OIL EXTRACTION AND INDIGENOUS LIVELIHOODS IN THE NORTHERN ECUADORIAN AMAZON

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ABSTRACT

Matthew Bozigar: Oil Extraction and Indigenous Livelihoods in the Northern Ecuadorian Amazon
(Under the direction of Clark Gray)

Since oil was discovered in 1967 under present-day Lago Agrio in the indigenous Northern Ecuadorian Amazon, oil extraction has induced many changes. This research uses a large sample of household and community survey data through descriptive and multilevel regression analyses across ethnic groups and over time, constituting a novel, large-scale, comparative approach for analyzing the regional relationship between extractive industries and livelihoods. Five livelihood outcomes were analyzed, in relation to two key oil extraction predictors. Results showed that when oil companies were present at the community level, indigenous households had more off-farm employment and earned more annually from it, hunting yields increased, assets increased, marginally more land was cleared, and fishing yields decreased. In the short-term, oil companies may indeed have somewhat positive effects on indigenous communities. However, in the long-term, indigenous livelihoods may be vulnerable due to finite oil resources, contamination, cultural erosion, and regional market integration.

To all who strive for knowledge and understanding in this increasingly complex world, and to my amazing fiancé Christine, my wonderful family, and my supportive friends.

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TABLE OF CONTENTS

LIST OF TABLES

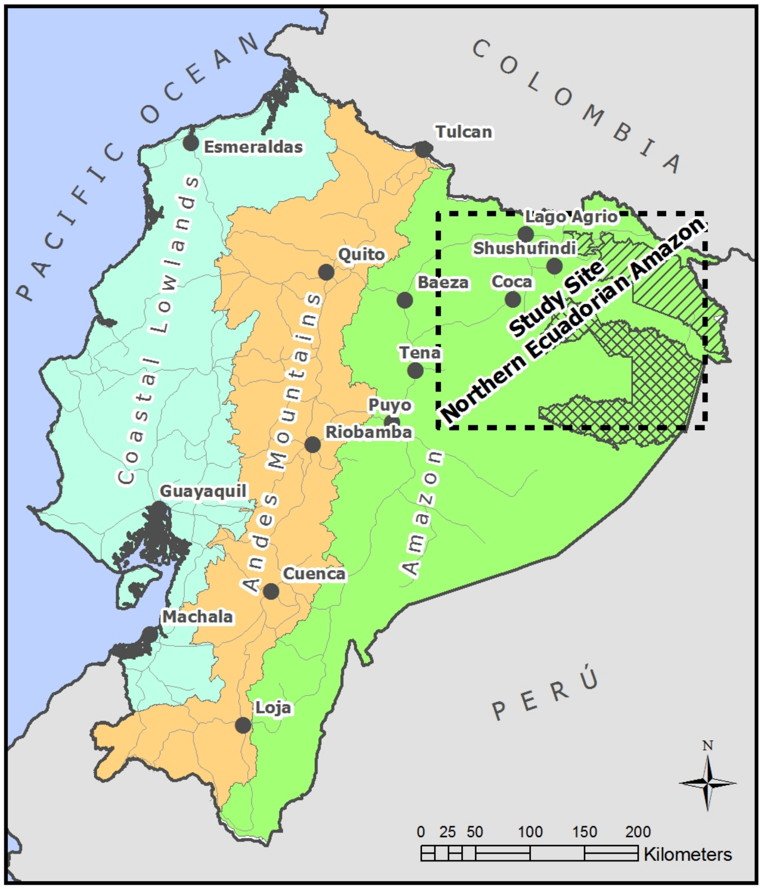
LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Large-scale commercial resource extraction activities that encroach into territories of indigenous peoples is an issue of great importance, especially in an increasingly globalized and developed world. How indigenous peoples react to and cope with these external pressures is a pressing topic because they tend to occupy relatively isolated territories, are often consequently marginalized from modern societies, commonly lag in development indicators, and have unique livelihoods, languages, and cultures. Large-scale resource extraction is influenced by global market demands; and though these influences are non-local, searches for minerals and resources often lead extractive operations to remote areas, such as those inhabited by indigenous peoples. Just such a situation has been unfolding in Ecuador due to the discovery of vast oil reserves in 1967.

Since the 1960s, the Northern Ecuadorian Amazon (NEA) has been affected by large-scale oil extraction activities. See Figure 1 for a map of Ecuador, its regions, and the NEA study area. Rather suddenly, indigenous ethnic groups, including the Kichwa, Shuar, Waorani, Cofán, and Secoya, were faced with pressures on their traditionally subsistence-based livelihoods as their territories were "opened up" to external influences, including external market forces. Oil companies operating in the NEA built networks of infrastructure including roads and pipelines, contaminated primary Amazonian rainforest, influenced communities directly through various processes, altered land use and tenure regimes, and created and affected markets.

Figure 1: Ecuador's regions and the study site.



This dynamic situation, characterized by oil extraction-induced changes to the NEA, inspired the central question of this research: how are the livelihoods of indigenous groups affected by oil extraction in the NEA? A conventional answer is that oil extraction activities undermine indigenous livelihoods and thus affects them negatively, though little attention has been paid to this assertion by previous studies (Garí, 2001; Sawyer, 2004). We tested this assumption with a goal of characterizing the relationship regionally across ethnic groups and over time. To accomplish this task, we undertook both descriptive and multilevel regression analyses that employed data from a large-scale and longitudinal (2001 and 2012) data collection effort, which included household and community surveys. For our multilevel regression models, we used two key predictor variables that measured the intensity of oil company involvement in communities through employment with oil companies and community technical assistance programs instituted by oil companies, respectively. We analyzed five livelihood outcomes, which included off-farm employment, land use, household assets, hunting, and fishing activities, in order to disaggregate the multidimensionality of livelihoods.

Few studies of the effects of extractive industries (e.g., oil extraction, mining, natural gas "fracking") have been conducted on a regional scale in the greater Amazon, as most have used small-scale case study, ethnographic, summary/review, or other methods (Basu et al., 2010; Finer, Jenkins, Pimm, Keane, & Ross, 2008; Kimberling, 2005; Larrea, 2013; Sabin, 1998; Sawyer, 2004; Suárez et al., 2009; Valdivia & Benavides, 2012; Wunder, 2003). This study is novel for its employment of a regional comparative approach to analyze multi-ethnic, multilevel, and longitudinal relationships between oil extraction and livelihoods in the indigenous NEA. To the researchers' knowledge, few (if any) past studies have implemented such an approach for explicitly examining relationships between extractive industries and livelihoods on a regional scale in the Amazon, much less between oil extraction and indigenous livelihoods in the Amazon.

This study is organized in the following manner. First, a focused section on pertinent literature and theory is provided. Then follows a detailed description of the study area, including a brief history and sketches of its indigenous inhabitants. A section describing the data of the study follows, along with a methods section. Next, the results of both the descriptive and multilevel regression analyses are detailed. Finally, a discussion of the results and conclusion is provided.

CHAPTER 2: LITERATURE AND THEORY

This research is motivated by the rural livelihoods framework in which rural households are the focal point for livelihood strategies, capital endowments of various forms, and multi-scale contextual factors (Ellis, 2000; Gray, Bilsborrow, Bremner, & Lu, 2008; Scoones, 1998). Under this framework, the household is the primary unit of analysis. Households pursue livelihood strategies within a context of capital endowments to which they have access, including natural, social, human, physical, and financial capitals (Sherbinin et al., 2008), though other researchers have classified these differently (Bebbington, 1999; Ellis, 2000). Rural households are able to diversify their livelihoods by accruing and converting stocks of capital. Rural livelihoods are multi-dimensional, exhibiting an array of both subsistence and market-oriented components that are adopted as a form of diversification for risk mitigation (Ellis, 2000; Lu, 2007; Newton, Endo, & Peres, 2012; S. G. Perz et al., 2013). The rural livelihood framework inspired and informed the outcomes used this study.

The question posed by this research is how processes related to large-scale oil extraction affect indigenous livelihoods in the NEA. Mechanisms of change in the NEA, initiated by oil extraction and associated road building, have taken many forms. This has led to large-scale migration, wild resource extraction, agricultural expansion, and habitat fragmentation (Bilsborrow, Barbieri, & Pan, 2004; Greenberg, Kefauver, Stimson, Yeaton, & Ustin, 2005; S. G. Perz et al., 2012, 2013; S. G. Perz, Cabrera, Carvalho, Castillo, & Barnes, 2010; S. Perz et al., 2008; Pfaff et al., 2007; Southworth et al., 2011; Suárez et al., 2009). It has also resulted in widespread environmental contamination that has affected the atmosphere, lithosphere, and hydrosphere (Kimberling, 2005; Larrea, 2013; Sabin, 1998; Sawyer, 2004; Wunder, 2003); direct and indirect changes to land use and tenure regimes (Bilsborrow et al., 2004; Bilsborrow, 1987; Rudel, Bates, & Machinguiashi, 2002), market integration (Godoy & Cárdenas, 2000; Godoy et al., 2005; Gray et al., 2008; Lu, 2007; S. G. Perz et al., 2013); and direct involvement in indigenous communities through employment, construction of community infrastructure, and institution of technical assistance programs (Holt, Bilsborrow, & Ona, 2004; Lu, 2007). One study did find positive affects on nutrition for indigenous employees of a nearby mining company in Guatemala due to the better diet offered by the company, indicative of the "healthy worker effect" (Basu et al., 2010), though other studies documented multiple adverse effects of commercial extractive operations in rural or indigenous areas beyond contamination and habitat degradation and fragmentation, including unbalanced power dynamics, threats to identity and social dynamics, and other effects (Bebbington et al., 2008; Perreault, 2005; Valdivia & Benavides, 2012). However, in sum, relatively few studies have investigated large-scale commercial extractive industry operations in the Amazon.

This study focuses on two measures of oil extraction company involvement in the indigenous communities of NEA, each representing a direct relationship between oil extraction and indigenous livelihoods in the context of regional market integration. These two measures were the number of indigenous employees of oil companies in a community, and the number of oil company-instituted technical assistance programs in a community. To isolate the effect of these key variables on indigenous livelihoods, we needed to control for other factors that influenced livelihoods, derived from the rural livelihoods framework. Other theories that informed our selection of controls include: the Chayanovian household lifecycle theory, which postulates that livelihood activities are mediated by household demographics and the household ratio of consumers (dependents) to producers (Barbieri, Bilsborrow, & Pan, 2005; Caldas et al., 2007; Chayanov, Kerblay, Smith, & Thorner, 1986; Sherbinin et al., 2008; Walker, Perz, Caldas, & Silva, 2002); the farm lifecycle theory whereby the age of the rural farm affects livelihood practices (Barbieri et al., 2005; López & Sierra, 2011; Mena et al., 2006); and the theory of multiphasic response that posits responses to pressures being multiple and simultaneous (Barbieri et al., 2005; Bilsborrow, 1987; Davis, 1963).

CHAPTER 3: STUDY AREA

The Northern Ecuadorian Amazon (NEA)

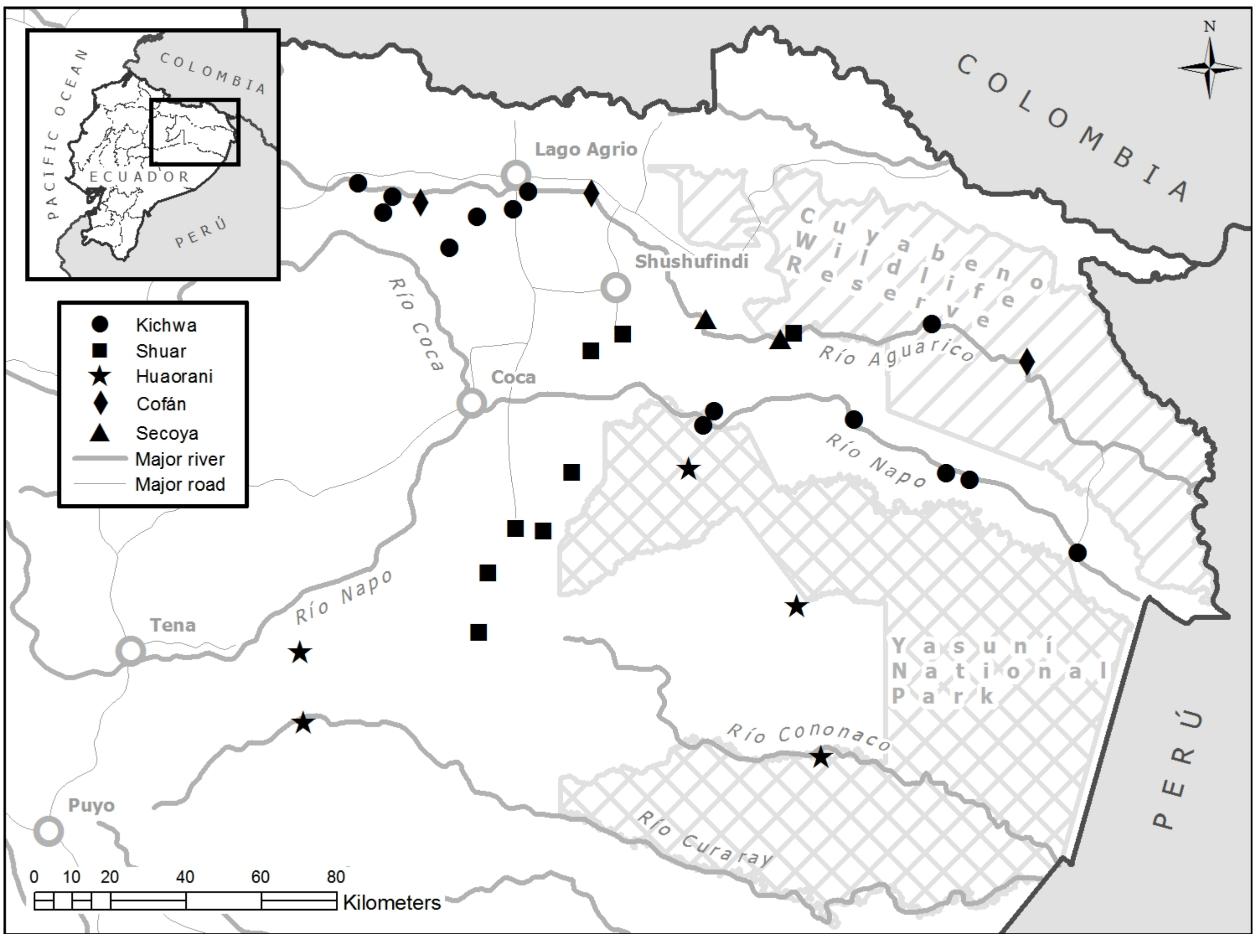
The NEA is a dynamic region. With extraordinary biodiversity, a sizeable indigenous population, and oil underfoot, the NEA continues to experience swift change. Some of the highest species counts per unit area in the world have been recorded in the western Amazon, which encompasses the NEA (Finer et al., 2008; Finer, Moncel, & Jenkins, 2010). Formerly, the largest city of the region was Lago Agrio (also known as Nueva Loja), in Sucumbíos province, though Coca (Orellana province) has recently overtaken it as the most populous city of the region. However, prior to the 1960s, the city of Lago Agrio didn't exist. The primary inhabitants of the region were the various indigenous ethnic groups. When oil was discovered in 1967, Lago Agrio was founded as a small town to facilitate oil extraction and to house oil workers. Since then, many other small cities have been founded and continue to grow, such as Shushufindi, Lumbaqui, and Joya de los Sachas. In 1972, Texaco completed the Trans-Ecuadorian Pipeline and began transporting crude from the Amazon west across the Andes (Kimberling, 2005). Road networks were built (over 600km of unpaved roads by Texaco, initially) to access both the new pipeline and the oil-related extraction infrastructure that included wells, pumping stations, intermediate facilities, oil camps with offices, housing, and more (Kimberling, 2005). During its period of operations in Ecuador from 1964-1992, Texaco "drilled 339 wells and built 18 central production stations" spanning an area of over 1 million acres (Kimberling, 2005). As oil production increased, Lago Agrio became more and more relevant as an important regional city in Ecuador.

The road networks had a secondary effect beyond providing oil companies access to their infrastructure. The NEA was effectively "opened-up" for migrants (largely mestizos from the rural Andes mountains and some Kichwa and Shuar) to claim lands along or near the new roads during a time period when Ecuador permitted or even promoted agricultural colonization of the region (Rudel et al., 2002). Land was distributed in 50 hectare allotments within specified sectors (*sectores*) parallel to the major roads in a systematic manner by the IERAC (*Instituto Ecuatoriano de Reforma Agraria y Colonización*) land management agency prior to its closing in 1993 as a consequence of the national neo-liberal shift (Bilsborrow et al., 2004; Rudel et al., 2002). Those who could not attain legal titles still claimed lands, as land tenure enforcement in the Ecuadorian Amazon was either nonexistent or minimally effective (Pichón, 1997). Thus, since the 1960s, the NEA has seen a rapid influx of migrants in search of better economic opportunities.

Indigenous Ethnic Groups

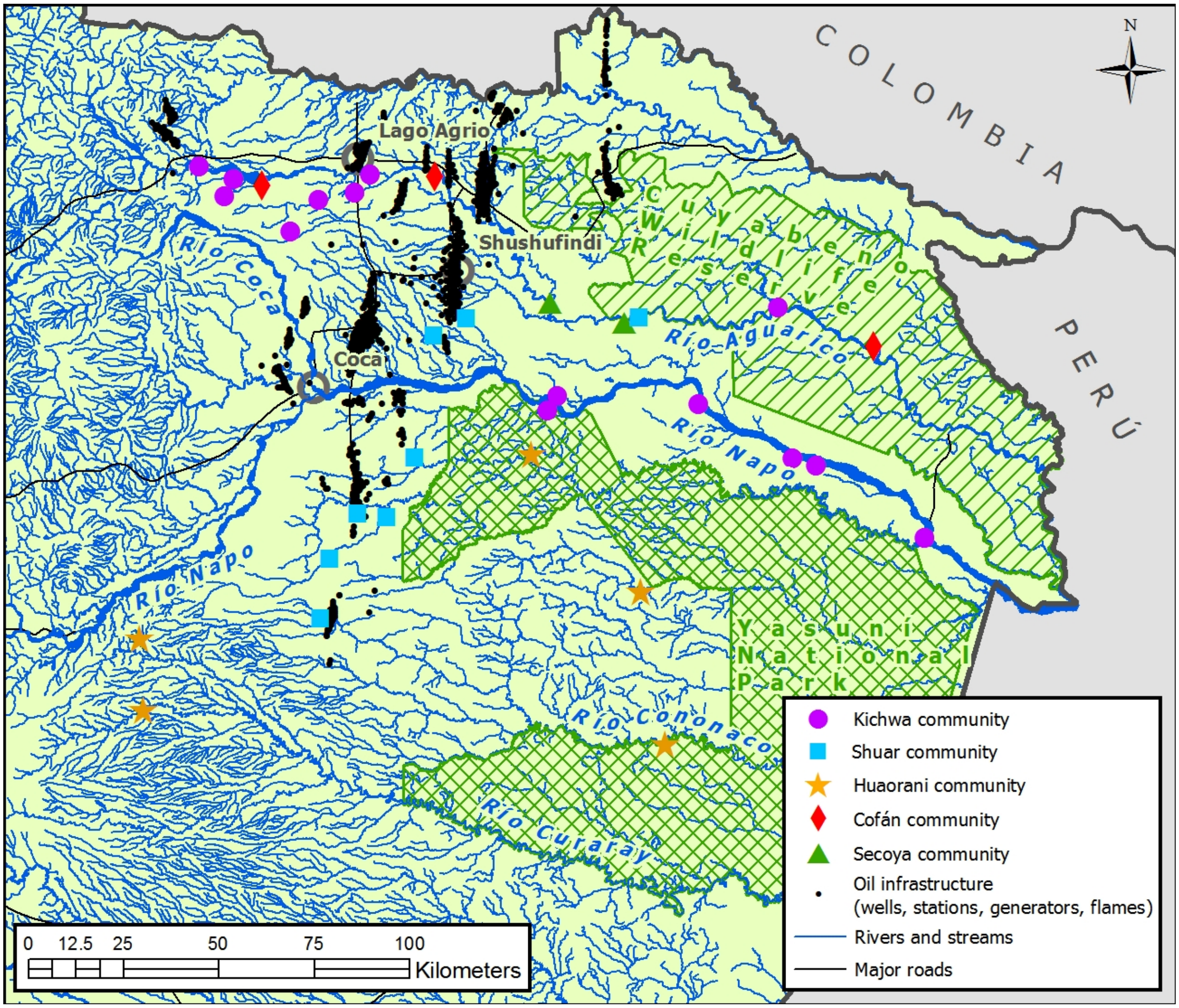
Indigenous habitation of the region predated the oil boom by hundreds or perhaps even thousands of years (Heckenberger & Neves, 2009). The indigenous residents of the NEA are almost entirely rural, living in dispersed communities near Lago Agrio, Coca, and Shushufindi, as well as remote areas far from any city. Figure 2 shows the locations of the indigenous communities of our study indicated by ethnicity. Being rural, many have a unique experience in regards to oil extraction because they are closest to the most harmful sources of potential contamination. Texaco, a main oil company that operated in Ecuador through the oil boom, "regularly sprayed roads with crude oil for maintenance and dust control, and deliberately dumped tons of toxic drilling and maintenance wastes, in addition to an estimated 19.3 billion gallons of oil field brine, into the environment without treatment or monitoring – contaminating countless rivers and streams that served as rich fisheries and water sources for local communities" (Kimberling, 2005). A class action lawsuit was brought against Texaco (which was sold to Chevron) in 1992 due to its unchecked and widespread pollution.

Figure 2: Indigenous communities of the Northern Ecuadorian Amazon included in the study.



Conversely, many communities are also in position to benefit in the short term from new forms of assistance, community infrastructure, and employment that oil companies can provide. Oil companies often offer wages, albeit for mostly heavy labor and security positions, that are higher than most other employers (if these other opportunities even exist). Figure 3 shows the indigenous communities in reference to known oil infrastructure locations in 2012.

Figure 3: Indigenous communities, oil extraction, and rivers of the Northern Ecuadorian Amazon.



The five indigenous ethnicities exhibit great heterogeneity in characteristics and livelihoods, including within groups, between groups, and in relation to colonist mestizos (Holt et al., 2004; Lu & Bilsborrow, 2011; Rudel et al., 2002). Relative to the indigenous population, colonist activities in the NEA remain much more oriented to the market: they have larger cleared plots, shorter fallow times, greater use of external agricultural inputs (e.g., fertilizer, pesticides), more cattle, and less crop variety, or agrobiodiversity (Lu et al., 2010; Perreault, 2005; Rudel et al., 2002). The indigenous ethnic groups are not self-sufficient, but they participate in market activities at various levels of involvement in addition to subsistence activities (e.g., subsistence hunting, fishing, farming, etc.) (Godoy et al., 2005; Lu & Bilsborrow, 2011; Lu, 2007).

Each indigenous group is unique in its characteristics and history. The largest indigenous ethnic group in the NEA is the Kichwa with a population numbering approximately 60,000 people; they speak Kichwa and Spanish (Lu & Bilsborrow, 2011). They have a relatively long history of contact with outsiders, and participate in market-oriented activities at an intermediate level.

The second-largest indigenous ethnic group of the NEA, the Shuar, have a population of about 40,000 people, and speak a language of the Jivaroan language group and Spanish (Lu & Bilsborrow, 2011). The Shuar in the NEA are these who migrated from the southern Ecuadorian Amazon to the NEA while reorganizing themselves from dispersed homesteads into clusters of households in villages during the period of colonization (Gray et al., 2008; Holt et al., 2004; Lu & Bilsborrow, 2011). They cleared large tracts of land primarily as a means to secure their claims and initiated market-oriented cattle ranching (Holt et al., 2004; Lu & Bilsborrow, 2011). Of all five ethnic groups, the Shuar in the NEA are the most market-oriented, which is characterized by their relatively high intensity of selling crops, larger areas cultivated, use of external agricultural inputs, cattle, high agrobiodiversity (Perreault, 2005; Rudel et al., 2002), less reliance on subsistence hunting and fishing activities, and purchases of more non-wild foods (Holt et al., 2004; Lu & Bilsborrow, 2011).

The Waorani were still un-contacted as of 1958, and they currently occupy the remote tracts of the rainforest in and around Yasuní National Park, though this is beginning to change. In terms of population, they rank third among the five ethnic groups of the NEA, numbering approximately 2000 people (Lu & Bilsborrow, 2011). Before being contacted, they lived in 30-50 kin longhouses, though they are now largely organized in smaller houses clustered in villages (Holt et al., 2004). They speak Huao Tededo and some Spanish. Their relatively remote territories provide them access to many wild resources, so they consequently hunt, fish, and gather forest products at relatively high frequencies. They exhibit a low tendency towards market activities (and are relatively far from markets) but tend to have high proportions of members in OFE, especially with oil companies. They still rely heavily on subsistence activities. Waorani society also exhibits more individualism than the societies of other ethnic groups in the NEA (Holt et al., 2004).

The Cofán of the NEA were displaced from their traditional territory in and around Lago Agrio during the oil boom to locations further east into the deeper forest. They are fourth in population relative to the other indigenous groups, having about 500 people in Ecuador (Lu & Bilsborrow, 2011). They speak A'i and some Spanish. Like the Waorani, they are largely subsistence-oriented, though they participate in some market activities and tourism. They are generally not involved with oil companies but are greatly involved with ecotourism companies. They also create and sell handicrafts. Also like the Waorani, they frequently hunt, fish, gather forest products, and participate in subsistence farming activities.

The Secoya are similar to the Cofán in terms of population size; the Secoya number approximately 700 in Ecuador and Peru combined (Lu & Bilsborrow, 2011). They primarily inhabit tracts along the Aguarico River and its tributaries. The Secoya exhibit "mixed" market/subsistence activities, as they have had a working relationship with the Occidental oil company while participating in subsistence activities at varying levels (Holt et al., 2004; Lu et al., 2010).

CHAPTER 4: DATA

In 2001, Bilsborrow and Lu designed a comprehensive household survey covering demographic information, health, land use, wild resource use, labor and employment, economic information, and perceptions and attitudes. Two different household-level questionnaires were constructed: one for the male head of the household, and one for the female head of the household, respectively. 36 communities in the NEA were originally included in the survey. For communities having 22 or less households, all households were listed and surveyed (Gray et al., 2008). In the few communities that had more than 22 households, 22 of them were randomly selected and surveyed.

Ecuadorian Spanish-speaking staff conducted the surveys orally. When present in a household, both male and female household head questionnaires were given. In some cases there was no female head of household, and in other cases the female was the only head of the household. In either of these cases, both surveys were administered to the available head of the household. In total, 484 households provided complete responses to the male head of household questionnaire in 2001. 476 households in 2001 provided both a complete male head of household questionnaire and a complete female head of household questionnaire.

In addition, in an effort to study contextual effects, a community-level survey was designed. This survey was administered to multiple leaders in each community. It inquired about population, institutional involvement in the community, infrastructure, and other community attributes. Additionally, all pertinent locations including households, important community features, and agricultural plots were geo-referenced using Global Positioning System (GPS) points.

In 2012 a follow-up (longitudinal) survey was administered. The majority of the same 476 households from the same communities in the 2001 survey were re-located and re-administered the 2012 version of the survey under the direction of Bilsborrow and Gray. By that time, many of the households had been subdivided through either inheritance, marriage of children (now adults) of the household heads, divorce, or through other circumstances. The 2012 fieldworkers interviewed both the original households and the split-off households, which resulted in a larger sample size of 599 households (completing both male and female head of household respective surveys). For logistical reasons, 4 communities were not interviewed in 2012, which brought the sample size of communities down from 36 to 32.

CHAPTER 5: METHODS

This study employs a large-sample, comparative approach using data from household and community surveys in the indigenous NEA to investigate the effects of oil company presence at the community level on indigenous livelihood practices. Two analyses are presented here. First, is a descriptive analysis comprised of comparing mean variable values across ethnic groups and through time. Descriptive analyses involved computation of p-values that were based on two-sided t-tests at a significance level of $\alpha = 0.05$. Relationships were deemed significant for those having a p-value less than 0.05. Marginally significant relationships were denoted as having p-values between 0.05 and 0.10. Each relevant table includes a legend to interpret p-value symbology. Second, we estimate multilevel statistical regression models of our livelihood outcomes that control for several factors.

Multilevel Regression Models

We employ a multilevel statistical framework due to the nature of the data, using data on households clustered within communities across the region. Multilevel models (known also as hierarchical linear models) extend linear regression models and are constructed in order to overtly model "contextual effects" (Bryk & Raudenbush, 1992). We present both random community effects models and fixed community effects models for our outcomes, respectively. We combine the data from both 2001 and 2012 (only for households that completed both the male and female questionnaires, respectively) for a total full sample of

1075 household-years.

We construct the following general two-level random-intercept model for random community effects:

$$y_{ijt} = y_{000} + \beta x_{ijt} + \delta w_{jt} + \alpha_j + u_{ij} + e_{ijt}$$

where y_{ijt} is the outcome for household *i* in community *j* in year *t*, y_{000} is the common intercept, β is a vector of household-level coefficients, x_{ijt} is a vector of household-level predictors, δ is a vector of community-level coefficients, w_{jt} is a vector of community-level predictors, α_j is the community-level random effect, u_{ij} is the household-level random effect, and e_{ijt} is the residual error term. For our fixed effects model, the general model is identical with the exception that u_{ij}, the random community-level error term, is replaced with fixed community effects.

Random effects models in the context of this study posit random variation both *within* communities and *between* communities. Fixed effects models in the context of this study focus only on *within* community variation, in order to account for the potential non-random placement of oil companies in regards to communities and their consequent effects on livelihoods. Gray et al. employed a similar random effects multilevel statistical approach in a study that utilized the cross-sectional data from the 2001 survey (Gray et al., 2008). However, Godoy et al. used fixed effects models for a study of comparable size having 36 communities (Godoy et al., 2005). Thus, large-sample survey studies have used both random and fixed effects approaches with success.

Multilevel Regression Outcomes

We model five livelihood outcomes: income from off-farm employment during the previous year (OFE), weight of animals captured on the previous hunting trip (hunting) censored at zero those that did not hunt in the past year, weight of fish caught on the previous fishing trip (fishing) censored at zero those that did not fish in the past year, physical household assets index score (assets), and hectares of land cleared during the previous three years (land use). These outcomes were selected to elucidate the variation in both traditionally subsistence-oriented activities and in livelihood activities commonly associated with market orientation, in order to capture shifts in livelihoods. The fishing outcome represents a traditional subsistence-oriented activity. The OFE, assets, and land use outcomes generally quantify changes to market-oriented activities. The OFE outcome measures the diversification of livelihoods from primarily subsistence activities to some market-oriented activities.

Much the same, the assets outcome is a measure of market consumption. The assets outcome was defined as an index variable, in which households were assigned a value along a continuous range from 0-10 based on the existence of a number of physical assets within the household. It was generated using polychoric principle components analysis on asset and housing variables on 2001 and 2012 data together; the first principle component was standardized on a ten-point scale and then used (Kolenikov & Angeles, 2009). The higher the value, the more assets a household had.

The land use outcome, which measured recently cleared land for agriculture, is indicative of increased market-oriented agricultural activities that may include farming of perennials and/or cattle ranching. However, regular crop clearing is expected for indigenous groups of the NEA, as they cyclically clear and fallow plots, given their household food demands and increases or decreases in plot soil fertility. Larger agricultural plots have been associated with increased market activities for indigenous groups in the NEA (Lu et al., 2010). The hunting outcome[1] can be considered both a subsistence and market-oriented activity. Away from markets, hunting is primarily for subsistence. Nearer markets, households with diversified livelihoods may hunt to sell wild meat to markets (Espinosa, 2008; Suárez et al., 2009).

Multilevel Regression Approach

In regards to the five outcomes modeled via multilevel regressions here, either a single stage or dual stage approach was implemented. A single stage approach was employed for outcomes in which nearly all households participated in the livelihood activity; this applied to the assets, land use, and fishing outcomes. These were modeled with continuous outcomes mentioned above, where the continuous outcomes measured intensity of the livelihood activity.

We used a dual stage approach when a substantial fraction of households did not participate in the livelihood activity, and this was therefore relevant for the OFE and hunting outcomes. This allowed us to deal with the many "zero cases" in our models that did not provide adequate variation in the data. For the dual stage approach, in stage I the whole sample was modeled using a dichotomous outcome of whether or not they participated in the activity (e.g., did a household have OFE in the previous year: yes or no). This allowed us to analyze which factors were associated with households participating in the livelihood activity. In stage II of the dual stage approach, only households participating in the livelihood activity (e.g., only households that had OFE) were modeled with a continuous outcome indicating the intensity of the outcome. The non-participants (e.g., the

[1] A few other outcomes were initially contemplated for inclusion as additional models. These included perception outcomes such as those about contamination, quality of life, and health. But we ultimately decided that these outcomes were not strongly grounded in livelihood theory. However, these were included in the descriptive analysis.

"no" or zero outcomes of the stage I model) were censored. The stage II model allowed for an analysis of the factors associated with the intensity of the livelihood activity for participating households. Noted above, these five outcomes (single stage and dual stage, collectively) were modeled using both random and fixed effects multilevel models. Additionally, livelihood outcomes that exhibited a right-skewed distribution were log-transformed and then modeled; this applied to all outcomes with the exception of assets.

Key Multilevel Regression Predictors

Two key predictors were examined for the five outcomes, which resulted in two specifications for each random and fixed effects multilevel model, respectively. Thus, for each single stage livelihood outcome, four models were run; and for each dual stage outcome, eight models were run. Several household-level and community-level predictors of oil company influence/impact on indigenous communities and households were initially considered. We decided that the number of community members employed by oil companies and the number of community technical assistance programs were the two strongest, direct, non-environmental influences on the indigenous households of the NEA (hereafter: oil predictors). We chose community-level oil predictors as opposed to household-level predictors for the reason that activities involving indigenous households and oil companies are mediated through the community. Often oil companies in operation nearby first approach community leaders (though these relationships can be very one-sided in favor of oil companies), who in turn involve the households of the community.

Households then make decisions within that framework. Therefore, key community-level oil predictors[2] were preferred.

Our final two key predictors were the number of indigenous employees hired from a community by oil companies in the previous 12 months (oil employees) and the total number of technical assistance programs instituted in a community by oil companies (from 1990 for the 2001 survey, and from 2000 for the 2001 survey) (oil programs). This latter measure encompasses several different types of programs, which range from health, growing perennial crops, growing coffee, growing cacao, reforestation, native plant cultivation, pisciculture, environmental education, food for children, to animal husbandry. But, our interest is primarily in the *intensity* of oil company involvement in communities in regards to the livelihoods of households. We predicted that communities with more oil employees and more oil programs would both be associated with more market-oriented activities (OFE, assets, cleared land, and hunting for market) and less subsistence-oriented activities (subsistence hunting and fishing, in addition to less land-intense annual crops), given that oil companies can facilitate market integration both directly in communities and indirectly through larger-scale processes.

Multilevel Regression Controls

We included a number of control variables in our regression models. These covariates were included to control for various other factors affecting rural livelihoods, including household demographics, stage in the household and farm lifecycles, cultural

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[2] Several different measures of the two key oil predictors were considered for the regression models. Dichotomous community predictors of whether or not oil companies hired indigenous employees and whether or not any community assistance programs existed were initially considered. Yet, to capture the *intensity* of the effect of both oil employment and assistance programs on indigenous livelihoods, we chose continuous measures of these community-level predictors.

characteristics, various forms of capital, distance to market, and the survey year. Household size and the age of the household head were included as controls for demographics, and for household lifecycle factors. Smaller and older households are likely further along in the lifecycle, and may be more inclined towards less labor-intensive subsistence activities, having more cattle and lands in pasture, and hiring more laborers among other things (for rural colonists, though a similar logic can be applied to indigenous households) (Bilsborrow et al., 2004).

Culturally, evidence has shown that indigenous groups are heterogeneous, having specific livelihood tendencies given their unique cultural identities (Holt et al., 2004; Lu & Bilsborrow, 2011; Rudel et al., 2002). Therefore, it is important in our statistical models to control for ethnicity. We included a categorical variable that designated each household head as being either Shuar, Waorani, Cofán, Secoya, or mestizo (who become part of indigenous communities through marriage to an indigenous person) in reference to the largest indigenous group, the Kichwa.

Natural capital is not explicitly controlled for in our model, as we did not feel our measures were satisfactory. But, the indigenous communities are rural and generally have similar access to wild resources (i.e., natural capital), though it should be noted that the Waorani and Cofán tend to live in deeper forest locations with greater abundance of floral and faunal resources (Lu & Bilsborrow, 2011), and other minor differences exist. Both human and social capitals were controlled for in various ways. Controls for the household head having a primary education, the household head not being able to speak Spanish, and the household head being female are each forms of human capital. More educated household heads are better able to access and manage market-oriented activities. The reverse is the case for household heads that can't speak Spanish; they are less able to access and undertake market-oriented activities because they cannot speak the regional language of business. And as both indigenous and colonist societies are patriarchal and male-dominated, having a female household head is similarly a factor that can impede market-oriented activities. Social capital is partially acknowledged through a variable designating whether or not a household head was born in the community. When the household head is born in the same community, there are more options for a larger and richer social network, and that household head can have greater knowledge (or access to knowledge) of agriculture and beneficial hunting/fishing locations in the community and region. We chose not to control for physical (i.e., assets) and financial capital (i.e., OFE earnings) because we explored these as livelihood outcomes in our models.

CHAPTER 6: RESULTS

Two analyses were conducted on the livelihood effects of oil extraction operations in the NEA. These were a descriptive analysis and a multilevel regression analysis. We sought first to explore general relationships in the data via a descriptive analysis. This involved examining differences in community and household-level variables between ethnicities and over time.

Descriptive Analysis

Table 1 shows community-level descriptive results. The NEA has experienced oil-related development and employment as long ago as the late 1960s. Thus, while oil company involvement in indigenous communities has been lengthy in some cases, we did not expect drastic changes between survey years regarding overall oil company operations. It must be noted that oil companies explore for oil deposits, locate them, often enter the nearby indigenous communities and offer gifts (e.g., cattle, infrastructure, etc.), employment, and technical assistance programs, and then vacate when oil production is exhausted while generally discontinuing support and relationships to communities. Thus, they can come and go relatively frequently and quickly, affecting specific communities dramatically, but while maintaining a relatively stable *regional* presence. Overall employment with oil companies in terms of absolute counts remained relatively stable (204 employees in 2001 to 239 employees in 2012). The Secoya ethnic group of our sample had the least employment with oil companies in 2001[3], and in 2012 both the Secoya and Cofán had no employment with oil companies. The Shuar, Waorani, and Kichwa had the greatest proportion of communities with at least two oil employees in the year previous to each of the survey years in both 2001 and 2012. Despite the Waorani traditionally occupying territories deeper into remote primary forest, they showed high levels of employment with oil companies. Because oil company operations follow the oil deposits, which can lead them to similarly remote tracts of forest, the fact that remote Waorani communities are employed at high levels for oil companies isn't surprising. Studies have also shown that Waorani have moved households and communities closer to newly-constructed roads, allowing them better access to markets and to employment (Suárez et al., 2009).

In terms of technical assistance programs instituted by oil companies, there has been an overall decrease from 28 total programs in all communities in 2001 to 18 in 2012. The biggest drop happened for the Waorani from 13 in 2001 to one in 2012, who, in contrast, jumped from 53 oil company employees in 2001 to 99 in 2012. The Cofán, relative to their total number of three communities in our sample, had a large number of assistance programs (three) in 2001, but dropped to zero in 2012, while the Secoya gained one program in 2012 up from zero in 2001. The Kichwa increased to nearly one program per community (from six to 13 programs in 14 total communities) in 2012, the only increase in technical assistance programs for any of the ethnicities with the exception of

[3] However, an oil company was directly involved in a Secoya community prior to the 2001 survey. That company gave the community cattle as compensation for being allowed to drill into the nearby land. They also employed several members of the community during the oil extraction process. Before the 2001 survey, the company ceased operations in that area and within a few years there was little evidence of significant cattle ranching in the community, as the households of the community reverted to more traditional subsistence activities.

the Secoya. Overall, the community variables show oil company employment maintaining a stable count, while total assistance programs decreased for all ethnicities except for the Kichwa.

Table 1: Community descriptive variables.

Variable	Full Sample		Kichwa		Shuar		Waorani		Cofán		Secoya	
	2001	2012	2001	2012	2001	2012	2001	2012	2001	2012	2001	2012
Employees of oil co. previous 12 mo. (count)	204	239	122	105	17	34	53	99	11	0	1	1
At least 2 employees off-farm (0/1)	17	17	8	7	4	5	3	4	1	0	1	1
At least 2 employees of oil co. (0/1)	15	13	6	5	4	4	3	4	1	0	1	0
At least 2 employees of 2 oil co. (0/1)	5	5	2	1	0	1	3	3	0	0	0	0
Assistance from oil co.: perennial crops (0/1)	0	3	0	2	0	1	0	0	0	0	0	0
Assistance from oil co.: reforestation (0/1)	4	2	1	2	0	0	2	0	1	0	0	0
Assistance from oil co.: health (0/1)	7	3	1	1	2	1	3	0	1	0	0	1
Total oil co. assistance programs (count)	28	18	6	13	6	3	13	1	3	0	0	1
Oil co. assistance significantly useful (0/1)	14	10	5	4	3	1	5	4	0	0	1	1
Oil co. assistance not useful or bad (0/1)	8	3	1	2	4	0	2	0	1	0	0	1
Multiple oil co. assistance programs (0/1)	12	7	3	3	4	0	3	4	1	0	1	0
	n = 32		n = 14		n = 8		n = 5		n = 3		n = 2	

Table 2 gives changes in mean values between survey years for the household and community-level predictor variables used in the subsequent multilevel models. Households were rarely headed by women (~5% of households), which continued to be characteristic of the patriarchal indigenous societies of the NEA. The average age of the household head significantly increased from 38.9 to 41.0 years. This may be explained by aging of the household heads of the sample. Household heads were significantly more likely to speak Spanish (from 91% to 96%). A significantly larger percentage of household heads had attained at minimum a primary education (from 58% to 75%) between the survey years. These latter two relationships are consistent with continued market integration, and government promotion and popular interest in increasing education. The average total members of a household remained steady just above 6 persons, and household heads that reported being born in the same community increased, but not significantly. In regards to community-level predictors, we expected to see travel time in hours to the nearest city to decrease between survey years resulting from ongoing processes of development and market integration. It indeed decreased from 3.40 hours to 2.46 hours between 2001 and 2012. The oil-related community variables (average number of oil employees and average number of technical assistance programs) were not significantly different between the survey years, per our expectations.

Table 2: Community and household predictor variables.

Household-Level Variable	2001	2012	p
Household head is female (0/1)	0.05	0.05	
Age of head of household (years)	38.9	41.0	*
Household head: no Spanish (0/1)	0.09	0.04	**
Household head: primary education or greater (0/1)	0.58	0.75	***
Total members of household (count)	6.3	6.2	
Household head: born same community (0/1)	0.27	0.38	
Household head is Kichwa (0/1)	0.48	0.56	***
Household head is Shuar (0/1)	0.19	0.14	**
Household head is Huaorani (0/1)	0.13	0.09	***
Household head is Cofan (0/1)	0.10	0.08	
Household head is Secoya (0/1)	0.08	0.06	+
Household head is Mestizo (0/1)	0.04	0.07	**
Sample size (households)	476	599	
Community-Level Variable			
Travel time to nearest city (hours)	3.40	2.46	+
Employees of oil co. previous 12 mo. (count)	7.04	8.75	
Total oil co. assistance programs (count)	0.83	0.75	
Sample size (communities)	32	32	

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Numerous descriptive variables are presented in Table 3. This table includes our five regression model outcomes. We expected that cleared land in the three years previous to each respective survey year would increase between 2001 and 2012 due to continued market integration. Yet, the percentage of households that cleared land decreased (88% to 82%), marginally. This occurrence may be due to the fact that households in the sample aged, and worked less land in 2012 relative to 2001. Quite significantly, the hectares of land cleared per household dropped from 1.98 to 1.46 hectares between survey years. Households of all ethnicities cleared less land in 2012 than 2001 except the Waorani, who significantly increased cleared land from 1.26 to 1.82 hectares. For the Waorani, this is consistent with their increasing market integration. We expected that the more market-oriented ethnic groups of the NEA would clear more land and have bigger plots. Consistent with theory, the Shuar had the most overall land in agriculture and pasture (5.21 hectares). Close behind in terms of average plot size were the Secoya and Kichwa, having 4.42 and 4.20 hectares, respectively.

Proportions of households having OFE and oil OFE slightly decreased, while household wages significantly increased for all OFE ($19.11 to $25.29 per day) between survey years, adjusted for inflation. Daily wages were not significantly different for oil company employees during the same period. Annual earnings per household from both OFE and oil OFE increased dramatically between survey years from $1,777 to $3,471 and from $1,644 to $2,589, respectively, in 2012 US Dollars per year. Interestingly, annual earnings in OFE rose for all ethnic groups except the Waorani, though it must be noted that they started with the highest annual cash earnings in 2001 relative to the other groups. Waorani, Shuar, and Kichwa households on average were the top three annual OFE income earners, in descending order. Months worked in OFE per household significantly dropped from 9.09 to 7.45 months, while months worked in oil company OFE significantly increased from 4.72 to 6.12 months per year. This indicates that there was a decreasing variety of types of jobs attained, and an increasing propensity to have employment with an oil company, overall. Waorani and Cofán household months worked in OFE decreased, while

Table 3: Household descriptive variables

Household (HH) Descriptive Variables	Full Sample				Kichwa				Shuar				Waorani				Cofán				Secoya				Mestizo			
	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p	2001 mean	2012 mean	n	p
Land Use																												
Cleared land in past 3 years (0/1)	0.88	0.82	1085	+	0.92	0.84	571	+	0.80	0.77	175		0.98	0.91	118		0.77	0.72	90		0.74	0.79	72		0.89	0.76	59	
Land in ag/pasture (hectares)	3.81	3.72	1083		4.20	3.48	570	*	5.21	7.13	175	+	1.38	2.20	117	**	2.11	1.89	90		4.42	3.20	72		3.31	3.06	59	
Land cleared in past 3 years (hectares)	1.98	1.46	1085	**	2.20	1.55	571	*	2.08	1.20	175	*	1.26	1.82	118	*	1.16	0.94	90		2.62	1.80	72	+	1.88	1.02	59	+
Off-Farm Employment (OFE)																												
Had OFE in past year (0/1)	0.58	0.52	1083		0.46	0.47	570		0.57	0.63	175		0.94	0.74	117	+	0.61	0.37	90		0.59	0.45	72		0.83	0.63	59	
Employed by oil co. in past year (0/1)	0.44	0.33	591	+	0.36	0.22	265		0.63	0.50	105		0.55	0.77	99		0.26	0.06	44		0.40	0.06	37		0.33	0.35	41	
HH avg. OFE daily wage ($/day)*	19.11	25.29	576	**	15.01	23.56	256	***	28.21	24.45	105		22.31	25.89	98		12.72	23.17	43	**	16.03	41.65	34		17.59	27.18	40	+
HH avg. oil co. daily wage ($/day)*	22.08	23.02	218		18.78	21.32	67		28.78	22.65	58	+	19.50	25.17	63		24.42	20.00	8		19.02	18.50	8		20.38	24.22	14	
Yearly earnings from OFE ($/year)*	1777	3471	579	***	1459	3508	258	***	1948	3657	104	+	2747	3160	98		1238	2448	43	**	975	3674	36		1502	3873	40	**
Yearly earnings from oil co. OFE ($/year)*	1644	2589	219	***	1483	2258	69	+	1478	2407	57		2222	2892	63		1128	1600	8		855	740	9		1960	3800	13	
Months worked in OFE per HH (mo./yr.)	9.09	7.45	586	*	8.33	7.98	264		5.76	6.69	104		13.08	6.69	99	**	11.15	6.69	43	+	7.28	6.02	35		8.33	8.40	41	
Months worked in oil co. OFE per HH (mo./yr)	4.72	6.12	225	**	5.10	6.31	73		2.91	4.64	59	+	7.00	6.55	62		2.43	4.00	8	+	3.38	2.00	9		3.60	9.11	14	**
HH Asset index score (0-10)	2.92	4.81	1053	***	2.74	4.62	554	***	2.50	4.52	170	***	3.14	4.70	112	**	3.44	5.53	88	*	3.85	5.40	70	*	3.37	5.76	59	***
Wild Product Harvesting																												
Hunted in past year (0/1)	0.88	0.65	1083	***	0.84	0.59	570	***	0.84	0.64	175	**	0.98	0.87	117	*	0.93	0.87	90		1.00	0.76	72		0.83	0.59	59	
Hunted in past month (0/1)	0.72	0.47	1083	***	0.69	0.42	570	***	0.62	0.45	175	+	0.88	0.64	117	+	0.80	0.72	90		0.82	0.50	72	**	0.67	0.44	59	*
Animals killed previous hunt (lbs.)	31.83	26.73	817		28.19	21.30	394		18.65	20.26	130		42.87	58.94	110		34.74	33.25	81		59.91	26.47	63		27.66	12.44	39	
Fished in past year (0/1)	0.95	0.83	1083	***	0.94	0.84	570	***	0.96	0.77	175	**	1.00	0.91	117		0.95	0.91	90	*	1.00	0.92	72		0.83	0.68	59	
Fished in past month (0/1)	0.84	0.66	1083	***	0.85	0.67	570	***	0.75	0.60	175	+	0.97	0.74	117		0.86	0.72	90	+	0.85	0.74	72		0.61	0.51	59	
Fish caught previous trip (lbs.)	14.14	12.52	886		13.68	10.60	469	*	8.22	5.72	137		21.23	18.13	109		22.30	27.42	75		10.53	14.87	54		6.59	11.64	42	
Perceptions and Environment																												
Experienced contamination nearby (0/1)	0.53	0.62	2169	+	0.50	0.54	1141		0.64	0.85	350	*	0.50	0.60	235		0.42	0.66	181	+	0.57	0.74	144		0.53	0.65	118	
Experienced river contamination (0/1)	0.90	0.83	1254	*	0.88	0.77	600	+	0.88	0.90	261		0.95	0.78	128		1.00	0.89	98		0.92	0.96	95		0.84	0.85	72	
Experienced air contamination (0/1)	0.42	0.41	1254		0.44	0.38	600		0.56	0.46	261		0.25	0.30	128		0.30	0.46	98		0.23	0.46	95		0.58	0.47	72	
Experienced soil contamination (0/1)	0.38	0.38	1254		0.43	0.40	600		0.36	0.42	261		0.28	0.36	128		0.46	0.43	98		0.21	0.20	95		0.47	0.26	72	
River contamination attributed to oil co. (0/1)	0.77	0.77	1073		0.73	0.65	488		0.84	0.97	232	*	0.98	0.96	111		0.89	0.74	91		0.50	0.81	90		0.50	0.69	61	
Air contamination attributed to oil co. (0/1)	0.84	0.84	519		0.76	0.75	243		0.89	1.00	131		0.94	0.95	35		1.00	0.86	39		1.00	0.81	35	*	0.82	0.88	36	
Soil contamination attributed to oil co. (0/1)	0.79	0.77	476		0.69	0.71	247		0.88	0.95	103	*	0.94	0.65	41		0.94	0.69	43		0.75	0.82	19		0.89	0.86	23	
Fishing worse because of contamination (0/1)	0.08	0.34	1254	***	0.05	0.31	600	***	0.05	0.39	261	***	0.30	0.30	128		0.05	0.43	98	+	0.05	0.46	95	+	0.05	0.21	72	*
Hunting worse because of contamination (0/1)	0.01	0.14	1254	***	0.02	0.14	600	***	0.00	0.16	261	**	0.03	0.14	128		0.00	0.13	98		0.00	0.07	95	*	0.00	0.09	72	
Health in Previous 3 Months																												
Illness reported (0/1)	0.78	0.60	1057	***	0.76	0.64	555		0.89	0.67	170	**	0.73	0.49	115		0.79	0.43	88	*	0.66	0.58	70		0.83	0.56	59	+
Illness disrupted HH activities (0/1)	0.93	0.85	718	*	0.95	0.87	380	+	0.89	0.72	133		0.96	0.73	71	*	0.88	0.90	53		0.90	1.00	43		0.93	0.91	38	
Total individual days sick per HH (count)	18.48	20.99	637		18.64	19.91	343		22.69	26.57	109		10.21	20.58	62		17.48	23.67	47		16.37	20.27	41		27.00	18.14	35	
Days sick per individual per HH (count)	3.26	3.66	637		3.10	3.64	343		4.49	4.13	109		1.72	3.28	62		3.11	3.50	47		3.15	3.90	41		4.30	3.10	35	

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

*Units are 2012 US dollars, corrected for inflation.

months worked in oil company OFE increased for the Shuar, Cofán, and Kichwa. Household assets increased dramatically between survey years, per the physical household asset index scores. The Cofán and Secoya had the most household assets in 2012 by our measure. Together with Table 1, results in Table 3 show that there were more indigenous people working for oil companies, earning more annually, working more months, and attaining greater numbers of household assets in 2012 relative to 2001.

Regarding perceptions and environmental topics[4], marginally more households experienced contamination, and significantly less reported river contamination in 2012 than in 2001, though it must be noted that overall, 53% of households in 2001 and 62% of households in 2012 reported nearby contamination, and the vast majority of this sample subset attributed river, air, and soil pollution in both of the survey years to oil companies. Overall, some 90% of households that reported contamination in 2001 and 83% in 2012 indicated that it took the form of river contamination, and this was consistently high across all ethnic groups. Collectively the indigenous groups reported that both fishing and hunting were significantly worse due to contamination in 2012 compared to 2001. Thus, there is an important environmental component here not addressed by our methods, and which we hope is addressed by researchers in the future.

In terms of traditional subsistence activities, we expected to see a decrease in overall hunting and fishing frequencies as communities became more integrated with market activities, though with caveats. We expected to see fishing catches maintain or decrease, but studies have shown increased hunting with better access to markets

[4] These data came from both the male head of the household and female head surveys, respectively. Sample sizes thus approximately doubled for variables derived from answers to the same questions asked to both the male and female respective heads of the same household.

(Espinosa, 2008; Suárez et al., 2009). In addition, we expected to see more market-oriented groups such as the Shuar to hunt and fish relatively less than other groups. Results showed that both hunting frequency and fishing frequency dramatically and significantly decreased, especially for hunting. Both the Cofán and Waorani hunted the most in both survey years, consistent with our expectations that these groups were the least market-oriented and most subsistence-oriented. The Kichwa and Secoya household hunting frequencies dropped the most between survey years, from 69% to 42% and from 82% to 50% in the previous month, respectively. Shuar and Kichwa households hunted the least frequently by both the monthly and yearly measures. In contrast, hunting and fishing yields decreased, but not significantly. Additionally, the Shuar fished the least frequently by both the monthly and yearly measures, consistent with theory and our hypothesized relationships.

For health-related survey questions, we expected mixed findings. On the one hand, the indigenous groups report high levels of contamination, which we hypothesize has potentially negative health effects. On the other hand, we know that access to modern forms of health care is increasing. In some cases, oil companies have also instituted health assistance programs, or even built health facilities for communities where there were none previously. Results show that reported illnesses in the three months previous to each of the survey years decreased both overall (78% to 60% of households reporting illness) and for every indigenous group. The case was the same for households reporting illnesses that disrupted normal activities (93% to 85% overall), with the exception that this figure for the Cofán slightly increased (88% to 90%). Overall, individual days sick per household increased between survey years, but not significantly. Of note, is that Waorani individual sick days more than doubled between survey years from 10.21 to 20.58 days sick per household, though, they did report the fewest days sick in 2001 and also tend to have larger households, relative to the other groups. However, it is important to reiterate that they also have a relatively high level of direct involvement with oil companies operating nearby.

Multilevel Regression Analysis

As indicated earlier, for each of the five livelihood outcomes modeled, either a single or dual stage approach was implemented. A dual stage model was employed for the OFE and hunting outcomes, respectively (Table 4). A single stage approach was applicable for the assets, land use, and fishing outcomes, respectively (Table 5). For both single stage and dual stage models a full random effects model is shown, and only key predictors are shown for the fixed effects model specification, respectively. While the controls, are not shown for the fixed effects models, these were run with an identical set of controls with the exception that 31 dichotomous dummy variables, one for each of the communities (i.e., the fixed community effects), were included in place of the categorical community variable.

Shown in Table 4, the results of stage I of the OFE model (logit) indicated whether or not a household had OFE in the previous year to the survey[5]. For households that had OFE (stage I), stage II then predicted the income (2012 US Dollars, adjusted for inflation) earned in OFE during the year previous to the survey year (OLS)[6]. We expected that both the stage

[5] Logit output is in the form of odds ratios, whereby a value above 1.00 indicates a positive effect, and a value below this threshold indicates a negative effect. The difference in the odds ratio from 1 corresponds to the percentage increase (or decrease) in odds that a 1-unit increase in the predictor will result in the outcome. For example, an odds ratio of 1.15 is interpreted as an increase in odds by 15% of a 1-unit increase in the predictor on the outcome.
[6] Continuous outcomes were modeled in OLS models. OLS output is in the form of raw coefficients, whereby a value above 0.00 indicates a positive correlation and value below this

I and stage II OFE model outcomes would be positively correlated with each of our key community-level oil predictors, respectively. Random effects results of the two-stage OFE model indicated that after controlling for several factors, the number of oil company employees in a community was significantly and positively correlated with whether or not a household participated in OFE (p = 0.003). Marginally significant and also positively associated was the oil programs variable (p = 0.094). Every additional community oil company employee increased the odds of a household having OFE by 2.4%. An additional community program increased the odds of a household having OFE by 12.5%, though only at marginally significant level. The fixed effects specification revealed an effect of oil employees that was somewhat less significant (p = 0.023) on a household having OFE and the coefficient was smaller. Using fixed community effects, the oil programs predictor was not significant.

Stage II of the OFE model showed that community oil employees were not a significant predictor of OFE income for either the random effects or fixed effects specifications. However, for both these specifications, the existence of community oil assistance programs significantly predicted annual household earnings in OFE. It is worth mentioning for the random effects model that, as households age, captured by the age of the head of the household control variable, both having OFE and income earned in OFE are less likely. This means that households tend to use OFE at earlier stages of the household lifecycle than later stages, which reinforces the household and farm lifecycle theories.

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threshold indicates a negative correlation. A coefficient gives the change in the outcome expected given a 1-unit increase in the predictor. Thus, for a coefficient of 0.15, this value is interpreted as a 0.15 unit increase in the outcome for a 1-unit increase in the predictor.

Table 4: Dual stage multilevel regression model results.

	Stage I: OFE (y/n)				Stage II: OFE ($/year)				Stage I: Hunting (y/n)				Stage II: Hunting (lbs. animals)			
Random Effects Model	O.R.	p	O.R.	p	Coeff.	p	Coeff.	p	O.R.	p	O.R.	p	Coeff.	p	Coeff.	p
Key Oil Predictors																
Employees of oil co. previous 12 mo. (count)	1.024	**	-		0.005		-		0.995		-		0.009	**	-	
Total oil co. assistance programs (count)	-		1.125	+	-		0.092	**	-		1.021		-		0.020	
Controls																
Household head is female (0/1)	0.448	*	0.444	*	-0.142		-0.165		0.269	**	0.270	**	-0.183		-0.170	
Age of head of household (years)	0.968	***	0.968	***	0.010	*	0.010	*	0.989		0.989		0.005		0.006	+
Household head: no Spanish (0/1)	1.833		1.814		-0.499	*	-0.514	*	0.382	*	0.382	*	0.002		-0.001	
Household head: primary education or greater (0/1)	1.376		1.296		0.360	**	0.316	*	0.736		0.737		0.067		0.063	
Total members of household (count)	1.071	*	1.073	*	0.012		0.012		1.073	*	1.073	*	-0.004		-0.003	
Household head: born same community (0/1)	0.840		0.829		0.003		-0.021		1.245		1.241		0.038		0.054	
Travel time to nearest city (hours)	1.080		1.078		-0.027		-0.032		1.086	+	1.088	+	0.013		0.008	
Year 2012 (0/1)	0.883		0.912		0.557	***	0.596	***	0.378	***	0.379	***	-0.232	**	-0.216	**
Household head is Kichwa (0/1) [Reference]	1.000		1.000		0.000		0.000		1.000		1.000		0.000		0.000	
Household head is Shuar (0/1)	1.751		1.637		-0.087		-0.085		0.867		0.897		-0.248		-0.292	+
Household head is Waorani (0/1)	5.285	**	5.167	**	0.491	+	0.432		4.449	**	4.426	**	0.448	**	0.456	**
Household head is Cofán (0/1)	2.236		2.081		0.070		0.033		3.293	*	3.569	*	0.256		0.186	
Household head is Secoya (0/1)	1.143		1.007		0.300		0.302		2.519		2.793	+	0.401	+	0.332	
Household head is Mestizo (0/1)	1.618		1.610		0.015		0.019		0.766		0.769		-0.066		-0.063	
Model constant	1.183		1.293		6.091	***	6.089	***	2.754	*	2.599	*	2.726	***	2.754	***
Sample size (households)	1075		1075		575		575		1075		1075		664		664	
Fixed Effects Model																
Key Oil Predictors																
Employees of oil co. previous 12 mo. (count)	1.017	*	-		0.003		-		0.990		-		0.007	+	-	
Total oil co. assistance programs (count)	-		1.067		-		0.086	*	-		0.981		-		0.003	
Model	Logit		Logit		OLS		OLS		Logit		Logit		OLS		OLS	
Interpretation (Odds ratios or coefficients)	O.R.		O.R.		Coeff.		Coeff.		O.R.		O.R.		Coeff.		Coeff.	

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

In reference to the hunting outcome, stage I modeled whether or not a household successfully killed an animal on the previous hunting trip in the past year for all sampled households (logit). For those who killed an animal (and who hunted in the previous year), stage II then predicted the weight in pounds of animals killed on that hunting trip (OLS). From prevailing theory, we expected mixed results for both stage I and stage II of the hunting models. Past research has shown a decreased reliance on hunting as a result of market integration (such as that facilitated by oil company activities), while some has shown an increased likelihood of hunting for profit and not solely for subsistence.

In Table 4, results showed that the likelihood of killing an animal on the previous hunting trip was not significantly associated with either of our key oil predictors for a household after controlling for other factors. The case was similar for both the random effects model and fixed effects model. Results from stage II of the random effects model did reveal a significant and positive effect of oil employees on hunting weight (p = 0.004). This means that for every additional oil employee in the community, a household that killed animals hunting increased the weight of its total kills by one tenth of a pound. Thus for a community with 10 oil company employees, the random effects model predicted that such households would average 1 lb. more meat on a hunt than a community with zero oil employees. For the fixed effects model the association was also positive though marginally significant (p = 0.053). The association is likely explained by the fact that oil companies often improve access to indigenous communities through road improvement or construction that facilitate potential sales of meat to market while simultaneously increasing demand for wild meats via oil workers and new markets. Indigenous households that are engaged in employment with oil companies may have more opportunities to hunt in new areas and in their free time, given that they are earning wages to offset time-consuming subsistence farming and fishing activities. The model indicates a significant overall decreasing trend for both whether or not a household killed animals hunting, and total weight of animals killed between 2012 and 2001, which was consistent with descriptive analysis results. Thus, between survey years it seems that households relied less on hunting in 2012 than in 2001. However, results showed that being a Waorani household was significant: they were more likely to both successfully hunt and catch several more pounds of meat than a Kichwa household. This is expected, given that the Waorani are known to be active hunters that live in relatively deeper forest locations than other ethnic groups in the NEA. Hunting results are consistent with previous studies of increased hunting resulting from market integration (Espinosa, 2008; Suárez et al., 2009).

Table 5: Single stage multilevel regression model results.

	Assets (index)				Land Use (ha. cleared past 3 years)				Fishing (lbs. fish)			
Random Effects Model	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p
Key Oil Predictors												
Employees of oil co. previous 12 mo. (count)	0.002		-		-0.001		-		-0.007	*	-	
Total oil co. assistance programs (count)	-		0.090	*	-		0.023	+	-		0.020	
Controls												
Household head is female (0/1)	-0.643	**	-0.654	**	-0.070		-0.073		-0.393	*	-0.395	*
Age of head of household (years)	0.022	***	0.022	***	0.003	*	0.003	*	-0.001		-0.001	
Household head: no Spanish (0/1)	-0.490	*	-0.505	*	-0.185	*	-0.187	*	-0.125		-0.137	
Household head: primary education or greater (0/1)	0.462	***	0.438	***	-0.013		-0.015		-0.004		0.003	
Total members of household (count)	0.053	**	0.055	**	0.019	**	0.019	**	0.034	**	0.033	**
Household head: born same community (0/1)	-0.088		-0.097		0.025		0.023		0.245	**	0.244	**
Travel time to nearest city (hours)	-0.023		-0.024		-0.014		-0.014		-0.012		-0.005	
Year 2012 (0/1)	1.715	***	1.734	***	-0.146	***	-0.144	***	-0.073		-0.076	
Household head is Kichwa (0/1) [Reference]	0.000		0.000		0.000		0.000		0.000		0.000	
Household head is Shuar (0/1)	0.024		0.026		-0.084		-0.078		-0.080		-0.081	
Household head is Waorani (0/1)	0.359		0.285		0.005		-0.016		0.228		0.227	
Household head is Cofán (0/1)	0.781	*	0.768	*	-0.159		-0.157		0.135		0.186	
Household head is Secoya (0/1)	1.197	*	1.196	*	0.031		0.043		0.400		0.441	
Household head is Mestizo (0/1)	0.519	*	0.513	*	-0.141	+	-0.142	+	-0.211		-0.217	
Model constant	1.299	***	1.267	***	0.728	***	0.708	***	1.567	***	1.488	***
Sample size (households)	1053		1053		1075		1075		1075		1075	
Fixed Effects Model												
Key Oil Predictors												
Employees of oil co. previous 12 mo. (count)	0.00		-		0.00		-		-0.010	**	-	
Total oil co. assistance programs (count)	-		0.077	+	-		0.02		-		0.019	
Model	OLS		OLS		OLS		OLS		OLS		OLS	
Interpretation (Odds ratios or coefficients)	Coefficients		Coefficients		Coefficients		Coefficients		Coefficients		Coefficients	

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 5 contains the results of the random and fixed effects models for our single stage outcomes: assets, land use, and fishing. We expected the assets outcome (again, measured by an index score) to be positively correlated with each of our key oil predictors, given the increased prospects of households for OFE and access to markets. Interestingly, our key community oil company employees variable was not significant in both the random and fixed effects models after controlling for several factors. Conversely, the community oil programs predictor was positively correlated with households having assets, which was significant in the random effects model (p = 0.011) but only marginally significant in the fixed effects model (p = 0.056). One program was worth almost one tenth of a point on the asset index scale. This is likely due to the fact that technical assistance programs tend to occur in communities where people are also working for oil companies, in combination with the fact that regional processes of integration are making household goods more readily available for purchase. Consequently, indigenous households are able to buy more and different types of assets. Across survey years, assets increased significantly.

Results from the single stage land use outcome are also shown in Table 5. The land use outcome was defined as the land cleared in the previous three years in hectares. Per theory, we generally expected the land use outcome to increase with our key oil predictors due to opportunities to increase land production and use through new knowledge and earning power, and a decreased reliance on small-scale subsistence crops in favor of market-oriented farming activities for indigenous groups with access to markets (Lu & Bilsborrow, 2011). Results were not significant for our community oil employees variable for both the random and fixed effects models, respectively. In the random effects model that included the oil assistance programs variable, it produced a marginally significant positive correlation (p = 0.090). The community oil assistance programs variable was not significant in the fixed effects model. Results showed that for every oil company-sponsored program in a community, a household cleared just over 0.023 hectares in the previous three years in the random effects model. This makes sense, as many of the technical assistance programs are geared towards knowledge of, understanding, and improving various agricultural activities. Additionally, households with more human capital can take better advantage of new and nearby markets by enhancing their market agriculture activities, which tend to be more land-intensive. In general, households seemed to be clearing significantly less land in 2012 than in 2001. This may have occurred because relatively more time was spent in non-agricultural market activities.

The fishing outcome was defined as the weight of fish caught on the previous fishing trip censored at zero those that did not fish in the past year. There were some competing processes at play for indigenous fishing. If we hypothesize that oil companies become involved in only the communities near their operations, then fishing might be negatively affected by nearby potential river pollution by the oil companies. Additionally, market integration hasn't been shown to influence fishing tendencies like it has hunting tendencies. Fishing rates remain high (higher than hunting) for indigenous households, and oil company involvement in a community may not alter subsistence fishing activities. Interestingly, Table 5 shows that the oil employees predictor was significant in demonstrating a negative correlation with weight of fish caught after controlling for various factors in the random effects model (p = 0.018). When oil companies were present at the community level, households were associated with catching 0.007 pounds of fish less per oil employee in the community. The effect was stronger in the fixed effects model (p = 0.003), which gave a coefficient of -0.010, the near identical *reverse* of the hunting yield results. Thus, it seems that oil companies are associated with a decreasing reliance of households on time-intensive fishing activities when they hire in an indigenous community, a novel finding. Earnings from oil company OFE may help to offset the need to fish as a form of provisioning food. However, this relationship may also be due, at least in part, to potential pollution caused by the nearby oil companies.

CHAPTER 7: DISCUSSION AND CONCLUSION

This study is unique for its large-scale, large sample, and comparative approach to the question of how indigenous livelihoods are affected by oil extraction. From a descriptive analysis, results are consistent with processes of urbanization and market integration for a frontier region. Relative to 2001, indigenous households in 2012 earned more annually in OFE, worked more months for oil companies, hunted and fished less, reported more contamination (attributed primarily to oil companies) and its detrimental effects on hunting and fishing, and reported less illnesses.

Multilevel regression models using both random and fixed effects approaches yielded noteworthy results. After controlling for various factors, the intensity of oil company involvement in an indigenous community significantly influenced multiple livelihood outcomes in our models. Fixed effect models that controlled for between-community variation and analyzed only within-community variation still showed several significant relationships in our models, giving further weight to our results. Communities in which oil companies hired indigenous employees were more likely to have OFE, kill greater weights of animals hunting, and catch lesser amounts of fish. Communities that had oil company-sponsored technical assistance programs were more likely to have OFE, higher OFE income, more physical household assets, and clear more land (though this is at most marginally significant).

Regression results show that the weight of animal kills increased with oil company involvement at the community level after controlling for other factors. For a region experiencing habitat fragmentation through infrastructure development (e.g., roads and pipelines built by oil companies) and acute pollution from oil extraction processes, wild faunal populations that are already at risk are being hunted less frequently but more intensely. In addition, large and slow-breeding species (e.g., monkeys, Cracid birds, peccary, armadillo, etc.) are typically most favored for hunting and for selling to market, and pressures mount for these sensitive species (Holt et al., 2004).

Additionally, regression models indicated a novel finding in regards to indigenous fishing: after controlling for several factors, the number of oil employees in a community was associated with *lesser* weights of fish caught. Results of this study show that indigenous households may begin to buy more non-wild foods in order to offset decreased fishing hauls, making them more dependent on the market for nutrition.

Thus, oil companies can have direct effects on indigenous households via their involvement in communities as shown by results here, but they are also facilitating a larger process of market integration by increasing transportation access, creating and increasing demand for wild and agricultural products in addition to labor, altering land use and tenure regimes, fragmenting habitat, and polluting. Policy makers should consider both direct factors such as oil company involvement in communities, and underlying factors of larger-scale processes of market integration that oil companies are collectively contributing to in a dual-scale developmental policy approach.

Moreover, it is important to recognize the differences in the effects that employment with oil companies and oil company technical assistance programs each have on associated livelihood outcomes. Increased counts of oil employees in a community were associated with more instances of OFE, greater hunting yields, and smaller fishing yields. Whereas, increased counts of oil programs in a community were associated with greater OFE earnings, more household assets, and more cleared land (marginally).

Results show overall mixed effects of oil company activities on indigenous livelihoods in the NEA, not considering human and environmental health effects of oil extraction-related contamination. Oil companies seem to allow some households to diversify, though it remains that much of the oil company contact with indigenous communities has been forced rather than invited. The simple hypothesis that led to our research question had little support in the end; indigenous livelihoods are not categorically eroded as a result of oil company involvement. Our results show that in a region experiencing overall decreases in subsistence activities in the context of market integration, oil companies can both help households and also detract from their traditional livelihoods in a complex, heterogeneous, and time-dependent fashion. It is important to remember that oil companies can enter indigenous areas quickly when oil fields are discovered, affect indigenous communities both directly and indirectly, and then often abandon both the exhausted oil fields and indigenous communities in a similarly swift fashion. The short-term window of benefits from oil company employment opportunities and community assistance programs may have only transitory affects on indigenous households directly, but these can be positive and do allow for livelihood diversification. Whereas, oil company roads, gifts in the form of community infrastructure, creation and expansion of markets, pressures on land use and tenure regimes, and environmental contamination can have long-lasting effects on households. These long-term effects could offset short-term gains and leave indigenous households precariously exposed with insecure and vulnerable livelihoods that may not be sustainable in the long run, as oil fields are increasingly tapped and exhausted. Moreover, because some (if not all) of the indigenous groups consider traditional aspects of their livelihoods (e.g., subsistence hunting, fishing, and farming) constitutive of their identities (Perreault, 2005), livelihoods are not the only facet of indigenous life that are under pressure of oil-induced change.

Accordingly, oil companies seem to be directly influencing life in a mixed if not marginally positive manner in the short-term (save for cultural identity issues and power dynamics) by increasing employment, purchasing power and assets, knowledge, hunting yields, and decreasing reliance on fishing. *But*, diversification of livelihoods in this favorable economic climate in combination with mounting environmental contamination and degradation, may be leading indigenous groups down a one-way path that makes their futures *more* vulnerable given the finite oil resources in the region. Policymakers should pay careful attention to not only short-term effects, but to broader, regional processes and long-term effects that may be difficult or impossible to reverse.

As such, the proposed drilling in the Yasuní's ITT (Ishpingo-Tambococha-Tiputini) blocks will have dramatic short and long-term effects for the residents and the region. Our study shows the potential for some short-term benefits of the project for indigenous groups. However, the potentially grave long-term effects on, quite literally, the "most biologically diverse hotspot in the Western Hempishere" (Finer et al., 2010; Larrea, 2013) may be irreversible for both the environment and its indigenous inhabitants. Additionally, the region is home to two of some of the last uncontacted peoples remaining on earth choosing to live in voluntary isolation: the Tagaeri and Taromenane, both of which are

Waorani subgroups (Larrea, 2013). Encroachment on their territory brings with it acute ethical issues of indigenous rights for even making contact with such groups, much less attempting to provide them free, prior, and informed consent. In addition to these two groups, the traditional livelihoods and identities of all the indigenous groups in the region would be put at risk. So, while short-term effects may be somewhat positive, it remains to be seen how in the long-term such a project would affect the region. Could the region reach a new equilibrium and/or recover? Or, would its pattern of development follow the parallel and thus far unidirectional processes that have opened-up the NEA through oil extraction?

Future studies could further complement this research by employing a probabilistic sample of communities, which would facilitate results that were generalizable to a larger indigenous population. Additionally, a larger sample of indigenous communities is required to bolster the statistical power of multilevel models by providing more data about the variation in between-community characteristics. Laboratory tests of both environmental (e.g., air, river, soil) and human biologic samples would further enhance the understanding of long-term processes. More detailed measures of both the different *types* of programs and employment, or other superior measures of oil company involvement in indigenous communities could better explain effects on livelihoods. Spatial measures, such as distance to nearest potential pollution source, number of upstream oil wells, and/or density of oil company infrastructure within a buffer distance of communities could be additionally detailed in a Geographic Information System (GIS), and pertinent variables extracted for implementation in multilevel models. Multiple and diverse measures of both market production and consumption activities could also aid future research. The topic of regional variation in livelihoods and how these are affected by large-scale commercial resource extraction has been understudied, and there are many opportunities for researchers to advance our understanding.

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