# POLICY ALTERNATIVES FOR BALANCING CONSERVATION AND AGRICULTURAL EXPANSION IN THE TROPICS

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 2005

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CONSERVATION AND AGRICULTURAL

EXPANSION IN THE TROPICS

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# ACKNOWLEDGMENTS

I would like first and foremost to thank my family for their continuous support and help during the time I worked on this project. To my wonderful wife Angela, my daughters Andrea and Daniela, my mother and my sisters. Your love, understanding, respect, and joy encouraged me, and knowing that you were always there for me kept me going. You have been my greatest strength and my greatest motivation.

Thanks also to my advisor, Dr. Veenstra, for having been willing to support me financially and logistically so that I could work on this project. Your highly proactive way of administering the project kept me on my toes and helped me produce better work.

To Dr. Stoecker, the professor with the best attitude towards students I've met, for his guidance, ideas, and instrumental help in removing obstacles and taking me out of impasses so that I could continue making progress in a smooth way.

To Dr. Lawler and Dr. Caniglia, for their insights, challenges, questions and praise that kept my motivation high.

To Mike White, for the unselfish way in which he spent numerous hours of his time helping me learn the many details of the SWAT model. Your instructions and knowledge were essential for me to complete the biophysical study.

To Dr. Brian Carter, for his help in translating the information I had for Costa Rican soils in the format utilized in the US. I truly appreciate your assistance.

And last but not least, to the many individuals who offered me their valuable time to discuss their ideas and to provide me with information about the complex problem of deforestation in Costa Rica. The data made the project possible, and their opinions enriched the study.

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# CHAPTER I

# INTRODUCTION

## 1.1 The problem

The purpose of this project was to analyze the political economy of forest preservation in a developing country with increasing foreign trade in agricultural commodities. The uniqueness of the work resided in the application of a multidisciplinary and quantitative approach to the solution of a natural resource exploitation problem for a specific nation facing the challenge of balancing the need to protect natural habitat with the opportunity of increasing the production of beef, which could require further clearing the tropical forest.

The tropical areas of the "New World" are home today to some of the last primary forests on Earth, and those forests have been disappearing over the years. Today's industrialized countries deforested vast tracts of land during the 19$^{th}$ century, when they were developing. The US, for example, cut its forested land in half to make room for agriculture, and at the end of the 1880s it had a rate of deforestation that exceeds by an order of magnitude the current rate in South America (Hartwick and Olewiler 1998). But the problem today is primarily circumscribed to the less developed nations.

The Neotropic has an immense value: it provides services such as carbon sequestration, soil conservation, oxygen generation, bio-prospecting, water storage, tourism, and others (Ramirez 2000). Castro and Barrantes (1999) provide a list of 36 benefits that natural ecosystems can provide. However, that knowledge has not been enough to stop deforestation. Why? Unsustainable natural resource exploitation is one of the reasons: new markets for timber and agricultural products have opened up, influencing land-use decisions that have favored the conversion of forests into pastures and cropland.

## 1.2 The relationship between trade and environment

Discussions on the relationship between environment and trade started in the 1970s (Muradian and Martinez-Alier 2001), when several industrialized countries already had environmental agencies, public awareness of ecological issues had reached unprecedented levels, and discussions were becoming global, as demonstrated for example by the 1972 United Nations Conference on the Human Environment at Stockholm. Then in 1992 "Agenda 21" proposed the promotion of sustainable development through commerce. The classical theory of comparative advantage demonstrates that unrestricted trade between nations results in higher welfare and consumption for all participating countries, although it admits that not every sector within each society will benefit. Trade makes sense if a country exports goods requiring a lot of resources widely available domestically and imports goods requiring scarce resources.

The result is specialization in the production of a few commodities with associated economies of scale and efficiency. What is the benefit for the environment?

A developing country that opens-up to foreign trade could enjoy increased revenue and foreign investment that could potentially be accompanied by a transfer of cleaner technologies, resulting in less marginal pollution (Husted and Logsdon 2001). If the country succeeds in raising the income level of its population this may in turn drive up their demand for a cleaner environment, as quality of life issues become significant for people. Higher income levels have also been associated with better education and lower fertility rates (Anderson and Strutt 1996). However, a true income level increase will depend on the "leakage rate" defined by the proportion of income spent in purchasing goods and services coming from abroad for a specific economy (Hackett 2001). Also, the income level after which a demand for environmental goods starts increasing may be too high (Perrings and Ansuategi 2000).

The potential benefits of increased international trade rest on a number of assumptions, therefore depending on which of those hold untrue, there could be negative consequences. For example, if technology is held constant in a country in which exports are increasing, then production will increase and associated pollution will also increase (Damian and Graz 2001-a). Moreover, comparative advantage is a dynamic phenomenon, and that is why expecting monetary benefits from trade that can then be used to modernize pollution control technology can be risky. The market prices for some commodities are very volatile, and as a consequence what could be perceived as a great business opportunity one year, could result in a financial fiasco the next year. The

benefits of specialization are greatly diminished if a large number of producers enter what once was a profitable market (Costanza et al. 1995).

When exports are primarily derived from natural resources exploited in small developing countries where property rights are not well defined, over-exploitation, poverty and environmental degradation are likely to form a vicious cycle, and open trade can actually be welfare reducing (Chichilnisky 2001, Brander and Taylor 2003). An increase in foreign trade fueled by the consumption of basic commodities in the North could result in natural resources being irreversibly depleted in the South before any significant economic benefit can be obtained.

On the other hand, if prices of commodities exported by developing countries are relatively low while their imports have high price tags, then impoverishment will be a likely consequence (Cabeza-Gutés and Martinez-Alier 2001). More poverty can result in more exploitation to generate some income, and the cycle continues while degradation is accelerated. Advantageous terms of exchange are then required if a country is to benefit from trade, and that is something difficult to achieve when the exporter is a "price-taker" (when the price is set by groups of buyers).

Another argument against free trade predicts that in order to attract foreign investment, countries will lower their environmental standards in a "race to the bottom" that will result in the lowest possible standard being adopted (Damian and Graz 2001-a). That premise lacks empirical evidence, probably because in the great scheme of things the cost of environmental compliance is quite low in typical industries, and companies look for a comprehensive "package" of benefits and incentives when deciding where to

build their factories. Environmental regulation is just one among many aspects to be considered (like labor costs, infrastructure, taxes, and political stability).

Labeling free trade as either beneficial or detrimental is too simplistic. The question is how to make it consistent with the protection of natural resources, the control of pollution, and the achievement of social equity. Proposals on how to make that happen abound. For example Damian and Graz (2001-b) suggest a balanced approach that goes beyond international policies and economic stimuli, one in which trade is "managed" having sustainable development as the end goal. Anderson and Grewell (2001) define "free market environmentalism" in which global goals are translated into local policies and decision-making aligned with the promotion of economic growth. Costanza et al. (1995) advocate for the inclusion of environmental safeguards in international trade agreements and for establishing mechanisms to force producers to internalize environmental costs.

However, past attempts at including far-reaching environmental clauses in commerce treaties have failed. During the making of the North American Free Trade Agreement (NAFTA), the harmonization of standards, the participation of NGOs in dispute resolutions, and the protection of domestic environmental regulations against treaty-related challenges were all left out. The only concession that came along with free trade was a program to improve conditions along the U.S.-Mexico border (Brunelle and Deblock 2001). The North American Agreement on Environmental Cooperation (NAECC) and the North American Development Bank (NADB) were created with NAFTA in 1993. Both institutions have had a ridiculously small budget and the overwhelming task of solving trade related issues and endemic misery problems along the

border (Runge 2001). Those problems persist today and the degree of investment provided by the NADB has been rather timid, totaling a few hundred million dollars that have been used to finance primarily potable water projects (Frisvold and Caswell 2000).

The supposedly observed and often predicted effects of free trade are issues that have existed for years in many places (wealth vs. poverty, environmental degradation vs. protection, etc). The extent to which those phenomena are influenced by international commerce is questionable and hard to measure, although it can be shown that the promises of free trade have not always held true. The relationship between trade and environmental decay is not direct. Domestic production and consumption are the ones directly related to pollution and changes in land use patterns (Anderson and Strutt 1996). Domestic environmental policy, therefore, could be the solution for sustainable trade, and that is the possibility that was researched in this study.

### 1.3 Why Costa Rica?

This project used the country of Costa Rica as the geographic, political, social and economic unit of analysis to study policy options for preservation. That country has been a relevant beef exporter in Latin America since the 1970s (Food and Agriculture Organization 2002), and although that sector of the economy is no longer as strong as it was during the 1980s, government officials have hopes that a future opening of new markets will give it a new momentum (Monge 2003). Many other reasons justify the selection of that nation for the study.

First of all, because of its fragmented landscape, access to two oceans, and because its territory serves as a bridge between two sub-continents, Costa Rica has 12 life-zones with an estimated 4% to 6% of the world's species in only 0.04% of the planet's terrestrial area, making it potentially the nation with the highest biodiversity per unit area of the world (Vaughan et al. 1998), and giving conservation efforts there high relevance and a global importance. Already identified species in the country include for example 850 birds, 9000 plants, 280 mammals and hundreds of thousands of insects, making it more bio-diverse than all of Europe and than the US and Canada combined (Evans 1999). Costa Rica is a valid case for the study of natural habitat preservation because there is a lot to be protected.

Gigantic conservation steps have already been taken in that country: 11% of its territory is protected under national park status, 4% under indigenous reserve and 13% under national forest, wildlife refuge or biological reserve status. The second justification in selecting Costa Rica is that its contemporary history shows that habitat protection is achievable. The question in this case is not how to justify the start of conservation efforts, but instead how to balance competing land use interests that involve the potential loss of the remaining unprotected natural habitat.

A third reason why studying Costa Rica makes sense is that its political, social and economic climate is such that the environment can realistically be put into the national agenda. The country has been politically stable since 1949, it has the oldest and most consolidated democracy in Latin America (Steinberg 2001), its society has a middle income level, and its education and health indicators are at par with developed societies (The World Bank Group 2003). Since the Human Development Index was instituted by

the United Nations, Costa Rica has consistently ranked among the top nations of Latin America, and according to the World Economic Forum (2002) the country ranks seventh among a group of 142 nations on the Environmental Sustainability Index (and second overall among developing nations). Those factors make it a promising case for environmental policy implementation.

The loss of natural habitat can be a highly complex phenomenon, driven by several factors like timber exploitation, subsistence agriculture, urbanization, an expansion of agricultural land, poaching, general population pressures and others. Trying to explain it by considering all possible factors can result in a shallow analysis, but concentrating on only one can be misleading if that factor is not the most significant. All authors on the topic agree that deforestation in Costa Rica has been driven primarily by the expansion of pastures to raise cattle for selling beef in international markets (Brockett and Gottfried 2002, Brown 1990, Castro and Barrantes 1999, Evans 1999, Goodstein 2002, Lutz and Daly 1991). That increases the validity of a project that precisely compared the societal benefits and costs of ranching and forest preservation. The fourth reason behind the selection of Costa Rica is that it allows for the isolation of one cause as the possible major explanatory variable for deforestation, allowing for a more detailed study. Other factors may also play a role, but a minor one. For example population growth in the country is currently close to replacement levels (except for immigration) and therefore it is not expected to be a major threat to preservation (The World Bank Group 2003).

The fifth reason why Costa Rica represents a case from which a lot can be learned is that natural habitat there continues to be threatened. The country already has in place

free trade agreements with six other nations, and negotiations are underway with several more. The Central American Free Trade Agreement, already ratified by most of its members, would double the export quota of Costa Rican beef into the US overnight, and that may stop the current pasture reforestation trend in the country (Ministerio de Comercio Exterior 2004). Far from being over, the search for a strategy to provide meaningful, long term conservation continues. A number of protected areas in a sea of deforestation provide only a mediocre solution to the problem of biodiversity protection. The purchase of all the remaining forest by the government would not be realistic or desirable from the perspective of a developing country with serious public budget restrictions and with a desire to limit the role of the state in private affairs. The challenge then consists of how to implement public policy in a non-interventionist manner, preferring to influence land use decisions by the private sector so as to favor reforestation instead of establishing strict limits or regulations.

Finally, Costa Rica was chosen for this study because the data needed to conduct it was available. The country has been widely studied from ecological and political perspectives. In the middle of the 1980s, for example, more articles published in the prestigious journal *Ecology* were studies performed in Costa Rica than in any other country (Vaughan et al. 1998). The digital maps and socio-economic data required to build the biophysical, economic and political models was obtainable. A few research projects have dealt with the issue of deforestation in Costa Rica. Those include comparing timber exploitation to cattle raising and corn and bean growing (Howard and Valerio 1996), modeling the watershed effects of deforestation in a cloud forest, predicting the effect of taxing pesticides on the production of crops and the potential land

conversion issues (Schipper et al. 1999), comparing the economic benefits and costs of producing different crops in specific regions of the country, and analyzing some of the benefits or costs of forest conservation (Ramirez 2000, Castro and Barrantes 1999). Some of those studies were conducted before the current conservation legislation was enacted, and some include only the ecological perspective of the problem, while others cover only the economic perspective, and none of them deal with more than one or two categories of monetary benefits or costs of conservation.

Naturally there are limitations in selecting any unit of analysis. Costa Rica is a very small country with a surface area slightly above 51,100 $km^2$ (about 10% smaller than West Virginia), so even if it has an enormous biodiversity value, gains in carbon sequestration achieved through conservation there would be very modest when compared for example to the Amazon basin. Also, the environmental achievements of its neighbors have not been that significant, and that constitutes a threat against the long term protection of natural habitat, which does not recognize political borders. If the rest of Central America does not do its part, the protection of biodiversity throughout the isthmus will be unfeasible.

## 1.4 Description of the dissertation

This study is organized into four major chapters beyond the introduction. Chapter 2 provides an overview of the conservation history of Costa Rica, and as such it places the research in a historical context that is useful to understand the current situation and the prospects for future environmental legislation. Chapter 3 presents a bio-physical

model that was built to estimate the pollution at the outlet of a major watershed in the Costa Rican North Pacific under different forest/pasture ratios. The model explains the potential gains in terms of environmental degradation that could be achieved through different policies, and it investigates whether the current land-use distribution is optimal or not. Chapter 4 describes an economic model aimed at finding the optimal land-use distribution, from the perspective of social welfare maximization, under different scenarios. Each scenario corresponds to a specific set of values for the variables believed to play a major role in determining what the optimum forest cover should be. The model shows the possible effect of different economic policies on the decision-making process of the private sector with respect to reforesting or deforesting. Chapter 5 includes an analysis of the perspectives different sectors of the Costa Rican society have around the problem of deforestation and its potential solutions, to provide the context for a comparison of two possible environmental policies: augmenting subsidies for conservation, and increasing the tax on pastureland. The policies are discussed from the perspective of legitimacy criteria, and observations about an implementation strategy are included.

Chapters three through five correspond to three distinct articles that were written during the course of this project. The biophysical model was presented at the 9$^{th}$ International Conference on Environmental Science and Technology in Rhodes, Greece, which took place from September 1 through September 3 of 2005. The paper was published in the proceedings, and it also was selected by the scientific committee for publication in the Journal of the Global Network for Environmental Science and Technology. The economic model was submitted the first week of August 2005 for

publication in the journal World Development, and the political analysis was submitted the third week of August 2005 for publication in the journal Natural Resources Forum of the United Nations. Each of those chapters starts with a brief introduction about how that part of the research was conducted, then the paper is included, and then a short conclusion lists some reflections about the work and opportunities for future research. Finally, Chapter 6 offers the general conclusions about the entire study.

# CHAPTER II

# ENVIRONMENTAL POLICY IN COSTA RICA

The government approach to environmental matters in Costa Rica has undergone an evolution similar to the one experienced by other countries (Lowry 2003), in that three distinct eras can be identified: “no regulation” or “laissez-faire”, “command with no control” or “interventionist”, and “balanced” or “hybrid”.

## 2.1 The no-regulation era

When in 1502 Christopher Columbus set foot on the land now called Costa Rica, only a few thousand natives lived there, spread out into tribes occupying vast natural spaces. Through the colonial regime Spain regarded that colony as an area of minor importance because its lack of precious metals and labor. The first permanent colonial settlement did not happen until 1562 and one century later the population of Spaniards in the area was just a few hundred (Wilson 1998). That situation gave Costa Rica a chance to acquire a greater level of autonomy than the other Latin American counterparts (Esposito 2002).

The emergence of a powerful and wealthy Spanish elite happened quite late in Costa Rica, and to a lesser degree when compared to its neighbors. Natives were few and hostile to the settlers. The Europeans were forced to cultivate their own land and had to be content with keeping small farms with just a few enslaved "Indians". The Spanish rule allowed for the acquisition of land by settlers after they had been peacefully occupying a given territory for ten years. That way of assigning property rights continued through most of the 20th century. Even though the population was very low during colonial times, in 1775 the governor of the province issued a proclamation discouraging controlled burns on the basis that too much land was being cleared and causing soil sterility (Evans 1999).

The Costa Rican elite could not base its economic power on just exploiting land and native labor: they had to develop the commerce and finance sector to generate more income. The farmers and merchants then overlapped and became a relatively homogenous class, while in the rest of Central America they continued to be distinct groups, often having divergent political and economic interests. After becoming independent in 1821, Costa Rica started growing its economy primarily through the exportation of coffee. By 1890 that commodity accounted for more than 90% of export earnings. The country moved from being the poorest province in Central America during colonial times to being the richest nation of the region at the turn of the 20th century. State intervention was prominent and included the free distribution of coffee saplings, availability of credits for the creation of processing facilities and infrastructure developments, like the construction of a railroad so that the product could be transported from the Central Valley to the Caribbean coast (Wilson 1998).

The government gave 800,000 acres of land on a 99 year lease to the foreign company that built the railroad as part of the payment, and they decided to plant bananas on it, for export to the US and Europe. The banana business then grew as a foreign entity, isolated from the rest of Costa Rica, self-sufficient and relying on its nexus to the US for financing, transportation, marketing, and supplies. A parallel labor market emerged when blacks were brought from Jamaica to satisfy the manpower shortages in the plantations. Coffee, as a contrast, grew as a business in which several Costa Ricans participated. By World War I, bananas and coffee represented 85% of the exports (Wilson 1998). The agricultural sector began to slowly put some pressure on the land through deforestation and pollution generation. Still today some coffee mills discharge their waste with no treatment into rivers.

But the income from foreign trade allowed the development of education. In 1844 the University of Santo Tomás was created, and it was staffed with European professors, some of which were naturalists who wrote books about the country, further motivating other scientists to visit the area. Discussions about constructing an inter-oceanic canal across Central America also drew scientists to the country (Evans 1999).

Politically, Costa Rica tried to stay away from the conflict between liberals and conservatives that was prominent in the Central America of the 19$^{th}$ century. Up to 1889, heads of state seized power by striking deals with the elite, by fraud or by political violence. Then on that year an election was won by an opposition candidate who was allowed to take office and finish up the term peacefully. That was the first time that such an event happened anywhere in Latin America (Wilson 1998).

A few regulations related to the environment were created during the first few decades of independence: decrees mentioning forest preservation, including the prohibition to cut trees near some key waterways, were proclaimed in 1833 and 1846; in 1853 hunting laws were passed, in 1881 a ban on dynamite fishing was approved and in 1888 a decree related to the protection of watersheds was signed (Steinberg 2001). Then at the beginning of the 20th century the National Geographic Institute and the National Museum were created and some of their employees were sent to study at the Smithsonian Institute. That move created key contacts with naturalists from the US who started to visit Costa Rica in larger numbers and continue to do so to this day.

Environmental regulations timidly continued to emerge when Law Number 36 was passed in 1906, asking the executive power to recommend a forestry policy that never became a reality. Then the first National Park was created in 1913. In that same year another law declared zones 600 ft from coasts and 800 ft from rivers "national forests", but no enforcement mechanism was devised for protection. Other attempts at environmental policy followed, but they were more written intentions than real regulations (Evans 1999).

Education continued to evolve and in 1926 an agricultural school was formed, and through 1940 it was a hub for the discussion of soil conservation and related matters. Finally in 1941 the University of Costa Rica (UCR) was born and after that citizens did not have to go to Europe or the US to pursue higher education. The school of agriculture designed in 1953 a draft for a Soil and Water Conservation Law, requiring studies to be conducted throughout the country to recommend land uses. That work was used as the

starting point for the creation of the first forestry law almost two decades later (Steinberg 2001).

The biology program at the UCR began in 1955. The number of local scientists increased significantly afterwards, and their political influence became relevant in the national conservation agenda. In 1956 a wildlife conservation law declared that all non-domesticated species were the property of the state, part of its renewable resources and something to be conserved, and regulations for hunting and fishing were enacted (Evans 1999). The establishment of higher education and research was also fueled by international institutions: in 1942 the Organization of American States established in Costa Rica the Inter-American Institute for Agricultural Sciences (IICA) to promote research and education in agriculture and natural resources.

Costa Rica first participated in an international meeting related to nature preservation in 1940: the Convention on Nature Protection and Wildlife Preservation of the Western Hemisphere in Washington D.C. Then in 1948 in Denver, Colorado, the country was part of the Inter-American Conference for the conservation of Renewable Natural Resources, a forum designed to share ideas and promote cooperation. In 1950 the government instituted the National Week for the Conservation of Natural Resources, to be celebrated each year in June to nurture a consciousness among citizens about the importance of preserving nature. In 1953 a Costa Rican wrote the "Universal Declaration of the Rights of Nature and the Responsibilities of Man", and presented it at the International Union for the Conservation of Nature (IUCN) world conference of that year (Steinberg 2001).

A foreign initiative was behind the creation of the first private reserve and first environmental non-governmental organization (NGO). In the early 1950s, a group of Quakers from Alabama left the US protesting the Korean war, looking for a peaceful place to live. They established what is today the largest and best known privately owned protected area in the country. Then in 1959 the international group "Brotherhood of the Green Turtle" created the Caribbean Conservation Corporation in Costa Rica. That NGO would later succeed in lobbying for the creation of a national park on the Caribbean coast (Evans 1999).

The second third of the 20th century was also characterized by the formation of important social groups such as unions, the middle class, church-sponsored labor groups, think tanks, and the precursors of today's political parties. That was the era of significant public health and labor reforms; the nationalization of the banking system, which allowed the government to take a central role in managing the economy; the abolishment of the army; the creation of state owned "autonomous institutions" that monopolized diverse services (electricity, water, telecommunications, insurance, oil refining, etc.) and provided them under highly subsidized rates; the recognition of women's and minorities' rights and the beginning of the import substitution strategy (Wilson 1998). All those changes were instrumental in the country improving its social and economic indicators faster than its neighbors. Increasing international coffee prices helped keep inflation and public debt under control.

Diversification was pursued not only in industry, but also in agriculture. As a result of that drive, the raising of cattle grew exponentially since the beginning of the 1950s, and other products were introduced, like cocoa and tobacco. But import

substitution was not easy for a small nation such as Costa Rica. The creation of the Central American Common Market (CACM) established high tariffs for products outside of the region, so each Central American country would have relatively easy access to the market of its neighbors. Costa Rica was not convinced of the benefits of the CACM, but offers of economic help from president John F. Kennedy influenced the government to join in 1963 (Wilson 1998).

Incentives were implemented to attract foreign and local investment. Growth in industry created an industrial elite, and growth in government a bureaucratic class. However, the incentives for investors were renewed repeatedly, discouraging industrialists from improving their production efficiency. Exchange rates promoted the importation of raw materials, creating a disproportionate trade imbalance, and natural resources were exploited with no considerations of sustainability. The environment was not yet part of a national agenda.

Since the beginning of time, throughout the 1800s and up to the middle of the 1960s conservation seemed unnecessary in Costa Rica, and it actually did not happen to any significant degree. That was the “no-regulation era”.

## 2.2 The command era

The “command” era starts when the government tries to impose restrictions on environmental degradation. That degradation became significant when agricultural production continued to increase and diversified to include sugarcane, fruits, flowers, etc.

### 2.2.1 Reasons behind the birth of environmental regulation in Costa Rica

Multinationals dedicated to the fruit exporting business became influential landowners and they showed no environmental stewardship in how they managed their plantations. United Fruit Co. abandoned most of its (now infertile) plantations in the Caribbean in the 1940s, and moved to the South Pacific. Accelerated degradation and deforestation continued until the beginning of the 1990s, when local and international environmental groups threatened banana companies with boycotts and forced them to improve their standards (Evans 1999). Recycling plants were built for plastic bags covering the fruit during its growth, reforestation programs were implemented and codes of environmental conduct were adopted.

On the other hand, the 2000 ranching families who control the cattle industry became the major actors behind deforestation (Brown 1990). The production of beef was initially for the domestic and Central American markets, but at the beginning of the 1970s there was an exponential growth in the US demand, to satisfy the fast food industry. In 1970 the US Department of Agriculture (USDA) gave Costa Rica a quota representing a full 10% of its beef imports. The quota was lowered in the 1980s (Evans 1999).

By 1980, one third of the country had been converted to grassland, while only 9% of its territory can support that use in a sustained way. The number of cattle went from 600,000 in 1950 to more than 2,000,000 in 1985 (Esposito 2002). Between 1950 and 1973, 71% of all newly cleared land was turned into pastures and dedicated to cattle grazing. The total grassland area grew from 0.8 million hectares in 1950 to 2.2 million

hectares in 1984 (Lutz and Daly 1991). By the mid 1990s pastures covered about 47% of the country, while some 40% of it was still forested (Brockett and Gottfried 2002).

Another factor influencing environmental degradation during the 20th century was the growing population, the unstable job market in several plantations and Costa Rica's lax property rights, which resulted in the proliferation of squatters who adopted subsistence agriculture as their way of life. In 1941 a law would allow possession of up to 300 hectares of land as long as the occupant cleared at least half of it and maintained cattle at the minimum rate of one animal for every 5 hectares. Those "improvements" would give the landholder a chance to obtain title, but many of them never cared to get their land registered, and up to 1990 still 60% of farms did not have formal titles (Brockett and Gottfried 2002).

In 1961 the Institute of Lands and Colonization (ITCO) was created to help settlers. Sanctions were imposed on owners not cultivating their land through a tax that was not abolished until 1977, while squatters were given access to some areas where they practiced subsistence agriculture. Some individuals obtained title to land they had been occupying, others were relocated, etc. Unfortunately, they used unsustainable practices, acquired debts, sold their properties to ranchers and then moved to new areas, often illegally. In the 1980s environmental education and fund raising were successful in helping settlers relocate away from protected areas. The law that created ITCO also emphasized that land with no title, not occupied and not in private hands was the property of the state. It also gave the government the right to declare which lands were not suitable for agriculture and the power to expropriate terrains that were not fulfilling any social function. Volcanoes, islands, rivers and lakes were officially declared the property

of the state, and a provision that banned tree cutting, construction and agriculture on those lands was enacted (Evans 1999).

It was the threat from squatters and to a certain extent ranchers that prompted the creation of the first state owned natural reserve in 1965. A Scandinavian couple that was living on the North Pacific coast felt that squatters and ranchers were encroaching into areas of high natural value. They wrote petitions to international conservation organizations, and over five of them donated the required money for the purchase of a tract of land that was given to ITCO for administration. At that time locals did not understand why the reserve was being set aside, and the country had no experience in managing protected areas (Evans 1999).

The second major development that initiates the command era is the expansion of epistemic communities through the consolidation of influential education and research institutions, in part thanks to the influx of a number of scientists from the US who were interested in the study of tropical ecology and felt attracted to Costa Rica because of its political stability and proximity to the US (Steinberg 2001). Some relevant examples of key organizations include the *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), or "Tropical Agricultural Center for Research and Education"; the Organization of Tropical Studies (OTS); the "National Council for Technological and Scientific Research" or *Consejo Nacional de Investigaciones Científicas y Tecnológicas* (CONICIT) and the *Instituto Nacional de Biodiversidad* (INBIO), or "National Biodiversity Institute".

CATIE was created from IICA in 1972 as an international higher education and research institution for the tropics. Its extensive campus is sited right in the middle of the

Caribbean lowlands, and the center is staffed by professors from various countries, but primarily from the US and Costa Rica. The student body is also highly diverse.

OTS is a non-profit research organization sponsored by 47 higher education institutions from the US and 5 from Costa Rica and the national museums of both countries. Its administrative headquarters are located at Duke University in North Carolina. Three reserves in Costa Rica are owned by OTS.

CONICIT is a state institution equivalent to the National Science Foundation of the US. Since their creation in 1973 they have supported a number of initiatives related to conservation and the environment. INBIO is also a state sponsored organization that was created much later, in 1989, with the goal of protecting the biodiversity of the country through the identification and classification of new species, which takes up most of their time, the implementation of projects to derive profit from biodiversity, and the environmental education of the Costa Rican citizens. INBIO was the first of its kind in the tropics and today it benefits from strong partnerships with the private sector.

These and other organizations provided avenues for the population to get involved in studying environmental matters, they gained an international reputation, attracted foreign support, and created durable links between the Costa Rican environmental movement and institutions in other countries.

### 2.2.2 The Forestry Law and the growth of the environmental movement

An increase in the awareness of the growing threat of deforestation among the intellectual and bureaucratic elite prompted the government to create in 1967 an interdisciplinary committee to study the issue and recommend the creation of a regulation

to solve the problem. The committee included some representatives from government agencies, the private sector and academia. Some of its members had been discussing the need for such a statute for decades, and finally the matter had been put on the political agenda. The committee looked at ecological and economic issues, reviewed laws and experiences of other countries, and after two years of work they presented a draft to the legislative body (Steinberg 2001). During the time the regulation was discussed letters from the general citizenry, groups of students, professional associations, and even schoolchildren poured into Congress in support of it. The media did not provide much coverage, deciding to focus on other issues instead. The statute was finally approved, in part because it had a "multiple use" language in it and it stressed economic benefits and the possibility of sustainable forest exploitation (Evans 1999).

The Forestry Law of 1969 was a breakthrough: it was the first statute with comprehensive conservation clauses in the history of the country. It was later amended in 1973, 1979, 1986 and 1996. Some of its main provisions included the creation of the National Parks Department, a forestry office within the Ministry of Agriculture, a system for recommending land uses, and an incentive program for reforestation and forest preservation. The incentives scheme resulted in more than 50,000 reforested hectares by the mid 1990s, when the first stage of the program ended.

The National Parks System grew exponentially throughout the 1970s, with the help of local institutions and domestic leaders: there were two parks in 1969, and there are over 29 today (Zebich-Knos 2002). Issues such as lack of experience and funding were solved by sending people abroad for training, by lobbying in Congress to secure budgets, and later during tough times by obtaining the financial support from

international conservation organizations. Public relations campaigns both domestically and abroad were intense and they focused on showing the richness of what was being protected. The participation of social civic groups like the local Boy Scouts and the Peace Corps was also helpful in getting things done, and schools from all over the country were often special guests at the parks. According to Evans (1999), the support from the First Lady between 1972 and 1974 and the leadership of the National Parks System (NPS) administrator during its first decade of existence were two major determining factors in the success of conservation during that time. Silva (2003) asserts that the existence of a national epistemic community was a constant influence that convinced politicians decade after decade about the importance of preservation.

The beginning of the 1970s saw the birth of significant environmental conflicts: members of UCR opposed the establishment of a bauxite extraction mine from the Aluminum Company of America (ALCOA) on Costa Rican soil in 1970; a local biologist organized public protests and got support from some politicians to defeat the proposal of an inter-continental oil pipeline that was to cross the country from ocean to ocean; and a few years later a group fighting against the construction of a new highway going to the Caribbean Coast finally agreed to the project under the promise that a new national park would be created on the forest to be crossed by the highway.

Environmental NGOs entered the social picture during the 1970s. ASCONA was the first one to emerge in 1972 when a group of people inspired by the Stockholm conference of the UN decided to get organized and fight for environmental causes. They worked in lobbying and litigation, and then lost strength at the beginning of the 1990s. Other groups include AECO (*Asociación Ecologista Costarricense*, or "Costa Rican

Ecological Association"), concerned about education and models of development, and the Fundación Neotrópica, a fund-raising group that works on research and the purchase of lands for conservation. By the mid-1990s there were 88 environmental NGOs in Costa Rica (excluding those sponsored by universities), and 19 of them were part of the Costa Rican Federation for the Conservation of the Environment. Today there are 245 local and national environmental groups, a few regional organizations (Central American or Latin American), and several international groups like Conservation International, the World Wildlife Fund, the Sierra Club, the Nature Conservancy, the Audubon Society and Friends of the Earth have projects, chapters and/or offices in Costa Rica (Steinberg 2001).

In 1974 the country ratified the Convention on International Trade of Endangered Species (CITES), in part thanks to the pressure exerted by local groups who were assisted by foreign NGOs. The second conference of the parties to CITES took place in San Jose in 1979. In 1976 the Convention for the Protection of Flora, Fauna and Places of Natural Scenic Beauty in the Countries of the Americas was signed. That convention outlined strategies to create national parks and preserves (Steinberg 2001).

The continuous creation of new protected areas happened because of a number of different reasons: recommendations from scientists to the government, recommendations from the NPS to Congress, support from emerging NGOs, lobbying by recreational groups, the support of presidents (some parks were created through executive decree), the efforts of local communities that wanted to protect their region, and the help and influence of international organizations. Between 1974 and 1978 the protected area of the country doubled, more than six national parks were created with little foreign support,

and the staff and budget of the NPS tripled. The number of news items related to environmental matters published by the major national newspaper went from 5 per year in 1965 to 70 per year during the mid-1970s, and over 80% of them discussed national issues instead of international meetings or organizations. During the same period, the number of "letters to the editor" with environmental content went from zero to twenty per year (Steinberg 2001).

The president, who had invested more than $2 million in conservation during his administration, declared 1977 the year of natural resources. During that year the Reforestation Law was passed. It abolished the tax on uncultivated land and it made loans and technology available for reforestation. Then the National Parks Act was enacted, giving the NPS powers to charge fees, expropriate, etc. The chamber of industries was against the statute for considering it too far reaching, but the support of political leaders and professional associations was enough to get it approved. The president saw tourism as a potential benefit for the country that would become a reality thanks to conservation efforts. He received the Albert Schweitzer award from the World Wildlife Fund in 1976 and the Green World Award of the New York Botanical Gardens in 1977. In that same year, the Open University began offering a program in environmental education. That program was complemented in 1982 with the creation of the Latin American Center for Environmental Education, that uses instructors from everywhere across the Americas to provide resources for teachers and courses in environmental issues.

The 1970s were a decade of economic bonanza for Costa Rica, with income per capita increasing 70% from 1968 to 1977 and the percentage of households living in

poverty decreasing from 50% in 1960 to 25% in 1980 (Schipper et al. 1998); but then in 1979 the country experienced the worst economic crisis in its contemporary history: it acquired the highest per capita debt in Latin America, international prices of coffee and other exports decreased, oil prices increased, and trade with Central America was almost nonexistent due to civil wars in el Salvador, Nicaragua and Guatemala. Unemployment and inflation reached historical highs. The country was left with goods manufactured inefficiently that could not compete elsewhere. In 1981 a representative from the World Bank told the president that he had to ask people to stop eating meat so everything could be exported, to aid in the monetary exchange crisis (Wilson 1998). Before 1979 foreign aid for conservation was only about 2-3% of what the national government would put in, but that changed during the following decade (Steinberg 2001).

### 2.2.3 The economic crisis of the 1980s

The crisis made the role of international lending institutions more important in shaping policy-making in the country. Some of the key players were the World Bank, the International Monetary Fund (IMF), the US Agency for International Development (USAID) and the Inter-American Development Bank. USAID was particularly influential during the 1980s, lending or granting over $2 billion over several years, and positioning itself behind key initiatives like the creation of the Ministry of Commerce in 1983 and the *Coalición de Iniciativas de Desarrollo* (CINDE), or "Development Initiatives Coalition" in the same year. CINDE is a semi-private institution whose goal is to attract foreign investment into the country. They have been a very influential interest group in economic policy making.

The 1980s forced the country to look for new export opportunities in non-traditional crops and markets outside Central America. At the end of the 1980s non traditional agricultural exports were 30% of the total. Free trade zones where companies enjoyed tax breaks for producing export commodities were established in several locations and grew in size rapidly. The Caribbean Basin Initiative established by the US unilaterally lowered their import tariffs for several Central American and Caribbean products, and that further stimulated the growth of the economy.

A neo-liberal wave has been the defining force behind the evolution of the state since that time. Welfare programs have been reduced and some privatization initiatives have been implemented, in opposition to the policies of the 1950s and 1960s that had taken the government expenditures to 54% of the GDP by 1980 (Schipper et al. 1999). The two dominant parties have been successful in carrying out that transformation by looking at ways to compensate the lower portion of society, operating gradually, influencing public opinion, and using the discontent of citizens regarding the performance of state institutions to justify privatization.

As in many other developing countries, some of the neo-liberal measures implemented were prescriptions from international lending institutions. Aid from the US had been historically low for Costa Rica, but at some point in the middle of the 1980s it reached an all time high of $200 million a year, and the country became the highest per capita recipient of aid from the US in the world. Shortly after that the monetary flow sharply declined again, particularly after Costa Rica rejected a proposal from President Reagan to use its territory as a launching pad for an invasion to Nicaragua. During 1994 the US aid was a mere $6 million a year (Wilson 1998).

The crisis motivated the government to make some controversial decisions regarding environmental matters. In 1981 the president announced he would segregate a portion of a newly created park because there was no money to pay the former landowners who had been expropriated. In reality he was trying to expand rice production to alleviate the crisis. Groups of students went to congress to protest, and letters were sent by local and international organizations. Nothing made the government change its position, but a few months later the agricultural businesses themselves decided to donate most of the land back to the state (Evans 1999).

The economic crisis, however, was no excuse to stop conservation. Both at the national and international levels efforts continued to expand protected areas. In 1979 the United Nations approved Costa Rica's request to create the "University for Peace" there, a research and education organization for non-military resolution of conflicts of all kinds, including environmental. Today the university has an active program that includes several graduate and undergraduate degrees, and its current and former chief administrators have a number of environmental credentials.

In 1980 the country participated in the "World Strategy for Conservation" meeting, sponsored by the United Nations Environment Programme (UNEP), the World Wildlife Fund (WWF) and IUCN. That helped with the revision of a national conservation strategy. That same year the first National Congress on Wildlife Conservation was organized by the government to obtain advice on how to improve the wildlife conservation law. The statute was amended in 1983 (and later in 1990 and 1992) by making hunting and fishing regulations stricter, by eliminating the "public utility" language and by creating a few national wildlife refuges. The 1980s also saw an increase

in the use of environmental themes in the media through radio shows, soap operas, nature photography contests, and an important emergence of nature in the arts (Steinberg 2001).

During the 1978-1982 administration protected land again more than doubled, to attain over 8% of the territory. The country turned to foreign sources for funds and received money from a number of governmental and non-governmental groups in Europe and the US. Fundraising after 1979 achieved $5.5 million in 5 years. The global benefits of the Costa Rican biodiversity, including for example the provision of habitat for migratory bird species coming from the US, were key selling points for foreign donors. The international aid trend continued throughout the 1980s, in part because sympathetic Western governments interested in winning the Cold War were quite agreeable to provide financing to Third World nations (Steinberg 2001).

A study conducted in 1985 by the "Costa Rican Tourism Board" or *Instituto Costarricense de Turismo* (ICT) determined that 75% of tourists visit the country because of its natural beauty. The visits to National Parks increased by 50% between 1985 and 1987. In 1991 for the first time the number of foreign visitors to protected areas surpassed the number of national visitors (Evans 1999). Today 11% of the country is under national parks and biological reserves, compared to a developing world average of 5.8% and a developed world average of 7.2% (World Resources Institute 1999). Another 14% of the land in Costa Rica is regulated as forest preserve, indigenous reserve, wildlife refuge or national monument. A significant proportion of the newest protected areas are in private hands (Brockett and Gottfried 2002).

Towards the end of the command era, a key institutional capacity improvement was made through the creation of the "Ministry of Natural Resources, Energy and

Mines", or *Ministerio de Recursos Naturales, Energía y Minas* (MINEREM). The president during 1986-1990 had been the planning minister four administrations before (1970-1974), and he had advocated then for the importance of creating an environmental agency, but the idea did not go far, until he was able to implement it himself while being in charge of the executive power of the nation. In 1990 an environmental office was created within the Ministry of Foreign Relations to analyze and propose the ratification of international treaties and provide follow up to their implementation. At the end of the 1990s UCR began offering an environmental law specialization. Between 1971 and 1975 only 4% of the theses from the Law School of UCR were on environmental topics, and between 1991 and 1995 the rate climbed to 35% (Steinberg 2001).

### 2.2.4 The mixed results of the command era

The first Forestry Law required that all tree cutting be approved by the Ministry of Agriculture on the basis of a management plan, that all land to be cleared for agriculture have a study showing that it was suitable for that use, and that all cutting be accompanied by a tax. Unfortunately the statute lacked support from the rural community surrounding the numerous "to be protected" areas. Peasants and farmers had not been involved in the creation of the law, and their economic activities were to be severely restricted or suspended.

Poor enforcement, lack of funding and insufficient staffing at the Ministry of Agriculture actually allowed continuous degradation and accelerated rates of deforestation by squatters, cattle ranchers, loggers, miners and even proprietors who were not compensated following the creation of National Parks or feared their future

expansion. In 2003 it was estimated that about $55 million were still needed to fully compensate former land owners who were expropriated when the various protected areas were created, but only about $5 million are allocated each year from the national budget for that purpose (Varela and Corella 2003).

Also during the 1970s and 1980s the government continued providing subsidies and credit for ranching and agriculture in general, and consumption in the developed world kept increasing, creating new markets for Costa Rican beef. From 1956 to 1982 the percentage of credit for ranching from total state credit rose from 13.8% to 23.3% (Lutz and Daly 1991).

On one hand, the National Parks System grew exponentially to the point that the country today has one of the highest percentages of protected land in the world, but on the other hand, land degradation outside the reserves increased, to the point that during the mid-1980s Costa Rica had the highest rates of deforestation in the world (3.9%) while grassland grew at 6.9% per year over the 1980s and into the mid 1990s (Goodstein 2002). The creation of reserves had not been enough to protect many species. For example by 1982 the habitat of the giant anteater had been reduced by 80% (Vaughan et al. 1998).

In 1987 the exportation of logs and unprocessed timber was banned, depressing domestic wood values to a fraction of international prices, weakening reforestation incentives, and subsidizing inefficient wood product industries (Southgate 1995, Hartwick and Olewiler 1998). However, deforestation in Costa Rica has been driven primarily by a demand for agricultural land, not by a demand for forest products. For example, up to 86% of the timber cut between 1953 and 1973 was burned or left to rot on-site (Brockett and Gottfried 2002). Even farmland has been turned into pastureland,

with negative consequences for the rural labor market: coffee requires 130 working days per hectare per year, rice requires 60, beans 37, and cattle only 6 (Evans 1999). Many of those who lost their jobs went to the city to look for employment.

The Forestry Law had been successful in creating protected areas, but not in controlling deforestation on a national basis. In 1983 a legislative commission on agricultural and natural resources proposed a total overhaul of the statute, in part because it had not controlled the logging and livestock industries. Three years later an amended law was proposed, but it was challenged repeatedly, and it had to be re-designed and approved in 1990 as a temporary regulation while a more comprehensive one could be drafted. That did not happen until 1996.

During the Earth Summit in Rio de Janeiro in 1992 Costa Rica proposed that an Earth Council be based in its territory to follow-up on the agreements of the conference. The proposal was approved and the Council remained there until 2001. Some sectors within the country spoke to the irony and the myth with no substance that was being created by selling Costa Rica as a center for ecology while trees were still being cut with little control. At the end of the 1990s only about 5% of the forests were outside protected areas (Evans 1999).

The command era goes from the end of the 1960s to the middle of the 1990s. Its most relevant features were the consolidation of agro-ecology research and education institutions, the birth of the Costa Rican environmental movement, the success in environmental diplomacy, and the enactment of the Forestry Law, that sparked the creation of the NPS but at the same time allowed land degradation to continue.

## 2.3 The balanced era

The transition into the 21st century is bringing evidence of a more balanced approach to conservation in Costa Rica. Hopefully this new era will be more participatory, equitable, innovative and easy to implement.

### 2.3.1 Regulatory framework

The amended Forestry Law of 1996 came up with simplified requirements for forest management, including renewable permits, and with participatory clauses to involve different stakeholders in the policy-making process. The National Forestry Office was created as an advisory council to the Ministry of Agriculture, and it includes representatives from wood industries, environmentalists, forest owners and wood product retailers.

The law also created a new fund to compensate forest owners for the services provided by their land. This latest regulation continued to prohibit cutting trees or converting forests to other uses in places were biodiversity and watershed protection are essential.

The environmental responsibilities of the government had been consolidated in 1995 in the "Ministry of the Environment and Energy" or *Ministerio de Ambiente y Energía* (MINAE), created through the Organic Environmental Law, which is the first purely environmental regulation in the history of Costa Rica. The statute was written to organize and unify under one roof the environmental responsibilities, regulations, policies and criteria of many government institutions, including diverse functions such as

conservation, pollution control and land use. It helped clarify concepts and it provided more regulatory tools than were available before. Specific discharge limits for wastewater were established, a process for reviewing environmental impact studies for new projects was defined, the use of leaded gasoline was banned, etc. MINAE was to function as a de-centralized agency divided into eleven conservation areas with autonomous administration (Sagot 2000).

The performance of the different areas has been irregular, partly because de-centralization has been too much of a burden for some local governments that lack the "know-how" to approve tree cutting permits and exert other functions. Nevertheless, some success stories demonstrate that the new system may very well be the solution the country was looking for. Funding coming from diverse taxes is being sent to the different regions, where the participation of local NGOs has been intense, to the extent that some communities rely on them for enforcement (Brockett and Gottfried 2002).

### 2.3.2 Integrative conservation

An example of a participatory approach was the creation of the Guanacaste reserve: it went from a single National Park in the 1980s to a comprehensive conservation area a decade later. Since colonial times, tropical dry forests were used more than the rainforest, due to the ease of transforming them into flat savannas after clearing, allowing quick conversion into agricultural fields. Guanacaste is today the only large, protected dry tropical forest in the world (Evans 1999). When "sustainable development" became a buzzword at the end of the 1980s, the government decided that they wanted the park to be part of a bigger picture of development and citizen consciousness.

Ecologists started by organizing field nature trips for schoolchildren, they formed fire control squads with locals and proposed grazing be allowed in a restricted area to control grass and build local support. Building buffer zones was in vogue around the world and Costa Rica was not an exception. That influenced the government to look for a budget to buy more land around the park. Former ranchers and squatters were invited to join in the conservation area as researchers, caretakers and instructors, benefiting for a stable source of income not previously available. Locals were better prepared than anybody else to control fires, poaching and other abuses. The local tourism industry also continued to flourish and provide more jobs. The reserve doubled its size in twenty years to attain 1,520 square kilometers in 2001 (Esposito 2002).

The goals of the government, the demands of the general population and the needs of the local citizenry were all combined into this integrative conservation case. The government did not have to forego its control of the area, but could influence the behavior of the peasants without having to resort to expensive enforcement practices. The case of Guanacaste could become the blueprint for other conservation efforts across the country and even around the world (Lowry 2003), particularly considering that the creation of new protected areas in Costa Rica is not as important as achieving a real enforcement of the land currently under preservation status. Properly protecting that one fourth of the territory may be sufficient to safeguard 95% of its biodiversity (Brockett and Gottfried 2002), as long as buffer zones are maintained around the parks and preserves, because some species are not suited for reproduction in fragmented habitats (James et al. 2001). About 80% of those potential buffer zones are today in private hands.

### 2.3.3 Ecotourism

Ecotourism emerged during the 1990s as a great incentive to conservation. By 1994 that sector of the economy was the major earner of foreign exchange (Brockett and Gottfried 2002). In 1995 Costa Rica hosted the second forum, seminar and workshop on eco-lodging, organized by the World Ecotourism Society, presided by a Costa Rican at that time. The tourism sector at large generates 20% of the country's foreign income, it represents 5% of its gross domestic product, and it employs about 12% of its labor force (Rivera 2002).

In 1997 tourism generated $700 million in revenues in the country, and national parks received $4 million in entrance and research fees (Evans 1999). Today it is not uncommon for land owners to cater to "ecotourists" on their own forests. The National Web of Private Reserves had, in 1998, more than 69 members, owning about 50,000 hectares. Forested land is now reported to have a higher market value than cleared land in some areas. A sub-set of eco-tourism is what has been called "rural tourism", in which residents of rural communities rent rooms to foreigners who are interested in visiting natural attractions. That trend began around 1999 as a strategy for families to generate extra income while at the same time giving tourists a more genuine taste of local culture. On occasions, neighbor associations have joined forces to purchase small tracts of land for conservation and recreation, and they have also built small lodges. That has represented a more stable source of income when compared to growing crops. Rural tourism was born in Europe during the mid-1990s as an incentive to get people to repopulate small abandoned towns. A guide to rural tourism in Costa Rica was recently

published with the help of the United Nations Development Program (UNDP) (Andrade 2004).

According to Zebich-Knos (2002), eco-tourism in Costa Rica is growing because there are ecological and economic needs, there is support from the government in the form of incentives, grass-root local movements are also encouraging and promoting tourism and there have been a number of private-public sector alliances. Other countries with higher levels of total biodiversity have preferred to market to traditional tourism (like Mexico).

Tourism has potential dangers associated with negative environmental impacts, though. One attempt to prevent its possible damaging effects was the creation in 1997 of a Certification of Sustainable Tourism (CST) by ICT, a performance-based, voluntary environmental program, pioneer in the developing world. CST was designed by a partnership of academic institutions, the major hotel trade association, and some environmental NGOs. By 1999 115 hotels had decided to enroll in the program and 52 had been audited and given a rating. By 2000 ICT began including CST in its international advertisements, and the World Tourism Organization decided to adopt the Costa Rican program as its voluntary environmental certification (Rivera 2002).

### 2.3.4 Other benefits of biodiversity

Bio-prospecting also emerged during the 1990s as a positive environmental force. In Costa Rica parks have low human influence and they are well suited for research, contrary to the case of most of the US, Europe or Africa. In 1992-1993, the pharmaceutical company Merck paid $1 million to INBIO for an agreement to conduct

research on potential drugs derived from the country's biodiversity to cure a few specific diseases. During those two years, the Merck payment was about 20% of INBIO's budget. Other bio-prospecting deals are underway, like the one involving INBIO, UCR, Cornell University and a Scottish University. In that agreement 60% of the profits from any marketable chemical will go to INBIO. The 1997 Biodiversity Law is aimed at conserving biodiversity, promoting its sustainable use as a resource, and distributing in a fair manner its associated costs and benefits. The law declares that biodiversity is the property of the state (Sagot 2000).

The 1996 Forestry Law also resulted in the creation of new incentives for conservation. The forest conservation certificate was designed for agreements spanning 20 years. The environmental service payment is given at a rate of $ 510 per hectare for reforestation, to be given during the first five years (50%, 20%, 15%, 10% and 5% per year) and with the commitment of the land owner to keep the area forested for another 15 years. For sustainable forest management $310/ha are given also during the first five years of a 20 year contract, and finally $230/ha are paid for forest preservation and natural regeneration during five years (Brockett and Gottfried 2002). Many of the recipients of those payments are NGOs. Financing comes primarily from a fossil fuel tax. In 1997 alone $14 million were paid for environmental services coming from some 100,000 hectares. The law includes in its definition of environmental service carbon sequestration and storage, and the protection of watersheds, biodiversity, and ecosystems (Castro and Barrantes 1999).

Up to 70% of the benefits from forest preservation in Costa Rica accrue to the global community through carbon sequestration (Brockett and Gottfried 2002). This is

where the "debt for nature swaps" and other similar initiatives come to play. The swaps were an idea proposed by a group of international environmental NGOs that were successful at enlisting the participation of a few donor governments and several recipients. During the early stages of that program fifteen countries participated and Costa Rica alone obtained one third of all the funds, in part because it had a lot of institutional capacity and a large network of NGOs willing to help and put pressure on the government. By 1991, over $40 million had been erased from the country's debt (Keohane 1996, Steinberg 2001).

The "Costa Rican Office for Joint Implementation" or *Oficina Costarricense para Implementación Conjunta* (OCIC), was created during the mid-1990s for the issuance of carbon bonds to be traded following the scheme proposed by the Kyoto protocol. A few transactions have already taken place: in 1997 Norway paid Costa Rica two million dollars for the sequestration of 200,000 tons of carbon. The following year, the Dutch government received a carbon bond equivalent for $673,000 it paid for projects aimed at reducing methane emissions, and the next year they put up another $334,000 for carbon fixation. Twenty-year carbon storage certificates issued by Costa Rica, valued at between $40 and $80 million, are currently being marketed at the Chicago Mercantile Exchange (Ramirez 2000).

## 2.4 Concluding comments

Costa Rica has been a very stable country since 1949, and it has been regarded as a pioneer in sustainable development for its efforts to conserve tropical forests, strike

agreements to place a value on future biodiversity discoveries, negotiate debt for nature swaps, and foster ecotourism (Brockett and Gottfried 2002). Conservation has been relatively successful in the country thanks to the talent and drive of conservationists and the vision implanted in the Forestry Law. The parks were created when there was still time left to provide meaningful protection and a large portion of the population showed an initial dose of enthusiasm.

Today the pressure of population growth is not very strong, although that could change due to immigration. The real pressure is coming from desired economic growth based on an expansion of agricultural land and continued uncontrolled industrial and municipal pollution. The country still throws some of its sewage directly into rivers, it still lacks a comprehensive strategy for pollution regulation, and it continues struggling to protect some of its most diverse National Parks, where the populations of some species are close to replacement level due to the work of poachers who can, for example, sell a jaguar skin for more than $10,000.00 (Loaiza 2003).

Will Costa Rica turn into a group of isolated conservation units in a sea of deforestation, unsustainable agriculture and pollution? Outside of protected areas a number of forest fragments isolate wildlife and prevent vertical and horizontal migrations (Castro and Barrantes, 1999). Land-use decisions regarding those private forests and their surrounding agricultural terrains will determine in the long run the real achievements of natural habitat protection in the country. Costa Rica's success stories are the result of efforts on the part of a few visionaries, concerned investors, exemplary public service officials and international organizations. A national vision for forest conservation exists, but its internalization by a critical mass in the population is

questionable. The progress in conservation is obvious. The question is whether it will be sustained and enhanced or not.

A number of things will need to happen if the country expects to live up to its reputation and truly become a model for sustainable development and biodiversity protection. Perhaps the first and more important step is to get government agencies to become role models of environmental stewardship. An obvious difference between recent environmental policy in Costa Rica as compared to the US is the fact that laws in the latter started by regulating the work of the government itself before they came up with standards for the private sector. Another indispensable task is to come up with a strategy for dealing with foreign debt. It is hard to alleviate poverty and assign a budget for forest preservation when 20% or more of the earnings from exports are sent back out as debt payments (Roddick 1999). The management of finances within the government is also subject to improvement, as most of the revenues from taxes and other sources (like entry fees to national parks) go to a unique fund from where all the budgets are created. That does not guarantee a fair allocation of resources for environmental protection (Silva 2003).

An interesting point is that economic development has not been a requirement for the Costa Rican citizenry to expect environmental protection. Studies suggest that pro-environmental attitudes in Latin American countries may be higher than in the U.S. (Rauwald and Moore 2002), demonstrating that high standards of living are not a prerequisite for being environmentally conscious. An explanation could be that in places where environmental policy is in its infancy people are demanding significant improvements, while in places with relatively strong environmental protection regimes,

people may already have some level of comfort with the current state of things (Schultz et al. 2000). Castro and Barrantes (1999) affirm that about 80% of Costa Ricans understand the value of conserving forests for water storage, and according to Steinberg (2001) a survey conducted during the mid-1990s concluded that 91% of citizens were willing to pay more for electricity and water if the additional money was to be used for biodiversity conservation. People's opinion about the seriousness of environmental problems has not correlated well to income per capita. Costa Rica has today more citizen environmental groups per capita than California (Steinberg 2001).

The list of solutions provided by Goodstein (2002) for developing countries to make progress in sustainability includes ending detrimental subsidies while minimizing harm to losers; establishing property rights by providing a combination of communal, state and private ownership; enforcing regulations; and promoting the transfer of sustainable technologies from industrialized nations. Those prescriptions are certainly applicable to Costa Rica. The desire to reduce the role of the state, the need to create buffer zones around protected areas and the goal of stimulating agricultural intensification may be compatible if policies are constructed considering the benefits and costs of different land-use schemes and if policy instruments compatible with the statutory history of the country are implemented.

Costa Rica's president announced in 2002 a plan to transform the country into an "ecological power" (Taylor 2002). He created a new National Park, banned the transportation of logs during night hours, and placed a moratorium on open pit mining. Little improvements continue to happen, but until the nation comes up with enough will

to implement a comprehensive strategy for land-use management and invest in effective enforcement, deforestation and species extinction could continue.

A land-use policy should consider the environmental effects of different land distributions. The following chapter describes the relationship between deforestation to make room for grasslands and river pollution.

# CHAPTER III

# BIOPHYSICAL MODEL

## 3.1 Introductory comments

This first paper is based on the application of the Soil and Water Assessment Tool (SWAT) to the Nosara watershed in the North-West of Costa Rica, with the purpose of estimating the concentration of three pollutants at the outlet of the basin under different proportions of forest and pasture. That area of the country was selected because data was available to conduct the study, the expansion of pastureland into forested land is viable, the largest ranches in the country are located there, and at the same time that area has some of the major reforestation projects underway.

SWAT is a software run through the Arcview interface that was developed in the mid-1990s by an interdisciplinary team working for the US Department of Agriculture and Texas A&M University. It has undergone many improvements over the years. In contrast with models based on purely empirical correlations, SWAT is based on theoretical concepts and extensive databases with measured values, making it particularly reliable. Furthermore, the data needed to run it is in general available, and its code is such that the number of calculations is minimized by lumping together different regions with similar properties in the watershed, making it computationally efficient (Arnold et

al. 1998).

The minimum information needed to run SWAT includes maximum and minimum monthly temperatures for the watershed selected, a topographic map, latitude and longitude coordinates for the watershed, soil type and land cover. The software uses the data to perform a series of detailed mass and energy balances in each sub-basin of the watershed, and it generates estimates of water flow out of the system, sediment run-off, pesticide residues, etc.

The program has a number of components with sub-routines that allow it to estimate intermediate variables such as daily maximum and minimum temperatures, solar radiation, relative humidity and precipitation. If available, data can be fed to the model and the "weather generator" can be turned off. The software also models plant growth, routing of nutrients (nitrogen and phosphorous) and erosion. The user can specify a number of management variables including irrigation, chemical application, grazing, harvest, and others. For grazing, the user inputs the rate of biomass removed, the amount of manure deposited daily and the degree of trampling. No adjustments are made for the possibility of having cattle directly at the edge of creeks and rivers (Neitsch et al. 2002).

The model has some limitations, like the inability to predict flooding events, to model the widening of channels, and to incorporate continuous changes in land-use patterns. Also some routines do not account for specific boundary conditions, like the cessation of plant growth above certain temperatures.

The use of SWAT to predict with reasonable accuracy specific flows of water or sediment under certain conditions in a given period would require significant amounts of data and calibration effort; but the comparison of scenarios and the relative increase or

decrease in the values of dependent variables is much simpler and requires less information to provide meaningful results.

For this study maximum and minimum daily temperatures and precipitation were obtained for 1984 through 2003 (Instituto Meteorológico Nacional, 2004). More than 99.9% of the information was available, and missing data were taken as the average for the specific days for the period. The land cover map is from 1997 and it has a resolution of 30 m x 30 m (Ministerio de Ambiente y Energía 1998). The soils had to be re-classified using the United States Geological Survey (USGS) system with the help of a soil scientist. The list of soils in the original and new classes is included in Appendix 1. The elevation map was taken from the USGS (2004), with a resolution of 90 m x 90 m. Four pixels were missing and they were filled by taking an average of the elevation in the neighboring pixels.

## 3.2 The impact of tropical deforestation on river chemical pollution

### 3.2.1 Extended abstract

Understanding how deforestation affects river water quality is essential in any comprehensive effort to manage watersheds and regulate land use. The main objective of this study was to provide a quantitative description of the impact of converting tropical forests into pastures for cattle grazing in terms of the sediment, nitrogen and phosphorus concentrations at the outlet of a river basin located in North West Costa Rica. This project also aimed at testing the possible environmental consequences of land-use management policies for that watershed.

Twenty years of daily precipitation, maximum and minimum temperatures, and digital elevation, land cover and soil maps were used with the Soil and Water Assessment Tool (SWAT) to model the watershed. SWAT had not been utilized to specifically model the potential effects of deforestation and related policies on river water quality in a tropical country in the way it was used in this project. A flow balance calibration was performed by comparing results to published measurements, and a regression coefficient of 0.9886 was obtained for the best-fit line of the predicted vs. measured flows.

Graphs for sediment, nitrogen and phosphorus concentration vs. percent area of the watershed under pasture were plotted and the results showed an expected monotonic increase in pollutants as deforestation increased. Contaminant levels at the main river outlet for the entire watershed as grassland were between 3 and 8 times higher than for the total area as forest, which could put at risk the drinking water supply and the tourism-based economy of the region. Keeping the current percent area under grassland constant, but restricting pastures to the less fragile and more fertile lands could decrease the sediment, nitrogen and phosphorus concentrations at the main watershed outlet by more than 35%, 12% and 21%, respectively, as compared to the predicted pollutant concentrations for the current land cover distribution.

The effect of varying stocking rates was also tested and this resulted in lower sediment and nitrogen run-off for areas with higher pasture yields and animal loads in which confined operations are used part of the year. The phosphorus concentration, however, varied only slightly, suggesting that in the absence of fertilization the broken terrain, uneven precipitation patterns, land cover and soil types are the main predictors of phosphorus contamination, not grazing intensity itself. The current drive by the

government of Costa Rica to promote agricultural intensification could therefore be beneficial for the environment, provided that manure is managed appropriately during the animal confinement period.

**Key words:** tropical deforestation, hydrologic modeling, watershed management, water pollution, SWAT, Costa Rica.

### 3.2.2 Introduction

Tropical forests have been disappearing over the years as a consequence of unsustainable natural resource exploitation, imposing a threat against biodiversity conservation, clean drinking water supplies, and climate stability [1]. The purpose of this study was to model quantitatively the extent at which the conversion of forests into pastures can degrade the quality of surface water, as determined by the concentrations of sediment, phosphorus, and nitrogen, in a watershed located in North-West Costa Rica. Deforestation in that country has been driven primarily by the expansion of grassland to raise cattle, in part to satisfy international beef markets. Other tropical nations facing challenging deforestation dilemmas, like Brazil, attribute most of their forest loss to the same phenomenon [2].

The Nosara watershed was chosen for the study because: 1) pasture and forest in that area share several borders and they are currently the dominant land uses; 2) the expansion of grassland into forested land is viable (part of the forest is on flat terrain and it is not under a strict preservation status); 3) the area is accessible and therefore allows for a good understanding of how land is managed; and 4) the watershed and its associated receiving body (the Pacific Ocean) have significant and diverse economic activities,

including tourism, agriculture, and fishing, making the case more relevant for future multi-disciplinary work.

The study utilized the Soil and Water Assessment Tool (SWAT) to estimate the concentration of the three pollutants at the outlet of the river basin under different ratios of forest to pasture within the watershed. The use of SWAT in developing countries is fairly recent and infrequent [3]. The present study is not only unique for being centered in a tropical and developing country, where deforestation is a critical issue, but it is also novel in that it specifically investigates the impact of converting increasing amounts of land from forest into pasture, allowing for a quantitative estimation of river water quality under several hypothetical scenarios, including the re-allocation of grasslands to areas of low erodibility, and the use of different cattle stocking rates.

### 3.2.3 Materials and methods

SWAT is a hydrological model for river basins that has been widely and successfully used during the past decade [4]. To set-up the model, twenty years of daily maximum and minimum temperatures and rainfall going from 1984 through 2003, and digital land cover and soils maps were obtained from diverse institutions in Costa Rica [5,6,7]. Soils were re-classified according to the US Natural Resources Conservation Service system and they were formatted for SWAT using published methods [8]. The digital elevation map was taken from the US Geological Survey [9].

The main basin outlet is the point where the Nosara river flows into the Pacific Ocean. The watershed has an area of 34,500 ha, an elevation that goes from sea level to 950 m above sea level, and a sub-tropical climate with a total average annual rainfall of

2150 mm and average maximum and minimum temperatures of 33 °C and 21 °C, respectively. Primary and secondary forests account for 52% of the area, while 47.5% is under pastures or range. The other 0.5% corresponds to urban areas, wetlands and permanent crops. The watershed was divided into 22 sub-basins and 116 hydrologic response units (HRUs). Figure 3.1 shows the land-cover map, sub-basins, and main channels. Details about grassland management practices in the area were obtained by directly interviewing several ranchers during August of 2004.

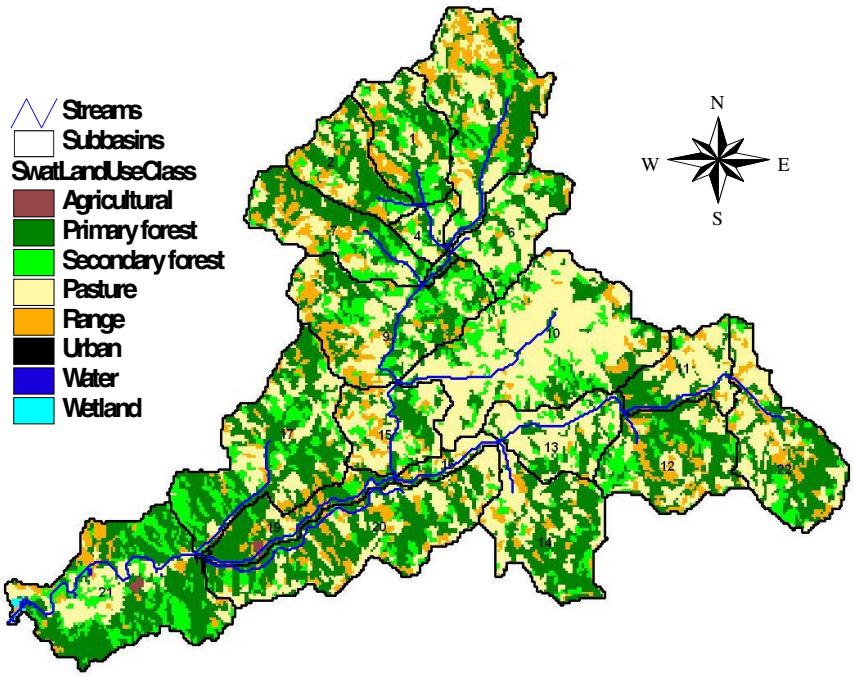



**Figure 3.1**: Land-cover map

A study that includes four flow measurements in one stream within the basin was used to calibrate the model by varying diverse parameters governing different processes of the hydrologic cycle [10]. Figure 3.2 shows the points and line of best fit for a plot of predicted vs. measured flows after calibration, with a regression coefficient of 0.9886.

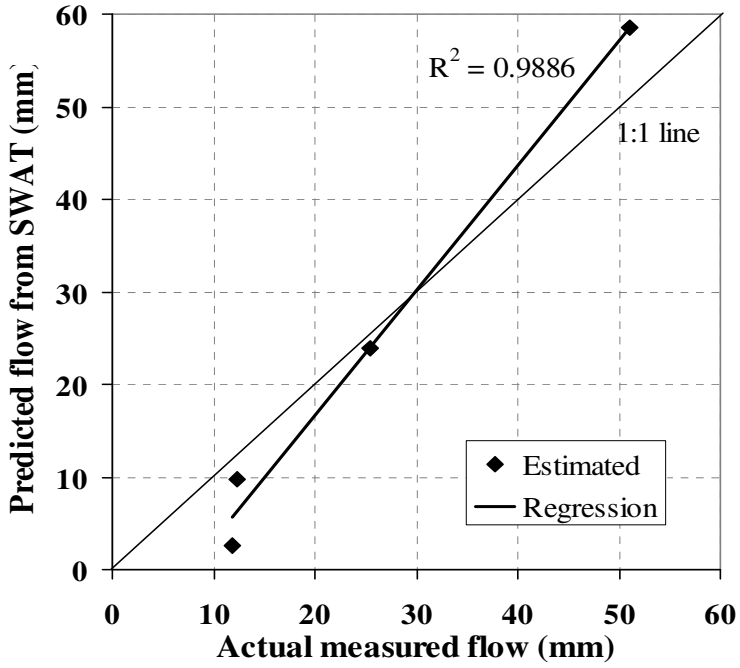
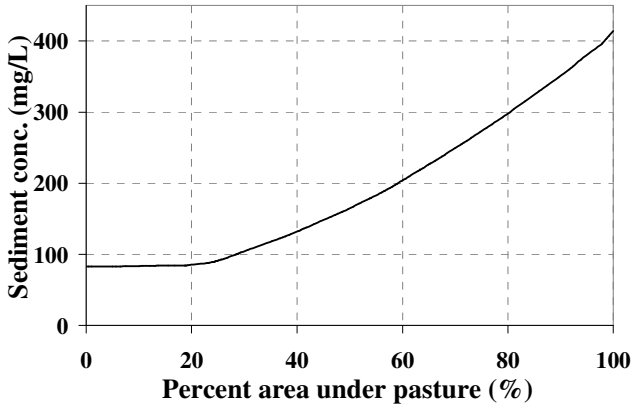



**Figure 3.2**: Model calibration

The model was run for the baseline land cover, for the entire area in forest, and then as pasture, using different stocking rates.

3.2.4 Results and discussion

The baseline concentrations for sediment, nitrogen and phosphorus were 247 mg/L, 3.75 mg/L and 0.85 mg/L, respectively. A comparison of the runs with the whole watershed as pasture and then as forest allowed for the ranking of the 116 HRUs according to the predicted increase in sediment concentration when the HRU is deforested. Figure 3.3 shows the result of that comparison, with the three graphs having the same HRU ranking.

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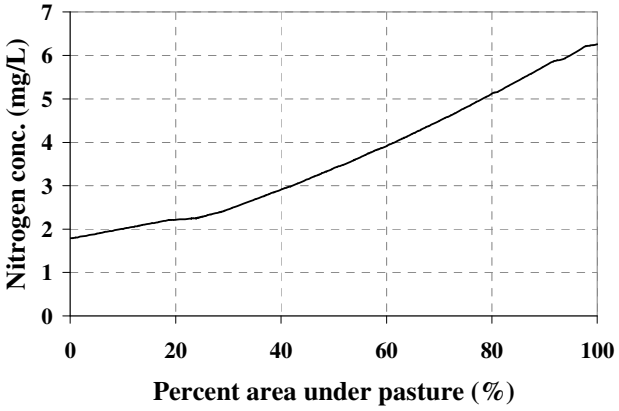


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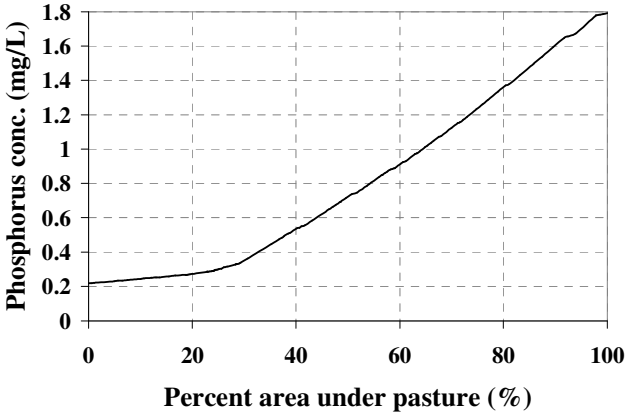



**c**

**Figure 3.3**: Effect of deforestation on pollutant concentration

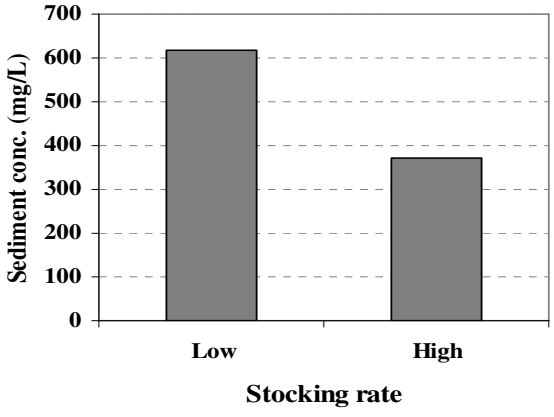
The left of graph 3.3a corresponds to areas that increase the sediment concentration only marginally when they are converted from forest to pasture, while those on the right increase it to a larger extent. Pastures are more erodible than forests and cattle grazing, biomass trampling and manure deposition increase sediment run-off in different proportions for different combinations of soil type and slope.

Similar observations can be drawn from graphs 3.3b and 3.3c for the nitrogen and phosphorus concentrations. Sediment contains nutrients primarily in organic and insoluble form, and therefore an increase in its concentration also tends to increase the concentration of total nitrogen and phosphorus. However, even where deforestation does not increase sediment run-off, soluble nitrogen and phosphorus will increase with pasture conversion due to higher surface water flow.

Figure 3.3 suggests that going from a watershed that is totally forested to one that is totally under pasture would increase the concentration of sediment at the main outlet by approximately 5 times, the concentration of nitrogen by 3.5 times and the concentration of phosphorus 8 times. If the current area under pasture was relocated to the less erodible HRUs, the concentrations of sediment, nitrogen and phosphorus would be 156 mg/L, 3.27 mg/L and 0.67 mg/L, respectively, as read from the graphs presented. That would result in decreases of 37%, 13% and 21%, respectively, compared to the baseline simulation.

Figure 3.4 shows the sediment, nitrogen and phosphorus concentrations when the entire area is pasture, for two sets of grazing parameters corresponding to two very different ways of managing pastures: a low stocking rate of 0.86 animals/ha and a high stocking rate of 3 animals/ha. In the first case cattle are left to graze the entire year and during the dry season there is over-grazing and pasture almost disappears, with tracts of

land turning into exposed bare soil. Sediment and nitrogen run-off are high under those conditions.

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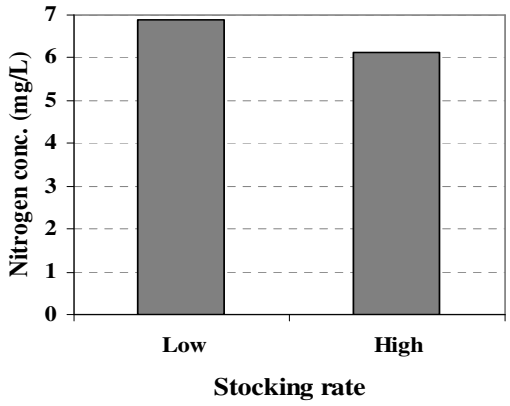


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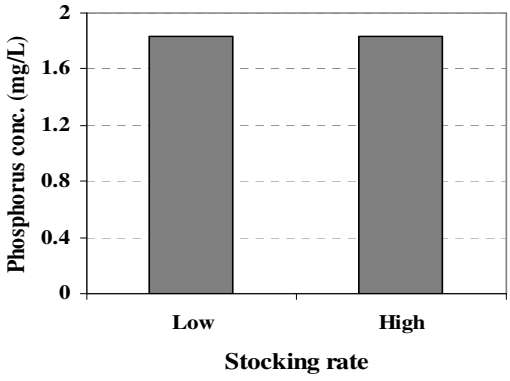


c

**Figure 3.4**: Effect of stocking rates on pollutant concentrations

The second case is representative of farms that have been influenced by the drive from the government of Costa Rica to promote agricultural intensification to improve productivity and earnings for the farmer. Ranches are divided into five areas were cattle graze one week at a time, allowing for higher grass (and cattle) yields. Animals are taken out of the pasture during the four months of dry season and they are placed in a confined feeding operation, which was not included in the model, to reflect the practice by many farmers of treating manure in lagoons or selling it as fertilizer. Figure 4 shows that the high stocking rate can actually decrease sediment concentration by 40% and nitrogen concentration by 11%. Agricultural intensification in the watershed can result in lower pollutant loads.

The phosphorus concentration varied only marginally from the first case to the second, due to the sensitivity of the model, the soils characteristics, and because that nutrient is always in excess in the system, independent from the duration or intensity of grazing. There were no phosphorus stress days in the simulation, while nitrogen was the limiting plant growth factor 86 days during the year on average. Even with a decrease in sediment run-off, more grazing translates into increased phosphorus deposition, at a rate higher than the uptake by plants. Fertilization is not used in the area.

### 3.2.5 Conclusions

The results of this study demonstrated that tropical deforestation can be accompanied by a significant increase in river chemical pollution. Studies in the US have recommended maximum concentrations of total suspended solids that go from 100 mg/L to 25 mg/L for recreational waters, primarily with the intention of protecting aquatic life

[11]. The sediment concentration at the outlet of Nosara, both for the baseline simulation and for the case of total deforestation are significantly higher than those recommended maximum limits. Tourism is by far the most important industry of the area, and that economic activity could be negatively affected if deforestation-driven pollution is not controlled.

In the case of the total nitrogen concentrations, both the value for complete deforestation and for the baseline land cover are below the United States Environmental Protection Agency (USEPA) standard for drinking water of 11 mg/L (as total nitrogen), and the World Health Organization (WHO) standard for short exposure of 53 mg/L, but the WHO establishes a maximum limit of only 0.2 mg/L for long term exposure [12]. Moreover, some of the HRUs generated total nitrogen concentrations of up to 10.4 mg/L. In the watershed more than 2500 individuals take their drinking water directly from creeks and rivers with no treatment.

Phosphorus can cause eutrophication, and although general recommendations from the WHO or the USEPA do not exist in terms of maximum concentrations for recreational waters, the values estimated for Nosara are very high.

No measurements for river sediment and nutrient concentration in the watershed have been published, and therefore comparisons to reference data were not performed, suggesting that the specific absolute values predicted by the model should be used with prudence. In spite of that limitation, the ratios and percent changes estimated in the study showed that agricultural intensification can decrease river chemical pollution provided that manure is treated and/or removed from the watershed during the cattle confinement period. The project also proved that implementing policies that would restrict grasslands

to the areas of lower erodibility can significantly decrease pollution, even if the total pasture area remains constant.

### 3.2.6 References


1. Ramírez O. A. (2000) 'The carbon cycle and the value of forests as a carbon sink: a tropical case study', In: M. H. I. Dore and R. Guevara (Ed.), *Sustainable forest management and global climate change: selected case studies from the Americas*. Edward Elgar Publisher, Northampton.
2. Brown L. R. (1990). The illusion of progress. In L. R. Brown (Ed.), *State of the world 1990*. Worldwatch Institute, Washington, D.C.
3. Barsanti P., Disperati L., Marri P. and Mione A. (2003) 'Soil erosion evaluation and multi-temporal analysis in two Brazilian basins', *2nd International SWAT Conference,* July 1-4 2003, Bari, Italy.
4. Arnold J. G., Srinivasan R., Muttiah R. S. and Williams J. R. (1998) 'Large area hydrologic modeling and assessment part I: model development', *Journal of the American Water Resources Association*, **34**, 73-89.
5. Instituto Meteorológico Nacional. (2003) 'Temperaturas máxima y mínimima para Guanacaste y Puntarenas', [CD-ROM], IMN, Costa Rica.
6. Ministerio de Agricultura y Ganadería. (1998) 'Mapa digital de capacidad de uso de la tierra', [CD Rom], MAG, Costa Rica.
7. Ministerio de Ambiente y Energía. (1998) 'Cobertura del Suelo 96-97', [CD-ROM], MINAE, Costa Rica.

8. Peschel J., Haan P. and Lacey R. (2003) 'A SSURGO pre-processing extension for the ArcView Soil and Water Assessment Tool', *ASAE Annual International Meeting*, 27-30 July 2003, Las Vegas, Nevada.
9. United States Geological Survey. (2004). 'Seamless data distribution system', URL: http://gisdata.usgs.net/website/Seamless/, USGS Eros Data Center, Sioux Falls, South Dakota.
10. Ministerio de Agricultura y Ganadería. (1986) 'Plan de manejo de la cuenca superior del río Nosara', MAG, Costa Rica.
11. United States Environmental Protection Agency. (2005) 'Office of Water', URL: http://www.epa.gov/OW/index.html, USEPA, Washington, DC.
12. World Health Organization. (2004) 'Guidelines for Drinking Water Quality', URL: http://www.who.int/water_sanitation_health/dwq/gdwq3/en/, WHO, Geneva, Switzerland.

### 3.3 Concluding remarks

This paper has shown that agricultural intensification may be a viable solution to increase the production of beef in Costa Rica while at the same time improving environmental performance. However, the Ministry of Agriculture needs to do more to make that happen by, for example, providing credit for the purchase of better pasture seeds, and offering technical support for helping ranchers deal with manure in a responsible way. The use of fertilizers in grasslands is uncommon in Costa Rica. A possible extension of this work would consist in analyzing the potential effect of reducing

area under pasture but intensifying grazing further by using fertilizers. Both bio-physical and economic studies around that subject could be conducted.

Further refining of models such as the one presented in this first paper included in Section 3.2 will be possible after government agencies install gages in rivers other than those suitable for hydroelectric power. The present study has shown the importance of analyzing the hydrology of the country with purposes other than energy generation. Periodic measurement of nutrients would also be helpful to allow for the calibration of the model and to expand its predictive accuracy. And finally, SWAT itself is subject to improvements and expansions. The inclusion of tropical soils in its databases would enable a faster and more methodical model set-up and the expansion of the crops database with different types of trees (beyond deciduous and perennial forest) and crops would generate more accurate results. There is certainly an opportunity for agencies from industrialized and developing countries to cooperate in building better, farther reaching hydrologic models.

The study presented here could also be expanded by utilizing flood prediction software to compare scenarios, and by including biological pollutants, like biochemical oxygen demand. Furthermore, each HRU could be analyzed independently with respect to its energy and mass balances for each pollutant, and soluble and organic nitrogen and phosphorus could be examined separately.

Studying the pollution effects of various forest/pasture ratios in the watershed offers only a partial understanding of the problem of reforestation. The economic dimension is always essential, and it is explored in the next chapter.

# CHAPTER IV

# ECONOMIC MODEL

## 4.1 Introductory comments

This second paper utilizes some of the results from the biophysical model to analyze the problem of deforestation from the economic perspective. The article uses an optimization model to determine the forest/pasture ratio in Nosara that maximizes social welfare, under different conditions.

The general framework for the study is Cost-Benefit Analysis (CBA), which has been a widely used, and also criticized, technique during the past several decades. For example, Lewis (2002) states that conventional markets have trouble dealing with irreversible changes, non-priced goods and the long time lag between cause and effect in ecosystems. Van der Straaten (2002) mentions that it is difficult to value nature when the opinion of future generations can not be accounted for, and Lumley (2002) affirms that CBA is about efficiency, but not necessarily equity.

However, the use of CBA has several advantages: it is a favored method in most policy cycles; it allows for a comparison of alternatives based on one consistent variable; it is a key and necessary step in any policy analysis, particularly in developing countries where the implementation cost of any public measure needs to be carefully weighted

against its benefits; and in this study it is not the only perspective that was considered. Any public policy can make sectors in society better-off and some others worse-off. Decisions based on CBA necessarily imply that redistributive or compensatory mechanisms can be implemented to minimize harm to those that could be negatively affected. Nevertheless, a detailed discussion about social equality at the national level within Costa Rica is beyond the scope of this project.

The model was set-up in Excel in such a way that its Solver function selects the land cover for each HRU as pasture or forest by trying to maximize total societal gains, subject to a maximum allowed pollution output. The model will therefore tend to allocate pasture in HRUs that generate less pollution. The economic data were obtained from interviews conducted on site during 2004 and from published information. The pollution data came from the biophysical model.

It was assumed in this second paper that the potential per area gains from cattle production are constant from one HRU to the next. In practice that may not be the case, because different soils and slopes will result in different pasture and cattle yields and perhaps different expenses for the farmer. However, an inspection of the files generated by SWAT revealed that changes in biomass yield from one HRU to the next are only between 17% and 30%, perhaps because SWAT uses an average slope per sub-basin for all HRUs. Also, higher biomass yields do not necessarily translate into higher animal yields, because grasses are different and after a certain biomass yield animals can not consume more. The biophysical model was based on a constant stocking rate across all pastures in the watershed, and therefore there would be no proper association between pollution levels predicted from SWAT for each HRU and economic data that assumes

different animal yields (and per area profits) in each HRU in this second paper. Finally, the budget from which farmer profits were calculated is for a typical ranch, and it is clear that this may also vary from one farm to the next due to an array of reasons. Therefore the assumption of constant per area returns from ranching is reasonable, particularly considering the many other uncertainties and assumptions included in the development of the model.

To include spatial variability for profits, the researcher would have to explore the biomass yield in each HRU and establish a relationship between biomass and profit. The stocking rate for each HRU would have to be adjusted to reflect the maximum carrying capacity of each area. Then SWAT would have to be run again, because changes in the stocking rate would alter the nutrient cycling in the system, resulting in new biomass yields, which would require another adjustment in stocking rates. Such an iterative process may result in a more realistic estimation of the maximum profits that can be achieved by the private sector in Nosara under different land cover schemes.

## 4.2 Determinants of optimal tropical forest/pasture ratios in the Costa Rican North Pacific

### 4.2.1 Summary

This project analyzed the potential effect of several factors on the proportion of forested land that maximizes net social welfare in a watershed in the North-West of Costa Rica. The ability of landowners to generate high profits from increasing amounts of forested land is the most important determinant of the optimum land cover distribution.

Under conditions of high profitability from private preserves, the current governmental forest subsidy is adequate to promote conservation. Under conditions of low profitability, both an increase in the per area subsidy and an increase in the property taxes for grasslands can accomplish meaningful conservation.

*Key words* – Latin America, Costa Rica, deforestation, forest conservation, economic policy

### 4.2.2 Introduction

Tropical forests have an immense value for providing humanity with dozens of environmental services that include carbon storage, soil conservation, bio-prospecting, water storage, and others (Castro & Barrantes, 1999; Ramirez, 2000). However, their livelihood continues to be threatened by continued falling of trees across the tropics to make room for cattle grazing, crop growing, urbanization and other uses. Productive land should not be expanded at the expense of forested land when the opportunity cost of doing so is greater than that of reallocating productive lands to more valuable uses (Lutz & Daly, 1991). Conversely, it makes sense to reforest if the net present value of such an undertaking is higher than that of exploiting the land in a different manner. The decision-making process of a landowner includes only aspects pertaining to his/her own economic transactions, therefore policy-makers need analyses to understand which resource use provides higher benefits for society at large, so they can implement regulatory instruments to influence the private sector in directions that increase social welfare. The purpose of this study was to estimate the optimum proportion of forested land in a watershed in the North-West of Costa Rica, on the basis of the net economic benefits it

could provide under different scenarios. The study also aimed at explaining and comparing the possible effect of different benefits and costs on that optimum, and at describing the potential consequences of alternative policies.

Costa Rica represents an interesting case to study economic policy for forest preservation. During the mid-1980s the country had the highest deforestation rate in the world, primarily because of an accelerated expansion of pastures to raise cattle for international markets (Brown, 1990; Esposito, 2002; Evans, 1999; Goodstein, 2002). By the mid-1990s pastures covered about 47% of the territory, while some 40% of it was still forested (Brockett & Gottfried, 2002). In 1996 the Forestry Law Amendments created the Environmental Service Payment (ESP): an annual, per hectare subsidy to forest owners for the environmental services their land provides (Sagot, 2000). Subsidies for reforestation and for sustainable forest exploitation were also created. Pastureland decreased from an all time high of 2.4 million ha to 1.35 million ha in 2000, in part because of the ESP, but also because of a decrease in international beef prices (Corporación de Fomento Ganadero, 2000).

The future of reforestation in private lands is uncertain. The push of the government for trade liberalization may result in new beef markets opening up for Costa Rican producers. Although the Forestry Law prohibits further clearing of private lands, visual observations and studies have shown that pastures on highly erodible land remain (Benavides & Veenstra, 2005). Moreover, the Ministry of Agriculture is in general promoting agricultural intensification. On the other hand, a draft bill intended to augment the budget of the ESP through a new tax on potable water has been waiting for approval in Congress for several years. If that bill is eventually signed into law, the best

way to utilize the new funds needs to be analyzed. What influences the optimal level of forest cover in Costa Rica? Is the ESP an effective mechanism to promote conservation? This study intended to shed some light on those inquiries, and on the general challenge of promoting tropical forest conservation in the developing world.

Previous research related to land use alternatives in Costa Rica includes the work by Schipper et al. (1998), who compared the output from different combinations of agricultural and forest commodities on the basis of production costs and local sale prices. They concluded that an annual conservation subsidy of $122/ha would increase the forested area in the North Atlantic zone at the expense of pasture by 50%, while a subsidy of $133/ha would increase it by 120%. Changes in the discount rate had little effect on the optimal land-use pattern. They did not consider indirect costs and benefits, or the potential earnings from exploiting the forest as a tourist attraction. Estimates by Ramirez (2000) indicated that the highest net present value from a reforestation/conservation project can be achieved if monetary compensation for carbon sequestration was received during the first 11 years of forest re-generation followed by a one-time payment for carbon storage. The total value per hectare of forest would be about $1000, but this is less than the typical farm value in Costa Rica today which is about $2400/ha (White, Holmann, Fujisaka, Reategui, & Lascano, 1999).

The present study was based on the Nosara watershed, where 47.5% of the 34,447 hectares are under pasture, 52% under forest, including a privately owned preserve, and the remaining 0.5% of the area includes permanent crops, wetlands and small towns. The basin outflows into the Pacific Ocean. The analysis that follows included not only rent from the land and potential subsidies, but also other factors that could change as a

function of different proportions of forest and pasture in the area due to varying pollutant concentrations in its rivers (Benavides & Veenstra, 2005)[1]: the rent from tourism at the coast and from nearby fisheries; the aesthetic, water and carbon storage, existence and option values of the forest; and the cost of drinking water for residents in the watershed.

The paper offers a conceptual framework in Section 4.2.3, in which all the variables and their relationships are defined, and their values are reported and justified. An explanation for how the optima were determined is given. Section 4.2.4 includes the major results, first for the economic analysis based on the net benefits for the Costa Rican society as a whole, and then for the financial analysis from the perspective of the landowners. The potential effect of subsidies and taxes is explored. Section 4.2.5 summarizes the major conclusions and provides suggestions for future research.

### 4.2.3 Conceptual framework

#### *4.2.3.1 Economic model*

The watershed was divided into 116 hydrologic response units (HRUs) in the construction of a biophysical model that estimated pollutant output from each of those area units according to their land cover (Benavides & Veenstra, 2005). Each HRU is a specific combination of a soil type, land cover and slope. A social welfare function is constructed by adding the profit from managing each HRU either as a pastureland or as a forest, subject to a given maximum allowable pollution level, and by adding other benefits and subtracting costs according to the following equation:

$$W = \sum_{t=1}^{20} \frac{P\sum_{i=1}^{116} A_i X_i + F_t(\sum_{i=1}^{116} A_i Y_i)^{\alpha} + O(\sum_{i=1}^{116} A_i Y_i)^{\beta} - \sum_{i=1}^{116} A_i Q_i + M(1+(R_o - R)\gamma) + N_t(1+(R_o - R)\delta)}{(1+r)^t} \quad (1)$$

Where:

W = discounted net benefit from managing the watershed according to a given pasture/forest land distribution;

t = time. The analysis is conducted for 20 years because current ESP contracts cover an identical period;

r = net social discount rate. It was taken as 2%, 5% and 8%;

i = HRU subscript;

P = annual per hectare profit from exploiting the land as a pasture to raise cattle. Its value is $62.60 and it was calculated from reviewing budgets of typical farms in the area in 2004;

A = area, in ha, of each HRU;

X = a binary variable that takes the value of 1 if the HRU is pasture and 0 otherwise;

Y = a binary variable that takes the value of 1 if the HRU is forest and 0 otherwise;

F = annual per hectare profit from exploiting the land as a preserve and charging visitors an entry fee. Its initial value of $32.76 was taken from the 2004 budget of the only preserve currently located within the watershed. The profit is assumed proportional to the number of visitors, which have been increasing every year since the preserve's creation. A polynomial extrapolation provided the value for subsequent years, until year 7, when the preserve attains its maximum visitor carrying capacity, and the profit is estimated at $102.3. However, a linear profit-

area relationship is not realistic (it would imply that doubling the size of a preserve would double the profits), and that is why F was multiplied by the total area of forested land raised to the power α;

α = area "elasticity" of preserve profit, which was assigned the values of 0.85, 0.90, 0.91, 0.92 and 0.93 in different optimizations;

O = annual per hectare estimated value of forest benefits other than the direct use values, and it includes for example carbon and water storage, aesthetic, option and existence values. The parameter was taken as constant over time, and equal to the amount the government is currently willing to pay owners for the environmental services their forests provide: $34.68 (Fondo Nacional de Financiamiento Forestal, 2005)[2]. Again, whether those benefits are directly proportional to area forested or not is debatable, and that is why variable β was included;

β = area "elasticity" of environmental benefit, which was assigned the values of 0.8, 0.9 and 1;

Q = annual per hectare cost of drinking water for the 2500 people in the watershed who take the water directly from rivers and creeks with no treatment, and therefore could be affected by changes in its quality. It was assumed that when the nitrate concentration in the water within a given HRU is below 7 mg/l, residents will pay the rate charged by a rural aqueduct that works by gravity, according to the approved rates published by the corresponding government authority in Costa Rica (Instituto Costarricense de Acueductos y Alcantarillados, 2004). The standard of 7 mg/l is 70% of the maximum recommended nitrate concentration in drinking water as published by the United States Environmental

Protection Agency (2004). When the concentration is above that level, it was assumed that the rural aqueduct would have to be sourced from a more distant location, requiring pumping, for which a higher rate applies. A water consumption of 75 $m^3$ per year per person was used, and the rural population was assumed to be homogeneously spread across the watershed[3]. Q takes the value of $1.19 for the gravity system and $2.01 for the pumped system;

M = yearly profit from the marine fisheries that could be affected by pollution coming from the watershed. Its value changed less than 25% from year to year during the past decade, and therefore it was taken as the average from the period going from 1992 through 1998, or $2,249,000 (Instituto Costarricense de Pesca y Acuicultura, 2004). The extent to which catch (and corresponding earnings) would be affected by pollution is difficult to estimate and has not been studied for Nosara, although previous research has shown that increases in the pasture cover at the expense of forest increase the concentration of sediment, nitrate and phosphorus at the outlet of the watershed, and that can impair aquatic life (Benavides & Veenstra 2005);

$\gamma$ = percent change in earnings from fisheries for a 1% change in the fraction of the watershed under pasture. The values tested for $\gamma$ included 0.05, 0.15 and 0.25;

R = fraction of the watershed under pasture;

$R_o$ = baseline pasture fraction, which equals 0.475 (Benavides & Veenstra 2005);

$N_t$ = yearly revenue from tourism at the coast, which has been increasing during the past decade and therefore it was taken as the linear projection in revenues from the area hotels from 1994 through 2003 (Instituto Costarricense de Turismo, 2004). The value for year 1 of the simulation equals $218,000 and for year 20 it

equals $471,000. No obvious limits to that growth exist in terms of space for new hotels. The demand for recreation at the coast is expected to decrease with increasing area covered by pasture, because of aesthetic reasons, and also because increasing pollution at the coast;

$\delta$ = percent change in tourism revenues for a 1% change in the fraction of the watershed under pasture. The values of $\delta$ that were tested include 0.4, 0.5 and 0.6.

Pastures can also be expected to have lower rainfall infiltration rates: their soils are less permeable due to compacting from the cows, there is less rainwater interception in the absence of trees, and therefore during strong rain events the probability of having a flood could increase if the pasture cover increases at the expense of forests (Brooks, 1997). However, the historical information available regarding the costs of response and reconstruction due to floods is very limited and it has been reported in varying formats that do not allow for a consistent estimation of the monetary expenses corresponding to the watershed under study. Those costs were therefore not included in the model.

Equation (1) is subject to the constraints that all variables are positive, and that the total sediment concentration S at the outlet of the watershed be less than or equal to a certain value. The sediment concentration was chosen as the pollution variable, because it is the most relevant in terms of potential negative effects for aesthetics, tourism and aquatic life (Brooks, 1997). For a given value of S, the solution of equation (1) is calculated by selecting for each land unit i its cover (pasture or forest), or equivalently, by assigning $X_i$ and $Y_i$ the value of 0 or 1, in such a way that the total net social welfare is the maximum possible. Subsequent changes in S will give way to new solutions with a

certain total percent area under pasture and a certain value of W. S can take values between 83 mg/l, corresponding to a watershed that is entirely covered by forest, and 414 mg/l, corresponding to a watershed that is totally covered by grassland (Benavides & Veenstra 2005).

*4.2.3.2 Financial model*

From the point of view of the landowner, only the net rent from exploiting the land and any government taxes or subsidies are relevant. The new objective function is as follows:

$$W = \sum_{t=1}^{20} \frac{P\sum_{i=1}^{116} A_i X_i + F_t(\sum_{i=1}^{116} A_i Y_i)^{\alpha} + O\sum_{i=1}^{116} A_i Y_i}{(1+r)^t} \quad (2)$$

In equation (2), O becomes the annual per hectare environmental service payment (subsidy) that can be given to owners of forested land. In addition to the baseline of $34.68, three alternative values were tested: $39.01, $43.35 and $52.02, corresponding to increases of 12.5%, 25% and 50% above the baseline, respectively. The third term in the numerator in equation (2) is subject to a constraint that it be less than or equal to a certain hypothetical budget B that the government would have, and that was chosen in different optimizations as the equivalent to what would be needed to subsidize 25% of the watershed, 50%, and 75%. The total amount of money needed to provide the subsidy to 25% of the land at the current per area rate is about $299,000 per year, which is feasible considering current budgets, past practices, and how this financial support has been managed up to now (Fondo Nacional de Financiamiento Forestal, 2005).

In the financial analysis, the profit P of exploiting land as a pasture for cattle grazing was modified by testing different rates of property tax ε. Currently, landowners pay as property tax the equivalent to 1% of the land value per year. The current land value in Nosara is around $2,262.00/ha, according to residents of the area. The values of ε tested included 1%, 2%, 3%, 4% and 5%, for corresponding values of P of $62.60, $57.48, $52.36, $47.25 and $42.13.

The models represented by equations (1) and (2) were both programmed in Microsoft Excel, and they were solved using the software's non-linear solver. All monetary values used and reported are in 2004 US dollars. The major results appear in the next section.

### 4.2.4 Results and discussion

#### *4.2.4.1 Economic model*

Figure 4.1 depicts the relationship between net discounted social welfare W and percent area in pasture, for different values of the area elasticity α of preserve profit. For all other variables the mid values were selected to plot the figure: β=0.9, r=5%, γ=0.15 and δ=0.5. When α=0.85, an increase in the size of a forest preserve results in only a modest increase in return, compared to the opportunity of keeping the land under pasture to raise cattle, and therefore moving from right to left on the graph W decreases rapidly. The optimum corresponds to 100% pasture. However, as α increases, the corresponding value of W for 0% pasture becomes larger and larger, and the optimum shifts towards the left: for α=0.9 the optimum is 92% pasture, for α=0.91 it is 83%, when α=0.92 it is 46% and the difference between W at 100% forest and at 0% forest is the smallest (about

$500,000), and finally when α=0.93, W is maximum at a percent cover under pasture of 0% and at that point the per area net discounted benefit is $1744/ha.

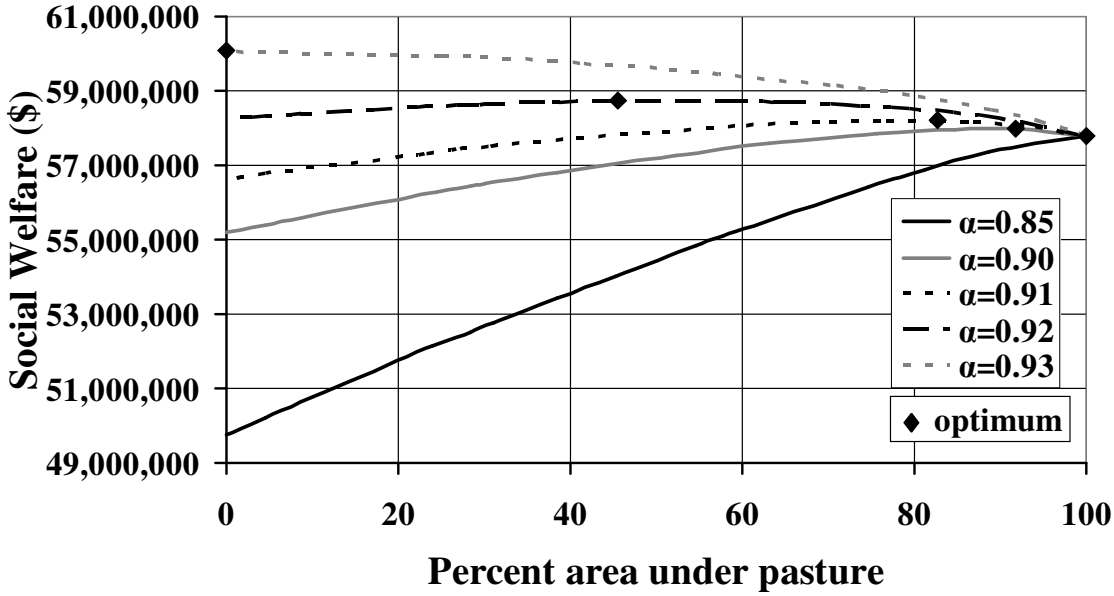


Figure 4.1. *Effect of the area elasticity of profit preserve on the relationship between social welfare and area under pasture*.

The extent to which new forested areas managed as private preserves could generate a profit similar to the one in operation today within Nosara is a major factor in defining what the optimum forest cover would be, from the perspective of a watershed manager or regulator. For subsequent results within the economic analysis, α was fixed at 0.93.

Figure 4.2 shows the effect of the area elasticity of environmental benefit β on the relationship between net social welfare and percent area under pasture. Higher values of β increase W for any given percent area under pasture, except for 100%, where W is fixed for any value of β because no significant environmental benefits are accounted for

when the watershed is entirely grassland. Changes in this elasticity do shift the optimum. Taking β=0.9 as a baseline, a decrease to 0.8 changes the optimum from 0% pasture to 82%, and an increase to β=1.0 keeps the optimum at 0% pasture but it increases W from about $60 million to about $70 million. The extent to which increasing forest cover provides declining returns from environmental services accounted for in variable O is a significant factor in calculating the optimum proportion of forest and pasture. For subsequent estimations, β was fixed at 1.0.

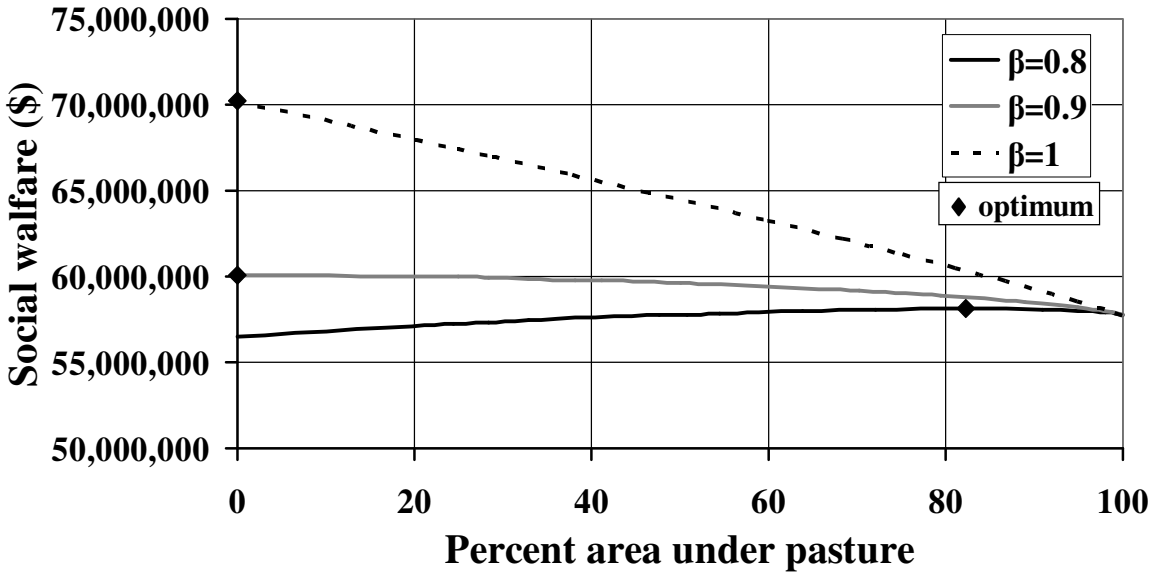


Figure 4.2. *Effect of the area elasticity of other environmental benefits on the relationship between social welfare and area under pasture.*

Table 4.1 summarizes the results for all the other parameters tested in the economic model. In all cases, under all combinations of γ, δ, and r, the optimum is 100% forest. Varying γ, the parameter that relates changes in fishing earnings to changes in land cover, only modifies W by about $1.4 million at the optimum. The effect of δ, the

variable that relates changes in tourism earnings at the coast to changes in land cover, is even less pronounced: it changes W by only about $200,000. Earnings from tourism are significantly lower than earnings from fishing, and that explains why the model is more sensitive to γ than δ. Finally, the net social discount rate r, when decreased from 5% to 2%, increases W by more than $20 million, because future profits are worth more in the present when r is lower. Consequently, when r is increased from 5% to 8%, W decreases by more than $14 million, and the present value of future profits is lower.

Table 4.1. *Effect of fisheries, tourism and discount rate on the optimum percent cover under pasture and corresponding social welfare*.

| Variable | Values tested | Optimum percent cover under pasture (%) | Net Social Welfare W ($) |
|---|---|---|---|
| γ | 0.05 | 0 | 69,029,719 |
| | 0.15 | 0 | 70,427,893 |
| | 0.25 | 0 | 71,826,066 |
| δ | 0.4 | 0 | 70,015,967 |
| | 0.5 | 0 | 70,221,930 |
| | 0.6 | 0 | 70,427,893 |
| r | 2 | 0 | 92,740,377 |
| | 5 | 0 | 71,826,066 |
| | 8 | 0 | 57,450,633 |

*Note*: in all cases α=0.93 and β=1.0

*4.2.4.2 Financial model*

The effect of the total subsidy budget B for the watershed at two different area elasticities α for preserve profit is presented in Table 4.2. When α is high (0.93), the optimum amount of land preserved as a forest from the point of view of the private sector is directly related to B. If the government has a budget equivalent to what is needed to provide subsidies for 25% of the watershed, then the private sector maximizes returns by keeping 25% of the land under forest. When B is 50% the optimum percent cover under forest is 50%, and a B of 75% "buys" the preservation of 75% of the watershed.

Table 4.2. *Effect of the subsidy budget on the relationship between net profit and area under pasture*.

| α | B | Optimum percent cover under pasture (%) | Net Social Welfare W ($) |
|---|---|---|---|
| 0.93 | 25% | 75 | 38,611,901 |
| | 50% | 50 | 40,621,314 |
| | 75% | 25 | 42,420,342 |
| 0.85 | 25% | 98 | 36,021,001 |
| | 50% | 98 | 36,021,001 |
| | 75% | 98 | 36,021,001 |

*Note*: in all cases r=2% and O=$34.68

Table 4.2 also shows that when α is high, as B increases the optimum value of net profit W also increases. When B=75%, the net discounted profit per area is $1,231/ha. Under the optimistic scenario of a high α, the current per area subsidy rate is sufficient to

promote conservation, and an increase in the subsidy budget would be able to keep more land forested[4].

When α is low (0.85), and as long as the annual per hectare subsidy O is kept at $34.68, no meaningful amount of conservation can be achieved, regardless of the subsidy budget. For all values of B, the optimum is to have 98% of the watershed as grassland, and at that point W is $36,021,001. If α equaled 0.85, what could be done to motivate the private sector to conserve the forest? Two other potential policies were tested: first increasing annual per hectare subsidy for forests, keeping B constant at 25% for each value of O, and then increasing the property tax for pastures.

Figure 4.3 shows how the net profit for the private sector changes as a function of percent area under pasture, for different values of the subsidy rate. A 12.5% increase above the baseline raises O to $39.01, and it shifts the optimum from a pasture cover of 98% to 94%, raising total discounted profit by about $90,000. A further increase to $43.45 (a 25% change with respect to the initial O) makes 75% pasture the new optimum, with W=$36,423,579, and finally making O=$52.02 (a 50% increase over the baseline value) keeps the optimum at 25% forest, but raises W to $37,668,903. Of the values tested, the last two achieve the preservation of 25% of the watershed, but the best option would be $43.45 because the government expenditure would be lower, and it would total about $374,000 per year (an increase of $75,000/yr above the baseline). Increasing the subsidy rate above current values can be an effective way of promoting conservation in the area under the pessimistic scenario of a low α.

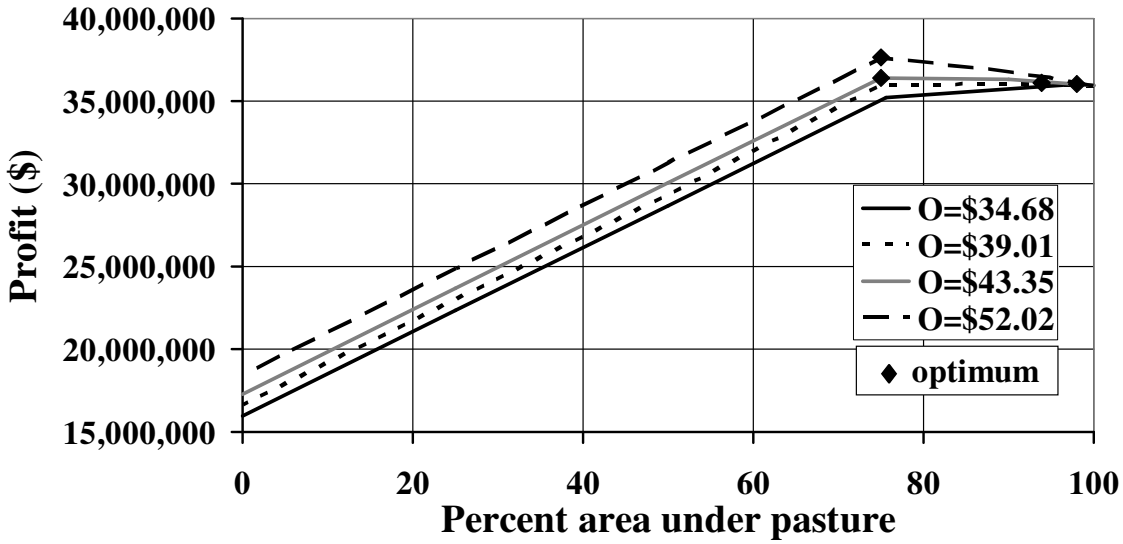


Figure 4.3. *Effect of the subsidy rate on the relationship between net profit and area under pasture*.

The effect of raising the property tax on pastures in increments of 1% is shown in Figure 4.4. In this series of optimizations, O is kept at $34.68 and B is kept at 25%. An increase in ε decreases net profit W for every percent area under pasture because higher taxes leave less money in the farmers' pocket. Changes in ε also shift the optimum. Increasing the tax from 1% to 2% shifts the optimum from 98% pasture to 92% pasture. When ε=3% or higher, the optimum W corresponds to 25% of the watershed as forest. The best tax rate is therefore 3%, as long as it is combined with the subsidy, because higher tax rates would not increase the forested area beyond 25%.

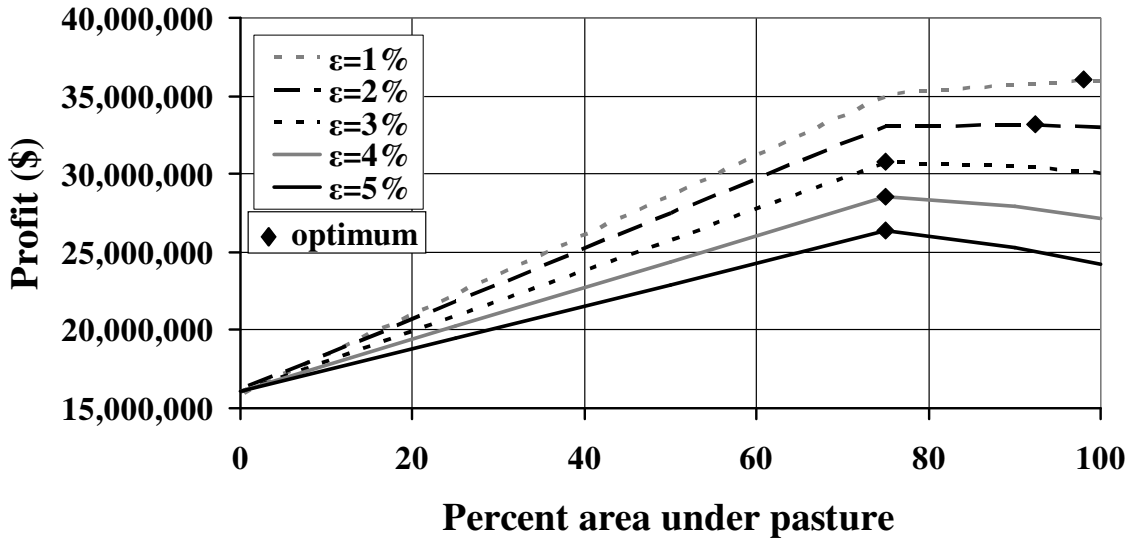


Figure 4.4. *Effect of the property tax on the relationship between net profit and area under pasture*.

The effect of the discount rate was also tested during the financial analysis. The results were similar to what was found in the economic analysis, in that higher values of r result in lower values of W at any percent pasture, without changing the optimum land cover distribution.

4.2.5 Conclusions

Of all the factors tested in this study, the ability of the private sector to generate profit from increasing amounts of forested land under preservation status is the most significant in predicting what the optimum land cover should be. Forest reserves in private hands have been growing in Costa Rica throughout the years; to the point that today almost 500,000 ha fall into that classification, representing almost 10% of the total surface of the country (Villegas & Hernández, 2004). Many of those properties have

ecotourism as their primary purpose, and they generate yearly rent that ranges from $21/ha to $90/ha depending on the number of services they offer[5]. A policy aimed at promoting conservation should therefore consider providing tools to the rural landowners to help them succeed in managing a preserve in a highly profitable way. Education and preferred lines of credit could be some of those tools. High profits from exploiting a preserve translate into more money for the owner, potentially a higher supply of land for conservation, and therefore more environmental benefits for society.

With respect to non-market values, two opportunities exist. First, aesthetic, option and existence values need to be measured in Costa Rica in a systematic and comprehensive way, utilizing techniques such as contingent valuation or others. Very few isolated attempts have been made, resulting in measurements hard to extrapolate at a national level (Pierce & Moran, 1994). And second, economic transactions for carbon sequestration and storage have in the past occurred, but again, in an isolated and inconsistent manner (Evans, 1999; Steinberg, 2001). The ratification of the Kyoto Protocol may open up new funding prospects for Costa Rica, as long as the country aggressively pursues them. More accurate measurements of non-use values and the establishment of a stable carbon market would favor conservation.

This study has shown that under conditions of high preserve profitability net social welfare increases as the forest cover increases. It follows that promoting conservation makes sense, to the extent that the country is not forced to import beef in the future for lack of pastures, something that to a certain extent can be prevented through agricultural intensification. We have also suggested that under those high profitability conditions the ESP is an effective mechanism to promote conservation at the current per

area rates and therefore new funds, if they became available from the proposed tax on potable water, would be better used to expand the area to be subsidized, instead of increasing the per area rate[6].

About 80% of private preserves are today receiving the ESP. Currently the number of applications is five times larger than the number of contracts being signed per year, which shows the interest of the private sector in that subsidy (Villegas & Hernández, 2004). Those already owning a forest may simply be trying to increase their earnings through the ESP, but it remains to be seen if the subsidy will motivate a significant amount of the remaining ranchers to let their land recover back into a forest, particularly considering conversion costs. A potential strategy for a rancher would be to apply for the reforestation subsidy first, reforest the farm in stages, and start offering tours to visitors as soon as the conversion starts. A number of farmers have actually been successful in keeping small forested areas within their properties and offering horseback riding tours. Visitors seem to be interested not only in the forested tracts, but also in learning about cattle raising and the local culture in general (Andrade, 2004). That strategy would guarantee a relatively constant rent for the owner until the conversion to forest is completed.

Under conditions of low preserve profitability, both an increase in the per area ESP rate and the use of an increased property tax on pastures would promote conservation. The difference would be in the policy and politics implications and the gains and losses of consumers' surplus among different sectors of the economy and the government.

The problem of deforestation in Costa Rica and the tropics in general is highly complex and dependent on more factors than one single study can cover. Potential future trade agreements could open new markets for Costa Rican beef and move the financial analysis in favor of cattle production due to an increase in expected returns for the rancher, decreasing the flow of environmental benefits. However, policy analysis is a dynamic phenomenon, and the use and adjustment of a regulatory instrument such as the ESP seems to be promising for promoting conservation in the developing world.

### 4.2.6 Notes

1. Pastures generate more pollution into rivers compared to forests because the plant cover is sparser, the soil becomes more erodible to the effect of wind and rain, grazing by cattle generates debris, and part of the manure is transported by surface runoff to the rivers. The study by Benavides & Veenstra (2005) modeled the effect of varying proportions of grassland and forest in Nosara on the concentrations of sediment, nitrogen and phosphorus at the outlet of the watershed.

2. The ESP rate for conservation is typically increased every year due to inflation. Because of changing exchange rates, its value in US dollars varies. For this study, the price of 2004 was utilized and it was converted into US dollars using the average exchange rate for that year. Twenty percent was deducted from the resulting figure due to administrative and legal expenses that have to be borne by the recipient of the subsidy every year, and that includes for example audits by a third party forestry engineer.

3. The value of 75 $m^3$ lies between what is considered optimum and what is considered the minimum acceptable by the World Health Organization (2003). The water cost factor is relatively unimportant in the model, as it represents only about 1% to 2% of the total net present value obtained from a typical optimization run.

4. The figures reported in this paper for the potential net present value of managing tropical forests and pastures lie between ranges offered elsewhere (Pierce and Moran, 1994), but it is clear that current land values are higher than the expected rent from either land use. Reasons like, tradition, being used to a way of life and lacking information about potential gains from alternative investments explain why some individuals would not consider anything other than raising cattle and they are not interested in selling their land. On the other hand, individuals not driven by profit, primarily foreigners, who see themselves as conservationists, or who simply want to own a piece of the tropics as a long term investment are willing to pay $2,400/ha or more for a property around Nosara.

5. This information, as well as many details about prices, costs and the managing of farms and forest preserves in Costa Rica was obtained from a series of conversations with landowners and administrators that took place, either in person, through the telephone or through email, during 2004.

6. The studies by Schipper et al. (1998) and Ramirez (2000) came up with significantly higher figures for the subsidy rates that would promote conservation, because they did not include in their analysis the potential gains from exploiting a forest preserve as a tourist attraction.

4.2.7 References

Andrade, Z. (2004, January 18). Tiquicia se reinventa. *La Nación*. Accessed on 18 January 2004. Available: <http://www.nacion.com/>.

Benavides, F., & Veenstra, J. N. (2005). The impact of tropical deforestation on river chemical pollution. *To be presented at the 9th Conference on Environmental Science and Technology*. Rhodes, Greece, 1-3 September 2005.

Brockett, C. D., & Gottfried, R. R. (2002). State policies and the preservation of forest cover: lessons from contrasting public-policy regimes in Costa Rica. *Latin American Research Review, 37*(1), 7-40.

Brooks, K. N. (1997). *Hydrology and the management of watersheds*. Ames, Iowa: Iowa State University Press.

Brown, L. R. (1990). The illusion of progress. In L. R. Brown (Ed.), *State of the world 1990*. Washington, D.C: Worldwatch Institute.

Castro, E., & Barrantes, G. (1999). Generación de ingresos mediante el uso sostenible de los servicios ambientales de la biodiversidad en Costa Rica. San José, Costa Rica: Instituto Nacional de Biodiversidad.

Corporación de Fomento Ganadero. (2000). Censo bovino nacional (unpublished document). San José, Costa Rica: Author.

Esposito, L. (2002). Integrative conservation. *SAIS Review, 22*(2). 53-75.

Evans, S. (1999). *The green republic: a conservation history of Costa Rica*. Austin: University of Texas Press.

Fondo Nacional de Financiamiento Forestal. (2005). Pago de Servicios Ambientales. Accessed on 12 January 2005. Available : <http://www.fonafifo.com/paginas/psa.htm>.

Goodstein, E. S. (2002). *Economics and the environment*. New York: John Wiley & Sons.

Howard, A. F., & Valerio, J. (1996). Financial returns from sustainable forest management and selected agricultural land-use options in Costa Rica. *Forest Ecology and Management, 81*(1-3). 35-49.

Instituto Costarricense de Acueductos y Alcantarillados. (2004). Tarifas para Acueductos Rurales (unpublished document). San Jose, Costa Rica: Author.

Instituto Costarricense de Pesca y Acuicultura. (2004). Estadísticas Pesqueras. Accessed on 13 November 2004. Available: <http://www.infoagro.go.cr/incopesca/estadis.htm>.

Instituto Costarricense de Turismo. (2004) Montos recibidos por trimestre por concepto de impuestos de turismo (unpublished document). San Jose, Costa Rica: Author.

Lutz, E., & Daly, H. (1991). Incentives, regulations and sustainable land use in Costa Rica. *Environmental and Resource Economics, 1*(1). 179-194.

Pearce, D., & Moran, D. (1994). *The economic value of biodiversity*. London: Earthscan Publications Limited.

Ramirez, O. A. (2000). The carbon cycle and the value of forests as a carbon sink: a tropical case study. In: M. H. I. Dore & R. Guevara (Ed.), *Sustainable forest management and global climate change: selected case studies from the Americas*. Northampton: Edward Elgar Publisher.

Sagot, A. (2000). *Manual de Legislación Ambiental: ley orgánica del ambiente, concordada, con jurisprudencia constitucional y legislación relacionada en anexos*. San José, Costa Rica: Investigaciones Jurídicas S. A.

Schipper, R. A., Jansen, H. G. P., Bourman, B. A. M., Hengsdijke, H., Nieuwenhuyse, A., & Sáenz, F. (1998). Evaluation of development policies using integrated bio-economic land use models: applications to Costa Rica. *Research program on sustainability in agriculture*. Turrialba, Costa Rica: Centro Agronómico Tropical de Investigación y Enseñanza.

Steinberg, P. F. (2001). *Environmental leadership in developing countries: transnational relations and biodiversity policy in Costa Rica and Bolivia*. Cambridge, Massachusetts: MIT Press.

United States Environmental Protection Agency. (2004). List of Drinking Water Contaminants & MCLs. Accessed on 10 December 2004. Available: <http://www.epa.gov/safewater/mcl.html#mcls>.

Villegas, J., & Hernández, C. (2004, March 13). Crecen áreas forestales privadas. *La Nación*. Accessed on 13 March 2004. Available: <http://www.nacion.com/>.

White, D., Holmann, F., Fujisaka, M., Reategui, K., & Lascano, C. (1999). Will intensifying pasture management in Latin America protect forests – or is it the other way around? In A. Algensen & D. Kaimowitz (Ed.), *Agricultural Technologies and Tropical Deforestation*. Wallingford: CABI Publishing.

World Health Organization. (2003). Domestic water quantity, service level and health. Accessed on 22 November 2004. Available: <http://www.who.int/water_sanitation_health/diseases/wsh0302/en/index.html>

## 4.3 Concluding remarks

A detailed shadow price analysis is beyond the scope of this study and it was not included in the paper, which was written for a multi-disciplinary audience. An inspection of the sensitivity reports generated by Excel from the optimizations in the economic model would allow for estimating the pollution based tax that would make society indifferent between keeping the land as forest and exploiting it for cattle production, under various scenarios. The shadow prices varied between zero dollars per milligram of sediment per liter when pollution is not constraining, to $27,000/(mg/l) when the combination of variables is such that the profit from raising cattle is greatest compared to the profit from exploiting a forest preserve.

An alternative to a shadow price analysis is to use the financial model to explore the effect of a tax on pollution, instead of a tax on the land. The results of those simulations are included in Appendix 2. A tax on pollution would "punish" highly erodible, infertile, sloped farms more than those on flat, fertile areas, potentially forcing the most polluting to go out of business first.

It is worth noting that the decision-making process of the landowner does not obey a pure cost-benefit comparison. Even with the existence of subsidies for conservation, some individuals decide to continue raising cattle in low productivity lands because of lack of information, customs, traditions and risk aversion. This second paper has shown that it makes sense to maximize forested land if profits from exploiting the forest are high, but knowledge is needed to successfully and profitably manage a preserve.

Another important consideration is the labor market. Cattle raising requires about one full time employee for every 50 animals, or about a person per 50 ha. The type and quantity of labor to manage a preserve can vary significantly. The only private preserve within Nosara has two full time employees for over 400 ha, and on a monthly basis they earn an amount similar to what an individual working in a farm would make. However, a preserve that includes a lodge, a restaurant, horseback riding tours and other amenities would require more personnel and a more specialized labor force.

The economic study compared two land cover conditions in steady state: forest and pasture. Conversion costs were not included in the analysis. Deforestation in Costa Rica is banned under the Forestry Law, except with approved sustainable management plans for forest exploitation. Reforestation on the other hand is what the tested policy instruments aim at achieving, but SWAT is not very suitable to model tree growth, and therefore it would be difficult to estimate pollution generation from the different HRUs during conversion from pasture to forest. The paper however showed that from the economic point of view the conversion is feasible because the land owner can receive a reforestation subsidy and potentially obtain some rent from tourism while the conversion to forest is completed. A detailed analysis that includes conversion costs would be a relevant addition to the project presented here.

Another way to further expand the study would be to test changes in other variables. For example the category of "other environmental services" (variable O in Equation 2) could be refined and divided into potential gains from carbon sequestration, water storage, option, and existence values, etc. That would require the design of surveys or other mechanisms to obtain the information.

An alternative to preservation and to cattle raising is forest exploitation. That third option could be included in an expanded land use analysis of the Costa Rican North-West. Schipper et al. (1999) estimate that forests in Costa Rica can be exploited in a sustainable manner with a yield of 0.6 $m^3$ of wood/ha.yr with an annual return of $16/ha. The value of wood in a plantation goes from about $179/$m^3$ to about $10/$m^3$ depending on the species and diameter of the tree (Cámara Costarricense Forestal 2003). The yield of common species like teak in Costa Rica is significantly higher than the world average. During the 1980s and 1990s more than 170,000 ha of land were reforested for wood exploitation and currently that sector of the economy provides jobs to about 20,000 people. The future of wood exploitation in the country is nevertheless uncertain, due to a recent decrease in import taxes that is allowing material from Chile and Canada to be sold in the national market at relatively low prices. Moreover, the average value of land for reforestation in Costa Rica is about $1,000/ha, while in neighboring countries like Nicaragua it is about $250/ha, making those countries more attractive to foreign timber companies (Barquero 2004).

In any case, the study of economic policy and the recommendation of a regulatory instrument based on an economic analysis are not sufficient to generate results. This second paper has shown that under conditions of low preserve profitability both an increase in the ESP and in the tax on grasslands can achieve meaningful preservation. But which of those alternatives is better? Which one is likely to enjoy wider acceptance if proposed in the Costa Rican Congress? What would have to happen for such a policy to be implemented? The next chapter answers those questions.

# CHAPTER V

# POLICY IMPLICATIONS

## 5.1 Introductory comments

This last paper describes the perceptions different stakeholders have about the problem of deforestation in Costa Rica and its potential solutions. It then compares two of the regulatory instruments analyzed in the economic model according to a number of criteria, and finally it recommends the instrument that turns out to be superior. The study is based on semi-structured interviews that were conducted during 2004 to fifteen individuals who represent different groups concerned with deforestation in the country and that have historically played a prominent role in environmental policy-making in Costa Rica (Evans 1999). The plan to conduct the interviews was filed at the Oklahoma State University Institutional Review Board, and their approval is included in Appendix 3. Furthermore, some of the questions utilized are listed in Appendix 4.

A discussion of policy implications is a key ingredient in any effort to propose a solution to a societal problem. A recommendation based purely on environmental and economic modeling, without regard to matters such as political implementability and stakeholder acceptability would leave out essential considerations about the possibility of the policy to be approved and implemented successfully.

However, policy analysis is a highly complex, non-linear, multi-disciplinary process. The information presented and analyzed in this third paper is only a sample of a full-blown public policy study, which is beyond the scope of this dissertation. For example, lengthy explanations about the causes of deforestation in Costa Rica, detailed justifications regarding the people who were chosen for the interviews, a thorough validation of the policy comparison criteria and an exhaustive substantiation of the final policy ranking were not included in the paper. Nonetheless, the information the 15 interviewees provided shed some valuable clarification about the many dimensions of environmental policy-making in Costa Rica.

## 5.2 Strengthening conservation in the tropics: the water canon of Costa Rica

### 5.2.1 Abstract

This article analyzes a policy intended to augment the funds for subsidizing forest conservation in Costa Rica through a tax on the consumption of potable water. The perceptions different stakeholders have toward the problem of deforestation and its potential solutions are described, and the potable water canon is compared on the basis of legitimacy criteria to the alternative of imposing a tax on the exploitation of marginal lands. Overall, the water canon is a superior policy from the point of view of technical implementability and political feasibility. The regulation is expected to increase the forest cover in private hands in a more effective way than the tax on marginal lands, while keeping government expenditures to a minimum. The policy context is one of high expert and social trust, and low government trust, requiring substantive stakeholder education and the creation of feedback mechanisms to increase acceptability during the

implementation period. If approved by the Costa Rican Congress, the water canon will become an innovative conservation policy from which other developing countries will be able to obtain valuable lessons.

Keywords: Deforestation; Costa Rica; Conservation policy; Subsidies.

### 5.2.2 Introduction

The tropics are home to some of the last primary forests on Earth, many of which continue to disappear at an alarming speed, even though they have an immense value for providing society with an array of services such as carbon sequestration and storage, soil conservation, bio-prospecting, water storage, eco-tourism, and others (Castro and Barrantes, 1999; Ramirez, 2000).

Although 28% of the surface area in Costa Rica enjoys some type of preservation status, the country lost more than 50% of its forest cover during the last century (Esposito, 2002). By the mid 1990s pastures covered about 47% of the territory, while some 40% of it was still forested (Brockett and Gottfried, 2002). The government reacted with the 1996 amendments to the Forestry Law, which created the Environmental Service Payment (ESP), a subsidy to be given to owners of forested lands as a compensation for the services they provide to society at large. During the past eight years, about 50% of pastures were left to recover into forest, perhaps due to the ESP, but also because of a fall in international beef prices that made cattle production a less profitable business (Corporación de Fomento Ganadero, 2000). The extent to which the ESP has been an effective mechanism is questionable, considering that several pastures still exist today in fragile, highly erodible and sloped terrains (Castro and Barrantes, 1999). An insufficient ESP budget may be part of the problem. Most of the funding

comes from a 3.5% tax on fossil fuels, but that can only subsidize one fifth of the current supply of land for conservation (Villegas and Hernández, 2004). Moreover, the push by the government to sign free trade agreements may open up new markets for Costa Rican beef, and that could stop reforestation efforts and put pressure on the last remaining forested tracts in private hands.

The Environmental Affairs Commission of the Costa Rican Congress has recently completed a three year process that culminated in the draft bill "Law of the Hydrological Resource". The act would impose a tribute on the consumption of potable water, a "water canon" or tax whose revenues would be used in part to augment the budget for the ESP (Asamblea Legislativa, 2005). The purpose of this article is to analyze that regulation as a solution to the problem of deforestation in Costa Rica, by comparing it to another option, based on aspects of technical practicability, economic efficiency, political feasibility, administrative implementability, and stakeholder acceptability (Clemons and McBeth, 2001), and subject to the perceptions or frames through which key stakeholders perceive the problem and its potential remedies (Bryson, 1995). The analysis is based on a series of interviews that were conducted during 2004 and that included representatives from academia, the central government, municipal governments, national and local activists, ranchers, and owners of private preserves.

The paper is organized as follows: Section 5.2.3 offers an explanation of the causes of deforestation in Costa Rica, Section 5.2.4 describes the views different stakeholders have about the problem, Section 5.2.5 lists the policy alternatives that were analyzed and compares them, and Section 5.2.6 presents a recommendation with a discussion about policy adoption considerations.

### 5.2.3 The problem of deforestation in Costa Rica

In 1775 the governor of the province of Costa Rica, under Spanish rule at the time, issued a proclamation discouraging controlled burns on the basis that too much land was being cleared and causing soil sterility. In 1846, several decades after independence, a decree stating the prohibition to cut trees near some key waterways was proclaimed (Steinberg, 2001). The phenomenon of deforestation is not new. It happens when a land owner chooses to cut the forest to make room for something else, or when squatters trespass on a property illegally for tree logging. The following paragraphs describe some of the current land uses that compete with the forest in Costa Rica, and some of the factors that can influence a private owner towards conservation.

#### *5.2.3.1 Illegal deforestation*

Unlawful logging began to take on significant proportions in Costa Rica during the middle of the 20th century, due to population growth, the unstable job market in banana plantations, the lack of a rural development policy, and lax property rights. In 1941 a law would allow possession of up to 300 hectares of land as long as the occupant cleared at least half of it and maintained cattle at the minimum rate of one animal for every 5 hectares. Those "improvements" would give the landholder a chance to obtain title, but many of them never cared to get their land registered (Brockett and Gottfried, 2002).

In 1961 the Institute of Lands and Colonization was created to help individuals with no land who were looking for a place to live. Tax sanctions were imposed on owners not cultivating their land (that regulation was not abolished until 1977), while

squatters were given access to some areas where they were allowed to practice agriculture. The problem was not well controlled until the mid-1980s, when environmental education and fund raising were successful in helping those individuals relocate away from protected and privately owned areas (Evans, 1999). Illegal deforestation in Costa Rica still occurs sporadically, but not as before. The issue has been reduced to controllable levels and that is why its influence in the overall deforestation problem can be considered weak.

*5.2.3.2 Urbanization*

Urbanization was a major driver of deforestation during the first half of the 20th century in the Central Valley, where two thirds of Costa Ricans live and where political and industrial centers are located. Outside of that region the weight of urbanization in the current landscape is not that significant. Moreover, this phenomenon is not expected to be a determining factor for the future of the last remaining private forests, because the population is expected to cease growing later this century, (the fertility rate today is just at replacement level). Immigration, often illegal, needs to be considered, but in the great scheme of things it is not expected to be a strong driver for the demand of urbanized land (Proyecto Estado de la Nación, 2003).

*5.2.3.3 Forestry*

In 1987 the exportation of logs and unprocessed timber was banned, depressing domestic wood values to a fraction of international prices, weakening reforestation incentives, and subsidizing inefficient wood production industries (Hartwick and Olewiler, 1998; Southgate, 1995). The government then established a reforestation and forest exploitation incentive to energize that activity, but pressure from non-

governmental organizations (NGOs) has weakened that policy instrument. Those who are interested in reforesting purely for conservation complain that the subsidies given are too small, while activists complain that forestry is profitable without any incentive and therefore tax-payers' money should not be spent in subsidizing it. According to the experts that were interviewed, although forestry continues being a viable economic activity in the country, it is no longer growing, primarily because the cost of land in Costa Rica has made it less profitable than before.

*5.2.3.4 Agriculture*

Coffee was the driver of Costa Rica's economic development from the middle of the 19th century through the third quarter of the 20th century. Bananas were introduced in the early 1900s, and agriculture was diversified in the 1950s. Another diversification wave occurred in the 1980s with the introduction of fruits, flowers, and other "non traditional products" (Wilson, 1998).

The harsh reality of the international coffee and bananas markets has taken growers through violent ups and downs and it has forced some of them to go out of business. In a monopsony with increasing producer competition prices can change drastically and growers are destined to loose. Agriculture continues being an important economic activity in Costa Rica, but it has fallen behind tourism and manufacturing, and nowadays it no longer poses a significant threat against conservation (Brockett and Gottfried, 2002).

*5.2.3.5 Pastures for raising cattle*

All authors agree in that deforestation in Costa Rica has been driven primarily by the expansion of pastures to raise cattle to satisfy external beef markets (Brockett and

Gottfried, 2002; Brown, 1990; Castro and Barrantes, 1999; Evans, 1999; Goodstein, 2002; Lutz and Daly, 1991). From 1956 to 1982 the funds used to provide credit to support ranching rose from 13.8% of total state credit to 23.3% (Lutz and Daly, 1991).

However, towards the end of the 1990s competition from other countries and a subsequent decrease in international prices forced a significant reduction in the production of cattle in Costa Rica. Today the beef sector is hoping to grow its production again by differentiating its product under the category of "organic", and by increasing exports after free trade agreements are signed.

The decision to reforest or not, or to deforest or not, is based on what the expected benefits of forested land are, as much as it is based on the expected benefits of deforested land. A few of the benefits of conservation are explained below.

*5.2.3.6 Recreational values*

Ecotourism emerged during the 1990s as a great incentive to conservation. By 1994 tourism as a whole was the major earner of foreign exchange (Brockett and Gottfried, 2002), and today that sector generates 20% of the country's foreign income. It represents 5% of Costa Rica's gross domestic product, and it employs about 12% of its labor force (Rivera, 2002).

These days it is not uncommon for land owners to cater to ecotourists on their own forests. On occasions, neighbor associations have joined forces to purchase small tracts of land for conservation and recreation. That has represented a more stable source of income when compared to growing crops (Andrade, 2004).

Tourism of course has potential dangers associated with negative environmental impacts. One attempt to prevent its possible damaging effects was the creation in 1997 of

a Certification of Sustainable Tourism (CST) by the Costa Rican Tourism Board (ICT), which is a performance-based, voluntary environmental program. CST was designed by a partnership of academic institutions, the major hotel trade association, and some environmental NGOs. By 1999 115 hotels had decided to enroll in the program and 52 had been audited and given a rating. By 2000 ICT began including CST in its international advertisements, and the World Tourism Organization decided to adopt the Costa Rican program as its voluntary environmental certification (Rivera, 2002).

*5.2.3.7 Bio-prospecting*

In Costa Rica national parks have a relatively low human impact and they are well suited for research, contrary to the case of most of the US, Europe or Africa. In 1992-1993, Merck paid $1 million to the National Biodiversity Institute (INBIO) for an agreement to conduct research on potential drugs derived from the country's biodiversity to cure a few specific diseases (Evans, 1999). Other bio-prospecting deals are underway, and both state owned and private preserves regularly host researchers and charge them fees. The 1997 Biodiversity Law was aimed at conserving biodiversity, promoting its sustainable use as a resource, and distributing in a fair manner its associated costs and benefits. The law declares that biodiversity is the property of the state (Sagot, 2000).

*5.2.3.8 Carbon sequestration and storage*

Up to 70% of the benefits from forest preservation in Costa Rica accrue to the global community through carbon sequestration (Brockett and Gottfried, 2002). This is where the "debt for nature swaps" and other similar initiatives come to play. The swaps were an idea proposed by a group of international environmental NGOs that were successful at enlisting the participation of a few donor governments and several

recipients. During the early stages of that program fifteen countries participated and Costa Rica alone obtained one third of all the funds, in part because it had a significant institutional capacity and a large network of NGOs willing to help and put pressure on the government. By 1991, over $40 million had been erased from the country's debt through that mechanism (Keohane, 1996; Steinberg, 2001).

The Costa Rican Office for Joint Implementation (OCIC) was created during the mid-1990s for the issuance of carbon bonds to be traded following the scheme proposed by the Kyoto protocol. A few transactions have already taken place: in 1997 Norway paid Costa Rica two million dollars for the sequestration of 200,000 tons of carbon. The following year, the Dutch government received a carbon bond equivalent to $673,000 it paid for projects aimed at reducing methane emissions, and the next year they put up another $334,000 for carbon fixation. Twenty year carbon storage certificates issued by Costa Rica, valued at between $40 and $80 million, are currently being marketed at the Chicago Mercantile Exchange, and the ratification of the Kyoto Protocol may bring several buyers in the near future (Ramirez, 2000).

*5.2.3.9 Government incentives*

The 1996 amendments to the Forestry Law resulted in the creation of new incentives for conservation that were established to compensate landowners for the environmental services provided by their forested lands. The environmental service payment is offered at a rate of $510 per hectare for reforestation, to be given during the first five years of a 20 year contract. For sustainable forest management the rate is $310/ha, and finally $230/ha are paid for forest preservation and natural regeneration for five year contracts (Brockett and Gottfried, 2002). Many of the recipients of those

payments are NGOs. In 1997 alone, $14 million were paid for environmental services covering some 100,000 hectares. The law includes in its definition of environmental service carbon sequestration and storage, and the protection of watersheds, biodiversity, and ecosystems (Castro and Barrantes, 1999). Although some activists complain that the amounts given are too small, today there are more applicants for the benefit than recipients, and consequently an increase in the ESP funds would be able to prevent further deforestation (Villegas and Hernández, 2004). The next section reflects on the current conservation policy context and whether it is conducive for the implementation of a regulation that would increase the ESP funds or not.

### 5.2.4 Problem framing

To analyze the perceptions surrounding the problem of deforestation in Costa Rica, a series of concept maps or frames were created from semi-structured interviews in which different stakeholders expressed how they understand the issue, its components, the relationships among them, and the potential solutions (Bryson, 1995). The interviewees were selected based on political or rational authority. All the participants hold some position of authority within organizations that participate in policy deliberation. People from both the capital city and a rural area were chosen, but not all regions of the country where incorporated, and the process did not consider demographic variables. The Nosara watershed, in the North-West of Costa Rica was selected as the rural area, and it is considered as a valid case for the study of deforestation because the biggest proportion of cattle ranches in the country are located there, and that area suffered the most intense deforestation during the 1980s and the most significant recovery during

the past few years. A major fraction of the forests in private hands are located in that region. However, other locations in the country may have slightly different dynamics, and the agriculture, urbanization, forestry and tourism components may mix differently in each place.

Each group of interviewees, along with their associated motives and trust judgments, is portrayed in Table 5.1. The major observation that can be drawn from the list is that trust is pervasive, except on the side of the NGOs, which distrust the central government's competence and degree to which they act in the public's interest. They also distrust the private sector's honesty. But that mistrust is not reciprocal. The central government has taken into account the views of activists in the past and they recognize them as legitimate players in the policy-making process, and that is acknowledged by NGOs themselves. The private sector is also not overly concerned with activists, which are seen as part of the political landscape, but not as a threat. The local government also has some reservations about some of the policies supported by the central government.

The context for a deforestation policy is one that first of all acknowledges the progress made in the country so far, in particular since the passing of the Forestry Law amendments of 1996. Since deforestation on private lands is practically banned, the real question is whether something can be done to increase the current amount of forest, particularly in highly unfertile, sloped, erodible terrain.

Another contextual dimension is that of the role of the state. The conservation policy of the 1970s and 1980s was based on a clearly interventionist drive by which the state would expropriate vast tracts of land that would then be converted into National Parks. Many of those expropriations have not yet been paid in full to former land

owners, and considering that more than 25% of the country is already under some type of preservation status, the current intent of the state is that of enabling and facilitating conservation by the private sector, instead of doing it themselves (Varela and Corella, 2003).

Table 5.1: Actors, their motives and their trust judgments

| Policy actor | Motto / motives | Trust judgment |
|---|---|---|
| Central government | Save the country – maximize benefits for all | No evidence of distrust toward other actors. Sees itself as open and receptive. Working on "continuous improvement". |
| Local government | Save the county – progress for all | No evidence of distrust to any other actor, but some reservations with respect to the central government. Sees itself as provider of the people. Interested in citizen's economic progress and county development. |
| National NGO | Save the forest – nature is to be protected | Distrusts both industry and the government, but satisfied with participation opportunities and has been able to influence other stakeholders in the past. |
| Regional NGO | Save the people – nature sustains people | Distrusts both industry and the government, but satisfied with participation opportunities and has been able to influence other stakeholders in the past. |

Table 5.1 (cont): Actors, their motives and their trust judgments

| Policy actor | Motto / motives | Trust judgment |
|---|---|---|
| National cattle growers organization | Save the ranchers – ranching is good for the country | No evidence of distrust to any other actor. Works to improve productivity and conducts production research. |
| Local private cattle producer | Save the ranchers – ranchers have a right to their way of life | Slight distrust towards central government, but overall satisfied with the status quo. |
| Local private preserve | Save the forest – protecting the environment is a good thing | No evidence of distrust to any other actor. Satisfied with the status quo. |
| Academia | Save the country – sustainable development is the key | No evidence of distrust to any other actor. |

The contemporary environmental policy history of Costa Rica suggests that lack of inclusiveness has been responsible for mediocre and ineffective solutions in the past. The alliance between the central government and the scientific community has always been strong. The role of the private sector has been irregular, and in terms of conservation their input has not been the determining factor in policy discussions, until

recently. Also recent has been the role played by NGOs (Evans, 1999). Any relevant move to perpetuate the conservation gains of the past few years and make deforestation policy robust in Costa Rica will have to be inclusive. A suitable stakeholder participation strategy would avoid extremes such as pre-emption or exclusive third party mediation. In the present case consultation seems to be the best approach, with the government taking the lead in the process, using academia as an objective technical resource, and making an effort to obtain and consider input from activists and the private sector.

The concept maps of different stakeholder groups are explained in the following paragraphs. Figures 5.1 through 5.4 were created by listing all the main terms or subjects mentioned by the interviewees and writing them on rectangles of three different sizes, according to how frequently they were mentioned during the conversation and how much importance was given to each of them by the stakeholder. The rectangles were positioned such that related concepts are close to one another. Arrows were used occasionally to show relationships emphasized by the participants.

Figure 5.1 suggests that the Costa Rican Federation for the Protection of Nature (FECON) considers the ESP a good policy instrument, and they emphasize the need to expand it through the revenues the water canon component of the Hydrologic Resource Law would generate. They also see the need to force the tourism industry to contribute to the ESP fund, because they are major beneficiaries from the protection of nature in general. More than 75% of the tourists in Costa Rica express that their major reason for choosing that destination is its natural beauty (Evans, 1999).

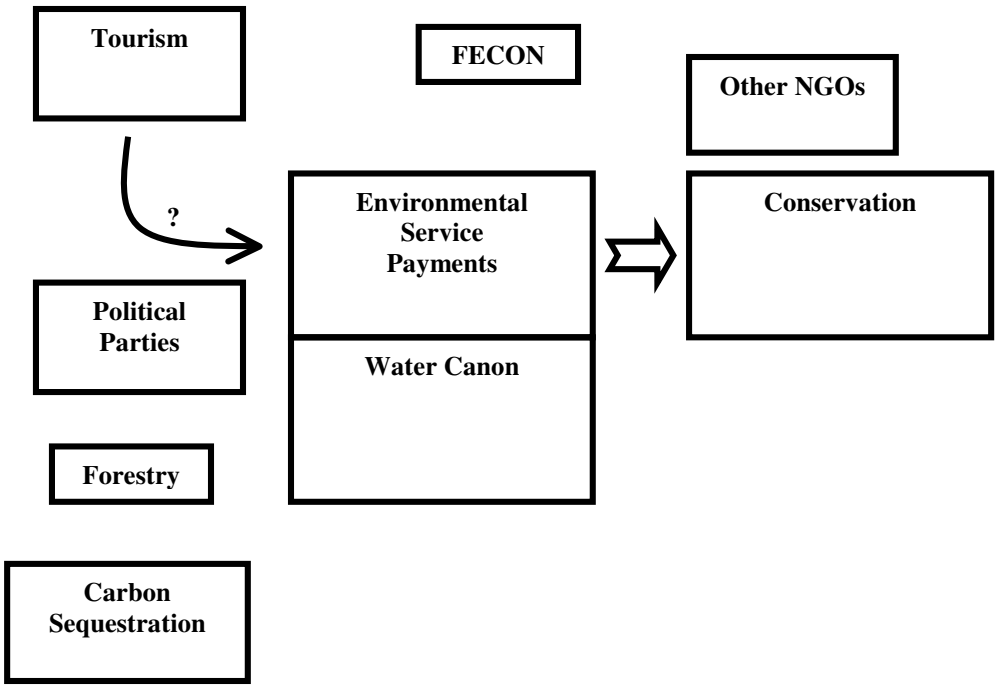


Figure 5.1: The frame of a national NGO

The view of FECON with respect to the role of the political parties and the difference between the two major ones is that their role has been irregular and inconsistent, for example they support the ESP but also massive tourism, which can be detrimental for the environment. The role of the government is accepted as that of a policy-maker with the legitimacy to establish regulations and enforce them, but there could be a potential conflict if prominent NGOs in Costa Rica continue feeling that the actions of the government are contradictory and insufficient. With respect to the role of forestry, FECON accepts it as a viable and legitimate economic activity, provided that no taxpayers' money is spent subsidizing them.

Figure 5.2 conveys the message from the cattle sector: problems related to deforestation do not stem from grasslands per se, but from improperly managed ones, corresponding to the "traditional pastures" rectangle on the left of the diagram, shown in

stark contrast to the "improved pastures" block on the right. Their view is that farms that utilize good seeds, rotation, and otherwise modern and sustainable techniques have only benefits for the community, but unfortunately still today many ranchers operate in a sea of ignorance where infertility, overgrazing, low yields and pollution are common.

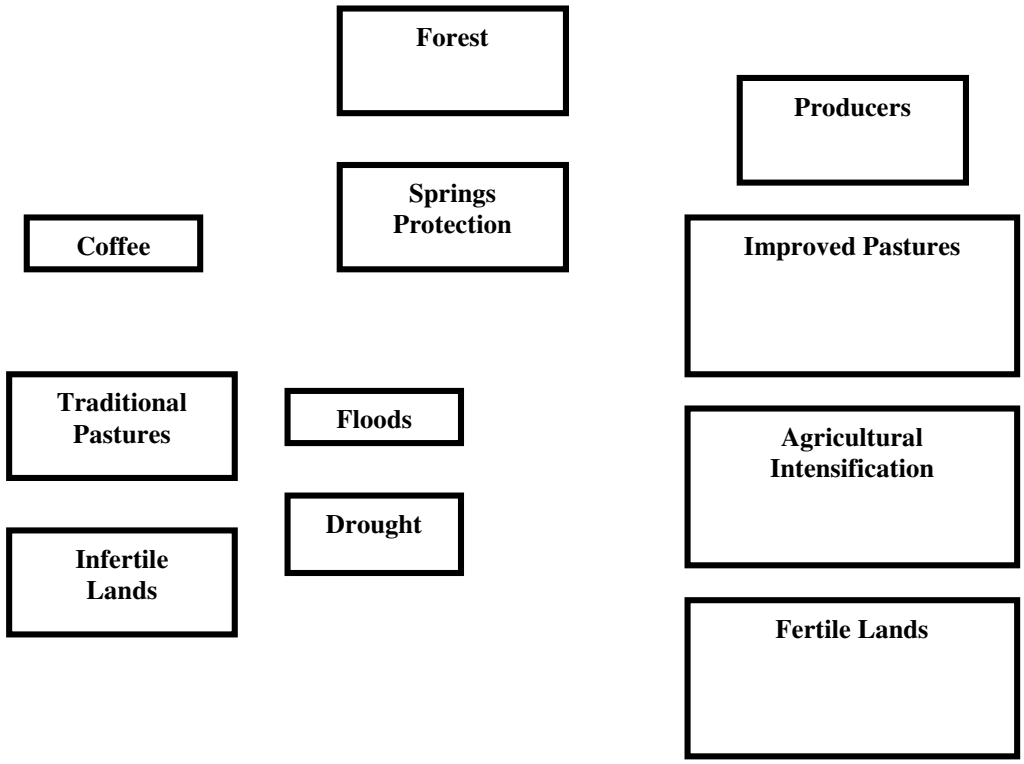


Figure 5.2: The frame of the cattle sector

Figure 5.3 is the result of a high degree of consistency in the opinions expressed by leaders from the major political parties and a congressman, who emphasize the strong degree of consensus in Congress around environmental matters. The major parties see the ESP as something to be fortified with the water canon, but they also recognize the

role, value, and importance of different sectors in society, like the cattle sector and the forestry sector, that can prevent undesirable wood imports.

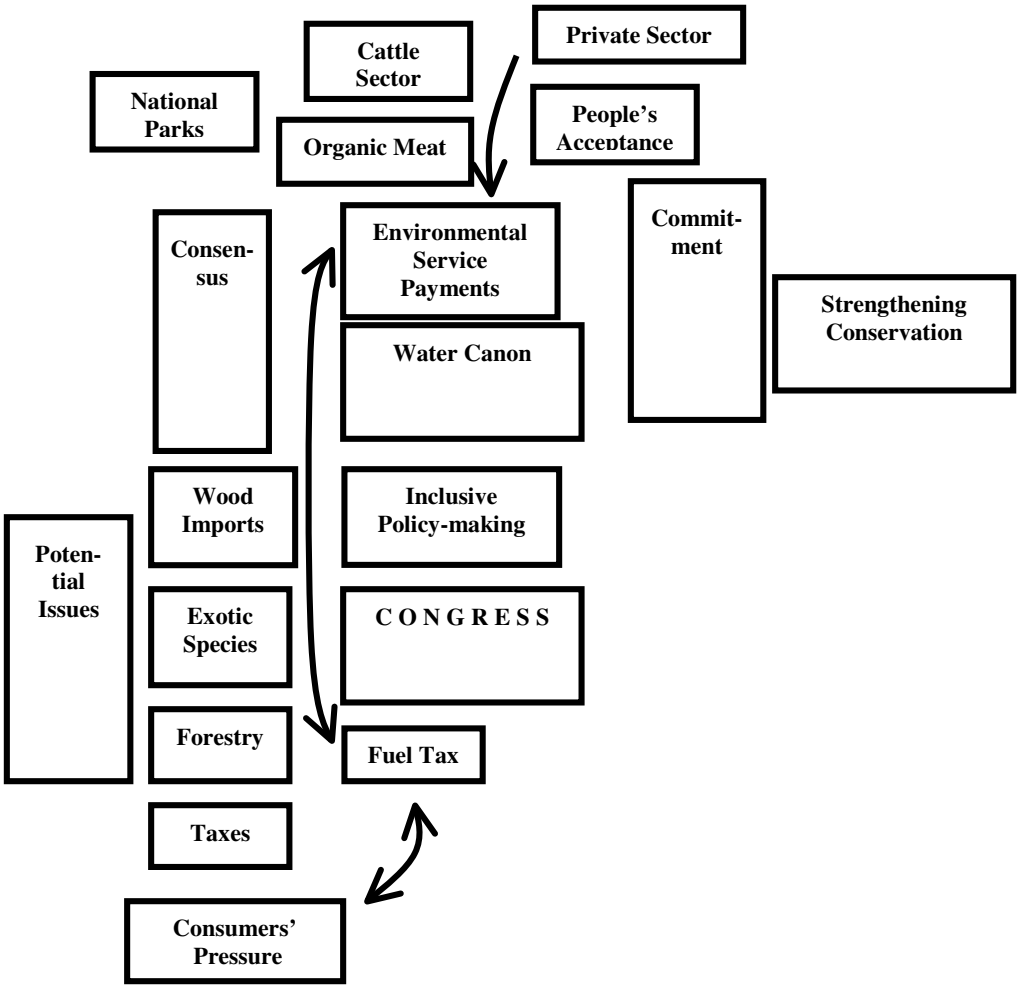


Figure 5.3: The frame of Congress

The congressional apparatus sees itself as committed to the protection of the environment, proud of the progress made so far with successes such as the consolidation of the National Parks System, and excited about the prospects of the draft bill Law of the Hydrologic Resource and its water canon component, which has been distilled from a

lengthy participatory process through which several sectors in society were consulted. Public acceptance of congressional actions is important to them. The government is also thinking about ways to motivate or force the private sector in general so they make contributions to the ESP. The national electricity distribution agency has been voluntarily donating funds to the ESP for a few years, because most of the electricity in Costa Rica comes from hydroelectric dams, fed by water stored in forests.

Figure 5.4 combines the views of a municipal government and rural offices of the agriculture and the environment ministries.

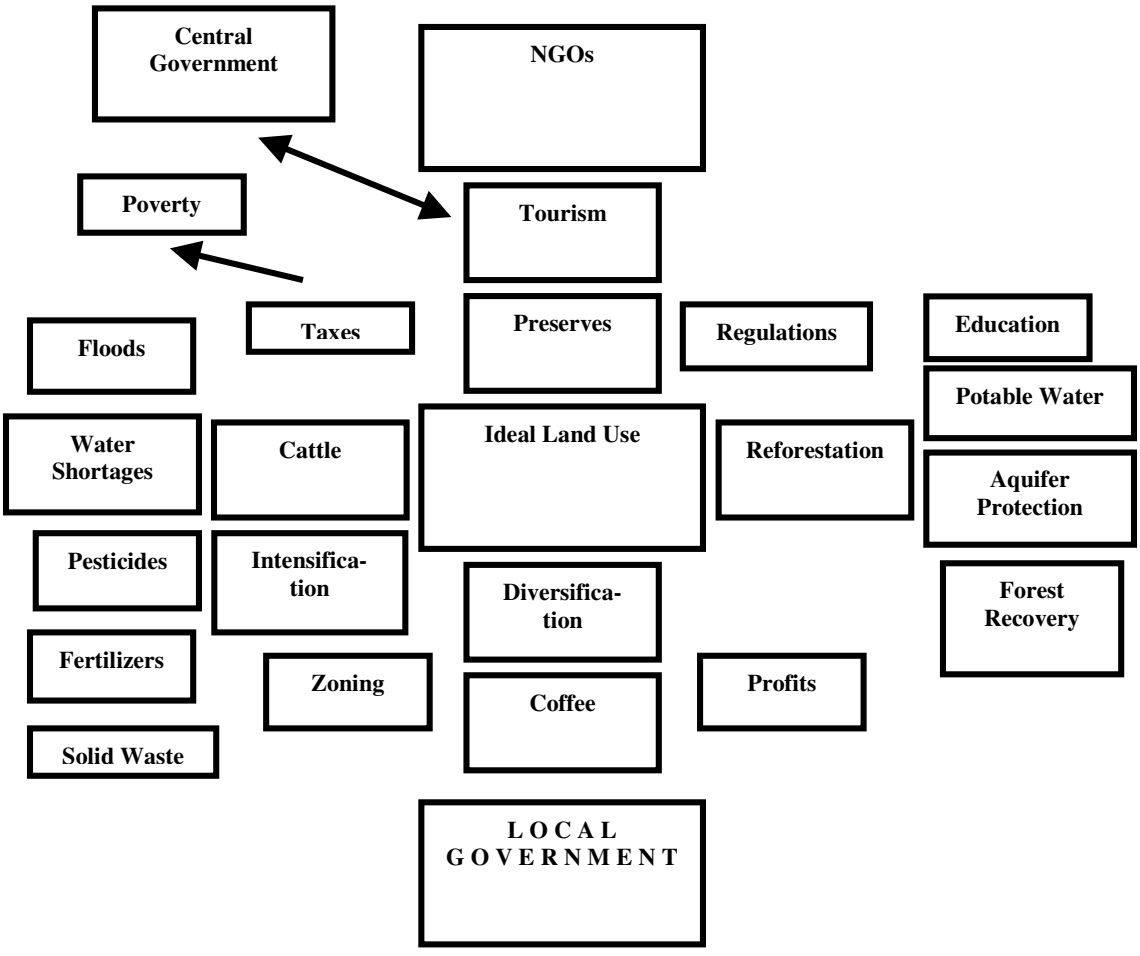


Figure 5.4: The frame of the local government

For them, the current land use is very close to being ideal. The current situation is the result of the interests of the private land owners and the implementation of effective regulations (including zoning and taxes). They see as positive and relevant the diverse existing land-uses and their associated benefits. The advantages of a balanced land-use pattern are listed on the right of the map. One case of policy consensus and one of policy conflict and can be drawn from this figure. The first one is the beneficial and prominent role that the local government gives NGOs, which are regarded as allies in the protection of the environment and the quest for sustainable development. The second one is the dissenting view with respect to some of the policies promoted by the central government, like massive tourism. There is a visible gap between the central and the local governments, and legitimate policy will require at least a partial closure of that gap.

Other observations from the figure include the view that taxes have to be regarded carefully, because the standard of living of citizens in remote locations is often low, and additional dues could draw people further into poverty. And finally, problems other than deforestation are regarded as more important by the locals, and those appear on the left of the map.

The aggregate map is shown in Figure 5.5. Society appears in the middle, as the entity that is composed of the actors previously described and others, and as the unit that debates between allocating land to conservation (right side) or other uses (left side). Conservation is in general seen as a good thing, while most actors tend to discuss other land uses in a negative way, or in a way that accepts them as valid but not preferable to conservation. The case of domestic demand for wood potentially becoming larger than supply stands out from the "forestry" rectangle, because it is a preoccupation of several

people. A crisis in the forestry sector could lead to the unwanted situation of importing wood.

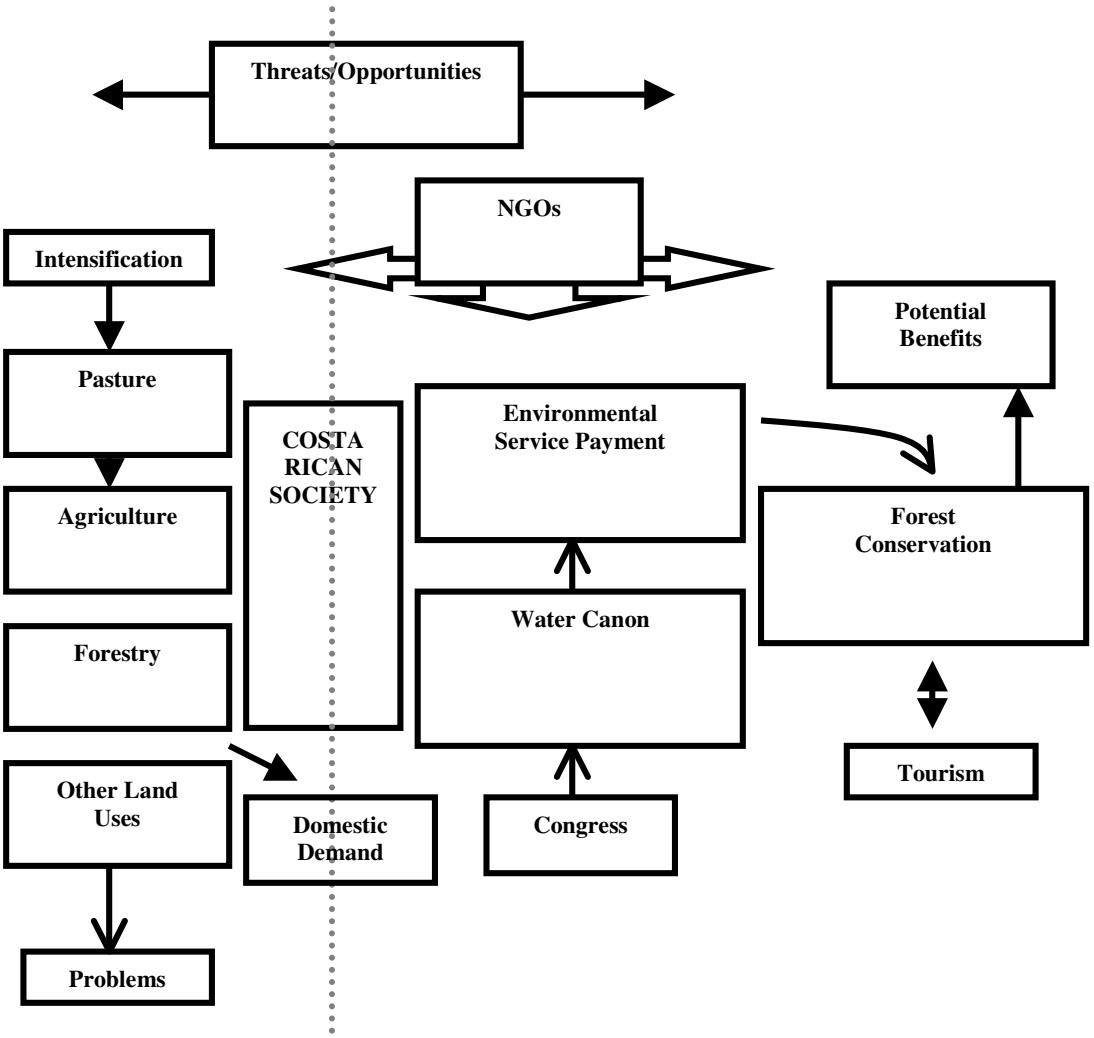


Figure 5.5: Aggregate map

Environmental service payments are seen as a good thing that should be augmented with the water canon, something to be discussed in Congress and currently supported at large by those who know about it. Tourism is both a beneficiary of conservation and a potential promoter or detractor of it, depending on whether it is done

in an environmentally sound way or not. Finally, NGOs appear represented in a prominent way as watchers and influencers of everything related to the dilemma of land use decisions and policies.

The main areas of disagreement apparently are between local and central governments and between NGOs and the central government. Since Congress is the one taking the lead in proposing legislation to strengthen conservation, it is imperative that the views of municipalities, ministry branches and NGOs be taken into consideration. The major potential consensus will take place among ranchers, local government offices, and NGOs.

### 5.2.5 Policy alternatives

The two policy alternatives were chosen from a review of the conservation history of Costa Rica and from the opinions of experts consulted. The first one consists in increasing the funds for conservation subsidies, like the water canon intends to do through the Hydrologic Resource Law by imposing a tax on the consumption of potable water. An alternative aligned with the drive by the government to avoid pure command and control is to increase the cattle production tax on marginal lands. Other types of more recent and complex regulatory instruments, such as tradable permits, are excluded from the analysis due to the lack of experience with them in Costa Rica[1].

[1] Inaction is also a viable alternative, but it is highly questionable that it would accomplish the goal of increasing the forested area in private hands. If the ESP continues with its funds limited to revenues from the fossil fuel tax and occasional donations, then very few new contracts would be signed for additional conservation. The panorama for the next few years would consequently be one similar to the status quo,

Table 5.2 shows the ranking of the two alternatives according to legitimacy criteria and associated goals (Clemons and McBeth, 2001).

Table 5.2: Policy alternatives ranked against legitimacy criteria

| # | Legitimacy criteria | Objective | Superior policy | |
|---|---|---|---|---|
| | | | **Increase subsidies** | **Tax ranching** |
| 1 | Technical implementability | Turn infertile, sloped, erodible land into forest | √ | |
| 2 | Technical implementability | Increase forested land in private hands | √ | |
| 3 | Economic efficiency and administrative implementability | Minimize expenses for the government | - | - |
| 4 | Political feasibility | Utilize tested policy instruments | √ | |
| 5 | Stakeholder acceptability | Maximize acceptance of the policy | | √ |

*5.2.5.1 Technical implementability*

The ability of the policy to achieve its major intended goal is explored here. The first objective is the most important one, since it would turn areas of low productivity and prone to high pollution loads into forests. The second objective is also relevant and it stems from the general desire by the government and other stakeholders to continue recovering the forest that was lost to pastures during the second half of the 20th century.

with the majority of the ESP used to pay existing contracts. For that reason this alternative was not included in the analysis.

There are obvious constraints to forest expansion, such as the societal need to satisfy to the extent possible the food and housing requirements of the citizenry, and the fact that forest in some locations can not grow due to climatic and soil conditions. Values, customs, and perceptions also play a role in the decision-making process of the land owner. Even after the implementation of policies aimed at influencing the private sector towards conservation, some individuals will continue keeping their farms.

The ESP however would make conservation more attractive for ranchers operating at low profitability levels, and therefore it is considered a technically feasible solution to increase forested land. The tax on marginal lands could also work by discouraging the production of cattle in those locations, with the added benefit of revenue generation for local governments.

However, an increase in the property tax is not as likely to influence a farmer as much as an incentive. The tax increase can prompt the farmer to negotiate with the authority the valuation of the property (the tax is based on property values), to look for ideas to maintain profitability, and to complain. The ESP offers something in exchange for abandoning the grassland and letting it recover into forest: a constant stream of revenue. It is also important to consider that although grassland is the major competitor of forest in Costa Rica, it is not the only one. The tax on cattle production attacks the biggest problem, but not the only problem, while the subsidy for conservation has a wider scope, promoting conservation in many places, not only around pastures. The water canon is therefore considered a superior policy from the technical implementability perspective.

*5.2.5.2 Economic efficiency and administrative implementability*

Decisions are made in a context of scarcity, and so the policy maker should be concerned about obtaining the biggest return for the minimum expense. Also, a policy that is perceived as "efficient" may gain higher acceptability than one that is not.

The increase in government expenses with the implementation of the Hydrologic Resource Law would be minimal, since the ESP and its administrative agency already exist. The program would simply have to establish a procedure whereby the money collected through the water canon is channeled from the water suppliers to them. The law calls for the creation of a new agency that would assume all the duties related to water use, but its staff would be composed of individuals currently working for other agencies that up to now have had partial responsibilities with respect to water issues. Also, since the law creates a new tax on the consumption of potable water it is expected that administrative expenses would be paid by the new revenues.

A similar reasoning applies to the tax on marginal lands: municipalities collect and administer property taxes in Costa Rica, and the program proposed here is simply a modification of such existing mechanism. The increase in government expenditures is therefore expected to be minimal in both cases, and as a consequence, both alternatives are considered equal from the perspective of economic efficiency and administrative implementability.

*5.2.5.3 Political feasibility*

For the past several years, Congress has lost interest in purchasing land to convert it into State-owned protected areas. Improvements in conservation are wanted, but through non-interventionist policies. Also, cattle production is perceived by most

stakeholders as a viable and needed economic activity in the country and therefore the use of pure command and control to force ranchers to abandon their lifestyle would not be supported by many.

Neither alternative is putting strict, specific limits on the grassland coverage in the country, but a tax that is automatically converted into a subsidy for conservation that can positively affect the entire country is a far more reaching and benign policy instrument than simply a tax that will affect a few and can be perceived by the far right as unjust and an attack on free enterprise. The increase in the subsidy budget is therefore considered superior in that respect to the tax on marginal lands.

*5.2.5.4 Stakeholder acceptability*

Since the Hydrologic Resource Law would impose a tax on drinking water, people living under the poverty line would be the most affected, but there could be an exemption for the first several liters consumed per month, so as not to affect the most disadvantaged. The regulation has been widely discussed and it is a good example of participatory policy-making. Also, according to Steinberg (2001), a survey conducted during the mid-1990s concluded that 91% of Costa Ricans were willing to pay more for electricity and water if the additional money was to be used for biodiversity conservation. Therefore, it can be envisaged that people's satisfaction with this alternative will be high.

The tax on marginal lands would be harder on small, low revenue farms. Those who decide to abandon cattle production would have to be helped in finding another way of making a living, and the design of such a compensation mechanism would minimize resistance against the policy. That is not unreasonable and it has been done in the past. Esposito (2002) for example, discusses at length the case of integrative conservation in an

area of the North-West of Costa Rica in which former farmers became park rangers or tourism entrepreneurs when their lands were expropriated to expand a conservation area. Another issue related to the tax may be a potential increase in the price of domestic beef. If the area dedicated to pastures decreases, supply may become limited forcing the price up. Nevertheless, the drive by the government to promote agricultural intensification on fertile lands may counter-balance that scenario. The tax would affect only a relatively small number of people, while the benefits would accrue to society at large, and therefore this alternative is considered superior to the water canon in terms of stakeholder acceptability.

*5.2.5.5 Summary*

Taxing cattle production in marginal lands is superior to increasing conservation subsidies only with respect to one objective, while increasing the subsidies for conservation is superior with respect to three objectives, and there is one tie in the analysis[2].

Although increasing taxes on marginal lands is a viable alternative that might enjoy wider acceptance by most stakeholders, the Hydrologic Resource Law is a superior policy because it is expected to be more effective in reaching the goal of converting all

[2] As an additional comparison tool, an analytic hierarchy process (AHP) was simulated with Expert Choice (2005). The software requires pair-wise comparisons between criteria and the ranking of each alternative against each criterion, either using a numerical system or value judgments. The final synthesis obtained corresponded to a score of 0.592 for the alternative of increasing conservation subsidies, while taxing cattle production had a score of 0.408, and the model inconsistency was 0.08. This result supports and complements what was obtained in Table 2, in that the subsidy option is superior to the tax option by a relevant, although not dramatic, margin.

remaining pastures in fragile lands to forest and increasing the total forested area in private hands. Both alternatives are less interventionist than pure command and control, none of them is expected to increase real government expenditures, and both are policy instruments that have been tested in the past with relative success.

The draft bill is seen in a positive way by the two major political parties, the main NGOs, and academia, and therefore it is expected that it will convey political benefits to the policymakers, considering that a strong opposition is not likely from any important constituency. The bill was a prominent part of two of the four individual concept maps and the aggregate map presented in Section 5.2.4, and the policy would not conflict with existing regulations or administrative agencies.

### 5.2.6 Conclusion

This study has shown that the views from the major stakeholders about the problem of deforestation in Costa Rica are conducive to the successful implementation of the Hydrologic Resource Law as a policy to strengthen conservation in the country. Its water canon component is a superior regulatory instrument when compared to the alternative of increasing taxes on marginal lands.

The problem of deforestation in Costa Rica is primarily about observable facts. Values play a role, but one that supports facts in that Costa Ricans are in general supporters of conservation. Trust in experts is therefore high. Moreover, about 80% of Costa Ricans understand the value of conserving forests for water storage (Castro and Barrantes, 1999), indicating that social trust is also high. Trust in the government, on the other hand, tends to be low. Although people tend to remember some of the highlights of

past administrations, in general the government is perceived as favoring the interests of a few and lacking implementation skill. Policy-making under this context needs to be articulated by experts with little stakeholder involvement, and then the government adopts the regulation (Focht, 1995). The process that culminated with the draft bill for the Hydrologic Resource Law was more inclusive, and perhaps that explains why three years of revisions were needed, but that enriched the outcome and it should prevent post-adoption critiques. The key to maximize stakeholder satisfaction is to educate the citizenry about the program and to publicize its benefits once they are measurable. People will need to perceive that the extra amount they pay for potable water is truly serving a purpose that benefits the country in a significant way.

Other considerations regarding the specific program design are worth mentioning. For example, an initial investment will be needed in education, coordinating the tax collection work of water suppliers, defining how the new monetary resources will flow into the agency managing the ESP, and planning how the new budget will be utilized for new and longer conservation contracts. Before the new tribute starts generating funds there will be some expenses that will need to be accounted for. The policy should also include a revision period that would force the executive branch to evaluate results and propose improvements. Such clauses have been rare so far in the Costa Rican legal codes (Sagot, 2000). And finally, a process for obtaining feedback from stakeholders should ideally be included in the ruling.

The current political landscape in Costa Rica makes the timing for a congressional discussion and approval of the Hydrologic Resource Law very uncertain. From the first time since the foundation of the Second Republic in 1949, the 2002 general elections saw

the emergence of a third prominent party, whose views on environmental matters are to this day unclear. Although they are still far from being able to mobilize the majority of the electorate, their existence can no longer be ignored and congressional negotiations will have to include them. With general elections taking place again in 2006, the timing for a discussion of the law in Congress it is not predictable, considering that matters such as tax reform and the ratification of free trade agreements are using up most of the legislative time, and taking into account that continuity is a challenge in a country where serving in Congress two consecutive terms is prohibited.

Will the Hydrologic Resource Law ever be implemented? The consensus about its benefits and the support from major stakeholders are not enough. Although Costa Ricans support environmental legislation, they are more concerned about poverty alleviation, corruption prevention and crime reduction. The leadership of concerned policy-makers and activists will be tested in the upcoming months. If they succeed, a historical milestone in the conservation history of Costa Rica will be reached.

### 5.2.7 References


Andrade, Z. 2004. Tiquicia se reinventa. *La Nación*. (18 January 2004).

Asamblea Legislativa. 2005. Ley del Recurso Hídrico (unpublished document). Author, San José, Costa Rica.

Brockett, C. D., Gottfried, R. R. 2002. State policies and the preservation of forest cover: lessons from contrasting public-policy regimes in Costa Rica. *Latin American Research Review,* 37(1): 7-40.

Brown, L. R. 1990. The illusion of progress. In: Brown, L. R. (Ed.), *State of the world 1990*. Worldwatch Institute, Washington, D.C.

Bryson, J. M. 1995. *Strategic planning for policy and non-profit organizations*. Jossey-Bass Publishers, San Francisco.

Castro, E., Barrantes, G. 1999. Generación de ingresos mediante el uso sostenible de los servicios ambientales de la biodiversidad en Costa Rica (unpublished document). Instituto Nacional de Biodiversidad. San José, Costa Rica.

Clemons, R. S., McBeth, M. K. 2001. *Public policy praxis theory and pragmatism: a case study approach*. Prentice-Hall Inc., New Jersey.

Corporación de Fomento Ganadero. 2000. Censo bovino nacional (unpublished document). Author, San José, Costa Rica.

Esposito, L. 2002. Integrative conservation. *SAIS Review,* 22(2): 53-75.

Evans, S. 1999. *The green republic: a conservation history of Costa Rica*. University of Texas Press, Austin.

Expert Choice. 2005. Web site of Expert Choice, Inc. <http://www.expertchoice.com>, (4 March 2005).

Focht, W. 1995. Gaining stakeholder acceptance of technological and environmental decision making. *Industrialization and Environment,* 1: 165-200.

Goodstein, E. S. 2002. *Economics and the environment*. John Wiley & Sons, New York.

Hartwick, J. M., Olewiler, N. D. 1998. *The economics of natural resource use*. Addison-Wesley Educational Publishers, Inc., Massachusetts.

Keohane, R. O. 1996. Analyzing the effectiveness of international environmental institutions. In: Keohane, R. O., Levy, M. A. (Eds.), *Institutions for environmental aid: pitfalls and promise*. The MIT Press, Cambridge, Massachusetts.

Lutz, E., Daly, H. 1991. Incentives, regulations and sustainable land use in Costa Rica. *Environmental and Resource Economics,* 1(1): 179-94.

Proyecto Estado de la Nación. 2003. *Estado de la Nación en desarrollo humano sostenible*. Author, San Jose, Costa Rica.

Ramirez, O. A. 2000. The carbon cycle and the value of forests as a carbon sink: a tropical case study. In: Dore, M. H. I., Guevara, R. (Eds.), *Sustainable forest management and global climate change: selected case studies from the Americas*. Edward Elgar Publisher, Northampton.

Rivera, J. 2002. Assessing a voluntary environmental initiative in the developing world: the Costa Rican certification for sustainable tourism. *Policy Sciences,* 35(4): 333-60.

Sagot, A. 2000. *Manual de Legislación Ambiental: ley orgánica del ambiente, concordada, con jurisprudencia constitucional y legislación relacionada en anexos*. Investigaciones Jurídicas S. A., San José, Costa Rica.

Southgate, D. 1995. Economic progress and habitat conservation in Latin America. In Swanson, T. M. (Ed.), *The economics and ecology of biodiversity decline: the forces driving global change*. Cambridge University Press, Cambridge, England.

Steinberg, P. F. 2001. *Environmental leadership in developing countries: transnational relations and biodiversity policy in Costa Rica and Bolivia*. MIT Press, Cambridge, Massachusetts.

Varela, I., Corella, R. 2003. Alerta roja en las áreas verdes. *La Nación*. (31 August 2003).

Villegas, J., Hernández, C. 2004. Crecen áreas forestales privadas. *La Nación*. (13 March 2004).

Wilson, B. M. 1998. *Costa Rica: politics, economics and democracy*. Lynne Rienner Publishers, Inc., Boulder, Colorado.

### 5.2.8 Appendix

Table 5.3: List of experts interviewed

| Name | Title | Affiliation | Organization type |
|---|---|---|---|
| Germán Rojas | President, Environmental Matters Commission | Congress | Central Government |
| Edwin Estrada | Advisor in Environmental Matters | PUSC political party | Political party |
| Marco A. Corrales | Advisor in Environmental Matters | PLN political party | Political party |
| Wadi Mejías | Officer | Hojancha Municipality | Local government |

Table 5.3 (cont.): List of experts interviewed

| Name | Title | Affiliation | Organization type |
|---|---|---|---|
| Danilo Méndez | Sub-regional chief | Environment Ministry Hojancha | Regional government |
| Gilberto López | Officer | Agricultural Ministry Hojancha | Regional government |
| Miguel Méndez | Manager | Monte Alto Preserve | Private sector conservation |
| Wilmarth Matarrita | President | Fedeagua | Local NGO |
| Juan Figuerola | Coordinator of forest issues | FECON | National NGO |
| Dr. Edgar Ortiz | Representative | FONAFIFO | Scholar |
| Alvaro Monge | Agriculture coordinator | Intl. Commerce Ministry | Central Government |
| Miguel Vallejo | Manager of consulting services | Fundacion Neotropica | National NGO |
| Carlos Sandí | Professor | EARTH University | Scholar |
| Gerardo Vargas | Representative | Corfoga | Private sector |
| Ronald Guerrero | General Manager | Precious Woods | Private sector |

## 5.3 Concluding remarks

It is not surprising that the water canon component in the Law of the Hydrologic Resource ended up being the preferred alternative by most stakeholders. After all, some of them have worked on the draft bill themselves, or they have been invited to provide input. Although imposing a tax on cattle production on marginal lands is a viable alternative, it is not seen by politicians or NGOs as something worth discussing in detail, because the other alternative is more far reaching and it has a number of key provisions beyond just taxing potable water to increase funds for conservation.

The Law of the Hydrologic Resource was sanctioned in April of 2005 by the Environmental Matters Commission in Congress. It declares that access to water is a human right, that the lack of absolute scientific certainty should not be used to postpone the implementation of solutions aimed at preventing environmental damages (precautionary principle), and that the unit of management of water in the country is the watershed.

The law would not only centralize in a new agency all the competencies related to water that today are distributed among several government offices, but it also creates a National Water Council that would be composed of representatives from the government, NGOs, academia, and industry for the deliberation, discussion, and coordination between the government and other sectors in society regarding matters related to water. The regulation also has a number of novel features that have not been used in previous legislative texts (Sagot 2000). For example, it imposes a tax on the use of water for the purpose of waste disposal, forcing the private sector to pay for fresh water, comply with

discharge limits, and also pay for those discharges. The discharge tax is to be adjusted annually according to inflation, and the discharge permits would not be allowed to exceed six years. The draft bill also specifies how the funds collected through the new tributes are to be used, and the list includes not only augmenting the budget for the ESP, but also expanding environmental education, research, monitoring, etc. For the first time since the ESP was created, this new law entitles indigenous groups to receive conservation subsidies for the preserves they occupy (Asamblea Legislativa 2005).

In sum, the law seems to be very well written and in accordance with the priorities and input received from many stakeholders during more than three years. The date when it will be discussed by Congress is unknown, but when that day comes, chances are it will be approved relatively easily.

# CHAPTER V

# CONCLUSION

This project has followed a method by which any developing country could approach conservation policy formulation, particularly those looking to increase their exports in agricultural commodities and at the same time trying to protect natural habitat. The only practical condition for the method to be applicable is that the information be obtainable, particularly for the hydrologic model. Naturally, other nations may have different dynamics where deforestation is caused by other reasons or the policy instruments to be analyzed are different, based on government structures, historical tendencies, etc. And then, places with high political instability or with a very low gross national product per capita will most likely be focused on solving those issues before they can turn their attention to matters of trade and biodiversity protection.

The Environmental Service Payment (ESP) in Costa Rica is a practical policy instrument, and this dissertation has shown that combined with other initiatives it can promote significant reductions in water pollution while increasing net social welfare and maintaining high stakeholder acceptability. Since forest owners are legally prevented from deforesting their land, it is reasonable that they try to increase their rent by applying for the ESP. The big unknown is whether the subsidy will promote, in the future, the reforestation of existing pastures. This study demonstrated that if the government helps

the private sector profit from other sources of income like ecotourism, conservation will be possible. The potential decrease in the production of beef due to some ranchers going out of the business can be off-set by agricultural intensification in other farms, with a potential decrease in river pollution.

However, for such a comprehensive strategy to work, different agencies in the government and other entities will have to work together and coordinate their efforts in a more systematic way. For example, the conversion from pasture to forest is long (over 10 years) and may be costly. A new type of ESP was recently created to compensate ranchers for every standing tree of a certain diameter in their property (Fondo Nacional de Financiamiento Forestal 2005). Those types of initiatives can make the transition easier from the financial point of view. To take the risk of reforesting, the landowner needs to be supported through credit to cover capital expenditures, particularly considering that larger investments may result in larger profits when managing a forest preserve as a tourist attraction. The Costa Rican Tourism Board could play a prominent role in facilitating those credits. Also, the energy and authority enjoyed today by NGOs in Costa Rica could be more useful if they spent resources analyzing and dealing with the cattle sector, major competitor of forests in the country, instead of watching only the shrinking forestry sector. And finally, agencies in general need to learn how to evaluate the programs they manage, and how to publicize their success. For example, after eight years no study has been conducted to estimate the benefits the ESP has provided the country.

Other types of studies also need to be undertaken. The whole theme of agricultural intensification, the gains in pollution and the economic implications should

be researched in more detail, including the consequence of utilizing fertilizers. The effect of pollution on fisheries and tourism also requires further examination. From an international perspective, a trade analysis could also provide key insights into the relationship between liberalization, environment and domestic policy. A basic two country, two commodity scenario could be the starting point, with Costa Rica and the US trading fine and cheap beef cuts. Another dimension that could play a role and therefore deserves attention is the power of foreign consumers and the possibility that they would demand or prefer certifications for beef (labeling requirements) with respect to environmental performance.

Meaningful and long term conservation is possible in the developing world. Countries such as Costa Rica can modernize and exploit their natural resources in a sustainable way. This work has shown one possible path to promote that type of development through domestic environmental policy.

# REFERENCES


Anderson K., Strutt A. 1996. "On measuring the environmental impact of agricultural trade liberalization". In M. E. Bredahl (Ed.), *Agriculture, trade and the environment: discovering and measuring the critical linkages*. Westview Press, Boulder, Colorado.

Anderson T. L., Grewell J. B. 2001. It isn't easy being green: environmental policy implications for foreign policy, international law, and sovereignty. *Journal of International Law, 2,* (2). 427-445.

Andrade Z. 2004. "Tiquicia se reinventa". *La Nación*. 18 January 2004.

Antweiler W., Copeland B. R., Taylor M. S. 2001. Is free trade good for the environment? *American Economic Review, 91,* (4). 877-908.

Arnold J. G., Srinivasan R., Muttiah R. S., Williams J. R. 1998. Large area hydrologic modeling and assessment part I: model development. *Journal of the American Water Resources Association, 34,* (1). 73-89.

Asamblea Legislativa. 2005. Texto de la Ley del Recurso Hídrico. Author, San José, Costa Rica.

Barquero M. 2004. "Fuerte caída en reforestación annual". *La Nación*. 19 January 2004.

Brander J. A., Taylor M. S. 2003. International trade and open-access renewable resources: the small open economy case. *The Canadian Journal of Economics, 30,* (3). 526-552.

Brockett C. D., Gottfried R. R. 2002. State policies and the preservation of forest cover: lessons from contrasting public-policy regimes in Costa Rica. *Latin American Research Review, 37,* (1). 7-40.

Brown L. R. 1990. The illusion of progress. In L. R. Brown (Ed.), *State of the world 1990*. Worldwatch Institute, Washington, D.C.

Brunelle D., Deblock C. 2001. "Chapitre 5: Les coalitions sociales et environmentales dans les Amériques". In: M. Damian and J. C. Graz (Ed.), *Commerce International et développement soutenable*. Economica, Paris.

Cabeza-Gutés M., Martinez-Alier J. 2001. "Chapitre 6: L'échange écologiquement inégal". In: M. Damian and J. C. Graz (Ed.), *Commerce International et développement soutenable*. Economica, Paris.

Cámara Costarricense Forestal. 2003. "Re: precios de madera", personal email (7 November 2003).

Castro E., Barrantes G. 1999. Generación de ingresos mediante el uso sostenible de los servicios ambientales de la biodiversidad en Costa Rica. *Instituto Nacional de Biodiversidad*. San José, Costa Rica.

Chichilnisky G. 2001. "North-South trade and the global environment". In: A. A. Batabyal and H. Beladi (Ed.), *The economics of international trade and the environment*. Lewis Publishers, Florida.

Costanza R., Audley J., Borden R., Ekins P., Folke K., Funtowicz S. O., Harris J. 1995. Sustainable trade: a new paradigm for world welfare. *Environment, 37,* (5). 16-44.

Damian M., Graz J. C. 2001-a. "Chapitre 1: Les grands paradigmes". In: M. Damian and J. C. Graz (Ed.), *Commerce International et développement soutenable*. Economica, Paris.

Damian M., Graz J. C. 2001-b. The World Trade Organization, the environment, and the ecological critique. *International Social Science Journal, 53,* (4). 597-610.

Esposito L. 2002. Integrative conservation. *SAIS Review, 22,* (2). 53-75.

Evans S. 1999. *The green republic: a conservation history of Costa Rica*. University of Texas Press, Austin.

Food and Agriculture Organization of the United Nations. 2003. FAO website. <http://www.fao.org>, (12 June 2003).

Frisvold, G. B., Caswell, M. F. 2000. Transboundary waste management – game-theoretic lessons for projects on the US-Mexico border. *Agricultural Economics, 21,* (1). 101-111.

Goodstein E. S. 2002. *Economics and the environment*. John Wiley & Sons, New York.

Hackett S. C. 2001. *Environmental and natural resources economics: theory, policy and the sustainable society*. M. E. Sharpe, Inc, New York.

Hartwick J. M., Olewiler N. D. 1998. *The economics of natural resource use*. Addison-Wesley Educational Publishers, Inc., Massachusetts.

Howard A. F., Valerio J. 1996. Financial returns from sustainable forest management and selected agricultural land-use options in Costa Rica. *Forest Ecology and Management, 81,* (1-3). 35-49.

Husted B. W., Logsdon J. M. 2001. "The impact of NAFTA on Mexico's environmental policy". In: A. A. Batabyal and H. Beladi (Ed.), *The economics of international trade and the environment*. Lewis Publishers, Florida.

Instituto Meteorológico Nacional. 2003. Temperaturas máxima y mínimima para Guanacaste y Puntarenas. [CD-ROM]. IMN. Costa Rica.

James A., Gaston K. J., Balmford A. 2001. Can we afford to conserve biodiversity? *BioScience, 51,* (1). 43-52.

Keohane R. O. 1996. "Analyzing the effectiveness of international environmental institutions". In R. O. Keohane and M. A. Levy (Ed.), *Institutions for environmental aid: pitfalls and promise*. The MIT Press, Cambridge Massachusetts.

Lewis D. K. 2002. "Cost-benefit analysis and the evaluation of new technology and policies in natural resources". In: K. Puttaswamaiah (Ed.), *Cost benefit analysis: environmental and ecological perspectives*. Transaction Publishers, New Jersey.

Loaiza V. 2003. "Caza ilegal extermina especies en Corcovado". *La Nación*. 30 March 2003.

Lowry W. R. 2003. "A new era in natural resource policies?". In Vig N. J. and Kraft M. E. (Ed.), *Environmental Policy: New Directions for the Twenty-First Century*. CQ Press, Washington, D. C.

Lumley S. 2002. "Cost-benefit analysis, ethics and the natural environment". In: K. Puttaswamaiah (Ed.), *Cost benefit analysis: environmental and ecological perspectives*. Transaction Publishers, New Jersey.

Lutz E., Daly H. 1991. Incentives, regulations and sustainable land use in Costa Rica. *Environmental and Resource Economics, 1,* (1). 179-194.

Ministerio de Ambiente y Energía. 1998. Cob Suelo 96-97. [CD-ROM]. MINAE. Costa Rica.

Ministerio de Comercio Exterior. 2004. Web site of the "International Commerce Ministry" of Costa Rica. <http://www.comex.go.cr>, (14 January 2004).

Monge A. 2003. "Re: Perspectivas del sector ganadero frente a ALCA", personal email (5 March 2003).

Muradian R., Martinez-Alier J. 2001. Trade and the environment: from a 'Southern' perspective. *Ecological Economics. 36,* (2). 281-297.

Neitsch S. L., Arnold J. G., Kiniry J. R., Williams J. R., King K. W. 2002. Soil and water assessment tool theoretical documentation: version 2000. Agricultural Research Service. Texas Water Resources Institute. Report TR-191.

Perrings C., Ansuategi A. 2000. Sustainability, growth and development. *Journal of Economic Studies, 27,* (1/2). 19-54.

Ramirez O. A. 2000. "The carbon cycle and the value of forests as a carbon sink: a tropical case study". In: M. H. I. Dore and R. Guevara (Ed.), *Sustainable forest management and global climate change: selected case studies from the Americas*. Edward Elgar Publisher, Northampton.

Rauwald K., Moore C. F. 2002. Environmental attitudes as predictors of policy support across three countries. *Environment and behavior, 34,* (6). 709-739.

Rivera J. 2002. Assessing a voluntary environmental initiative in the developing world: the Costa Rican certification for sustainable tourism. *Policy Sciences, 35,* (4). 333-360.

Roddick J. 1999. El Nino, el Viejo and the global reshaping of Latin America: surviving the UNCED coups. *Third World Quarterly, 20,* (4). 771-800.

Runge C. F. 2001. A Global Environment Organization (GEO) and the world trading system. *Journal of World Trade, 35,* (4). 399-426.

Sagot A. 2000. *Manual de Legislación Ambiental: ley orgánica del ambiente, concordada, con jurisprudencia constitucional y legislación relacionada en anexos*. Investigaciones Jurídicas S. A., San José, Costa Rica.

Schipper R. A., Jansen H. G. P., Bourman B. A. M., Hengsdijke H., Nieuwenhuyse A., Sáenz F. 1998. Evaluation of development policies using integrated bio-economic land use models: applications to Costa Rica. *Research program on sustainability in agriculture*. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.

Schultz P. W., Unipan J. B., Gamba R. J. 2000. Acculturation and ecological worldview among Latino Americans. *The Journal of Environmental Education, 31,* (2). 22-27.

Silva E. 2003. Selling sustainable development and shortchanging social ecology in Costa Rican forest policy. *Latin American Politics and Society, 45,* (3). 93-127.

Southgate D. 1995. "Economic progress and habitat conservation in Latin America". In T. M. Swanson (Ed.), *The economics and ecology of biodiversity decline: the forces driving global change*. Cambridge University Press, Cambridge, England.

Steinberg P. F. 2001. Environmental leadership in developing countries: transnational relations and biodiversity policy in Costa Rica and Bolivia. MIT Press, Cambridge, Massachusetts.

Taylor D. 2002. Costa Rica launches environmental initiatives. *World Watch, 15,* (5). 10.

The World Bank Group. 2003. <http://www.worldbank.org>, (29 January 2003).

United States Geological Survey. (2004). Seamless data distribution system. <http://gisdata.usgs.net/website/Seamless/>, (29 November 2004).

Van der Straaten J. 2002. "Challenges and pitfalls of cost-benefit analysis in environmental issues". In: K. Puttaswamaiah (Ed.), *Cost benefit analysis: environmental and ecological perspectives*. Transaction Publishers, New Jersey.

Varela I., Corella R. 2003. "Alerta roja en las áreas verdes". *La Nación*. 31 August 2003.

Vaughan C., Fallas J., McCoy M. 1998. "Conservation mapping in Costa Rica". In Savitsky B. G. and Lacher Jr. T. E. (Ed.), *GIS Methodologies for Developing Conservation Strategies: Tropical Forest Recovery and Wildlife Management in Costa Rica*. Columbia University Press, New York.

Wilson B. M. 1998. *Costa Rica: politics, economics, and democracy*. Lynne Rienner Publishers, Inc., Boulder.

World Economic Forum. 2002. Environmental Sustainability Index. <http://www.ciesin.org/indicators/ESI/index.html>, (7 March 2004).

World Resources Institute. 1999. Earth Trends. < http://earthtrends.wri.org/>, (1 July 2003).

Zebich-Knos M. 2002. "Ecotourism, economic development and the environment in Latin America: a policy perspective". In Nagel S. (Ed.), *Environmental policy and developing nations*. McFarland & Co., Inc., North Carolina.

APPENDIX I

SOILS RE-CLASSIFICATION

Table A.1.1. Re-classification of Costa Rican soils within the Nosara watershed into the United States Geological Survey soil series.

| # | Costa Rican soil code | USGS soil series | Series geographic origin | Percent watershed area |
|---|---|---|---|---|
| 1 | A010 | Atate | Guam | 78.29 |
| 2 | I156 | Chacha | Guam | 10.47 |
| 3 | A011 | Amelia | Puerto Rico | 4.33 |
| 4 | I153 | Pakala | Hawaii | 3.11 |
| 5 | E005 | Guayama | Puerto Rico | 2.51 |
| 6 | A014 | Callabo | Puerto Rico | 0.76 |
| 7 | I157 | Dorothea | Virgin Islands | 0.39 |
| 8 | I154 | Humacao | Puerto Rico | 0.14 |

APPENDIX II

USE OF A TAX ON POLLUTION

Table A.2.1 shows the effect a tax on pollution would have on the percent area under pasture that would maximize profits for the private sector in Nosara.

Table A.2.1. Effect of the pollution tax on the relationship between net profit and area under pasture.

| Tax on pollution $/yr/(mg/l) | Optimum percent cover under pasture (%) | Net Profit W ($) |
|---|---|---|
| 900 | 75 | 31,086,991 |
| 700 | 75 | 31,995,845 |
| 500 | 84 | 32,947,077 |
| 300 | 93 | 34,097,085 |
| 100 | 97 | 35,363,482 |

*Note*: in all cases $\alpha$=0.85, O=$34.68, B=25% and $\varepsilon$=1%

The table shows that increases in the pollution tax decrease W, because that means the farmer is paying the government higher amounts and therefore less remains as profit for the private sector. An annual tax of $100 for each mg/l would barely change the optimum percent area under pasture as compared to the baseline scenario of 98%, but

a tax of $700/yr/(mg/l) would shift the optimum to 75% pasture. Higher taxes would not increase forested area beyond that percentage.

The value of W for 25% of the watershed under forest in Figure A.2.1 is similar to that obtained in Figure 4.4 with the tax on grassland (about $32 million). However, in practice there could be differences in what specific HRUs or farms get converted first to forest.

It is important to consider implementability issues with respect to a possible tax on pollution. To be successful, such a program would have to allow for some sort of periodic measurement, inspection, and modeling so that the pollution generated from each farm can be estimated and the tax can be charged accordingly. Considering that Costa Rica is still far from having such a system in place, a tax on pollution is not seen as viable for the time being.

# APPENDIX III

# INSTITUTIONAL REVIEW BOARD APPROVAL

## Oklahoma State University
## Institutional Review Board

**Protocol Expires: 5/25/2005**

Date: Wednesday, May 26, 2004 IRB Application No EG0411

Proposal Title: Policy Alternatives for Balancing Conservation and Agricultural Expansion in Costa Rica: The Case of Beef Exports vs. Tropical Forest Protection

Principal Investigator(s):

Francisco Benavides
40 S. Univ. Place #8
Stillwater, OK 74075

John Veenstra
107 Engr. South
Stillwater, OK 74078

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

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Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact me in 415 Whitehurst (phone: 405-744-5700, colson@okstate.edu).

Sincerely,

Carol Olson

Carol Olson, Chair
Institutional Review Board

## APPENDIX IV

## SAMPLE QUESTIONS UTILIZED DURING THE INTERVIEWS

1. After loosing almost all of its forested land in private hands, Costa Rica made a come-back in the last decade. Is deforestation still a problem in the country?
2. What are the potential solutions to control deforestation in Costa Rica and promote the protection of natural habitat?
3. Has the environmental service payment been an effective tool so far?
4. Could the current oil price crisis jeopardize the ESP?
5. What are the chances of the water canon being approved by Congress promptly?
6. How would you describe the relationship between the two major parties with respect to the discussion of environmental matters?
7. How do you compare the water canon to the option of a tax on pastureland?
8. Why do you believe the water canon is a better alternative?
9. What objectives would the water canon satisfy?
10. What are other significant environmental problems in Costa Rica nowadays?
11. How do you describe the role of your organization in the issue of deforestation?
12. What other entities play a role in the conservation policy arena and how would you describe the relationships between your organization and those other entities?
13. Why are only 1/3 of farmers practicing agricultural intensification?

VITA

Francisco Benavides

Candidate for the Degree of

Doctor of Philosophy

Thesis: POLICY ALTERNATIVES FOR BALANCING CONSERVATION AND AGRICULTURAL EXPANSION IN THE TROPICS

Major Field: Environmental Science

Biographical:

Education: Bachelor of Science in Chemical Engineering, Universidad de Costa Rica. San José, Costa Rica. October 1991. Master of Science in Chemical Engineering, West Virginia University, Morgantown, West Virginia, May 1996. Completed the Requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 2005.

Experience: Quality Assurance Representative, the Coca-Cola Company, San José, Costa Rica, July 1988 through May 1994. Environmental, Health and Safety Manager, Intel Corporation, San José, Costa Rica, and Manila, Philippines. March 1997 through July 2002.

Name: Francisco Benavides Date of Degree: December, 2005

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: POLICY ALTERNATIVES FOR BALANCING CONSERVATION AND AGRICULTURAL EXPANSION IN THE TROPICS

Pages in Study: 144 Candidate for the Degree of Doctor of Philosophy

Major Field: Environmental Science

Scope and Method of Study: The purpose of this study was to analyze domestic environmental policy as a solution for balancing the need to promote conservation in Costa Rica with the opportunity of increasing the production of beef for international markets. The study is divided in three sections. The first one builds a biophysical model to describe the relationship between deforestation and river chemical pollution. The second one develops an economic model that determines what the optimum land cover distribution is, based on cost-benefit analysis. The final section analyzes the political implications of two environmental policies to promote conservation.

Findings and Conclusions: The environmental model suggested that tropical deforestation can increase river chemical pollution by factors of 3.5 to 8 compared to a totally forested watershed. The relocation of current pastures to areas of low erodibility can result in pollutant concentration reductions of 12% to 35%. And finally, agricultural intensification can reduce pollution, provided that manure is handled in a responsible way. The economic model showed that under conditions of high profitability from managing forest preserves, society would benefit by maximizing the area forested. The ability of the private sector to generate profits from increasing forested area is the most important factor in the determination of the optimum land cover distribution. When that profitability is high, the current subsidy scheme in place in Costa Rica is an effective tool to promote conservation. When the profitability is low, both an increase in the subsidy rate for forests and in the property tax for pastures could promote conservation. The increase in subsidies is a superior alternative based on policy legitimacy criteria.

ADVISER'S APPROVAL: John N. Veenstra