

*Economic Geography* 79(3): 221–240, 2003.  
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## Neoliberal Policy and Deforestation in Southeastern Mexico: An Assessment of the PROCAMPO Program

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**Abstract:** A lingering question in economic geography is the degree to which there is a link between neoliberal policies and environmental degradation. Research is needed to relate such policies empirically to local-level decision making, both to evaluate their consequences and to contribute to an understanding of how cross-scalar dynamics drive processes of land-use change. This study examines the environmental impacts of a Mexican rural support program, referred to by its Spanish acronym, PROCAMPO, which was introduced in 1994 as part of a comprehensive agenda to liberalize the agricultural sector. Using both descriptive analyses of the study region's political ecology and econometric modeling, we draw on a panel of farm-household data spanning 1986–1997 to assess the impact of PROCAMPO on land-use change in southeastern Mexico. The results indicate that the program has had the unintended effect of fostering deforestation and has led to an only modest increase in market production. These findings suggest that alternative mechanisms may be needed to achieve the market integration and agricultural modernization sought by neoliberal policies and that such policies may have to be restructured to avoid unintended environmental impacts. By connecting macro-level economic phenomena with regional and local environmental impacts, this study addresses the linkages of cross-scale human-environment interaction.

**Key words:** tropical deforestation, neoliberal policy, PROCAMPO, land-use change, Mexico.

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This research is part of the southern Yucatán peninsular region (SYPR) project. The SYPR project has core sponsorship from NASA's LCLUC (Land-Cover and Land-Use Change) program (NAG 56406) and the Center for Integrated Studies on Global Change, Carnegie Mellon University (CIS-CMU; NSF-SBR 95-21914), as well as sponsorship from various sources for particular elements of the project's research. Additional funding from NASA's New Investigator Program (NAG5-8559) supported the specific research in this article. SYPR is a collaboration of El Colegio de la Frontera Sur (ECOSUR), Harvard Forest—Harvard University, the George Perkins Marsh Institute—Clark University, and CIS-CMU (see <http://earth.clarku.edu/lcluc>). We thank Sergio Cortina V., Jenny Ericson, Eric Keys, Pedro Macario M., and Birgit Schmook for their helpful discussions and B. L. Turner II, Jacqueline Geoghegan, Rich Iovanna, Ron Shadbegian, Robert Elgie, David Angel, and two anonymous reviewers for their valuable comments at various stages of the writing process. We acknowledge the critical role that members of the SYPR project played in numerous aspects of this research.

A core research question in economic geography is the impact of neoliberal economic reforms on the environment. This question has particular urgency in Latin America, where developmental pressures on ecologically critical biomes are mounting in the face of economic policies that emphasize private investment, decentralization, and international free trade as the basis for modernization (Gwynne and Kay 1999; Place 2001; Robinson 1998). Although the relationship between neoliberal policies and environmental degradation has received some theoretical treatment, more research is needed to link such policies empirically to local-level decision making, both to facilitate programmatic assessments and to contribute to an understanding of how cross-scalar dynamics drive processes of land-use change (Bebbington 2002, 118; Folke et al. 1998; Gibson, Ostrom, and Ahn 1998).

In this article, we address the environmental implications of the Mexican experience with neoliberal reform, examining how recent governmental policy initiatives have effected land-use change in an agricultural frontier spanning the southern portions of the states of Campeche and Quintana Roo in the Yucatán peninsula (see Figure 1). As in other Latin American countries, neoliberal policies in Mexico have principally targeted the modernization of the agrarian sector by fostering the intensification of production. This emphasis results from the coalescence of domestic welfare imperatives and international pressures to save tropical forests, which together create a juxtaposition of environmental and economic policy interventions at the regional level. In the southern Yucatán peninsula, a series of rural development initiatives by the federal government has hastened the transition from a system of predominantly subsistence-based agriculture to one featuring the introduction of cash crops and commercialized ranching activities. Our focus here is on one such initiative, referred to by its Spanish acronym, PROCAMPO (Programa de Apoyo Directo al Campo/Program for Direct Assistance in Agriculture), which was introduced in

1994 as part of a comprehensive agenda to liberalize the Mexican countryside.

Specifically, we use descriptive analyses of the southern Yucatán peninsula's political ecology and econometric models of the farm area allocated to each of four principal land uses: forest, staple crops, commercial crops, and pasture. These analyses draw on a regionwide survey from which a panel of individual farm-level data for 1986 through 1997 was compiled. Because the data set straddles temporally the initiation of PROCAMPO support, it affords a unique opportunity to investigate how such a federally administered agricultural program affects local-level decision making. The findings indicate that PROCAMPO has had the unintended effect of fostering deforestation but has had only a modest effect on increasing the incidence of commercialized uses. We raise two policy implications that emerge from these results: (1) that alternative mechanisms may be needed to achieve the market integration and agricultural modernization sought by neoliberal policies and (2) that such policies may have to be restructured to avoid unintended environmental impacts.

### Forging Cross-Scale Connections

The forces that effect land-use change interact across multiple spatial, temporal, and political-hierarchical scales (Geoghegan et al. 1998; Gibson, Ostrom, and Ahn 1998; Mansfield 2001; Polsky and Easterling 2001; Walker and Solecki 2001). There is growing recognition that an important factor in understanding the interaction between macro-level and micro-level processes is the way in which individuals react to governmental policies. In the discipline of geography, the research framework provided by political ecology emphasizes fundamental linkages between local productive systems and national and global economic structures that determine regional trajectories of changes in land use (Blaikie and Brookfield

1987; Rocheleau, Thomas-Slayter, and Wangari 1996; Watts 2000). Political ecology has traditionally addressed these linkages through in-depth contextual analyses of in-situ decision making to connect local-scale dynamics up a hierarchical chain of influence. More recent research has augmented this approach to include richer descriptions of the changing external influences themselves, connecting them down the hierarchical chain to local-scale changes (Bridge 2002). Given the cross-scalar interaction of biophysical, socioeconomic, and political factors in driving environmental change, a key challenge in advancing this line of inquiry is to identify and quantify the impact of those cross-scalar linkages that significantly affect the rate of environmental degradation in particular locales (Kasperson, Kasperson, and Turner 1995).

The difficulty in quantifying cross-scale linkages is exacerbated by the fact that regional dynamics, in the words of Turner et al. (1995, 581), “can be understood only in the context of changing extra-regional linkages.” Among the most influential extra-regional changes to affect local-scale changes in land use are those associated with economic policy. By the end of the twentieth century, an increasing number of the governments of developing countries were adapting measures to accommodate, at least in the rhetoric of institutions such as the International Monetary Fund and G7/8, concerns about “sustainable globalization” (Kirton 2002a, 2002b). In Latin America and the Caribbean, for example, despite continuing implementation of structural reform policies, the average social expenditure as the share of total public expenditures increased from slightly over 40 percent in both 1980–81 and 1990–91 to almost 50 percent in 1996–97 (Stallings and Peres 2000).<sup>1</sup> It is this kind of shift in priorities, in this case toward social welfare, that Kirton (2002a, 2002b) describes in his characteri-

zation of a new form of neoliberalism that emerged in the mid to late 1990s.

Kirton (2002a, 2002b) argues that significant shifts in the principles and norms of neoliberalism occurred during this era as a result of mounting concern over the environmental and social conditions that were said to accompany the neoliberal policies of the 1980s and early 1990s. Drawing on the G7/8’s record of summit agendas and communiqués over the past decades, Kirton (2002a, 2) suggests that a new consensus has emerged that embraces a development process “in which trade liberalization, environmental enhancement, and social cohesion are tightly integrated, equally balanced, and mutually supportive.” He cites the environmental provisions of the North American Free Trade Agreement (NAFTA) as one of the first of several examples of the incorporation of such principles in international trade negotiations (see also Clark 1994). Kirton (2002a) refers to this emerging normative order as “embedded ecologism,” an ideology that includes the core tenets of neoliberalism—the promotion of international free markets, privatization, and deregulation, for example—but with a heightened concern for social welfare and ecological conditions.

Two important questions are raised by Kirton’s analysis: (1) what are the processes through which shifts in ideology among intergovernmental institutions are transmitted through national policies to affect local production systems, and (2) what are the associated environmental outcomes of these processes? In what follows, we address these questions with analyses of both the origins of the PROCAMPO program and its impacts on the land-use system of the southern Yucatán peninsula. Introduced to address sustainable development concerns, and to advance free trade—a keystone neoliberal objective—PROCAMPO represents a trend toward trade-environment integration in national policy.

<sup>1</sup> Stallings and Peres (2000) compiled these data for Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Jamaica, Mexico, and Peru.

## PROCAMPO and Embedded Ecologism

PROCAMPO was a direct output of the negotiations over the agricultural section of NAFTA (Shwedel 1994) in the context of heated debate about the ramifications of free trade for labor and the environment (see, e.g., Ritchie 1993). Introduced in 1993, with payments first awarded in early 1994, PROCAMPO extends agricultural support via payments for the continued cultivation of a fixed area of land until 2010, a period corresponding to the time in which agrarian price supports are to be phased out under NAFTA. Specifically, the program extends a per hectare payment on the production of a wide range of crops, including maize, chili, and pasture, as well as forestry.<sup>2</sup> The number of hectares eligible for support is restricted to the area that was cultivated in any of nine staple crops (e.g., grains, beans, and oilseeds) in one of three agricultural years prior to August 1993 (SAGARPA 2002; SARH 1993).<sup>3</sup>

Because aid is decoupled from the cultivation of a specific crop, the terms of PROCAMPO are intended to be consistent with the increased autonomy conferred by legal changes enacted in 1992 that gave farmers in Mexico's *ejido* sector the right to privatize their land.<sup>4</sup> According to officials at SAGARPA (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca, y Alimentación/Secretariat of Agricultural,

Livestock, Rural Development, Fishing, and Food<sup>5</sup>), the agency administering the program, it was believed that the financial support would make farmers more competitive in international commodity markets and give them an incentive to modernize their agricultural practices. Furthermore, by replacing crop-based subsidies with direct payments based on the area cultivated, legislators assumed that farmers who had previously produced too little to take advantage of the price supports would benefit from the new system (Bonnis and Legg 1997). In this regard, the program is intended to foster social cohesion by both easing the burden of adjustment to the elimination of price supports and by targeting a broader population of producers.

While PROCAMPO's primary goal is clearly to support agricultural modernization and social welfare during the transition from state intervention in the rural sector, an additional goal is to decrease environmental degradation through the promotion of more efficient land use (SAGARPA 2002; SARH 1993). As is stated in governmental literature, PROCAMPO aims to "slow down environmental degradation, promote conservation and reforestation to help reduce soil erosion and water pollution caused by excessive use of non-organic pesticides, and to promote sustainable development" (SARH 1993).<sup>6</sup> Because the area and location covered by PROCAMPO is fixed over time, these goals are rooted in the expectation that the funds are to be used

<sup>2</sup> In 1994, the payment was \$100 (350 N pesos, with N short for "new") per hectare, and in 1995 it was \$68 (440 N pesos) per hectare. By 1997, PROCAMPO payments were \$69 (550 N pesos), having been fixed in real terms in 1996 at \$64 (484 N pesos) through the end of the program.

<sup>3</sup> Smallholders who did not register with the program in its first year are precluded from any future participation.

<sup>4</sup> *Ejid*os are land grants, introduced following the Mexican Revolution of 1910, in which the land is held in usufruct and managed communally.

<sup>5</sup> This agency was formerly known as SARH, the Secretaría de Agricultura y Recursos Hidráulicos/Secretariat of Agricultural and Water Resources.

<sup>6</sup> The translation of the text from Spanish to English follows that of Martin (1997, 21). The original text reads, "Frenar la degradación del medio ambiente, propiciando la conservación y recuperación de bosques y selvas, así como coadyuvar a reducir la erosión de suelos y la contaminación de las aguas causadas por el uso excesivo de agroquímicos, en beneficio del ambiente y del desarrollo sustentable."

to intensify production and thereby decrease pressure on the remaining forest (SARH 1993).

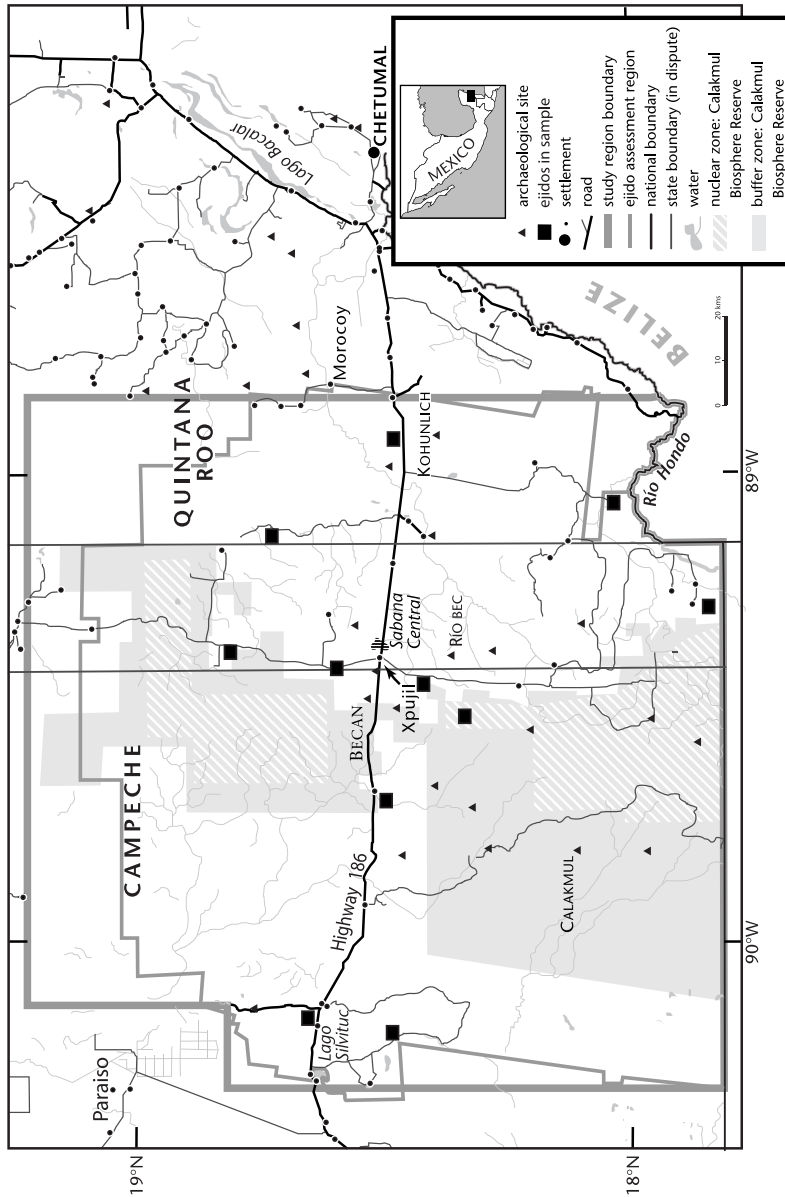
While the scope of PROCAMPO has been massive, distributing some \$1 billion per year to more than 3 million farmers, little research has been done on its consequences for either social cohesion or the environment—two key components of the new neoliberalism. One exception is an analysis by Sadoulet, de Janvry, and Davis (2001) of the multiplier effects of the program on household income. Among their findings are that households with more irrigated land and access to technical assistance are able to generate more income from the program than are households that lack these resources. On the basis of these findings, Sadoulet, de Janvry, and Davis conclude that to promote significant agricultural change, PROCAMPO would have to be accompanied by technical assistance and institutions to foster modernization and diversification.

Our empirical analysis complements that of Sadoulet, de Janvry, and Davis (2001) by exposing the implications of the program for environmental change in a region that is largely devoid of the elements that they identify as necessary to contribute to the program's success in increasing income. The inhabitants of the southern Yucatán peninsula operate within a predominantly semi-subsistence economy, which, in turn, is embedded in a biophysical context that significantly determines farm-production strategies. This recognition helps to interpret how PROCAMPO affects the decisions of the proximate agents of environmental change in the region, primarily *ejidatario* farm households (*ejidatarios* are members of the *ejido* with land rights). Specifically, our analysis reveals the susceptibility of the local land-use system—one that is based on slash-and-burn or swidden agriculture—to exogenous change through governmental policy.

### **Historical Context: Colonization, Policy, and Deforestation**

The study region, extending some 18,700 km<sup>2</sup> across a karstic upland, is part of the largest continuous expanse of tropical forest remaining in Central America and Mexico and has been identified as a “hot spot” of deforestation and biotic diversity loss (Achard et al. 1998). As dramatic as the current rate and extent of deforestation in the region is, however, it is not unprecedented. The site occupies a portion of the Maya lowlands and was nearly completely deforested 1,000 years ago during the Classic Period of Lowland Maya domination (A.D. 100–900) (Turner 1990). Following the collapse of the Maya civilization in A.D. 800–1000, the region experienced a period that was largely free of human intervention that, continuing past the birth of the Mexican nation-state in 1821, allowed the return of mature forest.

The completion of Highway 186 in 1972 opened the region to the first influx of large-scale settlement for agriculture (see Figure 1). Linking the two cities of Chetumal and Escárcega via a largely intact tropical expanse, Highway 186 was part of an extensive road-building project across the peninsula that was intended to integrate the peasant economy with local urban centers (Ewell and Merrill-Sands 1987). Settlers were primarily subsistence farmers who migrated from neighboring regions of Mexico, the majority of whom were driven by the search for land. Although *ejido* land grants were extended throughout the study site in the 1970s and 1980s, the government initially did little to ensure that *ejido* members had access to the capital necessary to produce beyond subsistence needs. Moreover, the region's remoteness kept access to outside markets costly. With land cheap and marketing opportunities few, most agriculture was practiced on an extensive basis under a traditional system referred to as *milpa*, or swidden agricul-



**Figure 1.** Location of the southern Yucatán peninsular region, Mexico (reprinted from *Land Use Policy*, Vol. 18, P. Klepeis and B. L. Turner II, "Integrated Land History and Global Change Science: The Example of the Southern Yucatán Peninsular Region Project," 27–39, Copyright 2001, with permission from Elsevier Science).

ture dominated by maize. Notable exceptions were the over 10,000 ha of wetland (*bajo*) forest that were cleared in the late 1970s and early 1980s as part of government-funded rice and cattle projects, located primarily on the eastern and western flanks of the study region (Klepeis 2000).<sup>7</sup> The majority of these projects were short lived, however, and collapsed within a few years primarily because of weed invasion, inadequate water control, and disease.

By the late 1980s, a restructuring of Mexico's macroeconomic environment toward greater liberalization was under way, bolstered by legal reforms beginning in the following decade. In 1986, Mexico entered into the General Agreement on Tariffs and Trade, the impact of which reached the agricultural sector by 1990, when tariffs on most products were dropped or drastically lowered, subsidies on inputs were withdrawn or sharply reduced, and a guaranteed price was eliminated for all crops but maize and beans (Foley 1995). The continuation of these reforms was secured under the terms of NAFTA, effective in 1994, obligating Mexico to liberalize fully its agriculture, including maize and beans, over a 15-year period. On the legal front, Article 27 of the Constitution, which had served as the embodiment of the government's commitment to the rural poor since the end of the Mexican Revolution in 1917, was amended in 1992 to (1) permit lands formerly held in usufruct under the *ejido* system to be bought and sold, (2) open the possibility for joint ventures between *ejidos* and private interests, and (3) terminate the continued distribution of land to peasant communities. Although it was anticipated that these revisions would, in the words of then-President Carlos Salinas de Gortari (1992, quoted in Foley 1995, 62), both "capitalize the countryside and open productive options," as of this study, no *ejidos* in the region have moved to a private property system.

Against this backdrop, deforestation in the southern Yucatán peninsular region

continued unabated, with mature forest (defined as greater than 20 years old) cut at a rate of between 0.32 and 0.39 percent per year between 1969 and 1997 (Turner et al. 2001). In response, and in the face of international pressure to impede the conversion of forests, the government established the Calakmul Biosphere Reserve in 1989, extending 7,232 km<sup>2</sup> across the center of the study region (see Figure 1). The government is now investing heavily in infrastructure and services associated with El Mundo Maya (the Maya World), an internationally funded ecological/archeological-tourism scheme that involves Mexico, Guatemala, Belize, Honduras, and El Salvador to promote the attraction of the region's Maya heritage and biotic diversity. These attempts to simultaneously encourage privatization, market production, and the conservation of tropical forests, are common elements in the suite of often-contradictory development initiatives that are ongoing in other tropical frontier locations in Latin America (see, e.g., Brown and Pearce 1994; O'Brien 1998; Place 2001).

### The Land-Use System: Composition and Trends

*Milpa* agriculture, jalapeño chili, and pasture constitute the three principal land uses in the region, the relative incidence of each reflecting a combination of a household's basic food needs; its capital endowment; its ability and willingness to sustain risk; its reliance on markets; and environmental constraints, notably the scarcity of water and highly variable rainfall (see Table 1). *Milpa* is the most ubiquitous of the three and can be considered the low-risk "hedge" in the farmer's portfolio of crops. Planted primarily for home consumption, *milpa* refers to a traditional swidden system of temporary cultivation and continuous rotation through forest fallow. The system is dominated by maize but is often intercropped with squash and beans. It relies on various complex management processes to maintain the fertility of the soil and to avoid infestations of pests, with minimal

<sup>7</sup> *Bajos* are seasonally inundated depressions dominated by clay soils (vertisols and gleysols).

Table 1

Incidence and Area, in Hectares, of Predominant Land Uses as of 1997

Land Use	% of Sample	Mean Plot Size	SD Plot Size	Median Plot Size
Forest	100	53.6	53.4	38.6
Milpa	100	5.1	4.5	3.5
Chili	52	2.6	3.6	1.0
Pasture: with grazing animals	28	25.9	28.9	15.0
Pasture: without grazing animals	23	12.9	20.8	5.8

Source: SYPR project survey.

Note: The figures for chili and pasture were calculated on the basis of the subset of farmers who were engaged in these activities.

reliance on purchased inputs (Ewell and Merrill-Sands 1987).

Jalapeño chili is the predominate commercial crop and is distinguished from *milpa* in its capital requirements, labor intensity, and risk. While a hectare of *milpa* necessitates, on average, 47 labor days per hectare per year, a hectare of chili requires over five times as much, requiring most chili-producing households to harness their entire stock of household labor for fieldwork in addition to hiring (Vance 2000). Chili production also requires intensive applications of fertilizers, herbicides, and insecticides. The substantial variability in prices and outputs, coupled with up-front production and marketing costs, exposes farmers to considerable risk, which is one possible explanation for why only half the sample produced chili as of 1997 (see Table 1).<sup>8</sup>

Pasture is the third major land use within *ejidos* in the region and can be regarded as a type of long-term equity in the farmer's portfolio of commercial and subsistence land uses. Depending on the number of cattle owned and whether fire or labor is used to eradicate weeds, farmers in the survey indicated that pasture could be maintained for up to 12 years with relatively low expenditures for labor and typically no expenditures for chemical inputs. By 1997, roughly half

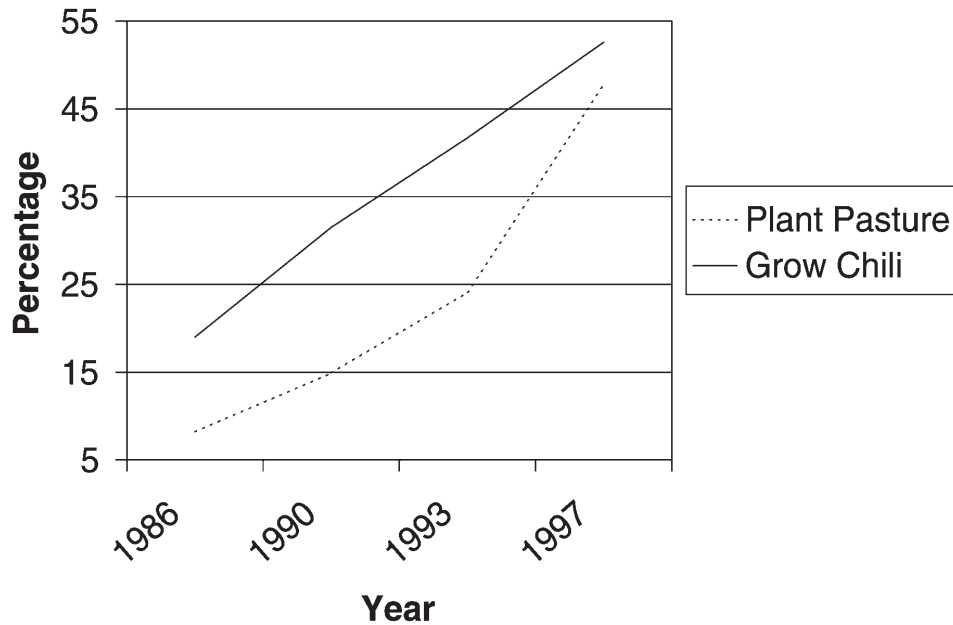
the sample of 188 farmers maintained some amount of pasture. Of these farmers, only slightly more than half owned grazing animals (cattle or sheep), with the nonowners invariably stating that they hoped to acquire cattle at some point in the future. Moreover, among the livestock owners, the ratio of heads of cattle to hectares in pasture was 0.47, far less than the density of about one head that could be supported.<sup>9</sup> Pasture can thus be regarded as a relatively extensive land use, the economic motivations of which may not be connected entirely to animal husbandry.

While the subsistence-based *milpa* has persisted as the principal activity of most *ejidatario* households in the region, land-use diversification has clearly taken hold. Pasture and the commercial cultivation of crops assumed ever-greater prominence in the agricultural system from 1986 to 1997, with the percentage of farmers engaged in both pursuits having more than doubled over this interval (see Figure 2). These trends correspond to a relative decrease in the land-use share allocated to the production of staple crops. By 1997, staples comprised an average 5.3 percent of the total parcel area, having fallen from 11.8 percent in 1990. The share allocated to pasture, by contrast, steadily increased, rising from an average of

<sup>8</sup> Keys (forthcoming) estimates that the cost of producing chili in 1998 approached roughly \$1,000 (9,500 N pesos) per season.

<sup>9</sup> The estimate that one hectare of pasture is required for each head of cattle is based on discussions with key informants.





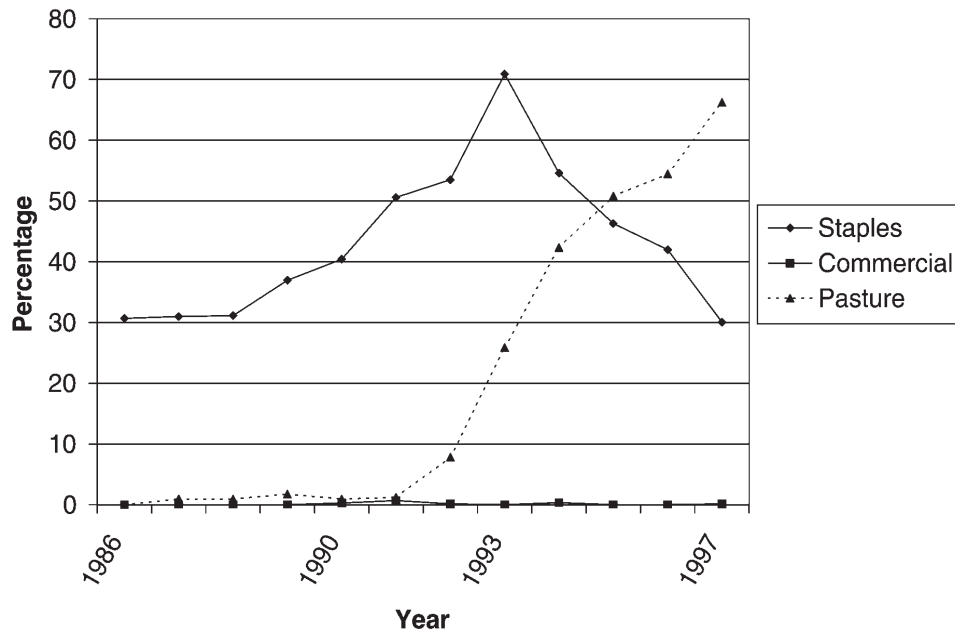
**Figure 2.** *Ejidatarios* (percentage) planting pasture and growing chili in the region, 1986–1997 (calculated from SYPR survey sketch maps).

5.4 percent of the parcel area in 1990 to 8.7 percent in 1997. Over the same period, the proportion of land planted with commercial crops also increased significantly, from 0.49 percent to 1.7 percent.

Figure 3 illustrates how these trends were accompanied by changes in the land-use shares allocated to staples, commercial crops, and pasture for the subset of agricultural lands eligible for PROCAMPO support. Although a pronounced increase in the share allocated to pasture began in 1992, the share allocated to staples peaked in 1993, with the result that by 1995 pasture was the predominant use of these lands. In absolute terms, the area allocated to staple crops on all agricultural lands decreased annually by 1.83 ha per household between 1994 and 1997, just over half of which, 0.94 ha, was on PROCAMPO-eligible land. This component of the decrease appears to have been partially compensated for by an increase in the rate of forest clearance for the production of staple crops. Between the 1986–1993 and 1994–1997 intervals, the area of land

that was deforested annually to plant staples grew from 0.81 to 0.88 ha per household, while overall annual deforestation increased from 0.84 to 0.94 ha. The production of staple crops thus accounted for roughly 70 percent of the increased deforestation that took place after 1994, despite the fact that the overall area in staple crops was on the decline.

While Figures 2 and 3 point to some evidence of discontinuous shifts in land-use trajectories beginning with the initiation of PROCAMPO in 1994, the overall trends toward the cultivation of commercial crops and the creation of pasture were clearly in place well before these dates. Several factors account for these trends, perhaps the most important of which are the aforementioned government-sponsored projects to introduce ranching activities and the transfer of agricultural technologies—particularly related to the cultivation of chili—from neighboring regions via immigration in the 1970s and 1980s (Keys forthcoming; Klepeis 2000). These influences notwithstanding,



**Figure 3.** Percentage of PROCAMPO-eligible lands allocated to select uses in the region (figure excludes fruits and experimental crops).

Figures 2 and 3 suggest that the implementation of the program may have created conditions that elicited a measurable behavioral response that is revealed by an econometric analysis of trends in land use.

### The Econometric Model

To test more rigorously the connection between PROCAMPO and changes in land use, we estimate four econometric models that relate farm area allocated to forest, staples (primarily the maize, beans, and squash mix of the *milpa*), commercial crops (primarily jalapeño chili), and pasture to the area subsidized under PROCAMPO. Eighty-eight percent of the sample participated in the program, receiving the payment on an average of 4.05 ha. As farmers started receiving PROCAMPO support in 1994, the explanatory variable measuring the program's effect assumes a value of zero prior to 1994 and a fixed value corresponding to the number of hectares subsidized thereafter, with observations on nonparticipants

assigned a value of zero for each year of the data.<sup>10</sup> We are principally interested in testing the null hypothesis that PROCAMPO support had no effect on the plot area under forest. If the effect of the support was consistent with its intent of stimulating market production and curtailing deforestation, rejection of the null would be indicated by

<sup>10</sup> That 12 percent of the sample did not participate in the program points to possible biases in the empirical analysis that would arise in the presence of unobservable variables that both determine participation and are correlated with the included explanatory variables in the econometric model. We regard this source of bias as unlikely. All the *ejidos* in the sample were reached by the program, and the majority of respondents in each *ejido* were PROCAMPO participants. Of the nonparticipants, 41 percent were not yet present in the region in 1993 at the time of registration. Many of the remainder reported having been away on the day that PROCAMPO representatives surveyed the plots. We see no evidence that the implementation process biased certain types of farmers.

a positive coefficient of PROCAMPO on commercialized land use and on forest.

Several other variables are included in the analysis to control for the range of factors affecting land-use decisions, the descriptive statistics for which are presented in Table 2. These variables are selected on the basis of previous studies of land use in the region (Geoghegan et al. 2001; Vance and Geoghegan forthcoming); a detailed accounting of hypothesized effects is beyond the space available here. Demographic pressures and the effects of human capital are captured by measures of household size, the education and age of the household head, and the household's duration of occupancy in the region as of 1986. To control for the effects of access costs, we include a measure of the distance separating the household from the farm plot and dummy variables indicating the mode of transport to the plot (horse, vehicle, or bike, with by foot as the base case). We also include a measure of the distance from the household to the nearest market center and a dummy variable indicating Spanish as the first language to serve as a control for the effects of transaction costs in market participation. Measures of ecological conditions and the physical environment are captured by the average elevation of the plot, a dummy indicating favorable soil, the size of the house-

hold's land endowment, and, to control for persistency effects, the lagged value of the dependent variable. Finally, year dummies control for autonomous shifts in the policy and economic environment that may have influenced land use in the study region as a whole. The inclusion of these dummies enabled us to isolate the effect of PROCAMPO in the presence of other regional-level influences that may have occurred simultaneously but were unrelated to the program.

Two econometric issues arise in selecting a specification to estimate the effects of the foregoing variables on changes in land use, the first of which regards the limited temporal variability for several variables in the analysis. Many of the household characteristics (education, Spanish language, distance to plot and market, mode of transport to plot, farm size, and the ecological indices) never change in the data set, while others change only slightly or at a discrete point in time (age, duration of occupancy, household size, PROCAMPO). The estimation of a fixed-effects model—a common specification for panel data—would, therefore, completely eliminate variables, such as distance to plot, that never change over time, and substantially reduce the variation for other explanatory variables. Moreover, the fixed-effects estimator may produce bias in

Table 2

Descriptive Statistics of Explanatory Variables Used in the Regressions

Variables	Mean	SD
PROCAMPO (ha)	4.1	4.0
Household size	5.7	2.6
Education of household head (highest grade completed)	3.0	3.3
Age of head (years)	43.7	14.3
Duration of occupancy as of 1986 (years)	8.2	9.5
First language Spanish (1, 0)	0.8	0.4
Distance from house to plot (km)	7.9	6.9
Mode of transport to plot: horse (1, 0)	0.2	0.4
Mode of transport to plot: vehicle (1, 0)	0.1	0.3
Mode of transport to plot: bike (1, 0)	0.1	0.3
Distance <i>ejido</i> to the nearest market (km)	29.6	22.7
Elevation (m)	155.5	69.1
Good soil (1, 0)	0.7	0.5
Land endowment (ha)	95.7	64.2

the estimated coefficients if there is substantial measurement error over time (Griliches and Hausman 1986; Gray and Shadbegian 2001). We therefore focus our analysis on results from an ordinary least squares (OLS) specification, formally written as:

$$y_{it} = \alpha + \mathbf{x}_{it}\beta + \varepsilon_{it} \quad (1)$$

where the subscript  $i$  refers to the observation, subscript  $t$  refers to the time,  $y$  is the dependent variable,  $\alpha$  is a constant,  $\mathbf{x}$  is a vector of explanatory variables,  $\beta$  is a vector of parameter coefficients, and  $\varepsilon_{it}$  is the error term, assumed to have a normal distribution. This estimation procedure is applied to the analyses of area allocated to forest and the cultivation of staple crops.

The second econometric issue regards the censoring of the dependent variable for the models of the cultivation of commercial crops and pasture. In assessing the determinants of these land uses, the application of a Tobit model is suggested because slightly less than half the farmers sampled planted no chili or pasture whatsoever. To accommodate this feature of the data, the Tobit combines elements of the probit and OLS regressions. The Tobit version of the model is as follows:

$$y_{it} = \alpha + \mathbf{x}_{it}\beta + \varepsilon_{it} \text{ if } y^* > 0 \quad (2) \\ = 0 \text{ otherwise}$$

where

$$y^* = \alpha + \mathbf{x}_{it}\beta + \varepsilon_{it} \quad (3)$$

In this formulation, the hectares planted in commercial crops or pasture,  $y_{it}$ , can be interpreted in terms of an index function,  $y^*$ , which is observed only when  $y^* > 0$ . To obtain robust estimates by correcting for the effects of potential heteroskedasticity, both the OLS and Tobit models use the Huber/White estimator of variance.

### Data Collection

Data were collected for this study over an 11-month period beginning in the fall of 1997. Households were selected according

to a stratified, two-stage cluster sample, with *ejidos* as the first-stage unit and *ejidatarios* as the second-stage unit (Deaton 1997; Warwick and Luinger 1975; for details of the survey design, see Vance 2000). This procedure resulted in the random selection of 11 *ejidos*, followed by the random selection of 188 *ejidatario* households. Because households in the sample immigrated at different times, some as many as 50 years ago and others as recently as the year preceding the interviews, the data-generation process resulted in an unbalanced panel totaling 642 observations. It is important to note that although *ejidos* are managed communally and held in usufruct, *ejido* members in this region of Mexico generally maintain permanent access to particular parcels of land throughout their residence, thereby enabling the linkage of specific household data with specific land units.

A standardized questionnaire with formal and open-ended components was used to elicit socioeconomic and land-use data from the *ejidatarios*. In the formal component, a panel of data was collected on household demographics, land-use systems (e.g., types of cultivars and fallow cycles), and farm capital. By collecting information on the births, deaths, and permanent out-migration of sons and daughters of the household head, it was possible to reconstruct estimates of household size through time.

The informal, open-ended component of the survey explored the respondents' perceptions of land use, governmental policy, and land-tenure reform. Completion of this component involved a guided tour of each respondent's agricultural parcel. Using a global positioning system, the interviewer created a geo-referenced sketch map detailing the distinct fields within the parcel as the farmer-respondent provided an interpretation of the use of these fields. The sketch map documented not only the spatial configuration of contemporary land uses, including forested areas, but the land-use transition histories of the principal areas of activity, emphasizing the period between 1986 and 1997 (for a description of how the sketch maps were created, see Klepeis

and Turner 2001). This information was later used to calculate various indices of land-use change, such as the area planted in different types of crops since the plot was acquired, as well as to inform the interpretation of available LANDSAT Thematic Mapper satellite imagery that was used to calculate some of the spatial explanatory variables (e.g., elevation and distance to road).

### Results of the Models

Several variants of the models were estimated to gauge the robustness of the results. Most of these exercises tested for the significance of additional variables, including one in which a dummy variable was included to test the hypothesis that the attribute of nonparticipation in the program significantly affected the dependent variable. This hypothesis was rejected. A fixed-effects variant of the model was also explored, yielding results only slightly different from those presented here. In the interest of parsimony, we therefore focus our discussion on models that include the core variables defined earlier, with brief references to other findings of interest.<sup>11</sup>

The first two columns of Table 3 present estimates of the OLS model on the area under mature forest and under the cultivation of staple crops (Models 1 and 2), while the latter two columns present results from the Tobit models of the area under commercial-crop production and pasture (Models 3 and 4).<sup>12</sup> Perhaps the most striking result is the negative and highly significant coefficient on PROCAMPO in the model of forest area, complemented by the positive and significant coefficients in the models

of commercial-crop cultivation and pasture. In particular, the estimate for Model 1 suggests that each additional hectare subsidized reduces the area in forest by 0.41 ha.

A direct comparison of this coefficient with those of Models 3 and 4 is not possible because the latter models were estimated with the Tobit specification, the estimates of which do not represent the marginal effects of a change in the explanatory variables. From the analysis by McDonald and Moffit (1980), however, we know that the marginal effects for PROCAMPO can be derived by applying the following formula:

$$\frac{\partial E(y)}{\partial X_i} = F(z) [\partial E(y^*)/\partial X_i] + E(y^*) [\partial F(z)/\partial X_i], \quad (4)$$

where the term to the left of the equality gives the change in the expected value of the dependent variable,  $E(y)$ , from a change in one of the independent variables,  $X_i$ ;  $F(z)$  is the cumulative normal distribution function; and  $E(y^*)$  is the expected value of the dependent variable for observations above the zero threshold. The first component shows the change in area planted by farmers who were already planting, while the second shows the change in area planted by farmers who were just starting to plant. Using the parameter estimates from Models 3 and 4, we estimated the total effect of each additional hectare subsidized by PROCAMPO to increase the area of commercial cultivation and pasture by 0.04 and 0.69 ha, respectively. In the case of commercial cultivation, 22 percent of the change is due to the increases in area from those who were already planting, whereas 78 percent is due to the effect of new entrants. The corresponding figures for pasture are 14 percent and 56 percent. Taken together, the results of Models 1, 3, and 4 suggest that although the program has had a modest effect in encouraging market-oriented production and the creation of pasture, its effect in promoting deforestation has been substantial.

The coefficients on the remaining variables, where statistically significant, are largely consistent with intuition and deserve

<sup>11</sup>All referenced results not presented in the tables are available from the authors.

<sup>12</sup> One of the 11 *ejidos* sampled was not included in the estimation because it operates under a nonparcelized form of land tenure in which farmers have access to an area of land that is not demarcated by formally recognized plot boundaries. Exclusion of this *ejido* resulted in the elimination of 26 of the 188 households in the sample.

**Table 3**

Regression Results Showing the Determinants of Farm Area Allocated to Principal Uses  
( $n = 642$ )

	OLS Regression		Tobit Regression	
	Forest	Staples	Commercial	Pasture
PROCAMPO	-0.41 <sup>b</sup> (-2.39)	0.02 (0.06)	0.08 <sup>b</sup> (2.06)	1.41 <sup>b</sup> (3.79)
Household size	0.11 (1.05)	0.05 (0.59)	0.02 (0.56)	0.78 <sup>a</sup> (1.86)
Education of head	-0.04 (-0.20)	0.17 (1.55)	-0.08 (-1.38)	-1.38 <sup>b</sup> (-2.91)
Age of head	0.02 (1.01)	0.03 <sup>b</sup> (2.00)	0.00 (0.39)	0.17 <sup>a</sup> (1.89)
Duration of occupancy	0.02 (0.40)	0.02 (0.41)	0.00 (0.09)	0.12 (0.90)
First language Spanish	0.54 (0.84)	-0.39 (-0.70)	-0.20 (-0.66)	13.02 <sup>b</sup> (4.11)
Distance to plot	0.31 <sup>b</sup> (2.26)	-0.08 (-1.41)	-0.09 <sup>b</sup> (-2.30)	0.14 (0.65)
Mode of transport: horse	1.42 <sup>a</sup> (1.87)	-0.50 (-1.03)	-1.00 <sup>b</sup> (-3.42)	-0.42 (-0.16)
Mode of transport: vehicle	-4.27 <sup>a</sup> (-1.77)	2.54 <sup>a</sup> (1.90)	1.11 <sup>a</sup> (1.64)	-10.04 <sup>b</sup> (-2.24)
Mode of transport: bike	0.69 (1.01)	0.24 (0.31)	-0.18 (-0.50)	2.93 (0.94)
Distance to the market	0.03 (1.28)	0.01 (0.47)	-0.02 <sup>b</sup> (-2.49)	0.07 (1.00)
Elevation	0.02 <sup>b</sup> (2.10)	0.00 (0.32)	-0.01 <sup>b</sup> (-2.59)	-0.09 <sup>b</sup> (-4.05)
Good soil	-0.82 (-1.16)	0.42 (0.64)	-0.12 (-0.40)	2.55 (0.99)
Land endowment	0.02 <sup>b</sup> (2.88)	0.00 (0.04)	0.00 (1.31)	0.24 <sup>b</sup> (9.82)
Lag dependent variable	0.96 <sup>b</sup> (89.54)	0.73 <sup>b</sup> (9.48)	0.96 <sup>b</sup> (17.14)	0.06 (0.96)
$F(10, 616)$ year dummies	1.99 <sup>b</sup>	0.85		
Chi-square (10) year dummies			36.22 <sup>b</sup>	12.00
Constant	-6.29 <sup>b</sup> (-3.08)	0.02 (0.01)	-0.22 (-0.20)	-51.29 <sup>b</sup> (-5.03)
$R$ -square	0.98	0.67		
Log-likelihood			-711.15	-1115.76
$F(25, 616)$	4474.11 <sup>b</sup>	24.60 <sup>b</sup>		
LR Chi-square (25)			450.49 <sup>b</sup>	360.63 <sup>b</sup>

Note: t-statistics are in parentheses, adjusted for robustness.

<sup>a</sup> Denotes significance at the 10-percent level.

<sup>b</sup> Denotes significance at the 5-percent level.

only a brief comment. The distance separating the household from the farm plot and from the market are seen to affect land use, confirming the importance of accessibility costs in determining cultivation decisions in a region with still poorly developed road and marketing networks. The distance-to-plot measure positively affects the area under forest and negatively affects the area under commercial-crop cultivation in Models 1 and 3. In the latter model, distance to market, which serves as a proxy for the farm-gate price received by the farmer for the commercial crop, is also seen to have a negative effect on the area under cultivation.

The mode of transportation to the plot is another significant determinant of land-use decisions, but in this case, opposing signs on the coefficient estimates for the transportation-mode dummy variables complicates a logically consistent appraisal of their effects. As is expected, vehicle travel has a negative effect on the area under forest, complemented by a positive effect on the area under staples and commercial cultivation. Curiously, however, horse travel, which should also lower access costs relative to foot travel, has a positive effect on area under forest and a negative effect on the cultivation of commercial crops. An explanation for the negative effect of vehicle travel on area under pasture is also not immediately evident, other than to speculate that it, and the effect of horse travel, reflects wealth effects that are not adequately captured by the models. In this regard, it is possible that households with larger asset endowments are more diversified in their income-generating activities, relying less on the natural resource base for their livelihoods (Vance and Geoghegan 2002).

Turning to the measures of human capital and the physical environment, education is seen to have a negative effect on the area planted in pasture, corroborating the idea that higher education deflects labor off the farm because of increased wage-earning potential. The other measure of human capital, age, has a positive effect in the models of the cultivation of staples and

pasture. The effects of the physical environment, as measured by the average elevation of the plot and the land endowment, are also seen to be significant determinants of land use. Elevation positively effects the area under forest and negatively effects the area allocated to the cultivation of commercial crops and pasture, while the land endowment has a positive effect in the models of forest and pasture.<sup>13</sup>

Finally, the lagged term in all models except that of pasture carries a positive and highly significant coefficient estimate, suggesting the importance of persistence effects in land-use decisions. To the extent that land-use allotments in the present period are largely determined by those in the previous period because of the costs of clearing and preparing land, we would expect a high degree of spatial overlap from year to year. The importance of this dynamic becomes particularly clear when the lagged variables are omitted from the analysis (results not presented). The *R*-squares for Models 1 and 2 drop just below 0.75, while the coefficients on several more of the explanatory variables (e.g., household size, education of head) reach significant levels in directions that are generally consistent with intuition. One possible explanation for these differences may be attributed to the effects of multicollinearity. Given that many of the determinants in the model vary only slightly over time (if at all), it is plausible that they are strongly correlated with lagged values of the dependent variable.

Returning to our core question of whether PROCAMPO affects land use and deforestation, it is of interest to move beyond assessing the statistical significance and magnitude of the coefficient estimate for the PROCAMPO measure to consider its impli-

<sup>13</sup>To explore the effect of farm size further, we ran a regression that included an interaction term comprising the variables measuring the land endowment and the extent of PROCAMPO support. The coefficient of this variable was insignificant, leading us to reject the hypothesis of a mitigating influence of the land endowment on PROCAMPO.

cations for the proportion of forest area cleared. From 1994 to the end of 1997, approximately 609 ha of forest were converted by farmers in the sample, of whom 141 were PROCAMPO recipients. Multiplying this latter figure by 1.66, the product of the coefficient estimate on PROCAMPO from Model 1 and the average number of hectares subsidized in the sample (4.05), yields 234 ha, an estimate of the total extent of deforestation accounted for by the program. Dividing this figure by the total reduction in forest cover over the period leads to the conclusion that the program was responsible for 38 percent of the deforestation in the sample between 1994 and 1997. If we alternatively use the lower-bound coefficient estimate of 0.07 from the 95 percent confidence interval of the econometric model, we obtain an estimate of 6.5 percent, which still suggests a substantial impact of the program on forest loss.

### Discussion

The research presented here suggests that governmental policy plays a significant role in delimiting the set of production possibilities faced by inhabitants of the southern Yucatán peninsular region. The first *ejidatarios* who settled in the region were confronted with severe environmental constraints, including a five-month dry season, extreme climatic variability, and costly access to markets, all of which made commercialized production in the absence of credit and technical assistance difficult. In response, farmers applied largely self-sufficient techniques that were aimed at ensuring household subsistence while minimizing reliance on the market. Today, the predominant form of organizing production in the region continues to be the semi-subsistence farm household. With continuing promotion of market production and the potential privatization of the Mexican countryside under the 1992 land-tenure reform, governmental initiatives have attempted to encourage further commercialization in which choices regarding the use of land

are increasingly decoupled from considerations of subsistence.

PROCAMPO support is identified as playing only a modest role in hastening this transition. The coefficient estimates from the econometric model indicate that the program has had a statistically significant effect in contributing to a preexisting trend toward the cultivation of chili and the creation of pasture, while promoting deforestation. One possible explanation for these findings may be gleaned from consideration of the program's effects on the fallow cycle. As we noted earlier, a key condition for eligibility is that the area and location subsidized must have been cultivated under some staple crop for one of the three years prior to 1994. Provided that the farmers have maintained that same tract under a "productive" use since 1994, which is *not* limited to staples, they are eligible to receive PROCAMPO payments.<sup>14</sup> The basic structure of the support is thus at odds with the cycle of forest/fallow practiced by the majority of the region's inhabitants. By stipulating that the land be maintained under production, the government precludes the use of fallow as a means of supporting repeat cultivation. The clearance of mature forest, which counters infestations of pests and presents an alternative source of nutrient-rich soil necessary for sustaining crop yields, consequently emerges as an indirect effect of the program.

PROCAMPO's terms may also be one reason why its effect has been greater for pasture than for commercial crops. To reiterate, relative to chili, pasture is inexpensive to initiate and maintain, both in terms of labor outlays and chemical inputs. The planting of pasture, therefore, offers a low cost means of ensuring continued support from the program for farmers who have little

<sup>14</sup> While forestry is considered one of these productive uses, the program gives credit only when there is active forest management. Land that is allowed to revert to forest and remain fallow is not covered. The survey included no cases in which PROCAMPO support covered forestry.



interest in the productive value of the land, per se. It may also partially explain the evidence presented earlier that a portion of this “retired” land is compensated for by the conversion of forested land. The economic logic of such a strategy becomes clear with a simple comparison of the support from PROCAMPO with the costs of clearing new land and of maintaining pasture. Per hectare, pasture maintenance requires roughly 1 to 2 labor days per year to burn the fields for the removal of weeds, while forest clearance per hectare requires roughly 12 labor days (Vance 2000). Multiplying the resulting sum of 14 days times just over \$3 (25 N pesos), the going daily remuneration for a farm hand in 1997, yields roughly \$44 (350 N pesos). Given that farmers were receiving \$69 (550 N pesos) per hectare from PROCAMPO in 1997, they received a net gain of roughly \$25 (200 N pesos) that could be used for the cultivation of newly cleared lands.<sup>15</sup>

Whether the gain is, in fact, used toward this end depends, in large part, on the extent to which the increase in yields garnered from clearing forest is greater than the increase that would occur from the purchase of chemical inputs for land already under cultivation. Although a rigorous analysis of this trade-off is not possible with the available data, a number of authors have suggested that the program’s payments are unlikely to provide sufficient capital to produce the kinds of improvements in land that are necessary to sustain yields, leading them to regard the payments as, essentially, a welfare support (de Janvry, Gordillo, and Sadoulet 1997; Myhre 1998; Sadoulet, de Janvry, and Davis 2001). For example, Sadoulet, de Janvry, and Davis (2001) found that 70 percent of the households in a nationwide panel survey (collected in 1994) used PROCAMPO money for agricultural production, although the respondents believed that the payment was insufficient

to induce changes in cropping strategies. In the southern Yucatán peninsula, forest clearance may thus be a direct response to the infusion of cash in a region in which the transaction costs of obtaining land-intensive inputs are prohibitive for many farmers.

Indeed, to promote intensified production, there are three interrelated factors that have not been adequately addressed in the context of the study region: physical isolation, the scarcity of water, and the need for chemical inputs if the forest-fallow land-use system is to be abandoned for a more intensive one. The capital needed to address these needs is large, however, and probably beyond the scope of the average individual farmer to resolve. Although road improvements are ongoing as part of the El Mundo Maya tourism scheme and may improve access to markets, it is doubtful that these improvements will substantially increase access to credit, given the absence of landesque capital to boost productivity (e.g., irrigation and chemical inputs). Farmers in the region are thus caught in a dilemma. Without basic land-augmenting inputs, it is difficult to attract investment in agricultural modernization because of the high risk of crop failure. Without significant capital investment, however, the *ejidatarios* are unable to overcome these limiting factors. This dilemma may be one possible reason why no *ejidatarios* have decided to privatize their land; presumably, they see limited scope for using their land as collateral to obtain credit.

## Conclusion

The agrarian program, PROCAMPO, represents new trends in neoliberal policy and exemplifies one way in which the rhetoric of enhanced concerns about social cohesion and the environment—key elements of “embedded ecologism”—is manifested. Using econometric methods, the research presented here quantifies the effect of the program on regional environmental outcomes in the southern Yucatán peninsula. The findings indicate that PROCAMPO has contributed to defor-

<sup>15</sup> Converting by the exchange rate implied by the purchasing power parity figure for 1997 (OECD 2002), the net gain would be roughly \$46.

estation, a result squarely at odds with its objective of slowing environmental degradation. We suggest that this result derives, at least partly, from the incompatibility of PROCAMPO's terms with the land-use system of forest-fallow that predominates in the region. An additional channel through which the program is encouraging forest loss is the provision of income to farmers who, even with the support, do not have the means to intensify production given the physical and economic constraints of their environment.

In light of the potential contradictions between the tenets of "embedded ecologism" and regional environmental outcomes revealed by this analysis, a recommended avenue for future research is to assess the scope for injecting sustainable development initiatives with the flexibility to fit unique regional human-environment conditions. Such a research agenda would necessarily move beyond the quantification of linear, cross-scale linkages of economic phenomena and environmental impacts to accommodate a web or nonlinear series of connections across scales (Bridge 2002). For example, in the Mexican context, a particularly pressing question is how constraints on increased market production may be addressed by more access to capital and how this access is linked to the liberalization of trade and to the 1992 reforms that have given *ejidos* the option to privatize (see, e.g., Johnson 2001). Answering this question requires conceptual models that delineate the links among Mexico's diverse tenure institutions, governmental programs, international trade, and environmental degradation. This research is necessary to inform how direct support programs, such as PROCAMPO, may be complemented with projects to address prevailing market and environmental constraints that thwart incentives to intensify production.

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