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LAND CLEARING BEHAVIOR IN SMALL FARMER SETTLEMENT SCHEMES IN THE BRAZILIAN AMAZON AND ITS RELATION TO HUMAN CARRYING CAPACITY

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SUMMARY

1 The behavior of colonists on Brazil's Transamazon Highway with respect to felling virgin forest and clearing second growth is modelled as a part of a computer simulation designed to estimate human carrying capacity.

2 Areas cleared are limited by the resources available to the colonists: land, labor, and capital. Input parameters for the simulation are based on interviews conducted with colonists in a study area located 50 km west of Altamira, in the State of Pará. Data from the Ouro Preto Colonization Project in the State of Rondônia show many similarities with the patterns observed in Altamira. For purposes of simulation, areas available to colonists in their lots are classed by age of second growth, with a separate class for virgin forest (not previously felled by colonists).

3 The probability of clearing each class is calculated based on data representing the proportion of lot-years in which the class was present and was cleared. The probabilities are for clearing some part of the area of the class in question; these "clearings" are preparations of land for crops other than pasture (pasture is calculated separately).

4 In Rondônia, cleared areas in lots occupied by a single owner increase linearly for about six years, after which a plateau is reached. Lot sales to newcomers lead to renewed periods of rapid clearing.

The effects of clearing behavior to carrying capacity include: (a) the lack of a fallowing schedule with uncultivated periods sufficient to restore soil quality, such as those in traditional systems of shifting cultivation, can potentially lead to degradation and lowering of carrying capacity, (b) rapid deforestation leads to the planting of pasture, which is linked to low human carrying capacity, and (c) exceeding a maximum limit for felling can be taken as one of the criteria for determining carrying capacity.

INTRODUCTION

Deforestation in the Brazilian Amazon, and in tropical rainforest areas generally, is increasing steadily and is a cause of both local and global concern (Brazil, Presidência da República, INPA 1979; United States, Department of State 1978, United States Interagency Task Force on Tropical Forests 1980; Myers 1980). Lack of adequate ground truth data for specific areas is often a hindrance to deforestation studies using remote sensing technologies, adding to the difficulty of assessing the extent and dynamics of this process.

Understanding the process of deforestation in the Amazon, and the eventual formulation of adequate governmental policies to bring this process under control, requires better knowledge of the causes of deforestation (Fearnside 1979a, 1982). One of these causes is the clearing of land by small farmers for agriculture, although most clearing on Amazonia occurs on large cattle ranches. Deforestation rates are affected by the decisions of farmers in chosing between clearing virgin forest and the re-use of areas in second growth of different ages. These decisions also affect the sustainability of the farmers' agricultural operations over the long term (Nye & Greenland 1960; Ahn 1979). Land clearing behavior therefore affects human carrying capacity, or the density of the human population that can be supported in an area indefinitely given appropriate assumptions concerning living standards, technology, and consumptive habits (Allan 1949, 1965; Street 1969).

The present paper forms a part of a larger study dealing with the effects of different factors on human carrying capacity in colonization areas on Brazil's Transamazon Highway in Pará (Fearnside 1978, 1979b, 1983a, 1983b), and Cuiabá-Porto Velho Highway in Rondônia. Carrying capacity is operationally defined in terms of a gradient of increasing probability of colonist failure with increasing population density within a limited range of densities. "Failures" are defined in terms of individual families falling below any one of a series of different criteria, most of which are measures of consumption levels. Environmental quality criteria can also be applied, such as a requirement that a certain fraction of the land remain uncleared. Brazilian law requires that 50% of the forest in each colonist's lot be left intact (Decree Law 4771, 15/ix/65), although this law is not enforced in actual practice (Fearnside 1979a). Carrying capacity is considered to be exceeded when the probability of failure over a long period of time surpasses a maximum acceptable level.

MATERIALS AND METHODS

Data Collection

Information on land clearing and agricultural practices was obtained from colonists settled in the Brazilian government's planned colonization area near Altamira, in the State of Pará and Ouro Preto do Oeste, in the State of Rondônia (Fig. 1). In the first area, an intensive study area was delimited which includes 236 lots (100 ha each) centered on Agrovila Grande Esperança, located in the Municipio of Prainha at 3^{o} 22' S. latitude, 52^{o} 38' W. longitude, 50 km west of Altamira on the Transamazon Highway. The study area includes the roadside lots from

km 43 to 58 and the full length of three lateral roads (15/17, 16/18, and 17/19). Colonization began in the Altamira area in 1970, and in the intensive study area in 1971. Most of the information presented here comes from interviews conducted while residing in the study area (1974-76) and during seven subsequent visits (1978-80). Some of the data from 1976 onwards were collected by field assistants. Questionnaires applied are of two types, one related to the clearing and land use decisions for the lot as a whole, and another for information related to individual field histories. Most of the area information is taken from colonist responses, although a few fields were measured using a rangefinder with a 500 m measure range (Topcon model DM-500). Rough visual confirmation was possible for many other areas, since soil samples were taken in most lots. Some of the larger clearings had been measured by the colonists themselves, since hired labor on a per-area contract basis is often used for clearing by financed colonists. Data on cleared areas collected by government agencies can sometimes be in error if clearing loans have been granted and the areas reported by colonists misrepresented (usually inflated) to conform to the areas specified by loan terms. As more colonists pass the legally allowed maximum cleared area of 50%, the sign of the bias in official records can be expected to reverse. No government data on land clearing were used in the present study, and the data are believed to be free of any major biases.

Data collection in the second study area was undertaken between September 1980 and February 1982 in 182 lots scattered over approximately 300 000 ha of the Ouro Preto Integrated Colonization Project, centered on the town of Ouro Preto do Oeste (10^{o} 44' 17" S. latitude; 62^{o} 13' 30" W. longitude). Older establishments are over-represented, as most sampled lots are within 20 km of the Cuiabá-Porto Velho Highway (BR-364), although a few are more than twice this distance. Data collection relies on responses to interviews using questionnaires simiar to those used on the Transamazon Highway, plus one which traces the history of each cleared area forward in time from the year of virgin forest felling. Most of the interviews in Rondônia were done by research assistants.

Simulation Procedure

Computer simulations were run for the Transamazon Highway agricultural system using a FORTRAN program called "KPROG2," which was written for estimating human carrying capacity under conditions prevailing in the area, and under those conditions as altered by various alternative assumptions (Fearnside 1979b). Both deterministic and stochastic runs were made. Stochastic runs include the probability distributions about the means for a number of parameters. In deterministic runs a single lot is simulated, while in stochastic runs calculations are based on 10 simulated lots of 25 ha each (one-quarter the size of actual lots on the Transamazon Highway). Colonist family size is frozen at six persons; all types of colonist are included (Fearnside 1980a). Simulated clearing and land use allocations are made for hypothetical "patches" of land 0.25 ha in area.

Land clearing decisions are a part of the resource allocation sector of the model. The patches of land available for allocation in the lot are "cleared," or prepared for planting, in an

order which is guided by the preference of the simulated colonist for the different categories of land available to him for clearing.

Patches to be cleared are chosen from those which are not occupied by a crop which would preclude the use of the patch for another crop. Excluded are patches planted in perennial crops or pasture, or in manioc (sweet or bitter) that has not completed its growth cycle. Patches are also excluded which have been under continuous cultivation for the maximum number of years permitted before weeds make the planting of a new crop impossible without an intervening fallow period. Here "continuous cultivation" includes annual crops, perennial crops, pasture, and bare or weeds (less than 240 days old). The intervening fallow period must be at least to the "second growth" (over 240 days) stage. The maximum number of years permitted in continuous cultivation is an input parameter, a value of two years being used to reflect the usual practice on the Transamazon Highway.

Each available patch is assigned to a clearing category depending on the age of the secondary vegetation, with a separate category for virgin forest (forest not previously cleared by colonists).

Financing for clearing operations is determined (Fearnside 1980a), and financed virgin felling is carried out before other types of clearing. For patches not influenced by virgin clearing financing, the clearing category of the patch to be cleared is chosen from among the categories for which there are some patches available in the lot. This is done based on clearing probabilities, which represent the probability of clearing some of the land of the class in question, given both the existence of virgin land and the presence of land of the category in the simulated lot. These probabilities are only for clearing land for uses other than pasture, pasture being planted after other uses (Fearnside 1980a). Clearing, and the associated land use allocations, continue until the simulated colonist's resources of land, labor, or capital have been exhausted.

RESULTS

Colonist Land Clearing

Transamazon Highway

The probabilities of clearing within the different land categories, as found by the questionnaire response, are given in Figure 2. These were used in simulating colonist decisions on the Transamazon Highway. The probabilities that a field is burned following clearing, were 0.271 ($\underline{n}$=48) for land less than eight months fallow, and 1.0 in the cases of land fallow 8 months to 2 years ($\underline{n}$=20), over 2 years ($\underline{n}$=20) and for virgin forest ($\underline{n}$=247). The probabilities that older second growth than the field in question was present in the lot and left uncleared were 0.295 ($\underline{n}$=19) in the case of land fallow less than 8 months and 0.077 ($\underline{n}$=13) in the case of land fallow 8 months to 2 years.

The probabilities in Figure 2 refer only to land cleared for uses other than pasture. For land cleared for use as pasture the probability is 1.0 (n=22) that some land of category 1 ("bare or weeds," or land which has been uncultivated for less than eight months) is cleared for this use, given both the availability of land of the category and the fact that pasture was planted somewhere on the lot in the year in question. Of 24 fields cleared for pasture, four were burned (16.7%). Six of the 24 fields (25%) belonged to colonists who had cattle; it should be noted that this applies to the 1973-76 period, and a substantially higher proportion of colonists have subsequently obtained cattle. None of the colonists with cattle at the time of pasture planting burned the fields as a part of the clearing procedure: the frequency of burning may therefore be lower at present, at least for fields planted to pastures immediately following annual crops. It should be noted that all but one of the 24 fields in the sample planted to pasture were in the "bare or weeds" category (< 8 months uncultivated), the one exception being a virgin field in which the burn was so poor that annual crops could not be planted. The greatly increased number of cattle in the area since the sample, as well as the ranching orientation of many of the wealthier newcomer colonists, may be leading to more pasture being planted in fields cleared for older second growths or of virgin forest, thus necessitating burning as a part of land preparation.

The number of years that a field has been under continuous cultivation could be expected to influence (reduce) the frequency with which a field in the "bare or weeds" condition following a crop will be cleared (prepared) for replanting. This should be especially true if the crop to be planted is other than pasture, as weeds and other problems will result in lower yields. For clearing in the "bare or weeds" category for crops other than pasture, the probability of clearing a field that has been under continuous cultivation for one year is 0.804 (n=51), and for two years is 0.750 (n=8). For three years the one case available was cleared; if this case is lumped with the two-year-old fields the probability becomes 0.778 (n=9). In the case of pasture as the next crop, the probability is 1.0 for both one-year-old fields (n=16) and two-year-old fields (n=6). The mean time under continuous cultivation for land planted in pasture is 1.27 years (SD = 0.46, n=22), while the mean for fields planted to other crops is 1.17 years (SD = 0.42, n=60).

The clearing rates of virgin forest on the Transamazon Highway for all uses are presented in Table 1. Cumulative areas cleared, expressed as percentages of the lot area, are shown in Figure 3 (n=60 lots).

Rondonia

Colonists' decisions to clear second growth rather than primary forest are closely tied to the intended land use (Fig. 4). Cattle pasture is much more likely to be planted on land in second growth or in weeds following the harvest of an annual crop; while virgin forest is usually felled if perennial crops are to be planted. Secondary and primary vegetation have equally high probabilities of being cleared for planting annual crops.

The turnover in the colonist population accelerates the expansion of cleared areas, as virgin forest felling is greater among newcomer colonists in the first four years after arrival than among original lot owners (Fig. 5). The amounts cleared are highly variable among colonists,

and for different years for the same colonist. When a newcomer colonist buys a lot, he often spends a year or two clearing second growth left by the previous lot owner before the increased level of clearing activity is reflected in virgin forest felling (Fig. 6). Even after the backlog of second growth has been reduced or eliminated, colonists often continue to fell in pulses, clearing a large amount one year followed by a year without clearing. Averaging felling over a four-year period, these irregularities tend to disappear (Fig. 6).

The pattern of felling in a lot during the tenancy of any given owner shows a linear increase for about six years, followed by a plateau when felling levels off (Fig. 7). The trend in cumulative felling by original lot owners up to the tenth year of occupation, shown in Figure 7 (n=18 lots), is identical to the trend for a larger sample size to nine years of occupancy (n=30 lots).

Simulated Land Clearing

Simulated land clearing from the KPROG2 carrying capacity estimation program is shown in Figure 8. The clearing probabilities from Figure 2 have been used as input parameters.

DISCUSSION

Observed Felling Patterns

Transamazon Highway

The observed colonist clearing choices (Fig. 2) indicate very high probabilities for clearing weeds or young second growth. This leads to the conclusion that the colonists are not following the pattern of traditional shifting agriculturalists in allowing land to lie fallow for sufficient time to permit regeneration of its former productive potential by regenerating soil fertility, restoring soil structure to the uncompacted state characterizing forest soils, and reducing losses from weeds, pests and plant diseases. The areas converted to perennial crops, such as cacao (Theobroma cacao) and black pepper (Piper nigrum), do not account for more than a tiny fraction of the areas cleared, the bulk of the land being planted in either annual crops (mostly upland rice) or Guinea grass (Panicum maximum) pasture. Annual crops cannot be expected to produce on a sustainable basis without either adequate fallows or the supply of a wide array of the nutritional needs of the plants through fertilization (Sánchez 1977; Sánchez et al. 1982), which is currently not economic (Fearnside 1984b). The most common result is for an ever larger portion of the land to be converted to cattle pasture as time progresses.

It should be noted that it is the height rather than the age of a stand of second growth which serves as the trigger for clearing by traditional farmers in most of Amazonia. The rate of growth of secondary vegetation is probably related to various soil properties which deteriorate with repeated or prolonged cultivation. In the colonization area of the Transamazon Highway, the regrowth is still quite rapid, stands of Cecropia reaching approximately 3 m in height after one year, 5-7 m after two years, and 9-12 m after three years. The agricultural activities in the

Transamazon Highway study area were too recent at the time of data collection for the computation of the clearing probabilities for stands of second growth to be available in the older categories.

The observed virgin forest clearing rates (Table 1) are higher in the years 1972 and 1973 than in other years. There are several possible reasons for this. The availability of financing is a key factor. In contrast to later years, during this period there was more promotion of financed clearing by the government agricultural extension agency, and fewer of the colonists had been disqualified from receiving further financing by failure to repay past loans. The terms of virgin clearing loans were also more favorable than in later years: beginning in 1974 the granting of loans with grace periods of three years, terms of eight years, and interest rates of 7%/year was discontinued and replaced by a program of loans with no grace periods, terms of one year, and interest rates of 10 %/year. Also, prior to 1974 the financing system encouraged the clearing of virgin forest instead of second growth, since second growth clearing loans had no grace period and one year terms. In the first years little re-use of second growth could be expected since the newness of the area meant that not as much was available.

The variability in clearing rates within any given year is quite high, as can be seen from the standard deviations in Table 1. At the average clearing rate for the 1971-1975 period of 3.49 ha/year/lot, the average 100 ha lot would pass the 50% maximum allowable clearing after 14 years, and would be 100% cleared 29 years after settlement. However, due to the high variance among colonists, a number of lots were over the 50% limit nine felling seasons after the beginning of colonization, and a few lots in the Altamira colonization area were completely cleared in that time. The differences among colonists in felling rates are mainly due to differences in capital resources, a part of which comes from financing, but a substantial part of which also comes from the colonists' initial wealth, especially in the case of more recent arrivals in the area.

The turnover in colonist population could be expected to result in increased felling rates as the original government- sponsored colonists are replaced by newcomers. The backgrounds of the newcomers differ significantly from those of the original colonists (Fearnside 1980a). The newcomers are more likely than original colonists to adopt ranching as a lot-development strategy, as well as having more capital to apply to realizing these schemes. Ranching is an activity which can easily occupy areas far greater than the 100 ha lots in the colonization area, thus leading to deforestation at the maximum rate that resources permit. It should be noted that for colonists generally, the areas cleared and planted are limited by the labor and capital restraints on the colonist, rather than by the satisfaction of subsistence requirements which often limits agricultural efforts among more traditional agriculturalists (Nietschmann 1971).

One factor which could potentially act to slow felling rates is the requirement of the Brazilian Institute for Forestry Development (IBDF), beginning in the 1979-1980 agricultural year, that a license be obtained certifying that the 50% clearing maximum had not been exceeded as a prerequisite for eligibility for bank financing. No increase was made in the area's small

IBDF staff; it remains to be seen whether the requirement will be enforced and felling rates affected.

In interpreting the felling observed on the Transamazon Highway (Table 1 and Fig. 3), it should be remembered that the location in question has many significant differences from other areas undergoing deforestation in the Brazilian Amazon. In this area of planned colonization, the number of colonists is roughly constant, whereas in the more widespread unplanned colonization areas elsewhere the influx of squatters is a major driving force for increased clearing on an area-wide basis, even if each individual clears a relatively small area each year. The Transamazon area also has lots of a uniform size, which is not the situation in spontaneous settlement areas or in areas of large corporate ranching operations. The regulated land tenure situation in the colonization area is also atypical of Amazonia as a whole. The colonists with properly surveyed and documented lots are free of the pressure to clear as quickly as possible as a means of establishing claim to the land (Fearnside 1979a), although some clearing is necessary to establish rights to a definitive title. The small farmers of the Transamazon Highway also have access to credit; most small farmers in other parts of Amazonia do not have this addition to their clearing capability since bank policies prevent loans being made to squatters.

Rondônia

In the Ouro Preto Colonization Project in Rondônia, clearing patterns show many similarities to those along the Transamazon Highway. Cattle pasture occupies most of the cleared areas in Ouro Preto: 39.5% of the deforested area in 105 lots surveyed in 1980 by Furley & Leite (1985) and 49% of the deforested area in 100 lots surveyed in 1980 by Léna (1982). Second growth is usually cut at a young age, most often to be replaced with pasture rather than allowing regeneration for future cycles of annual crops. Especially among the many recent arrivals to the Amazon region, part of the reason for elimination of second growth is the social stigma attached to being considered a quisaceiro (producer of second growth), with the implication of laziness. Lands left fallow long enough to form more advanced stands of second growth are likely to be in small patches where some special circumstance precludes clearing, such as the risk of accidental burning of adjacent cacao plantations.

Perennial crops are in large part planted in areas felled from virgin forest rather than second growth (Fig. 4) due to the policies of government agencies such as CEPLAC (Executive Commission for Cacao Production Plan) that require planting in virgin land as a precondition for approving bank financing. Often the higher per area labor demands of perennial crops (Fearnside 1980a) slow subsequent clearing.

The overall trend of increase in cleared area appears similar in the two colonization projects (Figs. 3 and 4). The approximately linear increase in the first years of colonization in Altamira (Fig. 3) is roughly comparable to the more controlled sample of a fixed cohort of original lot owners in Rondônia (Fig. 4), since for these early years most of the lots were still occupied by the original settlers, and most (but not all) of the data are complete for the time period.

The faster than linear growth in cleared areas observed in larger geographical areas in Rondônia (Fearnside 1982) is due to such effects as the acceleration in clearing from lot turnover (Fig. 5), the increased felling rate of colonists when road access to a lot is initiated or improved, and the continued heavy flow of new immigrants to Rondônia from other parts of Brazil, especially the State of Paraná. As on the Transamazon Highway, part of the explanation for the increased rates of felling by newcomers purchasing lots lies in the significantly greater financial resources they bring to the area, as compared to the original settlers (Fearnside 1980a).

Simulated Clearing

Simulated colonists clear their land at rates faster than the mean felling rates in the Transamazon Highway intensive study area (Fig. 8). This is partly due to overly optimistic assumption of a lack of limitations from fixed costs for virgin felling using family labor (Fearnside 1980a). More importantly, perhaps, is the optimistic assumption in the simulation that money received from the Bank of Brazil as financing is actually spent on hiring labor for clearing, rather than a substantial portion of the money leaking away to consumption as is often the case with real colonists. This discrepancy becomes more remarkable when it is noted that the level of financing for clearing at the time for which the monetary figures apply (1 January 1975) was about double the amount needed to clear the areas required by loan terms (if only labor expenses are considered). For a clearing of the standard loan size of 6 ha, the Cr$ 1037/ha received would pay for the labor to clear 12.32 ha at the prevailing rates for hired labor (Cr$15/man-day for 13.8 man-days/ha in July and October, and Cr$20/man-day for 14.9 man-days/ha in August and September). The areas which can be cleared are further increased if the hired labor is not used for the entire clearing operation, but rather as a supplement to family labor during the months of peak labor demand. The amount of time simulated colonists are able to contribute to the clearing effort when they are managing hired labor is probably optimistic as well. For all of these reasons, the simulated colonists have a greater capacity to clear large areas than does the average real colonist on the Transamazon Highway. This greater capability should result in upwardly biased estimates for the carrying capacity of the area.

Clearing Behavior and Carrying Capacity

The fact that weeds and very young second growth are commonly cleared by colonists means that soil properties will not regenerate sufficiently during the fallow periods to permit annual crops to be grown on a sustainable basis. The degradation resulting from inadequate fallow periods can be expected to decrease carrying capacity for an area where many colonists depend on annual crops as the mainstay for supplying both subsistence and cash.

Rapid clearing is closely tied to the expansion of cattle pasture on the Transamazon Highway as elsewhere in the Amazon. This effect works both ways: rapid clearing encourages planting pasture, as this can be done at little cost and occupies areas which would otherwise have to be allowed to revert to second growth, a use which is seen as unproductive by the colonists; pasture also encourages the rapid clearing since extensive areas are required for ranching

activities (Fearnside 1983b). Pasture is linked to a low human carrying capacity, due to the low labor requirement for this activity, the low rate of return per unit area, and the doubtful economic sustainability of ranching in the area in the face of second growth invasion and soil phosphorus depletion (Fearnside 1979d, 1980b).

Clearing can also be made a part of the set of criteria defining carrying capacity. Exceeding a maximum acceptable clearing limit, such as the 50% limit specified by Brazilian law, can be regarded as one of the indicators of colonist failure, along with other standards such as minimum criteria for nutrition and cash standard of living. Rainforest clearing can be expected to continue until all available land is exhausted as a consequence of: (a) non-sustainable use patterns of the cleared areas, (b) conversion to pasture, which can be planted in large areas with little effort, creating continual demand for more clearing for both subsistence and cash crops, including more pasture, and (c) the limitation of areas cleared solely by the colonist's labor and capital resources (including financing), rather than by some mechanism subject to either internal or external control. The inevitable result of these factors is the eventual exceeding of whatever acceptable clearing limit is specified. The clearing criterion for carrying capacity makes evident the impossibility of satisfying infinite demands with finite resources.

CONCLUSIONS

(1) Individual colonists fell rapidly at first, but reach a plateau after about six years.

(2) Yearly clearing is highly irregular: colonists fell in spurts.

(3) Colonist turnover speeds pace of clearing (partly due to greater financial resources of newcomers).

(4) Much young second growth is cleared for annual crops (not a sustainable practice).

(5) Harvested fields and young second growth are planted to pasture, preventing regeneration and causing continued felling for arable farming. (Also note: pasture not sustainable).

(6) Perennials are usually planted in felled virgin forest (largely due to financing restrictions). High labor demands of perennials slow subsequent clearing.

(7) Human carrying capacity is linked to clearing behavior by low sustainability of agro-ecosystems implanted and by inclusion of environmental criteria among those defining failure and carrying capacity.

(8) It should be noted that, while deforestation in government-directed small farmer settlement projects is significant, most of the clearing in the Brazilian Amazon as a whole is done by ranchers, squatters, and speculators.

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FIGURE LEGENDS

Figure 1 -- Map of Brazil's Legal Amazon, showing study areas on the Transamazon Highway in Pará and the BR-364 Highway in Rondônia.

Figure 2 -- Clearing probabilities on the Transamazon Highway. Land category times are age of regrowth.

Figure 3 -- Observed cumulative felling on the Transamazon Highway.

Figure 4 -- Effect of intended land use on clearing choices in Rondônia.

Figure 5 -- Effect of colonist turnover on felling rates in Rondônia.

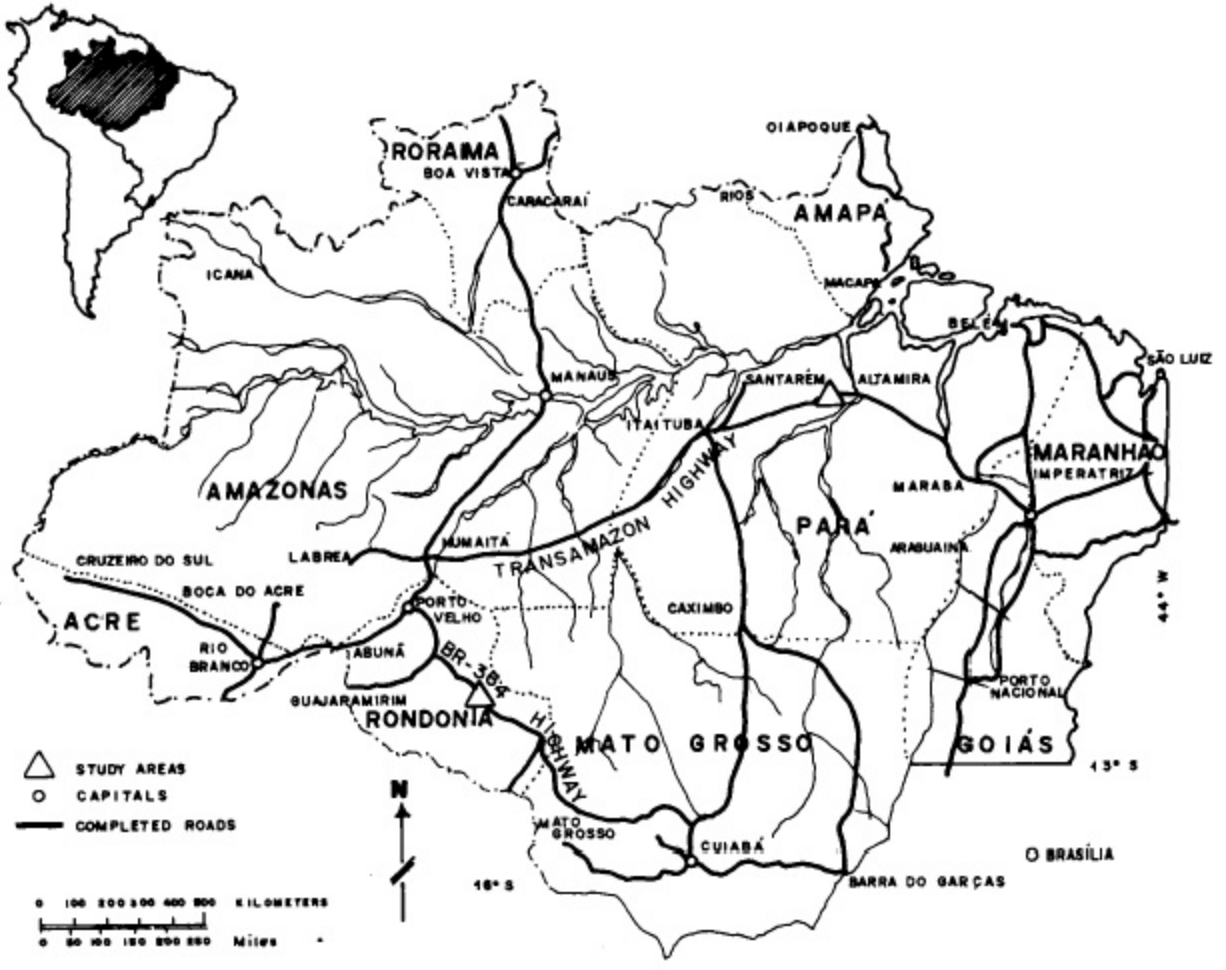
Figure 6 -- Frequency distribution of areas felled by newcomer colonists in Rondônia.

Figure 7 -- Observed felling in Rondônia in a cohort of lots occupied by their original owners.

Figure 8 -- Simulated felling on the Transamazon Highway.

Table 1: RAINFOREST CLEARING RATES IN COLONIST LOTS ON THE TRANSAMAZON HIGHWAY

Year of felling	Mean area cleared/lot during year (ha)	SD (ha)	n (lots)
1971	2.29	4.25	122
1972	4.29	4.43	120
1973	5.44	4.50	122
1974	2.77	4.40	124
1975	3.23	3.22	34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BOA VISTA
CARACARAI
OIAPOQUE
RIOS
AMAPA
MACAPA
BELEM
SÃO LUIZ
ICANA
MANAUS
SANTAREM
ALTAMIRA
ITAITUBA
MARANHÃO
IMPERATRIZ
AMAZONAS
MARABA
PARÁ
TRANSAMAZON HIGHWAY
ARAGUAINA
CRUZEIRO DO SUL
LABREA
HUMAITÁ
BOCA DO ACRE
PORTO VELHO
CAXIMBO
ACRE
RIO BRANCO
ABUNÃ
BR-364 HIGHWAY
PORTO NACIONAL
GUAJARAMIRIM
RONDONIA
MATO GROSSO
GOIÁS
STUDY AREAS
CAPITALS
COMPLETED ROADS
N
MATO GROSSO
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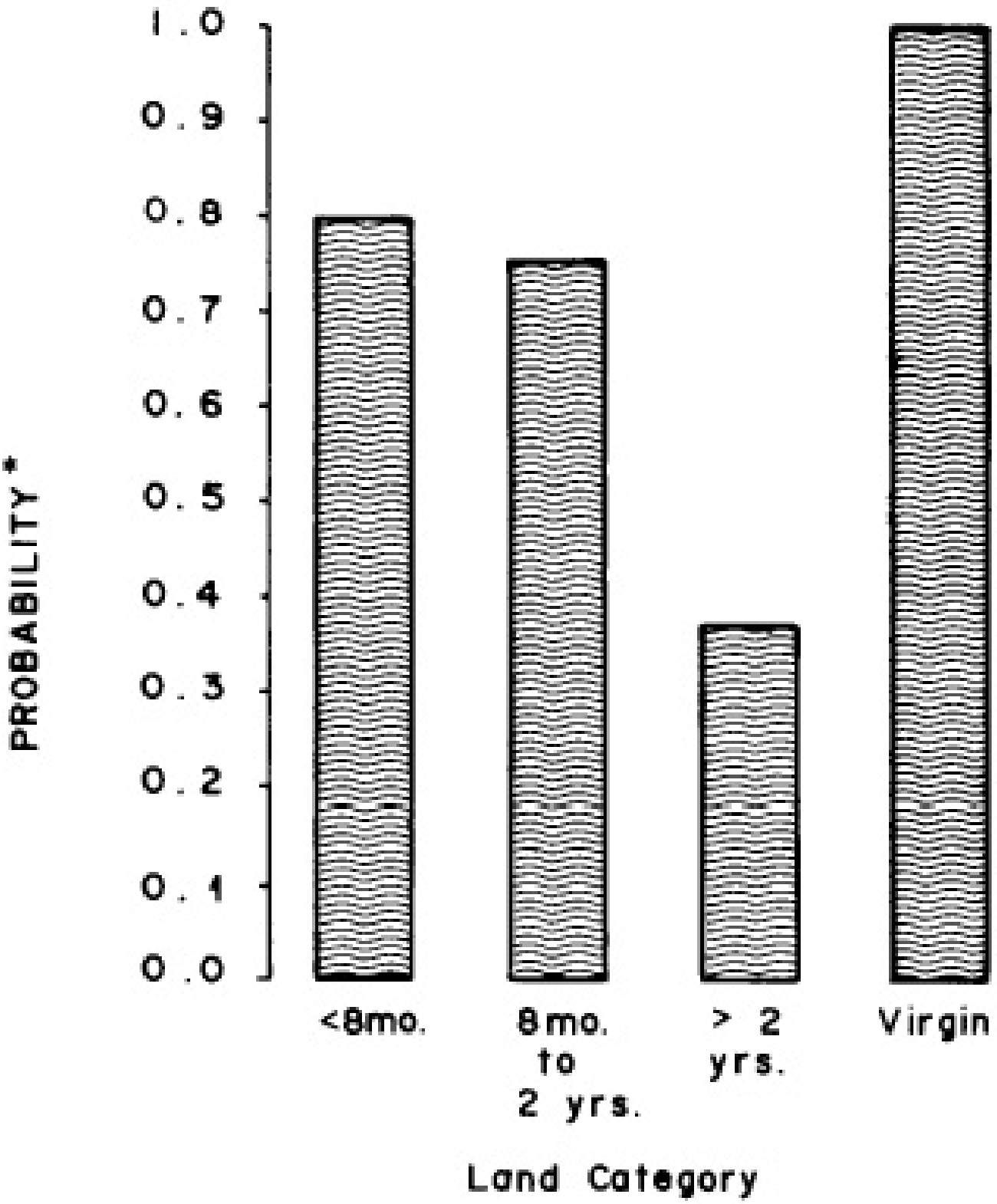
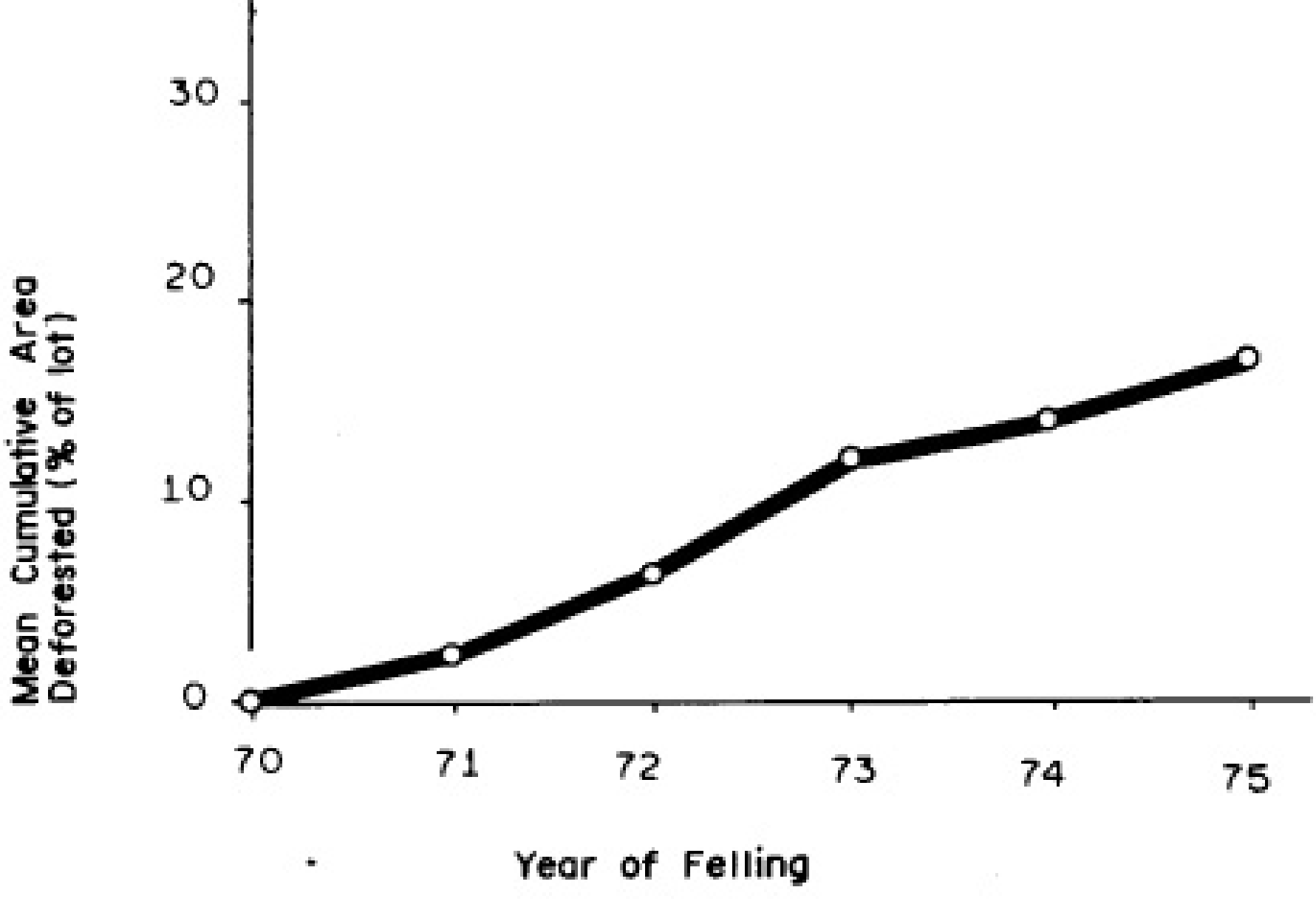
BRASÍLIA
BARRA DO GARÇAS
0 100 200 300 400 500 KILOMETERS
0 50 100 150 200 250 Miles
44° W
13° S
16° S

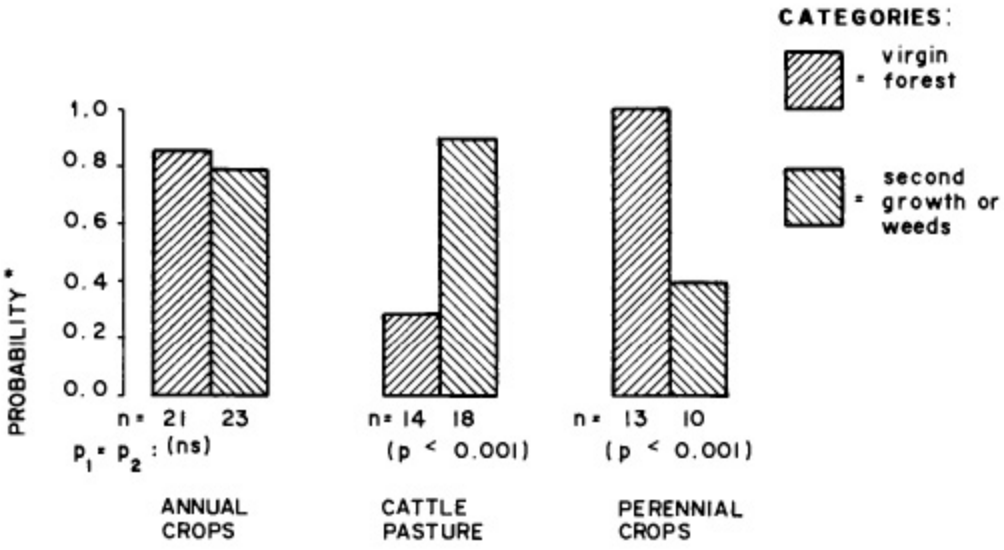
ANNUAL CLEARING PROBABILITIES BY LAND CATEGORY
Transamazon Highway, Pará.



* Probability of clearing some land of the category for uses other than pasture, given that land of the category is available, as well as virgin forest.

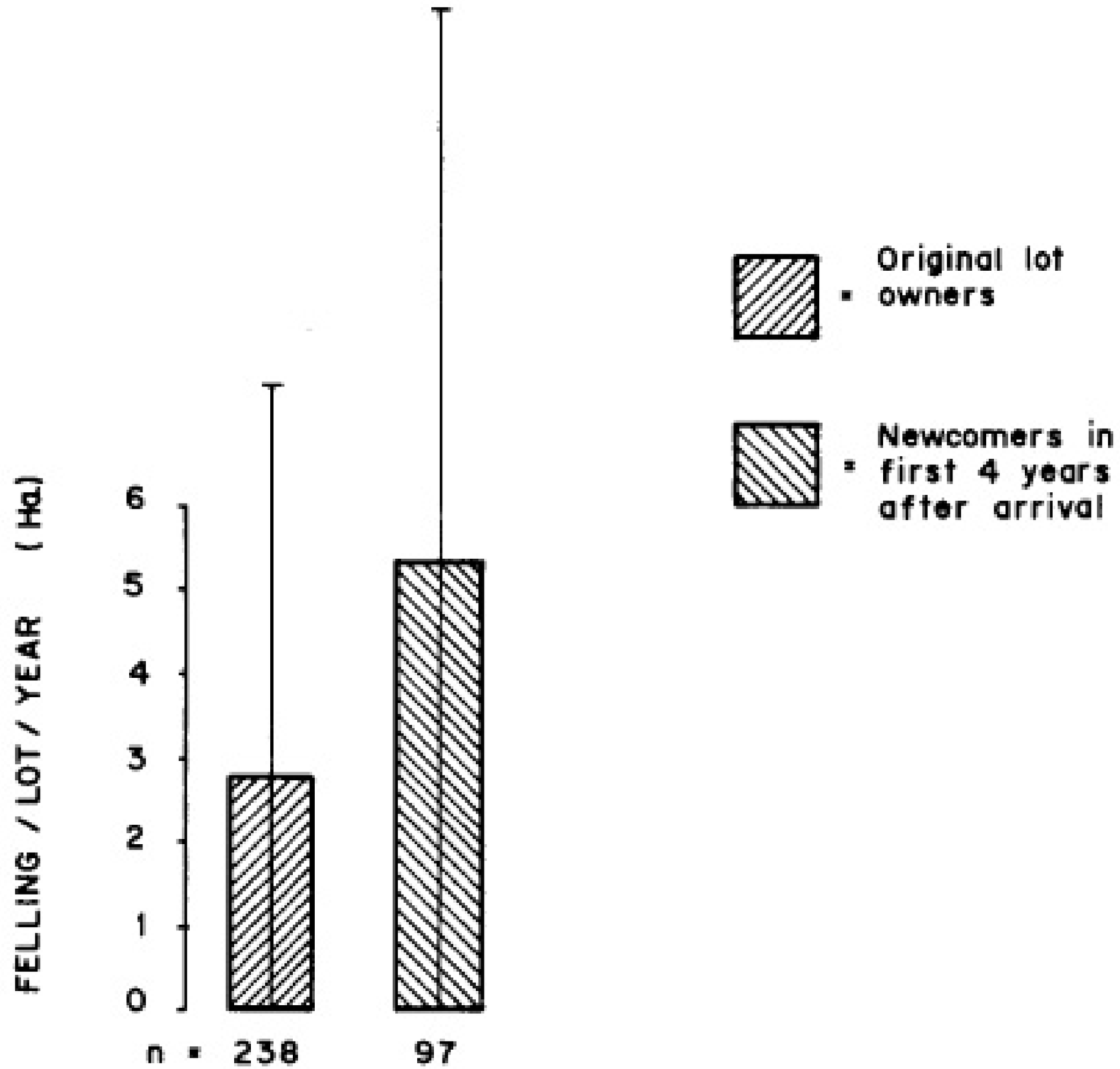

Mean Cumulative Area
Deforested (% of lot)
30
20
10
0
70
71
72
73
74
75
Year of Felling

EFFECT OF INTENDED LAND USE
ON CLEARING CHOICES (Ouro Preto, Rondônia)

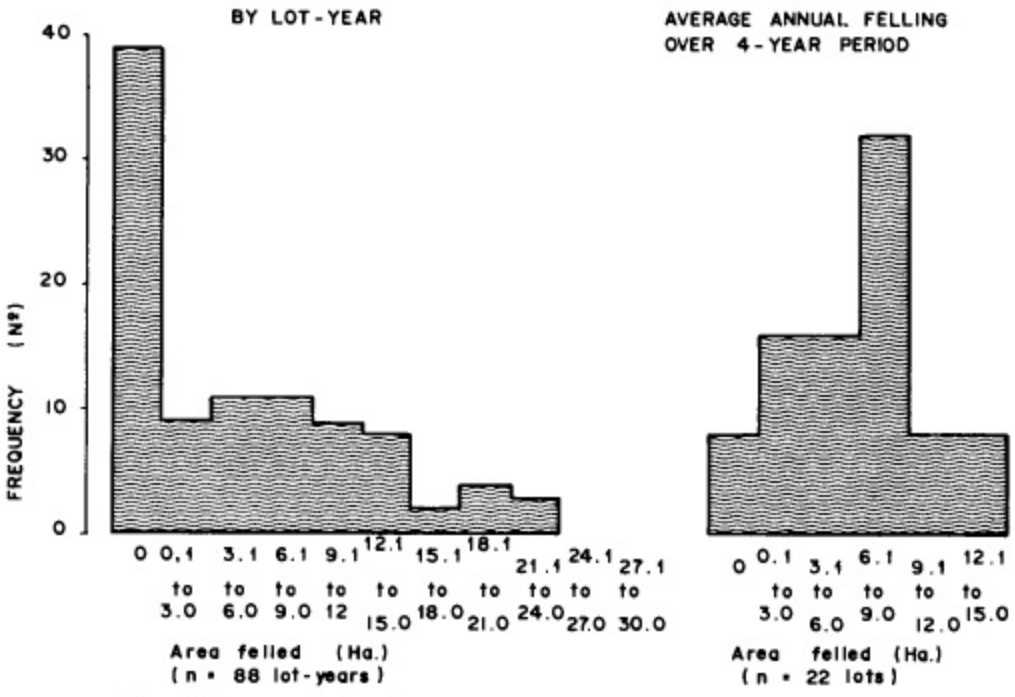


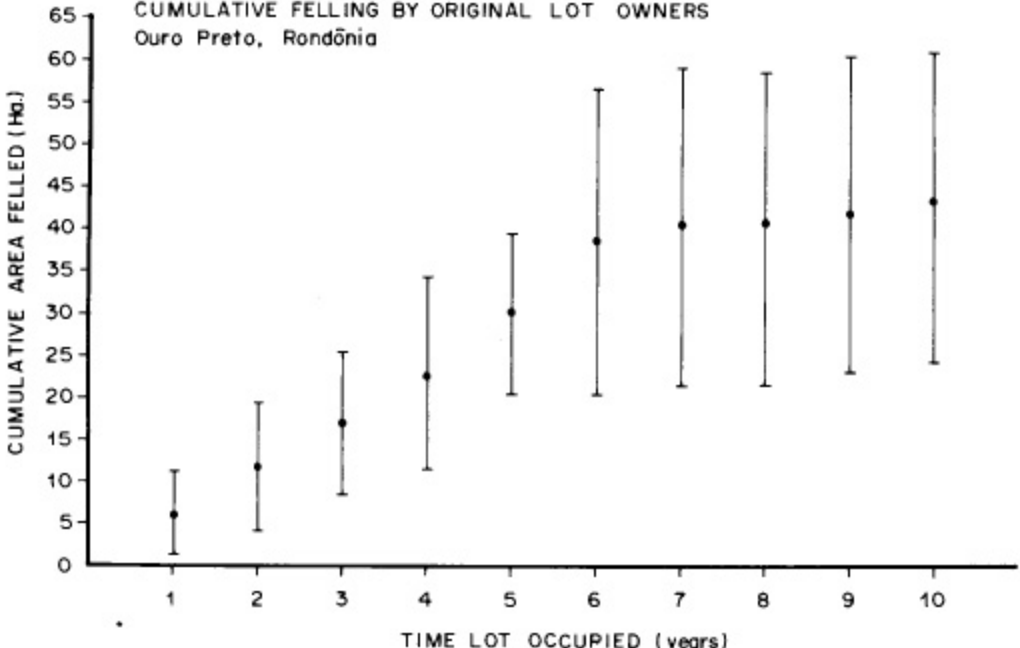
* probability of clearing some land of the category for the specified purpose given that land of the category is available, that the colonist allocates some of his lot to the specified land use in the year in question, and that land of the other category is available for clearing.

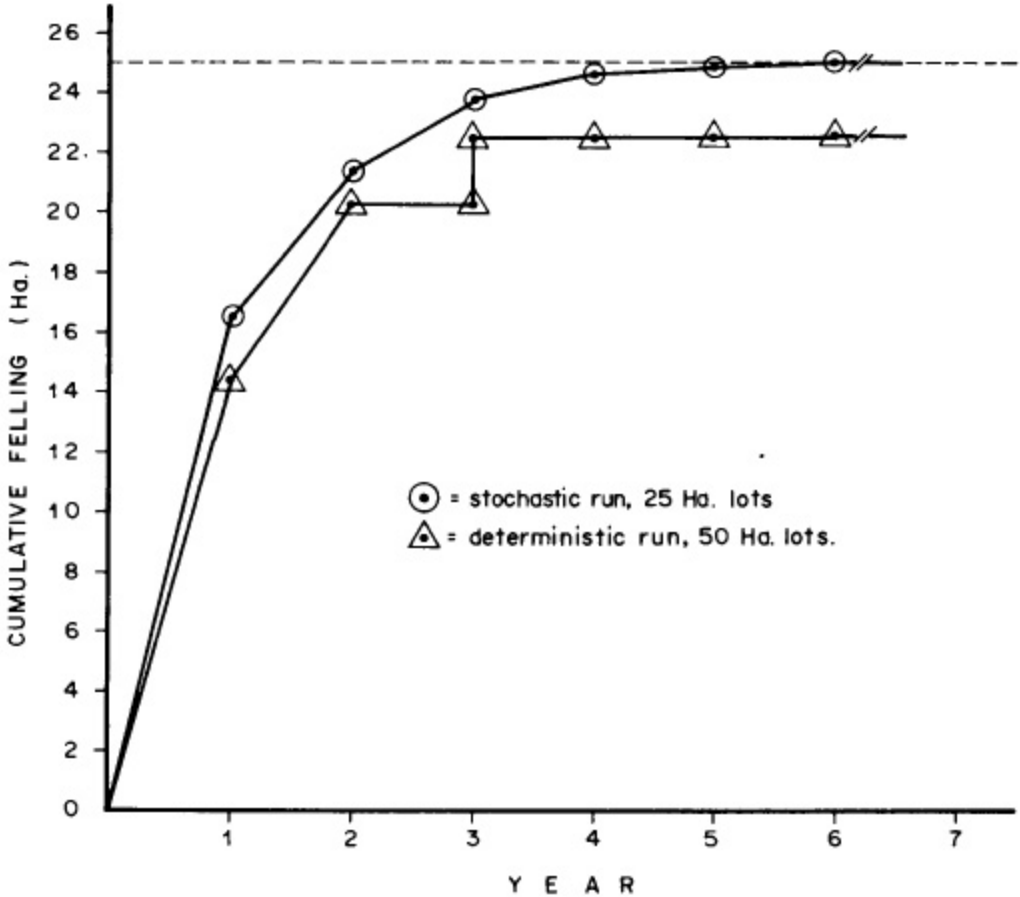
EFFECT OF COLONIST TURNOVER ON FELLING RATE
OURO PRETO – RONDÔNIA
1978 - 1981



YEARLY FELLING BY NEWCOMERS IN FIRST 4 YEARS AFTER LOT PURCHASE
OURO PRETO — RONDÔNIA




CUMULATIVE FELLING BY ORIGINAL LOT OWNERS
Ouro Preto, Rondônia
CUMULATIVE AREA FELLED (Ha.)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
1
2
3
4
5
6
7
8
9
10
TIME LOT OCCUPIED (years)


CUMULATIVE FELLING (Ha.)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
Y E A R
= stochastic run, 25 Ha. lots
= deterministic run, 50 Ha. lots.