Reprinted from HUMAN ORGANIZATION, Volume 36, Number 3, Fall, 1977.

Partible Inheritance and Land Fragmentation in a Oaxaca Village

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LAND FRAGMENTATION is accused of being an obstacle to agricultural development. It is claimed that fragmentation wastes the farmer's time, energy, and resources; reduces yields; sacrifices scarce land to defining boundaries between fields; hampers the introduction of mechanized farming; and encourages rural to urban migration by making it impossible for him to stay on the farm. In a comprehensive discussion of land fragmentation and its legislative "remedy," consolidation, Binns (1950) suggests that excessive fragmentation will occur in regions with: (1) long established agriculture; (2) limited land; (3) increasing population density; (4) strong microecological variations; (5) little nonagricultural employment; and (6) where land is the principle object of investment. Moreover, Binns and others (Wolf 1966:76-77; Jacoby 1953:22, Leibenstein 1963:41) claim that land fragmentation is a consequence of a pattern of partible inheritance which stresses the equal division of land to coheirs.

Binns contends:

> The attempt at equal distribution leads not only to the reduction of the area of individual farms but also to division into long narrow strips or small irregular plots and to actual fragmentation. Once the process of fragmentation has begun, it is accelerated with each succeeding generation in geometrical progression, so that in a very few generations a quite remarkable number of parcels may be formed (1950:14).

I wish to make a simple, yet important, modification to the assumption that partible inheritance leads to field fragmentation. Field fragmentation is not an either-or matter; rather, it takes place in degrees. Represented mathematically, the magnitude of fragmentation will be shown to depend on the ratio of fragmented to nonfragmented fields transferred from testators to heirs. Using evidence from a community in southeastern Mexico, I will show what factors influence the propensity of a field to be divided into two or more parts when it is being transferred to coheirs. The factors considered are population changes, the ecological characteristics of the field, and other characteristics of the inherited estate. Then, I will consider the implications of this research for the formulation of policies designed to retard fragmentation.

The Degree of Fragmentation

A claim that "partible inheritance leads to the fragmentation of land" lacks precision as a descriptive statement. It may be given at least three different interpretations:

1. Inheritance is fragmenting estates, thereby reducing the total capital of estates through time.

2. Inheritance is fragmenting the fields of an estate by scattering them throughout the countryside.

3. Inheritance is fragmenting fields by parcelling them into smaller and smaller parts.

It is useful to distinguish these as different processes: estate diminution, field dispersal, and land fragmentation, respectively. My discussion in this paper will focus on land fragmentation; estate diminution and field dispersal have been discussed elsewhere (Downing 1973).

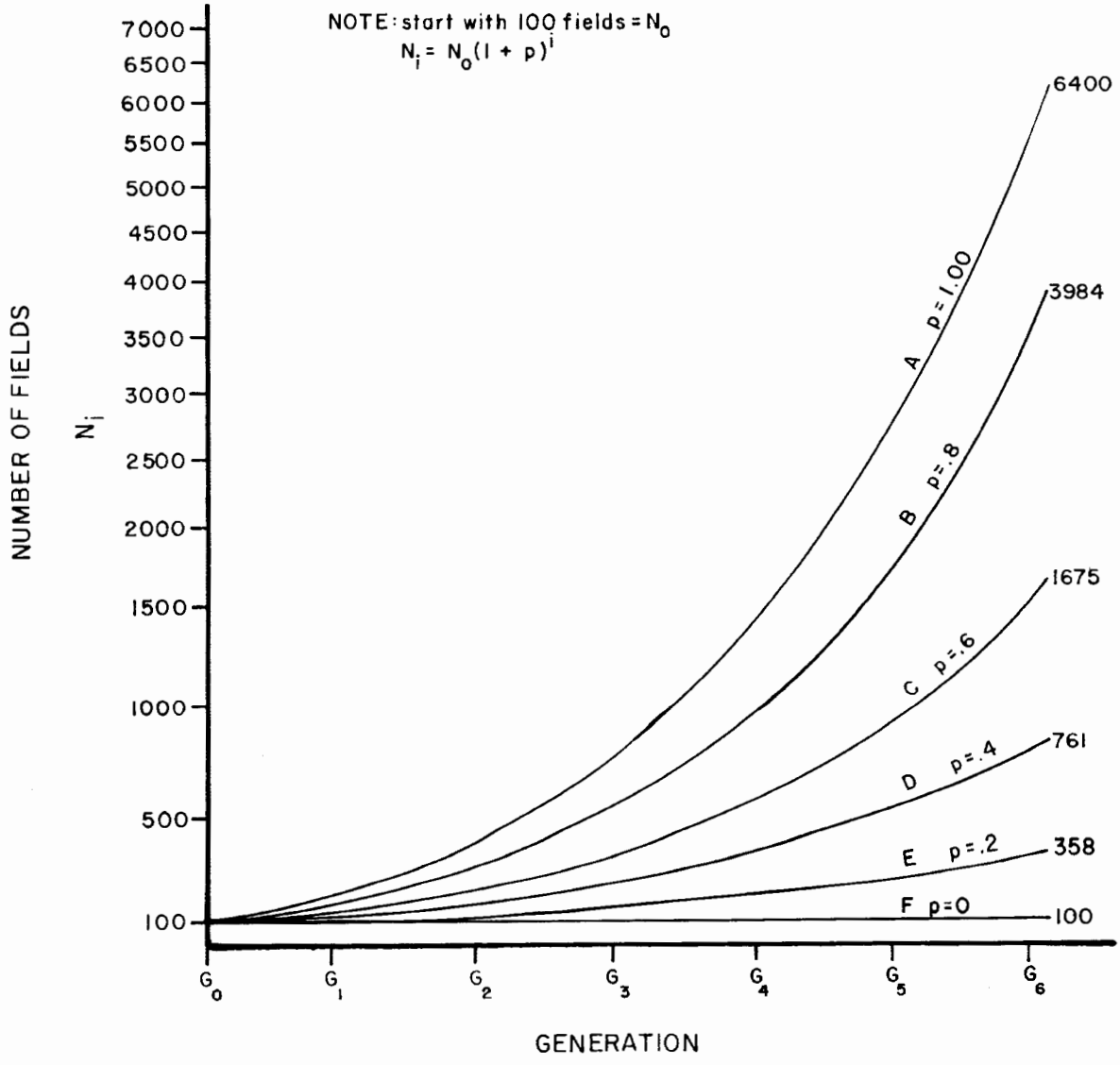
Binn's assertion that land fragmentation resembles a geometric progression may be formalized to show its underlying mathematical model. Assuming an initial number of infinitely devisable fields (N_0) are divided in half with a probability (p) at successive inheritance transfers 1, 2, 3, . . . i, then the number of fields (n) that would result after i transfers may be estimated by the function:

$$N_i = N_0(1 + p)^i$$

This function generates a family of curves called "geometrical progressions."

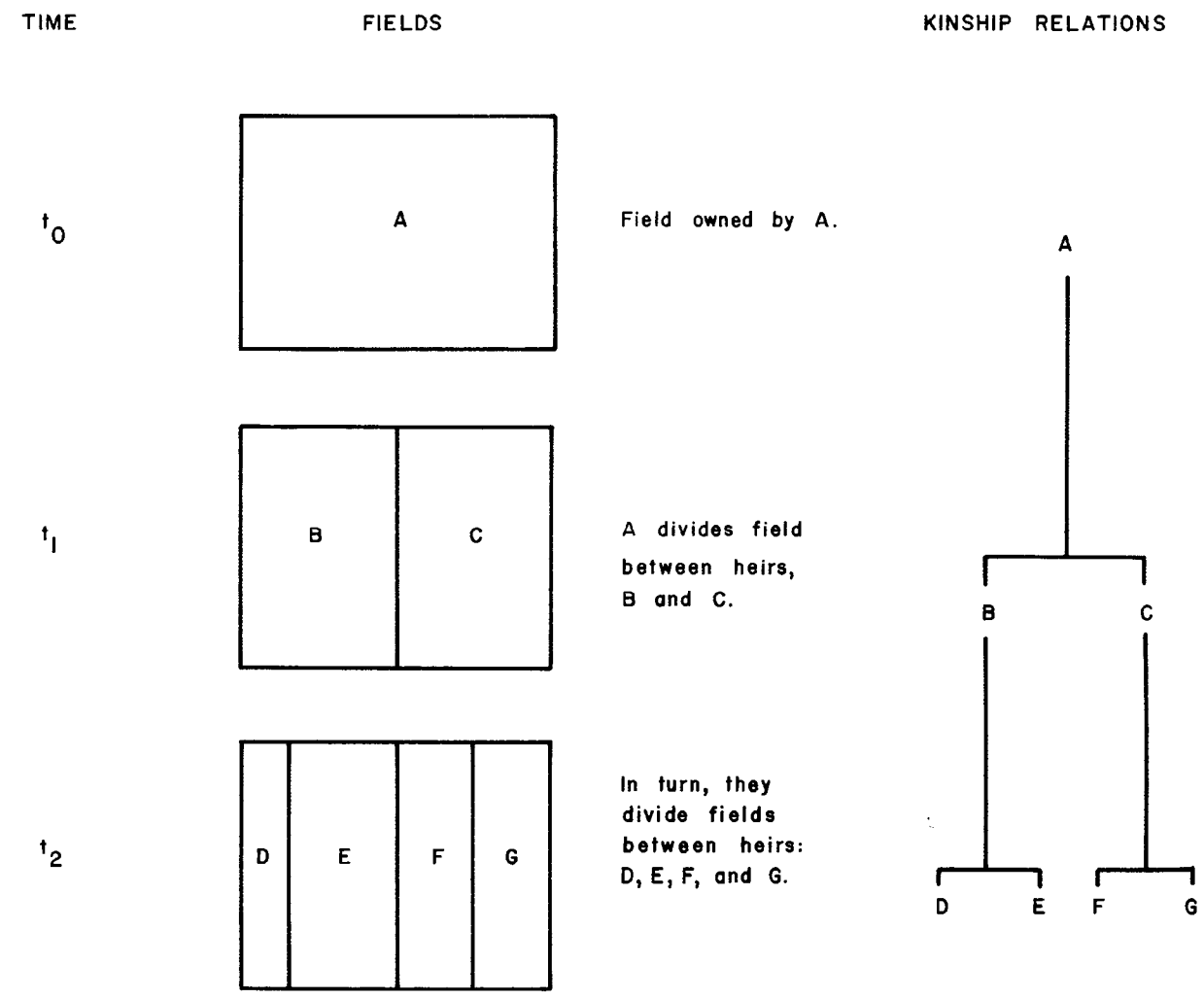
The trajectory of each curve depends on the value assigned to p, the probability that a field will be divided when it is inherited (Figure 1). The extreme possibilities may be illustrated by comparing an idealized genealogy and land map to its mathematical function. At one extreme, each field is divided into two parts each time it is transferred (Figure 2). This situation is represented by

FIGURE 1. MODEL OF LAND FRAGMENTATION*



*Number of fields (N_i) after six inheritance transfers of land, assuming that each field is divided in two parts when transferred to heirs (curve A) or when different proportions of the fields are passed *intact* (curves B through F).

FIGURE 2. ILLUSTRATION OF FIELD FRAGMENTATION



curve A, called a "binary sequence." In a hypothetical case where a community with 100 fields practiced a binary division of all fields, field fragmentation would result in a rapid increase in the total number of fields. Sixty-four hundred fields would result from the original 100 after 6 inheritance transfers. The opposite extreme, where all fields are passed *intact* and not fragmented, would result in the same number of fields as in the initial generation (curve F). This binary function is offered as an ideal type. Real land fragmentation situations should fall somewhere between these two extremes. Some land is fragmented, some land is passed intact. Allowance for intact transfers substitutes a lower value for p into the geometric progression than the binary sequence. Likewise, allowance for the possibility that fields are fragmented into more than two parts increases the expected number of fields. Since the effects of land fragmentation are cumulative, any increase in the proportion of fields passed intact greatly reduces the number of fields (N_i) resulting from land fragmentation.

Regional Conditions of Oaxaca

Located in the rugged mountains of southeastern Mexico, the Oaxaca Valley has most of the regional preconditions favoring excessive fragmentation. Its physiography and cultural history give it the distinction of being an area of long established agriculture in Mesoamerican history (Palerm and Wolf 1957). Archaeologists have discovered that the valley has been under continuous cultivation for at least 3,000 years (Winter 1972; Flannery, et al. 1967). Although the conquest brought significant introductions into agricultural technology (oxen and plow) and, to a lesser extent, new crops (wheat and chickpeas), this early synthesis of Spanish and Indian agriculture technology has changed very little since the 16th century.

The valley has been subjected to considerable changes in population following devastating declines after the Conquest. Since the Mexican Revolution and the introduction of modern medicine, the population of the Valley has risen sharply. The rural population density of the Valley is high (327 persons/km^2 in 1970) compared with the rest of the state of Oaxaca (less than 21 persons/km^2 in 1970) and increasing (c.f. rural population of the valley, 283 persons/km^2 in 1960).

Its 700 square kilometers are cultivated by almost every agriculture technique known to peasant Mexico, including swidden, dry farming, canal, flood irrigation, and well irrigation (Lees 1973). Over 250 nucleated villages dot the valley, with populations ranging from a few hundred to 5,000 people. Each village claims territorial rights to a distinct part of the valley floor, with most limiting land ownership to village members. Land is the principle object of investment as well as the focus of community and individual identification.

This attachment to land is intensified by the limited opportunities for nonagricultural employment within the valley. Although some villagers specialize in craft production and many others migrate as unskilled laborers to Mexico City, neither factor appears to have reduced the competition for agricultural land. Land is not a freely transacted commodity and almost 90% of all land holders received their property through inheritance. A further indication of this sustained pressure on the land is witnessed in the fact that almost 25% of the households in one village were landless (Downing 1976). When these regional conditions are linked with the facts that partible inheritance is the most common form of intergenerational land transfer and that the peasant's fields appear small and scattered, the region would appear to support Binn's thesis that land fragmentation is accelerating with each succeeding generation.

Diaz Ordaz

In 1972, I attempted to measure the rate of field fragmentation occurring in one of the larger villages in Oaxaca. Diaz Ordaz, also known as Santo Domingo del Valle, is a Zapotec and Spanish-speaking community in the Tlacolula market area of the Valley. The village has approximately 3,000 people inhabiting slightly over 500 households. Each household is a production-consumption unit, with two-thirds of these being almost completely dependent upon agriculture for their livelihood. Castor beans, and various assorted beans and squash are often intercropped with maize, while maguey is planted in the less productive lands.

Over half the community's 50 square kilometers of land is rocky, mountainous, and unproductive, only occasionally cultivated in swidden plots of beans, maguey, or sporadically used for grazing. This marginal land is owned communally and is not part of a household's private estate; it might be considered the common inheritance of all community members and will be excluded from this discussion. In contrast, the remaining half of the community's lands are located within the fertile valley floor. These lands are privately owned and heritable. Approximately a third of these privately owned fields are irrigated, forming the "breadbasket" of the community and yielding two crops per year (Downing 1974). All heritable fields show considerable microecological variation, responding to variations in microclimate. Several elaborate folk taxonomies reflect this variation and are based upon contrasts in location, slope rockiness, soil types, access to various kinds of water, and fertilization. These taxonomies mark measurable differences in productive potential.

Like many peasants in Mexico, the Diaz Ordaz villagers transfer their property from generation to generation by means of partible inheritance, meaning that all heirs, regardless of sex, receive shares of the estate.[1] The villagers define an estate as all the lands owned by a married couple, a definition that will be adopted for the following analysis. Most of the land in an estate represents a pooling of a wife and husband's own separate inheritances from their parents. Infrequently, a couple may increase or decrease their estate by purchasing or selling land. Normatively and actually, heirs are the children of a couple. Once parents have divided their inheritance among their heirs, the parent's estate ceases to exist and they become dependents of their heirs. The decision to fragment or keep a field intact in an inheritance transfer is made jointly by the parents, a practice strengthened by a principle which Selby (1966) has called the "supremacy of parental authority." Selby also notes, as I did, a principle of "equal apportionment of an estate," meaning that villages invariably state that heirs should receive equal shares of an estate.

FRAGMENTATION IN DIAZ ORDAZ. A measurement of the magnitude of field fragmentation was made from an opportunistic sample of 29 estates, totaling 151 former fields, now all privately owned and in the hands of heirs. Some of these fields were intact, others fragmented. In all, 59% of the former fields were inherited intact, while the remainder (41%) were fragmented (Table 1). Furthermore, these proportions seem to have remained relatively constant over five decades.[2] This means that the actual rate of field fragmentation is two and one-half times *less* than what would be expected from an idealized binary sequence. An adequate description of fragmentation in this village

TABLE 1. FIELDS PASSED TO NEXT GENERATION INTACT AND FRAGMENTED

		Intact		Fragmented	
		N	%	N	%
Year of Transfer	1925-54	50	(.60)	33	(.40)
	1955-70	39	(.57)	29	(.43)
		89	(.59)	62	(.41)

would state that fields were fragmenting at a geometrical rate of approximately .4. Remembering that the idealized binary sequence is a conservative estimate, based on an assumption that a field is divided into only two parts, results demonstrate that Diaz Ordaz land is being divided into smaller and smaller parcels, but at a less dramatic, slower rate than would occur under the extreme case of a binary sequence (compare Figure 1 curves A and D).

Notice that the change in Binn's assertion is one of degree, not kind. A probability statement is being substituted for an assertion that fields are or are not being fragmented.

CONSOLIDATION FACTORS. Some investigators seem to have realized that the rates of fragmentation are lower than implied by a binary sequence of a geometric progression model. Since the cumulative effects of intact vs. fragmented divisions were not considered, mechanisms of consolidation were singled out as responsible for the lower rates. Consolidation mechanisms are practices of the villagers which reunite fields, such as would happen if a man sold a field to the owner of a neighboring field. Allowance for consolidation mechanisms requires a revision of the fragmentation formula to correct for those fields that were recombined (N_c).

$$N_i = N_o (1 + p)^i - N_c$$

Consolidation proves a negligible factor in Diaz Ordaz field fragmentation. Villagers buy and sell fields, but infrequently. In a survey of another 129 estates, 11% had sold a parcel of land and only a handful of these were contiguous to a buyer's field. Another possible consolidation mechanism, the swapping of previously fragmented fields between heirs, occurs even less frequently than purchase. Only four cases could be recalled. Joint tendency also can delay the fragmentation of fields, occurring when fields are passed to several heirs who farm them together. Among Zapotecs, joint tenure contradicts one of the important principles of their social organization: that couples should achieve economic independence shortly after marriage and be minimally dependent on their siblings. As a result, only one case resembling joint tendency was present in Diaz Ordaz. Four brothers inherited equal shares of a long field only a few meters wide. They agreed to cultivate the plot in alternate years, as individuals, not together. The other fields they received from their parents were being farmed separately by each heir. Thus, purchasing, swapping, or joint tenure farming lands are negligible factors leading to the consolidation of fields in Diaz Ordaz.

Other Aspects Of Fragmentation

A probabilistic measure of land fragmentation generates new analytic problems. Are larger estates more likely to fragment their fields than smaller estates? Are couples with many heirs fragmenting more of their fields than couples with few heirs? Do the environmental attributes of a field, such as its size, water source, or cropping pattern, influence its propensity to be divided or remain intact? And how is the rate of fragmentation linked to population change?

ESTATES AND FRAGMENTATION. An estate, it will be recalled, consists of all the lands owned by a married couple that are ultimately alienated to the heirs. An investigation of 29 inheritance transfers revealed that rate of fragmentation varied with the size of an estate. (Table 2). Small estates (four or less fields) showed a

TABLE 2. FIELD FRAGMENTATION AND ESTATE SIZE*

		Percentage of the Estate's Fields Fragmented	
		Low (0–.49)	High (.5–1.0)
Estate Size	Large (⩾5 fields)	11	3
	Small (⩽4 fields)	3	8

N = 25 estates

*Fisher's Exact Test, null hypothesis rejected at the .025 level.

higher proportion of their fields fragmented than did larger estates (five or more fields). This finding seems reasonable because larger estates, with more fields, offer their owners more opportunities for intact transfers.

The principle that all heirs receive equal apportionments does not require that every field owned by an estate be subdivided into as many pieces as there are heirs. For example, a couple has several options for

transferring two fields of the same size to four heirs. They might divide both fields into four parts, or more likely, they might divide each field in half, giving one field to each heir.

An example might clarify matters. A couple, Juan and Francisca received five small pieces of farm land from Juan's parents, but Francisca's parents were landless. Juan also received two houselots from his parents, on one of them he built a small house. Despite hard work, the couple could never make enough money to purchase any additional farm land. In 1941, Juan accidently died, leaving his widow with three boys and a girl, the eldest son being only 17 years old. The estate, being jointly owned, continued under the control of Francisca. As the children grew up, the three youngest were given a parcel of farm land (unfragmented) when they married. The eldest son, in appreciation for his assistance to his widowed mother in raising his siblings, received the remaining parcel of farm land. The mother also gave a houselot to her youngest son and the other two sons each received half the natal housesite. The eldest received the natal house. The daughter did not inherit a houselot, although she did receive one as part of the inheritance of her husband. Twenty-two years after the father died, all the heirs received official title to their parcels, with none of the farm sites undergoing fragmentation. What will happen to the children of these heirs? If they have more than two children, would not land have to be fragmented? Actually, it appears that fragmentation may once again be minimal, since all four of the children pooled their small inheritance with that of their respective spouses (thus forming four new estates). The important mechanism operating in this example and in Diaz Ordaz in general is the constant combining and recombining of land through the pooling effects of marriage and the conscious attempt, on the part of testators, to avoid fragmentating fields in order to achieve "equality" in an inheritance decision.

An indication that decisions are being made to retain intact field transfers throughout the village may be seen in Table 3. The number of heirs does not appear to be related to the proportion of their parent's estate that was fragmented. In fact, those few cases in which fields were divided into as many shares as there were heirs involved legal disputes between coheirs where division was made by village officials, not the parents of the heirs.

FIELDS AND FRAGMENTATION. Looking at the fields that make up an estate, I suspected that fields with heavier investments of capital would be less likely to be fragmented. However, it was discovered that irrigated fields were as likely to fragment or remain intact as nonirrigated fields (χ^2=.03. P>.05. df=1, N=134).

TABLE 3. FIELD FRAGMENTATION AND THE NUMBER OF HEIRS

		Proportion of the Estate's Fields Fragmented	
		Low (0–.49)	High (.5–1.0)
Number of Heirs	Many (4 or more)	8	8
	Few (2–3)	8	2

N = 26 estates

Likewise, fields of various native-defined land classes did not differ in their likelihood to fragment (χ^2=.718, P>.05, df=2, N=151). Fields farmed with less intensive cropping patterns could not be singled out as fragmenting with greater frequency than those with more intensive cropping patterns (χ^2=1.97, P>.05, df=3, N=151). Thus, it appears that neither farming intensity nor capital investment in a field influences its potential to be fragmented or remain intact during an inheritance transfer. These null hypotheses also hold when statistical controls are used for the size of the estate to which the field is a part. Apart from these negative discoveries, it was found that fields of different sizes did show different patterns of fragmentation. Large fields tend to fragment more frequently than small fields (less than 2225 meter^2, with four kilos of seed input or less, and corresponding low yields).[3] This tendency for large fields to show more frequent fragmentation is true for fields which are part of both large and small estates.

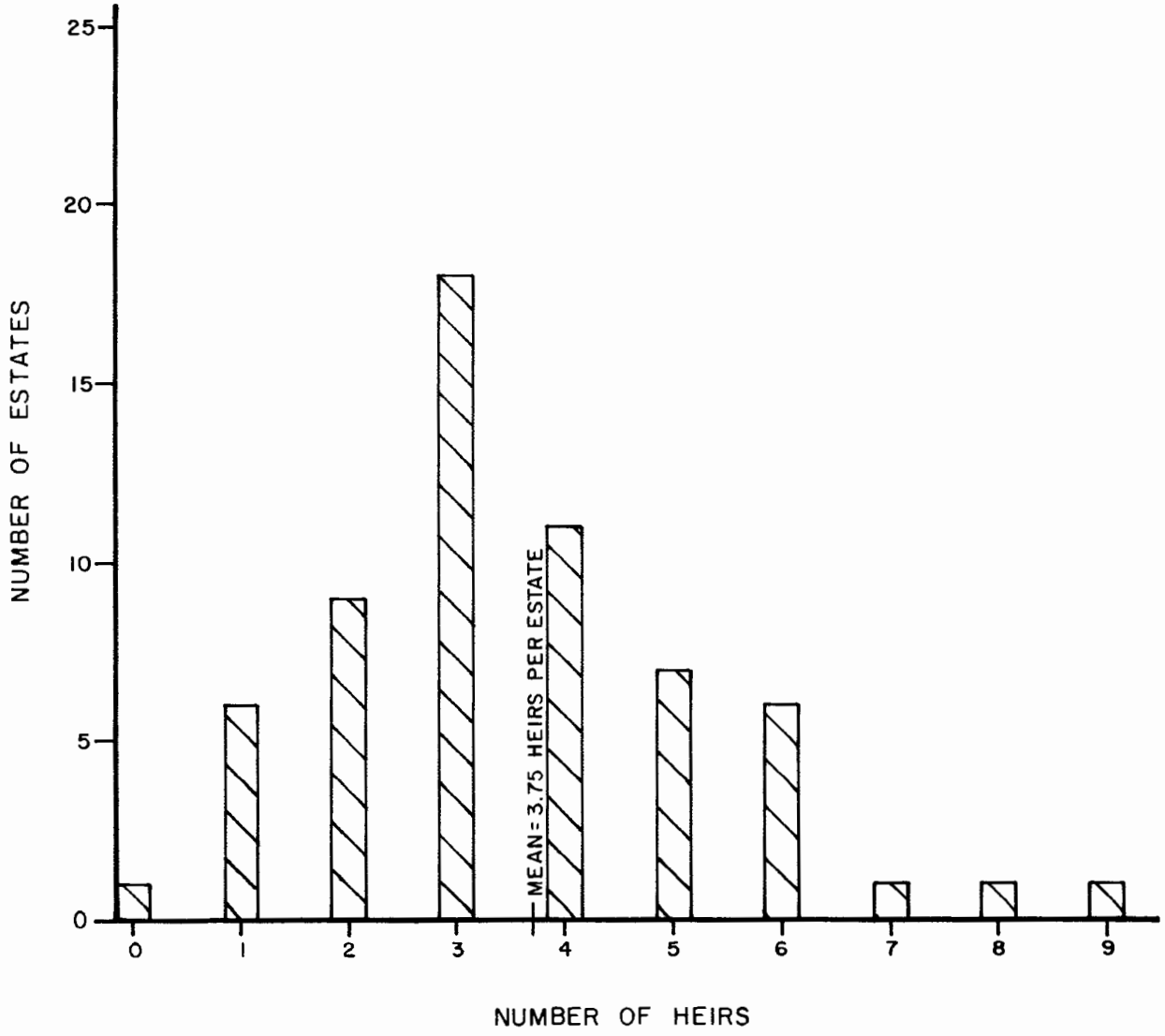
These data suggest a threshold of acreage exists below which fields are seldom divided, with testators fragmenting larger parcels in their estate more frequently than small parcels. However, the level of this threshold appears relative, depending on the specific situations of an inheritance transfer. As far as I was able to determine through interviews, testators in Diaz Ordaz do not adhere to an absolute level, but try to fragment as little as possible while, at the same time, adhering to what they subjectively consider a fair division of their estate.

Thus, a field appears more likely to fragment if it is (1) part of a small estate, that is, one with a few fields; and (2) if it is one of the larger fields in an estate. Another, as yet unquantified factor, may also influence field fragmentation. From observation, it appears that fields more easily accessible to the nucleated settlement are more likely to fragment than more distant fields, reflecting their relative higher value in terms of ease of access and as potential house lots. However, test of this

hypothesis demands more rigorous controls and tests than were possible with the data.

POPULATION AND FIELD FRAGMENTATION. An argument that population pressure increases field fragmentation or, for that matter, any other economic process, is theoretically inadequate unless it specifically states the causal linkages between the two processes. In the Diaz Ordaz inheritance system, two linkages between population changes and field fragmentation are apparent. First, land fragmentation may be retarded if a couple lacks children. The lands of childless testators revert to the couple's respective siblings. Consolidation of a previously fragmented field would occur only when the reverted land was adjacent to a field already owned by the sibling. Otherwise, childlessness merely transfers the inheritance decision from one set of testators to another in the same generation. Estates that lacked heirs accounted for only 2% of the inheritance transfers in Diaz Ordaz in the period of 1925 to 1970 (Figure 3).

FIGURE 3. NUMBER OF HEIRS IN INHERITANCE TRANSFERS.



A second demographic situation that may retard field fragmentation occurs when a couple has only one heir. In this case, the heir receives all lands of the estates intact; there is no fragmentation. Transfers with only one heir accounted for 10% of the cases in Diaz Ordaz, indicating that this situation has a greater relative impact

on retarding the rate of fragmentation than childless transfers or the previously discussed consolidation mechanisms.

Both of these demographically induced situations are directly dependent on the fertility of the testator's age-cohorts and the probability of the heirs survival to inheritance. Either decreased fertility of testators or increased mortality of heirs would increase the frequency of one and no-heir inheritance, thereby decreasing the fragmentation rate of fields. Increased emigration of potential heirs might also retard the rate of field fragmentation if the emigrants lose their rights to inheritance. However, they do not lose this right in this Oaxacan case.

A similar argument could be made concerning the necessity for considering the interlinkages between other factors thought to influence field fragmentation and the actual rates of fragmentation. All of Binn's list of regional factors, which are assumed to increase the rate of fragmentation, demand more careful investigation under explicit demography and social conditions before an adequate theoretical model of field fragmentation may be developed.

Implications

Insofar as public policy is based on assumptions about society, social scientists may influence policy by identifying and testing the validity of commonly held beliefs. This tack to applying anthropology has a respectful history, dating back at least to the Wenner-Gren Conference which discussed the assumptions behind federal Indian policy (Province et al. 1954). In this paper, I have applied anthropology by investigating the assumption that partible inheritance and other factors lead to the fragmentation of agricultural fields. An either-or model has been replaced with a probabilistic measure of field fragmentation. This model of land fragmentation creates new problems for proponents or opponents of consolidation and other remedial actions. It can no longer be assumed that either a policy maker, economist, or other social scientist's cursory impression of agricultural fields, inheritance patterns, or other regional conditions provide enough information to project the future consequences of land fragmentation. A region of apparent minifundia may be experiencing such a low rate of fragmentation that the status quo will not change for several generations. It is even theoretically possible that fields might be consolidating rather than fragmenting. In either situation, remedial actions would be unnecessary. On the other hand, the fragmentation process may be generating a serious problem in a region that, at the moment, has few visible symptoms. The current status of this anthropological model for fragmentation is such that only an "in the fields" survey will indicate the seriousness of the problem. Hopefully, further research will permit an estimation of fragmentation rates from data which is more readily accessible and inexpensive to collect. It may be possible, for example, to use agricultural and population census or aerial photographs for this purpose. Admittedly, a model based on such secondary data would be more useful than the expensive collection of inheritance cases and agricultural survey.

The probabilistic expression of field fragmentation rates also generates additional questions to the anthropologist and agricultural economist. If the rate of fragmentation is better expressed probabilistically, then we must also understand how various combinations of social, economic, ecological, and demographic factors interact to shift fragmentation rates through time. How are we to measure changes in farming efficiency caused by different rates of land fragmentation? And what are the consequences of this refinement for anthropological models using land fragmentation as an independent variable to explain rural to urban migration, peasant resistance to change, or other social behaviors? Solutions to these problems will come from ethnographic comparison and more complex modelling.

NOTES

[1] Other inheritable items are excluded from the analysis in this paper, including house lots, animals, farm implements, and debts. These items are part of separate spheres of inheritance, meaning that each class of items is distributed without reference to decisions made in other classes (Leyton 1970).

[2] Ejido fields were excluded from these calculations. Estates have between 0 and 3 ejido plots, but villagers do not consider them heritable. Ejido lands may not be fragmented, according to national legislation and local custom, although rights to cultivate an ejido are passed along to heirs along with other properties of an estate.

[3] The statistics on the three measures approximating field size are as follows:

	Measured in	X^2
Field fragmentation by field size	mtr^2	13.53
Field fragmentation by seed input	kilos	18.36
Field fragmentation by yields	baskets	12.54

In all these tests: $p<.05$, df=1, N=151 fields.

REFERENCES CITED

Binns, Bernard O.
1950 The Consolidation of Fragmented Agricultural Holdings, FAO Agricultural Studies No. 11. Washington: Food and Agriculture Organization of the United Nations.

Downing, Theodore E.
1973 Zapotec Inheritance. Ph.D. dissertation, Stanford University. Ann Arbor: University Microfilms.

1974 Irrigation and Moisture-Sensitive Periods: A Zapotec Case. *In* Irrigation's Impact on Society, Theodore E. Downing and McGuire Gibson, eds. Tucson: University of Arizona Press.

1976 Wealth Adjustment Mechanisms in MesoAmerican Communities. *In* Proceedings of the XLI International Congress of Americanists. In press.

Flannery, Kent V., Anne V. T. Kirkby, Michael J. Kirkby, and Audrey W. Williams, Jr.

1967 Farming Systems and Political Growth in Ancient Oaxaca. Science 158 (3800): 445-53.

Jacoby, Erich H.

1953 Inter-Relationship between Agrarian Reform and Agricultural Development. FAO Agricultural Studies No. 26. Rome: Food and Agriculture Organization of the United Nations.

Lees, Susan H.

1973 Sociopolitical Aspects of Canal Irrigation in the Valley of Oaxaca. Ann Arbor: Memoirs of the Museum of Anthropology, University of Michigan, No. 6.

Leibenstein, Harvey

1963 Economic Backwardness and Economic Growth: Studies in the Theory of Economic Development. New York: Wiley.

Leyton, Elliot H.

1970 Spheres of Inheritance in Aughnaboy. American Anthropologist 72:1378-88.

Palerm, Angel, and Eric R. Wolf

1957 Ecological Potential and Cultural Development in Mesoamerica. Monograph No. 3. Washington: Pan American Union of Social Sciences.

Province, John et al.

1954 The American Indian in Transition. American Anthropologist 56:388-94.

Selby, Henry A.

1966 Social Structure and the Deviant Behavior in Santo Tomas Mazaltepec (Oaxaca). Ph.D. dissertation. Stanford University. Ann Arbor: University Microfilms.

Winter, Marcus Cole

1972 Tierras Largas: A Formative Community in the Valley of Oaxaca, Mexico. Ph.D. dissertation, University of Arizona. Ann Arbor: University Microfilms

Wolf, Eric R.

1966 Peasants. Englewood Cliffs: Prentice Hall.