Institutional Arrangements for Watershed Management: A Case Study of Arenal, Costa Rica

Bruce Aylward and Alvaro Fernández González

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The Authors

Bruce Aylward is Principal Economist at Iwokrama International Centre, Guyana, formerly a Research Associate at IIED. He may be contacted at:

Iwokrama International Centre,
P O Box 10630, Georgetown, Guyana
Tel: 592 2 51504
Fax: 592 2 59199
Email: bruce@radel.com

Alvaro Fernández González is an independent consultant, formerly a staff member of the International Center in Economic Policy for Sustainable Development of the National University, Heredia (CINPE). He may be contacted at:

Apdo. 552-6150, Santa Ana, COSTA RICA 333
Tel/Fax (506) 282-8323
Email: guidofer@sol.racsa.co.cr

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Environmental Economics Programme
IIED, 3 Endsleigh Street
London WC1H 0DD, UK
Tel +44 (0)171 388 2117; Fax +44 (0)171 388 2826
e-mail: Jacqueline.Saunders@iied.org

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IVM, Vrije Universiteit
De Boelelaan 1115
1081 HV Amsterdam
The Netherlands
Tel: +31 20 444 9555; Fax: +31 20 444 9553
e-mail:secr@ivm.vu.nl

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Abstract

The CREED Costa Rica project conducted an exhaustive quantitative inquiry into the economic factors that determine land use in the Río Chiquito watershed of Lake Arenal, Costa Rica, and found that livestock production is likely to produce positive hydrological externalities. This paper integrates these results into an application of the Institutional Analysis and Development Framework that is informed by a participatory process conducted with watershed stakeholders. The paper identifies physical measures, institutional arrangements and incentive mechanisms to stimulate improved watershed management in Río Chiquito by expanding the analysis beyond just the internalisation of hydrological externalities, to consideration of the larger "bundle" of goods and services provided by the watershed. In so doing it provides a refined vision for the Action Programme drafted by stakeholders. The latter is evaluated using IAD criteria and appears to be a promising improvement on current arrangements.

Not surprisingly, the findings suggest that the public good characteristics of a number of the watershed goods and services produced in Río Chiquito imply the need for institutional arrangements beyond that represented by markets. However, the results suggest that simply labelling such goods and services as public goods is too simplistic an approach. In the Arenal case, although upstream landholders may find it difficult to exclude others from consuming the downstream benefits of land use decisions already made, the possibility remains that they may retain rights of exclusion over future land use decisions. Given the private good characteristics of downstream hydrological products this suggests that there does exist a basis for a market-driven, polycentric arrangement between upstream producers and downstream consumers. Thus, the advantage of investigating the public good natures of the myriad of goods and services produced by watersheds is that it provides an analytical basis for the suggestions of the types of institutional arrangements that might be most appropriate for the management of these goods and services.

As an incentive mechanism for implementing a polycentric scheme to improve watershed management, it is recommended that the inter-institutional commission, called for under the Action Programme, develop a two-way sealed bid auction system of allocating contractual arrangements. Producers would agree to undertake management improvements in return for compensatory resource transfers (or projects). External stakeholders wishing to obtain off-site services would not only contribute funds but also assist in establishing priorities for the awarding of contracts, up to and including establishing their willingness to pay for specific measures in specific geographic areas. Ideally, producers would likewise set their offer price for specific measures in specific geographic areas. The respective sealed bids would be sorted and matched in a cost-effective, optimising manner by an independent committee organised under the commission. The hydrological and economic information developed in the CREED project could be used to establish both hydrological and carbon storage priorities, while the offer price for the measures would be best left to the individual producers to decide.

Resumen

El proyecto CREED Costa Rica realizó un estudio cuantitativo exhaustivo sobre los factores económicos que determinan el uso de la tierra en la subcuenca hidrológica Río Chiquito del Lago Arenal, Costa Rica y encontró que la producción ganadera parece generar externalidades hidrológicas positivas. Este documento integra estos resultados en una aplicación del Marco de Análisis Institucional y de Desarrollo realizada por medio de un proceso participativo conducido por varios grupos de actores interesados en la cuenca.

El documento identifica medidas físicas, arreglos institucionales y mecanismos de incentivos que estimulen mejoramientos en el manejo de la cuenca hidrográfica de Río Chiquito, por medio de la expansión del análisis más allá de la internalización de las externalidades hidrológicas hasta a la

consideración de un amplio rango de bienes y servicios provistos por la cuenca. Este proceso provee una visión redefinida para el Programmea de Acción esbozado por los grupos de interesados. Este último fue evaluado utilizando el criterio IAD y se encontró que constituye un mejoramiento promisorio sobre los arreglos actuales. No es sorprendente que los resultados sugieran que las características de bien público de un número de los bienes y servicios producidos por la cuenca Río Chiquito implican la necesidad de arreglos institucionales más allá de aquellos representados por los mercados. Aun así, los resultados sugieren que simplemente designar dichos bienes y servicios como públicos es un procedimiento muy simplista. En el caso de Arenal, aunque para los propietarios río arriba sea dificil excluir a otros de consumir los beneficios río abajo generados por previas decisiones de uso de la tierra, existe la posibilidad de que ellos mantengan derechos de exclusión de futuras decisiones de uso de la tierra.

Dadas las características de de bien privado de los productos hidrológicos río abajo, ésto sugiere que debe existir una base para un arreglo de mercado, policéntrico , entre productores río arriba y consumidores río abajo. De esta manera, la ventaja de investigar la naturaleza de bien público de los innumerables bienes y servicios generados por las cuencas hidrográficas es que provee una base analítica para las sugerencias sobre los tipos de arreglos institucionales que podrían ser más apropiados para el manejo de estos bienes y servicios.

Como un mecanismo de incentivos para la implementación de un esquema policéntrico que mejore el manejo de las cuencas hidrográficas, se recomienda que una comisión interinstitucional, designada bajo el Programmea de Acción, desarrolle un sistema de subasta sellada de dos sentidos para colocar arreglos contractuales. Los productores acordarían llevar a cabo mejoramientos en el manejo a cambio de transferencias de recursos (o proyectos) compensatorios. Actores externos interesados en obtener servicios fuera de sitio no solamente contribuirían con fondos sino que asistirían en el establecimiento de prioridades para la entrega de contratos, incluyendo además el establecimiento de su disponibilidad a pagar por medidas específicas en áreas geográficas específicas. Los montos sellados respectivos serían mezclados y comparados siguiendo un proceso de optimización costo-eficacia, por un comité independiente organizado bajo la comisión. La información hidrológica y económica desarrollada en el proyecto CREED podría ser utilizada para establecer prioridades tanto hidrológicos como de secuestro de carbono, mientras que el precio ofrecido por las medidas sería dejado a consideración de los productores individuales.

Abrégé

Au Costa Rica, le projet CREED a réalisé une enquête quantitative exhaustive sur les facteurs économiques déterminant l'usage des terres dans le bassin versant du Río Chiquito, le lac Arenal, et a découvert que l'élevage peut avoir des retombées hydrologiques externes favorables. Le présent document intègre ces résultats à une application du cadre d'analyse et de développement institutionnels (ADI) alimenté en informations par un processus participatif mené par des ayants droits du bassin versant. Le texte repère les mesures matérielles, les dispositions institutionnelles et les mécanismes incitatifs susceptibles de stimuler une meilleure gestion du bassin versant du Río Chiquito; il y parvient en poussant l'analyse au-delà de la seule internalisation des retombées hydrologiques externes favorables, jusqu'à prendre en considération l'ensemble global des biens et services tirés du bassin versant. Ce faisant, il offre un tableau affiné de la situation, destiné au Programme d'action établi par les ayants droit. Ce dernier est évalué à l'aide des critère ADI et l'on découvre qu'il représente une amélioration prometteuse par rapport aux dispositions actuelles.

Il n'est pas surprenant que les résultats de cette recherche suggèrent que, de par la nature publique d'un certain nombre de biens et services de bassin versant produits dans la région du Río Chiquito, il existe un besoin implicite de dispositions institutionnelles au-delà de celles des marchés. Mais ils suggèrent

aussi que se contenter d'apposer sur ces biens et services la simple étiquette de «bien public» serait par trop simpliste. Dans le cas de l'Arenal, les propriétaires fonciers situés en amont risquent d'éprouver des difficultés s'ils tentent d'empêcher la jouissance, par d'autres, des avantages tirés, en aval, de décisions déjà prises en termes d'utilisation des terres. Ils n'en gardent pas moins la possibilité de préserver leur droit de veto sur toute décision future en ce domaine. Étant donné la nature privée des produits hydrologiques d'aval, tout cela suggère l'existence d'une base pour des arrangements polycentriques animés par le marché, entre producteurs d'amont et consommateurs d'aval. L'intérêt d'étudier la nature publique de la myriade de biens et services produits par les bassins versants tient au fait que cela fournit une base analytique pour suggérer les types de dispositions institutionnelles convenant le mieux

À titre de mécanisme incitatif pour la mise en application d'un schéma polycentrique d'amélioration de la gestion de bassin versant, on recommande qu'une commission interinstitutionnelle, que le Programme d'action appelle de ses vœux, mette sur pied un système d'appels d'offres anonymes pour la répartition des dispositions contractuelles. Les producteurs accepteraient d'entreprendre des améliorations de gestion en échange de transferts de ressources compensatoires (ou de projets). Les ayants droits externes désireux d'obtenir des services ailleurs que sur place seraient non seulement appelés à apporter leur contribution financière mais aussi à aider à l'établissement de l'ordre des priorités pour la répartition des contrats, jusqu'à, et y compris, la confirmation de leur désir de payer le coût de mesures particulières destinées à des zones géographiques spécifiques. Dans l'idéal, les producteurs devraient pareillement fixer leur prix d'offre pour des mesures particulières destinées à des zones géographiques spécifiques. Les offres remises sous enveloppes cachetées seraient triées et mises en correspondance, de manière économique et efficace visant à l'optimisation, par un comité indépendant organisé sous l'égide de la commission. Les informations hydrologiques et économiques développées dans le cadre du projet CREED pourraient servir à décider des priorités, tant en termes hydrologiques qu'en termes de stockage du carbone, alors qu'il vaudrait mieux laisser les producteurs individuels décider du prix d'offre pour ces mesures.

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Figures and Tables

Acronyms

ACA	Arenal Conservation Area
ACM	Monteverde Conservation League
ACT	Tempisque Conservation Area
AGUADEFOR	Guanacaste Forestry Development Association
ARCOSA	Arenal, Corobicí and Sandillal Hydroelectric Power Complex
CCB	Forest Conservation Certificate
CCT	Tropical Science Center, San José, Costa Rica
CINPE	International Center in Economic Policy for Sustainable Development of the National University, Heredía, Costa Rica
COOPETILA	Coffee Producers Cooperative of Tilarán
COOPELDOS	Coffee Producers Cooperative of El Dos
CPB	Forest Protection Certificate
CREED	Programme of Collaborative Research in the Economics of Environment and Development (IIED/IVM)
FAO	Food and Agriculture Organization of the United Nations
FDF	Fund for Forestry Development
IAD	Institutional Analysis and Development Framework
ICE	Costa Rican Electricity Institute
IDA	Costa Rican Institute for Agrarian Development
IGN	Costa Rican Geography Institute
IVM	Institute for Environmental Studies, Vrije Universiteit, Amsterdam
IIED	International Institute for Environment and Development, London
IMF	International Monetary Fund
ITCO	Costa Rican Institute for Land and Colonization
MAG	Costa Rican Ministry for Agriculture and Livestock
MINAE	Costa Rican Ministry of Environment and Energy (formerly MIRENEM)
NGO	Non-Governmental Organisation
PCDA	Arenal Conservation and Development Project
PRAT	Arenal-Tempisque Irrigation Project
SENARA	National Water, Irrigation and Sewage Service
SINAC	Costa Rican System of Conservation Areas
UK	United Kingdom
WWF	World-Wide Fund for Nature

Introduction

The conversion, fragmentation and disturbance of tropical forest ecosystems in developing countries over the last few decades are well documented. Increasing recognition of the role that the economic importance of intact forest ecosystems may play in providing incentives for the conservation of these forests has led economists to study the non-market benefits that are lost when intact forests are modified or converted. These benefits include locally consumed non-timber products, biodiversity prospecting, ecotourism, carbon sequestration, soil and water conservation, and option and existence values. This line of research serves to illustrate the importance of conservation and, ideally, to flag developments that although possessed of considerable market potential will adversely affect the non-market goods and services provided by intact tropical forest ecosystems.

A second and, again, ideally complementary line of research has explored the "incentives" for and against deforestation, focusing on market, political and institutional forces that drive deforestation. This research typically also explores the means by which conservation values can be made explicit in decision-making, through a mix of the creation of new markets, institutions and enabling policies/legislation. Despite the emphasis on deforestation it is worth noting that the problem can be viewed from either of two perspectives: that of preventing forest degradation or that of encouraging watershed protection (through soil conservation, reforestation or forest regeneration) once ecosystems are disturbed or converted to other uses. Thus, the type of problem faced will vary depending on whether or not the locale under scrutiny has reached the post-agricultural frontier stage in its development.

The CREED project "Economic Incentives for Watershed Protection" explores these issues with respect to soil and water conservation in the Río Chiquito watershed in Costa Rica. The watershed is located in north central Costa Rica on the Atlantic side of the continental divide. With an area of 9,000 hectares, Río Chiquito is one of three watersheds that form the upper Arenal watershed that provides the majority of the water supply to Lake Arenal. The lake serves as the reservoir for the country's largest hydroelectric facility and irrigation scheme. Río Chiquito has seen over 60% of its area converted to pasture, with some 150 producers currently engaged in ranching, dairy and mixed dairy/ranching activities on the deep volcanic soils that layer the mountainous slopes of the watershed. Within the Holdridge Life Zones system the watershed falls within the Premontane to Lower Montane zones and ranges from Wet Forest to Rain Forest. The watershed extends from 500 m.a.s.l. near the lake to over 1800 m.a.s.l. at its upper reaches. Large areas of cloud forest are found in the latter areas where strong winds force moisture over the continental divide, particularly during the dry season.

The adjoining areas in the upper watershed are largely forested and in the hands of conservation organisations. As far back as the 1970s, during the design phase of the reservoir and hydropower complex in Arenal, the conservation community began voicing its concern regarding the national importance of maintaining a hydrological function in Río Chiquito. Previous analysis suggested an extreme mismatch between land use capability and actual land use in much of the watershed. Thus, Río Chiquito has long been targeted for action by conservationists and remains an area of considerable debate and conflict in this regard. Given that Costa Rica is at a post-agricultural frontier stage in its development, Río Chiquito

exemplifies the incentives problem faced in the local context and was chosen as a focal point for the study.

In the case of watershed protection (or soil and water conservation) the development of effective, workable and cost-effective incentives relies on more than simply an analysis of behaviour or responses to differing incentives. Economists have argued that soil erosion in and of itself is not "bad" and that all too often soil conservation measures (as designed) are ignored by farmers because they are too costly in comparison to expected benefits. Hydrologists have long acknowledged that deviation from "normal" downstream hydrological function as caused by forest disturbance and removal is not unequivocally (and significantly) "bad" in biophysical terms. Once the sign and magnitude of subsequent economic effects are taken into account it is equally clear that the downstream impacts of changes to hydrological function caused by land use change are not necessarily negative. In other words, a significant misallocation of resources may occur if incentives for watershed protection are not grounded in biophysical and economic "valuation" of the effects of land use change.

Not all such programmes require a detailed research programme. However, given the paucity of comprehensive studies of this nature, particularly with regard to downstream effects, the validity of proposed incentives in the Arenal case study hinges on demonstrating the economic value of the hydrological impacts associated with livestock production. The first half of the CREED study, as reported in Aylward et al. (1998a), suggests three important results: (1) that livestock production in Río Chiquito is economically viable; (2) that erosion and associated on-site productivity losses are neither serious nor widespread; and (3) that the positive external effects of gains in water yield under pasture outweigh the negative effects of increased sedimentation.

In the second part of the CREED Costa Rica study, a parallel research inquiry investigated the options for improving institutional arrangements and incentives for watershed management in Río Chiquito. This paper presents the results of this investigation. Assuming that there existed important on- or off-site environmental problems (principally hydrological in nature) initial efforts were aimed at identifying and evaluating incentives for watershed protection using the environmental-economic relationships developed in the quantitative evaluation. However, a review of the evaluation reveals that while the quantitative approach would be useful in identifying more "efficient" land uses in the study area, it would not necessarily uncover practical solutions to the problem uncovered. More to the point, it would not resolve the social and institutional aspects of an incentives schemes, aspects shown to be of critical importance by the literature. The focus of the investigation, as reported here, is therefore broadened so that the project might be able to identify incentives and institutional arrangements that would be feasible on the ground. Although the primary objective remained the internalisation of hydrological externalities, the focus on feasibility also implied the need to expand the focus beyond a narrow focus on hydrological factors to a consideration of the larger "bundle" of goods and services provided by watersheds.

The study employs three methodological approaches: (1) an institutional approach; (2) an environmental-economic approach; and (3) a participatory-stakeholder approach. In reality all three approaches are integrated with the institutional approach providing the theoretical umbrella. The institutional approach is based on an application of the Institutional Analysis and Development (IAD) framework put forward by Elinor Ostrom and her colleagues at the Workshop in Political Theory and Political Analysis of Indiana University, Bloomington. The framework has its roots in classic political economy, neoclassical microeconomic theory,

institutional economics, public choice theory, transaction-cost economics and noncooperative game theory (Ostrom, Gardner, and Walker 1994).[1] Key concepts from the field of economics are, thus, embedded in the IAD framework.

However, the advantage of the IAD framework is that it spreads its web much wider. Considerable emphasis is placed on the issue of transaction costs. These costs are typically disregarded in standard (quantitative) economic analyses, as exemplified by the evaluation of market and policy incentives conducted in the other half of the CREED Costa Rica study. The IAD framework also incorporates non-economic and non-quantitative factors into the analysis. In particular, the institutional analysis feeds off qualitative information produced by local-level inquiry such as the participatory-stakeholder approach employed in this study. The latter therefore serves a dual function of informing the IAD analysis and of initiating an action process within the local context.

This paper begins with a brief presentation of the conceptual framework and methodologies employed in the study. It continues with a summary of the problematic that underlies the issue of land use in Río Chiquito viewed from the perspective of the stakeholders, the environmental-economic approach to valuation of Aylward et al. (1998a) and an analysis of existing institutional arrangements and incentives. The discussion of alternatives begins with a presentation of the Action Programme as originally devised by the stakeholders. It then undertakes a detailed analysis of the public good nature of watershed goods and services, with particular reference to Río Chiquito and Arenal. In the ensuing section the IAD Framework and the information from the environmental-economic approach and the participatory process are used to assess physical measures for improving watershed management and to identify a consistent set of institutional arrangements. With the practical measures and institutional environment defined, the next section presents proposed modifications to the Action Programme and puts forward proposals for a new incentive scheme involving contractual arrangements and compensatory resource transfers. In order to provide a preliminary validation of the proposals developed in the paper, an evaluation of the modified Action Programme is undertaken employing the criteria set for in the IAD approach.

[1] The framework has been applied to a variety of topics, although the framework is probably most commonly associated with research into common-pool resource problems.

Methodology

This section provides a brief overview of the Institutional Analysis and Development Framework that guided the intellectual approach to the work. Readers wishing more detail should consult Ostrom, Gardner and Walker (1994). The manner in which the environmental-economic valuation work and participatory-stakeholder approach are integrated into the IAD framework is also briefly discussed.

IAD Framework

The IAD framework relies on an analysis of the "action situation" and the "action arena." The action arena is the basic analytical unit in the IAD framework (Ostrom, Gardner and Walker 1994). The action arena incorporates the action situations and the actors as principal components. The action situation constitutes a special space in which individuals interact, interchange goods and services, are involved in activities of appropriation and provision, and encounter conflict and resolve problems. Although at times different action situations are subtly mixed in the various action arenas, it is useful to separate them in order to facilitate study. On the other hand, although one action arena alone could include large numbers of participants and complex chains of action, it is inescapable that social reality is made up of a multitude of action arenas, linked together in a sequential or simultaneous manner. In order to analyse a given action situation the IAD approach calls upon three types of knowledge regarding the action situation: (1) attributes of the physical world, (2) attributes of the community and (3) applied rules.

A strength of the IAD approach that is exploited in this study is its utility in identifying the institutional arrangements and incentives suited to the desired objectives of a policy. In this study the objective is to identify arrangements and incentives for improving watershed management in the Río Chiquito watershed.

In the first instance, institutional arrangements should reflect and be appropriate to the types of goods and services that are "produced" by the communities living in, and managing, the Río Chiquito watershed. The conceptual framework of the IAD presupposes the presence of patterns of incentives inherent in the attributes of all the goods and services, which influence the conduct of individuals towards them (Thomson 1992). Consequently, this paper places a large emphasis on identifying and understanding the attributes of these goods and services, within the context of the local communities and production systems. As the topic is watershed management it is also necessary to include downstream stakeholders that are affected by changes in upstream land management. The IAD approach adopts the theory of public goods as a means of understanding the attributes of goods and services and analyzing the incentives inherent to the characteristics of these goods. In particular, the attributes of excludability and rivalry lead to a classification of goods and services that is very useful in the analysis of particular situations of action.[2]

[2] Beyond the categories of exclusion and rivalry, the IAD provides for several other attributes of importance in an institutional analysis, such as whether there is storage in the system, whether resource units are movable or stationary, predictability, etc.

As institutions are basically groups of people that interact according to specific norms, it becomes crucial to identify those norms as well as the incentives or disincentives (economic or otherwise) through which they take effect and shape the actions of those involved. Ostrom, Schroeder and Wynne (1993) distinguish between three types of institutional arrangements for managing goods with public goods characteristics: centralised, decentralised (or dispersed) and "polycentric". In principle, the latter seem to be the most promising, in that they are the result of a pragmatic and flexible mix of commercial and hierarchical incentives, and collective action. Background and details of these institutional arrangements are presented in Annex 1.

Once institutional arrangements are identified, particular incentives, or pay-offs, that may be offered to attain policy goals may be developed. In the IAD framework pay-off rules are an element of the action situation by which benefits and costs are assigned to actions and outcomes. Although at times a pay-off is considered as an implicit part of an outcome, in reality it is useful to distinguish between the two. A pay-off differs from an outcome in that the pay-off is the method for assigning positive and negative weight to outcomes, and hence to the actions themselves. This is where the concept of incentives arises as it is through the determination of these costs or benefits (who wins, who loses and by how much) that institutions shape human behaviour. Ostrom and her colleagues use a broad notion of incentives in this respect: "incentives are more than just financial rewards and penalties. They are the positive and negative changes in outcomes that individuals perceive as likely to result from particular actions taken within a set of rules in a particular physical and social context" (Ostrom, Schroeder, and Wynne 1993: 8).

The IAD framework also puts forward a set of criteria for evaluating the varied institutional arrangements that either exist or could exist for the provision of all goods or services. Four of these criteria are general in character (economic efficiency, equity, accountability and adaptability) and two are intermediate (transformation and transaction costs). An additional, preliminary criterion is the degree of compliance that exists, or could exist in the analysed arrangements (Blomquist 1992). Blomquist also introduces the criterion of efficacy; distinguishing between efficiency (in the use of resources) and efficacy (in the achievement of objectives).

The Río Chiquito Case Study

As stated above, application of the IAD framework relies on developing an understanding of the attributes of the physical world and of the community that are relevant to the action situation. Second, the rules that govern the action situation must be known. In the Río Chiquito case study this understanding is developed using the participatory-stakeholder approach, the environmental-economic valuation analysis and a number of the standard methodologies from the IAD toolkit. Each of these is reviewed briefly below.

The participatory-stakeholder approach consisted of a series of consultation and interactions with the principal institutional actors and stakeholders involved in the management of Río Chiquito and Lake Arenal. The particulars of the process are described in detail in Annex 2.

The participatory process informs and enhances the application of the IAD framework in three ways. First of all, the process provided a valuable window into the perspectives of different stakeholders. Through the process, information was collected (and shared amongst stakeholders) regarding different stakeholders' views as to which aspects of existing

management of the watershed were problematic; that is, which watershed goods and services were over-produced and which were under-produced. More broadly, the process also yielded useful information about more generic challenges and opportunities that the communities in the watershed face in the struggle to achieve social and economic development. The interaction with stakeholders not only provided important background on biophysical and community issues, but it assisted greatly in documenting and unraveling the history of institutional development and of past incentives schemes in Río Chiquito and its environs. A summary of the knowledge base emerging from the participatory approach is reported in the next section, and a detailed description and analysis of existing institutional arrangements and incentives governing watershed management in Río Chiquito and Costa Rica more generally is presented in Annex 3.

The participatory process also serves the purpose of providing the research effort with a first approximation of an action programme for improving watershed management in Río Chiquito. This programme, presented at the end of the next section, serves as a "point of departure" for the ensuing analysis, which is nothing more than an analytically directed search for a set of rules that will yield a superior outcome to that achieved at present in the watershed. Clearly, the latter process could occur (and usually does) in the absence of a plan of action drafted by stakeholders as part of a participatory process. That said, having in hand a plan that has been cooperatively developed by the stakeholders themselves is extremely useful to the analyst as it provides a realistic idea of what solutions the stakeholders view as reasonable and feasible given existing circumstances. The analyst must then agree or disagree with the overall structure and objectives of the plan and, ultimately, proceed with filling in the details based on technical data and analysis.

The third way in which the participatory process adds to the IAD application is very indirect in nature. To the extent that the researcher is an objective and external observer it will always be difficult to gather the sorts of "insider" information that can be very useful in designing useful institutional arrangements and workable incentives schemes. While participatory methods offer an excellent opportunity to gather this information they also exact a responsibility in return. Prospective participants will always be keen to know "what is in it for them". The participatory process undertaken as part of the of the Río Chiquito case study (as described in Annex 2) brought together stakeholders in the watershed's future for a face-to-face meeting for the first time. Further, the development of the action programme led to the initiation of a Bridging Committee to take forward the agenda as reflected in the programme. While the principal benefits of this aspect of the participatory approach are garnered by the stakeholders, this outcome not only contributes to the realisation of the objective of the CREED project to make a substantive contribution to policy development, but demonstrates how the application of the IAD framework may provide tangible benefits to the communities involved.

At the other extreme from the participatory process is the environmental-economic analysis carried out as part of the first half of the CREED project. Purely technical in nature, this effort relies on a number of technical studies in the area of soil erosion, forestry, and hydrology as well as extensive survey work conducted amongst landholders and producers in Río Chiquito. This information is combined in a phased cost-benefit analysis that underpins a traditional neoclassical analysis of market and policy incentives. The analysis seeks to answer a series of questions related to the financial and economic profitability of livestock production when viewed simply in terms of livestock production, in terms of livestock and erosion/productivity interrelationships and in terms of downstream hydrological externalities.

As this analysis is presented in full in the companion CREED paper by Aylward et al (1998a) the results are summarised only briefly in the next section, in order that subsequent references may be clearly understood.

The environmental-economic analysis complements the IAD framework in a number of important ways. First of all, it provides a useful contrast with stakeholder perspectives in determining the crucial problems that an Action Programme might seek to solve. Second, the geographic referencing of the scientific and economic information and, indeed, of the cost-benefit analysis itself, enables the derivation of a set of landscape-based physical measures that are consistent with the Action Programme and that would yield economically efficient outcomes. Here the environmental-economic analysis begins to blend into the IAD framework as it contributes in many ways to the analysis of incentive compatibility for these measures and to the evaluation of different institutional arrangements using the IAD criteria.

Thus, the participatory and environmental-economic methodologies greatly inform the next section which provides background on the challenges and opportunities presented by watershed management in Río Chiquito. The application of the IAD framework begins in earnest in the subsequent three sections which analyse institutional arrangements and incentives for improving watershed management in Río Chiquito before turning to an evaluation of a revised Action Programme. The first step in the IAD framework is to understand the attributes of the relevant goods and services. The text begins, then, by summarising the conclusions of an extended analysis of the public good characteristics of the full set of watershed goods and services produced in Río Chiquito (as reported in full in Annex 4). The relevance of these goods and services to the different stakeholders is reflected in the costs and benefits associated with their production. By integrating the information on costs and benefits with that on the public good nature of watershed goods and services it is possible to not only define a set of physical measures that will improve watershed management, but to create an analytical basis for arguing in favour of specific types of institutional arrangements for the provision and production of these goods and services. This is achieved by an in-depth analysis of the incentive compatibility of different measures.

With recommendations for a defined set of physical measures and institutional arrangements in hand the Action Programme can then be revised for consistency in light of these findings. Attention is then turned to the issue of prospective incentive mechanisms and organisational arrangements. These mechanisms are discussed in light of the action situation in Río Chiquito and an appropriate selection, that of contractual arrangements and compensatory resource transfers, made. Focus then turns to developing a plan for how these contracts and transfers may be operationalised. Having outlined the practical details of such a scheme it is then possible to assess the prospects of the Action Programme utilising the criteria developed under the IAD approach. This is done by subjecting the measures, institutional arrangements and incentives of the Action Programme to an evaluation vis-à-vis the *status quo*.

Background: Stakeholders, the Environment and Institutional Arrangements

This section presents background material on the action situation as it exists in Río Chiquito with regard to watershed management. The emphasis is on describing the perceptions of different stakeholders, summarising technical findings relating to the management of the watershed and clarifying the institutional challenges and opportunities. The latter effort is complemented by the detailed review of existing institutional arrangements and incentives for watershed and environmental management in Río Chiquito, Arenal and Costa Rica (in Annex 3). The section closes by presenting the Action Programme for Río Chiquito as developed at the final stakeholder workshop. The Programme provides a first look at the options that exist for improving the management of Río Chiquito. Subsequent sections build on this introductory section by providing an analytical basis for revising this Programme and discussing options for its implementation in terms of institutional arrangements and incentives schemes.

Stakeholder Diagnosis

The stakeholder consultations produced a list of environmental and economic problems associated with the management of the Río Chiquito watershed (and more widely with the entire Arenal watershed) as perceived by different stakeholder groups (CINPE 1996). Annex 2 lists the various types of stakeholders in disaggregated form. However, it is possible to place the majority of these stakeholders in one of four groups with regard to their position and role insofar as watershed management is concerned:

1. Conservationists (ACM, ACA, CCT, SENARA and other environmental NGOs) who feel that livestock production is a marginal economic activity and that the Río Chiquito watershed needs to be protected and, indeed, reforested, the latter, primarily as a function of the forest's role in preventing the sedimentation of Lake Arenal and downstream effects on hydroelectric production and the Arenal-Tempisque Irrigation Project.

2. The Costa Rican Electricity Institute (ICE) which is not convinced that land use has any impact on hydroelectric power production, fearing only the impact of geologic factors such as earthquakes and eruption of the Arenal Volcano as natural factors impinging on operations.

3. Producers (i.e. landholders involved in livestock production) and the local municipality who are concerned about on-site impacts of land use (including on-farm erosion and local water supply from springs) and feel that they should receive some form of compensation from ICE as it is their land that "provides" the water used to make electricity.

4. "Providers," i.e. a group of cooperatives and government agencies that would be likely to be involved in the implementation of any watershed management programmes. Their interests are practical, with their allegiance divided between the conservationists and the producers.

A number of points appear to be generally accepted, based on both the positions of the stakeholders and available scientific information.[3] Other points are clearly debatable. Certain producers claim to be experiencing losses in productivity due to the erosion that results from establishing pasture on areas that are extremely susceptible to soil loss (and perhaps with limited soil depth). The scientific evidence suggesting that high rates of erosion can be expected from particular land use units supports this assertion. An application of the Universal Soil Loss Equation suggests that about one-quarter of pasture areas have erosion rates of over 50 tons/ha/yr (Saborío and Aylward 1996). However, survey data and available statistical analysis suggests that in the deep volcanic soils found in the watershed this problem is not of such concern that farmers are investing in significant soil-conserving measures. Producers support this conclusion by reporting that they consider only a portion of their holdings (20-30%) to be of marginal productive value.

With regard to sedimentation, expectations on the part of ICE and conservationists have been at opposite ends of the spectrum. However, recent empirical work and modelling efforts support the view that the truth lies in between these two views. Best estimates are that pasture in the watershed does generate considerable sedimentation (approximately 90,000 tons/yr). However, the valuation work carried out under the CREED project (as reviewed below) suggests that the implications of significant levels of sedimentation are not as dire as previously expected by conservationists.

Reports by producers of problems with water supply from springs and the suggestion that reforestation has ameliorated these problems require further investigation, given that the science on this matter is ambiguous. The possibility exists that long-term rainfall trends may be as important as land use in this case. The intricate relationship between land use and water supply to Lake Arenal identified by the CREED project went essentially unreported by locals and ICE. Interestingly, however, part of the friction that exists between local producers and ICE stems from the perception on the part of local residents that ICE has historically failed to assist in the socio-economic development of the upper watershed, thereby failing to acknowledge the role of local producers in water supply.[4]

In addition, the general feeling of the stakeholders was that there was little or weak coordination of existing institutional actions and incentives aimed at correcting the problems. Two specific difficulties were noted in this regard by participants. Larger farmers typically do not live in the area and therefore do not participate in local organisations and events. Second, poor communication exists within the watershed due to the absence of any telephone (or postal) service. The only medium of "mass" communication available in the watershed is the *tarro fax*. Messages can be delivered daily amongst farmers selling milk to Monteverde by attaching "faxes" to the milk jugs that are transported to and from the Monteverde Cheese Factory. Ranchers, however, must physically attend meetings, meet-up individually or send messages by messenger in order to communicate with other producers. Thus, communication

[3] See Aylward et al. (1998b) for a full history and review of the development of scientific and economic information on the management of Río Chiquito.

[4] That said, it remains unclear precisely what claim producers are making here. The issue of incentive compatibility in this regard, however, is examined in detail later in this paper

and integration between the different types and sizes of producer is a problem for institutional development and coordination in the local community.

The relatively low level of socio-economic development and poor provision of public services to the Río Chiquito area was cited as an important socio-economic factor, one that also detracts from community organisation. Cooperatives, health services, government services, banking services, telecommunications, etc are all located, at best, on the fringes of the watershed, if not at regional centres that are even further away. Using such services is therefore, time-consuming, inefficient and always takes the producer away from the watershed instead of towards it. Local residents and producers lay much of the blame with ICE, and locals have, thus, acquired a reputation for being distrustful of outsiders (particularly government employees) and uncooperative with outside and agencies agendas. Recent developments, particularly the programme of land purchase by the Monteverde Conservation League in the neighboring Caño Negro watershed and general finger-pointing by environmentalists (local and international) at ranchers as the cause of the deforestation problem, have beleaguered local producers even further. This new source of conflict affects the larger farmers perhaps more than the smaller farmers, given that they are more involved in national-level debate and more cognisant of changing international trends that affect beef exports.

In sum the diagnosis reveals that there are two limiting factors to working towards improved watershed management in Río Chiquito. First there is the lack of a clear stakeholder consensus on the nature and degree of environmental problems that is bolstered by the available scientific information. Second, the level (and history) of socio-economic and institutional development places serious obstacles in the way of the development of cooperative, stakeholder-based solutions to these problems.

Environmental-Economic Analysis of the Value of Watershed Goods and Services

Conventional wisdom amongst environmentalists holds that the cutting of tropical forest for livestock production leads to large and sustained increases in erosion and sediment flows, increasing flood risk, a decrease in dry season flows and even a drop in precipitation. It is also believed that livestock production is itself an activity that provides little benefit to the economy, particularly as erosion eats away at productive yields over time. In the first half of the CREED project, Aylward et al. (1998) conduct a comprehensive analysis of these issues in the case of Río Chiquito. The results stand conventional wisdom on its head, suggesting that ranching, dairy farming and their associated downstream hydrological effects on hydropower production represent important values to the Costa Rican economy.

The study finds that the economic returns to livestock production are considerable in the case of large producers, with dairy operations producing the largest returns, followed by mixed dairy/ranching and ranching operations. Smaller mixed dairy/ranching and dairy producers generate less significant, but still positive, returns. Only small ranching operations appear to operate at a net economic loss, though still providing a positive cash flow to the rancher given the extensive use of family labour. Analysis suggests that the incentive to engage in livestock production would increase with trade liberalisation as input distortions are removed. Removal of trade barriers on milk product imports would reduce the profitability of dairy operations, however, the larger operations would remain viable businesses. The analysis also argues that there is little economic rationale for claiming that Costa Rican milk producers are “inefficient”

given large subsidies received by OECD milk producers. Finally, even a moderate increase in beef prices from the depressed levels encountered during the study would greatly increase the profitability of beef production.

Alternatives to livestock production in Río Chiquito are limited. An analysis of the profitability of forestry options, including natural regeneration, forest management and plantation forestry, suggests that the area has marginal potential in this regard. Meanwhile, problems of access to markets and biophysical conditions in the area have typically limited the attractiveness of agricultural options in the watershed. Ecotourism (or agroecotourism) has potential, but the Monteverde/Santa Elena area that adjoins the watershed to the south already provides a range of fairly sophisticated ecotourism experiences.

Due to the deep, volcanic character of the soils in Río Chiquito the CREED project (unlike previous efforts) did not expect to find a significant relationship between soil erosion and pasture productivity. Anecdotal reports of problems with soil fertility, however, led to both qualitative and quantitative efforts to establish the existence of an excessive pattern of intertemporal soil loss. Neither analysis offered evidence in favour of the hypothesis that soil erosion and subsequent losses in productivity are severe and widespread in the watershed. It is likely that some landholders are experiencing problems, but in the majority of cases the actual level of erosion is probably less than that previously reported and of little economic consequence given the volcanic nature of the soils.

With regard to hydrological externalities, the study clarifies that in the case of a large hydroelectric reservoir such as Lake Arenal, sedimentation and annual water yield are likely to be the most critical hydrological functions, with the seasonal distribution in water yield playing a minor role as well. The removal of forest in favour of pasture will increase sedimentation and water yield, although the direction of the effects on dry season baseflow will be site-specific. In cloud forest areas, the situation typically runs more in favour of forest cover, which serves to precipitate moisture from the clouds (fog drip). Changes in peakflows during storm events are of little consequence in the case of large reservoirs. Outside the Congolese and Amazonian basins little evidence exists to suggest that land use change alters precipitation. However, it is a remote possibility that land use change in the lower Río Chiquito watershed has raised the level of cloud cover in the upper watershed. This could reduce the amount of fog drip captured by the cloud forest.

Economic valuation of the hydrological externalities associated with pasture in Río Chiquito suggests that the water yield effect will lead to increased hydroelectric power production of an order of magnitude higher than the decrease in power production expected as a result of changes in sedimentation. The results are not very sensitive to a potential change in the seasonal distribution of water inflows to the reservoir. In the lower watershed, the expected gain in water yield is large and varies only slightly with location. Howevr, the estimates rely on the expected difference in evapotranspiration between pasture and forest across the three ecological life zones found in Río Chiquito.

In the cloud forest, experimental results from Río Chiquito suggest that the added capture of fog drip may put mature forest at a par with pasture in terms of water yield, i.e. that the they may have similar rates of evapotranspiration in cloud forest environments. However, the results also show that substantially higher amounts of fog drip are captured in cloud forest fragments, thus, supporting the belief that by maintaining a patchy mosaic of forest and pasture much higher water yields may be achieved than in a landscape dominated by either

forest or pasture. Further, the bulk of this fog drip capture occurs during the dry season when water is more valuable for hydroelectric production. Expected gains in water yield in the cloud forests of Río Chiquito will, thus, vary considerably depending on the patchiness of the landscape. Interestingly, in the upper watershed where small dairy producers are most numerous the landscape is exceedingly patchy and, thus, pasture in this area can be expected to produce the largest positive hydrological externalities.

In other words, the research suggests that it would be imprudent to pursue large-scale watershed protection schemes in Río Chiquito. At the same time, the results suggest that altering land use or management practices on particular landholdings may generate economic gains if the relationships between vegetative cover and sedimentation and water yield are properly understood and combined with knowledge of the economic productivity of different types of livestock production. The physical measures for improving off-site externalities presented later in this paper, therefore, represent a practical extension of the valuation work in Aylward et al. (1998a).

Existing Institutional Arrangements and Incentives

The institutional arrangements that exist for improving watershed management in Río Chiquito suggest that there is an important institutional transition occurring at the local level; a transition that follows the larger transition to polycentrism observed in Costa Rica. Production of environmental services in Río Chiquito appears increasingly to be of mixed character, following the definition of Ostrom, Schroeder and Wynne (1993). Part of the production is directly in private hands, while another part is developed through, or with the support of, public agencies. The more detailed review of existing institutional arrangements and incentives that appears in Annex 2 is summarised in this sub-section and conclusions are drawn on the challenges and opportunities that exist.

A range of actors is involved in pushing the agenda for watershed management in Río Chiquito, including various levels of government, cooperatives and other producer organisations, private firms, NGOs and private individuals. In a sense these actors can be seen to have been extending their "territory" towards Río Chiquito, starting from the three defined areas of influence: (1) the Santa Elena-Monteverde area (ACM and the Monteverde Cheese Factory), (2) the Tempisque area (COOPELDOS, COOPETILA, AGUADEFOR, ACT) and (3) Tilarán (MAG-FAO, Ranchers Association). The respective cultures of these regions clearly influences the packages that are being brought to Río Chiquito: a serious conservation interest from Monteverde; a coffee and smallholder forestry production perspective from Tempisque (on the Pacific side of the continental divide); and an emphasis on sustainable production and soil conservation from the ranching town of Tilarán.

Although many initiatives exist in surrounding areas, ongoing efforts at watershed protection, reforestation and soil conservation within the boundaries of the watershed are few. These are limited to the recent participation of a number of landholders in the government's Forest Conservation Certificate (CPB) incentive programme, ICE's reforestation scheme, the Monteverde Conservation League's (ACM) "Forests on Farms" programme and initiatives undertaken spontaneously by producers. Efforts designed to improve conservation through the intensification of production is limited to the technical assistance offered to dairy producers selling to the Cheese Factory and that sub-contracted by ICE for participants in its scheme. Note here that there may be substantial overlap between the latter two efforts as both

have their largest concentration in the upper watershed area adjacent to Santa Elena. In general, ongoing initiatives can be characterised as representing two types of institutional arrangement: centralised provision with decentralised production, and polycentric arrangements of provision and production.

In the case of the ICE programme, an arm of the central government is providing for the activities but much of the actual work is contracted to local institutions (COOPELDOS for seedlings and Dos Pinos for technical assistance on livestock production) or carried out by individual landholders. Production is, thus, decentralised although provision is centralised. In the case of the CPB incentive programme again the provision is arranged centrally but the actual production is carried out via a number of local cooperatives (AGUADEFOR, COOPETILA and COOPELDOS) and the landholders themselves.

The recent initiatives begun under the Watershed Management and Recuperation Programme of ICE may at last reflect a change in ICE's attitude towards the area. However, there can be no doubt that the population would prefer infrastructure and services to seedlings. Indeed, one interviewee cites the concern of locals upon being contacted by the reforestation effort. It transpires that they feared that having flooded the best lands in the area in creating the enlarged Lake Arenal, ICE was now embarking on an agenda to reforest and expropriate the upper watershed. This reaction speaks to the considerable difficulties created in working towards improved watershed management when the institution involved has historically used its dominant, centrally-derived power to command and control natural resources in the area, with little to no corresponding pay-off for the community.

At the same time the ACM and Cheese Factory initiatives (as well as unassisted efforts by landholders) are characterised by their non-centralised nature. Private groups (an NGO and a firm, respectively) have involved themselves in offering assistance in watershed management. Although it has not succeeded to date, the proposal to develop a research and demonstration project on "sustainable ranching" on the part of the Tilarán Ranchers Association would fit into this category as well. The Cheese Factory initiative would be the most purely private initiative of the three, given that the other two initiatives involve relationships with either government agencies (the Ranchers Association would team up with the Ministry of Agriculture and Livestock) or a large international constituency of environmental NGOs that are themselves managing government funds (ACM). Finally, there are the producers that have engaged in conservation activities (either explicitly or implicitly by leaving their land in forest) purely on their own motivation.

The Project for the Conservation and Development of Arenal (PCDA) working as part of the conservation effort in the Arenal Conservation Area (ACA) has also served as an important stimulus for decentralisation and uptake of polycentric arrangements in the Arenal area. In particular, plans to develop a centre for experimentation in sustainable development on the part of PCDA and other local actors may prove to be an important initiative. The centre will investigate, systematise, disseminate information regarding and encourage local and regional experiences of sustainable development.

Recent state efforts by other agencies of central government to change current land use practices are well intended, but flawed by their centralist and technocratic bias. According to local producers, this is the case with the Ministry of Environment and Energy's (MINAE) presence in the form of ACA, where policies were initiated with a strong top-down environmental approach even when specifically providing for consultation with local

institutions and organisations, and allowing for developmental concerns; this, despite the apparent success of ACA's institutional partner PCDA in achieving a more participatory and polycentric outlook. The soil conservation projects undertaken jointly by the Ministry of Agriculture and Livestock and the FAO, and by the Institute for Agrarian Development and the FAO are also considered to be very much top-down in nature.

Further evidence of the staying power of centralisation in the local context is the prohibition on land use change in forest areas under the new Forestry Law. The imposition of such a legal mandate represents very much of a traditional command and control (from the centre) approach to land use management. Further, the CCB incentive programme that provides for payments for environmental services to landholders who place their forests under conservation management and for reforestation incentives is not very encouraging. Although the implementation of these incentives is decentralised, the centralised nature of their provision remains a serious flaw. It is doubtful that an incentive programme that prescribes a single reforestation incentive or payment for environmental services across a country with as varied an ecological and economic landscape as Costa Rica will promote efficient resource use.

Thus, the vestiges of centralisation remain, even as "experiments" are conducted with more flexible polycentric approaches. These experiments in the provision and production of environmental goods and services are nonetheless an important emerging trend towards differentiated marketing. It is also worth noting that these experiments may be considered to be part and parcel of the transaction costs involved in moving towards better institutional arrangements and more efficient use and production of natural resources and environmental services in the area. This suggests that future transaction costs involved in implementing new incentives schemes will be lower as progress is made up the institutional learning curve. The next sub-section considers this point in greater detail.

Of fundamental importance is the increasing level of inter-institutional coordination between actors that is demonstrated in existing initiatives. This suggests the possibility of a polycentric arrangement for management of the watershed, and in general, for the management of the existing natural resource base where, as suggested by Ostrom, Schroeder and Wynne (1993), there is a special jurisdiction emerging for the provision of these goods and services. Also of importance in this respect is the emergence of user groups that complete the differentiation of the market on the side of the demand for environmental services.

A number of recent experiences serve to document this tendency towards inter-institutional coordination. First, a number of inter-institutional committees (such as the Regional Environmental Commission) have been formed as part of the development of the Arenal Conservation Area. Second, the Ranchers Association's effort to develop a project on "sustainable ranching" involved significant inter-institutional linkages. Third, an inter-institutional commission was created in Tilarán at the beginning of 1996. This commission brings together in an informal fashion representatives of a mix of public agencies and private organisations interested in developing new initiatives for the development of the Lake Arenal watershed. Initial efforts of the Commission are directed at a diagnostic exercise and the design of potential options for taking advantage of opportunities identified by this process.

Finally, the participatory process undertaken as part of the CREED project led to the creation of the Bridging Commission for Río Chiquito. The commission was formed in response to the interest expressed by the various stakeholders present at the final workshop of the project. The commission includes representatives of a variety of public and private organisations

working on watershed issues in Río Chiquito, and is charged with developing plans for institutional development within the watershed. In addition, the Commission aims to develop (fundable) watershed management projects that address the concerns of stakeholders, as represented by the Action Programme for Río Chiquito, which is summarised at the end of this section.

Historical Roots of the Problem: Transaction Costs and Externalities

The preceding discussion suggests that a number of polycentric arrangements already in operation in Río Chiquito have the aim of conserving existing forest and planting additional forest. These arrangements reflect a number of perceived values of forest goods and services, particularly reduction of sediment delivery and carbon storage. In this sub-section the upstream and downstream transaction costs involved in initiating collective action (and deriving a polycentric institutional arrangement) between ICE and producers in Río Chiquito with respect to watershed hydrological services are examined. This discussion takes a historical perspective to examining the reasons why it has taken ICE so long to involve itself in watershed management in Río Chiquito and, in the process, clarifies the opportunities now available in this regard. In a sense, this takes the quantitative analysis of Aylward et al. (1998a) one step further by explicitly considering how transaction costs have altered, and are altering, the perceived net benefits of investing in watershed management.

Historically, ICE has taken little or no action regarding land use in the Arenal watershed. It is also clear that ICE is the principal user of the hydrological services provided by the watershed. The question therefore is: why has ICE done nothing? In terms of the Coase Theorem it would be expected that were true Pareto efficiency gains available, ICE already would either have reached a mutually beneficial agreement with Río Chiquito landholders to produce more of the desired hydrological services (or less of the undesirable ones) or have simply purchased all the land and turned it to the preferred land use. The latter, after all ,was almost identical to the proposal made by CCT in 1980 for the upper Arenal watershed upon studying the problem (CCT 1980).

There are two possible reasons why such actions might not have been perceived as worthwhile: (1) the transaction costs associated with either course of action were too high, or (2) the benefits of such action were not viewed as worth the effort. Two elements of transaction costs might be of particular importance in this case: the characteristics of the parties to the transaction, and the availability of technical options and implementing capacity to undertake reforestation and regeneration. The first factor affects the prospects for initiating collective action and the second factor affects the possibility of implementing collective action. With regard to the perception of benefits, the role of information regarding the impacts of land use on hydroelectric production appears to be central to the perceptions of different stakeholders.

Transaction costs reflect the difficulty of fostering and implementing collective action between relevant actors (or groups of actors) in order to produce goods or services with public good characteristics (or to curtail the production of public bads). The characteristics of these groups that are expected to influence the magnitude of the transaction costs are the size, the geographic location and the degree of diversity of the group. In the case under analysis there are two grouping levels worth considering. First, there is the distinction between ICE and the

producers and, second, it is important to consider the characteristics of different groups of producers and the nature of ICE as an institution.

The historical antipathy between ICE and the producers who inhabit the area or live in local towns is well documented. The culture of top-down, centralised planning in the historical development of the Arenal area has no doubt engendered anger and resentment in the producers. Such a planning process has typically placed ICE and its personnel in the position of telling producers what will happen, rather than consulting with them regarding alternatives. For the largest producers in the area, who have the societal status that comes with being large, successful ranchers, one-to-one communication with ICE representatives is possible. However, for the smaller producers the socio-economic and cultural differences involved have no doubt impeded any attempt to communicate in either direction. It is difficult to conceive of representatives of ICE, an institution staffed by engineers and bureaucrats and based largely in San José, travelling to Río Chiquito to discuss a contractual arrangement with producers who are on a much lower educational and socioeconomic level.

As far as the group of producers is concerned, the difficulty of reaching a cooperative agreement to resolve externalities associated with livestock production (whether positive or negative) can be expected to be high. Although reduced in recent years, there are a large number of individual producers in the watershed. The 1995 census conducted for the CREED Costa Rica project suggests 165 holdings, whereas in 1987, over 300 holdings were found (Aylward et al. 1998b; Matamoros 1988). The geographic location and surroundings of the watershed in which the producers operate and the degree of diversity between producers are also important obstacles to collective action. The poor state of road infrastructure and telecommunications clearly impede communication between producers. There are large commercial landholders and small subsistence holders who have little in common. In particular, the tendency for larger producers to live well outside the watershed further impedes the ability of the group to reach any common understanding. The diversity of production methods employed in the watershed leads to further segregation amongst the producers. Only in the case of the relatively tight-knit group of dairy producers who sell to Monteverde and communicate by means of the *tarro fax* can it be said that these smaller groups might lower transaction costs.

As suggested, the high transaction costs of developing an agreement between ICE and the producers have probably been sufficiently large as to dissuade ICE from getting involved in any form of contractual arrangement between parties. In addition, in the late 1970s and early 1980s there was little in the way of established organisational capacity in the area to carry out soil conservation or reforestation projects, and no experience with incentive programmes to stimulate such efforts. In other words, there was little knowledge of how to ameliorate negative hydrological effects while enabling livestock production to continue (i.e. without wholesale evacuation of the area).

It is also probable that the cost of expropriating the land and turning Río Chiquito and, indeed, the entire upper watershed into a protected area was quite high. The donors for the Arenal dam project did not feel that this was a high priority at the time. There was probably very little institutional energy and enthusiasm on the part of ICE for further expropriation of land (following that required to build the dam). Nor could it be expected that such an effort would go without resistance on the part of producers who had lost their lands to ICE once before. Undertaking such a step would also have involved considerable costs in inter-institutional

coordination. ICE's mandate does not include establishing or managing protected areas. Cooperation between ICE and the National Park Service would have been necessary in this respect, although both fall (and fell) under the power of the Ministry of Environment and Energy (and its previous incarnations). Thus, even if the benefits of acting unilaterally were considered significant, the substantial transaction costs may have impeded action.

In sum, high transaction costs were probably sufficient in the past to bar the spontaneous emergence of any market-driven institutional arrangements to internalise hydrological externalities in Arenal or Río Chiquito. However, it is also a possibility that ICE viewed the benefits of acting as marginal and, thus, was loath to get involved in Río Chiquito. Historically the debate has raged over the importance of the increased sediment generated by pasture. The perceived importance of this problem varies dramatically depending on the figures employed. ICE's internal data suggested sedimentation rates of minimal magnitude while the CCT claimed rates ten times these levels in its 1980 study.[5] If ICE was basing its decision on its own data the lack of action would probably have been justified by the (imperfect) information it had developed.

It is, however, interesting to note the historical lack of debate over the relationship between land use and water yield, given the overwhelming importance of the potential gains in hydroelectric production due to water yield gains coming from pasture areas, as illustrated by Aylward et al. (1998a). This can be explained in one of two ways. It may be that ICE was simply unaware of these potentially positive externalities of livestock production. The model used by ICE to predict inflows into the lake is an extremely accurate model, but it does not explicitly incorporate land use as a variable and represents a practical data mining approach to forecasting and is, thus, of little use in developing an understanding of causal relationships. Alternatively, ICE may have known or suspected that this relationship existed but acted strategically in not discussing it in public.[6] This presumes that ICE's strategy was to be content with the level of deforestation already in existence in Río Chiquito (and the entire Arenal watershed) by the late 1970s and to settle for resisting any efforts to alter land use patterns in favour of forest.

Finally, it is also worth questioning the extent to which a parastatal bureaucracy and its staff are actually concerned with longer-term issues of economic efficiency, particularly where they concern raising the operating efficiency of existing installation versus simply making new additions to the capital stock. The ability to squeeze more generation out of ARCOSA in the face of rising demand is clearly a long-term issue. Changes in water yield may also have a short-term impact, but both sedimentation and water yield changes have implications over a much longer time frame. However, if these changes are viewed as small and distant in terms of their potential impact, and if institutional incentives do not reward attention to such details it might be difficult to table the issue of land use. In this case the centralised nature of the provision and production of electricity may count against ensuring efficiency at the watershed or project level.

[5] See Annex 5 of Aylward et al. (1998b) for a review of studies of erosion and sedimentation in Lake Arenal.

[6] ICE personnel were no doubt aware of the joking claim that the most efficient land use for a hydroelectric watershed (with storage) is pavement (i.e. no sediment and no evapotranspiration).

Future Opportunities: Intertemporal Analysis of Transaction Costs

Attempts to explain the historical rationale behind ICE's refusal to involve itself in the land use debate in Arenal or Río Chiquito remain speculative as the real reasons will never be known. In light of recent ICE efforts to initiate reforestation projects in Río Chiquito it is perhaps more meaningful to assess how developments over the last two decades may be altering the situation. Interestingly, ICE's current rationale for this intervention appears to be mistaken, based as it is upon the notion that reforestation would produce large benefits in terms of both carbon and sediment reduction. Nevertheless, the precedent is important and it raises the question of whether it is simply a matter of a re-evaluation of the benefits that has engendered action or is it also possible that the transaction costs have also been lowered in recent years? The changes in factors that influence the transaction costs for ICE and for producers in the area are briefly discussed below.

As noted above the livestock producers in Río Chiquito continue to be a large and heterogeneous group. The only change in the last decade has been a concentration of land holdings, reducing the number of producers in the watershed. While this trend may have improved conditions for collective action on the part of producers, serious obstacles remain in effecting action of this nature. In particular, the change in land tenancy has led to the control of an increasing share of the watershed by larger landowners that reside outside the watershed. Not surprisingly, this trend means that there has been little impetus for a change in the poor level of infrastructure in the area, which in turn continues to impede communication and organisation amongst those producers resident in the area or its surrounding communities.

In recent years, the continuing poor performance of beef prices has undoubtedly reduced the attractiveness of ranching to the point where conservation or reforestation opportunities that involve the possibility of cash compensation are increasingly attractive. Nevertheless, it remains clear that for ranchers the transaction costs of organising to exploit such opportunities are very high, limiting action on this front.

In the case of ICE a number of factors mentioned above have changed in the last decade. In particular institutional development within public agencies (ACA, SINAC, MINAE), private organisations (COOPELDOS and COOPETILA) and NGOs (ACM and CCT) during this period have greatly improved local capacity in protected area management and reforestation. All of these organisations are currently working in areas that surround the Río Chiquito watershed and some have already entered the watershed. In addition, the development of ACA has also led to a an increasingly decentralised planning process capable of coordinating inter-institutional initiatives that include both state and private organisations.

Thus, as opposed to just a few years ago, it is now possible to use the infrastructure, technical knowledge, human resources and institutional capability of these organisations to initiate conservation or reforestation programmes in Río Chiquito. In other words, the transaction costs of producing watershed services through these programmes have declined considerably. In essence, new initiatives may free-ride on the efforts and investments made in nearby areas, investments principally undertaken by NGOs and cooperatives (albeit in some cases with government funds). For example, the new programme developed by ICE is directed by a former employee of ACM and employs a number of ideas and methods developed under the ACM reforestation programmes. In this case, ICE did not have to pay the up-front costs of developing the personal capability of this professional nor did it have to pay for the technical knowledge of forestry in the area (use of native species, etc). Perhaps even more important is

that by "piggy-backing" upon the ACM experience, ICE obtained access to personnel with technical expertise in forestry and also practical experience in establishing a constructive dialogue with producers from the area.

Assuming a unilateral change in intent by ICE to provide for increased watershed services in Río Chiquito, then the transaction costs of implementation have been greatly reduced in recent years. Such a change in intention does appear to be occurring. The increasing consciousness at the national level regarding the importance of the environmental services provided by forests has no doubt filtered down into ICE operations. The creation of the new watershed unit at ICE reflects this changed attitude. To date, this consciousness remains centralised and top-down in origin and approach (the intent filtering down the executive chain of command from the President, to the Minister in charge of MINAE, and from there to ICE, which is under MINAE's direction).

Two difficulties with this unilateral change and two opportunities may be mentioned in closing this sub-section. First, such a technocratic approach from the executive branch is susceptible to changes in administration. For the change to have a lasting effect it must take root within the institutional structure of ICE as well as with the producers themselves. As long as the process is unilateral, a change of heart at ICE or in MINAE could end the entire process. In other words, until the provision of watershed services is decentralised, or, better still, becomes polycentric in nature, the entire process is held hostage to the whim of centralised authority. Thus, the issue of transaction costs and producer organisation in the watershed remains crucial to success in the long run, even though the short-term outlook is positive based on a centralised impetus for provision and reduced transaction costs of producing.

A second difficulty, as indicated in this report, relates to the need to reach a scientifically defensible consensus on what constitutes an optimal land use pattern for the watershed. Until the objective is clear and agreed upon, institutional arrangements, organisational developments and incentives will be open to criticism and may lead to less efficient instead of more efficient allocation and use of resources in the watershed.

In this regard, it is hoped that the companion paper by Aylward et al. (1998a) provides an opportunity to settle the debate over the importance of sedimentation and to turn attention towards the issue of water yield and water regulation. A further opportunity exists in the current atmosphere of uncertainty regarding the future of ICE and the private/public balance of future power generation in Costa Rica. Traditionally, ICE has taken a supply side approach to meeting electricity demand. Once a project is built it is essentially forgotten as additional increments in demand are forecasted and additional supply projects are planned to meet this increase in demand. The option of improving management of existing facilities does not enter into system expansion planning; such facilities are essentially exogenous to the modelling exercise (ICE 1996).

However, current interest in demand management amongst the technocratic elite of the country, increasing pressures on sources of large project finance and the potential for increasing competition from private generation sources may be interpreted as providing an opportunity for a reassessment of the traditional approach taken by ICE. Under such a re-evaluation perhaps ICE (in conjunction with local landowners, NGOs and other public agencies) might take a closer look at the related issue of how to increase production from existing hydroelectric facilities through a cooperative approach to coordinating land use activities in the watersheds that feed these facilities.

Action Programme for Improved Watershed Management in Río Chiquito

The Action Programme reflects the stakeholder diagnosis of environmental and institutional problems and the agreement reached by stakeholders at the final workshop in June 1996. The six principal working objectives of the Action Programme are detailed below.

Forest conservation and regeneration. This proposal consists of efforts to conserve existing primary forest and to continue the process of natural regeneration where already established in Río Chiquito. This would be achieved within the guidelines and incentive mechanisms of the new forestry law. The intention of this objective would be to assist landholders to avail themselves of the CCB programme. Landholders not interested in participating in this programme would have the alternative of obtaining approval from the authorities for a management plan designed to ensure a sustainable harvesting cycle.

Land use change in marginal pasture areas. A change in use of pasture to forest is proposed for areas within holdings that are of only marginal productivity. Natural regeneration of forest and the formation of biological corridors through reforestation would be the principal activities.

Improving livestock technology. The Programme proposes to support land use change on marginal areas by promoting technological improvement of production processes on remaining productive areas to intensify production on these areas and raise their profitability.

Community development. A wide range of measures is proposed to improve the level of social and economic development of the watershed. These measures include the construction of infrastructure (roads, schools and health centres) and provision of social services (electricity, telecommunications, education, etc.). It is also proposed that a new district (including the main towns in the Río Chiquito watershed) be formed that would respond to the needs of the watershed.

Development of local ecotourist projects. It is proposed to take advantage of improved management of the watershed by internationally marketing an ecotourist experience that is centred on the concept of a mixed forest/pasture landscape and sustainable ranching and dairy production. This follows on from efforts by ACA to attract international ecotourists to a series of rustic ecotourist lodges that have received subsidised credit from PCDA.

Inter-institutional coordination. Under this proposal an inter-institutional mechanism for Río Chiquito would be created, in which all interested sectors would participate, that would administer the resources and incentives (both new and existing) which would support the Action Programme.

These ideas have since been taken forward by the Bridging Committee formed at the workshop. Within the framework of the six proposals presented under the Action Programme the Bridging Committee plans two principal strategic elements for action in the medium term (2 to 3 years): (1) an initial nucleus of demonstration projects, and (2) the extension of the programme to other potential users. The Bridging Committee also formulated six activities for completion in the short term: (1) completion of an inventory of producers; (2) establish a zoning of the watershed; (3) extension of the CCB incentives to interested landholders as per the zoning; (4) establishment of a demonstration project for improved pasture management combined with reforestation; (5) extension of existing environmental education projects of

ACA and ICE to Río Chiquito; and (6) design of a joint implementation project for carbon

The Action Programme as originally envisioned and subsequently developed under the Bridging Committee is a laudable attempt to confront the issue of watershed management in Río Chiquito. However, two findings embodied in the companion paper by Aylward et al. (1998a) imply the need to return to the underlying justification for the proposals under the Programme in order to reassess the exact nature and dimensions of the plan. The first finding regards the determination that the relative economic importance of the increase in water yield associated with livestock production significantly exceeds that of the rise in sediment delivery. The second, and admittedly preliminary, finding suggests that outside of carbon storage values there is little reason to suspect the existence of other significant negative externalities associated with livestock production. Further, the positive hydrological externalities of increases in water yield appear to be significantly larger than the negative externalities associated with carbon storage, even given a fairly generous value for stored carbon. Finally, the implication of positive hydrological externalities is the combustion of additional fossil fuels. Thus, the existence of any claim on a "carbon credit" for reforestation activities in the watershed is weak at best.

These two findings are somewhat surprising considering previous diagnoses of watershed issues in Río Chiquito, and are potentially at odds with the prevailing understanding among stakeholders who were involved in the consultative process that produced the Action Programme0. These findings, therefore, raise questions about what type of reforestation or natural regeneration (and how much) is actually "good" in terms of managing the watershed for the provision and production of the range of watershed goods and services described earlier in this paper. The commitment of public funds to the watershed or, more broadly, the undertaking of collective action by society relies on the justification that only by doing so will a "bundle" of watershed goods and services be produced that optimises the provision of goods with both private and public good characteristics. It is, therefore, useful to return to an analysis of these goods and services, their public/private nature and their relative importance in Río Chiquito in order to validate the objectives and proposals set forward under the Action Programme. At the same time it is possible to propose and assess the incentives and institutional arrangements that might be useful in improving watershed management in the area. These tasks are undertaken in the remainder of the paper.

Institutional Arrangements for Watershed Management

In this section an analytical basis is developed (and applied) for recommending institutional arrangements appropriate to the provision of physical measures for improving watershed management in Río Chiquito. Fundamental to this analytical process is the integration of the quantitative information on the value of watershed goods and services in Río Chiquito, with a qualitative assessment of the public good characteristics of watershed goods and services. Analysis of who gains and who loses from the production of these goods and services leads to an understanding of the compatibility of existing rules and incentives with the larger objectives of economic efficiency. This in turn generates a set of fundamental observations regarding the justification for improved institutional arrangements, the likely objectives of such arrangements (practical measures for improving watershed management) and the form that such arrangements might take.

This is an applied yet theoretical exercise, given that a set of institutional arrangements already exists for the provision of watershed goods and services in Río Chiquito (although they are not necessarily an efficient set). In cases where institutional arrangements already exist they can be compared to "ideal" arrangements to assess the efficiency of the current arrangements and suggest future opportunities for improving these arrangements. In cases where arrangements do not currently exist, the analysis suggests appropriate arrangements. At the end of the sub-section the "derived" measures for improving watershed management can then be compared with those envisioned under the Action Programme to suggest modifications to the Programme or changes in emphasis.

The Public Good Nature of Watershed Goods and Services

"Watershed management" in its largest sense encompasses a vast range of environmental and productive goods and services. Typically, productive goods are private in nature and environmental goods have public good characteristics. Annex 4 presents an analysis of the degree of excludability and rivalry of watershed goods and services produced in Río Chiquito. As with the rest of the study, the focus is on hydrological impacts, particularly externalities, with a secondary focus on other externalities and values consistent with watershed protection. In Figure 1, an effort is made to summarise the classification of these watershed goods and services according to their public good characteristics for the case of Río Chiquito. As far as is possible, doubts regarding the classification are noted with a thin arrow, and a thick arrow denotes future possibilities for movement from one category to the other.

Figure 1. Exclusion and Rivalry of Watershed Goods and Services in Río Chiquito

Exclusion \ Rivalry	Non-Rival (low)	Rival (high)
Non-excludable (low)	Public goods and services sediment delivery water yield water regulation flood risk reduction biodiversity prospecting⇓ existence value	Common-pool goods and services ⇐sedimentation carbon storage⇓
Excludable (high)	Toll goods and services	Private goods and services ←soil productivity on-site extractive uses annual flows dry season baseflow

With regard to hydrological services, the spatial nature of production (upstream by landholders) and consumption (downstream by a range of different users) makes it useful to distinguish between the status of the services as produced by the landholders and the disposition of the downstream (or instream) product as seen from the perspective of potential users. The analysis, therefore, makes a distinction between (1) sediment delivery rates and sedimentation, (2) water yield and annual flows and (3) water regulation and seasonal flows and flooding. This distinction is most relevant in the case of the characteristic of exclusion. That is, the extent to which upstream landholders can exclude downstream consumers from the upstream service and the degree to which downstream consumers can exclude each other from access to the instream resource. Rivalry is only relevant as a characteristic of the downstream product.

This distinction accounts for the upstream and downstream nature of land use/hydrology relationships. Typically, the function and the output are controlled by different actors and, as noted in the Figure 1, may demonstrate differing levels of excludability and rivalry. For example, the water yield function is very much a public good as it is not possible for the landholder to exclude downstream users from changes in water yield associated with land use change. As discussed in Annex 4, the only exception to this rule is when downstream benefits would be created (or costs avoided) by a change in land use that is not in the interest of the landholder. In such a case the landholder excludes the downstream beneficiary by not altering the land use. This exclusion is referred to as *ex ante* exclusion as opposed to *ex post* exclusion implicit in the aforementioned difficulty in excluding downstream consumers from benefits already created by a change in land use.

As far as downstream annual flows are concerned, ICE's legal mandate and physical control over Lake Arenal enables it to exclude others from the benefits of changes in these flows and to fully consume the potential energy attribute of the water held in the lake. Thus, the annual water inflow arriving at Lake Arenal from Río Chiquito is essentially a private good. That these inflows are private becomes of particular significance in the case of *ex ante* exclusion as the possibility of achieving a Coasian solution to the problem are greatly enhanced if the downstream hydrological product has private, rather than public, characteristics.

Public Goods, Watershed Management and Institutional Arrangements

Improving watershed management is typically considered to have as an objective an improvement in the level of environmental goods and services offered by watersheds. There is, however, no *a priori* reason to suppose that the net effect of such management will lead to a decrease in "production", although this might be the conventional assumption. For example, improved watershed management might imply an increase in the area dedicated to environmental pursuits relative to "productive" pursuits and, at the same time, an intensification of production on lands remaining in production. Unless the objective is to fully protect the watershed most watershed management schemes will often have both a conservation and production component. This suggests the need to consider the effects of such schemes on the whole range, or "bundle" of goods and services produced by watersheds.

Traditionally, environmental management, or the improvement of environmental quality, has been considered as a public good. For instance, Thomson (1992:10) suggests that that is the case for environmental management in arid areas because such improvements increase the resilience and productivity of the natural systems, and the benefits are available to all with the consumption by some not impeding the enjoyment of others. Nevertheless, in the case of watershed management, the analysis of public good characteristics suggests that this is not the case when viewed from either the level of individual goods and services or the aggregate level of watershed management as a whole. The complexity of both individual components and the entire "bundle" of goods and services suggests that watershed management solutions may need to be considerably more complex than a simple one-dimensional approach predicated on the "public good" assumption.

As revealed in the analysis of the public good characteristics of watershed goods and services in Annex 4, a range of factors will affect the excludability and rivalry of each and every such good and service. These factors include:

- the range (spatial, temporal or economic) in which the good is available (i.e. local, national or global)
- the biogeophysical environment (in the case of hydrological services topography and climate will be very important)
- the institutional arrangements for administering each good, in particular existing and enforceable property or use rights
- the relationship between supply and demand for each good (relative values of different products) and the technologies employed in their production

As a result, the classification of a given service may vary between one particular set of circumstances and another set of circumstances. In view of the range of possibilities it is, therefore, difficult to generalise about the classification of a particular good or service. A further implication is that an incentive programme or institutional arrangement that succeeds in providing or producing the good in one site may not be appropriate to another.

At the aggregate level, the complexity of individual interactions supports the contention of Cornes and Sandler (1986) that an agent producing or consuming a private good, may simultaneously be contributing to the production or consumption of a second good, of public

good character. Amongst other examples, these authors cite the case of expenditure on education and health, which produce private benefits but also contribute to the overall welfare of the population. Alternatively, of course the production of a private good may lead to the production of public bads. In general, then in the presence of joint production it would be difficult to generalise to the point of labelling environmental improvements as public goods *per se*, although frequently such improvement will involve the production (intended or otherwise) of goods that have public good characteristics.

Implicitly, therefore, an understanding of the public good characteristics of the full range of goods and services produced (or whose production is altered) should inform the analysis of incentives and institutional arrangements. Positive and negative production feedback loops between different goods and services must also be noted to fully analyse the "bundle" of goods and services. An example from Río Chiquito illustrates this process. For example, a rancher's investment in a physical soil-conserving technology such as infiltration ditches may have the knock-on effect of lowering sedimentation without affecting water yield. Given that soil productivity is essentially a private good the rancher may choose to implement such a technology without reference to the impacts it will have on downstream users. It is logical for the rancher to ignore the downstream impact as the rancher has no means of excluding ICE from exploiting this reduction in sediment delivery. In this simple case no incentive is required and existing institutional arrangements may be considered more or less optimal.

However, the degree of rivalry that exists with regard to the sedimentation downstream suggests that it may be considered a common-pool resource. As ICE is a single beneficiary of the ranchers proposed actions this suggests that there may be room for an institutional arrangement that would change existing incentives and enable this process to be managed in common so as to increase the benefits to both parties. In other words, in return for compensation the rancher might be encouraged by ICE to construct more infiltration ditches than would be profitable from the perspective of improving on-site production. Although the nature of the interchange between upstream producer and downstream user is local and potentially market-driven in nature, the involvement of ICE, an agent of central government, suggests a polycentric arrangement.

Similarly, in the case of reforestation initiatives, where the on-site benefits might not be clear or decisive the public good nature of role of downstream hydrological impacts may also be of importance. In the case of reforestation, both sediment delivery and water yield would be likely to be affected. As noted in Figure 1, an increase (or decrease) in annual inflows to the Lake Arenal are a private good. It has also been shown that changes in land use in Río Chiquito may lead to relatively important changes in the value of hydroelectric production (Aylward et al. 1998a). Once again, the incentive for the user of the downstream product, ICE, to be actively involved in a polycentric arrangement to provide incentives for an improvement in upstream watershed management is clear.

How ICE might become involved would vary depending on whether the holding is sited in a cloud forest area or not. In a cloud forest area, the installation of contoured windbreaks would not only alleviate soil loss and sediment delivery problems, but the windbreak would strip water from the clouds, increasing water yield. Again, as annual flows are a private good in Arenal this suggests the theoretical possibility that the rancher might approach ICE on this matter. The rancher could suggest that the institution assist with the increased costs of the windbreak (relative to the infiltration ditches) given the ability of ICE to capture the (relatively

larger) benefits of increases in water yield. In a non-cloud forest area the installation of a large windbreak would increase evapotranspirative losses. Thus, the incentive might be for ICE to suggest to the rancher that they assist in some manner with the infiltration ditches so as to avoid producing water yield losses that might outweigh the improvement in sediment delivery.

It is important to note that the identification of the downstream products as private goods and common-pool resources leads to a search for local solutions to the problem, of involving the producers and consumers in considering ways of managing these resources in common.[7] Were the products true public goods, the inclination might be to fall back upon some broader form of centralised collective action, such as top-down government intervention, as a means of ensuring the production of these services, instead of a market-driven polycentric arrangement as suggested here. Thus, an understanding of the characteristics of the goods and services involved, their inter-relationship and the different ""bundles" of jointly produced goods and services associated with different courses of action lead to suggestions regarding the types of institutional arrangements and incentives that might be appropriate.

This discussion also highlights the usefulness of having a clear picture regarding the physical interactions that govern production, and the economic consequences of such production. As demonstrated above, the consequences of reforestation being a good thing in one case and a bad thing in another leads the analysis in different directions regarding potential outcomes. It does not change the general nature of the arrangement as a form of common property management, but it certainly may affect the types of incentives and instruments employed. Ideally, such matters might be left to the participants who are assumed to know what is in their best interest. However, if outside interests are involved in footing the initial costs of developing such transactions and if information is imperfect, than a failure to understand these physical and economic impacts may be disastrous. Further, it becomes clear that in order to have a meaningful and conclusive discussion regarding potential institutional arrangements and incentives, an understanding of the transaction costs associated with collective action becomes of paramount importance.

The preceding sub-sections have illustrated the public good nature of the watershed goods and services produced in Río Chiquito and discussed in general how these characteristics underpin the incentives and institutional arrangements for their provision and production. The following sub-sections combine the technical information from the environmental-economic analysis of the CREED project with this approach in a search for landscape-based physical measures that will yield net benefits to society. Detailed consideration of the public good nature of the "bundle" of watershed goods and services provided by these measures sheds light on the incentive compatibility of the measures and suggests appropriate institutional arrangements for their provision and production.

[7] It is interesting to note that the water yield externality is the more compelling issue, both from the standpoint of its value (relative to sedimentation) and relative to its public good nature. As noted in the analysis, downstream sedimentation may become a public good in the future as demand increases for the water supplied from the reservoir, implying that arriving at arrangements for internalising the externality would have higher transaction costs.

Measures, Incentive Compatibility and Arrangements for On-Site Goods and Services

Under the existing structure of land use in the Río Chiquito watershed, livestock production generates direct costs and benefits for producers. The net benefits of these activities appear to vary considerably across the watershed, although when viewed at the watershed level they are on average significantly positive. The direct inputs and outputs of this activity are private goods and, consequently, the producers have every incentive to engage in the production of these "watershed" goods.

The potential exception is that of soil productivity, which is an asset, owned by producers and employed in producing output. Producers may have difficulty in fully appropriating the potential value of this asset, particularly when it comes to the tradability of the asset at the point of sale (of the land).[8] Nevertheless, both theoretical concerns and the opinions expressed by stakeholders suggest that the conservation of this resource is largely a private concern.

Clearly, the balance between the degree of incentive required will vary with the extent to which the outcome of the process in terms of goods and services is appropriable by the producers, that is, with the private/public nature of the goods and services. Non-vegetative soil conservation measures lead directly to the enhancement of soil productivity in the area treated and, subsequently, to increased livestock production. Such benefits are largely appropriable by the producer. Short-term vegetative fallowing using leguminous plants would also be appropriable by the producer, although such measures are not practised in the study area. Soil conservation involving reforestation provides wood products derived from the trees (i.e. fenceposts) and improves productivity in the surrounding, non-treated area. In Río Chiquito this productivity improvement results from the windbreak effect and from improving surface hydrology. The latter might involve increasing infiltration and thereby lowering surface run-off and erosion, as well as serving as a barrier or filter for sediment flows.

Productivity enhancements will be appropriable by the producer subject to the issue of its value in asset markets. Typically, wood produced by reforestation is a private good and will be appropriated by the producer. This may, however, vary depending on the manner in which reforestation is engendered. If reforestation is developed under a conservation easement, for example, the private nature of a reforested stand of trees would be greatly reduced. The producer will not be able to appropriate the wood benefits of the trees. In rare cases reforestation may provide other appropriable services. For instance, by building an ecotourism lodge or a restaurant near the stand a producer may be able to capture an additional set of on-site benefits associated with the trees.

As suggested by Aylward et al. (1998b), reforestation of pasture for commercial wood production in Río Chiquito is not likely to generate large economic benefits. Reforestation on a smaller scale for on-farm wood use in fencing may however generate reasonable benefits in terms of the opportunity costs of purchasing fencing materials. Meanwhile the establishment of fully protected forests through reforestation or regeneration schemes is expected to be fairly costly when implemented at a large scale. At the sub-holding scale, the direct costs of such

[8] See Annex 4 for a full discussion.

efforts may be fairly insignificant. However, as pointed out in the case of easements, the benefits that might be captured by producers engaging in full protection would be minimal.

On the basis of on-site values, the private character of the inputs and outputs used in livestock production is likely to be sufficient to encourage watershed management activities with only a minimal requirement for collective action and external inputs into the watershed. Producers will be able to capture either the benefits of directly or indirectly caused productivity enhancements and may also garner benefits from wood products that result from investments in small scale reforestation.

Intervention might, therefore, be restricted to the provision of technical assistance and activity-specific inputs that are not well known or widely available in the watershed. At least initially, obtaining access to these items and educating producers on their use represent a transaction cost for producers in the watershed. The costs of learning about silviculture, starting up a nursery and purchasing all the required inputs is probably quite large compared to the benefits that would be garnered by a single producer. As the producer's holdings and intentions with regard to reforestation increase it can be expected that the benefit-cost ratio will improve. Clearly, there will be some scale at which the aggregate benefits to producers are likely to outweigh the transaction costs (as well as the direct costs). By grouping together and acting collectively, therefore, such a set of producers could resolve the collective action problem.

To the extent that the benefits of investments in soil conservation are not appropriable, soil productivity becomes a toll or club good. Theory then suggests that collective action for the provision and production of soil productivity would be likely to take the form of a club to which producers contribute (fees, labour or other contributions) in return for obtaining access to technical assistance and inputs. This, of course, closely resembles the function of a producer cooperative.

Currently, there is no such club providing such services within the watershed. On the fringes of the watershed two cooperatives of coffee producers, COOPETILA and COOPELDOS, do provide these services and in the case of the ICE reforestation programme they are providing such services to producers in Río Chiquito. The key difference is that the transaction costs involved have been borne by ICE's Programme in Watershed Management. The producers involved in these programmes devote resources to the programme, but only in so far as they bear a portion of the direct costs of reforesting their holdings. They do not contribute to the administrative costs of the programme as a whole and, thus, do not share in the costs of developing or providing these services to others. In the case of the soil conservation programme sponsored by the Ministry of Agriculture and Livestock (MAG) and FAO, centralised provision of these services is available in the Arenal area. This might represent a much larger concept of a "club". The need for such a scale in order to surmount the transaction costs involved is probably not necessary. Economies of scale in a reforestation programme can probably be attained at the district level. Indeed, the scale and centralisation of such an effort suggests a susceptibility to standardisation that might lead to obstacles to the efficient serving of local clientele as reported earlier (in the case of MAG).

The lack of action to internalise the potentially public good nature of soil productivity in Río Chiquito, thus, leads to one of three conclusions. First, the biophysical problem itself is not of sufficient severity to have important effects on economic productivity. In other words the transaction costs outweigh the perceived benefits of collective action. In this case, it is difficult to justify the existing attempts to provide these services to the watershed based simply

on on-site considerations of soil productivity. These efforts are publicly funded and as such the transaction costs incurred represent an opportunity cost to society. If these expenditures are not generating significant benefits in terms of soil productivity then they are effectively wasting valuable economic resources.

A second possibility is that the economic problem posed by the erosion of soil productivity is a significant one but the appropriation problem is sufficiently marginal that producers do not suffer from an incentive compatibility problem. The suggestion made earlier that a number of producers do have significant erosion and productivity problems and are making investments in soil productivity of their own accord suggests that this may be the case in the watershed. In this case, polycentric or centralised arrangements for the provision and production of soil productivity are not necessary. A differentiated market in which buyers and sellers can equilibrate demand and supply for soil productivity and investments in soil conservation is sufficient. In all likelihood a differentiated market will be more efficient in allocating resources than a polycentric arrangement. Although an improvement over a centralised arrangement, a polycentric arrangement will still involve the transfer of a certain amount of planning and decision-making regarding resource use to centralised (or decentralised) functionaries. Presumably they will not be as informed as producers themselves and will, therefore, make mistakes that lead to inefficiencies in production.

A third possibility is that although the underlying problem is significant, the scale at which collective action becomes possible is not reached at the watershed level. In such a case by assuming at least a portion of the transaction costs, the ICE programme is making a positive contribution to the economy. At the same time it is worth noting the theoretical result obtained earlier, that a producers' club would be the appropriate institutional arrangement for providing this service. This suggests that it would be worth investigating ways in which the existing programme could be converted to a club in which participants are charged a fee (or toll) that supports the administrative and development costs of the programme. This has the benefit of contributing to the financial sustainability of the programme and ensuring that the investment is indeed providing real economic benefits to participants.

The recommendation emerging from the applied analysis suggests that there may be little motivation for investing public funds in enhancing soil productivity in Río Chiquito. Given the range of goods and services currently available with respect to reforestation the transaction costs of undertaking reforestation must now be regarded as relatively low. Thus, it is likely that producers can either respond to this problem as individuals or as part of a group, or club, within the bounds of an increasingly differentiated market. The picture with regard to non-tree-related soil conservation technologies is less clear given the lack of experimentation with such activities in the watershed. However, in a recent review of soil conservation projects in Central America, vegetative barriers and changes in land management are generally regarded to be superior to mechanical or physical conservation technologies (Lutz, Pagiola, and Reiche 1994). In other words ranchers are reluctant to invest in technologies that only provide soil conservation benefits and do not produce other usable products.

The exception to this analysis would be the case of producers with little access to land and capital. For these smaller producers, such investments, either in terms of the opportunity cost of lost production in the short-term or the up-front investment costs, may be too high to bear given the uncertainty and experimental nature of such treatments.

In sum, this analysis coincides with the opinion voiced by Lutz, Pagiola and Reiche (1994). These authors suggest that subsidies should not be used to assist producers in adopting soil conservation technologies except in the case of providing seeds or seedlings for producers in order to facilitate experimentation with new technology. A further exception to the rule opined by these authors is in the case where off-site considerations are important. In the next sub-section the focus shifts to the off-site goods and services provided by watersheds.

Measures for Improving Provision and Production of Off-Site Goods and Services

In discussing the externalities associated with livestock production the comparison is implicitly made between the services provided by pasture and those provided by forest. Nonetheless, there are various soil conservation technologies that will affect downstream hydrology without involving reforestation. The previous sub-section suggests that these technologies are typically less favoured by producers and, in any case, are not currently practised in the watershed. Thus, the latter will be discussed only briefly and the primary focus will be on the comparison of pasture versus forest. The relative magnitude and distribution of the costs and benefits associated with off-site environmental services are listed in terms of the *status quo* and a number of practical measures that can be used to minimise external costs and increase external benefits.

The quantitative analysis conducted in Aylward et al. (1998a) concludes that the principal externalities of livestock production would be an increase in water yield, a decrease in carbon storage and an increase in sedimentation, in that order. Once the offsetting effects of increased thermal power generation under a reforestation scenario are included, the carbon benefits are likely to be considerably reduced. There is the possibility of an effect on seasonal flows, although the direction of such an impact is ambiguous (based on the literature). It is, however, expected that cloud forest areas will capture significant amounts of horizontal precipitation in the dry season, in particular cloud forest fragments interspersed with pasture. Other environmental services that are provided by forest such as biodiversity prospecting and existence values are not expected to be significant in this case.

Under the current situation ICE captures the benefits of an increase in water yield. Action to further increase water yield would consist of the following options: (1) cutting or clearing additional areas of forest in non-cloud forest zones, and (2) optimising the level of fragmentation in cloud forest areas by re-establishing forest patches and windbreaks within pasture and cutting or clearing patches within forest. It is also assumed that increasing the fragmentation of cloud forest areas will also lead to benefits in terms of enhancing the capture of horizontal precipitation during the dry season. Land use change that changes water yield is, thus, assumed to lead to corresponding changes in seasonal flows.

Efforts to re-establish forest in order to capture additional horizontal precipitation could be accomplished by reforestation, natural regeneration or the planting of windbreaks. Regeneration occurs relatively quickly in the rainforest life zones in which the cloud forests are located (Bolaños and Alpízar 1995). In addition, the more complex and multi-layered the forest surface, the more horizontal precipitation will be captured (Fallas 1996). This argues against plantation style reforestation for the establishment of forest patches, except in the case of severely impoverished soils, and in favour of natural regeneration. For windbreaks, planting would probably be best undertaken with species whose leaf characteristics provide a superior physical substrate for the condensation of horizontal precipitation.

ICE also captures the costs of increased sedimentation. Reduction of these costs is accomplished by re-establishing forest on lands currently devoted to pasture. Re-establishing forest along streams and in areas especially susceptible to erosion would be particularly effective measures to lower sediment delivery. The method of establishing forest and the species employed would be of lesser importance than in the case of water yield. From the standpoint of reducing erosion and sediment delivery the height and quality of the forest stand is of much less importance than its ability to quickly colonise pasture and provide ground cover. Re-establishing forest on erosion-prone surfaces implies a need for a substantial leaf litter that will protect the soil from rainsplash erosion. The primary function of ground cover in buffer strips would be to filter surface flow, storing the sediment and, hence, preventing it from entering the stream.

Bolaños and Alpízar (1995) observe that sites in the study area subjected to severe erosion were subject to a relatively slow and impoverished colonisation, and that the predominant pasture in the area, African King Grass (*Cynodon nlemfuensis*), also impedes secondary regrowth. Thus, reforestation and post-planting management might be required in these conditions, with a species mix that would guarantee substantial ground cover. Alongside streams, natural regeneration might be preferred given that such areas are likely to be relatively fertile and that natural regeneration would potentially lead to a relatively more complex ground cover than in the case of reforestation.

Actions that would tend to lead to increased external benefits (primarily to ICE) would then include the following eight measures and classified by whether they take place in non-cloud forest areas:

1. Cutting and/or conversion of forest in areas that are not erosion-prone

2. Reforestation of erosion-prone pasture areas

3. Natural regeneration of buffer strips alongside streams

or in cloud-forest areas:

4. Cutting and/or conversion of patches within large contiguous blocks of existing forest

5. Planting of windbreaks in pasture

6. Allowing natural regeneration of forest in large areas of pasture

7. Reforestation of erosion-prone pasture areas

8. Natural regeneration of buffer strips alongside streams

The benefits of carbon storage that would be associated with efforts at reforestation or regeneration are diffuse and accrue to consumers globally.

The direct costs of reforestation and the opportunity costs of reforestation and regeneration in terms of lost livestock production benefits are felt directly by producers. The size of the opportunity costs are expected to vary considerably across the watershed with smallholders typically bearing smaller per hectare opportunity costs than the owners of large holdings (Aylward et al. 1998a). Clearing of forest for use as pasture, on the other hand, would

generally produce net on-site benefits to producers, subject to the considerations just mentioned. Engaging in production forestry on lands currently forested would be expected to generate positive net benefits to producers, although the relatively poor species composition, from a commercial viewpoint as noted by Bolaños and Alpízar (1995), might limit the profitability of this endeavor.

On the issue of cutting versus converting forest it is worth mentioning a third possibility. The former implicitly assumes forest production, i.e. the harvest of wood for sale or use. For the sake of argument, given the size of the potential benefits in terms of water yield, it might even be economical to simply cut existing forest and leave it to decompose. This would generate water yield benefits akin to those realised under production forestry. At the same time, by eliminating the extraction of logs this option would effectively limit the production of sediment that would be associated with cutting and clearing of logs and subsequent livestock production.

Incentive Compatibility and Institutional Arrangements for Off-Site Measures

The latter point raises the issue of the compatibility of the measures proposed in terms of the trade-off that exists between water yield, sediment delivery and livestock production. To complete the analysis it is useful to review each of the actions, taking into account this trade-off as well as the effects of these measures on carbon storage and soil productivity. In this manner it is possible to assess the need for new institutional arrangements aimed at the production of environmental services under each of these actions. The four environmental goods and services of potential significance to the measure proposed above are water yield, carbon storage, sediment delivery and soil productivity.

Water yield and sediment delivery were classified as public goods with regard to the *ex post* ability to exclude ICE from the consumption of benefits or costs associated with changes in annual water flows and sedimentation of the reservoir. In both cases the *ex ante* ability to exclude ICE is high. Thus, the classification of water flows as a private good and sedimentation as a common-pool resource is of importance in cases where landholders are not inclined to produce external benefits (or are inclined to land uses that produce external costs). Carbon storage was identified as a common-pool resource that is increasingly private in nature. Finally, soil productivity was identified as a private good with tendencies towards being a toll good.

In cases where private incentives to landholders for the production of these environmental benefits are compatible with incentives, as viewed from a larger economic perspective and incorporating both land use and downstream effects, new institutional arrangements are not strictly necessary. For instance, to the extent that current land uses are producing approximately optimal downstream results for ICE, there is no argument for offering compensation to upstream landholders.

Cases of incentive incompatibility, however, may argue for new arrangements subject to the issue of the size of the transaction costs involved. The transaction costs involved and the likely nature of institutional arrangements for solving the incentive problem surrounding the hydrological externalities are discussed in detail in the next sub-section. At this point it is sufficient to argue that a contractual arrangement between ICE and the landholders would allow these hydrological services to be managed in common. The emphasis below is on

identifying such cases of incentive incompatibility and analyzing the potential institutional implications of including carbon storage and soil productivity into the assessment.

Each of the eight measures proposed above is examined in turn. It is important to note that both cloud and non-cloud forest areas include production types that, on average, span the range from negative to high private and economic profitability. Thus, in order to accurately reflect the diversity of on-site production benefits garnered by producers in Río Chiquito, each case is considered in light of the producers that are producing either substantial or only marginal (or negative) economic returns to land.

Measure 1: Cutting/conversion of forest in non-erosion-prone areas. In non-cloud forest areas the cutting or conversion of forest in non-erosion prone areas leads to both on-site production benefits (livestock and wood products) and increased hydrological benefits. The outcome in terms of carbon storage depends on whether the forest will be managed for forest production or livestock production. Dedication of the land to a sustainable rotation for the production of timber that is subsequently used in the production of durable goods should have a positive effect on carbon storage. Conversion of forest and burning of much of the wood would liberate carbon on net, having a negative impact. Nonetheless, it appears that even in the negative scenario, the costs incurred in loss of carbon storage would be outweighed by the benefits of increases in water yield.

Private incentives are, thus, largely compatible with the production of the private good benefits of increased water inflow to the reservoir. An exception is the case of smallholder ranchers who have large negative returns to production. In such cases, producers might be unwilling to generate additional benefits for ICE without sharing in the hydrological value added. Local efforts at collective action involving ICE and affected producers would then be required subject to transaction costs. Although of a local market-driven character, this arrangement would inevitably be polycentric given that ICE would be involved (representing centralised interests). With regard to carbon storage, however, the incentive for landholders to engage in forest management (instead of simply clearing forest for pasture) is not necessarily consistent with the economic benefits generated by the former. As a result it is possible to argue for an institutional arrangement that enables representatives of global carbon interests to participate in influencing the decision on the part of the landholder to choose forest management over land use change.[9] Given that carbon storage is a global commons problem, and the developing international arrangements for its management will involve at least a degree of centralisation, a polycentric arrangement involving all three stakeholders (producers, ICE and representatives of global interests) is likely to be preferred.

Measure 2: Reforestation of erosion-prone pasture areas. Reforestation of erosion-prone soils in non-cloud forest areas will result in increased evapotranspiration and subsequent losses in water yield. From an off-site perspective a purely economic definition of the term "erosion-prone" would be erosion of such severity that its marginal costs in terms of sedimentation (caused both by rainsplash erosion on the site and by surface erosion caused by run-off from compacted soils) are just equalled by the marginal benefits generated by the higher level of

[9] As mentioned earlier and discussed further below, land use change is not actually a legal option under current legislation. In this case, the analysis happens to support the direction of this legislation (as an intervention on behalf of the larger economy).

water yield (under pasture). The analysis of soil productivity suggests that investing in limited reforestation or regeneration on severely eroded soils may lead to productivity increases on adjacent areas as well as providing an important source of fencing materials. Thus, the private benefits of such an alternative will be positive, assuming that production benefits from such areas are, indeed, very low (if not negative) due to the degraded conditions of the soil. In addition, reforestation will provide larger economic benefits in terms of carbon fixation produced by re-establishing forest. Private incentives are, thus, largely compatible with economic efficiency.

However, this conclusion will be very site-specific. In general the magnitude of the trade-off between water yield and sedimentation suggests that from an off-site perspective few areas will be "erosion prone." If, however, the private production benefits and economic benefits of carbon storage are large, the two combined would suggest that it will be efficient to reforest beyond this off-site margin. In part the incentive to do this may be private and in part economic. The ideal institutional arrangement would then involve all three stakeholders: producers, ICE and those representing global interests on carbon storage. If ICE is left out and reforestation proceeds based solely on arrangements between the former two stakeholders than it can be expected that too much reforestation will occur. Thus, a polycentric arrangement amongst all three stakeholders aimed at managing this process of joint production in common would be ideal. Central to this arrangement would be the participation of the producers, given that they are the only participants that can accurately judge the opportunity costs (or benefits) of replacing livestock productivity of different sites and the likely benefits of reforestation in terms of wood products and soil productivity.

Measure 3: Natural regeneration of buffer strips. Incentive compatibility for the natural regeneration of buffer strips alongside streams is similar to that under Measure 2. Again, a polycentric arrangement involving producers, ICE and representatives of global stakeholders would be ideal. The distinction might come in the relative incentives facing different parties. Private incentives to participate would be diminished, given that the reforestation buffer strips alongside streams would be likely to have higher opportunity costs in terms of foregone livestock production and lower utility in terms of wood production. Carbon storage and sedimentation effects might also be different under this scenario, although probably only marginally so in relation to the change in private incentives. Under this measure, then, an increased participation of the carbon storage stakeholders and ICE might be required to motivate producer involvement.

Measure 4: Cutting/conversion of patches within cloud forest. The cutting or conversion of patches within large contiguous blocks of cloud forest lead to increased off-site benefits in terms of water yield is similar to Measure 1. Again, whether forest is simply cut, cut and harvested, or converted to pasture will determine the size of the counteracting costs of increased sediment delivery, as well as the type of private benefits (livestock and logs) and economic impacts (carbon stored/liberated) engendered. In the case of holdings with low profitability, participation of the primary beneficiary, ICE, would probably be required. Again, in terms of realising an economically efficient allocation a polycentric arrangement involving all three stakeholders would be best.

Measure 5: Planting of windbreaks in pasture. Planting of windbreaks in pasture (within cloud forest areas) will provide direct benefits to ICE in terms of water yield and reductions in sediment delivery, and private benefits to producers in terms of wood products and

productivity enhancement (due to wind abatement and soil retention). The latter will be weighed against lost livestock production. Carbon storage benefits would also be present, although they might be marginal given the limited nature of the reforestation activity. Private incentives would be largely compatible with the realisation of a certain level of planting and economic efficiency where livestock productivity is low. When productivity is high, concerted effort between ICE and the producers would be necessary. Even in the case of extreme profitability (large mechanised dairy), windbreaks might generate net efficiency gains when employed on less productive areas or as a means of sectioning off pasture.

In the case of marginal producers for whom incentive compatibility exists, additional net benefits could be generated by developing a cooperative arrangement between ICE and producers for increasing the density of windbreaks within holdings. This implies extending windbreaks beyond the area desired by producers on their own account. From their perspective, producers may have only a limited need for wood products. In addition, the productivity benefits of windbreaks may argue for a relatively loose spacing of windbreaks compared to that which would produce the optimal capture of horizontal precipitation. Thus, although producer interest in windbreaks may be limited, both of the off-site effects are positive in this case and may be of sufficient merit to warrant cooperative action. The opportunity costs of lost livestock production under such an arrangement would, therefore, need to be compensated from the production of off-site benefits. An arrangement between producers and ICE for the provision and production of these goods and services would, therefore, be of central importance to this measure.

Measure 6: Natural regeneration of cloud forest in large areas of pasture. The regeneration of forest patches within large areas of pasture is a measure that in essence competes with Measure 5, with the exception that windbreaks may be useful even in rather small expanses of pasture. The choice of which measure to employ will revolve around two principal issues: the degree of profitability of livestock production on the site and the relative merits of windbreaks versus forest patches in the capture of horizontal precipitation. The implications of these for incentive compatibility are as follows. The more profitable the livestock operation, the less likely it is that the producer will be interested in re-establishing large patches of forest and the more appropriate it might be for windbreaks to be established. However, if it can be demonstrated that increasing the size of a windbreak until it truly becomes a forest patch or fragment leads to increasing levels of moisture capture (per unit area), then the establishment of forest patches may be the preferred option in this case. In either case efforts in this direction would depend on the participation of ICE in a cooperative arrangement, as the opportunity costs of reforesting larger patches would tend to lead to incentive incompatibility.

Measures 7 and 8: Reforestation of erosion-prone areas and regeneration of buffer strips. The reforestation of erosion-prone areas and regeneration of buffer strips along streams in cloud forest areas differs from the same measures (2 and 3) in non-cloud forest areas in one important aspect. In cloud forest areas, the effects of these measures will have a positive, not negative, impact on water yield. Thus, from an economic perspective the likelihood of these measures being of interest is much greater. Thus, the constraint on the definition of erosion-prone elaborated earlier, the internal trade-off between decreased sediment delivery and decreased water yield, disappears. In cloud-forest areas, then, the measures are similar to Measure 6 in terms of the arrangements required.

In the case of Measure 7, assuming that high erosion rates and low productivity are correlated, producers would prioritise the reforestation of such areas based on the private incentives involved. The availability of a cooperative arrangement with ICE, and to a lesser extent with global carbon stakeholders, might subsequently motivate producers to reforest areas beyond what constitutes "erosion-prone" in purely biophysical terms. Where production levels remain high, even on sites defined in biophysical terms as "erosion-prone", such cooperation would be essential. In the case of Measure 8, there may be little private incentive to leave buffer strips for regeneration (where they already make good pasture) and a cooperative arrangement will, therefore, be required. In both of the latter cases, where the opportunity costs of reforestation or regeneration are relatively high, the returns from off-site benefits must be compared (either implicitly or explicitly) with the loss in production.

The discussion above can be summarised by specifying the extent to which implementation of the measures is either compatible with private incentives or requires an institutional arrangement that ensures common management of the "bundle" of watershed goods and services on the part of the three principal stakeholders. The analysis above suggests that measure by measure the participation of different groups is of more or less importance. The following table tries to capture this distinction by noting the relative importance of the extent of cooperation between the principal stakeholders, as disaggregated by the relative productivity or profitability of the site involved. In cases of incentive compatibility producers will largely make the right choice on their own. In other cases it will be important to have some mix of producers, ICE and carbon stakeholders involved.

Table 1. Watershed Management Measures and Stakeholder Involvement

Measures	Degree to which these arrangements are sufficient to motivate efficiency			
	Producer	Carbon Stakeholder	ICE	All Three
Non-Cloud Forest Areas				
1. Cut/convert forest	sufficient (high)	important to cut vs. conversion	required (low)	not important
2. Reforest erosion-prone areas	sufficient (low)	important (high).	not important	not necessary
3. Regenerate buffer strips	not sufficient	important (all)	important (all)	important (all)
Cloud Forest Areas				
4. Cut/convert forest	sufficient (high)	not important	important (low)	not necessary
5. Plant windbreaks	sufficient (low)	not important	required (high)	not necessary
6. Regenerate forest patches[a]	not sufficient	not important	required (low)	not necessary
7. Reforest erosion-prone areas	sufficient (low)	useful (high)	required (high)	useful (high)
8. Regenerate buffer strips.	not sufficient	useful (all)	required (all)	useful (all)

Notes: The indication of high, low or all in parenthesis suggests the relevant group of producers in terms of the degree of livestock profitability. [a]In this case it is assumed that holdings with high levels of profitability would only be interested in planting windbreaks.

Clearly, implementation of each of the measures alters the costs and benefits as viewed by the three stakeholder groups. Thus, the ideal arrangement would be a polycentric arrangement involving all three groups. However, the table shows that as the outcome of each measure is different, in terms of the production of a "bundle" of watershed goods and services, so the necessity of attaining such a "complete" arrangement for the implementation of the measures changes. In order to implement the measures and capture most of the efficiency gains it is not necessary to attain such a comprehensive arrangement. The table suggests that producers

acting on their own and in concert with ICE would be able to achieve substantial improvements over the *status quo*. Adding in the participation of the global interests surrounding carbon storage would lead to further gains. In theory, prior to implementation these arrangements should also pass a cost-effectiveness test insofar as the expected gains should be demonstrated to be larger than the transaction costs of engendering such collective action vis-à-vis the current institutional arrangements.

Modifications to the Proposed Action Programme

Before turning to prospective incentives mechanisms for encouraging adoption of the physical measures it is useful to first re-evaluate the suitability of the Action Programme. The discussion of potential measures focused on the issues of forest management, reforestation and forest regeneration. In other words, these measures are directly related to the first two elements of the Action Programme which consist of conservation and regeneration of forest and the change of land use in areas of marginal productivity. The issue of soil productivity was judged to be a sufficiently private matter not to warrant its inclusion as a measure *per se*. Thus, the third element of the Action Programme should be interpreted as a compensatory element, rather than as a direct effort to raise productivity. In other words, investment of public funds in this area should be undertaken only if access to technological improvement is directly linked to participation by producers in one of the measures identified above. This does not represent a significant change in orientation as the original intent of this part of the Programme was to give producers a means of increasing production on remaining land, once a portion of their pasture was committed to regeneration or reforestation.

The remaining three elements of the Action Programme - community development, development of local ecotourism projects and inter-institutional coordination - do not have specific impacts on land use *per se*. Rather, they are measures that reflect the interests of local communities (the first two) and a basic prerequisite of establishing a participatory approach to the implementation of a polycentric action plan (the latter). As such, community development and ecotourism projects, strictly speaking, should also be interpreted as compensatory mechanisms. For example, in place of improving livestock technology some producers might be more interested in developing an ecotourism project as an alternative means of generating revenue once pasture area is reduced. Similarly, communities as a whole might prefer improved infrastructure as an “incentive” for engaging in changed land use practices.

Thus, it is not really necessary to alter the basic components of the Action Programme to reflect the biophysical and economic findings produced in the companion paper by Aylward et al. (1998a) regarding hydrological externalities and their implications for incentive compatibility. Instead, what is required is a shift in emphasis in terms of the actual types of measures that can be expected to produce hydrological benefits. For example, conserving existing forest in non-cloud forest areas would be of low priority where they are not in areas prone to erosion. Should landowners wish to avail themselves of the CCB incentives under the new forest law in conserving those areas they are free to do so. However, given that the expected result may be negative hydrological externalities, an action programme should not devote resources towards this end.

Incentives for Watershed Management

The previous sub-section explored the application of the tools of neoclassical economics (as reported in Aylward et al. 1998a) and the IAD framework to the question of what "ought" to be the priorities for action in Río Chiquito and what "ought" to be the institutional arrangements for implementing such action. This sub-section explores the practical feasibility of the different measures and the economic incentives that might be used for their implementation. This exploration is conducted within the confines of existing or proposed institutional arrangements as outlined above. Given the need to work, at least partially, within the existing rules of the game, the available menu of incentives will necessarily represent second-best solutions.

The principal arrangement that restricts the measures put forward above is that the new forest law does not permit a change in land use in areas under forest cover. This legal imposition effectively limits the measures (1 and 4) aimed at opening up the forest canopy to either reduce evapotranspirative losses or increase the capture of horizontal precipitation in cloud forest to selective logging interventions. In a sense, then, the discussion above of the potential benefits of clearing forest serve as an indication of how the new forest law changes the institutional framework in a less efficient direction (see Watson et al. 1998:76 for additional criticism of this law).

In the IAD framework, pay-off rules are an element of the action situation by which benefits and costs are assigned to actions and outcomes. Although at times a pay-off is considered as an implicit part of an outcome, in reality it is useful to distinguish between the two. A pay-off differs from an outcome in that the pay-off is the method for assigning positive and negative weight to outcomes, and hence to the actions themselves. This is where the concept of incentives arises as it is through the determination of these costs or benefits (who wins, who loses and by how much) that institutions shape human behaviour. Ostrom and her colleagues use a broad notion of incentives in this respect: "incentives are more than just financial rewards and penalties. They are the positive and negative changes in outcomes that individuals perceive as likely to result from particular actions taken within a set of rules in a particular physical and social context" (Ostrom, Schroeder and Wynne 1993: 8).

Discussion of Prospective Incentive Mechanisms

The analysis by Aylward et al. (1998a) suggests that there are no policy distortions that can be said to be drastically affecting the production of hydrological externalities in Río Chiquito. The need then is for a new incentive mechanism that will serve to internalise these externalities. A number of economic incentives mechanisms exist for resolving watershed management problems insofar as hydrological services are concerned. These include the traditional avenues of using new regulations, taxes and subsidies, or land purchase; as well as four more novel methods:

1. Implementing the "polluter pays" principle

2. Creating marketable permits

3. Developing legal and enforceable property rights for environmental commodities

4. Developing contractual arrangements involving compensatory resource transfers.

Each of these traditional and novel mechanisms are examined below.

Clearly, a number of important national regulations and incentive programmes are either already affecting conservation decisions in the watershed or have the potential to do so in the near future. Legislation prohibiting land use change on lands with forest cover under the new forest law represents an important regulation that, as already mentioned, impinges on land use in the watershed, albeit in a negative fashion. Traditional approaches to subsidising reforestation that include subsidies in cash or in kind are being used under the reforestation incentives of the new forest law and the ICE Río Chiquito reforestation initiative, respectively. The implementation of these programmes appears to be polycentric (i.e. polycentric in production) although both programmes are derived from centralised initiatives (centralised in provision). There exists the need to adapt both programmes to local needs and conditions in order to promote the type of reforestation (as outlined in the measures above) that will produce both productive and hydrological benefits.

Newer approaches, such as the Forest Conservation Certificates (CCB) programme, represent a centralised approach to establishing contractual arrangements in return for compensatory payments. Again, the limitations of a single, centralised approach (for the whole country) to the provision of forest conservation are nowhere more evident than in Río Chiquito where it can be argued that maximisation of the economic benefits provided by environmental services is not consistent with maintaining uninterrupted expanses of primary forest.

Land purchase in Río Chiquito (by the state) is an unlikely prospect for both practical and theoretical reasons. The country currently has a large backlog of lands that remain in private hands despite having been designated as belonging to the protected area system. Second, the area is fully colonised and is capable of producing productive benefits under livestock production. Third, an efficient use of the land is not consonant with total reforestation; thus, the desired land management strategy as pictured above is consistent with livestock production and a variety of forestry activities (that are consistent with the capabilities of small and large landowners). As land purchase for the creation of a protected area is not warranted, there is little opportunity that land purchase for this purpose would merit consideration for funding, particularly given the existing backlog of important projects of this nature and the scarcity of funds for this purpose.

Purchase of the land by ICE expressly for the purposes of turning it to hydrological production has similar limitations. Perhaps more fundamental, however, are the transaction costs that would be required to develop the legal mandate that would enable ICE to engage in such an activity. Given that current land use and ownership patterns are not inconsistent with hydrological production, this solution also appears somewhat drastic solution. It would be preferable to find an instrument that could be used to push existing practices in the desired direction, than a wholesale disruption of the pattern of tenancy and economic production in the watershed. Thus, land purchase is not a useful or realistic option in this case.

All of the above existing initiatives might be creatively employed within the framework of the Action Programme or modified to better serve the purpose of the Programme. However, it is clear that no incentive mechanism currently exists that directly tackles the issue of how to

provide an incentive to producers to produce even larger quantities of run-off while simultaneously attempting to limit sediment delivery. For this reason each of the four novel approaches listed above are scrutinised to see if they have potential to serve as mechanisms for internalising hydrological externalities. Each of these mechanisms have both their theoretical and practical advantages and disadvantages, some of which have already been mentioned in passing with regard to Costa Rica or Río Chiquito. In order to winnow the field it is useful to make explicit at the outset some of the factors that limit these options.

Prospects for applying the "polluter pays" principle in Costa Rica are discussed in Annex 3 with the conclusion that while progress on this issue is being made, much remains to be done to make this instrument an effective means for deterring environmentally inappropriate behaviour. Meanwhile, the principal finding of the paper by Aylward et al. (1998a) is that the crux of the hydrological externalities "problem" in Río Chiquito revolves around how to improve existing positive externalities (i.e. to make a good situation better). This implies the need for instruments to increase the production of goods with public good characteristics rather than the need for instruments to limit the production of public "bads." Thus, the "polluter pays" principle is not the theoretically appropriate mechanism for improving efficiency of land use in Río Chiquito.

The use of marketable permits in watershed management in Costa Rica is, albeit indirectly, already a going concern in Costa Rica. Although yet to be formally approved by the Conference of Parties to the Climate Convention, the idea of land use offsets for carbon storage and fixation has taken hold in Costa Rica. Several Costa Rican offset projects have already been approved by the US Joint Implementation Initiative and a number have received financing. Until formal approval is awarded this activity must be regarded as speculative. Nevertheless, it demonstrates the potential for internalising the externalities associated with this environmental function of forests through a system of marketable permits in carbon.

The question that remains, however, is whether marketable permits might be a theoretically interesting and practically feasible mechanism for internalising the hydrological externalities reviewed in this report. Typically, of course, marketable permits are used to limit the production of public "bads", such as air pollution, or to regulate open access system of resource collection, such as fisheries, that are subject to threshold levels of congestion at which productivity can be expected to be adversely affected. If sedimentation were the most serious problem, then such a system of marketable permits (to deliver sediment) might be a theoretically pleasing option. Practical problems that would be encountered include the measurement and monitoring both for the source of "emissions" and their accumulation, and the means of enforcing compliance. These problems are complicated by the fact that emissions are not fully controllable by producers but are instead subject to the vagaries of current weather patterns (yearly rainfall intensities) and year-on-year climate patterns (wet versus dry periods).

In the case of water yield the same limitations apply, with one additional problem: the potential applicability of marketable permits is not clear, given that there is no discernible threshold that can be used to define the desired quantity. When it comes to increases in dry season flow, for example, more is almost always better. Thus, a "closed" system of permits makes little sense when the incremental benefits of changes in water yield are fairly constant in either direction.

The potential for developing property rights over hydrological services or outputs is an attractive one from a theoretical perspective. A differentiated market in which "units" of

hydrological output, such as cubic metres of sediment and yearly run-off, are exchanged at prices that equilibrate demand and supply is an attractive notion. The difficulty, of course, lies in the feasibility of implementation. The problems of measurement and monitoring of hydrological services to establish actual amounts produced are considerable, as noted above. The need to assign such units to specific holdings only compounds the problem. As indicated in Annex 3, the current legal status of many environmental resources or services in Costa Rica is far from that envisioned in a well-functioning market with well-defined and enforceable property rights. Such property rights are either not defined or are simply vested in the state. Despite its theoretical appeal, therefore, the property rights approach is at best an option in the very long term, requiring significant advances in technology to permit adequate definition and enforcement of such rights.

The remaining option is that of contractual arrangements involving compensatory resource flows. This approach is best compared to that of establishing property rights. Contractual arrangements enable a number of concessions to the practical necessities of the case while sacrificing only a degree of theoretical advantage. Most importantly, contracts may be established for the means to the end rather than the end itself. In other words, contracts may sidestep the measurement problem by specifying specific actions to be undertaken by landowners in terms of changes in land use or land management. The contract then becomes verifiable, even if the exact result remains unverifiable. Each side of the negotiation then is left to negotiate based on the information at their disposal. Each side brings a different type of information to the table. The users of hydrological services must base their negotiating on their best estimates of the hydrological impact of the changes in land use that are on the table and on their willingness to pay for these changes. The producer of hydrological services will negotiate based on the changes in production costs and benefits that will result from introducing different land uses or land management strategies.

In a sense then, the negotiation proceeds with asymmetries of information, not unlike those in other markets where sellers are most informed about their supply function and buyers about their demand function. The difference, of course, is that there will typically be few buyers and many sellers, and probably no intermediaries. The advantage of fully establishing property rights is that a competitive market is more assured. If there is only one buyer (or a monopsony), then the assurance of property rights will lower the transaction costs of market entry for those who would take advantage of the arbitrage opportunity. When rights are only effectively established through contracts then the likelihood of a competitive market appearing is small.

Contractual Arrangements and Compensatory Resource Transfers

If contractual arrangements appear to be the only and, therefore, most promising mechanism for improving the production of positive hydrological externalities in Río Chiquito, they still have their difficulties. As indicated earlier, the CCB and CPB incentive programmes have already pioneered this approach in the Costa Rican context so the concept is not a foreign one. However, there are clearly theoretical and practical difficulties with levying a single incentive (with the same structure and amount) for the same objective across the entire territory of the country. As hydrological externalities can be expected to vary in direction and magnitude from one watershed to the next, the need for a polycentric approach that incorporates both centralised information regarding demand (in this case for hydroelectricity) and local socioeconomic and biophysical information regarding supply is exceedingly important.

The difficulty that exists in the Río Chiquito case is that there is a single buyer, ICE, and a group of sellers. The transaction costs of collective action for the latter are, therefore, considerable. The asymmetries of information and market power in this situation are also likely to be problematic. Other things being equal, it can be expected that ICE would be tempted to act as a monopsonist, which would lead to an inefficient level of hydrological services. In order to ensure a sufficient degree of adaptability to local conditions within the watershed itself and to limit the market power of ICE, negotiations between parties (such as they are) should be conducted within the context of the inter-institutional commission proposed by the Action Programme. These negotiations should revolve around two issues: defining the amount of funding or resources that would be made available annually over a set period to the "compensation fund" and designing an auction system for the allocation of contracts. The advantage of this approach is that it separates the issue of how much compensation will, in principle, be available from the decision of exactly how the funds will be spent. It also provides ICE with the opportunity to budget precise sums for the programme and to make a gradual commitment to the Action Programme. Further, the negotiation takes place in a public space allowing political and other non-economic incentives to play a role in guiding the negotiation. Finally, there is no reason why ICE must be the only contributor to the fund, or why all contributions must be made in cash.

Conceptually, the auction system for disbursement could work in a number of ways. The first prerequisite would be the creation by the inter-institutional commission of a "compensation committee". This committee might function in one of two ways. In a simplified system, producers would be responsible for submitting sealed bids reflecting what payment they would be willing to accept for undertaking a given intervention on a particular section of their property. The bids would be submitted to the committee, which would then apply their own criteria in selecting a set of cost-effective bids given funding constraints. The advantage of the auction system is that it does not require producers to organise into a single unified negotiating force, but still permits them to participate in community groups if they so desire. In addition, the system allows for a variety of different hydrological conditions (from the demand side) and socioeconomic conditions (on the supply side) leading, in theory, to an efficient microeconomic allocation of available resources.

Given that the compensation committee represents the "buying" interests it would in effect be representing the interests of ICE. However, for reasons mentioned above, it is debatable whether ICE should be the sole representative for the buying side of the market in such an incentive scheme. The committee ought to be comprised of representatives of a number of "public" institutions and interests, one of which would be ICE. Technical support to this committee might be offered by a group of experts drawn from ICE and relevant academic institutions and NGOs.

Alternatively, a more neutral compensation committee could be formed which would receive bids from producers (as before), as well as a set of sealed bids from ICE suggesting buying thresholds (maxima) for various measures according to geographic area. Depending on the information available, these purchase bids could represent just a few categories of land use units and measures, or a more thorough spatial overlay of biophysical, hydrological and economic parameters.

The committee would then optimise the matching of buy and sell "orders" as follows. In an initial round of sorting all sell offers for which the selling price exceeds the buying price would

be identified and dropped from consideration.[10] The difference between the maximum buy price and the offer price for a given hectare could then be calculated in order to generate the net benefit of each potential transaction. The net benefit to cost ratio would then be calculated, where the cost refers to the selling price. The Committee could then rank all the projects and fund as many as possible from the top of the list. Producers would, of course, be compensated according to the amount they are willing to accept; not what ICE is willing to pay.

Note that this simplistic methodology presupposes that there is a fixed budget constraint for purchasing sell "orders" and that the sell offers are divisible in the sense that an offer for a given hectareage would be accepted at a lower hectareage. If the former is not the case the Committee would want to fund all offers that produce positive net benefits. If the latter is not the case, the Committee will need to exercise caution in selecting the subset of available offers that maximise net benefits subject to the budget constraint. In practice, this is likely to mean selecting from the top of the list until funds run short at which point the most efficient subset of projects would be chosen with the funds remaining.

A number of practical details regarding such an incentive scheme are worth mentioning in order to clarify the idea. First, the interventions that would be accepted by the committee would ideally reflect the spirit of the measures put forward earlier. However, the final list of interventions would be subject to consensus of the inter-institutional commission for the watershed. As suggested above, this commission would be a prerequisite for developing the incentive scheme. It is intended to represent both local communities and stakeholder organisations with a presence in the area. Thus, a process of consultation, capacity-building (as necessary) and participatory planning would ideally precede the attempt to build a consensus list of "fundable" interventions.

Through this process of participatory planning the types of payment to be received in compensation would be defined. Essentially three types of payments are envisioned under the Action Programme: cash payments to individuals; payment in kind to individuals; and payment in kind to social groups, particularly communities. Strictly speaking, payments in kind are generally considered by economists to be less efficient than cash payments. If it is assumed that producers have better information regarding the costs and benefits of various uses of their lands, than those providing the incentives, then it is better to let the producer attempt to optimise the allocation of available resource in production.[11] Even where the objectives for a programme of environmental improvement (in terms of its scale and the allocation of benefits) will be decided on technical information and political consensus, the implementation of the

[10] Note that if producers' sell offers are very high, there is at least the possibility that an initial matching may not yield any matches at all. In such a case, it will be necessary to repeat the process to assess whether the problem is strategic behaviour by producers (or colluding groups of producers) or whether there are simply few cases where land use change will produce net economic benefits. To preclude endless repetition and an extended bout of strategic behaviour, the number of times that the bidding process may be repeated will need to be limited at the outset.

[11] Note that different groups of producers may have differing abilities to accurately assess the costs and benefits involved. A small programme of technical assistance may, therefore, be useful in "levelling the playing field" amongst producers.

programme is most efficient if the microeconomic decisions are left to those on the ground and not to the "experts" or bureaucrats (Daly 1992).

Economic efficiency is then best accomplished by providing the producer with cash payment rather than limiting producer choice through payment in a pre-established number of goods and services. This argument applies whether the discussion surrounds the provision of inputs for realising the intervention, the provision of assistance with alternative activities such as soft credit for ecotourism projects or new genetic material for livestock production, or the construction of community projects.

Unfortunately, theory appears at odds with experience, at least in the case of rural smallholders in developing countries. For example, a strong recommendation emerging from one of the oldest reforestation programmes in Central America involving small producers (the CARE Programme in Guatemala) is never to give incentive payments in cash. In this respect it is worth noting that there is little or no experience in Río Chiquito of cash incentives. Although a few producers were involved in the old CPB incentive programme, confusion over its status and the relatively short period of implementation means that no lessons can yet be drawn from this experience. Certainly, the practical success of the ACM and ICE reforestation programmes suggests that payment in kind does produce results. Certainly, then the issue of what type of payment to utilise must be carefully considered. Providing that the risk of future non-compliance in fulfilling the contract can be minimised, there is no *a priori* reason for excluding either option from consideration.

Nevertheless, the possibility of three different types of compensation does suggest that the process of matching resources to producer bids would be a multi-dimensional problem. If flexibility is allowed in terms of the types of contributions to the compensation fund (i.e. not just cash incentives) there will be a range of compensation types. In addition, some of these compensation types will be specific to particular interventions and, thus, will have limited geographic scope. There is then a trade-off between increasing the flexibility of the fund in terms of the contributions that are accepted and the number of interventions that are acceptable under the bidding system, and the level of complexity associated with the allocation process for awarding contracts.

A host of other practical details would also need to be decided upon in order to establish the "rules of the game" for the incentive scheme. These elements, and those already mentioned, would be based on the outcome of a formal design process for the scheme directed by the inter-institutional commission and would include (but would not be limited to) the following:

- terms of reference for the "compensation" committee
- types of interventions considered for funding
- type of compensation permitted
- maximum and minimum scale of interventions planned
- the time horizon of the contractual arrangement
- type of proof of land ownership required to participate in the scheme, with the intent of accommodating holdings that are not fully titled

- creation, assignation or contracting of an agent, organisation or subcommittee for administering the incentive scheme

- development of a credible monitoring and enforcement plan

A key element of the design of the incentive scheme is to ensure that the process of bidding and the allocation of incentives is conducted in a fashion that allows it to benefit (instead of losing) from the iterative nature of the interaction between buyers and sellers. In other words, it should be a learning process, but one that is not asymmetrical. For example, the bids accepted by the "compensation" committee could be published and distributed along with the interventions to be undertaken so as to better inform the next round of bidding and also so as to make public the commitments made by successful bidders.

Having indicated the general guidelines for a new incentive programme focused on increasing the hydrological returns to land use, it is important to consider how this element of the Action Programme would relate to existing incentives for watershed management in Río Chiquito. The justification for developing a new incentive scheme for production of hydrological externalities that is specific to Río Chiquito is derived from the analysis demonstrating that important opportunities to improve hydroelectric production may be missed given the current incentive programmes. Despite their intent, the government conservation incentives, the CPB and CCB, do not promote hydrological production *per se*. Rather, they might be viewed as useful mechanisms for accessing the value of stored carbon. In any case their centralised nature and uniformity of structure and application make them very blunt, and therefore limited, instruments. The ICE reforestation programme has many advantages. However, it is a fairly restricted programme in scope and method. It is essentially a payment in kind (of inputs) scheme for reforestation. In addition to its limited scope, the principal limitation of the ICE programme is that it is not currently directed towards the sorts of measures that will lead to improved watershed management for hydrological production.

With respect to these ongoing programmes two suggestions can be made regarding how their efforts might be coordinated with the Action Programme. First, the inter-institutional commission should definitely monitor the participation of landholders in the CPB or CCB incentive programmes and pass this information to the "funding" committee. The purpose here is to ensure that participants do not claim a double credit for commitments already made to the government programmes. In addition, it is expected that the inter-institutional commission will also serve to encourage and facilitate, where appropriate, the participation of additional landholders in these programmes. An additional consideration would be for the CCBs to actually be administered by the funding committee, rather than by cooperatives and other organisations located outside of the watershed. This would assist the committee to effectively achieve its goals and would be a significant innovation: local administration of centralised state funds.

With reference to the existing ICE programme, it would appear that the most logical strategy would be to link this programme into the new incentive scheme as one of the options by which participants may contract into the overall Action Programme. This would require the ICE programme to set aside a specific amount of its annual operational budget and contribute this amount to the compensation fund. These resources, being contributions in kind, would be designated for allocation to sealed bids that involve reforestation and require compensation in terms of reforestation inputs. The ICE programme would then honor these commitments

under an agreement in this regard with the inter-institutional commission. The alternative of course, would be to subsume the entire ICE programme within the overall ICE contribution to the Action Programme.

Similarly, opportunities to interface with existing soil conservation programmes and livestock technology improvement programmes, such as those of MAG-FAO, the Monteverde Cheese Factory and the Tilarán Rancher's Association, should be exploited. In fact, should interest in a programme of technological improvements for livestock production be important enough to warrant a fully-fledged programme, the potential for expanding this programme beyond those involved in the incentive scheme should also be explored. As suggested earlier, improving the productivity of soils can be regarded as a toll or club good. Thus, consideration should be given to establishing a club of producers who receive technical assistance in compensation for undertaking watershed management interventions, in return for purchasing entry into the club or in return for contributing to other community development activities initiated as forms of compensation. Cash payments made by members could then be directed towards cost recovery of the technology programme or be deposited into the "unrestricted" account of the compensation fund.

The basic premise of the contractual incentive mechanism is the exchange of improved watershed management in return for compensation in cash or improved production opportunities. However, should the "community" development and organisational aspect of the Action Programme take off, there is no reason why access to existing programmes for improving production opportunities should not be exchanged for contributions to community development projects.

Finally, the Action Programme is essentially a pilot programme, focused as it is upon the needs and conditions of the Río Chiquito watershed. However, there is the potential for expanding the scheme to the entire Arenal watershed once it has been tested and proven to be successful.

Evaluation of the Action Programme

In evaluating projects, policies or institutions, economists typically apply the concept of Pareto optimality or economic efficiency. To this set of narrow criteria, political scientists normally add a measure of the level of equity provided. Under the IAD framework, evaluation of institutional arrangements and incentives implies that all of the following must be evaluated: the rules in use in an action situation (including both economic and non-economic incentives), the interaction of the action situation and actors that leads to outcomes, and the institutional configuration that results - whether the aim is *ex ante* or *ex post* evaluation. Within the larger framework of the IAD approach, then, a number of additional evaluative criteria beyond simply efficiency and equity are added based on Ostrom, Schroeder and Wynne (1993) and Blomquist (1992): compliance, efficacy, adaptability and accountability. In the ensuing discussion, these criteria are applied to the current situation in the watershed and to that expected under the Action Programme. The analysis is qualitative and necessarily speculative, given its *ex ante* nature. The principal objective of the exercise is to assess the major advantages and disadvantages (if such exist) of the Action Programme as versus the *status quo* and, as a consequence, illustrate the potential benefits of undertaking the Programme.

For the purposes of analysing the *status quo* it is assumed that despite the number of "initiatives" referred to earlier there are four institutional arrangements governing watershed management in Río Chiquito. The first is the current differentiated market for livestock production. The incentive to produce in this case is determined in part by the market and in part by government regulations. The second is the centralised programme of conservation incentives promulgated by the government (CPBs and CCBs). The incentive mechanism employed under this programme is a centralised contractual arrangement with cash payments. The third arrangement is the centralised regulation under the new forest law that forbids the changing of land use on land currently in forest. Finally, there is the polycentric arrangement under which the ICE reforestation programme provides in kind contribution (reforestation inputs) to farmers who are interested in planting trees. The latter three items are referred to as the existing "conservation" programme.

The Action Programme as analysed below consists of the polycentric Action Programme presented earlier, taking into account the subsequent modifications suggested in this paper. The first step in the Programme is the development of an inter-institutional commission which represents the stakeholders in the watershed. The commission will coordinate the development of the incentive mechanism that will be employed to implement the specific components of the Action Programme. The analysis below considers the development of a programme of contractual arrangements in which producer commitments to undertake measures aimed at improved watershed management (principally hydrological production) are exchanged for compensatory resource transfers.

Compliance

As suggested by Blomquist (1992), the first criterion is the degree of compliance achieved with respect to the rules governing an institutional arrangement or incentive package. One possible measure of this criterion is indirect in nature: how often the participants fail the established requisites or violate the defined limitations.

Current Situation. Livestock producers are essentially in full compliance with the current rules governing production. The nature of the output of this production, i.e. a marketable commodity, implies that the rules are minimal. Undoubtedly, at the margin there is some non-compliance with state and local regulations regarding fiscal requirements (e.g. taxes) and land use (e.g. observance of buffer strips around watercourses) due to the large transaction costs that would accompany any effort to actually enforce such regulations.

As regards the CPB and CCB incentives, it is too early to cite examples of compliance or non-compliance. However, discussions with producers suggest that they are unhappy with the size of the monetary incentive. This suggests that given the minimal capacity of the government or MINAE to enforce the contractual terms of these arrangements changes in market conditions, such as an increase in beef prices, may in the future increase the incentive to engage in non-compliance. The same conclusion, only stronger, may be reached with regard to the prohibition of land use change, as this is simply a regulation levied on land use from the centre without any accompanying compensation.

In the case of the ICE reforestation programme it is not clear what constitutes compliance given that recipients of assistance do not make explicit contracts in return for the assistance. If compliance is defined as following through with the management of areas planted and re-planting following harvest then the results will no doubt vary with the observed success of the interventions. For example, if pasture productivity is improved by lessening the impact of wind and conserving soil and if the plantings produce useful wood products a high level of compliance is likely with windbreaks. Although the ICE programme is significantly different from past efforts at reforestation in Río Chiquito, it should nevertheless be mentioned that past experience with reforestation in the watershed has had a very low (if not zero) level of compliance.

Action Programme. The Action Programme proposes to incorporate the CCB programme and the ICE reforestation programme into the Programme and, thus, there will be similarities in compliance in this respect. The distinction insofar as reforestation measures are concerned is that the Action Programme will involve the signing of specific contracts for specific measures. Making the contract explicit, increasing the transparency and clarifying the intent of the contract should increase the level of compliance. Further, the publishing of successful bids may serve to establish non-economic incentives (e.g. reputational incentives) for compliance on the part of producers.

The incorporation of additional types of compensation into the Action Programme may also result in a higher level of participation and compliance. For example, the inclusion of a programme of livestock technology improvement alongside a "conservation" programme is often a means of ensuring enhanced compliance with the conservation elements of a programme. A programme in El Salvador offered a single package of incentives that incorporated technologies for improving both conservation and productivity (Saín and Barreto 1996). The programme had a higher rate of adoption than a similar, non-unified programme. The authors attribute this success to the existence of both economic and institutional incentives, in particular the existence of a short-term productive benefit to compensate the longer-term conservation benefit. Also playing an important role was the additional requirement that the package was offered only to groups, the members of which all agreed to adopt the entire package. This example confirms the sentiment expressed by stakeholders in

Río Chiquito suggesting that the Action Programme may increase its compliance level to the extent that it can involve groups of producers in the scheme and not just individual producers.

Efficacy

Efficacy refers to the achievement of stated objectives for the institutional arrangements and incentives put in place. In many cases, the evaluation of a situation of action should be undertaken, not according to the efficiency gained in the achievement of the planned objectives, but according to whether the objectives were achieved at all.

Current Situation. Aylward et al. (1998a) suggest that most producers in the watershed are deriving private returns from their livestock activities. However, there are a number of producers who may not even be covering the opportunity cost of their labour, much less providing a return to their use of the land. The larger objectives of the existing conservation programme in Río Chiquito are essentially the same, being the maintenance of the environmental services provided by forest. The problem is that the quantitative analysis presented in Aylward et al. (1998a) suggests that the measures taken will not necessarily achieve these objectives.

Action Programme. The Action Programme would lead to an improvement in the private profitability of producers who are borderline profitable by enabling them to access some of the off-site hydrological benefits they are generating for ICE. For producers who are already achieving their objective of profitability the programme holds the potential for increasing their profitability in certain instances by participating in the Programme. The Programme would, therefore, increase the achievement of the respective objectives of the livestock sector.

Again, the larger objectives under the Action Programme are not dissimilar to those under the existing conservation programme. An important difference, however, is the recognition by the Action Programme that the key objective of the Programme should be to maximise the water yield (while limiting sediment delivery) of a given parcel of land under the full range of uses. In other words, the objective is both expanded and contracted: expanded to include improved watershed management under pasture or forest; and contracted to focus on the hydrological function.

The Action Programme promises to be more efficacious, as the interventions proposed will target (as directly as possible) the increase of water yield. The existing conservation programme can be interpreted to work against the achievement of its objective, given the misinterpretation regarding the evapotranspirative role of forests in non-cloud forest areas and the role of logging in opening up forest fragments for the capture of horizontal precipitation.

Thus, the Action Programme appears to have a definite advantage in terms of its potential for efficacy. This evaluation is, of course, tempered by consideration that the Programme still only a plan on paper and will face many obstacles before it can be judged to be efficacious. Principal amongst the obstacles is the issue of the level of transaction costs that must be incurred in achieving the inter-institutional coordination required to get the Programme underway.

Efficiency

In general terms, economic efficiency is determined by the magnitude of the change in the flow of net benefits associated with the allocation or reallocation of resources. The concept is used in different ways, two of which are of interest for the purposes of evaluation. First is administrative efficiency, which refers to the cost-efficiency of action and administrative effort as incurred in the achievement of desired objectives. Transaction costs (related to coordination, the negotiation of information and the management of opportunism, and corruption) and transformation costs (related to the transformation of product input, material or symbolic) can be included here. Second is the level of efficiency in the use of natural resources. Given that these resources produce a range of goods and services and require the use of economic inputs in production, it is important to assess whether changes in use patterns will lead to an increase in economic efficiency. This is, of course, analogous to traditional concepts of economic efficiency, absent transaction or transformation costs.

Current Situation. The current conservation programme can be regarded as administratively efficient, as the ICE reforestation programme and the CCB programme build on a range of initiatives underway in the area surrounding Río Chiquito, substantially lowering transaction costs. Economically, however, the programme must be regarded as inefficient in the use of natural resources. The prohibition against change in land use is clearly contrary to economic efficiency in Río Chiquito. Opening up of areas in cloud forest areas would provide important hydrological inputs to ARCOSA in the dry period. However, such action is effectively ruled out under the forest law.

Action Programme. Given the quantitative analysis provided in Aylward et al. (1998a), it is clear that the chief advantage of the Action Programme is that it represents an attempt to target interventions in the watershed that will raise economic efficiency in the use of natural resources. Given the current forest law this improvement is likely to come principally in the improvement of hydroelectric production. However, given the possibility that this law will be modified in the future, there also exists the possibility of realising win-win scenarios in with gains in both livestock and hydroelectric production. At the same time, the Action Programme does entail significant transaction costs and, thus, is probably administratively less efficient than existing programmes. Before proceeding with the Action Programme it would be useful to have an idea of what these transactions will cost and to compare them with the expected benefits from improving efficiency in the use of natural resources.

Equity

Under the IAD framework equity is divided into fiscal and distributive equity. Fiscal equity refers to the extent that administrative costs are made in a form correspondent to the received benefits. Distributive equity refers to whether the benefits of an institutional arrangement under analysis are distributed in an equitable manner between the participants, taking into account their respective ability to pay. These two criteria pertain to equity of outcomes in terms of resulting costs and benefits. However, equity in terms of the process that is followed in arriving at outcomes is also of importance. This could be termed participatory equity. It involves at least three elements: (1) the ability of all stakeholders to express their opinions during the process (equity of voice), (2) the ability of all stakeholders to access information regarding the process (equity in access to information) and (3) the degree of equity in decision-making (equity in power).

Current Situation. The historical pattern of the development of the livestock industry in Costa Rica and the larger regulatory framework under which it falls cannot be said to have been equitable either in terms of distribution or participation. Large landowners have typically had a disproportionate influence on national politics, ensuring that they capture a disproportionate share of the benefits of policies and regulations enacted, such as credit for livestock development. And even though Costa Rica has a long history of democratic government, the highly centralised and bureaucratic history of the welfare state in Costa Rica has not engendered an equitable participation of rural smallholders in policy and decision-making processes. Thus, on grounds of equity it would appear that ensuring that small producers participate and benefit from new opportunities would be a priority.

Within Río Chiquito more specifically, fiscal and distributive equity with regard to hydrological services provided by lands under production can be regarded as inequitable. ICE is not bearing administrative costs related to land management in the watershed (with the exception of the new reforestation programme). Nor has ICE gone out of its way to extend basic services or infrastructure into the watershed. In terms of distributive equity, outside of the limited options under the ICE reforestation programme and the CCB incentives, producers have no way of sharing in the hydrological benefits generated by their use of the land.

The prohibition on land use change under the new forest law would have to be regarded as equitable in the sense that the law applies to all lands, effectively expropriating use rights from all landholders. The extent to which the process by which this resolution was reached involved equitable participation of all sectors was, however, probably limited, given that it fulfills a radical environmentalist agenda with little concession to the needs of rural landowners.

As for the CCB programme it is too early to tell whether it will be equitable. Certainly, the previous CPB programme was not equitably distributed across the country, with most of the certificates going to the Guanacaste province. Another limitation of the CPB was that MINAE required that land be fully titled in order for access to CPBs to be granted. This regulation implicitly excludes the lower socioeconomic bracket of the population from this programme. Nevertheless, the CCB incentives may represent a degree of fiscal and distributive equity given that producers signing up for the CCB will be accessing carbon benefits and that directly or indirectly, carbon consumers will be contributing to the administrative costs of the programme. For example, if the CCB programme is actually able to access funds from the new gasoline tax, carbon consumers within Costa Rica (not just global consumers) will be contributing to the programme.

The ICE reforestation programme, on the other hand, appears to be available to those evincing an interest in participating regardless of their antecedents, which suggests a reasonable level of distributive equity. As ICE is shouldering the administrative costs of the programme, it can also be considered to be fiscally equitable. The programme could be faulted on grounds of low participatory equity, given that the process of defining the programme was likely to have been dealt with at headquarters level and not discussed publicly (however, see below under adaptability).

Action Programme. Under the Action Programme fiscal equity can be expected to improve, as the off-site users of environmental services will be expected to bear the administrative costs of the incentive programme. Distributive equity will also be improved, as landowners, particularly smallholders, will have the opportunity to share in the benefits of increases in

hydroelectric production. As indicated, the process of pulling together the inter-institutional commission and the subsequent design of the incentive mechanism is intended to be, to the extent possible, a participatory process. The opinions of the community and other stakeholders will be heard and all of these groups will share in the decision-making. Further, the aim of the programme will be to divulge relevant information to all concerned regarding the bidding process, its outcome and the status of contracts reached (as evidenced by the monitoring function). This will ensure that all involved in the initial process may continue to stay informed and participate in a knowledgeable fashion as the programme is refined. Thus, participatory equity should also improve under the Action Programme.

Adaptability

A key criterion, and one that is often overlooked, is the capacity of an institutional arrangement to adapt itself to changing circumstances and to exploit new ideas as they emerge.

Current Situation. The differentiated market that governs livestock production can be seen to have a limited degree of adaptability insofar as producers may switch amongst the different production types and the concentration of land-ownership may rise or fall. However, in terms of developing better production methods, the sector has shown little in the way of advances for some time. Most producers use the same pasture, and the main type of technical assistance obtained is for artificial insemination.

In fact, the idea of planting windbreaks is probably the most innovative development in recent years. In this respect the ICE programme is likely to have a high degree of adaptability. As it does not require firm contracts with users, the programme is free from the typical bureaucracy of government programmes. It can also be expected that the techniques employed will be adapted to local needs and the programme will learn from its experiences, given its emphasis on dialogue with producers and its nature as an on-farm laboratory of sorts. In a more general sense the ICE programme reflects the larger trend in Río Chiquito and the surrounding area from centralised to polycentric arrangements, the latter implicitly being more responsive and, hence, adaptive to local conditions.

This sort of flexibility is totally absent from the provisions of the new forestry law, which represents a step backwards into a centralised regulatory framework. Under the Costa Rican constitution, government programmes must be non-discriminatory. Unfortunately, this has been interpreted to mean that incentives for forest conservation offered by law in one section of the country must be the same as those offered in another part of the country, albeit under completely different biophysical and socioeconomic conditions. Thus, the CCB and Forestry Law demonstrate little to no adaptability.

Action Programme. Adaptability should be a key feature of the Action Programme, which will attempt to capitalise on the growing emphasis on polycentric institutional arrangements in the area. A key factor enhancing the adaptability of the Programme is that it is a pilot project and, thus, should be continually reviewed for means of improving performance. If anything, the proposed design for the contractual arrangements will need to be rendered less flexible as it moves towards implementation. The potential to incorporate different sources of funds and to develop a variety of interventions with a number of forms of compensation suggests that the initial problem to be faced will be limiting the choices involved in order to control the

complexity of the programme. In addition, it can be expected that the participatory planning process and subsequent monitoring and dissemination of information about the progress of the programme should enable the programme to profit from observations made by producers and the local communities themselves as to how to improve the programme.

Accountability

An essential element for the adaptability of an institutional arrangement is the presence of mechanisms through which those responsible for certain tasks can be held accountable for successfully (or not) completing these tasks.

Current Situation. Users and beneficiaries of current institutional arrangements in Río Chiquito have typically had little means of control over the programmes that target them. Even when programmes such as the CCB and ICE's reforestation programme are well intentioned, reasonably effective and polycentric in nature, the fact remains that local participants are generally not able to hold these programmes accountable for their actions. This is at least in part due to the preponderance of centralised bureaucratic power that still exists within MINAE and ICE. For example, despite the decentralisation of executing authority to organisations in the regions (e.g. AGUADEFOR) the ministry remains heavily involved in assigning the incentives across the regions and in setting the administrative procedures for implementation. The ministry in turn is heavily influenced by national party politics, with local and regional interests having little political power at this level. Authority then remains in the centre with the political elite despite the decentralisation of operations.

Action Programme. To the extent that the proposed Programme will be lodged within a transparent and participatory process of design and implementation, it is expected that the Programme will lead to a higher degree of local accountability. At the same time, it is not the intention to completely divorce the Programme from national accountability. Rather, it is intended that ICE be the principal national stakeholder in the process, a stakeholder with a significant interest in monitoring the level of compliance of producers with their contractual obligations. Thus, there will remain the need to account for the Programme to the nation as a whole, given that the funds flow from the centre. The key questions to be answered at this level are as follows: how were the resources used, to what extent were the promised interventions undertaken, and how effective were the interventions? Thus, national accountability should function at the level of monitoring and serve as an ultimate backstop for enforcement should things get out of control.

However, it would be ideal, if not a necessary component of success, if the Programme could generate a consciousness amongst the local programme that those running the programme and those participating in it are, in the first instance, accountable to the local community. This is related to the concept that for such a programme to really be sustainable in the long term it must be "owned" by the local population. There is no better indicator of ownership than the exercise of the power of accountability by local communities.

In sum, the evaluation reveals that the institutional arrangements and incentives proposed under the Action Programme are likely to perform better across all six of the criteria investigated. The existing conservation programmes fall considerably short of what can be expected from the Action Programme on the criteria of efficacy, efficiency and fiscal and distributive equity. This is not unexpected, given that the Action Programme emerges from a

process of in-depth biophysical and economic analysis, whilst the other programmes represent more of a political agenda, albeit a technocratic one. It is also likely that under the Action Programme the livestock sector will also perform better on these two substantive criteria.

With regard to the more process-related criteria of participatory equity, adaptability and accountability, the ability to plan for a participatory process involving all relevant stakeholders also leads to superior performance for the Action Programme on these criteria. As an attempt to create a truly polycentric institutional arrangement, the Action Programme will benefit greatly from empowering local communities to take an active role in steering the process of institutional change and design of incentive mechanisms.

Conclusions

This paper presents an Action Programme including objectives, institutional arrangements and incentives for improved watershed management in Río Chiquito. The Programme is grounded in the original version of the Action Programme, developed through a participatory-stakeholder process initiated by the CREED project. Modifications and extensions to the ideas presented in the original Programme are based on integration of the quantitative environmental-economic analysis contained in the companion paper of Aylward et al. (1998a) and the application of the Institutional Analysis and Development Framework, as developed in this paper. Proposed extensions to the original Action Programme include the identification of specific watershed management measures and proposals for new institutional arrangements and incentive mechanisms to govern the provision and production of the "bundle" of goods and services produced in the Río Chiquito watershed. Finally, a preliminary evaluation of the modified Action Programme is undertaken employing the IAD evaluative criteria.

Examination of stakeholder views suggests that much work remains to be done on developing a consensus view regarding the principal environmental problems experienced in Río Chiquito under current watershed management practices. The environmental-economic analysis provided by the CREED project may succeed in bringing stakeholders closer together insofar as an assessment of the threat of sedimentation of Lake Arenal is concerned. However, the suggestion that both pasture and fragmented cloud forest provide large gains in hydroelectric production by means of an increase in annual water yield will be controversial, though good news to producers who are often criticised by conservationists. Certainly, the participatory process engendered under the current process has at least opened up a stakeholder dialogue, one that may eventually enable a consensus to be reached.

Review of local and national trends in watershed management within Costa Rica and Río Chiquito suggests that a transition is underway from market and centralised arrangements towards polycentric arrangements, with a mixture of market and non-market incentives being employed in the provision and production of environmental services. Pasture management, soil conservation and forestry initiatives are produced largely by private actors operating under market incentives, yet there are also a host of public agencies and NGOs that are either supporting these activities or considering initiatives in this area.

With regard to the point of central interest to the study - the existence of hydrological externalities - the analysis suggests that the substantial transaction costs implicit in moving forward to tackle these externalities has probably led to inaction in the past. This problem may have been exacerbated by the poor quality of internal ICE information on the extent of the sedimentation problem and apparent ignorance of the linkage between land use and water yield. However, changes in organisational abilities and attitudes at both national and local levels suggest that the transaction costs of actually producing improved watershed management have been lowered dramatically in the last decade. Indeed, both the technical aspects of the CREED project and the participatory-stakeholder approach, and resulting Action Programme for Río Chiquito, may be interpreted as efforts aimed at reducing uncertainty regarding the benefits of watershed management and stimulating efforts to improve watershed management through collective action.

The Action Programme, as put together at a stakeholder workshop, proposes to focus efforts on six objectives: (1) forest conservation and regeneration, (2) land use change in marginal pasture areas, (3) improving livestock technology, (4) community development, (5) development of local ecotourism and (6) creation of inter-institutional coordination. This paper examines in great detail the justification for items 1-3, based on an integration of information on the relative benefits provided by different watershed goods and services in Río Chiquito with a discussion of the public good nature of these goods and services. The practical measures for improving watershed management that emerge from the technical analysis are then examined in terms of their incentive compatibility and the consistency of existing institutional arrangements and incentives. From there, recommendations emerge for changes to these arrangements and specific ideas for the incentives mechanism in order to alter producer behaviour and turn land use towards more economically efficient watershed management practices.

Not surprisingly, the findings suggest that the public good characteristics of a number of the watershed goods and services produced in Río Chiquito imply the need for institutional arrangements beyond that represented by markets. However, the results suggest that simply labelling such goods and services as public goods is too simplistic an approach. In the Arenal case, although upstream landholders may find it difficult to exclude others from consuming the downstream benefits of land use decisions already made, the possibility remains that they may retain rights of exclusion over future land use decisions. Given the private good characteristics of downstream hydrological products this suggests that there does exist a basis for a market-driven, polycentric arrangement between upstream producers and downstream consumers. Thus, the advantage of investigating the public good natures of the myriad of goods and services produced by watersheds is that it provides an analytical basis for the suggestions of the types of institutional arrangements that might be most appropriate for the management of these goods and services. In addition, the analysis suggests that the public good nature of these goods and services must be placed in a historical context and take account of current trends affecting levels of exclusion and rivalry.

Generalising on results from such an analysis is complicated by the inescapable fact that the classification (and value) of these goods and services is site specific and that the goods are jointly produced. In the case of off-site hydrological services the discussion highlights the variability that may exist from site to site, and from one downstream use to another, in terms of the degree of exclusion and rivalry that exists. At the same time the "bundle" of goods and services and their relative economic importance will vary from one site to the next. As a result, it is likely that centralised arrangements for the public production and provision of these goods and services will generally be inappropriate. Instead, decentralised or, better still, polycentric arrangements are required. Under such arrangements the identification of an appropriate mix of market, bureaucratic and collective action incentives must be made in a pragmatic, almost ad hoc fashion that permits both local and national stakeholders to inform the process.

In light of these findings, the original Action Programme is reviewed, modifying the relative emphasis placed on the different objectives of the Programme. Analysis of on-site goods and services yields the conclusion that there is little cause for investing public funds in soil conservation measures in Río Chiquito for the express purpose of enhancing on-site productivity. Such measures, however, may be appropriate if conditional upon the provision of positive off-site externalities. Specific measures for improving the provision and production

of off-site benefits are differentiated by whether they pertain to non-cloud or cloud forest areas. In both areas these include the reforestation of erosion-prone, marginal pasture areas and natural regeneration of buffer strips alongside streams. In non-cloud forest areas the cutting or conversion of forest in areas that are not prone to erosion would increase water inputs to the reservoir. Measures in cloud forest that would similarly promote water production by increasing the capture of horizontal precipitation are highly recommended. These include cutting and/or conversion of patches within large contiguous forest areas, natural regeneration of forest in large areas of pasture and planting of windbreaks in pasture areas.

Given reduced transaction costs of providing the technical assistance required to initiate such measures, it is expected that the economic interest of the three principal stakeholders (ICE, livestock producers and international/carbon stakeholders) should drive the development of a polycentric institutional arrangement coordinated by the inter-institutional commission for the watershed. Existing conservation arrangements are only loosely polycentric. Despite the devolution of operating authority to local agencies, planning and decision-making authority remain vested in the centre. Critical to the success of the polycentric arrangement is that ICE and international stakeholders allow local communities to have a more effective say in establishing the rules for the Action Programme.

As an input to this process, an incentive mechanism suitable to Río Chiquito is proposed based on a technical review of the suitability of a number of traditional and novel mechanisms for resolving externality problems of this nature. It is recommended that the inter-institutional commission called for under the Action Programme develop a two-way sealed bid auction system of allocating contractual arrangements under which producers agree to undertake management improvements in return for compensatory resource transfers (or projects). External stakeholders wishing to obtain off-site services would not only contribute funds but assist in establishing priorities for the awarding of contracts, up to and including establishing their willingness to pay for specific measures in specific geographic areas. Ideally, producers would likewise set their offer price for specific measures in specific geographic areas. The respective sealed bids would be sorted and matched in a cost-effective, optimising manner by an independent committee organised under the commission. The hydrological and economic information developed in the CREED project could be used to establish both hydrological and carbon storage priorities, while the offer price for the measures would be best left to the individual producers to decide.

As a preliminary means of validating the Action Programme, the proposed institutional arrangements and incentive mechanisms are compared to those already in existence according to the criteria developed under the IAD framework: compliance, efficacy, efficiency, equity, adaptability and accountability. Not surprisingly, given the degree of consultation and analysis involved in its preparation, the Action Programme appears to represent an important improvement over the existing situation. From a purely economic standpoint of efficiency, further research should consider whether the incremental net benefits that would be realised under this Programme would, in fact, be greater than the transaction costs implicit in its development. However, given the potential that the approach may have as a pilot project for the entire Arenal watershed and other sites, such a condition may be overly restrictive given the substantial transaction costs inherent in any novel yet replicable institutional innovation.

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Annex 1. Institutional Arrangements[12]

An "institution" is a set of norms or effective rules used by a group of people in order to organise a certain sphere of their collective activities. In action situations it is possible to identify a number of institutional arrangements including market, centralised, decentralised or polycentric arrangements. Three types of market arrangements exist: simple markets, differentiated markets and user groups. Markets are generally regarded as appropriate institutional arrangements for the production of private goods.[13] Non-market arrangements, including centralised, decentralised and polycentric arrangements, are necessary when society faces the problem of administering goods with public goods characteristics.

A simple market is one in which each consumer is individually responsible for the process of providing the required goods and services, articulating their demand directly to producers (also individuals) of those goods and services. In a differentiated market, there are provider organisations that orchestrate the production required to meet the final demand of the consumer individuals. As a result, the costs of coordination are less than in the simple market.

User groups, operating within a differentiated market, can function as provider organisations made up of final consumers who orchestrate the production of required goods and services either through individual producers or through organisations of producers. For example an irrigation association consists of a group that bands together to produce the good in question (irrigation) and simultaneously consumes the final product. As compared to production under a differentiated market (by individual producer units) the scheme results in a reduction of transaction costs because there is better control of opportunistic behaviour (rule-breakers may be effectively excluded by the group). Such conclusions are subject to user groups that are relatively small and well defined.

A centralised institutional arrangement has, as distinct from the three situations indicated above, specialised groups of public functionaries - some elected, others not - that take national decisions as much for the provision as for the production of the goods and services required by the consumers. The future career of these full-time functionaries depends to a greater or lesser degree (according to the level of influence or pressure the consumers are able to exercise) on their superiors, increasing strategic costs (of corruption and shirking) and the costs of coordination and development of local information. There is evidence that these problems could be overcome through local participation in processes of decision-making and implementation; however the existing incentives for public functionaries in this sense are weak.

Ostrom, Schroeder and Wynne (1993) argue that the predomination of centralised schemes for the provision and production of development infrastructure is based on a "truncated" analysis, centred on three performance criteria: economies of scale; access to technical knowledge and

[12] This sub-section is based on Ostrom, Schroeder and Wynne (1993).

[13] See Annex 4 for an explanation of this argument.

control of opportunist behaviour. Such an approach does not take into consideration all the implicit costs (excluding the operational costs and those of maintenance, coordination, information and strategies) nor all the possible institutional options (excluding those of a decentralised or polycentric character). In certain cases, a more comprehensive analysis might favour the option of mixed arrangements. Examples include centralised provision with decentralised production (this might be in private hands or enacted through public agencies, not only on a national level but also on a local one) or non-centralised arrangements of provision and production with lower intermediate costs and better global performance.

With regard to the analysis of decentralised arrangements, Ostrom, Schroeder and Wynne (1994) clarify that they mean the concept of administrative decentralisation or deconcentration. This involves the transference of authority held by national government functionaries in metropolitan areas to national government functionaries based in dispersed localities. This approach can reduce the costs of acquiring locally relevant information but the information that is produced is not always used effectively, given the existing incentives for local functionaries to put metropolitan mandates over and above local interests. The key to radical and effective decentralisation is in the transference of authority and responsibility to the local functionaries, citizens and users.[14]

A final option consists of non-centralised or polycentric institutional arrangements which "distribute circumscribed but independent rule-making and rule-enforcing authority among numerous jurisdictions. All public authorities have official standing, and no individual or group serves as the final, all-purpose authority that stands above the law" (Ostrom, Schroeder and Wynne: 177-178). A polycentric government structure offers its citizens the opportunity of organizing not one but many governing authorities. Each authority is primarily a unit for the provision of goods and services, capable of producing for itself or contracting the required production, thus, attaining available economies of scale in the design, construction, maintenance and operation of services. Some of these government offices have general authority, providing a wide range of services, but others have one unique or specific aim. The functionaries of each government office are selected independently from those of other jurisdictions, so that hierarchical relationships that exist inside one government office do not exist inside the others. Disputes over jurisdiction are resolved outside the administrative hierarchy, in courts or other places designated for the resolution of conflicts.

The Chhattis Mauja, a large-scale, farmer-managed irrigation system in Nepal provides an example of a polycentric arrangement (Ostrom, Schroeder and Wynne: 188-189). The system is self-organised and involves a nested system of governing authorities that has four levels:

1. Village committees and a chairperson that set distribution rules and organise maintenance work

2. Regional committees made up of village chairs that coordinate village work on the diversion structure and main canal, and solve intra-village disputes

3. A central committee made up of regional chairs, that organises development, operation and maintenance of the main canal and diversion structure,

[14] Thus, the distinction between administrative decentralization and the decentralization of decision-making.

4. The Tinau Committee on which the central committee chair sits, that allocates water to the Chhattis Mauja and four other irrigation systems

Each of these governing bodies exercise independent authority within their respective area of authority and geographical area and, thus, the entire arrangement is polycentric, i.e. it has many centres.

Annex 2. Participatory-Stakeholder Process

The participatory-stakeholder process began with consultation of the principal institutional actors or stakeholders involved in the management of Lake Arenal, with a specific emphasis on those actors involved in Río Chiquito. The actors can be divided into nine groups as follows:

1. Livestock producers, including both large and small producers, with considerable participation by the local Livestock Producers Association.

2. Other producers, mainly small coffee growers, affiliated to a regional coffee cooperative (which is also linked to a regional foresters association, AGUADEFOR) and small-and-medium foresters, some of whom are currently experimenting with soil conservation technologies (primarily reforestation and windbreaks).

3. The Monteverde Conservation League (ACM), which protects a large expanse of forest, including cloud forest (called the "Children's Eternal Rainforest") and operates a set of incentive and technical assistance programmes for soil conservation and reforestation in the area adjacent to Río Chiquito.

4. The local municipality (Tilarán), which has in the past tried to negotiate arrangements with ICE to ensure that the local people share in the benefits of the Lake Arenal hydropower scheme.

5. The Arenal Conservation Area (ACA), the government agency responsible for the large conservation area which includes all of the Arenal watershed and Río Chiquito. ACA functions with the support of WWF-Canada and the Canadian International Development Agency, and its activities include small pilot projects aimed at protecting the Río Chiquito watershed.

6. The Costa Rican Electricity Institute (ICE), responsible for the national electricity and communications monopolies and, consequently, the operation of Lake Arenal and its power complex (ARCOSA).

7. The national water and irrigation service, SENARA, the end-user of water from Lake Arenal for the PRAT irrigation project in the Guanacaste province.

8. Two FAO programmes with pilot soil conservation projects in the area (one with the Ministry of Agriculture and Livestock (MAG) and another with the Agrarian Development Institute (IDA)).

9. Two national environmental NGOs (CEDARENA and AMBIO) concerned with legal innovations that are required to empower national efforts in conservation with development.

Three rounds of consultations were undertaken with these actors over a three-month period (March-May 1996). The first round of consultations consisted of semi-structured interviews with some thirty-four key informants selected to represent the different stakeholder groups. Each interview focused on the following areas:

- existing land uses and alternatives in the watershed, particularly in Río Chiquito
- stakeholder criteria for evaluating these uses and alternatives
- relevant incentives and institutional arrangements which, on the one hand, underlie current land uses and, on the other, would serve to promote other alternatives.

The second round of consultations consisted of interviews with the original contacts in order to validate and correct a transcript of the first interview and to obtain feedback on a preliminary systematisation of results gathered in the first round (current uses and alternatives; evaluation criteria; incentives and arrangements). Although this second interview was also semi-structured, the interviewees were given a closed-end questionnaire in order to evaluate the proposed systematisation according to the criteria of efficiency, equity, adaptability and accountability.

The final round of consultations was a one-day workshop, held on 1 June, 1997 in which 40 representatives of the stakeholder groups were brought together to discuss a second systematisation of results under the general heading of an action programme for watershed management in Río Chiquito. The first session of the workshop consisted of a plenary presentation and group discussion of the underlying problems of the watershed. Two subsequent rounds of plenary, group discussion and reports back to plenary were then held on two themes: actions for resolving these problems and plans for taking the agenda forward, particularly with regard to inter-institutional development within the watershed. The workshop's principal objective was to initiate a long-overdue dialogue between stakeholders aimed at producing a common understanding of existing action proposals and the respective criteria of the different stakeholders. The product of the workshop was an initial consensus agenda for further discussion and action.

Annex 3. Existing Institutional Arrangements and Incentives for Watershed Management

In this Annex the historical tendencies towards centralisation and their implications for the incentives and institutional arrangements that govern resource and environmental management in Costa Rica and in Río Chiquito are described and analysed. At both national and local levels, however, the trend is towards decentralisation. This transition is subsequently explored in terms of fundamental changes in national level processes and the initiatives in the area surrounding Río Chiquito that are beginning to be promoted in the watershed.

Centralised Institutional Arrangements and the Environment in Costa Rica

Historically, policies governing the management of natural resources and the environment in Costa Rica have had their origin in top-down, centralised arrangements. Five centralised arrangements that have had an important impact on the environment are summarised below.

1. Land colonisation policies, including the Family Providers Law of 1934 and Land Tenancy Information Law of 1941, established an initial legal (and cultural) framework in which ownership of land was accomplished by demonstrating that the land was in "use," evidence of which was produced by clearing the land (Segura and Solórzano 1995; Watson et al. 1998).

2. State provision of subsidised credit for the development of the ranching industry began in the 1950s (Segura and Solórzano 1995).

3. The internal organisation of state institutions and the relationships of these institutions with the public they are designed to serve are characterised by a bureaucratic, centralised and top-down mind-set.

4. Legal principles ensured that "the polluted paid" instead of the "polluter paid" as the rights associated with the use and management of private property held sway over collective rights to environmental quality and other goods of public nature.

5. Property rights over environmental goods and services (typically vested in the state) have excluded the local population from participating in their management and sharing in the benefits of these services, particularly as relates to protected areas.

Notwithstanding historical tendencies, recent trends suggest that the biases towards centralisation is changing, or at least is under sustained pressure to reform. Increasing recognition of the importance of forests as a provider of natural resources and environmental quality has led to important changes in the elements mentioned above in recent years. No longer is clearing of land required to demonstrate ownership, although the general lack of any remaining areas for colonisation makes this a moot point. The availability of soft credit for ranching has been drastically reduced in the 1990s. Pressure on forests and the environment, led by the expansion of the traditional agro-livestock export model may, therefore, be said to have diminished considerably. However, it can be argued that while these symptoms of a development model based on state-led and financed export promotion have disappeared, the

underlying model still has life left in it. Export industries currently enjoying centralised support include ecotourism and the production of non-traditional agricultural exports.

Developments in the forestry sector from the 1980s onwards, however, presage the beginning of a less centralised approach to natural resource management. The origins of a more polycentric approach may be seen in the implementation phase, from 1979, of the first forestry law, with the creation of a series of direct incentives for reforestation and forest management (Segura and Solórzano 1995). It is within this larger framework that the experience of the Guanacaste Forestry Development Association (AGUADEFOR) as a regional intermediary organisation in the allocation of these forestry incentives and the role of two local intermediaries, COOPETILA and COOPELDOS (Coffee Producers Cooperatives of Tilarán and El Dos, respectively) were developed in Guanacaste province.

Two important institutional innovations also suggest the desire to change the traditionally centralised and hierarchical internal organisation of state agencies and their relationships towards their "clients." The National System of Conservation Areas (SINAC) originated in the late 1980s, receiving formal legal standing only in the mid-1990s. SINAC has as its aim the creation of regional conservation areas centred around existing protected areas (parks, wildlife reserves, forestry reserves, etc) and including buffer zones (areas targeted for conservation activities) and zones of "influence." Recent modifications to the system have essentially led to the division of the entire country into these Areas. More importantly, in 1996 the Ministry of Environment and Energy (MINAE) began a process of administrative decentralisation, transferring bureaucratic authority that was previously held in San José to conservation area headquarters located in the field. This was accompanied by the merging of the wildlife, forestry and park service into a single body charged with a broader conservation agenda. In addition, some areas have engaged in limited efforts to transfer administrative authority to local government and regional environmental commissions.

A second initiative is the strengthening of municipalities, heretofore relatively weak and inefficient actors. Changes in 1996 to the law governing property taxes now assign authority for the collection of these taxes to local government. In the short-term this will greatly increase the power of municipalities to execute development and infrastructure projects. In the longer-term it is possible that the interest of local authorities in regulating the process of local development by means of planning regulations at the municipal level will lead to important changes in environmental regulations. Accompanying this increase in the resource base available to local authorities is a proposal to further democratise local authority by requiring that Municipal Directors be elected, as well as other measures aimed at increasing participation and accountability of local government.

Progress in sensitising basic legal principles and legislation to environmental concerns has also been made in recent years. Reform of Article 50 of the Constitution of the Republic of 1994 and the new Organic Environmental Law (No. 7554) suggest the potential for limiting the exercise of private property rights, stipulating that environmental health and the conservation of natural resources constitute basic rights of citizens. Under these reforms it is increasingly likely that citizens or groups acting on behalf of the state (and for the public good) will be able to seek legal vindication and compensation for environmental "crimes." There is currently no precedent for such action in Costa Rica, nor indeed in Central America. A court case currently underway seeking damages from the local subsidiary of an international banana producer for a variety of irregularities in the clearing of primary and secondary forest on the

Atlantic coast suggests, however, that environmental groups will quickly avail themselves of this avenue to make "polluters pay."

Progress in opening up property rights to environmental resources is more difficult to gauge. Typically, government ministries or parastatal institutions are endowed with property rights to the resources they manage, or state monopolies to markets in which such resources are traded. National Parks remain off-limits for any use by local people; indeed they must pay an entrance fee to visit. The Costa Rican Electricity Institute (ICE) and National Water, Irrigation and Sewage Service (SENARA) command a large degree of centralised power over the hydrological resources (rivers, lakes, reservoirs and waterways) of the country. This pattern of centralised control extends to private property. Wildlife remains national patrimony irrespective of its location. The new forest law (N° 7575) established in 1996, effectively expropriates the use rights of landholders by forbidding a change in land use on land that is defined as forest land.

In sum, a number of initiatives and movements aimed at limiting the traditional pattern of centralised control and governance over natural resources and the environment are currently underway in Costa Rica. Nevertheless, much remains to be done. In part the difficulty lies in moving towards political processes that are participatory rather than hierarchical and top-down in nature and that are truly democratic rather than autocratic. In other words, moving towards a culture that is polycentric rather than centralised.

The Influence of Centralisation in Río Chiquito

The tendency towards centralisation that is found in Río Chiquito is a result of a polarised model of accumulation and development based on centre-periphery relationships that historically prevailed in the country. The socio-demographic and economic origins of the human settlements formed in the area are, thus, founded on this model. The arrival of the first migrants to the area in the 1920s and 1930s formed part of a centrifugal movement of coffee workers that were expelled form the Central Valley during the economic crisis of those years. Compelled by national legislation, these *campesinos* cleared forest land in order to prove that they had made "improvements" to the land and would thereby be eligible to obtain legal title to the land. Faced with uncertainty over the prospects of agricultural markets, poor infrastructure and a difficult climate these campesinos opted for extensive ranching as a means of capital accumulation, with little regard for the environmental impacts of their action. Cattle effectively privatised the natural resource base (turning grass into meat) and did not require roads to reach local markets. In this manner, large areas of forest were converted to pasture in the space of a few decades. The government's desire to fund the expansion of ranching in the country only added additional support and legitimacy to the general productive focus of the local population.

A second factor influencing the degree of centralisation in the area is the state's dominance of the provision and production of hydroelectricity and irrigation, manifested through the creation of state-run monopolies in each area by ICE in 1949 and SENARA in the 1970s. These trends ultimately led to the insertion of the state and its centralised power into the Arenal area with the development of the dam that greatly enlarged Lake Arenal, the Arenal hydropower complex (ARCOSA) and the Arenal-Tempisque Irrigation Project (PRAT). This centralisation undoubtedly constituted an advance in terms of national development. In effect, first electricity and later irrigation were transformed into goods of public interest. As a result, these goods became more widely available and more equitably distributed than would have

occurred had their provision and production been left in private hands, where purely commercial motives rule.

The deadweight of centralised provision and production is demonstrated, however, in the problems state institutions have encountered in developing an adequate vision with regard to local-periphery relationships, particularly in taking into account the peculiarities of environmental problems. Three examples of this phenomenon are explained below based on interviews conducted during the study.

Deadweight Example: The Ministry for Agriculture and Livestock (MAG). MAG has shown an interest over the years in accommodating local conditions and interests. Nevertheless the bureaucratic and centralised structure of the institutions operates as a perverse incentive preventing the achievement of these goals. Two types of such problem exist: the first is the centralised definition of functions and activities, which disregards local opportunities for employing institutional resources in a more productive fashion; the second is the absence of adequate internal procedures for evaluating objectives, functions and actions. New objectives, roles or tasks often go unannounced, or are simply ignored by staff because the evaluation process is unlikely to reward compliance with new policies, and the policies may quickly be reversed. Such new initiatives may also be at loggerheads with the interests of the local office's "clients."

A case in point is the proposal initiated by the Tilarán Ranching Association to develop demonstration projects for "sustainable" ranching in the Arenal area. For the Tilarán office this proposal represented an important opportunity to study patterns of livestock technology that would be appropriate to the local area. At the same time as this proposal was circulating, however, the Figueres Olsen administration, was pushing MAG towards a new institutional focus on the establishment of basic agricultural centres in local communities. The lack of flexibility of central management in accommodating this local agenda and the uncertainty as to how their performance would be assessed in relation to these two very different agendas prevented local MAG technicians from fully involving themselves in the Ranching Association project. As a result the project has been shelved and an excellent opportunity has been missed.

Deadweight Example: SENARA/PRAT. Interviews with SENARA personnel employed on the PRAT project reveal a significant difference of opinion between these personnel and the working policy of the institution. The latter is set in SENARA headquarters in San José. For example, under the pricing policy on the PRAT project, water users are charged a token fee on a per hectare basis. The technicians on the project state that this policy simply encourages users to ignore the real value of the water they receive and gives them no intrinsic incentive to consider where the water comes from or who produces it, much less to participate in any effort to internalise externalities should they exist. This set of circumstances reflects the centralised bureaucratic mindset of an institution that is nurtured by the dependence on the government purse without regard to the level of service or "income" being produced in the field. The preoccupation with short-term issues in the central office and the lack of incentives that would lead field staff to suggest institutional changes does not bode well for the long term maintenance of the project, given the difficulties that will arise once the "token fee" period ends.

Notwithstanding these problems, a proposal for subsequent phases of the PRAT project did include a transfer aimed at "improving" watershed management in Arenal.[15] The exact motivation for this intervention is not clear; however, it does reveal that process is one thing and substance another. For example, the sustainable development strategy announced by the Figueres Olsen administration upon taking office in 1994 was very much a centralised, technocratic effort, although it did receive support from some environmentalists. The ripple effects of such a strong emphasis on a particular theme are likely to be widespread in a strongly hierarchical, centralised system. Furthermore, the efforts of a given agency to be perceived as supporting the president's agenda may often be hasty and ill considered, despite their strategic justification. For example, SENARA is the institution that sponsored the studies that clearly show that the offtake from Lake Arenal will be more than sufficient to satisfy demand, even if the project is fully completed. Thus, based on the agency's own planning documents, SENARA's intention of altering watershed management in Arenal has no logic.

Deadweight Example: ICE. The third example is that of ICE which, until very recently, has shown very little appreciation for the development needs of local people in the Arenal watershed. In theory, the development of state monopolies in energy and telecommunications was, as stated above, intended to ensure that these services reached all areas of the country in an equitable fashion. While tourists may find a telephone and electricity in the most remote coastal towns of Costa Rica, the people living in the upper Arenal watershed have access to neither. This is ironic given that the watershed is a major source of water for the single largest power plant complex in the country. It could be argued therefore, that the antagonism of the community towards ICE is justified. ICE came to the watershed and, based on its centralised mandate, expropriated the people's land and expropriated the water (once the watershed became part of an ICE project legal control over the rivers came under the domain of ICE). In return, the people expected a reinvestment in the socio-economic development of the community, but received none.

The weight of centralism as described above manifests itself in the difficulties faced in efforts to ensure an adequate administration of natural resources in general, and for the management of Río Chiquito in particular. The most important problems in this respect are the existence of large transaction costs for the coordination of institutional policy and the absence of a differentiated market (for supply and demand) of the provision and production of environmental services. However, as discussed in the next two sub-sections it is precisely with respect to these two difficulties that the situation has been improving in recent years. At national level, the movement from centralised to polycentric institutional arrangements may well be an important component of solutions to environmental problems more generally. This change in the arrangements governing environmental management responds to the suggestion that until local people are able to participate in the provision and production of environmental services, and to benefit in an equitable fashion from this production, sustainability will be an elusive goal for the country.

[15] Unfortunately, the analysis by Aylward et al. (1998a) suggests that such an intervention is unwarranted.

Incentives and Institutional Arrangements in Río Chiquito and its Environs

In this sub-section the existing incentives and institutional arrangements governing the environmental services produced by improved watershed management in Río Chiquito and neighbouring localities are described. Inclusion of initiatives from outside the watershed is very important as the pattern of movement suggests that many of these initiatives have begun outside the watershed in response to local concerns and, once proven, are being extended into the Río Chiquito watershed. Principally, these efforts consist of water and soil conservation by means of reforestation and conservation of existing forest. Instances of arrangements more specific to livestock production and ecotourism are identified as well.

Reforestation and Forest Conservation

The first programme aimed at watershed management in Río Chiquito was the diffusion of reforestation incentives supported by funds from international donors and the government. These initiatives began in 1988-89 and were pushed by COOPETILA, COOPELDOS, the Monteverde Conservation League (ACM) and ICE.

Interest in reforestation in this area may be assumed to be a direct consequence of the difficulties experienced by the ranching industry in this period. However, as compared with other areas in Costa Rica the interest has not been to replace pasture with forest plantations, but to introduce limited reforestation in order to improve livestock productivity. Reforestation efforts are typically limited to the establishment of windbreaks that protect the soils, pasture and animals from the wind and to a lesser degree from erosion. As noted earlier, the interesting aspect of windbreaks is that they are likely to have an important effect on sediment delivery and, therefore, generate downstream benefits as well.

Initial efforts focused simply on the protection from wind, with subsequent efforts attempting to introduce species with commercial uses, particularly as fenceposts. Species introduced initially were exotic, including cypress (*Cuppresus mexicana*) and eucalyptus (*Eucaliptus saligna*). In the 1990s efforts have been made to experiment with native species, principally *colpachí* (*Croton sp*.) and *manzana rosa (Eugenia jambos*). Much of this reforestation has been accomplished under government incentive programmes, particularly the Fund for Forestry Development (FDF). The advantage of the FDF is its ability to finance activities in situations of informal land tenure such as those that exist amongst smallholders in the study area. Although the funds were intended to finance plantation forestry, the ACM was able to adapt the FDF to their programme entitled "Forests in Farms", which emphasised windbreaks, "live" fences and the interspersing of groups of trees within farms. The inhabitants of the upper Arenal watershed easily accepted the idea of windbreaks ("live" fencing already being popular) but have not responded to the idea of reforesting small patches within their pasture as proposed by the ACM. The difficulty with the latter is that it reduces the area in pasture and shades pasture.

While precise data for Río Chiquito do not exist, figures provided by ACM for the Monteverde and Santa Elena area (which includes the upper regions of the Río Chiquito watershed) suggest that 265 landholders are involved in reforestation. Approximately 80% of those involved are dairy farmers. The remaining 20% are foreign nationals who are interested in forest regeneration, ecotourism or simply improving the local landscape. These efforts have reached 13 different communities and have resulted in the reforestation of roughly 500 hectares. Under the ACM programme 95% of species employed are native in origin. In the

COOPELDOS area of influence, further to the north, it is estimated that 80 hectares of pasture have been replanted in coffee.

In the lower watershed of Río Chiquito reforestation policies have not been successful. The principal reason for the lack of interest may be the structure of land tenancy. Large landholders living in Tilarán or San José have little direct contact with the community and little attachment to local problems. Meanwhile, the attraction of forestry or forest incentives is likely to be marginal given the productivity of large-scale ranching or dairy operations. In addition, it is important to mention the cultural weight attached to being a rancher. Ranching is synonymous with economic power and social prestige in the local culture, whereas being a forest producer has no such attributes.

The principal programmes that have been implemented, are underway or are under consideration are reviewed in order of the implementing agency.

Agriculture and Livestock Ministry (MAG). The Tilarán office of MAG has, in conjunction with the Agriculture Centre of the Canton, developed its own tree nurseries and attempted to implement reforestation activities since 1985. These activities have by and large failed. Reasons for the failure include the established culture of best practice in which a "good" field is a clean field (i.e. no trees), the inevitable trade-off in productive terms between trees and pasture, the costs of reforestation and the uncertainty over future harvests and revenues. More recent efforts include the MAG-FAO project in the Tilarán area in which subsidised credits were made available to fund conservation practices. As part of a larger national effort at watershed management, this project has developed programmes aimed at promoting the use of "live" fences, improved pasture management and the mixture of pasture species.

ACM. The "Forests in Farms" programmes developed by this NGO are reported above. A variety of technical assistance and inputs is offered under these programmes including advice on woodfuel consumption, forest management and propagation; the provision of transport, subsidised seedlings, barbed wire, fertilisers, equipment and payment for labour inputs. These programmes are by far the largest and most successful efforts at reforestation underway in the area (that surrounds Río Chiquito). The ACM is also responsible for the purchase and conservation of large tracts of property in the adjoining watersheds of Caño Negro and Aguas Gatas as part of the Children's Eternal Rainforest, supported by donations from children's groups around the world and other international donors. The ACM also has an environmental education programme that works with local schools, teaching principles of environmental and watershed management.

Ministry of Environment and Energy (MINAE). Since the late 1970s MINAE has legally provided for a range of reforestation incentives including income tax deductions, tax credits and subsidised credit under several different programmes (Segura and Solórzano 1995). At the national level the success of these programmes has been mixed, with roughly 170,000 hectares reforested by the end of 1995 (Watson et al. 1998). In the case of Río Chiquito there is no evidence that local producers availed themselves of these incentives. In 1996 MINAE began a pilot programme of Forest Protection Certificates (CPB) in Guanacaste province. AGUADEFOR and the Tempisque Conservation Area (ACT) were chosen to develop this programme. Implementing agencies in the Río Chiquito area include COOPETILA and COOPELDOS.

The Río Chiquito watershed was designated as a priority recipient of CPBs by MINAE and ACT under the pilot programme. Six parcels with a total of 185 hectares of forest located in the lower and mid-watershed area were registered under the programme by COOPETILA. COOPELDOS signed up five parcels for a total of 183 hectares in the upper watershed. The CPB provides participants with a certificate worth approximately $50/ha/year for five years. Participants are responsible in return for conserving these parcels. The new forest law effectively ended the CPB, substituting in its place the Forest Conservation Certificate (CCB). Regulations governing the CCB were published in early 1997 (following completion of the participatory fieldwork) and are discussed in the text section on the Action Programme for Río Chiquito.

ICE. Efforts at reforestation by ICE may be divided into two phases. In the 1980s ICE attempted to reforest areas around Lake Arenal, particularly the strip of land owned by ICE. These efforts were not very successful. In some cases poor management and intense competition from established pasture and other plants prevented the seedlings from thriving. In other cases, locals had been using these lands as pasture prior to expropriation and simply continued to use the lands, seasonal burning being sufficient to eliminate the seedlings.

A much more recent second phase corresponds to a specific proposal to develop a programme of reforestation in the Río Chiquito area based on the ACM experiences with the "Forests in Farms" programme in Monteverde and Santa Elena.[16] This proposal is part of a larger effort by ICE that is to be financed by the institution, with the aim of seeking additional support from the developing international market for carbon storage.[17] The package to be offered to ranchers would also try to improve productive practices so as to liberate areas for reforestation. Research into native species and other conservation technologies is also supported.

Work began in earnest in 1994 with the creation of the Programme for Watershed Management and Recuperation and the Programme for Biological Corridors and Reforestation. By the end of 1996 a total of 32 participants had joined the programme including 25 in the upper watershed, five in the mid-watershed and two in the lower watershed. Approximately 60 hectares and 60,000 trees had been planted (given the emphasis on windbreaks, the estimate of trees is a more useful measure of activity than the estimate of hectares). The trees are actually provided under contract by COOPELDOS and are roughly

[16] The coordinator of this programme previously worked for ACM's reforestation programme and, thus, is familiar with their methods and with the producers in Río Chiquito.

[17] This initiative had only reached the stage of a two page draft proposal for Río Chiquito when the Sub-Division for Sustainable Development was eliminated in an ICE re-organization. It is interesting to note that the proposal suggested that trees planted in Río Chiquito should receive two types of carbon credits. The first credit was to be earned by storing carbon in the trees. The second credit was to have originated from the reduction in sediment delivery that would accompany reforestation, leading to more hydroelectricity and a saving in the burning of fossil fuels for thermal power. In light of the analysis contained in Aylward et al. (1998a) this approach should be reformulated. A single credit may be earned for carbon storage in the case of windbreaks and fragments planted in areas of cloud forest, as increased water stripping is compensated for by higher evaporation and transpiration effects. No (or opposing) credits are earned in the case of non-cloud forest areas where reforestation will lower water yield, requiring an increase in fossil fuel burning. At the same time, the increase in thermal power generation that would be necessary to cover the loss in water yield due to reforestation would clearly reduce this credit.

50% native and 50% exotic species. The landholders choose the species to plant and are given seedlings to plant. In return for technical assistance (and replacement seedlings should any die) the landholder promises to follow a strict management regime for the first four years. Technical assistance on improving pasture selection and pasture management is offered to participants by means of an agreement between ICE and the Dos Pinos Dairy Producers Cooperative in Tilarán.

Institute for Agrarian Development (IDA). Another programme, silvipastoral in nature, is that of the IDA-FAO project in Arenal. IDA is a parastatal organisation charged with the resettlement of landless peasants onto smallholdings. The project has promoted reforestation with fruit trees, windbreaks for family gardens and small plantations on the smallholdings.

Private Initiatives. As suggested by data from a survey undertaken in the Río Chiquito watershed, slightly less than half of the respondents indicated that they were engaging in some form of reforestation or soil conservation (Aylward et al. 1998b). The fieldwork conducted by CINPE identified the various programmes of public or private nature (as listed above) that support such efforts. A rough estimate suggests that perhaps a quarter of the holders in the watershed are involved in some form in one of these programmes. This suggests that the remaining quarter is engaged in conservation activities on their own, without external support. Many of these activities are fairly minor in nature and oriented as much towards alleviating systemic problems (such as weeds and wind) as problems caused by land use itself. Whatever the actual intention of such efforts, the level of participation may signal that the benefits of such investments are sufficiently private in nature as to enable their development under purely market forces, i.e. without outside intervention.

Other Initiatives

Arenal Conservation Area (ACA). Since 1993, the Arenal Conservation and Development Project (PCDA) has supported a range of different management alternatives in the buffer zone areas of ACA. PCDA is the result of an agreement between MINAE, ACA, the Canadian Agency for International Development and WWF-Canada. Subsidised finance and technical support is provided for activities such as animal nurseries, organic agriculture, tree nurseries, agroforestry systems, soil and water conservation, and ecotourism/forest management. In the upper watershed area of Río Chiquito there are projects in El Dos (a nursery of native tree species), Cabeceras (sugar mill, arts and crafts derived from cane, organic vegetables) and Monte de los Olivos (an ecotourism project). The latter project is actually located within the Río Chiquito watershed and consists of the construction of an ecotourist lodge (and accompanying restaurant) by a local association made up mostly of small dairy producers.

Monteverde Cheese Factory. The Monteverde Cheese Factory carries out a number of actions and initiatives that are aimed at intensifying dairy production whilst conserving the natural environment. Elements supporting conservation include provision of technical assistance on soil management, awarding of prizes for "sustainability" of production and refusal to accept new producers whose areas are not suited to dairy production.

Tilarán Ranchers Association. In 1994 the Association, in cooperation with local MAG and ACA officials and the Central American School of Livestock Production, began developing a proposal to identify, study and disseminate local practices that supported "sustainable ranching." The proposal was linked to the idea of developing a "green" niche in the local or export markets for beef. The initiative is important in signalling a move on the part of

traditional ranchers towards a more proactive stance on environmental issues. It also marked an important change in relations between ACA and local ranchers, the latter group feeling that the pro-environment stance of ACA had led them to ignore the ranching community. Despite the initial interest by all concerned and the selection of a number of farms to serve as demonstration sites, the project has since faltered and little headway has been made. The inherent difficulties felt by MAG in making this effort work were discussed earlier as an example of the restrictions placed on the institution by its centralised, bureaucratic nature.

Annex 4. Exclusion and Rivalry of Watershed Goods and Services

"Watershed management" in its largest sense produces a vast range of environmental and productive goods and services. Typically, productive goods are private in nature and environmental goods have public good characteristics. In this annex a review of the public good nature of all of the watershed goods and services relevant to the Río Chiquito context is presented. The goods and services are grouped according to whether they are on-site or off-site goods and services and, for those off-site elements, according to whether or not they are hydrological in nature. As with the rest of the study, the focus is on hydrological impacts, particularly externalities, with a secondary focus on other externalities and values consistent with watershed management.

Exclusion and Rivalry

The attributes of these goods and services are discussed according to the two defining characteristics of public goods. The first characteristic is excludability, that is whether it is easy or costly to exclude or limit consumption by potential users or beneficiaries once a good is provided, either by nature or through the activity of other individuals. The exclusion could be achieved through means of physical barriers, but this is likely to be effective only if property rights are established which can be defended (economically and legally) within the legal framework available in a determined jurisdiction (Ostrom, Gardner and Walker 1994). It could be concluded from this, furthermore, that the ease of exclusion is dependent not only on the physical attributes of goods and services but also on the institutions that function in that particular jurisdiction.

The second characteristic is rivalry: the degree to which the use of goods or services by an individual reduces, or not, the potential for use of the same goods or services by others. This depends a great deal on whether the consumption of a particular good or service is of a collective or separable nature. For instance, consumption of a food item by one individual prevents it from being consumed by others, while on the other hand it is possible for many people to simultaneously access and consume information without that information losing the potential of being consumed by others.

These two characteristics permit the classification of products and services into four major categories. In a simplified manner the interpretation of the combination of these two attributes proves to be a powerful method for understanding the incentives that different actors may have for the provision or production of different goods and services.

Private goods and services are subject to exclusion, making them easy to confine or control. Those who want to consume them are excluded from their consumption, unless they pay the price the producers set for the goods and services. The consumption of these goods and services by consumers is also rival, or separable. Once the consumer has purchased the good it can be consumed at leisure, and once the quantity purchased is consumed, it is no longer available to the consumer (or other consumers). Because of this, if a demand exists, the producers have incentives to satisfy it, given that they can expect to cover production costs and even make a profit. Private goods and services are generally produced and distributed in

the most efficient matter through competitive and private markets; provided that an institution (typically government) exists that provides a stable framework for transactions and allows for the resolution of disputes and the fulfillment of contracts.

On the contrary, public goods and services do not lend themselves easily to exclusion, and are non-rival. Once produced, everyone has access to them (within certain limits, geographic or political). These attributes allow those who do not contribute equally to the costs of production to be able to consume them (free-riding). Hence, the provision of public goods requires collective action and is typically considered to be the province of government.

Common-pool resources, like public goods and services, do not lend themselves easily to exclusion either, but their consumption is separable: they have a degree of rivalry. As long as total demand does not exceed the productive capacity of the resource, individual users can consume the goods or services without impeding their consumption by others. When demand exceeds availability, congestion occurs and users operating on an exclusively voluntary basis have a strong incentive to continue appropriating the goods or services as fast as possible; those that abstain from consumption simply favour the consumption by those who do not.

Typically, common-pool resources are considered to be allocated in one of two ways. In the absence of any definition of property rights or usufruct over common-pool resources, they are left to open access; all users are at liberty to consume the resource. Economists typically presume that this leads to an inefficient level of production of these resources as the well-known "Tragedy of the Commons" ensues. Alternatively, a common property management regime may exist (or evolve) if there is a societal group that has recognised property or use rights and is able by a variety of mechanisms (not necessarily economic in character) to control access to the resource. Viewed from afar (or from a national perspective), common-pool resources often appear to be left unmanaged in a state of open access, but in practice there is often a local group of traditional users that exercises control over access to the resource. That said, it is likely that the potential for sustainable development based on community-based solutions is rather less than that generally supposed (Leach, Mearns and Scoones 1997).

Finally, toll (or club) goods and services are non-rival in consumption, but are subject to exclusion. Typically, these are goods and services that are consumed collectively by members of a group. This same group is capable of excluding others by means of mechanisms that exclude others at a reasonable cost. Clubs may assume a range of institutional forms according to the desires of their owners: the members themselves, a firm or the government (Cornes and Sandler 1986).

Despite the generalisations that emerge from the literature regarding the optimal forms of management of each type of good, in reality there is not necessarily a one-to-one relationship between the type of good and a particular type of institution. It is not inconceivable, for example, that a common-pool resource could be managed effectively by government or a large corporation. Rather, each case must be considered in light of existing relationships and in the context of an evaluation of potential alternatives. The analysis of public good characteristics is, however, an important step in this process and serves to identify likely alternatives.

In the following sub-sections the degree of rivalry and exclusion of watershed goods and services is analysed in the Río Chiquito context. The conclusions drawn relate to whether the good is public, private, a common-pool resource or a toll good.

Exclusion and Rivalry of On-Site Goods and Services

In Río Chiquito three on-site goods and services are produced: livestock, extractive uses of biodiversity and soil productivity. Each is considered in turn.

Livestock Production. As livestock production results in sales of milk and cattle to purchasers in a market environment these goods are considered to be subject to a high degree of exclusion and rivalry, making them private goods.[18]

Extractive Use of Biodiversity. Additional on-site harvesting occurs in the case of the extraction of other natural or biodiversity products. These include wood products and wildlife (hunting), with the former probably being of primary importance in Río Chiquito. Trees and brush are stationary, rooted objects while wildlife is mobile. This implies that wildlife, through time, will be only partially subject to exclusion. However, as the act of harvesting is assumed to occur at a given point in time on the landholder's property the user does have the ability to exclude others from harvesting the same physical units. These products are rival, given that once the game is eaten, or the wood is used in construction, there can be no subsequent consumption of these goods by others. In general, therefore, on-site extractive uses may be considered as private goods.

Soil Productivity. In its natural state the soil's productivity is a classic case of a common-pool resource. Exclusion of others from a given land area is difficult and costly. Agricultural and livestock production effectively consumes the product of the soil, transforming the soil resource into a marketable product. In the case livestock production, for example, congestion effects occur as stocking rates rise, effectively consuming the resource in the present period and, eventually, degrading its ability to produce in future periods.

The means of excluding others from access to the soil productivity held on one landholding are both *de jure* (legal) and *de facto* (practical ability) in nature. *De jure* rights stem from the concept of private property rights in land as enforceable under Costa Rican law. These would apply in the case of one producer attempting to use another's land and soil in a more-or-less permanent way, for example in agriculture or housing. *De facto* rights exist due to fencing and supervision of the property by those administering the property. This applies in the case of what might be an intermittent use, such as one producer grazing stock on another's property.[19] By either route landholders in Río Chiquito can attain a high degree of exclusion. Given the prevalence of livestock production as a land use, however, this exclusion comes at a significant cost.[20]

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[18] Though note the close relationship with soil productivity, which does display some public good characteristics.

[19] Interestingly, the benefits of fencing are themselves in a way a public good. Once a fence separating two properties is built, the landholder who did not build the fence cannot be excluded from enjoying the benefits of the fence, nor are the benefits rival. The benefits may be construed as both limiting access of others and not losing one's own stock. The costs are the direct cost of fencing plus the loss of the ability to steal another's soil productivity. However, the structure of the resulting collective action problem, one producer and one consumer, suggests that Coasian bargains may be easily struck. The degree to which each party invests will depend on the relative level of perceived benefits and costs.

[20] Fencing is a significant element of fixed costs on most properties (Aylward et al. 1998).

Soil productivity in Río Chiquito also appears to be rival as the benefits of its consumption are fully realised through beef and dairy production, which are private goods. An intertemporal examination of rivalry, however, suggests that soil productivity may be non-rival to a minor degree. The crux of the issue is the extent to which a landholder can appropriate the value of soil, and therefore of soil-conserving technologies or production methods, upon sale of the property. It is generally recognised that markets for agricultural land often do not adequately account for the state of soil on the land in the US, and this trend probably extends to Costa Rica (Barrows and Gardner 1987; McConnell 1983). As a result, although soil productivity should be generally regarded as a private good, it is often considered to be a toll good as well.

Exclusion and Rivalry of Off-Site Hydrological Services

In this sub-section hydrological services are classified according to their public good nature. Given that these services generate off-site impacts and are considered to be "externalities" the conventional classification would typically label these services as public goods. However, given the lack of precedents in this regard and the wide range of downstream uses of hydrological services, this analysis attempts to explore the validity, and applicability, of this claim.

The application of the concept of exclusion to the provision of upstream services is generally straightforward, depending on the extent to which landholders can control access to changes in hydrological services that result from changes in land use. Rivalry is more difficult to interpret given that downstream users do not directly consume the upstream service (i.e. an increase in run-off from pasture) but rather a downstream "product" (i.e. an increase in downstream annual flow).[21] Nor, it is assumed, do upstream landholders compete with downstream users for the consumption of the water. This is tantamount to assuming that existing run-off represents the surplus "supply" once on-site needs are met. Given the lack of upstream consumption, discussing the rivalry in consumption of the upstream service makes little sense.

Intuitively, however, it is clear that the degree of rivalry and exclusion in consumption that exists with regard to the downstream products may affect the ability of upstream landholders to access the economic rent that may be derived from these services. If landholders could exclude downstream users from consumption of a change in hydrological services and the downstream product is a private good, then, by extension, the landholders would be well positioned to capture the associated rent. Under the same circumstances, if the downstream product were instead a public good, rent collection would be more problematic. If, on the other hand, landholders cannot exercise exclusion over the upstream service the characteristics of the downstream product would appear to be irrelevant. There is simply no way for the upstream landholder to exercise a claim over the economic rent.

In other words, the absence of upstream exclusion implies that the change in hydrological service is a public good from the perspective of the landholder. If upstream exclusion is feasible it then becomes necessary to determine the public good nature of the downstream

[21] The examples used here relate to water quantity although they could equally well relate to water quality. Note that erosion, the on-site aspect of sediment delivery, is discussed above under soil productivity.

service in order to understand the incentives for provision and production of the hydrological service.

It is also worth noting that exclusion over the provision of the upstream service and, subsequently, the downstream products may be exercised by the upstream landholder in either an *ex post* or *ex ante* fashion. Given that a particular land use change is desired by the landholder for its level of net on-site benefits, exclusion can be defined in terms of potential means of exclusion following the land use change. These means are typically physical in nature, but are also potentially legal in nature. *Ex ante* exclusion occurs when the landholder may choose to avoid an investment in land use change in order to exclude downstream users from prospective hydrological benefits. In theory, this would occur only when the land use change is not profitable on its own terms for the landholder. Both types of exclusion are considered, but more attention is given to *ex post* exclusion, as *ex ante* exclusion is, as a rule, feasible by definition. That *ex ante* exclusion is feasible underscores the importance of exploring the public good nature of the downstream products.

Thus, the spatial nature of production (upstream by landholders) and consumption (downstream by a range of different users) make it useful to distinguish between the status of the services as produced by the landholders and the disposition of the downstream (or instream) product as seen from the perspective of potential users. The discussion below, therefore, makes a distinction between (1) sediment delivery rates and sedimentation, (2) water yield and annual flows, and (3) water regulation, and seasonal flows and flooding. As suggested above, this distinction is most relevant in the case of exclusion, that is, the extent to which upstream landholders can exclude downstream consumers from the upstream service and the degree to which downstream consumers can exclude each other from access to the instream resource. Rivalry is discussed only as a characteristic of the downstream product.

The presentation in each case contains a brief description of the general case in an effort to identify crucial factors in the classification, and then the specific application to the situation in Río Chiquito and Arenal. The pairs of upstream service and downstream service are presented in reverse order (downstream first) in order to facilitate conclusions regarding the public good nature of the hydrological services.

Sedimentation/Suspended Sediment. The downstream products of a change in sediment delivery rates are changes in instream suspended sediment levels and sedimentation of downstream waterways and reservoirs. Each of these three cases is considered below.

The location and method by which the sediment is precipitated from run-off is of great importance in determining levels of exclusion and rivalry. Natural precipitation of sediment is, of course, determined by various factors, including the nature of the suspended sediment and the topography through which a river flows. Precipitation of sediment can be increased by building ponds or reservoirs and may, in unusual cases, be reduced by an increase in the rate of flow. Both actions are expensive propositions. Once precipitated, the sediment may lead to a variety of economic impacts including changes in water navigation, changes in reservoir operation, potential extraction of fertile sediments for use, clogging of irrigation canals, etc. It is also worth noting that suspended sediment (i.e., sediment that is not precipitated) may also have an economic impact. For example, the concentration of suspended sediment may affect maintenance and capital replacement requirements of turbines used in run-of-stream hydroelectric plants or the treatment costs of water supply facilities.

Construction of settling ponds or reservoirs would be the principal mechanism by which one consumer might seek to exclude another from access to the suspended sediment, or increments thereof, in a given waterway. Typically, this will be extremely costly for a single consumer to undertake. However, such an option may not be feasible given that waterways are often publicly owned. Moreover, as suggested below, reservoir construction does not exclude downstream users from water quantity effects of reservoir sedimentation. Thus, the degree of exclusion will be low in the case of instream suspended sediment.

As access to river bottoms is typically not limited or controlled, either by legal mechanisms or practical means, sedimentation would appear to be subject to a low degree of exclusion in free-flowing streams. Much depends, however, on the use to which the sediment and river are put (if any). Clearly, it is difficult to exclude those who would use a waterway for navigation purposes from the benefits created by lowering sediment delivery and deposition. On the other hand, if sediment is of high fertility and has subsequent use as a fertiliser, then the act of dredging by one farmer will effectively exclude others from the consumption of that same fertility. Thus, generalisation in the case of free-flowing streams is difficult.

Where reservoirs are already in place, a change in the level of sedimentation will affect reservoir operation and it will be difficult to exclude any downstream users from associated costs or benefits related to water flows from the reservoir. As a dam's storage capacity is lost this will affect the timeliness of downstream flows as well as economic production at the level of the reservoir (e.g. hydroelectricity or recreation). Thus, the level of exclusion may be characterised as low in the case of installed reservoirs.

If water containing suspended sediment is utilised in economic activity without precipitating the sediment, a change in sediment delivery may be "consumed" by many different users. For example, run-of-stream hydroelectric plants typically have sediment ponds designed to trap a portion of the sediment. However, sediment not trapped by these ponds will pass through the generators and on to the next downstream use. Both the hydroelectric plant and the downstream users will, thus, feel the beneficial effect of lowering sediment levels. Instream suspended sediment is, therefore, non-rival in nature.

The degree of rivalry for instream sedimentation is more variable; depending not only on topography, but also on the type of economic activity located downstream, the technology employed to utilise downstream flows and the institutional arrangements governing downstream production. The effects of sedimentation on navigation are non-rival in that the costs of siltation are consumed by all that navigate through an affected area. The extraction of sediment, on the other hand, will be a largely rival use as it adds to soil productivity on farmland.

Large hydroelectric reservoirs (such as Arenal) trap practically all the sediment. However, the actual economic consumption of these effects is not necessarily limited to one use. As discussed earlier, the possibility exists that sediment arriving in a reservoir may affect both hydroelectricity and irrigation. It might also affect recreation and fishing in the reservoir. Thus, in addition to the issues of deposition and leakage, there are potentially a number of consumers of the effects of sediment deposited in a single location. A complication here is that deposited sediment may subsequently be dredged or flushed from a reservoir, leading to further knock-on effects. Consequently, the degree of rivalry associated with the sedimentation of reservoirs appears to be fairly low (i.e. non-rival).

The discussion above suggests that it is difficult to generalise about the public good nature of instream sedimentation. It may be either a public or a private good depending on the uses to which it is put or the activities upon which it impinges. The lack of institutionalised rules or regulations governing the allocation of sediment suggest that its status will depend also on practical considerations regarding when and were it is deposited and what infrastructure is installed on the waterway. Nonetheless, the general impression is that instream suspended sediment and the sedimentation of reservoirs are public goods.

In the case of Arenal, the reservoir effectively precipitates all the sediment and essentially excludes others from a direct physical use of the sediment for its fertility. As noted above, however, any change to sediment delivery rates will affect dam operation and downstream flows. As a result, the degree of exclusion is mixed. Nonetheless, the observation that downstream users in Costa Rica extract water but not sediment from streams implies that exclusion from water flows would be the more important aspect of the problem. On this basis, therefore, the Arenal case matches the general expectation that the degree to which other potential consumers are excluded from the costs or benefits of a change in sedimentation from Río Chiquito is low.

However, sedimentation of the dam does not appear to actually affect the operations of the downstream irrigation project (PRAT) given current levels of demand for water (Aylward et al. 1998b). In addition, it is unlikely that sedimentation affects the minor economic use of the lake itself for fishing and boating given that such uses are relatively minor. For all practical purposes, therefore, a change in sedimentation is rival insofar as the ARCOSA hydroelectricity complex is the sole consumer. With low excludability and a high degree of rivalry this suggests that in the Arenal case, sedimentation is a common-pool resource. By implication, were downstream demand for water to increase sufficiently in the future to toggle the classification to non-rival, sedimentation would be characterised as a public good.

Sediment Delivery. In general, landholders will be interested only in excluding downstream users from benefits, not costs, incurred by changes in sediment delivery that will result from intended changes in land use. In this regard it must be acknowledged that an increase in sediment delivery may lead to either downstream costs or benefits.[22] Similarly, the reverse applies. A decrease in sediment delivery might, therefore, also lead to costs or benefits. As a result, it is necessary to consider how landholders might exercise exclusion over both increases and decreases in sediment delivery.

As sediment (in its suspended form) is transported by water flows, the landholder would need to have a physical or legal basis for either controlling downstream users' access to water flows that carry the suspended sediment or changing the level of sediment actually suspended and delivered downstream. One way to limit access to increases in sediment delivery would be ponds or canals for settling sediment at property boundaries. However, the trap efficiency of such a pond would be proportional to its size. Large ponds, relative to the size of the holding, would therefore be necessary to ensure that there is no leakage of sediment. Furthermore, depending on the drainage density and topography, water storage becomes either more or less feasible given the costs of damming the waterway. The ability to exclude others from a

[22] See Enters (1995) for a description of how sedimentation is extracted from streams in Thailand for use on fields.

decrease in sediment delivery would face the same problem of excluding downstream users from access to the water flows.

As for legal mechanisms for exclusion, there is little precedent with the potential exception of the application of the "polluter pays" principle. However, this principle represents a sanction on landholders for generating costs for downstream users and is imposed by others (or society) on upstream users. Legal mechanisms by which landholders might benefit from improvements in downstream conditions are a different matter. Clearly, establishment and monitoring of the rate of pollution (sediment delivery) would be particularly problematic, depending on the complexity of the terrain, number of holdings, etc. In general, therefore, the degree of exclusion governing changes in sediment delivery is likely to be very low.

In the case of Río Chiquito and Arenal, off-site benefits are associated with a decrease in sediment delivery. Given the topography of Río Chiquito, water storage for the purposes of excluding others from changes in sediment delivery would be very costly, if at all feasible in a physical sense. In other words downstream users are free to consume the off-site benefits of reductions in sediment delivery that are associated with reforestation. As a result the classification of sedimentation as a common-pool resource is not relevant to the classification of the upstream hydrological service, which must be regarded as a public good.

It is also the case that downstream users in Arenal have no physical or legal means of either preventing landholders from increasing sediment delivery or of encouraging them to reduce sediment delivery. This underscores the point made at the outset of this discussion: that the landholder may effectively exclude downstream users from the hydrological effects of land use change by controlling land use itself (*ex ante* exclusion). This is true regardless of the ability of the landholder to physically alter hydrological processes once land use change has occurred. The landholder may always "exclude" downstream users by not changing to what is viewed as an "improved" land use from the downstream perspective or by threatening to change to a "worse" land use. In the Arenal case, then, the potential to garner economic rent would be relatively good given the nature of sedimentation as a common-pool resource and the existence of a single, large user of the downstream product.

Annual Flows. In this analysis, water yield is assumed to represent a general increase in water flows over the course of a year. As a result the discussion here is limited to a discussion of simply increasing or decreasing water availability. Later, the discussion extends to consider seasonal flows and flooding, i.e. the effects of having more or less water at particular times (i.e. in the dry season or immediately following a storm event). Given that water has an almost infinite number of uses, just a few uses are selected in order to illustrate the concepts under discussion. Water has a very obvious function as an essential compound for sustaining organic life, whether human or otherwise. The potential energy attached to a unit of water may also have a significant function in terms of generating hydroelectricity, providing transport services or performing work in a more direct function. Water is also useful as a "sink" with which to dissipate heat or to lower nutrient or chemical concentrations at industrial or agricultural sites.

Defining what constitutes the "consumption" of water is not an easy task, but is central to the understanding of the public good nature of water flows. Water is often said to be "consumed" when it is flushed down a toilet, imbibed by humans, embedded in marketable products, used to irrigate crops, etc. In the case of hydroelectric power and navigation, "consumed" water is simply passed on further downstream. Given its mass, fluidity and the presence of gravity

many of these uses do not completely "consume" a given quantity of water. In fact, given the cyclical nature of hydrological processes the "consumption" of water is very much a "chicken and egg" problem. Nonetheless, two types of water "consumption" may be defined. First, consumption when the natural hydrological cycle is cut short, as in when water use results in evaporation and, second, when water use reduces the useful attributes associated with a unit of water (such as its potential energy or heat "sink" potential). As with sedimentation, the use to which water is put, by whom and under what institutional circumstances will, thus, largely determine its public good nature.

Free-flowing water is inherently mobile but (unlike wildlife or fish) extremely predictable in the course it will take. Depending on the prospective use, potential "consumers" have devised any number of ways to exclude another from a given unit of water. Typically, by investing in extracting or routing water into containers, reservoirs or onto fields, "consumers" attempt to exclude others from the use of a given unit of water for purposes of hydration, of use as a heat sink or extraction of potential energy. An increase in water availability may be controlled in a similar fashion. However, it is worth noting that the fixed costs of these initiatives are considerable. Perhaps more importantly, standing water and canals are accessible to other interested parties, even once diverted. As a consequence, full exclusion requires an investment in monitoring and enforcement. This is particularly the case when demand is high enough to provoke "congestion" effects. To counter this problem such diversions of free-flowing water are often legitimised by systems of usufruct (i.e. doctrines of prior appropriation or riparian use rights). Many uses of water must therefore be regarded as having a high degree of exclusion.

Use of water for navigation or recreation would appear to be exceptions to the general rule, given that there is often little practical means of limiting access. Legal restrictions or concessions over certain areas may lower the costs of controlling access and make exclusion possible. In most cases, however, the importance of an increase or decrease in the flow of water to these uses is debatable.

In general, therefore, changes in annual flows are likely to be subject to exclusion where water is a valued commodity.

The ability to predict with certainty the degree of rivalry associated with water flows is more variable, depending on whether the use in question consumes water and/or its attributes, and whether the use of water demonstrates susceptibility to congestion. As suggested earlier a number of uses of water do not actually result in its "consumption", instead resulting in the reduction of the attributes of water or its partial "consumption." Ostrom, Schroeder and Wynne (1993: 89) note that water used for hydroelectricity can be "used" again downstream and suggest that this demonstrates that the flow is not fully rival. While this is true, it is worth noting that if the only "valued" attribute of a water flow at a given geographical point is its potential energy, then the flow may be considered as rival at that point, even if it is not really "consumed" at that point.

An example of partial "consumption" of water flows is wasteful irrigation, in which "wasted" water will percolate through to groundwater only to be once again available from wells or streams that are located "downstream." Where evaporation due to use is not complete, the remaining water will continue to flow towards other prospective users. This said, most uses do tend at least to reduce the water flow quantity that is available or its desired attribute. For

example, upstream use of water for irrigation effectively reduces the availability of river flows downstream for hydroelectricity.

As more users crowd in to use (in different ways) particular water flows, congestion effects will develop. Irrigation is typically considered to be a toll good and, thus, non-rival in nature. Ostrom, Schroeder and Wynne (1993: 89) comment that this reflects a failure to distinguish between the rivalry of the facility and the flow. Although many may use the same facility without impinging on the ability of others to use the facility, the authors point out that when it comes to a given unit of water flow the potential for congestion effects and rivalry do exist. For this reason, irrigation flows may in fact be rival making them private, not toll goods.

The tendency to "consume" water or its desired attributes (at a given instream point), as well as the problem of congestion, suggests that changes in water flows will exhibit a high degree of rivalry. The exception again would be navigation and recreation.

The general expectation, therefore, is that water flows are subject to a high degree of exclusion and rivalry and, therefore are frequently appropriable as private goods. Exceptions to this rule must be considered on a case by case basis. For example, navigation may be either a public or a toll good. In the latter case, a concession over a waterway may enable the concessionaire to exclude customers that do not pay a toll from access to a non-rival service. Irrigation may also be considered a toll good at low levels of demand, but is probably congestible and hence a private good at higher levels of demand (and particularly in the dry season).

In the case of Arenal, the reservoir and ICE's legal mandate from the state permits ICE to exclude others from access to the potential energy attribute of the annual flows arriving from the Río Chiquito watershed. With regard to the water flows themselves, the nature of the Arenal reservoir as an inter-annual regulation reservoir suggests that ICE and ARCOSA may even be able to exclude other potential downstream consumers of water from small changes in annual flows. The reservoir also makes other attributes of water available to others in the form of boating and recreation, as well as providing water supply to the dry Guanacaste plains on the Pacific side of the continental divide. However, a change in the absolute level of annual yield is unlikely to significantly affect the level of consumption on the part of other consumers. In sum, changes to downstream annual flows appear to be subject to exclusion, insofar as the major use of such flows would be related to their potential energy.

It is also clear that a very large portion of the potential energy that was associated with the water as held in Lake Arenal is consumed by ARCOSA once the water passes through the turbines. The potential energy attribute of consumption is clearly rival. The PRAT irrigation project that subsequently receives the water effectively turns water into a toll or private good as the sequence of canals enables SENARA to exclude non-paying consumers from access to water. ARCOSA and PRAT's uses of water are essentially compatible and complementary. These, as irrigation and hydroelectric uses of the water from Lake Arenal, rely on maximum offtake during the dry season, with much less demand during the wet season. Thus, these two principal uses of water are non-rival in consumption. However, as noted above, changes in water production from the dam are unlikely to affect consumption by the PRAT project for a long time. Thus, the principal use of changes in annual water flows in the case of Arenal would be for their potential energy, a use that must be considered as rival in nature.

Given current infrastructure and the institutional arrangements governing the use of water from Lake Arenal, water flows appear to be exclusive and rival, suggesting characteristics of a private good.

Water Yield. It is even less likely that landholders will be able to exclude downstream users from access to changes in water yield using water storage mechanisms than is the case for sediment delivery. Landholders might be able to construct barriers or reservoirs to limit downstream sediment delivery, but even water storage projects have limited ability to limit the annual flow of run-off to downstream users. Implicitly, an inter-annual reservoir would be required for this. The exception, of course, is the construction of a set of canals by which water is routed past other users. In this case the degree of exclusion would be quite high. The feasibility of such an option would be low in general, given the problems and cost of diverting drainage from high in a watershed past prospective downstream users. In addition, property rights regimes governing water use rights might make such an endeavor impossible. Thus, exclusion is highly unlikely in most cases of upstream changes in water yield.

Water yield is in general, therefore, a public good. Given conditions in Arenal, this assessment applies equally to landholders in the Río Chiquito watershed. As in the case of sedimentation, the exception, would be in the case where downstream benefits would be created (or costs avoided) by a change in land use. If such a change is not already in the interest of the landholder (who would, thus, require an *ex-post* exclusion mechanism) then the potential does exist to extract rent from ARCOSA and ICE, given that the downstream use of annual flows is a private good.

Seasonal Flows and Flooding. In the case of seasonal flows, typically, the most relevant benefits derived from the water regulation impacts of land use change would be those derived by downstream users from having higher dry season baseflow (the minimum flow level during non-rain periods) and lower flood risk due to reduced peakflows (during storm events). As noted earlier, the biophysical basis for the existence of these benefits is more limited than commonly believed. Dry season baseflow cannot be said to be unequivocally higher under forest and the benefits of flood control are very localised in nature.

The public good characteristics of dry season baseflow are likely to be very similar to the case of annual water flows. In the dry season, the degree of rivalry may be expected to be even more significant, as evaporative demand and agricultural and livestock demand for water are high, and water supply and soil moisture are low. Dry season baseflow can be expected to become increasingly congested and, therefore, more rival as the dry season progresses. Thus, it is easy to conclude that such flows would be even more likely to be private goods than in the case of annual flows. This essentially suggests that annual flows might be broken down into dry and wet season flows with the former being more likely to be a private good and the latter more likely to be a public good.

In the case of peakflows it is reasonable to assume that it would be difficult for a downstream property owner to exclude others from sharing in the benefits of efforts to protect property from flooding. It is also difficult to conceive of how the same property owner might exclude another consumer from the benefits of a reduction in flooding or flood risk. This would appear to be a particularly perverse result if flooding is non-rival in nature. Certainly, it would seem that in the case of floodwaters the degree of rivalry is low as all "consumers" in the path of the floodwaters will feel the effects of the flood. Floods are not so much "consumed" as

dissipated by topography. Thus, changes in flood risk that occur as a result of changes in land use may be considered as public goods (or bads).

In the case of Arenal there seems little reason to deviate from the general rule and, hence, dry season baseflow is considered a private good while (any) change in flood risk would be a public good.

Water Regulation. As stated above it is highly unlikely that upstream landholders would be able to exclude downstream consumers from the consumption of changes in annual water yield. In general, it could be assumed that the shorter the relevant time period over which land users would need to exercise exclusion, the more feasible this might become. The installation of small dams might give landholders some ability to regulate water flows. In other words by being able to store run-off and release it at a later point, the landholder can exclude others from access to the short-run changes in water regulation that may be caused by changes in land use. The shorter the period required for storage and the smaller the volume of water to be contained, the more feasible this becomes.

The literature suggests that the effects of land use change are *a priori* ambiguous with respect to dry season baseflow (Bruijnzeel 1990). If, for the sake of the discussion, it is assumed that conversion of pasture back to forest would increase dry season baseflow, then the relevant question becomes whether or not landholders could exclude others from these flows.[23] Clearly, this depends on the vagaries of the site in question. Generally speaking, it would be difficult, as it is the increase in infiltration that will raise baseflow. This implies that landholders would need to control access at the point where subsurface flow from their property enters stream channels. Should this be possible, landholders could effectively store the increment in dry season flow for release at their discretion. Much, of course, would depend on the size of inflows relative to storage capacity, as well as the schedule of needs of downstream users. If flows are low relative to storage and downstream needs are fixed, it is at least possible to conceive of upstream landholders denying crucial dry season baseflow to downstream users at crucial periods.

In the case of peakflows, it is likely that the compression of the relevant time and the reduction of the storage volume required to influence such flows could exercise even greater control. Release prior to severe storms from small dams may permit storage of significant amounts of stream water. In addition, it should be noted that flood risk is derived during the most severe storm events, when infiltration rates are typically exceeded and much overland flow towards the stream channel is observed. At such times it is not just the storage of subsurface flows after they enter stream channels that is important, but what happens to this overland flow. For example, small dams or natural hollows that are typically dry may serve as extra storage during severe events. Clearly, then the possibility of reducing the impact of water flows is greatly enhanced when the discussion turns to consideration of peakflows.

However, the issue is not so much one of landholders' ability to exclude others from enjoying a positive externality associated with reduced peakflows, but rather their ability to lessen the effects of increased peakflows when infiltration is reduced by land use change. Conversion of

[23] Note that this assumption reflects conventional wisdom more than it does empirical evidence, as most experimental work suggests that baseflow diminishes upon reforestation or afforestation.

pasture to forest should increase infiltration leading to a reduction in peak flows, which in turn should lessen the localised effect of potential flooding. Given that the on-site effect is a lowering of flows, it is not clear how a landholder could exclude others from this benefit, short of actually increasing release of dammed water during a storm event. This option is ignored given its perverse nature. Instead, it is more useful to consider that in the case where land is being converted from forest to pasture, thus raising peakflows, landholders may effectively buffer the downstream effect by the use of water storage facilities.

However, this is analogous to the case where land use change operates as a mechanism for exclusion. In the case where the potential change (whether in land use or construction of water storage) brings no direct benefit to the landholder, exclusion of downstream users from potential benefits is simply enforced by not undertaking the change (i.e. not building the dam).

In the case of Río Chiquito the feasibility of exercising exclusion over water regulation either during a single storm event (for flooding) or over the course of the seasons appears remote and probably very costly. Water regulation can, therefore, be considered as a public good from the upstream perspective. As noted more generally, there is at least the possibility that a limited degree of exclusion may be possible the shorter the duration of water storage required. In such cases the analysis of dry season baseflow and flooding suggests that water regulation would produce downstream private and public goods respectively. Likewise, the potential for exclusion through avoiding land use change (*ex ante* exclusion) would probably yield the potential for rent collection in the case of seasonal flows but not with respect to flood reduction.

Off-Site Environmental Goods and Services Produced by Forests

The three goods and services mentioned below are considered to be off-site in the sense that these particular services offered by forest are consumed at a great distance from the forest concerned, even if they are produced and harvested locally. Generally speaking, each of these is considered to be a public good with low levels of rivalry and exclusion. Nevertheless, as argued below, in the last few years an increase in the degree of private good characteristics demonstrated by these goods and services have emerged alongside new institutional arrangements for their provision and production. In the Costa Rican case, it is worth noting that a number of new incentive programmes for forest conservation and reforestation make allowances for a Payment for Environmental Services, under the new Forestry Law. This facility may prove to be a useful mechanism for the sharing of benefits that can be captured by the government abroad, with local communities and smallholders.

Biodiversity Prospecting. Biodiversity prospecting is the extraction of small samples of biodiversity for use in the research and development of new pharmaceutical, biotechnological and genetic products, typically at a great distance from the forest. Prospecting is often considered to be a public good due to the difficulty of excluding collectors from large expanses of protected areas and due to the nature of the good as a source of information (a perfect example of a non-rival good). Practical steps taken by countries such as Costa Rica to, on the one hand, limit access to biodiversity and, on the other, to market samples are quickly establishing a degree of excludability over these samples (Aylward 1992; Aylward 1993; Aylward 1996). At the local landholder level within Costa Rica the *de jure* case for exclusion is poor. The 1992 Wildlife Law (N° 7317) establishes that species are national patrimony and that landholders cannot exclude others from using species found on their holdings. The *de facto* case for exclusion is not as weak, as in order to harvest samples collectors must trespass

on private property. In the Río Chiquito context, therefore, exclusion is probably low at present. The potential for gaining access to the Payments for Environmental Services and Costa Rica's strong position in the international market suggest, however, that movement is being made toward a higher degree of excludability.

The status of biodiversity prospecting samples as non-rival remains unchanged. Only in the case of endangered species or species of a very limited geographic distribution might there be congestion effects and, therefore, a higher level of rivalry due to the difficulty of restocking the R&D process with additional raw material (Aylward 1993). Biodiversity prospecting in Río Chiquito must, therefore, be classified as a public good, with a tendency towards becoming a toll good.

Carbon Storage. At first glance, carbon storage has a very low degree of excludability. Having improved the global carbon balance by growing trees the landholder has no way to exclude others around the world from consuming this improvement. At the same time, the degree of rivalry must be regarded as high, given that the consumption of the carbon stored by the landholder (through emissions of carbon or deforestation) can occur only once. Carbon storage, therefore, starts from a position as a common-pool resource. The development of pilot carbon offset projects under the Convention on Climatic Change, may, however, presage the ability to effectively exclude others from taking "credit" for the carbon stored. If this is so, then carbon storage would be subject to both exclusion and rivalry and be considered as a private good. The institutional arrangements (at the national and international levels) that are required to make this fully operational are still in progress. The regulations governing the participation of Costa Rican landholders in the Payment for Environmental Services schemes stated that in return for these payments, the landholder would cede all rights to the carbon storage credits to the government. Such a regulation would effectively link national efforts at exclusion to the local level.

Existence Value. It is generally suspected that people care about the existence of forests and biodiversity regardless of intentions to actually use it (in the widest sense) and that they are willing to pay to conserve these areas on this basis. Donations routed through conservation organisations arriving in Costa Rica as conservation projects are indicative of this global value. Nevertheless, it is clear that local landholders in Río Chiquito are incapable of excluding such existence value "holders" from obtaining satisfaction based on conservation activities undertaken in the watershed. Nor is it possible to control how many foreigners (or even nationals) enjoy the continued existence of forests and species in Río Chiquito. As a result, existence value must be considered to have low levels of exclusion and rivalry, and be considered a public good (Aylward 1992).

In Figure 1 (page 23) the classification of watershed goods and services according to their status in Río Chiquito is summarised.