the 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. 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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