Demography, Socioeconomics, and Geography: Endeavoring to Explain Land Cover Change in and around the Cuyabeno Wildlife Reserve, Ecuador

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Abstract

The literature on land cover change in national parks and protected areas is fairly limited, prompting Sanchez-Azofeifa (2001) to comment that "information is sparse on the nature, dynamics, and spatial dimension of land use and land cover change processes that contribute to park vulnerability." This work aims to provide information about the landscape changes in and around the Cuyabeno Wildlife Reserve as well as extend the study of landscape change in parks and protected areas by examining possible socio-economic, demographic, and geographic drivers. Datasets integrated for this project include a 1998/99 cross-sectional survey of 652 households located in territory ceded by the Reserve, a 2000 survey of communities in the northern Ecuadorian Amazon, a 2001 survey of indigenous communities within and nearby the Reserve, a satellite image time-series, and a GIS database of geographic accessibility and resource endowments. Population pressure from both sides of the Reserve boundary as well as oil exploration have resulted in major changes in forest land cover, concentrated particularly in the western portion of the Reserve. Population pressure from within the Reserve comes from four indigenous ethnic groups who make their home within the Reserve, the Siona, Cofan, Quichua, and Shuar. Outside the Reserve, the pressure is primarily from settlers who have migrated to the area, largely from other parts of the Ecuadorian Amazon or from the Sierra.

Introduction

Ecuador's protected areas comprise 26 percent of its total area (WRI 2004). The Cuyabeno Wildlife Reserve is one of the most important protected areas in Ecuador because of its biological richness. The Reserve has registered the greatest density of tree species in the world, 473 species per hectare (Valencia et al., 1994). Other taxa are extremely biodiverse as well; 514 species of birds, 117 species of mammals, and 117 species of amphibious and reptiles (SUFOREN 1993).

The Cuyabeno Wildlife Reserve was created in 1979 with an area of 256,760 ha. Its boundary has been modified twice, increasing the Reserve's size. In 1991, the Reserve was expanded to the southeast to include the entire lower Aguarico Basin from the mouth of the Cuyabeno River to the mouth of the Aguarico River at the Napo River, increasing the park's area to 655,760 ha. Biological/ecological, economic, political, and geopolitical reasons contributed to the expansion (Little 2001), as the expansion aimed to include vast tracts of optimally preserved tropical rainforest, sustain wildlife populations, and buoy tourism as well as preempt oil industry expansion in as yet undeveloped areas and protect the Ecuadorian border from Peruvian encroachment. In 1993, the park boundary was again modified, excluding a 52,401 hectare area which by that time had been occupied by colonists; this area was converted to "patrimony forest". The park's current area is 603,380 ha (Registro Oficial del Ecuador 1993).

Indigenous communities and petroleum development existed in the area prior to the designation of the Reserve boundaries. The indigenous groups with established communities within the current Reserve boundary include Quichua, Cofan, Siona, Secoya, and Shuar. Colonists have established themselves in the area as well. Human activities that take place within the Reserve, therefore, range from oil exploration to tourism to agriculture.

The purpose of this project is to determine the pattern and extent of land cover change in the areas in and around the Cuyabeno Wildlife Reserve and describe the drivers of this change. Of particular interest is the transition from forest to agricultural crops or pasture. Satellite imagery, in combination with socio-economic, demographic, and geographic data, will be used to help explain landscape changes. A land cover change model will also be created.

Theoretical focus

The theoretical background of this work is seated in the literature examining the drivers of tropical deforestation. Socio-economic, demographic, biophysical, political, and infrastructural factors have all been cited as contributing to the problem of deforestation (Wood and Porro 2002; Geist and Lambin 2001; Bilsborrow and Hogan 1999; Rudel and Horowitz 1993). In this frontier environment relatively isolated from markets and urban centers, demographic structure and dynamics are expected to be a central determinant of land use and land cover change. Malthusian and household life cycle theories will be used to explain how age, gender, and time since settlement affect deforestation rates and patterns. Chayanov (c.f. Cancian 1989) first explored household size and age structure and its effect on the proportion of land cultivated. More recently McCracken et al. (1999) have worked to adapt and extend Chayanov's theory to the Brazilian Amazon, identifying and describing five life cycle stages in small farmer households.

Literature Review

Examination of land cover change in parks and protected areas has generally been limited to using classified imagery to calculate change in various land cover classes in terms of percent, proportion, or area and/or examining landscape structure (Sanchez-Azofeifa et al., 2003; Vasconcelos et al., 2002; Sanchez-Azofeifa et al., 2002; Liu 2001; Smith 2001). We will provide data on landscape changes in and around the Cuyabeno Wildlife Reserve, as well as extend existing work on landscape change in parks and protected areas, by experimenting with modeling socio-economic, demographic and geographic drivers.

Methods

Datasets

Change in forest cover in and around the Reserve will be determined using Landsat TM satellite imagery from 1986, 1996, and 2002. A cross-sectional survey of 652 households in territory ceded by the Reserve, undertaken between September 1998 and March 1999 by Petramaz, will be used to provide data on household composition by age and gender, area in agricultural production (hereafter referred to as UPA, Unidad de Producción Agropecuaria), proportion of farm in crops, proportion of farm in pasture, and accessibility to the nearest market town.

Two additional surveys will be used to provide contextual information about the study area, a NASA-sponsored survey of 59 communities in the northern Ecuadorian Amazon completed in 2000, and a NIH-sponsored survey of 28 indigenous communities completed in 2001. Four of the NASA communities are in the neighborhood of the Reserve; two of the NIH survey communities is located within the Reserve, with four additional communities close by. Data from these two surveys used to provide context will include population size and change since 1990, agriculture and cattle raising, and community infrastructure (bus transportation, coffee dryer, rice peeler, sawmill, market for crop or animal sales).

Geographic data that will be used to inform analyses include data sets of oil wells dug in the region between 1967 and 2002 and transportation networks. Figure 1 depicts the Cuyabeno Wildlife Reserve and surrounding areas. The area covered by the Petramaz survey is shown, as well as the colonist communities surveyed by the NASA project in 2000 and indigenous communities surveyed by the NIH project in 2001.

Analysis

Post-classification change detection methods will be applied to the satellite images to arrive at a measure of from-to change between 1986 and 2002. The extent of change and the proportion of change area in agricultural crop and pasture classes will then be quantified, and the spatial pattern of change described.

Descriptive statistics will outline major characteristics of Petramaz survey data. Models of land cover change will be limited to the area surveyed by Petramaz; three OLS models will be estimated. As the dependent variable, the first model will use the amount of primary forest cut down on a UPA in the previous year, the second model will employ the area of the UPA in agricultural crops, and the third model will utilize the area of the UPA in pasture. Independent variables used in these models will include accessibility (type – vehicular, non-vehicular, fluvial; distance from market town; distance from the main road), UPA area, total number of UPA residents, working age residents, number of male residents, hired labor, age and education of household head, and date of settlement.

Expected Findings

Land Cover Change

Land cover change from forest to agricultural crops and pasture will be most intense in the western portion of the study area, where colonist communities are located in the area ceded from the Reserve.

Modeling

Demographic characteristics, particularly the number of males and the number of working age household members, are expected to be positively correlated with amount of forest cleared as well as the amount of land in crops and pasture. Accessibility, in terms of distance to the road or nearest market town, is expected to be negatively correlated to the area of forest cut down as well as the area of land in crops and pasture.

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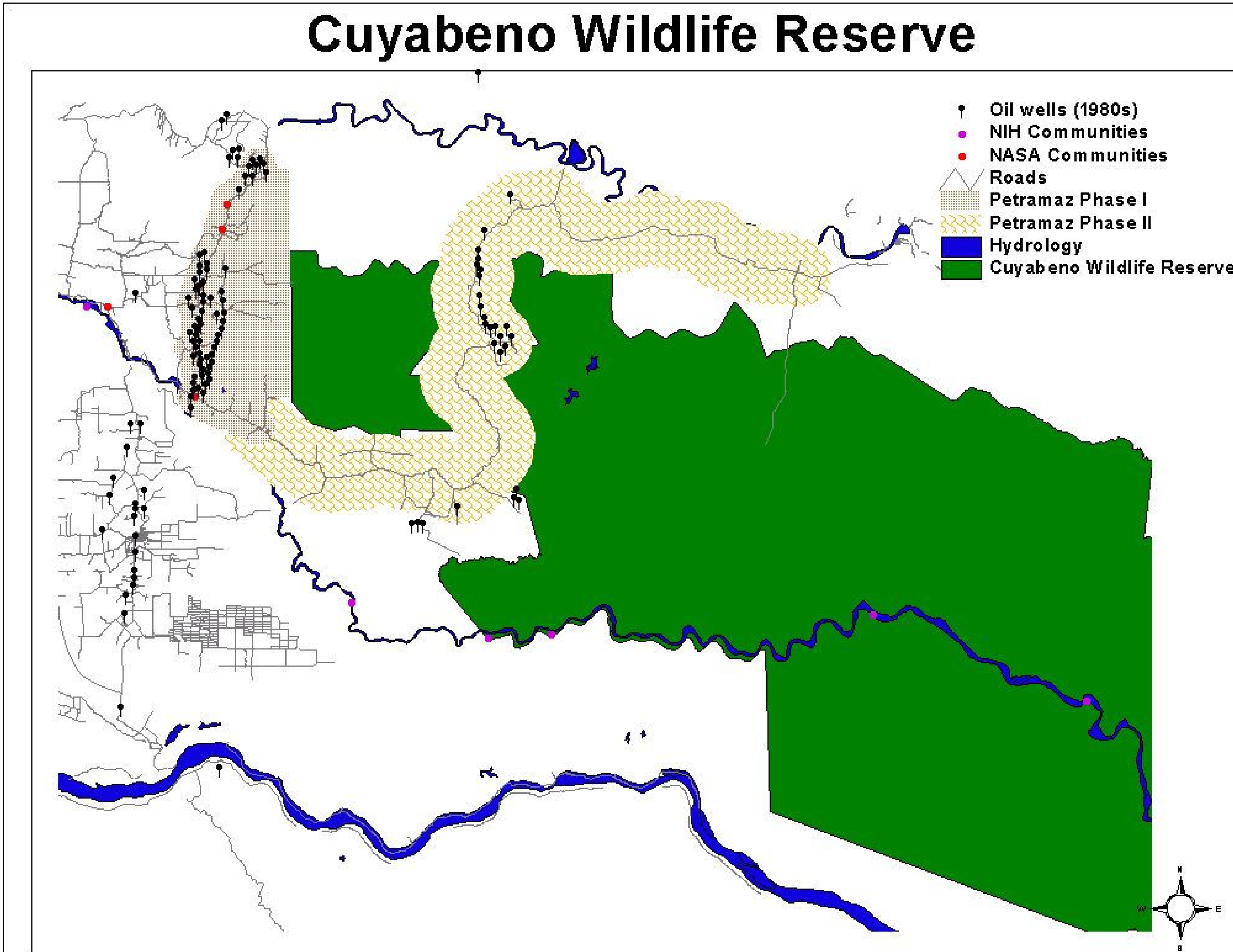

Figure 1. The Cuyabeno Wildlife Reserve, Ecuador, and surrounding area.