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Intermittent Use and Agricultural Change
on Marginal Lands: The Case of
Smallholders in Eastern Sonora, Mexico

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Abstract

Most studies of agricultural land use tend to treat change as though it is essentially permanent. This paper argues that in some cases marginal lands are used intermittently, being brought into and taken out of cultivation frequently, rapidly, and repeatedly. Improvements to the land are made each time a parcel is brought back into use so that over extended periods permanent cultivation becomes feasible. A model of intermittent use is first outlined and demonstrated with data from northwest Mexico. The way in which permanent improvements are made is then described. Last, the theoretical implications are discussed.

Studies of agricultural land use treat change as if it is essentially permanent for the system in question. Once land is brought into or taken out of cultivation, it is considered to remain so for an extended period of time. This conceptualization threads through such diverse themes as von Thünen's agricultural land use zones (Peet 1970:181-201; Muller 1973:228-242; Norton and Conkling 1974:44-56; Ewald 1977:123-133), and Boserup's (1965) land use intensities (Brown and Podolefsky 1976:211-238; Sanders and Bein 1976: 593-610; Dato 1978:135-144; Grossman 1984: 135-144).

For the most part, studies have tended to ignore the role of intermittent agricultural land use, a circumstance in which land is brought into and taken out of cultivation frequently, rapidly, and repeatedly for reasons other than fallow. The paucity of attention to intermittent use is probably due to several factors. In some cases it may not be recognized because it involves lands that are perceived to be of little importance--lands of marginal quality, small plots interspersed among larger, permanently cultivated fields, or segments of a zone on the margin of cultivation. In cases where it has been recognized, intermittent use has not been deemed significant in the larger scheme of agricultural change. For example, in his discussion of agricultural expansion, Peet says, "with the resulting increase in supply, prices may fall and the (von Thünen) zones contract again, but in the final equilibrium all zones are wider and the whole system of zones larger"(Peet 1970:187-188).

Understanding intermittent agricultural land use is important for at least two reasons. First, it affects the elasticity of land supply and results in greater land use variability. Second, it can involve the accumulation of capital improvements over a lengthy period of time so that marginal land is transformed into permanently cultivated land. Intermittent use of agricultural land is demonstrated here through the case of smallholders in eastern Sonora, Mexico. The example study is preceded by a overview of the concept of intermittency and is followed by a discussion of its implications.

The Concept of Intermittency

Just as food production varies by place, so does the elasticity of the supply of agricultural land. Where land-extensive circumstances prevail, supply tends to be highly elastic to increased demands (Renne 1947:18). This

is so because it is generally less costly and more efficient to expand agriculture than it is to intensify it (Grigg 1976:133-176, esp. 149); expansion increases production while intensification increases output per unit area and time (Turner and Doolittle 1978:297-301). Where land is limited, on the other hand, agriculture is typically intensified as demands increase because the supply tends to be inelastic. Differences in elasticity become less distinct as demands decrease. Regardless of the amount of land that can be brought into use, land can always be taken out of production. The supply of agricultural land is, therefore, always highly elastic to decreases in demand.

Not only can land supply be elastic, it can be so with differential parameters per plot or section. Agricultural land is rarely of uniform quality for cultivation and, as such, has different input requirements, economic rents, and usages. If demand is low, land thought to be marginal may not be used for cultivation. But if demand reaches sufficiently high levels, technological adjustments may be employed to make this land usable (Denevan 1981:217-244, esp. 219); that is, the input costs to use them become acceptable (Johnson 1983:1-8, esp. 1-2).

These conditions exist for both large-scale, commodity or market production and for smallholder, consumption or subsistence production. Where choices exist, optimal lands tend to be used first and more permanently than are marginal lands. Where large-scale commercial and smallholder consumption productions coexist, the latter tend to be forced to more marginal lands and the intermittency of land use may become significant.

The intermittent use of agriculturally marginal land is related conceptually to agricultural expansion as first proffered by David Ricardo (1817). His ideas have been refined by numerous scholars, (Samuelson 1959:1-25; Hansen 1979:611-627), and recently agricultural change has been elucidated as occurring in a step-wise fashion (Stryker 1976:347-358; Doolittle 1980:328-342; Robinson and Schutjer 1984:355-366). Ideally, farmers first practice extensive, cost- or labor-efficient agriculture on optimal land to satisfy production demands (figure 1A). As production pressure increases, agriculture is expanded throughout the optimal land without technological change (figure 1B). When demands no longer can be met within this option, agriculture is

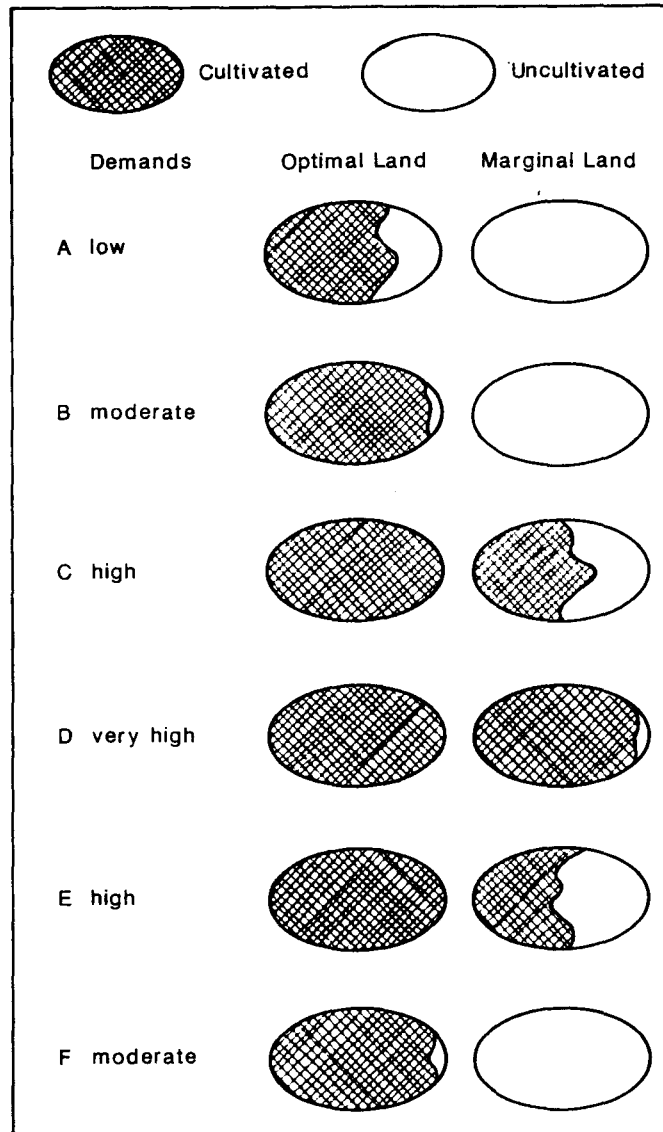


Figure 1. Schematic Map of Intermittent Agricultural Land Use

intensified to increase output on land already under cultivation, expanded onto marginal lands, or intensified and expanded coevally in some combination (figures 1C, D). Land of optimal agricultural quality is typically under complete cultivation before land of marginal quality is brought into use (Grigg 1974:275; Camm 1976:173-181; Grigg 1980:65).

As demands decrease, contraction of agriculture from lands of varying quality follows a sequence opposite that for expansion (figures 1D, E, F). Because they require greater inputs to produce comparable yields, lands of marginal quality are taken out of production prior to lands of optimal quality (Brookfield 1972:30-48). Marginal lands, therefore, not only are the last to be brought into use, but they tend to be the first to be affected by contraction.

Many seemingly marginal areas have, of course, been continuously cultivated for a long time. In such cases, agriculture has persisted largely because increases in demand have been paralleled by capital or technological improvements, such as terraces and canals (Grigg 1970:51). These improvements, however, have in many cases taken decades to complete (Serpenti 1965), perhaps because land was used intermittently. Under such conditions new features can be added and existing ones upgraded each time a field is reused (Geertz, 1963:34). Presumably, as demands increase, and as more improvements are made, intermittency becomes less common, the periods of cultivation increasingly longer, and the periods of nonuse increasingly shorter. Eventually the field has been sufficiently modified to be permanently and continuously cultivated (MacNab 1965:279-290, esp. 280). Once completed, a field system becomes an investment that is not quickly abandoned (Woodbury 1961:42).

The degree of intermittent use to changing levels of demand and the speed of conversion to permanent cultivation vary by specific case. In areas where stark dichotomies in land quality exist, such as arid zones, intermittency can be most pronounced. Similarly, agricultural change can be rapid where demographic and economic forces are great.

The Eastern Sonora Example

Referred to locally as the serrana, eastern Sonora is a semiarid transition zone between the coastal plain of the Gulf of California and the Sonoran

Desert on the west, and the pine-covered Sierra Madre Occidental mountains on the east (Brown 1982:59-65, 100-106). Forming the extreme southern end of the Basin and Range physiographic province of North America, the region is composed of a series of generally parallel north-south trending ranges approximately 30 kilometers apart. Partly controlled by structure, the valleys between these ranges are filled with thick Quaternary-aged alluvium. These deposits have been incised by southward-flowing perennial rivers that have formed floodplains varying in width up to 4 kilometers, and by numerous arroyos or ephemeral tributaries of varying length and width. Rainfall is temporally, spatially, and quantitatively variable, but averages approximately 350 millimeters annually, most of which falls during the late summer. The region has a long growing season, more than 300 days in the lower elevations (Garcia 1981:181-185).

Agriculture has long been practiced on both the floodplains and the bottoms of the large arroyos. In both places, the soils are deep, fertile, and rock-free. Other areas have soils that are too thin and rocky for cultivation, or have steep slopes that are subject to extremely rapid runoff and erosion. These areas are used only for grazing. Because of the dependability of water, which allows for irrigation and hence the production of two crops per year, floodplain lands near the river are preferred for cultivation and therefore are classified as optimal agricultural lands (Hewes 1935:284-292; Meyer 1984:128; Bahre 1984:57-66, esp. 62), even though flooding can result in catastrophic losses.

This criterion for designating lands of high quality has a long history of use throughout Latin America (Eckstein et al. 1978). Floodplain lands distant from the river and arroyo lands are considered to be agriculturally marginal. Peripheral floodplain lands are so considered because of the lack of easily obtainable water, and the arroyos because they are dependent principally on runoff which is sparse and erratic, and as often as not results in flash floods that destroy crops (Hewes 1935:289; Meyer 1984:127; Bahre 1984:62). On both types of lands, one crop per year is all that is possible.

Given the large number of arroyos in eastern Sonora, it is impossible to determine with any degree of accuracy the amount of marginal agricultural land (Bahre 1984:62). Arriving at a reasonably accurate estimate of optimal lands,

however, is considerably less difficult. These lands stand out rather distinctively on black and white stereoscopic aerial photographs and topographic maps, both provided by DETENAL, the Mexican federal mapping agency, at the scale of 1:50,000.

The amount of lands of each type cultivated at any one time varies considerably. Time-series data are, therefore, essential in order to assess agricultural change. Very good current land-use data are available through the Secretaría de Agricultura y Recursos Hidráulicos (SARH), Dirección General de Economía Agrícola. These data, however, are available only for the past few years, and then not for every municipality; they are not of sufficient time depth to monitor long-term changes. The best available information on long-term land use in Mexico comes from the censuses of agriculture for 1950, 1960, and 1970 (Dirección General de Estadística 1957, 1965, 1975) and, because the 1980 census data are unavailable at this time, the state agricultural statistics for 1982 (Gobierno del Estado de Sonora 1984). These data are presented by municipality, a political division that is often considered the equivalent of the county in the United States because of the manner in which data are enumerated. Municipalities function, however, more like New England townships (Brand 1951:97). Although these data may not be as robust as those available from SARH, they do have the advantage of showing land-use changes over long periods of time.

Although agricultural censuses are usually reliable and, accordingly, are often used without reservation (Clark, Knowles, and Phillips 1983:115-120), those for Mexico must be used with caution. The greatest problem with these censuses is that aberrant figures sometimes appear, usually a result of poor enumeration practices, careless tabulation, typesetting error, or some combination of the three (Yates 1981:271-279). For example, the municipality of Aconchi was recorded as having a fortyfold increase in nonirrigated hectareage between 1960, and 1970 followed by a comparable decline by 1982. Nonirrigated land reportedly under cultivation in Aconchi involved 66 hectares in 1950, 60 hectares in 1960, 2,475 in 1970, and 250 in 1982. Field reconnaissance revealed, however that there are not 2,500 hectares of land suitable for any type of agriculture in the municipality.

Because there is no way of correcting problems of this nature, Aconchi and seven other eastern Sonoran municipalities with similar data discrepancies are not included in this study. Another seven are excluded because they do not contain any land classified as optimal. Inclusion of these municipalities would bias the analysis because virtually all land-use change involved marginal land. Three municipalities are excluded because they have land areas that extend well beyond the serrana, including large tracts on the coastal plain where mechanized agriculture and technological developments are widespread. In these cases it is no more possible to delimit optimal land than it is to delimit marginal areas. Finally, one municipality is excluded because a large reservoir constructed during the period involved removed much land from cultivation, thereby breaking the continuity of the land-use record. Data on irrigated and nonirrigated hectarage from the remaining 17 eastern Sonoran municipalities are used here to assess intermittency (figure 2).

Permanent Use of Optimal Lands

The approximately 8,500 hectares of optimal agricultural land in the study area have a long history of intensive cultivation. Prehistoric residents built the canal irrigation system and cultivated maize, beans, squash, and other crops on these lands (Doolittle 1984b:246-262). The Spaniards later farmed the same lands using the same canals (Pennington 1980:64-67). Those farmers, however, improved the agricultural base by introducing a number of new tools and crops, not the least of which was wheat (Treutlein 1939:289-311). Present-day cultivators continue to use the canals and plant many of the same crops on the optimal lands. The emphasis today, however, is on growing fodder, mainly alfalfa, for sale to neighboring ranches and dairies (United States Department of Agriculture 1969b: 5), high-yielding varieties of grains, and vegetables for market in the capital, Hermosillo. The average yield per hectares of optimal land is difficult to calculate because of the variety of crops produced, the large number of holdings, and because more than one crop per year is grown on many parcels. However, yields do tend to be high with great predictability and dependability. The perennial alfalfa, for example, can be cut and baled several times each year.

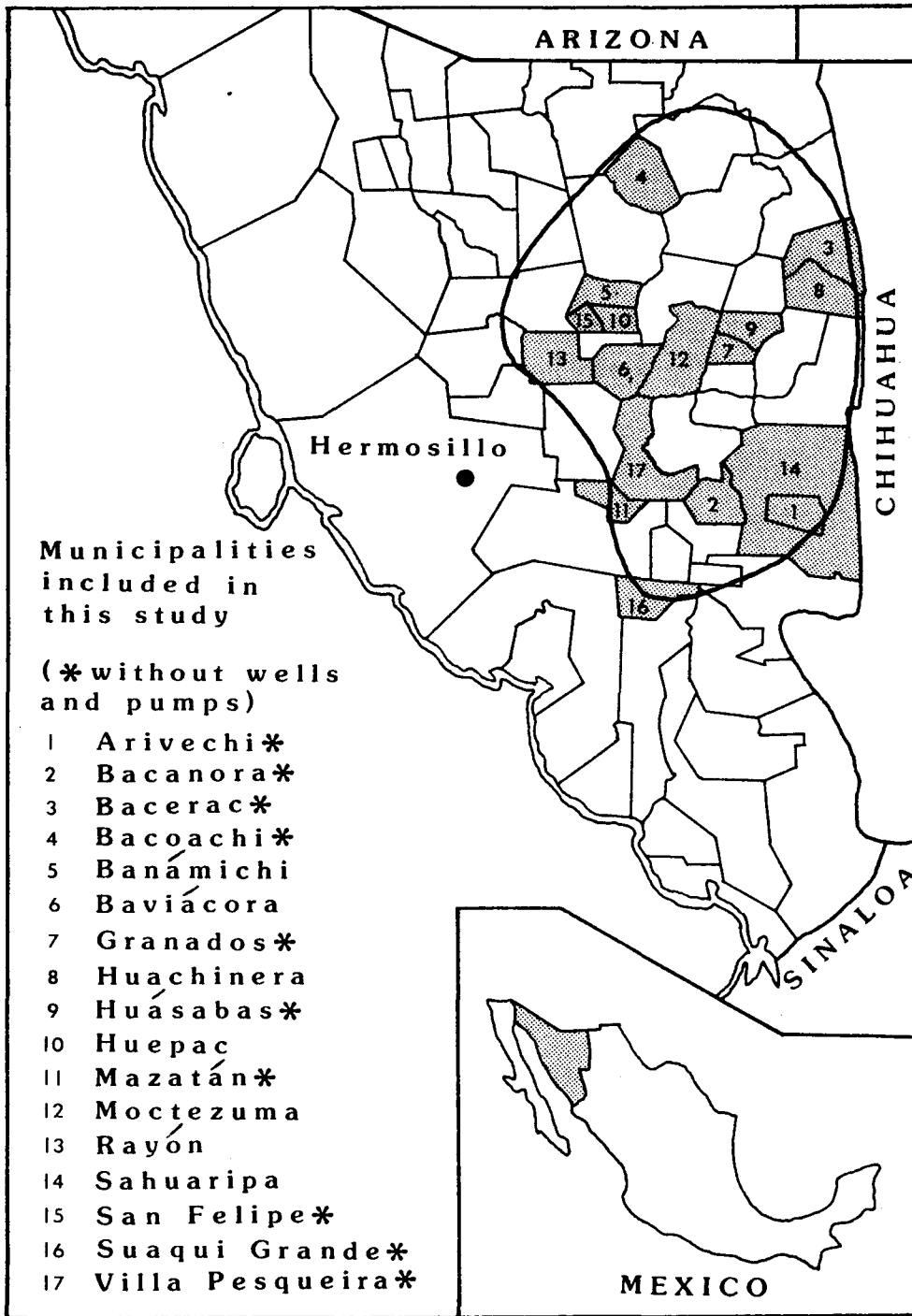


Figure 2. Sonora, Mexico, the serrana and Its Constituent Municipalities

Although the total irrigated area was much less than the optimal land area in 1950, the norm has been for the optimal lands to be completely under permanent cultivation (Table 1 and figure 3). The continued and persistent cultivation of these lands is especially evident in the total disaggregated differences--the sum of all differences regardless of whether they were increases or decreases--between optimal and irrigated hectareage. On the whole, such difference ranged between 12.7 and 42.1 percent and averaged less than 25 percent (table 2). More important, however, disaggregated differences averaged only about 17 percent for those municipalities without technological improvements such as tube wells and pumps; for the 1950s, 1960s, and 1970s disaggregated differences averaged only about 12 percent (table 2). The principal cause for the 1950 discrepancy was flooding of significantly greater than average frequency and magnitude in 1949 (Dunbier 1968:95). Flood damage, which was most severe in Bacerac, Banamichi, Huepac, and Rayon, accounted for the irrigated hectareage being less than the optimal land area.

Intermittent Use of Marginal Lands

In contrast to the optimal lands, marginal lands have a long history of intermittent use. Arroyo bottomlands were the first to be cultivated, as early as A. D. 1000 (Doolittle 1980:338-340). The Jesuit missionaries who arrived in the early 1600s promoted the almost exclusive use of irrigation, the result being that marginal lands were rarely cultivated. During the 18th century, the growing number of Spanish settlers led to the recultivation of these lands (Pineli 1709). The Mexican Revolution, 1910-1917, was extremely harsh on agriculture (Carr 1969:151). The marginal arroyo lands fell out of use again, mainly because the number of farmers decreased (Doolittle 1983:301-313, esp. 304-305). By the early 1930s, only a few marginal tracts were being cultivated (Hewes 1935:288); there was a surplus of land in eastern Sonora, just as there was in other parts of Mexico (Lentnek 1969:65-84).

The principal factor underlying the intermittent use of these lands is water, or, more correctly, water deficiency. Arroyo fields are dependent on runoff, which is sparse and unpredictable; cultivation is, therefore, limited to a drought-resistant summer crop. As throughout the country (Argúellas 1978:21-24), maize is the principal and, in many municipalities, the only

TABLE 1

OPTIMAL FLOODPLAIN LAND, IRRIGATED HECTARAGE, AND DIFFERENCES
BETWEEN THE TWO FOR EASTERN SONORAN MUNICIPALITIES, BY DECADE

Municipality	Opt. Land (est. ha.)	Diff.	1950 Irr. ha.	Diff.	1960 Irr. ha.	Diff.	1970 Irr. ha.	Diff.	1982 Irr. ha.
Arivechi*	175	- 3	172	+ 3	178	- 50	125	+325	500
Bacanora*	125	- 14	109	+ 26	151	- 1	124	+ 44	169
Bacerac*	650	-180	470	- 70	580	+ 4	654	+ 50	700
Bacoachi*	825	+ 4	829	- 45	780	+ 20	845	+ 2	827
Banamichi	1,000	-252	748	-277	723	+ 89	1,089	+784	1,784
Baviácora	1,100	- 83	1,017	- 40	1,060	+ 269	1,369	- 32	1,068
Granados*	325	- 32	293	- 14	311	+ 31	356	+185	510
Huachinera	200	- 66	134	- 17	183	+ 63	263	- 40	160
Huásabas*	550	+ 12	562	- 6	544	+ 149	699	+ 86	636
Huepac	600	-383	217	+ 12	612	- 3	597	- 44	556
Mazatán*	100	+ 32	132	- 26	74	- 41	59	+210	310
Moctezuma	550	+ 22	572	-114	436	- 80	470	+145	695
Rayón	1,000	-181	819	+208	1,208	+ 370	1,370	+992	1,992
Sahuaripa	800	+ 9	809	- 31	769	+ 831	1,631	+452	1,252

Table 1, continued

Municipality	Opt. Land (est. ha.)	Diff.	1950 Irr. ha.	Diff.	1960 Irr. ha.	Diff.	1970 Irr. ha.	Diff.	1982 Irr. ha.
San Felipe*	300	+69	369	+9	309	-32	268	+37	337
Suaqui Grande*	125	-18	107	+28	153	-18	107	-44	81
Villa Pesqueira*	125	-39	86	+157	243	-56	69	-125	0
Total	8,550	-1,103	7,445	-197	8,314	1,545	10,095	3,027	11,577
Mean	502.9	64.9	437.9	11.6	489.1	90.9	593.8	178.1	681.0
Percent of Opt. Land		-12.9		-2.3		+18.1		+35.4	

*Municipalities without wells and pumps

