Under the Shadow of a Star:
Sustainability and oil development in the Ecuadorian Amazon

OAD2: The second in a series of occasional papers examining the interaction of oil development and deforestation in Latin America.

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Submitted to Christaan Beyers on November, 1996

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1.0 INTRODUCTION

During the course of this paper, assuming a reading time of thirty minutes, approximately 34 hectares of agricultural land will be lost, world population will grow by over 150 persons, and three plant or animal species will disappear into extinction. These trends are mutually destructive and indicate the rise of a new discourse between the function of natural systems, or ecology, and the management of human societies, political economy. By working towards short-term goals, development practices in many parts of the world are undermining the future potential for human societies. This has created the need for an alternative, a way out of the deadlock left by the failure of development.

This paper is divided into several sections which cover three themes. Section two examines the reasons for environmental crisis and its influence in creating sustainability as a political space. The second theme uses the case of oil development in the Ecuadorean Amazon as an example of the failure of development by describing its history, operation, and future. The seventh and eighth sections briefly analyze the environmental and social impacts of this development before these themes are connected in section nine. In addition. large amount of reference material has been regulated to series of five appendices.

2.0 Why an Environmental Crisis?

"If enough data points trouble the theory, the theory may be wrong. If the theory is basic, the paradigm may have to change." (Robinson, 1995)

Why an environmental crisis? It all has to do with the above statement. Scientists, by their nature as scientists, measure phenomenon in an attempt to better explain the workings of our world. Social scientists are called such because they measure phenomenon in human societies and environmental scientists measure phenomenon in the natural systems of the planet. Each measurement is a datum and taken collectively, measurements are data points which can be interpreted into trends occurring in the system under study.

For, more than fifty years, environmental scientists have been collecting data points on change in natural systems since before the industrial revolution, because it now appears that it has been changing. For example, locate graphs describing trends in global atmospheric carbon dioxide levels, atmospheric content of ozone destroying CFC molecules, world human population, PCB concentrations found in the Canadian Arctic, loss of agricultural land, or absolute numbers of persons without access to potable water.

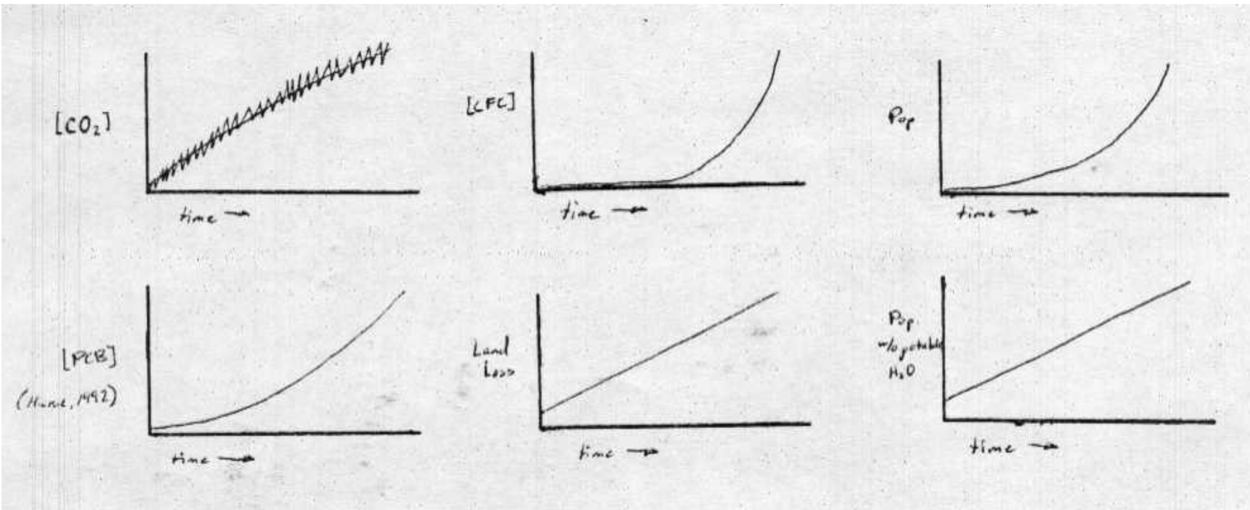


DIAGRAM 2.1: ENVIRONMENTAL INDICATORS OF CHANGE

The data points on each graph indicate long-term trends, which are then represented by what is called a "line of best fit" through the points. While some of these graphs slope upwards from the time of the industrial revolution, all have been increasing since the end of World War Two.

Although a jump in logic, the development student can sympathize that these trends of change in the natural world correlate with the worldwide push towards modernization. In short, human activity appears to be responsible for this change. (That itself is an interesting debate, but I ask the reader to accept this as given. After all, PCBs and CFCs are molecules which do not exist in nature and represent an easily traceable human impact.)

2.1 THE INFLUENCE ON DEVELOPMENT

This data appears to describe an increasingly acute conflict between the natural world, or ecology, and the way modern human societies operate, or political economy. The first warning of this conflict was the "Limits to Growth" report by the Club of Pome which first addressed the contradiction of infinite growth models in what is known to be a finite world. The conflict appears to strike deeply into the roots of each system.

SUPPLEMENT: A NEW BASIS

Another, and perhaps easier, way to understand the trouble with current practices is the amount of human appropriation of photosynthesis. It is a cornerstone of ecology that for all practical purposes, all the energy available in an ecosystem comes from the sun. Some of this energy is used to drive natural cycles of waterflow and atmospheric movement, but for our purposes a much more interesting aspect of solar energy is that it is of little use directly and must be converted to a biologically useful form for human use. This conversion process is called photosynthesis and may be represented by the following equation:

$$CO_2 + H_2O \xrightarrow{\textit{photon}} (CH_2O)_x$$

Atmospheric carbon dioxide is taken up by photosynthesizing plants and combined with water by the energy of sunlight into the sugars of varying complexity. Of course, the actual chemistry involved is a great deal more complicated, but this equation will suffice for the purposes of this paper.

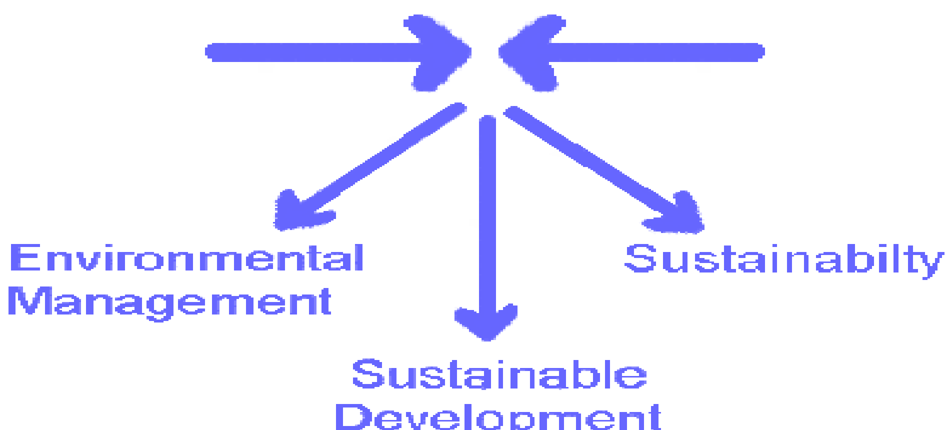
The material produced by photosynthesis can be called biomass (biological constructed matter) and has a variety of direct uses for human societies, including food and woodfuel. Yet, biomass is also makes up forests and animals and is what allows ecological systems to regenerate and reproduce. Therefore, although humanity can appropriate part of the biomass, a certain amount must stay within the ecological system. (An example of failure to keep biomass in the system is the need to put fertilizer on soils when the nutrient content is carried away with the food crop produced.)

Currently, humanity is appropriating approximately 40% of the biomass produced by photosynthesis worldwide. As seen with our data points, this appropriation is already having an effect. Considering world population doubling time is approximately 35 years and assuming a constant increase in demand, humanity will be appropriating 80% of the biomass produced by photosynthesis by 2031. There is, in fact, evidence that this is not practical or possible and indeed the world photosynthesis rate is currently falling due to soil erosion, desertification, deforestation, and pollution. Therefore, if not already, humanity may soon be drastically overshot on the capacities of this world to support it.

ECOLOGY	POLITICAL ECONOMY
dynamic balance	**continual growth based on static balance**
decentralized	**centralized**
controlled by feedback	**runaway cycles**

The implication for development studies has meant two things: First, a confusing multiplication in the terminology of the field. Secondly, the attempt to integrate ecology into development has meant the creation of a new political space. Consider the following diagrams.

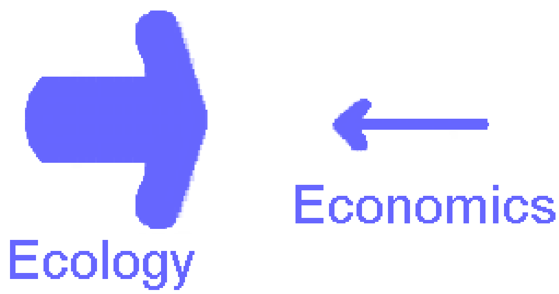
A.



B.

Retreating again into science, or more precisely classical physics, envision ecology and political economy as two projectiles on a collision course. In light of the afore-mentioned data points this may not be too great an exaggeration. Diagram B has the possible results of that collision depending on one's opinion of the momentum of each projectile. If one considers the two to be of equal weight, the result of the collision is sustainable development. If political economy is assumed to be of greater importance, then the result is an economic management of ecology where environmental services in the natural world are given prices and society continues as always. However, if what we are witnessing is data from the natural world that troubles the longer-term prospects for political economy theory, then the result is a more ecologically based goal of sustainability.

The purpose of this exercise is not to prompt the reader to start throwing objects at each other. In fact, equally voluminous works have been written on each subject to make that a messy prospect indeed. Instead, I have used a physical analogy for the collision of ideas and assumptions occurring in development theory. (Indeed, I incorporate my own bias on the subject in diagram C).



C.

Data from the environment shows that it is changing. That change troubles the longer-term prospects for political economy theory while that while that theory has become one of the basic paradigms of modern society. Therefore, according to our quote at the beginning of this section, the paradigm may have to change.

It is not within the scope of this paper to present a detailed vision for a new development paradigm. Yet, that is a challenge currently being met by theorists worldwide and I will attempt to describe in part how that future alternative paradigm is forming and some of its vocabulary.

The fundamental need for change appears to lie at the heart of the assumptions inherent in economic logic. This is not to say that economics is necessarily wrong; indeed, as Rafeal Negret (1994) observes, classical economic theory has survived relatively intact for two hundred years since the time of Adam Smith. From an ecological perspective, the implications of this economic model have been generalized as follows:

"The natural resource base was liquidated and the resulting revenues were invested in economic growth. Land and forest were exploited with little because the frontier seemed endless. Wastes were discharged freely because the absorptive capacity of air and water was great." (Goodland and Leder, 1984)

The basic principle of such a model is that it views the world as empty and awaiting the expansion of development. The alternative would be an economic model that acknowledges and works within the physical limits of the environment. In fact, just such a logic appeared in a World Bank paper as early as 1984 In a paper entitled "The role of environmental management in sustainable economic development":

"technical innovation can allow humanity to squeeze more economic value out of its limited natural resource base. However, it cannot increase the real quantities of natural resources ultimately available on this planet, nor can it increase the earth's natural waste assimilation capacity." (Goodland and Leder, 1984)

That is the alternative, full-world economics. Or, in other words, an economic logic that realizes that one cannot substitute more sawmills for less forests (Monbiot, 1994).

Inspired by this search for limits, I would like to put forward the term "sustainability" as the desirable goal for future human society. Sustainability can be defined as the political space, or physical discourse, created between an organism and its environment. As Sioli mentions:

"An organism has its own internal laws according to which it acts and reacts (eg. its physiology, psychology, etc.) while the environment has another internal law structure which rules its functioning... Between the two law-systems there is a field of tension which has to be overcome actively and passively by the organism for it to win its life." (Sioli, 1934)

According to Sioli, the organism can modify its environment, but it is also simultaneously acted upon by that environment. What results is a dynamic and continuous process of adaptation where the elasticity of the law-structures define the buffering capacity, or the capability of the organism-environment relationship to survive change. If this buffering capacity is surpassed then the relationship collapses and the organism dies.

The reason for mentioning Sioli's view is that I believe that (within certain limits) this model for organism-environment relationships can be applied to society-environment relationships. This should not be too great a leap in thought since society is a social creation and human beings are organisms dependent on the environment for their survival. Indeed, history has shown human society to be susceptible to environmental change even when such has not threatened the survival of humanity. Therefore, where the term sustainability appears in this paper, it intended in the Sioli meaning of the word as opposed to the wealth of definitions that exist regarding sustainable development. For our purposes, the two shall be considered separate ideas.

As previously mentioned, the changes occurring in the natural world can be seen to be challenging the paradigm of political economy. Therefore, given sustainability as the core goal, what will an alternative paradigm look like? We have already touched upon full-world economics, and I refer to some other subjects being debated within theory in Appendix A. This is not a paradigm for development, but if words possess a power, the mere existence of this vocabulary may be proof of the creation of such.

The purpose of this section has been two-fold: First, to establish why there exists an environmental crisis, and second, to introduce sustainability in order to examine the impracticality of oil-led development in the Ecuadorian Amazon in the long-term.

3.0 HISTORY OF OIL DEVELOPMENT IN ECUADOR

As mentioned above, essentially all energy utilized by human society in one form or another comes from the sun and the most important form of solar energy are products derived from photosynthesis. Even the energy base of modern society, namely petroleum, continues to be a product of photosynthesis. This has to do with how petroleum, or crude oil, is created. Crude oil is ancient photosynthesis in that it consists of plant material that has been buried, compressed, and heated for millions of years. Ecuador’s prehistoric climate and geology denote conditions that were optimum for the formation of crude oil deposits.

The first oil well in Ecuador was drilled in the Santa Elena peninsula in 1911 (Kimberling, 1991) exploration continued to varying degrees of intensity for the next fifty years. The strategy of the Ecuadorean government in the second half of the twentieth century has been to allow foreign companies to explore and prepare reserves for extraction in a specific land area, called a concession, before entering into a partnership with the foreign entity. This led to a significant effort in exploration on the part Dutch Shell and others, but the discovery of large reserves in the Northern Ecuadorean Amazon had to wait until the Texaco-Gulf consortium entering the country in 1964 (Gomez et al. 1992, p.49). Herein the Ecuadorean Amazon shall be referred to by its local name of "Oriente" since it encompasses the eastern part of the country.

These reserves soon established Ecuador as an oil exporting country and set off the so-called oil boom from 1972 to 1982. After the discovery of the northern Oriente reserves many events happened in quick succession, The Trans-Andean pipeline (the Sistema del Oleoducto TransEcuadoreano, or "SOTE") was completed in August 1972 to connect the Oriente reserves to refining and off-shore port facilities built on the Pacific Coast at Esmeraldas. The cities of Lago Agrio and Shushufindi became prominent, with the construction of new small-scale refining and storage facilities, and became magnets for immigration into the Oriente. From an estimated 24,000 inhabitants in 1962, Oriente population reached 115,000 by 1982, with most demographic growth focused around the Northern Oriente (Gomez et al., 1994). Quick to realize its new-found wealth, the Ecuadorean government nationalized the petroleum industry in 1974, thus creating the Corporacion Estatal Petrolera Ecuadoreana, or CEPE (Moreno, 1987). CEPE was restructured in 1989 and renamed Petroecuador which continues operation today (EIU. 1995, P.19).

4.0 THE PROCESS OF OIL DEVELOPMENT

As mentioned earlier, the state strategy for oil development in Ecuador relies on foreign companies to conduct exploration. Under such contracts, an approximately 200 000 hectare parcel of Oriente land is delineated and exclusive rights for exploration are granted to the foreign company. The costs of exploration are assumed by the foreign company and are only reimbursed by the Ecuadorean state should significant reserves of crude oil be proven to exist. For this reason, oil concessions are considered "risk- contracts".

The physical development of a concession may be divided into three stages: surveying, exploration, and production.

Surveying is the first stage of activity in any concession. This involves using aerial observation and satellite imagery to examine terrain for surface features that may denote oil deposits. Once identified, helipads are cleared in the forest and surveying teams of engineers are brought in by helicopter. These teams then clear straight trails and lay explosives along the trail at even distances. These trails are called seismic lines since their purpose, when the explosives are set off simultaneously, is to create seismic waves which travel through the Earth and reflect from subsurface geological formations. Once recorded, this creates an underground map of the concession.

This map identifies underground areas which may be deposits of crude, yet to confirm the presence of oil requires exploratory drilling (refer to diagram 4.1b). In this stage, wells are drilled at promising sites to test for oil and to obtain core samples of the geological strata of the well. These core samples complement the seismic maps to construct a better model of the concession’s sub-surface structure. This stage also involves the construction of more helipads for the transport of drilling equipment.

Should exploratory drilling reveal the existence of an economically viable reserve of crude oil, the foreign company submits a list of its expenses to the Ecuadorean government for reimbursement. At this point, negotiations begin in order to establish a partnership between the two entities for extraction of the crude.

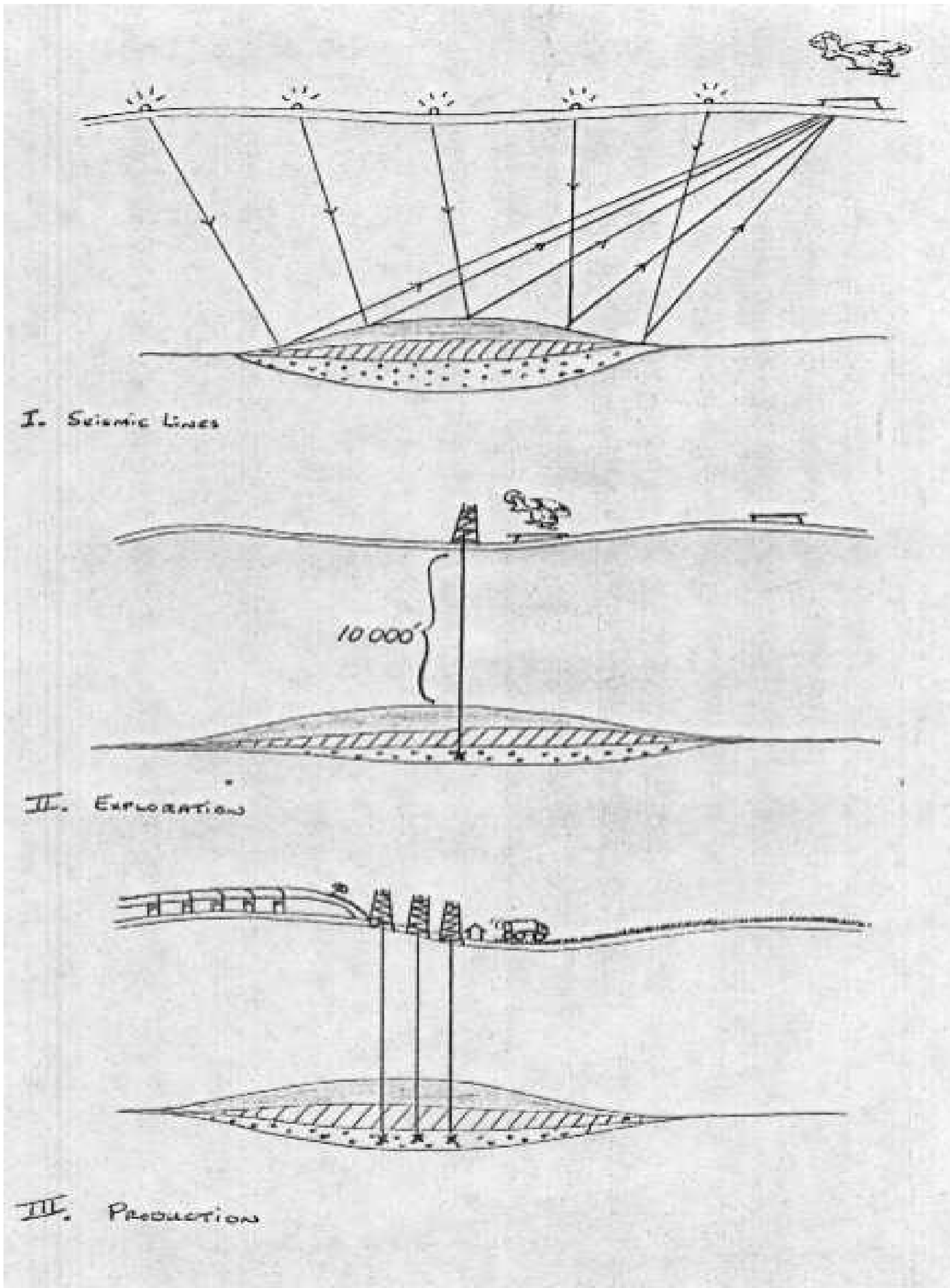


Diagram 4.1: Stages of Oil Development

This final stage is called production and involves drilling new wells, and the construction of roads, pipelines, and production camps (refer to diagram 4. lc). Roads are built to reduce the high cost of transportation incurred by the continual use of helicopters, while pipelines are rather self-evidently required to transport extracted crude to refining and port facilities outside the concession.

Production camps become the heart of activity within the concession and consist of varying combinations of five main elements: housing facilities, cleaning equipment, wells, storage tanks, and production pools. Housing facilities provide for the physical needs of concession workers and contain some sort of natural gas or gasoline powered electrical generators for power. Crude oil, especially in recent Oriente concessions, tends to have a high water content. This water is called formation water and must be removed be cleaning equipment before being sent into the pipeline. Wells extract crude oil from underground deposits while storage tanks provide holding areas for the crude until it may be sent into the pipeline. Production pools, occasionally referred to as production pits, consist of areas encompassed by earthen dikes for the storage of formation water, chemicals, and drilling muds. Some production camps have developed sophisticated methods of waste management, thus altering the primary purpose production pools to controlling drainage.

Once production begins, a well relies on primary extraction to pump the crude oil to the surface. This method relies on the pressure of the surrounding deposit to push crude into the well and may be likened to a straw removing liquid from a crushed ice-filled drink. This method is generally successful for removing a fifth of a deposit's crude, as much remains in pores within the rocks of the deposit.

To increase production, secondary extraction techniques are implemented whereby natural gas or water is pumped into adjacent wells to increase pressure on the crude to enter the pumping well. Finally, tertiary extraction way be implemented with the insertion of detergent chemicals into adjacent wells in order to wash oil out of the deposit's rock pores. Although each stage increases the amount of crude oil removed from the deposit, it also increases the cost of production (Hyne, 1984, p.270).

As a final note, traditionally wells have sunken a bore-hole straight down into the earth from various points on the surface. Recently, the new technology of directional drilling has been introduced whereby the well's bore-hole may bend and turn underground to better follow the structure of the oil deposits and thereby increase recovery.

Although directional drilling appears promising for reducing the amount of land area cleared as a result of oil activity (as many wells may be located together or the same well-pad), in practice these wells have yet to extent more than a kilometre from the well-pad. It is likely that the trend towards concentrating oil infrastructure on smaller land areas has surpassed the point of diminishing returns and that oil company propaganda to the contrary represents more rhetoric than truth.

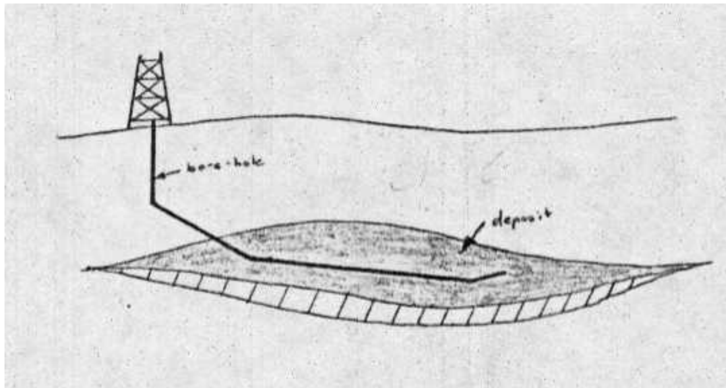


DIAGRAM 4.2: DIRECTIONAL DRILLING

5.0 OIL INFRASTRUCTURE IN ECUADOR

Although off-shore oil exploration also occurs around the Santa Elena peninsula, it accounts for less than 5% of Ecuador’s proven reserves and may be considered insignificant with respect to the Oriente reserves. As of 1991, more than 100 000 hectares of the Oriente were within assigned oil concessions by which time the area contained more than 300 producing wells, 29 production camps, and over 1300 kilometers of pipelines (Kimberling, 1991, p.43).

Crude oil brought to the surface in the Oriente is sent via secondary pipelines to either Shushufindi or Lago Agrio where there are small refining and storage facilities (10 000 barrels / day and 1000 barrels / day respectively) (EIU, 1995). Crude oil is then sent overland to larger refining facilities in Esmeraldas via the SOTE pipeline at a rate of 320 000 barrels / day. After a large earthquake in 1987 destroyed eighteen kilometers of the SOTE pipeline and halted oil exports for eight months, a contingency plan was established to transport crude oil through the Colombian pipeline system, if needed, at a modest rate of 50 000 barrels / day (Moreano, 1987).

Not all crudes are alike and the API scale has been developed to differentiate crude oil quality (refer to Appendix C). Since 1972, the northern reserves have yielded a medium quality crude varying from 25 to 34 API.

At present much of the natural gas formed in the Oriente is either burned off or used to generate electricity in production camps. There is a small-scale project in Shushufindi to compress natural gas into liquidified petroleum gasoline and a gas pipeline exists between

Shushufindi and Quito. However, this pipeline rarely operates, above 50% of its 6700 b/d capacity (Moreano, 1987).

Production levels have increased since 1972 and, by 1991, over one half of the estimated three billion barrel Northern Oriente reserve had been extracted. Primary extraction has already surpassed the point of diminishing returns and secondary production is now widely practiced. (Before its departure in 1989, Texaco proposed beginning tertiary extraction in the northern reserves, but as of this time of writing this paper I have no evidence for the existence of this practice in Ecuador.)

Current estimates point towards a decreasing level of production over the next decade with an economic end to the northern reserves between 2012 and 2017 (Kimberling, 1991 and confirmed in personal interviews).

With Texaco's departure from Ecuador in 1989, all of its wells and production camps became the property of Petroecuador. These fields are outside the current concession system and represent the bulk of present production.

Since 1939, the names involved in Oriente exploration have changed drastically. As of the seventh round of concession contracts Occidental, Elf, YPF, Petrobras, Arco, Amorco, Oryx, Tripetral, Santa Fe Energy., and Triton Energy are operating in Ecuador. Petro-Canada was involved in the exploration of what used to be concession nine, but left in 1989 (Kimberling, 1991). Conaco left Ecuador in 1991 where upon Maxus purchased the rights to operate inside concession 16. Maxus itself has recently been purchased by Argentina-based YPF and is now known as YPF Ecuador (David Shores, personal interview, Nov. 1996).

Concessions 3 to 5, 11, l8, 19, 21 through 26, 29, and 30 through 32 have been delineated by the Ecuadorean government since a relatively unsuccessful eighth round of concession contracts, but have yet to attract foreign investment (Petroecuador, 1995). Nonetheless, their delineation is important because as each concession encompasses an area of approximately 200,000 hectares. This represent a significant expansion in the quantity of forest areas and indigenous communities under threat by this industry.

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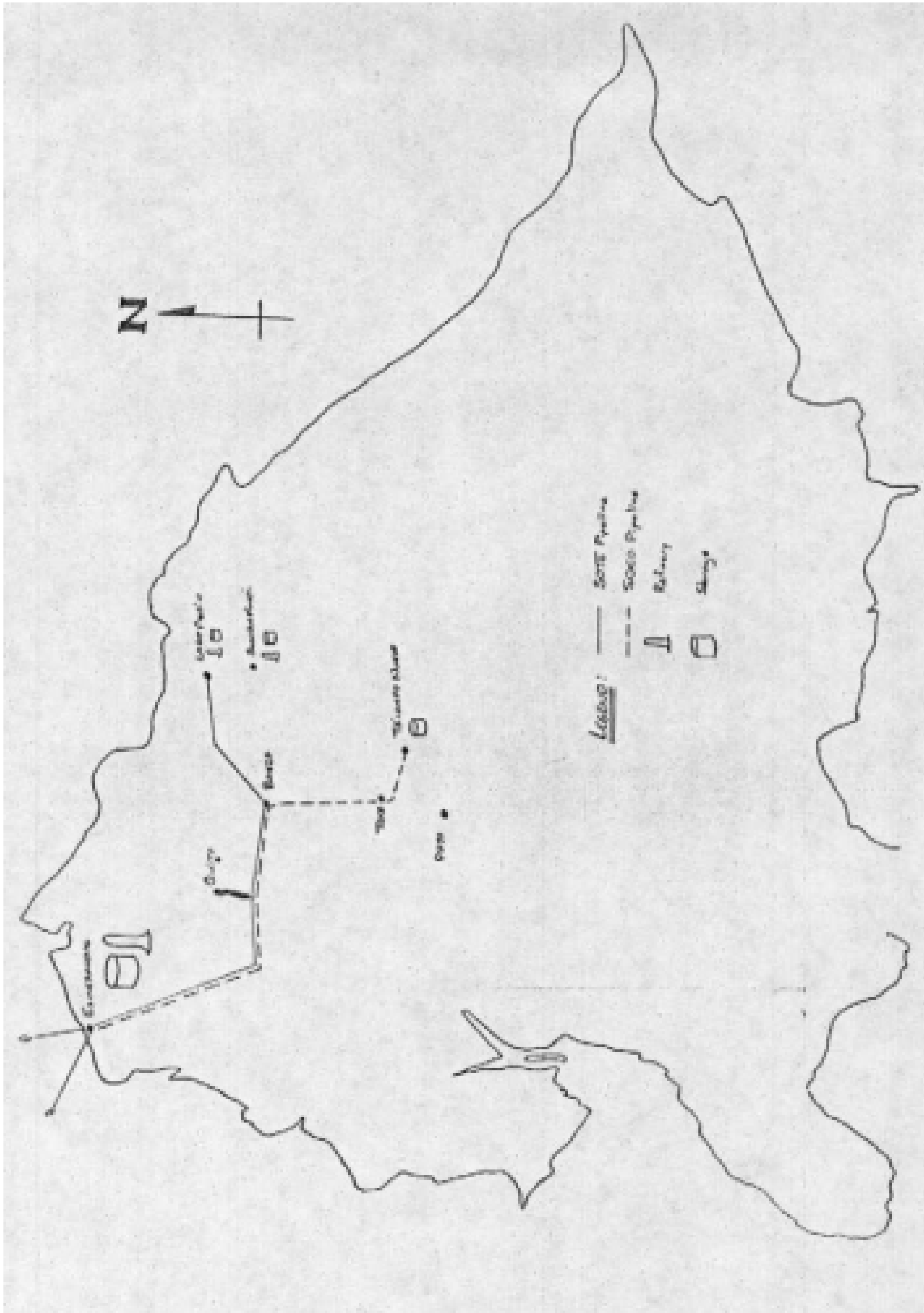

DIAGRAM 5.1 : OIL INFRASTRUCTURE IN ECUADOR

(PETROECUADOR, 1995)

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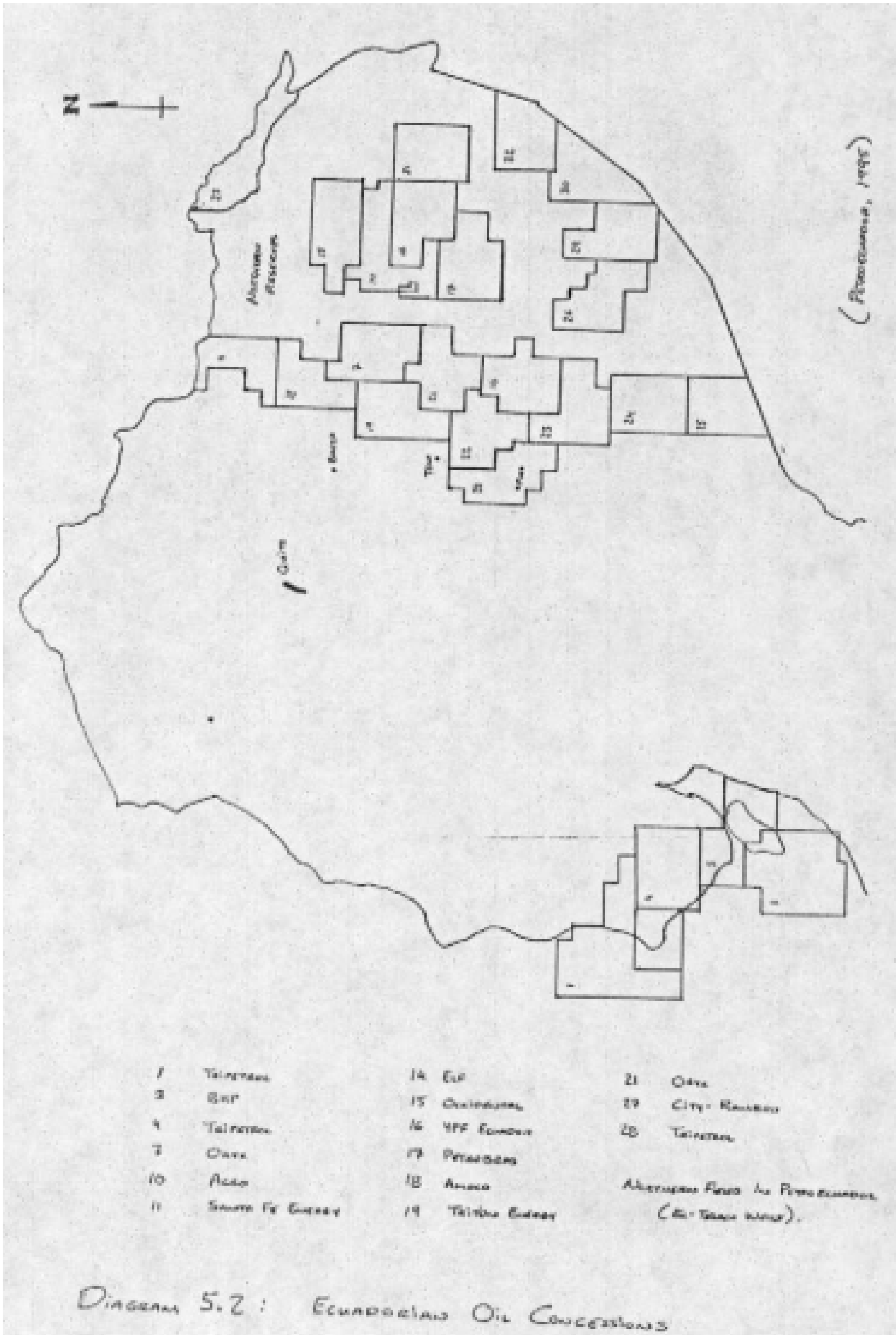

Diagram 5.2: Ecuadorian Oil Concessions

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6.0 THE FUTURE OF OIL

The future of Ecuador's oil industry lies increasingly in the exploitation of previously marginalized heavier crudes. Any doubt of that was eliminated with recent declarations by the general manager of Petroecuador and the Ecuadorean Ministry of Energy which express not only the intention to exploit heavier crudes, but to also construct a new pipeline for such (La Hora, Oct. 28, 1996).

With the decreasing rates of production in the northern reserves, newer concessions south of the Napo River have become an increasingly important element of Ecuador's oil strategy. Yet, these same concessions contain heavier, less valuable crudes. For example, concession 16 has been yielding crudes of 17 API and projections dictate a move to 14 API in the future.

This increasing reliance on heavier crudes has had a price. Despite mixing with lighter crudes from the north, the crude coming from the Oriente has fallen from a high of 34 API to less than 27 API. This has recently prompted a reclassification of Oriente crude on the world market with a corresponding drop in prices (refer to Appendix C).

According to the Ecuadorean Ministry of Energy, future extraction of crude will come primarily from three reserves, Ishpingo, Panacoch-Yuturi, and Concession 31. All three apparently contain crudes of less than 20 API and are estimated to contain 700 million, 40 to 70 million, and 200 million barrels respectively (El Comercio, Oct. 27, 1996). That makes for a total of approximately 950 million barrels which should yield another 150,000 barrels / day to Ecuador's production within ten years.

The exploitation of these reserves marks a significant geographical shift in the centre of oil activity from the northern to central Oriente or, in other words, from Sucumbios to Napo and Pastaza provinces. This shift in location, combined with the increasing age of the Trans-Ecuadorean pipeline (SOTE), has led to the proposal for the construction of a new pipeline. The Sistema de Oleoducto del Central Oriente (SOCO), will run parallel to the existing SOTE from Esmeraldas to Baeza and then run southwards towards storage facilities to be built east of Puyo in Pastaza Province. As of the writing of this paper, the government is about to officially open bidding for the construction contract. Nonetheless, two bids are already public, one from Arco Oil and another from a consortium of Techint-Odebrech-Enro-Williams brothers. Each estimate the cost at approximately US$ 450 million (La Hora, Oct. 28. 1996).

The new pipeline has been announced by the manager of Petroproduccion, Oscar Garzon, to be dedicated specifically to the transport of heavy crudes. Meanwhile, construction has already begun on an expansion of the Esmeraldas refinery that will permit the processing of heavier crudes. The SOTE pipeline will remain in use for the northern reserves, but its lack of shut-off valves and automated monitoring have drawn considerable criticism and have led to a dramatic quantity of crude oil release throughout its twenty-four years of life. Therefore, it appears that Ecuador is entering a new age of petroleum exploitation. In Oscar, Guzman's own words:

"Debemos orientarnos, educarnos para que comencemos a pensar en que se esta creando una nueva industria petrolera, especialisima, muy direccionada a lo que realmente va a ser la base de nuestra economia en los proximos 50 anos: la exploitacion de crudo pesados." (La Hora, Oct. 23, 1996)

Nonetheless, that age will only buy time for the Ecuadorean economy. Even assuming wide-spread use of secondary extraction, the new reserves are unlikely to remain economically viable beyond twenty years at projected rates of production. Therefore, it appears that for Ecuador, domestic demand for petroleum will be greater than production by 2030 (author's own calculations).

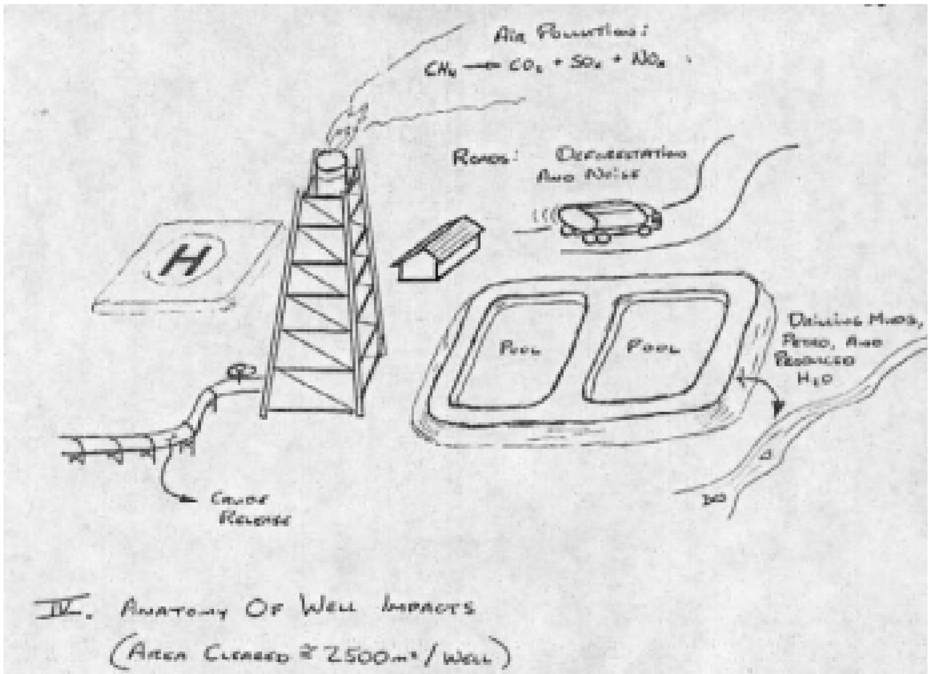
7.0 ENVIRONMENTAL IMPACTS OF ORIENTE OIL DEVELOPMENT

Until now, Oriente oil development has been treated descriptively. I would now like to shift focus to an evaluation of its environmental impacts in this section and an analysis of its social impacts in the next. As has been shown, oil development is land extensive and technologically intensive. The combination of these characteristics leads to environmental impacts that can be generalized into two categories: failure of technology and land disturbance. These categories are not exclusive, however, and each are best subdivided into further categories.

7.1 Failure of Technology

Failure of technology includes direct failure of proper operation or management of some stage of the oil development infrastructure or a failure in the design of such which leads to significant environmental impacts. Failures of technology include handling of liquids, releases of crude oil into the environment, and noise pollution.

Apart from crude oil, drilling operations involve large, quantities of formation water and drilling muds. Formation water is water pumped to the surface along with the crude and contains a higher salt content than sea water. Formation water is in excess of 30 000 ppm of salts and often reaches over 100 000 ppm while sea water is generally accepted to contain 35000 ppm (Kimberling, 1991). Current best practice sees this water separated from the crude and re-injected into the ground for secondary recovery. However, this practice is relatively recent and is not yet universal. The rule of operation, especially during Texaco's involvement in the 1970's and 1980's, has been to place formation water in production pools next to the wells. These pools are seldom well constructed and often lack plastic liners along their bottom thus leading to the eventual release of formation water into the local watershed. Even when well constructed, the quantity of formation water involved in combination with the Oriente's prodigious amounts of rainfall lead to overflowing of the production pools.



When formation water reaches local rivers and streams the effects are devastating. Considering that Oriente rivers possess an average salt content of 6 ppm, the input of even small amounts of formation water can radically alter river water chemistry. The result is that new conditions cannot support the life-forms native to the river and there is a massive loss of life.

Drilling muds are liquids circulated in the well to keep the drill bit from overheating (Hyne, 1984, p.270). Chemically, these muds consist, primarily of benzenes and other hydrocarbons mixed with significant quantities of chlorides, aluminum, mercury, cadmium, and lead (Kimberling, 1991). Documented operations have seen drilling muds stored in production pools where they have been subject to the same releases as formation water. According to Kimberling, to avoid overflow conditions in production pools, CEPE practices included setting the pools on fire.

This can hardly be considered a rational management decision for these materials since such leads to a concentration of metal toxins in the liquid which remains and leads to air pollution and fallout of toxins downwind of the burning. Nonetheless, a recent visit to Shushufindi may indicate the continuation of combusting waste material in the Oriente.

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The second failure of technology is the release of crude oil into the environment. In this case, the primary actor has been the SOTE pipeline which has had a prodigious number of breaks during its lifetime.

Combustion of oil waste in production pools north of Shushufindi, 1996.

Although the March 1987 earthquake's damage to the pipeline skews the numbers somewhat, SOTE releases of crude oil between 1972 and 1987 surpassed the release of crude oil by the Exxon Valdez by one and a half times (Aranz, 1989). The major impacts of crude oil release are soil contamination, loss of life in aquatic environments by lower levels of dissolved oxygen, and the presence of toxins which can bio-accumulate in the food supply of local human populations. Breaks in the SOTE pipeline and secondary pipelines are likely to continue as their surface show evidence of extreme corrosion leading to a weakening of the metal.

The final failure of technology is the failure to mitigate noise pollution caused by oil operations. Noise pollution comes from a variety of sources, yet primarily electrical generation in production camps and transit of vehicles along roads through the concession. In all cases, the noise scares away wildlife from these sources, thereby reducing the size of their habitat. Therefore. even if a production camp clears but a hectare of land, the loss of habitat for forest species is much greater.

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7.2 Land Disturbance

Oil development is a land extensive operation. Although it may directly clear only 1% of the forest from a 200,000 hectare Oriente land area, other direct and indirect effects leave a lasting impression on the entire concession. These effects can be divided into deforestation and loss of biological diversity.

Construction of helipads, trails for seismic lines, production camps, and roads clear little of a concession's total forest area and recent initiatives by oil companies are reducing that amount even more as a part of campaign for a greener image. Yet, direct clearing of the forest is only the beginning of land disturbance of forests for, as described in Appendix B, there is a dramatic difference between conditions above and below the forest canopy. The cutting away of the canopy allows for a mixing of the cooler forest air with the outside atmosphere resulting in a change in temperature and moisture conditions under the canopy for as much as a kilometre away from the deforested area.

Yet, oil development acts as only a catalyst for the main source of Oriente deforestation: colonization. This topic deserves greater attention than can be afforded in the space of this paper, but suffice it to explain that roads constructed by oil development provide access for colonists to previously inaccessible areas of the Oriente whom strip away existing vegetation in order to acquire land title to that area. The results of this process in the Northern Oriente have been remarkable. Although still green, much of the province of Sucumbios appears to have become either grassland or secondary forest.

This oil development sponsored colonization of the Oriente has given Ecuador the highest rate of deforestation in Latin America. As of 1995, 330 000 hectares of Ecuadorean forests have been disappearing annually (EIU, 1995, p.17). This is especially worrisome given the Oriente's position at the headwaters of the Amazon river system. Changes in Oriente ecology have impacts in the lower part of the basin. This sensitive keystone position and the scale of environmental changes occurring in the Oriente prompted the Inter-American Development Bank to comment:

"(Although only) 1.67% of the Amazon Basin, Ecuador has the highest Amazonian population density... Andean countries have a profound influence through destruction of biodiversity, soil erosion, sedimentation, the contamination of rivers and lakes, and squandering of hydro-energy reserves. This influence is as pronounced or greater than in Brazil."

Recent trends in the construction of oil development in Ecuador has moved to isolate concession roads from the Ecuadorean road system. An example of this is the highway through concession 16, which is only accessible from the Napo River via ferry and entrance is restricted to YPF Ecuador security pass holders. However, YPF Ecuador's contract ends in 2013 and with it will end the restricted access. It appears more than likely that a private ferry operator could provide transportation services to a new wave of colonists. Furthermore, by that time, the concession's highway should connect with the adjoining concession 31 and areas to the south.

The loss of the forest means much more than the loss of timber resources. It means the loss of habitat for forest species, including indigenous human populations, with a corresponding decrease in biodiversity and cultural diversity.

The value of biodiversity, the number of different plant and animal species to be found in a given area, has been rationalized in many ways. From extractive reserves to pharmaceutical research, all of these attempts share a narrow economic view of the worth of biodiversity. These approaches have tended to exclude the ecological importance of having many species of life which include maintaining the integrity of local ecologies, opportunities to adapt to environmental change, and alternative food sources.

Loss of biodiversity, from an ecological perspective, is an example of positive feedback whereby the result of a process prompts the continuation of that process. The loss of one species can eliminate the food source for another leading in turn to its extinction. This causes a domino effect that alters food patterns and energy flows through the ecosystem and inducing severe changes in local ecology. When one considers that the planet is losing more than 5000 species a year, and that this represents one of the six greatest periods of extinction in the history of terran life, the threat to human society and survival becomes clear.

As a whole, the Amazon Basin is estimated to house one half of all the planet's plant and animal species, making it one of the world's warehouses, or "hotspots", of biodiversity. This is especially true of Ecuador whose dramatic change in altitude provides many unique opportunities for species specification. In one hectare of Ecuadorean Oriente primary forest, more tree species have been catalogued than exist in all of Canada, and in each tree can exist more species of insects that are found in all of the British Isles (IADD, 1992, p.ix).

Biodiversity loss in the Oriente is pronounced. Although qualitative data is hard to come by (it is not known exactly how many species there are, much less have they been catalogued or studied.), environmental. impact assessments performed for Petroecuador are revealing. Five abandoned well sites which had been reclaimed by secondary forest were compared to nearby primary forest in terms of both bird and plant species. The results, in diagram 7.3, show that in many cases biodiversity falls to 10% to 15% of previous levels (Petroecuador, 1991).

8.0 SOCIAL IMPACTS OF ORIENTE OIL DEVELOPMENT

Thus far, the linkage between the impacts of oil development on human society has been made indirectly through environmental degradation that is assumed to have an impact on human health.

In this section, I shall outline two of the more striking direct impacts of Oriente oil development: cultural conflict and publicly subsidized costs of oil. My own background in social impact analysis is weak, so I apologize in advance for any gross omissions and the rather technocratic presentation herein.

Although Gomez (1994) outlines a more complicated six element structure for conflict in the Oriente (and indeed, the presence of the Ecuadorean armed forces is not to be taken lightly), this paper will address only two forms of cultural conflict; that of oil companies versus indigenous communities and, colonist versus Indigenous communities. Indeed, the two are related in that oil development facilitates colonization and that power relations in both forms of conflict tend to be unbalanced.

The conflict between oil companies and indigenous has two facets; that of environmental degradation and that of opening communities to modern Ecuadorean society. As indigenous communities rely on their local ecologies for the majority, if not all, of their subsistence needs, they are more greatly and more immediately affected by Oriente environmental degradation than other populations. The contamination of Oriente rivers eliminates an often important source of food for these communities and offers health risks for drinking and bathing.

Equally destructive, however, is the practice of hiring indigenous guides and the interaction between oil workers and introduction of luxury goods into the communities which in turn begin to imbalance and disrupt existing social relationships. In the past, this has been the prelude to a process of acculturation of the community by the Ecuadorean state. 0il companies are now conscious of their impacts in these communities and many have taken great pains to project themselves as agents allowing indigenous communities to maintain their culture and protecting them from the immediate shock of integration into national society. Nonetheless, recent promotional material presented by such companies as Occidental and YPF Ecuador (formerly Maxus) suggest an extremely paternalistic attitude on the part of these companies.

Colonist intervention into a concession has the effect of expanding the land annexation began by the construction of oil infrastructure. This action reduces the resource base that these communities depend upon and sets the stage for more unbalanced contact which further challenge indigenous cultural practices. The reduced resource base available to indigenous communities can have three effects: migration deeper into the forest, the altering of resource management strategies to often unsustainable forms, or increasing ties to the market economy in the form of wage labour and production for profit (including agriculture and eco-tourism). In practice, the result of colonization of indigenous territories is a combination of all three reactions.

Contact with outsiders, oil workers and colonists alike, introduce indigenous communities to new "truths" which undermine their certainty and adherence to their own cultural truths. A visit to YPF Ecuador's concession 16 during the writing of this paper is revealing in this case.

An anthropologist in the concession told me of a time when the Huaorani called for him and showed him a poster of the alphabet with drawings to illustrate each letter: B for burro, C for car, D for dragon (a three-headed monster breathing fire), and E for elephant. The Huaorani proceeded to ask him: "The burro and car we know, and you shown us the elephant in video and we know that it lives in a far-away land called Africa... but where does the dragon live?"

The varying extent to which individuals adapt these new truths, and their accompanying forms of behaviour, can create divisions and conflict within indigenous communities which further weaken their resistance to acculturation.

Yet, the acculturation of indigenous communities is only one of the hidden costs of oil development. Other costs are unconsciously carried by the entire Ecuadorean population. Such costs include: land disturbance, environmental pollution, health, and loss of future opportunities.

All of these costs are a result of an ecological criticism of the current economic rationality that surrounds oil development in which such are ignored as externalities. As an example, deforestation in the Oriente for the construction of oil infrastructure is rationalized in terms of the profit of oil sales versus the profit of timber or extractive resource use by private industry. This view of the Oriente forest's value disregards the value of resources from the forest for local indigenous populations and the value of the environmental services, such as climate control, provided by the forest for other Ecuadoreans. A more rational decision-making criteria would be to treat Oriente forests as a common property resource (see Appendix A).

A list of these externalities appears in table 8.2. A full treatment of this topic merits its own investigation, but for the purposes of this paper, let it suffice to indicate that the cost of oil (much less the price of an exported barrel of crude) ignores very real social environmental costs. These costs are left to the Ecuadorean people who, already suffering under debt load and poverty, are ill-prepared to pay for such and reinforces their position of dependence relative to developed countries.

Table 8.2: Externalities of Oil Development

AREA	EXTERNALITY
Deforestation	Costs of resource loss to local indigenous and cost of loss of environmental services (ie. climate control).
Environmental Pollution	Cost of clean-up of environmental degradation of oil development left as a public expense (ie. pools of toxins in Northern Oriente left by Texaco).
Health	Increased health costs from carbon dioxide and urban smog left to public or individual.
Future Opportunities	Use of oil eliminates energy source for future Ecuadorians and commits society to non-renewable energy base.

9.0 CONCLUSION AND RECOMMENDATIONS

The previous three sections indicate that oil-led development in Ecuador's Oriente region is far from our defined goal of sustainability. Furthermore, it is likely to remain so throughout the near future. It seems that oil development in the Oriente will continue until it is no longer economically viable, a process already underway with the decision to exploit heavy crudes, and oil development cannot be adjusted to be sustainable in any ecological sense. Therefore, the task for Oriente development must follow two parallel strategies.

The first is management of oil development so as to lessen its impacts and direct it towards greater social benefits. Such a strategy would include a more rational pricing policy for crude and oil products in order to integrate current externalities and policies for the conduct of oil companies working in the Oriente. Requirements of such policies could include the installation of automated monitoring and shut-off valves along pipelines (including SOCO), isolating concession roads to inhibit further colonization, enforcing the use of best-available practice in waste management, and avoiding contact and interference with local indigenous

The second strategy concerns long-term plans for the Oriente after the inevitable end of the importance of oil development in the twenty-first century. Specific suggestions should come from local Oriente communities and include their participation within a framework based upon an ecologic definition of sustainability. This is a general criteria, but its development into powerful discourses inside Ecuador, and resulting alternative paths for society, are bound to be exciting.

Adherence to these strategies would see a shift from spontaneous or oil-led development of the Oriente region to one more centred upon the state and involvement of civil society, including NGOs. Such a shift will have problems, as this paper has virtually ignored the tremendous influence foreign actors possess in determining Oriente development and the state is each year in a weaker position to execute unilateral action as a result of structural adjustment policies. Furthermore, it shall be extremely complex to coordinate action among so many development actors.

9.1 PRAXIS

"There is a tendency to restrict science to only description and explanation and not to include prescription. In the context of global environmental problems scientists should understand and then propose necessary actions, bringing about a broader general awareness and common understanding between individuals, communities and nations." (Human Dimension of Global Change Conference, Sept. 26-28, 1989)

The political space created by the collision of ecology and political economy, often referred to in the context of this paper as synonymous with existing development practice, requires the integration of environmental information into development discourse. This is both an opportunity and a danger. By bringing the natural scientist, or ecologist, into the sphere of what is called the social sciences there is the opportunity to balance human needs with the requirements of the natural world, the organism and its environment.

The danger lies in the limitations of knowledge of how natural systems, ecologies in the physical sense, function and where that knowledge fails there will a tendency to view human societies in general ecological terms. This has happened before with the historical advent of Social Darwinism where an all encompassing theory for biological evolution saw widespread application to human populations, capitalizing primarily on cultural characteristics. The same sort of exporting of an explanation of how the natural world works to dictating how our socially created worlds should work violates an important difference between the two.

Natural systems exist and function whereas human societies are systems which not only exist, but are aware that they exist. This cognitive ability is often called intelligence, yet a more appropriate term may be Noosphere, the realm consisting of things aware of their existence and able to act beyond instinct (Negret, 1994).

The importance of introducing this term at the end of this paper is one of limitations, for just as rules of bevhaviour change from the geosphere to the biosphere, so too ecological theory is bound to the biosphere and may not be directly applicable to human societies. Criticism of development from an ecological perspective reduces human individuals to organisms which does not correspond to instinctive behaviour and violates the capacity of their ecosystems to support them. Such a bias should be insulting to everyone and without a balancing cultural perspective, ecological criticism will remain inhuman.

In this paper, I have focused on oil development in the Ecuadorean Amazon region as an example of development which is not viable over the long-term and as highlighting the reasons for which an ecologically influenced framework for analysis is required. Such an approach has limitations, and although only referred to occasionally here, this form of development analysis will benefit from more integration with cultural study. The quest for paradigm would seem to be an academic exercise, but when considers the human costs of development and existing trends towards greater imbalance between human societies and their ecologies, the need for alternatives becomes clear.

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APPENDIX A: ELEMENTS OF EMERGING PARADIGM

Investigation into ecology have identified two main weaknesses of current economics logic: one, the inability to ensure long-term optimum allocation of resources; and two, a blindness to services provided by the environment.

To compensate for the first failure, if I may be forgiven for so naming such, is a plethora of ideas to make the market more far-sighted. Inter-generational rights, for example, have been discussed since at least the Brundtland Report and basically call for the addition to economic logic of satisfying the needs of today's population without sacrificing opportunities of future generations to meet their own needs (Commission for Environment and Development, 1987). As yet this is a vague concept, especially in how to define future opportunities, but is nonetheless a popular idea. A much more concrete goal is that of food security. This concept is the assurance of food supply for society and encompasses such ideas as soil preservation, diversity in food stocks, decentralized production and distribution, and local and national food self-sufficiency.

The other failure of economic logic, that of not valuing environmental services, is being approached in a variety of ways that are all attempting to evaluate and internalize these services. A valid debate exists as to the validity of this approach given the complexity of ecological systems and our limited ability to understand them, but it is nonetheless generating creative ideas.

Under a classical evaluation of a forest, a tree only represents a potential value that is realized when cut down and modified by human labour into a usable item. Yet, ecological investigation has established that a standing tree provides, among other "free' environmental services, oxygen generation, cleaning of the atmosphere, and habitat for many species of life. The ability of a tree to do this in now being referred to as "natural capital", just as a person's ability to do work is called human capital. To stretch the analogy a bit further, just as investments in education and health enhance human capital, so too do investments in conservation enhance natural capital.

The failure of fisheries in different countries has highlighted the need for common property resources logic for market decision-making. At present, a new boat is added to the fishing fleet if it can obtain enough catch to pay for its expenses, and hopefully provide a livelihood for its crew. What is left out of such an evaluation is the loss of income to other fishing boats of the fleet due to a decreased catch as the same number of fish are divided among a greater number of boats. The economic rationality therefore becomes not whether a project can pay for itself, but can it pay for itself despite the added cost of lost income to other users of that resource. Although not perfect, for example there is still no guarantee against overfishing, the same rationality may be applied not only to fisheries, but to air and water resources and their pollution.

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Another attempt to internalize environmental services is to adjust pricing practices. In the case of renewable versus non-renewable resources, it is argued that the consumer should pay a premium on nonrenewable content in products since the cost is not only the value of the product to the consumer, but the loss of use of that resource to the another potential user.

On the more radical extreme of pricing policies, since ecological systems are based on finite energy input from the sun, then it seems natural that prices could be altered to reflect the energy content of the product. The implications of such a policy are many. One, this would translate well into ecological values since, for example, a recycled metal can would cost less than a new metal can since the cost of the latter must include the extra energy involved in mining and ore processing. Two, this would eliminate the bias towards human labour. Raw materials in themselves are made to possess little value, but when altered by human labour, their value increases substantially. Instead, under an energy content pricing scheme, the product's value would be its physical energy content plus the energy used by the worker to modify the raw materials into the product's final form. Admittedly, there are problems with such a system, including the elimination of profit and a communist approach to labour (ecological Marxism?), but such may yet be accommodated.

Finally, it is important to note that the word "environment" has come to mean different things to different people; "there is not one, but many" (Beyers, 1996). This has led to the creation of many environmental perspectives and the reader must understand that each is relative to the individual writer's experience.

(Based-on memories from Brenda Leith's lectures at Trent University, ES100 course, 1994.)

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APPENDIX B: AMAZONIAN ECOLOGY

Any investigation into sustainability and development in the Ecuadorean Amazon must be based on an understanding of the Amazonian reality. This is especially important given the dramatic differences between temperate and tropica1 ecologies.

TOPOGRAPHY:

By any account the Amazon Basin is enormous. Covering approximately 6,000,000 square kilometers, or 7% of the world's surface, it is the largest watershed on earth. Containing as much as 20% of the world's freshwater, it discharges between 200,000 to 220,000 cubic metres of water into the Atlantic Ocean each second.

In Ecuador, the basin begins on the eastern slopes of the eastern cordillera of the Andes mountains at an altitude of approximately 3000 metres. Between the Andes and the Ecuador-Peru border, the land falls to 300 metres above sea level, yet it takes all of Brazil for the land to descend the final 300 metres to meet the Atlantic Ocean.

By nature of being located in tropical latitudes, daily temperature fluctuations are greater than seasonal changes. This leads to important differences in biomass production and lake stratification. Without a pronounced cold season, biomass production remains relatively constant year-round and is high relative to temperate forests. The lack of seasonal temperature fluctuations also makes lake stratification more unpredictable and variable than in temperate latitudes.

Due to a minor difference in water density with respect to temperature (maximum density is at 4'C), water of different temperatures do not mix and effectively create different layers within lakes. In summer, temperate lakes remain at approximately 4'C at the bottom and at air temperature at the surface. In winter, the same lakes can be freezing at the surface, yet remain at warmer below. In between the two extremes, in spring and fall, the layers achieve thermal equilibrium, turn-over, and mix chemically. The situation is rather more complicated in tropical climates and lake stratification tends to be locally defined by wind patterns and water chemistry rather than universally determined by temperature.

WATER CHEMISTRY:

Amazonian waters are divided into three classes: black, clear, and white. Although these class names are based on their physical appearance. there are greater differences between the three. Indeed, the divisions from black to clear, and then to white-water, are rather arbitrary and represent a gradient from lesser to higher amounts of river biodiversity and biomass (refer to Table B1). It is also important to note that erosion caused by the dramatic change of altitude on the slope of the Andes mountains accounts for a great part of water-borne nutrients in Amazonian rivers.

Table B1: Chemistry of Amazonian waters

BLACK:	Transparent with red or brown colour Acidic (pH<4) Low amounts of phosphorus
CLEAR:	Greenish appearance pH between 4 and 7 Medium phosphorus content
WHITE:	Rich in organics pH of approximately 7 High phosphorus

ECO-SYSTEM:

Amazonian ecosystems are radically different from their temperate equivalents. A closed canopy to absorb and diffuse sunlight marks the mature Amazonian forest. The canopy, located at approximately thirty metres from the surface, also serves as a type of "skin" separating the outside atmosphere, from an isolated micro-climate of cooler, humid air the forest generates below the canopy. Breaks in this skin allow mixing between the outside air and the forest air, disrupting the micro-climate for as much as a kilometre from the break.

The greatest lesson of recent times is that despite high levels of. biomass and biodiversity, Amazonian soils are extremely nutrient poor. Indeed, when cleared and put under intensive western style agriculture, these soils can seldom support crops for more than three years. The reason that Amazonian soils are relatively nutrient poor has to do with the fantastic rate of nutrient recycling inside the Amazonian ecosystem. A wealth of insects and micro-organisms rapidly decompose any dead biomass, which is then rapidly taken up by plants. Since rates of nutrient uptake roughly equal that of nutrient release, unlike temperate forest ecosystems, there is little accumulation of humus or organic material in the soil.

The roots of some Amazonian plants actually hang loosely in the air and absorb sufficient nutrients from rainwater. Those roots that do extent deep into the ground the to serve more as an anchor for the plant rather than for nutrient absorption.

This summary prepared from notes from the works of Sioli (1984), Prance and Lovejoy (1984), Deadle (1981), and IADB (1992).

APPENDIX C: CLASSIFICATION OF CRUDE OIL

Crude oil is a complex mixture of hydrocarbons, which are long chains of carbon and hydrogen atoms, with some impurities which can include nitrogen, sulphur, oxygen, and trace amounts of metals such as nickel, vanadium, iron, and cadmium (Institute of Petroleum, 1963. p.157). The hydrocarbons in crude oil all have more than four carbon atoms and are divided into four classes: paraffins (alkanes), naphthalenes (cycloalkanes), aromatics (those with benzene structures), and asphaltics. With the exception of asphaltics, which are hydrocarbon chains of more than forty carbon atoms, all these classes are valuable and are readily refined into petroleum products (Hyne, 1984, p.132).

Crude oil quality is measured in two ways: specific weight and grades API. Specific weight is defined as the ratio of the weight of a litre of crude to an equal volume of water at an equivalent temperature (60 F or 15.6’C) and may be expressed as follows:

$$\textit{Specific Weight} = \frac{\textit{weight of one litre of crude}}{\textit{weight of one litre of water}}$$

A far more commonly used measure of crude oil quality is the American Petroleum Institute (API) scale. The API scale is expressed in grades while specific weight is a unitless value. Grades API are related to specific weight by the following equation:

$$\textit{Grades API} = \frac{141.5}{\textit{specific weight}} - 131.5$$

(Institute of petroleum, 1963, p.160)

Therefore, grades API and crude oil quality are related to the density of crude. The lighter the crude, the more readily it is refined, the lower the cost of processing, and in general the lesser the amount of impurities. The following chart compares crude oil quality, grades API, and specific weight:

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QUALITY	API SPECIFIC	WEIGHT
water (standard)	10	1.0
light crude	45 to 55	0.80 to 0.76
medium crude	30 to 40	0.88 to 0.83
heavy crude	5 to 20	1.04 to 0.93

(Hyne, 1984, p.132)

There are multiple prices for crude oil offered by the world market depending on the quality of the crude expressed in grades API. The lighter the crude, the higher the API, and the higher the price. Recently, a continuing fall in Ecuador's Oriente reserves' API value throughout 1996, from an average of 27 API in 1995 to 26.11 API by September 1996, prompted a downgrading of the reserves' quality rating an the world market. This resulted in a drop in prices from US$ 21.02 per barrel in October (El Comercio, Nov 4, 1996) to US$ 13.02 per barrel (El Comercio, Nov 13, 1996) within two week's.

Volumes of crude oil are most often measured in number of barrels. A standard barrel is accepted to be equivalent to 42 imperial gallons (159.1 litres), and possesses an average energy content of 6 120 000 kiloJoules.

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