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PROTECTING BIODIVERSITY RESERVES FROM AGRICULTURAL ENCROACHMENT: AN ANALYTICAL FRAMEWORK WITH AN APPLICATION IN ECUADOR

NOVEMBER 1994

APAP III
Research Report
No. 2002

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE III

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Preface

Protecting biodiversity and promoting sustainable economic development are emerging as high priorities in tropical developing countries. Loss of biological diversity through the extinction of species, the degradation and destruction of natural habitats, and the disruption of ecological processes, is occurring at a rapid rate. As the habitats and species disappear, so do products of present and future economic value--genes with which to improve crop varieties, medicines to treat and cure diseases, and the resiliencies of living resources to respond and cope with climatic and environmental change. In the tropical humid regions of Latin America, Africa, and Asia this problem is particularly acute because therein lie the repositories of greatest biotic diversity. Establishing and effectively managing protected wilderness areas seem to be the most feasible means of preserving biodiversity. However, humans driven by the desire to improve their material lot in life or just susbsist sometimes infringe on these protected areas. Understanding what forces drive frontier expansion and unsustainable resource use in and near protected tropical humid areas will be critical to designing appropriate project interventions and reforming relevant legislation, policies, and institutions.
The contractors of the USAID-funded Agricultural Policy Analysis Project, Phase III (APAP III) are pleased to join the collaborators of the USAID-funded Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) in attempting to better understand this phenomenon of encroachment on protected areas in Ecuador. The mandate of the SANREM program is to use the landscape approach to interdisciplinary and participatory research, training, and development activities. APAP III with its strengths in qualitative and quantitative policy analysis at the national and sectoral level, can complement the watershed and household focus of the SANREM project in undertaking socio-economic and biophysical analysis of agricultural production and natural resource use near the Cotacachi-Cayapas Nature Reserve in Ecuador (See Wilcock and English, 1994).

This paper first highlights the general factors that explain agricultural frontier expansion and encroachment on protected areas. Second, using Ecuador and the Cotacachi-Cayapas Reserve as specific examples, it identifies economic and tenurial incentives that seem to both determine the rapid pace of frontier settlement and unsustainable resource use patterns in fringe areas of the reserve. Third, the paper presents a schematic of encroachment issues and corresponding investigatory techniques that could serve to facilitate discussion on applied research priorities in the conservation of protected areas. Fourth, one particular methodology, the policy analysis matrix (PAM), is be used in an illustrative manner to analyze the issue of moving from inappropriate resource degrading technologies to more sustainable ones, bearing in mind that current policies have influenced the choice of technique. PAM, however, is just one methodology and it has some limitations. The main advantage of PAM is that it relates national level and sectoral policies to household economic realities, and it could indicates ways to integrate conservation and economic development in fringe areas of protected parks.

Through this effort, APAP seeks to generate discussion between the USAID Ecuador Mission, SANREM, and APAP that could to collaborative research on some of the issues.

1.0 Introduction

This paper presents a conceptual framework that provides guidance for substantive analysis of environmental-economic linkages in the context of integrated conservation and sustainable development project planning. The main aim is to explain economic factors driving peasant encroachment in nature reserves and to explore the policy options for controlling further encroachment and promoting sustainable resource use in the areas bordering reserves. Particular reference will be made to the Cotacachi-Cayapas Nature Reserve in northwestern Ecuador, one such reserve experiencing infringement problems due to large-scale land clearing for agricultural and forestry exploitation. The policy and institutional weaknesses as well as demographic pressures that underlie and explain much of what is occurring in Ecuador is representative of those in many other developing countries.

An analytic understanding of the economic policy, institutional, demographic, and household factors behind frontier development in the humid tropics is important because of the enormous amount of biodiversity within such ecosystems and the life supporting functions they provide. Loss of unknown pharmaceutical benefits and the climate regulating services of largely intact tropical forests would impose a high cost on the global community. Nonetheless, the impetus to improve human material living standards at specific sites forces human agents to sometimes pursue short term gain at the expense of long term sustainable resource use. Thus, the demands of environmental stewardship and poverty alleviation often seem to conflict. In short, the challenges are to identify and assess the viability of alternative policy and institutional reform measures for creating incentives to conserve natural resources as well as to promote rational and equitable economic growth.

One methodology that can be useful in such an exercise is the Policy Analysis Matrix (PAM). PAM calculates private and social profitabilities for a particular agricultural commodity and technology. In the process, divergences between what is privately advantageous and societally efficient arising from differences in resource valuation and the amount of actual income transfers between key groups of economic actors become transparent (Monke and Pearson, 1989).

Three important issues--the impact of pricing policy on competitiveness and farm-level profits, the influence of investment policy on economic efficiency and comparative advantage, and the effects of agriculture research policy on changing technologies--can be studied with the PAM method. Of particular concern in the context of encroachment will be farm policies that promote soil conservation and crop intensification. Extensive, low-input agricultural technologies such as slash and burn agriculture are motivated by rapid loss of soil fertility on cleared fields. The challenge lies in finding ways to maintain soil fertility and increase incomes on cultivated plots.

In moving toward a strategy and plan for remedial action, concerted action seems to be needed on several fronts. First, macroeconomic and sectoral policy distortions need to be

minimized or eliminated. Inappropriate economic and tenurial incentives are often major causes of resource degradation. Second, at the household level, new environmentally benign technologies need to be developed and measures taken to encourage adoption. Discovering how these technologies affect productivity and how much they cost to adopt will be important. Third, at the community level, encouraging groups to manage natural resources and police themselves seems to be more cost effective than depending on distant central government authorities with serious administrative and budgetary constraints. The PAM analysis can illuminate some of these points.

This paper is organized as follows. Section 2 sets the stage for discussing the integration of resource conservation with economic development. The section reviews concepts of sustainable development, underlines the economic significance of maintaining biodiversity, identifies general factors explaining frontier development and environmental degradation in the humid tropics, and outlines the conditions necessary for successful buffer zone management around protected areas. Section 3, using Ecuador as a case in point, describes how specific economic and tenurial incentives may contribute to resource degradation and poverty in developed areas and encourage migration to the agricultural frontier. Once on the frontier, unsound economic policies help foster the adoption of unsustainable resource use practices and weak park enforcement authority jeopardizes the integrity of the protected area. Section 4 explains the PAM methodology and develops an illustrative set of applications. The aim of the PAM exercise is to define the costs of moving to more sustainable resource use. Section 5 summarizes the findings of the paper and sets forth an agenda for further applied research. Appendices contain more detail on the Ecuadorian policy regime and a general schematic of encroachment issues and relevant economic methodologies for analyzing these issues.

2.0 Background

2.1 Concepts of Sustainable Development

Since the 1980s, sustainable economic development has entered the lexicon of conservation and development analysts and represents a paradigm shift in economic development thinking. It replaces previous emphases on rapid, efficient growth in the 1950s and 1960s and equitable distribution in the 1970s (Munasinghe, 1993). Despite a variety of definitions, sustainable development commonly is accepted as meaning the maximization of current welfare benefit streams without unduly diminishing the stock of natural capital and thereby limiting the future streams of benefits for unborn generations (Pezzey, 1989). The concept has three distinct dimensions: an economic, an ecological, and a socio-institutional.

The *economic aspect of sustainable development* focuses on maximizing income and welfare benefits from a stock of capital that includes renewable natural assets, non-renewable natural assets, manufactured capital, and human capital. Much controversy surrounds the degree of substitutability between and the valuation of these different types of assets (Munasinghe, 1993). Given uncertainty and the irreversibility of certain paths of action, there is a growing acceptance that the human race is approaching ecological limits and that intergenerational equity should be accorded greater weight (Munasinghe, 1993).

The *ecological view of sustainable development* focuses on the stability and resilience of ecosystems. Of particular importance is the viability of subsystems that are crucial to the stability and perpetuation of the larger ecosystem in question. As a result, maintaining biodiversity is a key aspect because of the interconnectedness of ecological processes. The emphasis is not on static preservation but on preserving the resilience or the adaptive capabilities within ecosystems. Instead of prohibiting exploitation of an ecosystem, which may be impractical due to population pressure and poverty alleviation needs, it is more important to avoid collapse and marked degradation by unduly stressing an ecosystem. Points of conflict arise from a lack of well documented scientific knowledge about the functioning of ecosystems and the acceptable balance between human modification of ecosystems and allowance for natural evolution or conservation.

The *social and institutional aspects of sustainable development* emphasize respecting the views and rights of aboriginal hunter-gather peoples as well as building effective property rights regimes and natural resource management structures. For millennia aboriginal peoples have largely had negligible adverse effects on or symbiotic relationships with their surrounding ecosystems due to small numbers, primitive technology, and effective communal use rights systems. By the late 20th century, however, many of such peoples cultures and notions of use rights are vanishing. Typically in their wake, new colonists without the local knowledge of the regenerative and assimilative capacities of the ecosystems, animated by the profit motive, operate under a regime of open access property rights. The result is often unsustainable resource use and environmental degradation. Thus, preserving indigenous peoples' knowledge bases about

ecosystems, promoting community and user group participation in decisionmaking, and defining and enforcing property rights are key elements in remedial strategies.

Reconciling the three conceptual strands and operationalizing them are very difficult tasks, for there are inherent tensions between the strands. Yet for success to be had, they must be resolved. For example, a wholly economic approach may lead to the conclusion that maintaining the total value of the asset basis is all that is needed, while a wholly ecological approach may lead to the conclusion that fixed asset value is not as important as maintaining the broadest set of opportunities. Similarly, a purely sociological approach could emphasize the preservation of the rights and safeguarding the well-being of a pre-industrial minority group, ignoring the demographic and economic forces that drive the more technologically advanced majority to encroach on their lands.

As a compromise, the practical definition of sustainable development espoused in this paper holds that maximization of net benefits should be pursued, subject to maintaining the services from, and stock of natural resources over time.[1] This implies that renewable resources, especially if they are scarce, should be utilized at rates less than or equal to the natural rate of regeneration. The efficiency with which non-renewable resources are used should be optimized subject to substitutability between these resources and technological progress. Waste should be generated at rates less than or equal to the assimilative capacity of the environment, and efforts should be made to protect intra-and intergenerational equity. Lastly, highly participatory and pluralistic consultative frameworks should be used for the design and implementation of projects and special attention should be paid to building rational property rights regimes and strengthening organizations with natural resource management functions.

2.2 Importance of Maintaining Biodiversity

Maintaining biological diversity is important for the following reasons. Biotically rich and diverse habitats provide *direct economic benefits* (food, fiber, fodder, timber, medicinal extracts). These benefits can be non-marketed, own-use direct consumption or they can be income gained from the commercial sale of products. A second reason biodiversity is important is that it provides *indirect ecological services* (gene pools, climate regulation, watershed protection, production of soil, nutrient recycling, filtration of pollutants). These ecological services can be valued using existing statistical and survey methodologies. Lastly, biodiversity yields indirect non-use and future values, namely *existence*, *bequest*, and *option values*. Many derive a sense of well-being from knowing that irreplaceable and scenic beauty is preserved and could be visited and enjoyed at a future date by themselves or by unborn generations (existence value). Another significant aspect is a desire to preserve and bestow a rich biotic legacy to future generations in and of itself (bequest value) or because of likely but as yet unknown

[1] The Brundtland Commission defines sustainable development most succinctly as a process which "meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition commonly appears in the literature. (See World Commission on Environment and Development, *Our Common Future*. Great Britain: Oxford University Press, 1987, p. 8.)

economic exploitation values (option value).

As one moves from direct use values to option and existence values, intangibility and attendant measurement problems increase. In the case of a nature reserve, for example, how does one assign a monetary value to an unnamed plant that may be the cure to some dreaded disease (option value)? How does one assign a value to the benefits of climate stabilization, watershed protection in the absence of basic taxonomic inventories and ecological field studies that sketch and explain the interrelationships of organisms and processes in a given ecosystem?

Concepts of Resource Economic Value

Total economic value (TEV) of a resource consists of:

(1) Use value (UV)
(2) Non-use value (NUV).

Use value can be decomposed into direct use value (DUV), the indirect use value (IUV), and option value (OV). The major categories of non-use value are existence value (EV) and bequest value (BV).

Thus we may write algebraically:

$$TEV = UV + NUV$$
$$TEV = [DUV + IUV + OV] + [EV + BV]$$

Despite the paucity of scientific knowledge on ecosystems and valuation problems, social and biological scientists are still faced with the task of recommending sensible actions in the face of rapidly accelerating rates of extinction for known species and the growing awareness that human welfare and survival are intimately linked to healthy and well functioning ecosystems.[2] The emerging consensus is that human society should be prepared for unpredictable future biological and socioeconomic shocks by maintaining a safety net of biological diversity--as many gene pools as technically possible of wild species with actual or likely economic significance (McNeely et al., 1990). Genetic variety increases the potential for developing cultivars of higher disease resistance and productivity as well as producing new pharmaceuticals.[3]

Establishing and effectively managing protected areas is likely to be the most practical way of preserving the largest amount of the world's biological diversity and the complex ecological processes that sustain it. Of particular concern are ecosystems that are megadiverse. Most of these lie in the tropical regions of the world. Of the estimated 10-50 million species that possibly exist, only 1.4 million have been described and almost all of the undescribed species are in tropical ecosystems (McNeely et al, 1990).

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[2] According to E. O. Wilson, the world is experiencing extinction rates of greater scale and impact than at any other time in earth's history except for four mass extinction episodes due to meteorite impacts and geophysical upheavals.

[3] Forty percent of all drugs manufactured in the USA are derived from plant sources. Most all modern drugs, including painkillers, birth control agents, and malaria control agents, came originally came the from the wild but are now produced synthetically. In India and China, traditional medicine uses some 7,500 plants in its pharmacopoeia. (See McNeely et al., 1990).

2.3 General Factors Explaining Frontier Expansion and Environmental Degradation

The literature has generally identified three broad determinants of frontier expansion in developing countries and attendant deforestation and habitat lost. They are *misallocation of resources*, *maldistribution of assets*, especially arable land, and *inappropriate scales of operations* (Foy and Daly, 1989). Frontier expansion can be driven by one or more of the following conditions:

- insufficient access to arable land in more developed areas;
- extensive fragmentation of land holdings in developed areas;
- a marked increase in population creating additional food demand and in turn demand for opening of new agricultural lands and productivity enhancing technology;
- declining yields on currently cleared and cultivated land;
- government incentives to relocate to frontiers, such as credit, energy, transport, and land subsidies and infrastructure investments;
- pricing policies and market demand conditions that favor the expansion of a particular crop or livestock activity in new areas;
- exchange and trade policies that promote the production and expansion of a particular crop or livestock activity.

Environmental degradation occurs when these policies cum market failures result in a decrease in or loss of the ecological service flows, products, and soil fertility from the natural capital base due to reduction in the assimilative capacity or the regenerative capacity of the environment. Environmental degradation problems vary in their degree of urgency depending on the tradeoffs involved and the reversibility of action as new knowledge becomes available. Some natural capital losses may be more that compensated in terms of new manmade capital. Other natural capital losses may be much larger than the corresponding gains in manmade capital. In the context of tropical humid forests, a high degree of uncertainty and risk reigns because of the dearth of scientific knowledge and the inability to regenerate them, even with a fraction of their original species. Furthermore, many of the soils underlying tropical forests are thin and unsuited for continuous agricultural production. Thus, large losses of humid tropical forests with accompanying losses in the vital indirect use values seem to be commonplace without compensating gains.

2.4 Protected Area Management and Community Participation

The publication of the Bruntland Report reflected a growing consensus among scientists and development professionals regarding the links between poverty, development and the environment (WCED, 1987). Since then, donor agencies, NGOs and developing country governments alike have been seeking to formulate more sustainable, i.e., environmentally sound and socially equitable, development strategies.

The success or failure of sustainable development initiatives lies in the capacity of governments to link the conservation of a particular resource with the development priorities of the population that is dependent on that resource for its livelihood. In its simplest form, the argument that supports this linkage has three strands:

1) a community's impact on a particular resource can be reduced if the development needs of that community can be met from alternative sources;

2) economically impoverished communities cannot be expected to participate in conservation activities while their basic subsistence requirements remain unsatisfied;

3) communities are more likely to participate in conservation initiatives if they are actively engaged in the planning and management of a particular resource, and if they share in tangible economic returns from doing so (Gilmour and Blockhus, 1993).

The SANREM/CRSP project, through its Landscape Approach to Sustainability in the Tropics (LAST), has spearheaded an approach to sustainable agriculture and natural resources management that links participatory community development with adaptive research in improved production practices. In effect, LAST addresses the third strand of the sustainable development argument. The PAM approach addresses the first and second strands of this argument in its attempt to identify the impact of national economic policies on the subsistence strategies of farming households. The PAM methodology has been adapted and expanded to incorporate concerns for sustainability in agricultural production and natural resources management. The development of a natural resource policy inventory and an application of PAM, provides for the convergence of macro-level and micro-level (LAST) approaches to agriculture and natural resources management. This convergence constitutes an important framework for the promotion of conservation of biodiverse resources.

2.4.1 Protected Areas and Buffer Zones

The international concern for protecting biodiversity has, over the last half century, given rise to a rapid expansion of protected areas (national parks, reserves, natural monuments, wildlife sanctuaries, etc.). Since the mid-1970s, most of the new national parks have been

created in developing countries. As of 1985, developing countries accounted for 43 percent (186 million hectares) of the world's total protected areas (423 million hectares) (Dixon and Sherman 1990). These protected areas are by and large "paper parks" in that the government institutions charged with their oversight are often weak, their boundaries are typically not clearly demarcated, access to them not consistently regulated, and the allowable utilization of their resources not adequately managed. The following text box, adapted from the *Green Book* (Johnson and Lorraine 1994), highlights key points in the planning and management of protected areas.

Rapid population growth, poverty, poorly conceived and inconsistent government policies and market forces all combine to threaten the attempts of developing country governments' to conserve biodiversity. In many countries, the policy of total protection has given way to a policy of sustainable utilization whereby governments attempt to manage the harvesting of resources in a protected area in such a way as to conserve the underlying ecological processes. This easement of policy in part serves to satisfy local economic needs. In many countries, these policies have been formalized in the creation of various types of "buffer zones", or areas on the periphery of protected areas where restrictions are placed on resource use or special development measures are undertaken to enhance the conservation value of the area. Buffer zones are designed to take pressure off the principal conservation area by allowing a wider range of resource use in the buffer zone, and to enhance the conservation value of the protected area as a whole (Gilmour and Blockhus, 1993).

2.4.2 Integrating Conservation and Development

The SANREM/CRSP approach -- one that engages communities in the development of improved production practices that conserve resources --epitomizes the efforts of development planners over the last decade to link conservation and development for sustainable economic return. Within the context of the Cotacachi-Cayapas Nature Reserve, the application of the SANREM/CRSP approach promises to provide an understanding of the sustainable management requirements of the reserve's ecosystem. The PAM methodology provides the tools to identify overarching policies that drive human production and resource extraction strategies within the reserve. Understanding the effects of these policies is key to the rational reform of the policies themselves and to the development of economic incentives that reform human practices from ones of exploitation to ones of sustainable use.

The objective of applying the PAM methodology to the analysis of resource exploitation in the Cotacachi-Cayapas Nature Reserve is to explore the linkages between local-level economic practices and national-level economic policy. With an understanding of those linkages, analysts and planners can better identify the policy distortions -- the so-called perverse incentives --that favor environmentally unsound practices, discriminate against the rural poor, reduce economic efficiency, and waste budgetary resources (McNeely, 1988). Collaboration between SANREM/CRSP and APAP III provides a unique opportunity to examine the cultural, socioeconomic, political and institutional dimensions of protected area management and

Key Points in the Planning and Management of Protected Areas

- Although legislated protected area systems in Central and Latin America are extensive, there is often no government presence in the field and most areas are being rapidly degraded through human encroachment.
- Population pressure and poverty are the main threats to protected areas. Policies to establish, manage and protect conservation areas must anticipate and take into account demographic trends.
- Effective protection requires changing, limiting or preventing the ways in which resources are extracted from an area.
- If enforcement capabilities are absent, then changes in behavior require an integrated package of incentives that alter individual decisions about the gains and losses associated with various uses.
- Successful management policies must provide benefits for both the protected area and nearby residents.
- Incentives, especially those aimed at stimulating production, may have unanticipated outcomes.
- Fiscal incentives generally result in overexploitation of biological resources rather than conservation of biological resources.
- Protected and reserved areas must be supported by appropriate national policies and be part of an integrated package that includes rural development, education, protected-area-management, training, institutional development and legislative reform.

Source: The *Green Book*, 1994

encroachment on protected resources within the context of macroeconomic policies that create incentives to encroachment.

3.0 Ecuador: A Case Study

3.1 Frontier Expansion in Ecuador

Forests cover 43 percent of Ecuador's total land area, lying mostly in the northwest along the Colombian border and the east of the Andes in Amazonian lowlands (See Figure 1: Map). With a stagnant economy and rapid population growth rate (2.5 percent per annum), Ecuador is currently experiencing one of the fastest deforestation rates in Latin America. Although the data are not fully reliable, 200-340,000 hectares of forest are being cleared annually. Most of which is converted to pastures. Recent studies show that only about 16 percent of the area cleared is suitable for agriculture due to fragile soils (World Bank Ecuador Agricultural Sector Review, 1993). Furthermore, the utilization rate of commercial timber is very low, ranging from 18-30 percent of the total available on land cleared (ibid).

What drives the rapid expansion of crops and livestock on the frontier are the combination of demographic pressure; highly skewed distribution of land; high rates of soil erosion in highland areas due to insecure land tenure and lack of appropriate technology and extension services; credit subsidies especially for cattle ranching; land claim laws that give incentives to clear cutting; and persistent and high inflation rates (World Bank, 1989). Unrealized economic growth due to distortionary policies and mismanagement has not stimulated sufficient investments and job creation in urban, manufacturing sectors nor alleviated rural poverty. Thus, poor, landless peasants have increasingly migrated from the overcrowded and degraded Sierra (Central Highlands) to the Northwest and the Amazon Region in search of cheap or free land. In these regions, open access property rights exist and after squatting for a number of years the claimed lands can be adjudicated, titled, and legally recognized as private property (ibid).

3.2 Allocative Factors as a Cause of Degradation

The policies that cause overuse of natural resources, stimulate the exploitation of fragile lands, and inhibit investments in conservation and/or sustainable use can be divided into two categories: those that are unsound economic policies and those that are related to weak property rights.

Between 1982-92, Ecuador had a very uneven and chaotic economic stabilization program. Since 1992, the new administration seems more committed to market-oriented policies and to streamlining the public sector. The goal is to eliminate distortions, facilitate investments, and restrict the role of government. Nonetheless, a review of economy-wide and sectoral policies reveals that biases still persist and influence frontier expansion. The most compelling

Figure 1. Map of Ecuador

ones seem be the ban on export logs, transport policies, credit subsidies, weak agricultural research and extension services, land claim laws, the excessive fragmentation of land in the highlands, and the skewed distribution of arable land ownership. A list of other policies that have less clear effects on frontier expansion is contained in Appendix 1.[4]

3.2.1 Unsound Economic Policies as a Cause of Degradation

Forestry Laws In an effort to curb the export of raw tropical hardwoods and encourage the development of a value-adding domestic wood processing and furniture industry, the government banned the export of logs. As a result, stumpage fees tend to be lower than border price equivalents. This stimulates waste. Commercial timber on many exploited plots is either left to rot or is burned because extraction to a neighboring market would cost marginally more. In addition, the reduced price for timber doesn't give industry actors an incentive to invest in efficient sawmills, to pursue long term timber concessions, nor to reforest cleared land.

Energy Policies Until 1992, the Government of Ecuador subsidized energy prices, creating a distortion that hid the true cost of frontier expansion.[5] In the 1980s, pan-territorial pricing of gasoline at less than US$.50 per gallon provided strong incentives for the conversion of the most distant forest areas into cropland. Transportation costs to and from the frontier were much lower than if full economic pricing were adhered to. Thus, the low marginal costs of transportation stimulated commercialization of products from the Amazon Region and the Northwest.

Transport Projects In the 1960s and 1970s, petroleum company exploration in the Amazon Region opened access roads to their drilling sites. Colonists from the highlands soon used these same roads to penetrate the tropical forest and stake claims. The lack of an environmentally sensitive petroleum development policy and sound land-use policies, contributed to massive and wasteful deforestation. Few of the access roads run through areas suitable for agricultural exploitation.

Road construction between Quito and Santo Domingo and later between Santo Domingo and Esmeraldas in the 1960s, permitted migrants to flock to the northwest frontier region (Southgate et al, 1992). In the last 25 years or so, much of the Northern Littoral has been deforested, with livestock and African oil palms now predominating now.

Whereas land hunger may have provided the impetus for migration, access roads definitely provided the means. Transport policy, directly or indirectly has played a significant role in frontier expansion.

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[4] Please note that many economic policies are contradictory and the net impact of the relevant policies on frontier expansion or sustainable resource use practices can not be determined without resort to formal modelling and empirical testing.

[5] Prices are now higher.

Monetary Policy Historically, Ecuadorian monetary authorities have accommodated deficit spending by increasing the money supply at high rates, resulting in high inflation rates throughout the 1980s. These high inflation rates (in excess of 50 percent from 1982) stimulated investment in real assets such as land. High inflation rates in combination with easy land claim lands and low agricultural taxation rates, promote frontier expansion.

Agricultural Credit Policies The state agricultural development bank (Banco Nacional de Fomento (BNF)), has a long history of extending subsidized credit to agricultural producers.[6] Much of the credit goes to large farmers due to the high cost of lending to small farmers. Small farmers tended to either do without formal credit or to rely on informal sources. The absence of soil conservation extension services and restricted profit margins, often did not allow farmers to invest in costly conservation measures with own resources or informal loans. In the last two years, credit policies have been liberalized and formal interest rates have risen substantially but the lack of clear land title, still seems to limits access for farmers. The ongoing pattern of heavy lending for livestock, however, is still evident and promotes deforestation.

Within the Amazon Region, livestock lending accounts for 93 percent of the total lending compared to 30 percent in the Coast and 58 percent in the Sierra.[7] Because of the high inflationary regime and problems with insecure collateral, livestock lending is commonplace and rational from a financial perspective. Liens could be issued against the livestock and be better enforced than against field crops. Moreover, livestock is a more liquid asset than a standing crop and less perishable, providing owners with a ready store of value and source of income.

Despite the large historical subsidies directed to the livestock sub-sector, annual economic growth (1.7 percent 1982-91) has been anemic. For example, pasture area in the Oriente (Amazon Region) has increased 151 percent between 1980 and 1990 compared to 13 percent for the Costa (Coastal Region) and 7 percent for the Sierra (Central Highlands).[8] Despite the massive increase in the Oriente, the number of heads carried per hectare declined between 1980 and 1990. In 1980, .63 heads were carried per hectare compared to .48 heads in 1990. In the other regions, the head per hectare ratio improved, suggesting an intensification of production (World Bank Ecuador: Agricultural Sector Review, 1993). The result of the heavy subsidies has been the conversion of farmland to pasture and the expansion of the agricultural frontier.

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[6] Real interest rates approximated -24 percent between 1987 and 1990 and the 1980s and loan recovery rates tend to be below 70 percent. Since 1991, BNF has charged 47-52 percent rates of nominal interest but the inflation rate has been slightly higher, resulting in still slightly negative or zero real interest rates. Despite a change in credit policy, fiscal indiscipline is creating pressure for strong monetary policy with contractionary economic effects.

[7] The Amazon Region is the largest frontier area but similar lending patterns apply to the Northwest frontier region that spans both the Coastal and Highlands zones.

[8] Note that cattle production is the most readily financed activity on the frontier. Banks perceive field crops and non-traditional exports to be more risky. Disaggregated statistics are unavailable for the northwest frontier region.

Agricultural Research and Extension The National Institute for Agricultural Research (Instituto Nacional de Investigaciones Agropecarias (INIAP)) is the government agency in charge of agricultural research and technology transfer. The Ministry of Agriculture (MAG) is primarily responsible for providing extension services to farmers, however, a number of other public and private entities are active in the area. Both INIAP and MAG have experienced difficulties in achieving their mandates with the result being slow sectoral growth rates and rational resource use. Since 1975, INIAP has faced constantly declining budgets. Agricultural research expenditures as a share of GDP declined from .85 percent in 1975 to .17 percent in 1988. As a result of shrinking budgets the quality of research has deteriorated and the most accomplished staff have resigned.

On the extension front, both resource poor and larger farmers suffer from the poor quality of public extension services. Despite a large number of public entities involved in the area, both the coverage and the quality of information dissemination remains inadequate, contributing to a gap between current performance and the potential of the agricultural sector. The weaknesses in service delivery stem from a series of interrelated problems: (1) inadequate documentation and perception of farmer's needs and constraints; (2) poorly trained extension agents; (3) failure to develop appropriate technology packages; (4) coordination and monitoring problems; and (5) budgetary pressures.

The result of an inadequate agricultural science base and poor extension services is low yields and unwitting resource degradation. The main source of sectoral growth (4 percent per annum) mostly stems from area expansion, not yield increases. The growing proliferation of entities providing extension services, usually tied to an internationally financed donor project, indicates lack of success in reforming MAG.[9]

Agricultural Taxes In Ecuador agricultural land taxes are extremely low and the proceeds go to municipalities and local government. The low rates encourage idle speculation in land holding and does not penalize low rates of intensification. This perverse incentive in combination with the high inflation rates, encourages agricultural extensification and frontier expansion.

3.2.2 Weak Property Rights as a Cause of Degradation

Lack of clearly defined and well enforced property rights historically have contributed to overexploitation and degradation of natural resources. Without clear rights and sanctions, investment in and sustainable use of resources is not encouraged. Property is not an object per se but a structure of rights and duties characterizing the use and control of a physical (land) or

[9] At the moment, several regional development authorities such as Research Commission for the Development of the Guayas River Basin (CEDEGE), Manabi Rehabilitation Center (CRM), Center for the Economic Recovery of Azuay, Cañar, and Morona Santiago (CREA), other ministries such as Ministry of Social Welfare (MBS), and numerous NGOs are providing extension services. Many of the entities have different objectives, methodologies, and delivery systems making coordination difficult.

intangible (tradename) resource. Sets of institutional arrangements define, adjudicate, and resolve disputes surrounding the relationship of individuals to property. There are three general types of property regimes; state property; private property; and common property. Each regime can fail and contribute to resource degradation (Bromley and Cernea, 1989). Usually, the failures for state properties arises out of the lack of enforcement capacity and poor pricing or concession granting policies. The failures for private property can result from very short time preferences of the individual user, external policy disincentives, and or excessive fragmentation if too many heirs are honored during intergenerational transfer. The failures relating to common property regimes generally stem from the concomitant displacement of traditional authorities, acculturation of different values, and population pressure. When effective communal management collapses, the often lamentable "tragedy of the commons" occurs (ibid). Open access regimes depending on population pressure are most prone to rapid and unsustainable exploitation.

In Ecuador, several land use policies and weak legal enforcement of standing property rights stimulate frontier expansion. First and foremost, the national government has actively encouraged frontier settlement since the 1960s, seeing the frontier as an "escape valve" for the landless poor and as a means to protect national borders by having a presence in remote areas. A series of land claim laws and titling initiatives have been the main instruments.

The Law for the Settlement of the Amazon (Ley de Colonizacion de la Region Amazonica (1978)), declares the settlement of the Amazon to be a national priority and instructs local authorities and government agencies to assist organized groups in relocating to the frontier and providing the settlers with land titles through Agrarian and Colonization Agency (Instituto Ecuatoriano de Reforma Agraria y Colonizacion (IERAC). Under the law, settlers have to clear eighty percent of their land which ranges in size from 10-100 hectares or risk repossession by the government.

The Unused Land Law (Ley de Tierra Baldias) defines any unused land as the patrimony of IERAC. This law applies mostly to unzoned land and is especially applicable to the northwest frontier. IERAC has designated 15 percent of the Amazon as conservation areas; 3 percent for indigenous people; 10 percent for planned settlement; and the rest as unknown. Settlers can claim and receive legal title to such unknown and unused land if they clear 50 percent the forest and replace it with either crops or pasture within five years, thus showing domain and productive use. The concept of "unused lands" conflicts directly with the rights of indigenous groups that have occupied the lands for centuries and use extensive fallow systems and hunter-gathering activities and does not recognize the ecological functions of tropical forests.

Indirectly, attenuated property rights in the Sierra have contributed to migration to the frontier. The Communal Law (Ley de Comunas (1937) recognized traditional indigenous common property rights but forbade resale and titling. Over the years, the plots were no longer collectively cultivated and defacto parcelizations have occurred. Without secure individual rights and the inability to sell, plot users have little incentive to invest in soil conservation, afforestation, and agroforestry. As population pressure increases, fragmentation of plots

increases with each passing generation leading to overuse and rapid soil erosion. For example, between 1965-1985, 341,000 ha. or 60 percent of the total cropland in the Sierra was converted to pastures or abandoned (Southgate and Whitaker, 1992a).

In summary, the Law for the Settlement of the Amazon and the Unused Lands Law have stimulated excessive forest clearing, even by indigenous peoples as a defensive mechanism. Land rights have become synonymous with land clearing. The Communal Law has resulted in increased pressure to leave the rural highlands and migrate to other areas in the country.

3.3 Distributive Factors as a Cause of Degradation

A skewed distribution of ownership rights to productive land can contribute to degradation on suboptimal allotments and generate pressure to migrate to frontiers or urban areas.

In Ecuador, despite a land reform program in 1964, significant inequality in land ownership persists with all of its negative implications for economic growth and income distribution. The 1964 reform program succeeded in granting many sharecropping tenants land, but the land tended to be marginal quality and located on the steep, highly erodible sides of the intermontane valleys in the Sierra.

Available census data show that in the most populous region of the country, the Sierra, 77.9% of the farmers had extensions between .5 and 5 ha. but only cultivated 11.4% of the total area while 3.1% of the farmers had holdings greater than 50 ha. and controlled 62.7% of the total area. In contrast, land distribution was much more egalitarian in the Oriente, which is a frontier region and while the Costa has a skewed pattern, it was not as bimodal as in the Sierra. In the Costa there where relatively more holdings of medium size, 5-50 ha. The high population density in the Sierra, the high erodibility of the soils, and the small plot sizes combine to create the impetus for migration (Table 1.1).

3.4 Excessive Scale as a Cause of Degradation

When the scale of resource use activities exceeds the carrying capacity of the resource, degradation of the natural resource can occur.[10] If the total physical load of resource use (consumption and pollution) is greater than the regenerative and assimilative capacity of a particular ecosystem, environmental problems will arise. For instance, continual population growth will expand the scale of total resource use and eventually cause serious deterioration

[10] Kircher et al. define carrying capacity as follows: "The carrying capacity of a particular region is the maximum population of a given species that can be supported indefinitely, allowing for seasonal and random changes, without any degradation of the natural resource base that would diminish this maximum population in the future."

TABLE 1:1 Land Distribution in Ecuador (000 holdings and 000 hectares)						
Farm Size	SIERRA		COSTA		ORIENTE	
	Number	Area	Number	Area	Number	Area
0-.5	57.9	15.6	9.5	2.6	.3	.1
.5-1.9	51.2	34.4	15.3	16.8	.3	.2
1-2	60.4	96.8	21.9	36.8	.8	1.8
2-3	48.6	96.5	18.3	45.5	.8	1.8
3-4	21.4	71.4	9.6	33.4	.7	2.8
4-5	15.8	68.2	9.6	43.4	.5	2.2
5-10	29.9	196.3	23.9	168.4	1.9	12.9
10-20	18.2	241.2	28.3	279.1	2.3	36.7
20-50	13.8	421.3	21.8	655.4	6.9	221.7
50-100	6.8	368.8	8.2	529.1	7.9	449.1
100-500	2.9	564.7	4.9	911.6	1.7	252.8
500-1,000	.3	296.7	.4	391.3	.1	37.4
1,000-2,500	.2	388.8	.2	363.1	.62	24.4
2,500+	.1	471.8	.1	436.3	.61	52.8

Source: 1974 Agricultural Census

of the natural capital even if allocation is efficient and distribution is egalitarian. Scale and carrying capacity are dynamic and variable constructs for humans because (a) per capita resource consumption levels or "living standards" can change over time and culture; (b) the degree of equality in consumption or distribution can vary widely across place, time, and culture; and (c) technology evolves relaxing what previously appeared be a constraint. These three variables, nevertheless, do not change in unpredictable and discontinuous fashions. Upper limits exist. Thus, the concepts of scale and carrying capacity are indispensable for planning rational and sustainable resource use. Scale of use should always be less than equal to carrying capacity. Moreover, sustainable scale should be a constraint on the maximization of present value and not a consequence of solving the maximization. Given the great uncertainties around the valuation of natural resources, irreversibilities, and discount rate choice, efficient allocation rules resulting from simple maximization may result in environmental disasters in the future (Foyer and Daly,

1989).[11]

At present, the Northwestern frontier in the Costa region and the Oriente or Amazon region of Ecuador have not exceeded their carrying capacity. Nevertheless, the current pace of development seems to be unsustainable. Taking the Amazon region as an example, it has area of 132,000 square kilometers and a 1988 population of 350,000, yielding a density of 2.6 inhabitants per square kilometer (World Bank, Development Issues and Options for the Amazon Region, 1989). Nevertheless, the region population growth rate is very high, averaging about 5 percent per annum (ibid). If current migration and exploitation trends continue without major breakthroughs in technology and knowledge base, irreversible resource losses are expected; diminished returns to economic activities over time; and increased conflicts between the migrant and indigenous populations seem highly likely.

The entire country's population growth rate is 2.5 percent meaning that the current population of 10 million will double to 20 million in 25 years. The rural areas of the Sierra and the Costa are already experiencing net emigration due to demographic pressure, ecological deterioration, and droughts. Aside from the major cities the only other escape valve is the Amazon lowlands. If we assume that the maximum carrying capacity of the Amazon is 30 persons per square kilometer, the present country wide population density, then the Amazon can not absorb the additional ten million.[12] The maximum the Amazon Region can absorb is 3.9 million. Thus, policies will have to be set in place starting now, policies to slow population growth and increase carrying capacity, that is economic productivity and better employment opportunities outside the Amazon Region.

3.5 Profile of the Cotacachi-Cayapas Protected Area

The Cotacachi-Cayapas Nature Reserve (RECC) was created in 1968 and is of particular significance to the people and government of Ecuador because it is probably the most important protected area in terms of biodiversity on the western face of the Andes. More than 180,000 hectares of its tropical forest belong to the Choco biogeographical region, a region thought to have the highest percentage of plant species endemism in Latin America. Approximately 12 ecological zones are found in the park, from alpine meadow (4,000 meters above sea level) to tropical humid forest (180 meters above sea level). In addition, several major watersheds or tributaries start inside the RECC boundaries.

In recent years the Cotacachi-Cayapas Nature Reserve and its zone of influence has been subjected to growing environmental pressures. Unsustainable forestry exploitation, agricultural

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[11] Optimal scale in not well defined except in very general terms as that scale which equates marginal cost of further growth with marginal benefit. Until we develop better measures of marginal costs and benefits associated with aggregate growth, optimal scale is an economic formalism. The immediate obstacle is lack of information about ecological systems.

[12] Given the known data on the extreme fragility of Amazonian soils this assumption is very optimistic.

production, and cattle ranching present the most important environmental threats and have contributed to deforestation, soil erosion, and loss of biodiversity. Harmful fishing and mining practices present secondary environmental threats. Commercial loggers, with the help of local communities, have cleared vast tracts of forested area around the RECC, creating islands of wilderness and contributing to species loss. Both the indigenous peoples and newly arrived settlers have converted the cleared land to crop use or pasture. Little or no reforestation is occurring. Inappropriate slash and burn (swidden) agriculture, cultivation on steep hillsides, and plowing against the contour lines are depleting soil fertility. In addition, agricultural chemical run-off, mining activities, and fishing with dynamite are adversely affecting the area's water quality.

Cotacachi-Cayapas Nature Reserve at a Glance

Location, Size, Access: Located in Northwestern Ecuador in the provinces of Esmeraldas and Imbabura. It covers 204,420 hectares, with an altitudinal range of 180 to 4,939 meters above sea level. It is most accessible through Cuicocha, which receives approximately 90,000 tourists a year.

Outstanding Features: The reserve is perhaps the most important of the 15 protected areas in Ecuador because of its great biodiversity. Plant endemism (being native or limited to certain area) is particularly high. There are 12 broad ecological zones and many micro habitats due to altitudinal range and varying topography. In addition, several major watersheds or tributaries originate within the reserve.

Culturally, the buffer zone has a rich diversity. Four indigenous tribes (Chachi, Awa, Embera, and Quichua) , Afroecuadorians, and mestizo (European-Indian mixture) live in the buffer zone. Different degrees of assimilation to the national hispanic culture and varying amounts of commercial market integration exist among the minority indigenous and African descent populations.

Management Problems and Environmental Threats: Serious problems exist due to colonization close to and within the park boundary. Economic activities that pose immediate threats include logging, cattle ranching, hunting, fishing, and agriculture. In the near future, intensified gold mining could pose a new threat. Poor economic policies, ill-suited tenurial incentives, and the absence of appropriate technology encourage unsustainable resource use practices and encroachment. Lack of sufficient staff and budget prevent effective enforcement of the reserve's boundaries.

Institutional Actors: Several government agencies, donors, and non-governmental agencies are active in the region. The Ministry of Agriculture and Livestock (MAG) manages the reserve. IERAC (colonization agency) issues land titles, and SRNF (forestry service) issues logging permits. Currently, three USAID financed projects are underway: SUBIR, la FETANE, and SANREM. The first project is promoting ecotourism; the second is installing a yucca processing plant; and the third is a participatory-led natural resources management and training program. The World Wildlife Fund and Fundación Natura, a local NGO, manage an institutional development and park management program (UTEPA). In addition, the Smithsonian Institution is constructing a scientific research station, Missouri Botanical Gardens is conducting flora studies, and Conservation International is funding a tagua (vegetative ivory) commercialization project.

Current Park Personnel, Infrastructure, and Budget: Infrastructure is very limited and is concentrated in Cuicocha, the area that receives the most tourists. Some trails are being developed in other areas of the park but at a slow pace. In 1992, the reserve had one manager, two conservation officials, and fourteen guards. The limited budget was absorbed mostly by salaries. A critical problem is that the lower altitude portion of the reserve, which has the largest amount of biodiversity, receives a disproportionately small share of the budget and personnel.

Immediate Needs: The reserve needs a resource management plan, increased staff and training, and boundary demarcation.

3.5.1 Description of Major Ethnic Groups in Cotacachi-Cayapas Boundary Zone

The RECC and its zone of influence contain several ethnic and cultural groups, the main ones being the Chachi, Embera, Awa, Afroecuadorians, and mestizo colonists. Of the five groups, the Chachi, Afroecuadorians, and colonists have the most direct environmental impact on the area.

The Chachi, an indigenous people, are settled in three zones in the Esmeraldas province: Muisne, Canande, and Borbon. They are in most direct contact with the reserve in Borbon, and, to a lesser extent, in Canande. They are involved in forest exploitation, including logging, and also practice small-scale intensive agriculture. They have 30, 000 hectare at the western edge of the reserve (USAID, 1992). Cultural conflict looms though since, colonists pose a threat to Chachi communal lands near Lita-San Lorenzo, northwest of the reserve.

Afroecuadorians arrived in Ecuador in the 16th century as a result of shipwrecked slave vessels. They mostly settled between the eastern margin of the Santiago river and the western margin of the Cayapas river. They have communal property rights to land, which they cannot legally sell, and families hold property by usufruct. The communities near the Cayapas river survive mainly from forest exploitation, while the communities near the Santiago river depend on the production of cacao and rubber for commercial sale, and bananas as their staple food crops. In addition, they collect and sell tagua (vegetative ivory).

The mestizo colonists are distributed on three sides of the reserve-the west, the south, and the east. They are involved in ranching, crop production, and commercial logging. Because of the lack of transportation and communication infrastructure in the area, colonists are negotiating the development of roads and bridges to facilitate the marketing of their products. Many of them are organized in cooperatives.

3.5.2 Environmental Threats Posed by Economic Activity in the Reserve's Buffer Zone

Renewable natural resources are being visibly degraded in the RECC area. Some are becoming scarce, and the reserve's buffer zone is shrinking. The forest in the RECC buffer zone is slowly being cleared for timber, pasture, and crop land. In Cristal, farmers and ranchers are intensively colonizing this boundary area. In Placer, the IERAC district of San Lorenzo has surrendered land which has drainage problems at the border and even inside the RECC. In the Canande and Cuellaje zones the forest has been cleared for pasture and farmland. As a result of the above processes, the biodiversity of the region is undoubtedly declining. Hunting has noticeably decreased due to the pressure of agriculture and deforestation. Fish are also scarce because of intensive exploitation and the use of dynamite.

Inside the RECC, the cover vegetation is still fairly intact. There are two exceptions:

the deforested area surrounding Lake Donosa in the Andean area of Pinan, and the deforestation by new colonists at the outskirts of the reserve area near the Santiago River. Despite the relatively pristine condition of the reserve, the resource depleting activity on its borders is growing and threatens to move into the park.

Timber Exploitation The activities of the commercial logging companies have caused environmental degradation in several ways. Because timber and gasoline prices have been kept artificially low in Ecuador, commercial loggers have little reason to employ conservation measures. Often, they clear the forest with huge tractors that compact the soil and open the way for major roads. The inadequate procedures for felling and hauling cause high levels of wood wastage and enormous damage to the surrounding vegetation (USAID, 1992).

Local communities are also playing a crucial role in timber exploitation. The Chachi, in particular, depend heavily on timber exploitation for income, and the last Andean forests around lake Pinan are being destroyed rapidly by the indigenous people(ibid). As this tribe becomes more engaged in the cash economy and responds to market signals, sustainable resource use practices are disappearing(ibid).

Deforested land is often converted to cropland or pasture. Around the RECC, agriculture and herding practices have been unsustainable and are leading to soil erosion. Studies on actual soil erosion rates in Ecuador are rare, but the few studies conducted indicate that soil erosion is a serious threat in parts of the Northwestern region including the RECC. Because land is undervalued, land tenure is insecure, and agricultural credit is expensive, the farmers and ranchers, like the commercial loggers, have little incentive to employ soil conservation measures(ibid). When land has been depleted, it is simply easiest to colonize a new area, rather than to spend the time and energy to improve soil productivity on a given tract of land.

Agriculture Unsustainable agricultural practices in the RECC buffer zone have led to environmental degradation. Marginal land, characterized by thin soils, steep slopes, or both, is being cultivated by encroaching small farmers. For example, in the Cuellaje zone, intensive sisal cultivation is carried out on slopes of up to 70% (ibid). The farmers slash and burn the forest near river beds to later establish pastures, a practice which has led to erosion of the riverbeds(ibid). Then they wash the sisal in the rivers, contaminating the water with toxic substances.

Another agriculturally related cause of soil erosion in parts of the region is inappropriate tilling technology. Although still relatively rare, mechanized plowing is being promoted by government agencies, even for small farmers who live in hilly areas with fragile soils, sometimes at the cost of increased soil erosion. Despite the instructions of extension agents to plow following the contours of the hill, these farmers frequently plow up and down the slopes to avoid tipping the tractors, and to save time and effort (Southgate, 1992b). Soils are much more vulnerable to being washed away without the protective contouring.

Cattle Ranching Abandoned crop lands are often converted to pasture (Southgate,

1992b). Not indigenous to Latin America, cattle have cloven hoofs and can do great damage to soils. Complementing this, herders periodically burn old grass to promote the new growth that is more desirable to their livestock. This often exacerbates soil erosion and mineral depletion because wind and rain following fires can more easily carry off exposed soil. (Southgate, 1992b).

Mining Mining presents a serious future threat to the RECC. Presently, mining is predominantly artisan in nature and practiced by only a few communities (USAID, 1992). Gold extraction from the rivers through traditional means is a supplemental activity of the population settled on the banks of the Santiago and Cayapas rivers (ibid). There is some evidence, however, of harmful effects from mechanized extraction in the Playa de Oro sector. Furthermore, studies have revealed that commercial quantities of gold and platinum exist within the RECC (ibid). While some exploratory concessions have been granted, as of 1992, they had not been acted upon. Mining activity on this scale would devastate a large part of the RECC and lead to formidable downstream environmental problems.

4.0 Framework for Analyzing Encroachment Issues

In this section a general schematic and a partial listing of relevant economic methodologies for policy analysis are developed. Preventing and controlling encroachment on biodiversity nature reserves encompass many interrelated and complex socio-economic, institutional, and biophysical factors. Identifying, analyzing, and prioritizing the various facets can be daunting. The general schematic below outlines the major forces at play. Two separate stages are defined: Initial Migration to the Agricultural Frontier and a Second Round of Frontier Expansion.

From the perspective of a representative migrant family, two general sets of forces are at work that prompted the initial decision to uproot and move to the frontier. On one hand, conditions of extreme poverty, landlessness, or natural disasters can help "push" the move. On the other hand, the ready availability of land along with the means to get there must exist. In addition to these preconditions, a number of government policies and external conditions such as credit subsidies and proactive colonization agencies can motivate the move. The combination of the preconditions and one or more attracting features can serve as a magnet and "pull" the migrant. The more intense the "push" factors and the more attractive the "pull" factors, the more rapid will be the settlement of the frontier (See Figure 2).

Once the representative migrant family is on the frontier, the rapid loss of soil fertility oftentimes motivates the clearing of additional land. The original plot may continue to be cultivated, depending on the availability of labor, left fallow, converted to pasture for livestock raising depending on capital constraints, or abandoned (See Figure 3). Barring cases of extreme soil fragility, the rapid loss of soil fertility is often due to either the inability or unwillingness to invest in soil conservation and cultivate crops appropriate for the soil. Understanding the constraints to soil conservation and farm improvements is critical to controlling frontier expansion (See Figure 3).

The combination of an ever expanding wave of first time migrants and expansion of existing homesteads accelerates the disappearance of the frontier. Consequently, protected nature areas are likely to be subject to increased development pressure over time. In the context of developing countries, where park enforcement measures are likely to be weak or non-existent due to lack of budgetary resources and trained personnel, the threat of encroachment is heightened.

Analyzing each of the aforementioned facets requires different methodologies. Clearly, being able to disaggregate the impact of policies and identify their stakeholders will allow an organization or government to understand how policy combinations may or may not promote its interests; to understand the trade-offs associated with various alternatives; to identify the points of convergence, divergence, and conflict as preparation for conflict resolution.

If the ideal decision-making process is accepted as being a largely linear and logical one,

then the steps in the following text box can be said to exist. The decisionmaker or group of decision-makers move sequentially through stages from identification to analysis to remediation to implementation. At each step in the process, there will exist peculiar data and evaluation methodological needs. The choice of final methodology(ies), however, depends not only the relevant place in the policy analysis process but on budget, timing, human capital, and data availability. See appendix 2 for a fuller discussion of steps in the analytical process and relevant methodologies.

Figure 2. Initial Wave of Agricultural Frontier Expansion

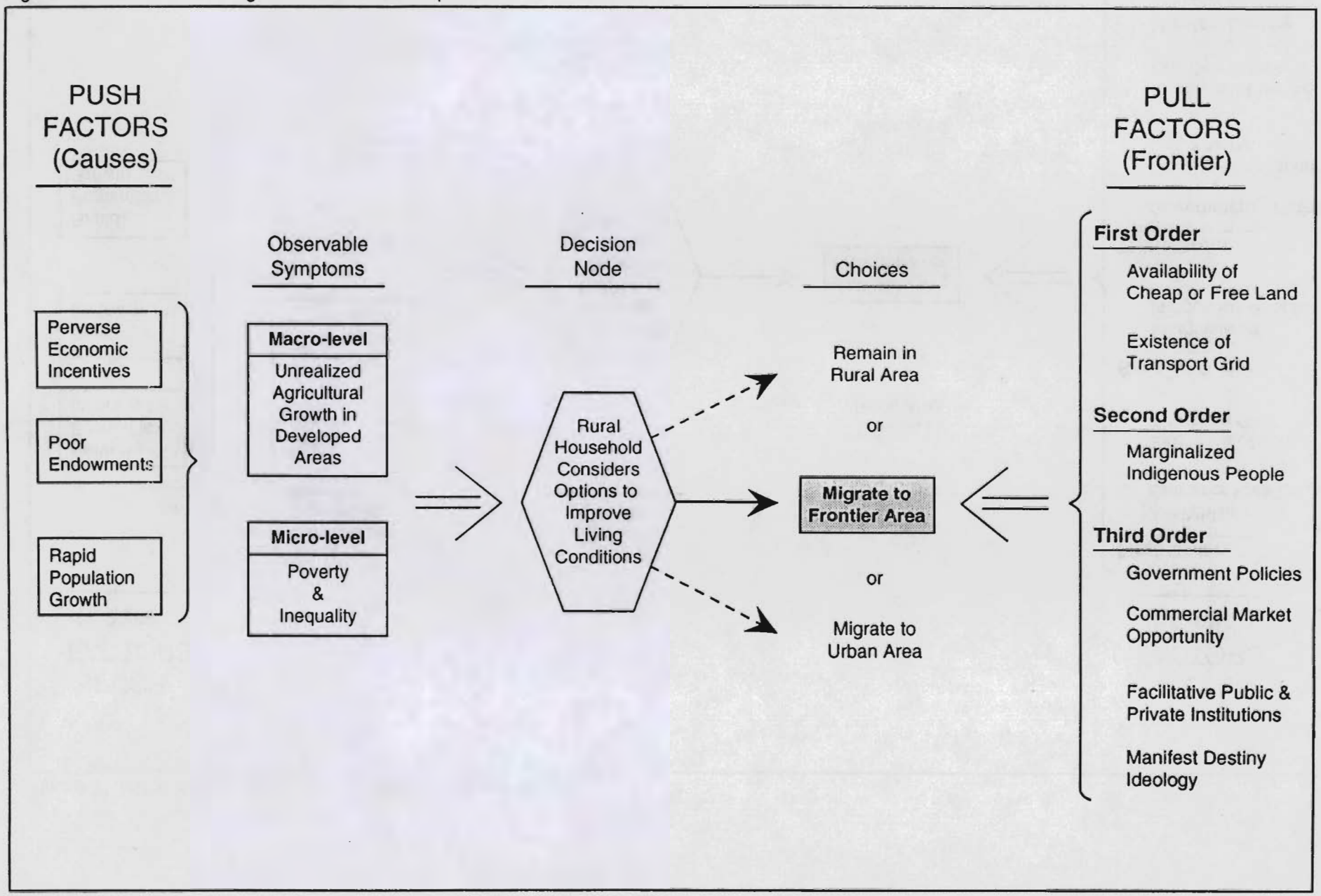


Figure 2. Initial Wave of Agricultural Frontier Expansion

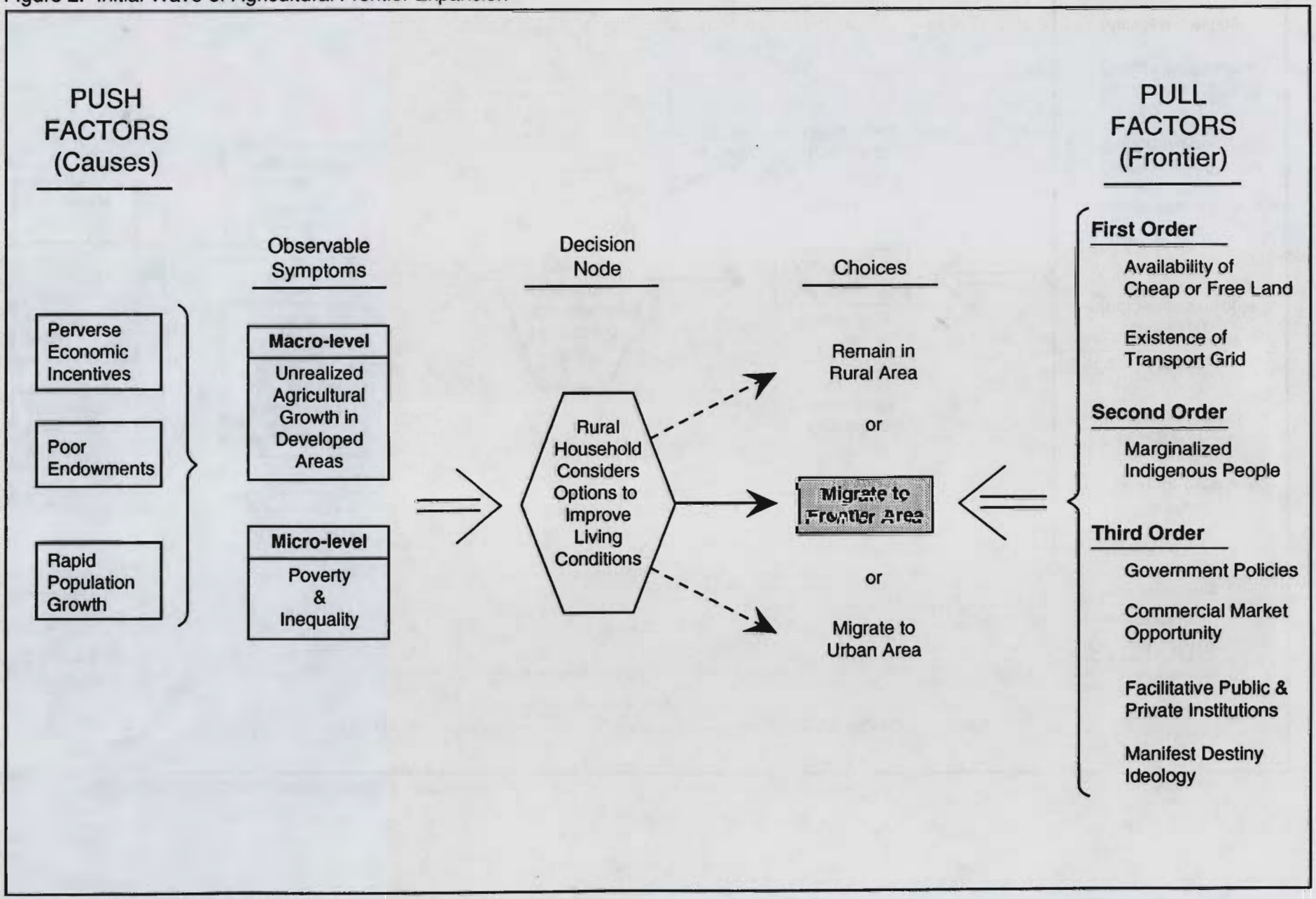
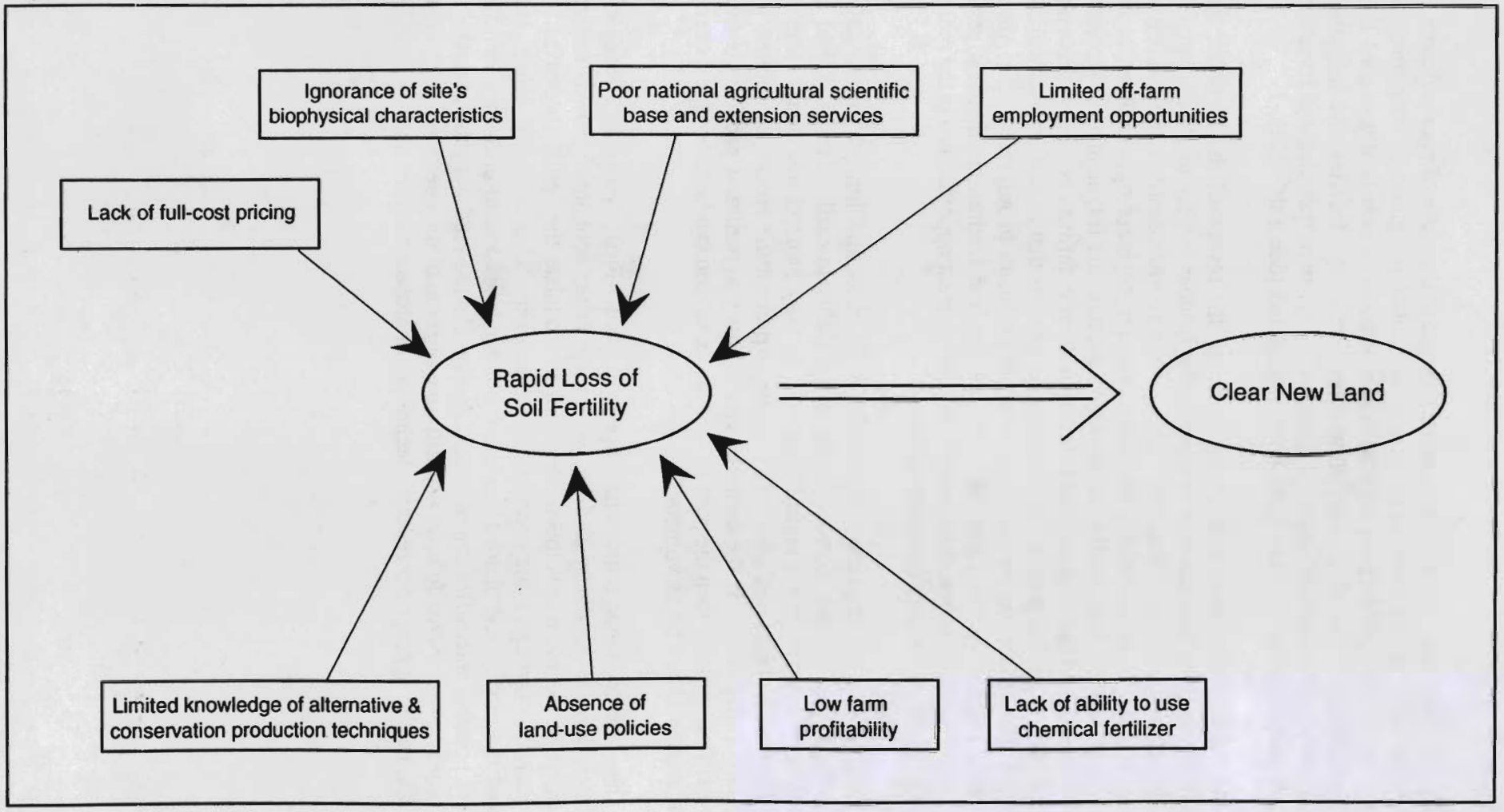


Figure 3. Secondary Wave of Agricultural Frontier Expansion



In order to make the discussion more relevant to the issue of encroachment in Ecuador, the following table of has been developed as an illustrative guide to how some of the more important determinants of frontier expansion can be more systematically studied in preparation of a reform program aimed at controlling migration to the frontier and in particular to the boundaries of environmentally sensitive areas. Clearly, more policies and issues exist but for the sake of parsimony only a few have been highlighted (See Table 1.2).

On the push or supply side of the equation, the review of the literature indicates that small farmers and landless laborers migrate to the frontier largely to obtain better quality and larger plots of land. The poor and near landless farmers who constitute the majority of migrants have little formal education which limits off-farm employment opportunities in urban areas. Also, the large size of rural families in the Sierra creates land fragmentation problems when the head of the household has to pass control to a small family farm to numerous descendants. Ever decreasing farm sizes and poorly functioning land markets that inhibit land consolidation forces some of the descendants to leave. Thus, what drives them to migrate to the Amazonian and northwestern frontiers is the culmination of policies and institutions that has generated high levels of poverty and circumscribed growth and employment opportunities in the more developed Sierra (highlands) and Costa (coastal) regions.

What draws the migrants, despite all of its risks and limited infrastructure (clinics, schools, electricity, bridges, potable water) is the ability to easily claim a plot of land free of charge. Once on the frontier, rapid loss of soil fertility prompts additional clearing. Why is soil fertility loss so rapid and what can be done to prevent the process or replace the nutrients becomes a burning issue. If the colonists can intensify agricultural production and avoid soil erosion and fertility loss, then the pace of frontier expansion can be slowed and environmentally sensitive areas will not be as vulnerable.

Thus, the economic policy challenge is twofold. First, "push" incentives to migrate to the frontier have to be diminished by generating faster economic growth and employment opportunities in the more developed areas and to modulate the "pull" incentives fully pricing natural resources through policy and regulatory reform. Second, strong efforts are needed to understand the biophysical characteristics of frontier lands and to encourage sensible land use and where possible intensification of production on cleared land with the requisite investments in soil conservation. What follows is illustrative of some of the questions that can be asked and what might be the appropriate research technique to answer the question.

Table 1:2 Ecuadorian Encroachment Policy Issues and Relevant Economic Methodology Matrix				
		Push-Pull Factors		
Factors	*Current Specific Policies*	*Policy Questions*	*Methodology*	*Likely Data Sources*
Perverse Economic Incentives:	Antiquated Land Tenure Laws Pricing and marketing policies that encourage deforestation and inhibit investments in soil conservation.	1. How can land markets be made more vital in Sierra and Costa? How can land fragmentation be overcome. 2. What incentives are needed to promote more soil conservation techniques in the Sierra and the Costa? 3. What constraints exist for off-farm agro-industrial employment in the Sierra and Costa?	1. Econometric land model that simulates amount of transfers for changes in real prices, titling/registration procedures, and availability of capital. 2. Household soil conservation model that focuses on the costs of and returns to soil conservation in the context of the constraints perceived by the household. 3. Agribusiness Inventory 4. Multi-market model that links production externalities between two commodity markets. 5. Regional CGE models that links the Sierra, the Amazon, and the Coast.	Agricultural Census Land Records Household Surveys Trade Statistics

Table 1:2 Ecuadorian Encroachment Policy Issues and Relevant Economic Methodology Matrix				
		Push-Pull Factors		
Factors	*Current Specific Policies*	*Policy Questions*	*Methodology*	*Likely Data Sources*
Poor Endowments:	Maldistribution of Land in the Sierra and Coastal area Low rates of land titles accorded Poorly functioning credit markets	Does a clear link exist between tenure status, especially titled owner and access to credit, productivity, on-farm investments, higher incomes? If it exist what can be done to increase titling? What can be done to encourage willing seller-willing buyer land transfers in Sierra? How can threats of land invasions be reduced in Sierra?	1. Review of literature on credit access, titling, and productivity in Ecuador. 2. Legal and economic review of tenure situation in Sierra coupled with stakeholder analysis.	Journal articles and unpublished dissertations Government reports. Land records.
High Population Growth Rate	Lack of family planning services in rural areas. Poor educational attainment of women	What are the determinants of fertility? What are the determinants of demand for family planning?	Knowledge, Attitudes, and Practices Survey of women in their reproductive years. Estimate Demand for family planning services as a function of a set of standard socio-economic and locational variables.	Medical Records. Surveys

Table 1:2 Ecuadorian Encroachment Policy Issues and Relevant Economic Methodology Matrix				
Push-Pull Factors				
Factors	*Current Specific Policies*	*Policy Questions*	*Methodology*	*Likely Data Sources*
First Order: (Pull)	Open Access Property Regime	What land-use and tax policies would make sense in frontier regions? If land claims were separated from land right, how would the policy be enforceable? How would government be able to prevent squatting in remote areas?	1. Develop model Land-use plan using GIS. Based on this plan develop economic tax incidence econometric models. 2. Legal and economic studies of enforcement mechanisms and use of tax/subsidy incentives.	Soil surveys Forestry inventories Hydrologic surveys Ecological Studies Taxonomic inventories Satellite Images
Second Order: (Pull)	1. Policy on roads developed for petroleum industry 2. Marginalization of Indigenous Peoples	1. What restrictions should be placed on new road construction? 2. How can the cultural rights of native peoples be better protected?	1. Regional Planning Study keyed on promoting developments in areas only were soils are adequate. 2. Sociological and legal studies.	Soil surveys Satellite Images GIS database developed for #1

Table 1:2 Ecuadorian Encroachment Policy Issues and Relevant Economic Methodology Matrix				
Push-Pull Factors				
Factors	*Current Specific Policies*	*Policy Questions*	*Methodology*	*Likely Data Sources*
Third Order: (Push-Pull)	1. Subsidies to cattle ranching 2. Antagonistic relation between Park authorities and local residents. 3. Rapid soil erosion occurs on cleared frontier land.	1. What macroeconomic and sectoral polices are needed to dampened the production of environmentally harmful commodities? 2. How can the Park Service cooperate with park neighbors to improve sustainable resource use? What resources would be necessary? **3. How can soil conservation techniques be effectively promoted in frontier regions, especially those bordering protected areas?**	1. Natural Resource Policy Inventory (See the *Green Book* by Johnston and Lorraine, 1994) 2. Cases studies demonstrate successes of community resource management schemes. **3. PAM analysis that compares farm returns from unsustainable practices to sustainable practices.** 3. Dynamic soil conservation economic model.	Farm budgets Government Statistics Rapid Appraisal Interviews Household survey of settlers and indigenous peoples.

In the next section, one of the methodologies is applied in generic form to studying the issue of soil conservation of a farmer on the boundary of a protected area. If the farmer does not succeed in maintaining yields and income, expansion of the farm is likely at the expense of the protected nature reserve. The section that follows elaborates on the bolded question from the above table on how can soil conservation be promoted at the frontier or nature reserve fringe areas.

4.0 PAM Methodology Applied to Soil Conservation and Biodiversity Loss

4.1 The Traditional Commodity-Based PAM

The advantage of the PAM methodology is that it condenses and quantifies the incentive effects of the previously mentioned economy-wide and sectoral policies into a readily comprehensible framework. A brief description follows.

The PAM methodology is based on farm budgets that reflect the costs, returns and profits of producing a particular commodity (Table 1.5). Private profits, shown in the top row of the PAM, are computed from the physical input-output data and domestic market prices. The private profit calculation provides information on the incentives faced by the private economic agent; it also gives an approximate indication of the competitiveness of the economy. Substantial private profits suggest that there are rents accruing to the owners of fixed factors due to market imperfections. Private losses suggest the opposite. Losses cannot be sustained over time with the result that the values of factor prices will have to decline.

Table 1.5: The Policy Analysis Matrix (PAM)

	TRADEABLE		DOMESTIC	
	REVENUES	COSTS	FACTORS	PROFITS
PRIVATE	A	B	C	D
SOCIAL	E	F	G	H
DIVERGENCE	I	J	K	L
PRIVATE PROFITS	D=A-B-C	NOMINAL PROTECTION COEFFICIENT		A/E
SOCIAL PROFITS	H=E-F-G	EFFECTIVE PROTECTION COEFFICIENT		(A-B)/(E-F)
OUTPUT TRANSFERS	I=A-E	PRIVATE RESOURCE COST		C/(A-B)
INPUT TRANSFERS	J=B-F	DOMESTIC RESOURCE COST		G/(E-F)
FACTOR TRANSFERS	K=C-G			
NET TRANSFERS	L=D-H			

The second row of the PAM utilizes the same input-output coefficients as the private profits row but multiplies them by social rather than market prices. For tradables, these social prices are border equivalents. For domestic factors, they are opportunity costs, i.e. the foregone value from employing the factor in its best alternative productive activity. A positive value for H, the measure of social profits, is an indication that internationally priced value-added is greater than the cost of domestic factors used in the production process. Commodities that show positive social profits are said to have a comparative advantage in production.

Policy effects and market failures, shown in the bottom row, constitute the difference between private and social values of outputs and inputs. These divergences provide insights into the extent of policy interventions in the form of taxes, subsidies, trade restrictions and exchange rate distortions. They also point to imperfections in the functioning of commodity and factor markets. The sum of the policy effects constitutes net transfers to and from producers of a particular crop. Net transfers also indicate the difference between private and social profits for the commodity system.

4.2 Incorporating Present Value and Soil Conserving Technology

The PAM methodology can be extended to incorporate "sustainability issues" in agricultural exploitation.[13] A comparison is made between an "unsustainable" system i.e. the currently observed one and an alternative "sustainable" system described by a second set of input-output coefficients. The "sustainable" technology has to minimize negative externalities, maintain yields, raise income levels, and fully account for all user costs. This usually implies modifications in the existing farming activities. For example, sustainability may imply agroforesty as opposed to single or intercropped field crops in cleared tropical humid forests.

The extended analysis proceeds by comparing the second (sustainable) PAM to the traditional (observed) PAM in order to (a) ascertain the cost of compliance of moving from an unsustainable to a sustainable system, and (b) determine the total transfers (economic and environmental) between private producers and society as a whole.

Table 2 demonstrates the calculations of an extended analysis. Table 2A is simply the traditional PAM based on observed (unsustainable) practices. Private and social profits are computed in the manner described above. Table 2B is based on the set of input-output coefficients that are deemed to be sustainable over the long run. The private and social prices used in the computation of profitability are the same prices used in Table 2A.

Table 2C is obtained from the private profits row of the unsustainable PAM and the social profits row of the sustainable PAM. The former reflects existing practices, the latter reflects a production system whose long term effects are considered socially desirable. The

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[13] See Appendix 2, Table A2.1 Section 4-Economic Analysis Block for discussion of advantages and weaknesses of PAM methodology.

"Divergences" row in the economic and environmental PAM therefore encompasses both the difference between private and social prices and the physical difference between sustainable and unsustainable production practices.

Table 2D shows the compliance costs of moving from an unsustainable to sustainable system. Private costs are those that will be felt by producers and are defined as the difference between the private profits in the unsustainable and sustainable PAMs. In the presence of externalitities and unrecognized user costs, they are the disincentive for producers to move to a new system. The social costs row reflects the difference between the two systems measured in social prices.

Table 2A	Unsustainable Technology PAM			
	Tradables		Domestic	
	Revenues	Costs	Factors	Profit
Private	A	B	C	D
Social	E	F	G	H
Divergence	I	J	K	L
Table 2B	Sustainable Technology PAM			
Private	A'	B'	C'	D'
Social	E'	F'	G'	H'
Divergence	I'	J'	K'	L'
Table 2C	Economic and Environmental PAM			
Private	A	B	C	D
Social	E'	F'	G'	H'
Divergence	I"	J"	K"	L"
Table 2D	Cost of Moving to a Sustainable Farming System			
Private	A-A'	B-B'	C-C'	D-D'
Social	E-E'	F-F'	G-G'	H-H'

In the context of protecting the Cotacachi-Cayapas Reserve, PAM could be applied to farmers involved in crop production or livestock. With the aid of farmers, extension agents, and biological scientists budgets for current practices would have to be gathered and biophysical

assumptions on the rate of soil fertility loss, erosion, compaction as well as what are preferred cultivation techniques, stocking rates, or soil investments that could be made and their attendant costs. From government and private research institutes, information on market prices, opportunity costs, and border prices would have to be gathered as well. Logging, hunting, and mining are other common economic activities in the fringe area of the reserve. However, PAM would not be the appropriate technique to use because these activities are extractive and the current property rights regimes seem inimical to sustainable use practices. Optimal control models that derive sustainable harvesting or extraction rates and minimization of negative externalities would be more appropriate. Take alluvial gold mining for example. De jure or de facto property rights may exist to a claim site but the real environmental problem is due to changing the courses of riverbeds and mercury poisoning, externalities whose costs are not internalized to the miner. Valuing the costs of these externalities would be very difficult especially given the fact that the miner may move with some frequency. In the case of logging, resource users are cutting patrimonial forests largely under open access rules or illegally. Therefore, PAM with its implicit assumption of "exclusive control or ownership" of the renewable resource base, would not be useful.

4.3 Incorporating Option Value into the Extended Soil Conservation PAM

In calculating the social prices in the aforementioned PAM exercise distortions in the pricing of inputs and outputs were corrected. However, this correction is incomplete in the context of protecting a neighboring biodiversity reserve. "Full cost pricing" should include an option value or the risk premium citizens are willing to pay in order to preserve the wilderness farmers are encroaching upon. The main uncounted benefits of preserving the wilderness areas would be the future recreational use and scientific values from the discovery of pharmaceutical compounds. In the economic literature, the means by which such a future and uncertain benefit is quantified is through option valuation. Option value is defined as

$$OV = OP - E(CS)$$

where OP = option price or the maximum amount the consumer in question would be willing to pay in time t for an option to visit or use the environmental amenity in time $t+1$ and E(CS) = expected consumer surplus or the expected benefit derived from enjoying the environmental amenity. Because of scientific ignorance and uncertainty about income across states, the size and sign of option value is largely indeterminate theoretically, probability based mathematical programming methods are not very reliable.[14] Indirect methods such as hedonic house values

[14] Theoretical analyses on both the demand and supply side have demonstrated that a priori attempts to determine the sign of OV will be unsuccessful except in special situations where specific information about individuals' utility functions on the environmental good in question are available. Even if the sign of the OV were unclear, the problem would not have practical relevance if is seemed likely that OV was small relative to consumer surplus. Available empirical estimates of OVs tend to be relatively large, to the extent that ignoring them could lead to substantial biases. Moreover, nothing suggests that OV is a random variable with an expected value of zero. (Willis, 1989 p 246)

are also not advisable, especially in the case of valuing wilderness areas because property markets around wilderness areas are usually not well developed. Thus, the only practical means of estimating option value is through the use of willingness-to-pay contingent valuation (CV) surveys. Respondents are presented with an array of hypothetical scenarios and are asked to state how much they would be inclined to pay in order to preserve a wilderness area from development. To date most empirical estimates of OVs for protecting wilderness areas have consistently been large and positive (Willis, 1989).

In the context of the PAM exercise, having an estimate of option value is likely to increase the wedge between private and social prices and thereby making a more compelling case for remedial action.[15] In order to estimate the OV of protecting Cotacachi-Cayapas Nature Reserve two related valuation surveys would have to undertaken. One survey would have to be directed at a panel of experts with the aim of approximately estimating the scientific value of the preserve under a set of future states and assigning probability weights to each state. For example, an index of the biodiversity value of Cotacachi-Cayapas Reserve may have to be developed based on the density of species for types of habits in the reserve.

A second random survey would be contemplated of respondents close to the park, not-so close, and distant from the park that would ask them to break down their willingness to pay according to utility derived from (1) actual consumer surplus form actual direct or recreational use; (2) payment of an insurance premium to retain the option of possible future recreation use; (3) existence value, the satisfaction from knowing that the site exist as a natural habitat; (4) scientific value, or the worth of preserving the site based on the probability of future scientific and commercial benefits (tied to index developed by panel of experts); and (5) bequest value, the satisfaction from knowing that the site will be protected for future generations.

To date, the empirical estimates of OVs from the CV technique have been suspect (Willis, 1989). The estimates produced can not be easily explained nor predicted with the typical set of socio-economic variables collected. Great care is to be needed in all phases of design, implementation, and interpretation of the CV questionnaire. Empirical studies typically do not define the time over which the option would exist, doesn't attempt to identify the respondent's rate of time preference; do not account for probability of an individual use of the resource, nor account for a spectrum of habitat states in the future, nor use control groups. These factors may explain the divergence between empirical and theoretical results and the poor explanatory power of models of empirical behavior.

With regards to the Cotacachi-Cayapas Nature Reserve, despite all of the problems surrounding the CV technique, the incorporation of some approximate option value for preservation could be very important, given the ongoing program of macroeconomic and sectoral liberalization. Input and output price distortions are diminishing over time. Without explicit valuation of an unobservable and uncertain future benefit, substantial biases can be introduced.

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[15] The average option value would enter in Table 2A of the soil conservation PAM and all other steps would remain the same.

5.0 Conclusions

5.1 Summary

Maintaining biodiversity is an important and worthwhile goal, especially in the humid tropics, because of the large potential direct economic benefits and significant ecological services provided. Nevertheless, valuing biodiversity poses problems for economic analysts largely due to absence of markets and the high degree of uncertainty and risk revolving around species loss. Establishing and effectively maintaining wildness nature reserves is the most feasible means of ensuring biodiversity for future generations. However, scientific ignorance, lack of enforcement capacity, widespread poverty, and unsound economic policies make the task extremely difficult.

In general perverse economic incentives, namely tenurial incentives and price distortions induced by government interventions in markets, and demographic pressure encourage agricultural frontier expansion and the subsequent destruction of natural habitats hitherto largely unmodified by humans. In the case of Ecuador, land claim laws, government subsidies, price supports, the lack of a national agricultural scientific base, poor extension services, a national ideology promoting settlement of remote and disputed territories, and unrealized economic growth allows demographic pressure and poverty to force a rapid rate of frontier expansion. Unfortunately, much of the new land is unsuitable for agriculture and would be best left with its forest cover.

An illustrative schematic of encroachment issues and relevant research methodologies was laid out to help guide interested analysts in better studying the phenomenon of encroachment on protected areas. One specific methodology, the extended policy analysis matrix was developed in detail and proposed as an easy and rudimentary technique that could yield insights on how to promote the adoption of more sustainable agricultural practices by smallholders. PAM could be applied to a number of commodities but it has its limitations. A contingent valuation survey designed to obtain measures of option values were also discussed but it would be a more complicated and expensive undertaking. These analytical techniques presented, however, will have to be complemented with others in searching for alternative income generating activities that are compatible with park protection and integrity.

Economic analysis, however, does not suffice in fully understanding the phenomenon of encroachment. Research on the social aspects of managing natural resources and clarifying property rights is recognized as equally important. Sustainable resource use is a function of market forces, social organization, and technology. In the context of Cotacachi-Cayapas Nature Reserve, aggressive park enforcement is unlikely given budgetary constraints. Therefore, cooperative arrangements will have to be sought with colonists and colonists will have to view the reserve as asset to be protected and not as a free good. Achieving this attitudinal change will require changes in social organization and improved development alternatives.

5.2 Future Research Needs

In general, natural resource management analysts and biological scientists concerned about biodiversity protection agree that concerted action is needed in four broad areas: policy improvements; institutional strengthening; integrating development with conservation; and mobilizing more financial resources for conservation (McNeely et al, 1990; Southgate et al, 1992b; Bromley and Cernea, 1989). In each of the areas, high quality research is needed to understand the constraints of human actors, to trace causal relationships, and to explore the likely effectiveness and costs of alternative measures and institutional arrangements.

5.2.1 Improving the Policy Environment

A wide range of policies, laws, and regulations result directly or indirectly in the depletion of biodiversity or nullify efforts at conservation. Identifying and quantifying the impacts of these perverse incentives should be a high research priority. A next step would be studying the costs and likely impacts of eliminating or diminishing these perverse incentives. Social sector polices, especially education, primary health care, and family planning services should not be overlooked. While the "right prices" and "effective social organization", can increase efficiency in resource use and spur environmentally benign technological innovation, improvements in education and health care delivery increase human productivity and earning power, resulting in higher per capita incomes and lower fertility rates.

5.2.2 Strengthening Institutions and Clarifying Property Rights

Conservation in many countries is limited by weak administrative and scientific research agencies. A classic problem is conflicting mandates within an agency ostensibly charged with protecting and managing a natural resource. For example, many Forestry Directorates are responsible for protecting national forests but at the same time with maximizing timber production. Most often, the development interests win and unsustainable practices occur. Analyzing the incentive structures, the training needs, and coordination functions within and between institutions with mandates that affect natural resource use is an important research need.

5.2.3 Integrating Conservation and Development

Enforcement is unlikely to be a long-term solution in pursuing effective protection of nature parks and reserves, particularly in very low-income, densely populated countries. Therefore, successful management of protected areas will depend heavily on cooperative arrangements wherein local people are convinced of the utility of protecting the park and derive tangible benefits from non-threatening or even complementary economic activities. Unfortunately, in practice few initiatives have succeeded in reconciling the needs of local peoples with conservation. Ecotourism is emerging as a promising activity, however, greater study is needed of existing experimental designs and experiences.

5.2.4 Mobilizing Financial Resources for Conservation and Environmental Education

Creating innovative funding mechanisms will be required to finance conservation efforts and environmental education. These mechanisms should be to the maximum extent market-related and based on the principle that those who benefit from natural resource use should pay proportionately more of the costs of ensuring that such resources are used sustainably. Efforts are needed at the community, national, and international levels. At the community level and national level, approaches to be used can include entry fees to reserves, levying of taxes, allocating fiscal incentives, building conditionality agreements to replace, reinvest, and/or mitigate environmental damage in concession contracts, the linking of proceeds from high returning projects to "nature trust funds", and the establishment of private-public partnerships in education, restoration, and conservation. At the international level, greater use of debt-for-nature swaps, international conventions, provision of more direct technical assistance in biological and social sciences, and greater financial assistance from conservation associations, private entities, and governments in industrialized nations will be needed. Understanding and evaluating the effectiveness of various tax/subsidy schemes and funding mechanisms across locales and countries would be helpful in identifying interventions that work.

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CAVEAT: The authors reserve the right to correct factual errors that may be present in the report at a later date. The authors were unable to visit the country to verify information and no information was received from the SANREM/Ecuador team prior to submission of the report to USAID.

APPENDIX 1: Policy Inventory

The policies listed below have unclear effects on frontier expansion and unsustainable resource use patterns. More rigorous modeling and empirical analysis is needed before stronger conclusions can be offered.

Exchange Rate Policy Until the onset of the debt crisis in 1982, Ecuador pursued a fixed nominal exchange rate policy. Prior to that date, the sucre was grossly overvalued simulating imports and penalizing exports. As a result, investment in tradeable agricultural commodities was discouraged. Between 1982-1992, exchange rate policy vacillated between crawling peg, dual systems, and finally free floating regimes. Since the fourth quarter of 1990, the real effective exchange rate has been appreciating albeit slowly, reducing export competitiveness (IMF, Recent Economic Developments, 1994).

The long period of currency overvaluation probably provided a stimulus to invest in subsistence agriculture, especially products than were not importable. Thus, overvaluation may have encouraged frontier expanision in conjunction with other policies.

Trade Policies Trade reform in 1990, significantly reduced tariff barriers and quantitative restrictions. In March 1993, Ecuador along with other members of the Andean Pact (Colombia, Venezuela, and Bolivia) agreed to a system of common external tariffs (AEC), with four main rates (5,10,15, and 20) with about 100 items excluded. As a result of trade liberalization, the spread in effective rates of protection have been greatly reduced with manufactures still enjoying a slight advantage over agricultural commodities. These differentials, theoretically could influence investment flows.

The major trade policy that affects the agricultural sector is the *system of price bands* that covers the imports of corn, barley, rice, sugar, wheat, soybeans, palm oil, poultry, powdered milk, and their derivatives.[16] The main purpose of the price band mechanism is to stabilize import costs and to protect against the rapid increase in imports enjoying heavy subsidization such as U.S. and EC grains, dairy products, and meats. During 1993, the band system was set in such a way that imports were priced above current market prices. The preference afforded domestic producers increased profitability but decreased consumer welfare. Most commercial agricultural production, however, occurs in the Coastal region, suggesting that much of the protection afforded, benefits larger more commercially-oriented farmers and not subsistence-oriented smallholders on the frontier.

[16] Under the system, floor and ceiling levels are established based upon monthly average prices from the preceding 60 months in the representative international commodity market. When the CIF price exceeds the ceiling, the imported commodity will not be levied the full ad valorem tariff. When the CIF price cum the ad valorem duty falls below the floor level, a variable levy will be applied to the imported commodity sufficient to increase its price plus the ad valorem duty to the floor level.

On the export side, observed farm-gate prices for traditional export corps (banana, cacao, coffee, shrimp) are closely tied to international prices. However, due to an oligopolistic export market structure, producer prices are a relatively small fraction of the price paid to the final exporter. For bananas, over 80 percent of total exports are handled by four companies. For coffee, three exporters control 50 percent of the market. Similarly, for cacao, four export companies control nearly 60 percent of the trade. The marketing structure evolved this way largely because entry was limited by licensing requirements.

Because many of the small-scale producers encroaching on protected areas in the Northwest and Amazon are primarily subsistence oriented, these policies probably have negligible effects. Others, however, are engaged in the production of cattle, African oil palm, coffee, and cacao and benefit from trade liberalization, especially measures to reduce export taxes. However, careful study of each marketing system would be needed in order to determine the extent to which benefits are transmitted to producers and stimulate additional demand for new farm land.

Price Controls The Government sets producer and consumer prices through the Ministry of Agriculture and Livestock (MAG) and the Ministry of Commerce, Industry and Fisheries (MICIP) for corn, rice, wheat, and sugar. While corn and wheat have been protected in recent times (producer prices higher than international equivalents), rice and sugar have been taxed (producer prices less than international equivalents).

The observed price support for corn and wheat, two commodities commonly grown by smallholders, penalizes consumers and encourages investment in commodities that Ecuador is calculated as not having a comparative advantage. (World Bank Ecuador: Agricultural Sector Review, 1993)

Marketing Controls In order to implement the pricing policies noted, the government uses marketing boards which have monopoly powers in the international trade of strategic commodities and commercialize a sizeable proportion of domestic production.

La Empresa de Almacenamiento y Comercialización (ENAC) is an government agency charged with providing price support for producers as well as attaining the food security goals set by the government. The Empresa Nacional de Productos Vitales (ENPROVIT) regulates consumer prices for 77 products. Its purpose is to provide low cost basic food stuffs to the poor through a network of 1125 urban and 1103 rural outlets.

ENAC primarily handles rice, attempting to smooth the marketed volume thereby reducing variation in consumer prices. Whereas ENAC average annual domestic purchases of rice represented 15 percent of marketed supply between 1986-90, it only acquired 8 percent of the hard corn supply. Rice is the country's major staple and a large item in household budgets, especially the lower incomed. The Government is very interested in maintaining an adequate, low priced supply. It is charged with maintaining a strategic reserve of 4-5 months consumption needs, but it has not been very successful in reducing inter-year variation in

constant domestic consumer rice prices despite access to subsidized credit and a monopoly on trade. In the 1980s the domestic variation has been several times larger than international prices. In regards to the other basic grains, budgetary and storage constraints often prevent commercialization of a larger share of the domestic supply. Most often only large farmers are able to take advantage of the higher official prices.

Similarly, ENPROVIT has not been successful in accomplishing its mission of improving the nutrition levels of the poor. Many of the goods are purchased by unintended beneficiaries i.e. middle class families. Both agencies have been plagued with enormous financial losses and high administrative costs.

The result of these two marketing parastatals on frontier expansion is indirectly negative. The inefficiencies of the two agencies contributes to fiscal deficits and higher inflationary pressures promoting investment in land, a real asset that is a hedge against inflation. In another channel, the ineffectiveness to assuage poverty and improve nutritional status may be a minor contributing factors to migration to the frontier.

Input Policies Until 1991, the government was active in the input market through two public enterprises--a fertilizer company and a certified seed company: Fertilizantes Ecuatorianas (FERTISA) and ENSEMILLA, respectively. In December 1991, FERTISA, which previously dominated the imported raw ingredients and mixed fertilizer for local resale was shut down. Private traders and companies now dominate the sub-sector. ENSEMILLA continues as a public entity but liberalized importation of seeds in 1990 permits private companies to compete with it. Most of the seeds produced or imported by ENSEMILLA are for Coastal zone cash crops: rice, soybeans, and horticulture.

Input prices have been very volatile due to the highly concentrated structure of input distributors, few changes in exchange rate policies and rising international prices. For example, the average cost for a metric ton of nitrogen fertilizer between 1980 and 1990 in constant 1978/79 sucre was 15,060 but the range was large with a peak of 32,620 realized in 1986 when the government shifted from dual rate exchange rate system to an open market rate resulting in a pronounced devaluation to a low of 8,600 in the following year, when the government reverted to a fixed nominal rate exchange system. Tractor costs, similarly have shown a similar jagged series for the same period. While the average unit price for a tractor was 636,330 constant sucres, the range ran from a high of 1,115,920 constant sucres realized in 1990 to a low of 509,430 constant sucres in 1980. Despite the sharp price movements, input use has on averaged grown 3.3 percent throughout the decade of the 1980s due to intensification of crop production, especially hard corn, soybeans, potatoes, rice, and cotton. Nevertheless, chemical input usage is 30 percent below recommended levels. Ecuadorian producers obtain yields per hectare or per livestock unit that are considerably below other producers in the Andean region and in Central America (See Table A1.1).

The low input usage rate contributes to lower than expected sectoral growth rates which

encourage the poor to migrate to the agricultural frontier, where land and land can substitute for scarce and expensive chemical inputs. Increases in production, come more from area expansion than from yield gains. For example, yields for banana, coffee, cacao, African oil palm, potatoes, soybeans, wheat, and cassava, either remained unchanged or declined slightly between 1986 and 1990. However, all these crops with the exception of potatoes, wheat, and coffee, exhibited strong increases in area harvested. For instance, banana area increased 40 percent, African oil palm jumped 41 percent, hard corn area expanded 3 percent, soybean area increased 140 percent, and cassava area swelled 36 percent in the same period.
(World Bank Ecuador Agricultural Sector Review, 1993).

Table A1.1: Crop Yields in Andean Countries (Kilograms/Hectare/Year)

Crop	Colombia	ECUADOR	Peru
Barley	1,908	**889**	1,170
Corn	1,360	**1,369**	1,962
Peanuts	1,442	**893**	1,892
Paddy Rice	4,697	**2,302**	4,809
Soybeans	1,998	**1,890**	1,795
Wheat	1,740	**972**	1,278

Source: M. Whitaker, "The Human Capital and Science Base," in Agriculture and Economic Survival: The Role of Agriculture in Ecuador's Economic Development ed. M. Whitake and D. Colyer (Boulder, CO.:Westview 1990) op cit Southgate and Whitaker, 1990.

Water Policies Water in the Sierra and the Amazon Regions is relatively abundant and treated as a free good. In the dry western coastal littoral, water is a scarce commodity but still is treated as a free good. Numerous irrigation projects have occurred in an attempt to increase arable land and permit multiple crops in the same year. Approximately 60 percent of the Government's annual agricultural expenditures between 1986-91 were devoted to capital investments in irrigation.

Despite the substantial investments, the real return on irrigation projects and the increases in farm productivity have been less than expected. Three main problems explain the less than stellar performance in the subsector: (1) inadequate project evaluation; (2) deficient implementation; and (3) insufficient ancillary research and extension services supporting irrigated agriculture. Poor data and lack of inter-agency inhibits accurate project appraisals and projections. The National Institute for Water Resources (INERHI) is hampered by lack of human and financial resources. Meteorologic stations need more modern and accurate measurement equipment and staff needs to be better trained. Once irrigation projects are approved, attaining international standards of efficiency has been very difficult and long-delays

in construction have been commonplace. As a result, a greater proportion of water is wasted and the stream of economic benefits are delayed. In addition, less than 5 percent of operational costs are recovered from users. This untargeted subsidy discourages better user group management of the water works. Lastly, the research and extension failures contribute to the planting of ill-adapted varieties and field losses.

The overall poor performance of the irrigated subsector, absorbs scarce public resources without generating a high return in terms of marketed value, export earnings, and employment generation. The relative underinvestment in other agricultural subsectors, especially those dominated by smallholders probably encourages migration to the frontier.

APPENDIX 2: Schematic of Encroachment Issues and Relevant Methodologies

The discussion will focus on the first five steps in the analytical process: problem identification; policy identification; institution and stakeholder analysis; quantitative policy analysis; and remediation strategy design. Both qualitative and quantitative approaches have to be used and the importance of multidisciplinary collaboration and interchange can not be overemphasized. The intended purpose is to present a comprehensive menu cognizant that a fraction of the listed exercises may be pursued due to peculiar interests of decisionmakers and their constraints. Each of the techniques has its strengths and weaknesses. What technique is appropriate depends on the interest of the analyst(s) and available resources.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies

Steps in Analytical Process	Methodology	Description	Pros	Con
1. Problem Identification	1. Biophysical Surveys (Includes soil mapping, water quality studies, taxonomonic and resource inventories, remote sensing of vegetative cover and topology, soil fertility studies, ecological field studies, hydrological studies) 2. Socio-economic surveys of resource users 3. Informed observer interviews	Understanding the magnitude and directional thrust of the natural resource problems associated with encroachment are documented through quantitative studies and anecdotal accounts.	1-2. Quantitative scientific and socio-economic surveys are far superior to anecdotal accounts. 3. In practice, the well publicized alarm calls of a few informed observers is usually how the debate is joined. Calls for rigorous studies come afterward with the motivation of either refuting or substantiating their original assessments. In highly budget constrained and data poor environments, informed observers may be the only sources of information.	1-2. Quantitative biological and social science field surveys tend be expensive, time consuming and require specialized equipment and trained personnel. 3. Subjective bias and faulty memory can be problems.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies

Steps in Analytical Process	Methodology	Description	Pros	Con
2. Policy Identification	1. Natural Resource Policy Inventory 2. Agribusiness Policy Inventory	1. A systematic cataloguing and linking of macroeconomic, sectoral, and resource policies in a manner that shows how they influence resource use. See "Green Book" by George Johnston and Hillary Lorraine. 2. A comprehensive listing of macroeconomic, sectoral, and credit policies as well as firm structure and how they influence competitiveness and investment.	1. Highly participatory in design and well suited for agenda setting and consensus building. Relative easy to undertake. 2. Good at systematically identifying constraints to off-farm employment generation and investment in agro-industry.	1-2. Qualitative and lacking in predictive power. Relaxing some of the obvious constraints may not generate expected responses. Need to understand the interactive effects of the various policies and methods cannot disentangle these effects.
3. Institution and Stakeholder Analysis	1. Institutional Mapping 2. Stakeholder Analysis	1. A comprehensive listing of all institutional actors who have mandates in the "problem domain". 2. A systematic assessment of the positions and interests of all relevant actors in the "problem domain."	Both activities are essential first steps in strategic analysis. Knowing who the relevant actors are, who has what power, and what is the position of each actor, and what are their likely positions vis-a-vis proposed reforms is necessary in building a strategic alliance for programmatic action. Presenting compelling economic and biophysical data is not enough to mobilize support for reform.	Two descriptive tools that need to be complemented by quantitative and technical analysis.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
4. Economic Policy Analysis	1. Measures of Protection and Intervention (Nominal and Effective Rates of Protection, Subsidy Equivalents)	1. Static measures of distortion and income transfers between producers, consumers and government.	Essential to understanding of incentive or disincentive patterns in commodity markets. The production of certain goods enjoying protection may be environmentally unfriendly. Others that are being taxed may be environmentally friendly but its production is being discouraged.	Static in nature. Need to updated frequently to determine direction. Need better understanding of the linkage between incentive structure, choice of commodity production, and environmental impact. The existence of an incentive doesn't mean anything in a priori terms about environmental impact.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	2. Policy Analysis Matrix Extended to Natural Resource Management (Farm Budget Approach)	PAM makes the distinction between what is privately and socially profitable based on farm level budgets for a particular commodity. Extended PAM compares current practice with what would be a desirable "sustainable standard of behavior" i.e. maintaining yields over time. The comparison of private and social profits under the sustainable choice of technique is compared to the old PAM, making the interplay between economic and environmental trade-offs transparent.	PAM is conceptually rigorous and easy to compute. Data requirements can be substantial but in most cases, fairly reliable budget information can be readily obtained.	1. PAM's do not permit analysis of supply response or impact of changes in output demands. Net Present Value PAMs are susceptible to criticism of not being able to adequately incorporate price and weather shocks. In certain environments characterized by high variability in rainfall or a high degree of volatility in prices, the validity of results can be undermined. Stochastic dynamic programming may be better technique. 2. Defining "standard of sustainability" and getting the biophysical assumptions right requires substantial consultation with ecologists and other biological scientists. 3. Farm households tend to be diversified operations with competing demands for scarce labor and capital. Thus, the focus on one commodity ignores the interactive and allocative effects of policy changes on other household activities.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	3. Single Commodity Market Models	Using single commodity partial equilibrium models permits an analysis of adjustments to changes in prices. Adjustments incorporate both supply and demand side of market. If prices are exogenous (set by gov't policy or international markets), foreign trade provides the mechanism by which supply and demand are balanced. If the commodity is a non-tradeable, a simultaneous set of demand, supply, and market clearing equations (usually inventory holding) permit a deterministic solution.	Effects of policy interventions (tax, tariff, ban, quota) can be easily modelled and analyzed from the perspectives of producer, consumer, and government. Best use for environmental analysis if source of distortion is in the pricing of the output.	1. Approach is dependent on use of elasticities in order to calculate supply responses and accordingly welfare changes. Elasticity calculations are suspect given the data situations in most developing countries. 2. If rapid structural change is occurring, statistical validity of model will be violated because not estimating movement along supply curve but discrete jumps from one supply curve to other. 3. Single commodity models do not capture what is occurring in related markets or the entire farming system. 4. In natural resources, distorted input prices, namely the undervaluation of factors, is a major cause of observed resource degradation. In this approach, it is very difficult to introduce input price distortions. Natural resource valuation is needed as a prior step.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	4. Multi-Market Models	Many environmental problems manifest themselves as production or consumption externalities. For example, the activities of one farmer results in run-off of fertilizer, pesticides, and soil which pollutes nearby bodies of water posing health hazards to aquatic and human life downstream and silts up rivers and dams or kills coral reefs. Correcting for externalities implies analyzing allied production and consumption systems and focusing on complements and substitutes. Externalities can be corrected by attempting to internalize costs through a variety of means: (1) changing property rights (2) setting quantitative controls (3) imposing taxes, (4) offering subsidies.	Incorporates demand analysis so that consumer preference can play a role in response to price changes.	1. Elasticity calculations are suspect given the data situations in most developing countries. 2. In particular, the lack of long time series with sufficient market-based variations may not be available, conceptually invalidating pre-liberalization with liberalization experiments.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	5. Trade Models (Note: Can be single, multi-market, or general equilibrium)	Analyses usually the extraction of a resource for export. Imposition of tariffs, taxes, bans, and quotas can be studied and welfare and income impacts on producers, consumers, and governments simulated.	Partial equilibrium analysis can give clear and strong results but assumptions are critical. General equilibrium analysis can give both direct and indirect effects but is much more difficult to accomplish.	1. Many indirect effects that may be very important can not be incorporated in partial equilibrium approaches. In general equilibrium approaches the linkage between resource intensiveness, degradation impact, and trade importance is not clear. 2. Comprehensive and accurate social valuation of the most commonly traded natural resource products that are internationally traded (timber, minerals, petroleum) is very difficult to do. Thus, current techniques tend to grossly undervalued these resources, possibly leading to faulty conclusions.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	6. Optimization Models (Household or Linear Programming Models)	An objective function is defined that maximizes farm profits or satisfies a minimum consumption need subject to a set of constraints of the supply of factors of production and technical input-output coefficients. These types of models allow for rich and varied representations of factor markets.	Provides endogenous supply response to external policy changes thus providing predictive power as to how resource users or farmers are likely to react. Very rich insights possible on how the household allocates capital, labor, and land across different activities in response to policy changes. Most small farm households are diversified enterprises and understanding linkages between production, consumption, and off-farm activities is critical.	1. Linear modelling approach is most common because of tractability but may misrepresent reality. Increasing evidence suggest that real life decisionmaking is best modelled by nonlinear systems. Data requirements and computational complexity, however, tends to be prohibitive. 2. Whereas linear programming models can use expanded farm budget data, household models require longitudinal survey data to identify slack and peak periods in labor demand and consumption needs.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	7. Agricultural Sector Models and Computable General Equilibrium Models (CGE)	Sector models make prices endogenous but there is no income effects from changes in factor prices. CGE models incorporate factor incomes and captures the circular flow of an economy. Firms produce and sell commodities following the profit maximization rule; firms use receipts to pay for factors of production; factors are apportioned to prototypical households (rich-urban, poor-urban, rich-rural, poor-rural); households use factor incomes (rent and wages) to purchase outputs of firms.	Makes more economic variables endogenous and thus enriches the analysis. CGE models provide information on both the direct and the indirect impacts or feedback loops of policy proposals.	1. The high level aggregation necessary to make these models tractable makes it difficult to relate results from model solutions to individual commodity markets. 2. These models are extremely data intensive and require high levels of computational and economic skills.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	8. Indirect and Non-Market Valuation Techniques: (i) Travel Cost (ii) Wage Differences (iii) Property Values (iv) Proxy Marketed Goods (v) Contingent Valuation	Many environmental goods and ecological services have no observed value therefore valuation must be imputed using the concept of willingness to pay (WTP) to retain an amenity value or willingness to accept compensation for loss of an amenity value. The techniques listed to the left all attempt to estimate the demand for an environmental resource by either deducing WTP to be revealed by an actual expenditure to visit a wilderness site (travel cost) or by posing a hypothetical question to an interview subject as to the dollar value the subject would be willing to pay to protect and preserve the wilderness area). These valuation techniques are very important is estimating the "true demand" or "monetary worth" of a natural resource.	The WTP concept is the principal conceptual tool, neoclassical economics has at the moment to study non-market valuation problems.	WTP criteria is clearly a useful construct but the most commonly used estimation technique, CVM, must be done with extreme care. The questionnaires must carefully designed, implemented, and interpreted to prevent status quo and strategic biases. In general, higher income people tend to reveal a higher valuation for environmental amenities than lower income persons. What is difficult to untangled whether the higher ability-to-pay and higher amounts of leisure time of the higher income explain this artifact or whether they are intrinsic preference differences and the neoclassical utility assumptions that prevent interpersonal comparisons is too restrictive. Second, the more educated people, the easier it is for them to understand WTP questionnaires. Third, people always seem to be willing to receive more compensation than to pay out a set amount to preserve the same amenity. Fourth, poor people seem more willing than the rich to accept a high level of status quo pollution and degradation.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	Conventional Market Valuation Techniques (i) Defensive Expenditures (ii) Loss Potential Earnings (iii) Replacement Cost	Some subset of environmental problems can be valued through markets and can serve as guideposts of cost of environmental actions or conversely revealed benefits of mitigation. For example, a polluted water source may prompt the use of expensive filtration devices which represent the value of safe water to that household or community. Likewise, deforestation may impair the power generation of a hydroelectric dam or kill coral reefs which support rich fisheries. The lost income from the utility and the fishermen represent the potential benefit of mitigation. If the defensive expenditures or loss earnings sum to be greater than the cost of intervention, clear grounds exist for intervening on Pareto efficiency grounds.	Calculating opportunity costs of environmental investments or actions is a very direct means of building consciousness among policymakers.	Clear ecological understanding of the links needed. Data and time requirements may be substantial.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
Remediation Strategy Design	1. Cost-Benefit Analysis (CBA)	In deciding what is the optimal project intervention, CBA is the traditional technique used to compare the discounted future stream of benefits and costs. If the net present value of the project is greater than zero or its competitor projects, it is accepted.	CBA is conceptually rigorous and consistent if all valuations and assumptions are correct.	1. CBA often encounters difficulty in implementation. Quantification of externalities can be difficult, assumptions can be overly optimistic or faulty, and technical input-output data can be wrong. The result is that costs can be undervalued and benefits overestimated. 2. Choice of discount rate can be problematic as well as the incorporation of risk and uncertainty. In developing countries the rate of capital productivity and individual rates of time preference tends to be very high. High discount rates discriminate against projects that yield most benefits in the distant out-years and thus favors the consumption desires of the present generation over future unborn generations. In projects involving wildness and biodiversity protection, this problem is acute.

Table A2:1 Matrix of Analytical Tasks and Relevant Methodologies				
Steps in Analytical Process	**Methodology**	**Description**	**Pros**	**Con**
	2. Multi-Criteria Analysis (MCA)	Often projects have significant social and ecological dimensions that can not be quantified in monetary terms and made concurrent with the economic efficiency criteria making CBA less than satisfactory as a decision tool. MCA calls for decisionmakers to specify desirable objectives and uses one of five evaluation techniques (aggregation, lexicographic, graphical, consensus-maximizing, or concordance approaches) to arrive at a decision that is technically and financially feasible and socially acceptable to the parties.	MCA compared to CBA, makes value judgements more transparent, incorporates qualitative data, weights relative priorities of groups as opposed to prices and income levels.	1. MCA is not a substitute to CBA but a complement. 2. MCA is best used in settings with very few or relatively homogeneous actors. The greater the number of actors and the more divergent their interests, it may not be possible to determine a single best solution. 3. Mathematically the approach is very constrained. Non-linear, stochastic, and dynamic formulations of the planning problem can not be easily made.