Common Property as an Institutional Response to Ecological Variability

by

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Abstract

Relationships between the potential productivity of the land and property rights generally have been couched in terms of measures of central tendency or means. But risk, or variance as a measure of risk, also is critical in relating property rights and organizational arrangements developed within various property regimes. Meteorological and hydrological research results support the appropriateness of risk-spreading property regimes, especially in semi-arid and arid lands of the world. Spatial diversification models indicate that common property regimes can be a rational response to ecological variability. In the case of the *ejido* system in Mexico, the current reform efforts may have limited appeal on the grazing areas in the northern half of the country.

> "A whole village may depend on rainfall conditions within a single square kilometre. Under such circumstances, spatial variations in rainfall for individual days are perhaps more important than is generally realised, except by the peasant farmer. Since a large proportion of the rain occurs in a few days, whether or not a single heavy storm 'hits' an individual small area, particularly at the start of the rainy season or at certain short, critical periods in a crop life cycle, could mean the difference between success and failure."
>
> I. J. Jackson (1978, p.284)

Introduction

The debate surrounding the efficacy and viability of common property regimes has produced the recognition that a continuum or plurality of property regimes exists, where an ebb and flow between regimes occurs as societies change. Open access, state property, common property and private property represent the major categories along this property continuum. Each can be differentiated by decision unit, benefit incidence and regulations. The open access regime is a free for all where benefits accrue to the agent that can exploit the resource first. There are no institutional constraints on the agent's behavior. State property is managed by a government agency and benefits accrue to agents with permits authorizing their access and regulating their use of the resource. Common property provides for the co-equal ownership to the rights to a bounded resource where group-established rules govern its use. Finally, private property empowers the owner to experience all the costs and benefits from individual actions subject to broad societal guidelines or constraints.

Standard analytical treatments of common property issues have emphasized human management of established rules to insure an economically viable property regime.[1] Cooperative arrangements, where rules exist to discourage shirking by individuals in the group, can produce an efficient and economically sustainable economic environment. However, these institutional arrangements alone may not give a complete picture of the incentive structure confronting the decision maker in a common property regime.

We argue that ecological conditions can play an equally important role in the determination of optimal property regimes. Ecological uncertainty in the form of extreme rainfall variability across time and space produces an incentive to develop cooperative rules which insure access to widely dispersed fields or grazing areas. We therefore reformulate Bromley's equation which relates property rights to economic yield to read for physical yields,

$$\text{Property Regime} = f\left(\mu_{p,}\, \sigma_p^2\right) \qquad (1)$$

where μ_p and σ_p^2 are the mean and variance of physical yields, respectively. These first two moments of the probability distribution for yields can be directly related to economic welfare through an expected profit equation.[2] Higher order moments also could be included in this revised formulation. We hypothesize that ecological variability is particularly relevant on extensive margin lands, i.e. land in the semi-arid and arid-regions of the world where low mean productivity and high yield variability predominate.[3] Other authors like Sandford and Runge have postulated the importance of the second moment in this functional relationship but have failed to verify it empirically with meteorological evidence.[4]

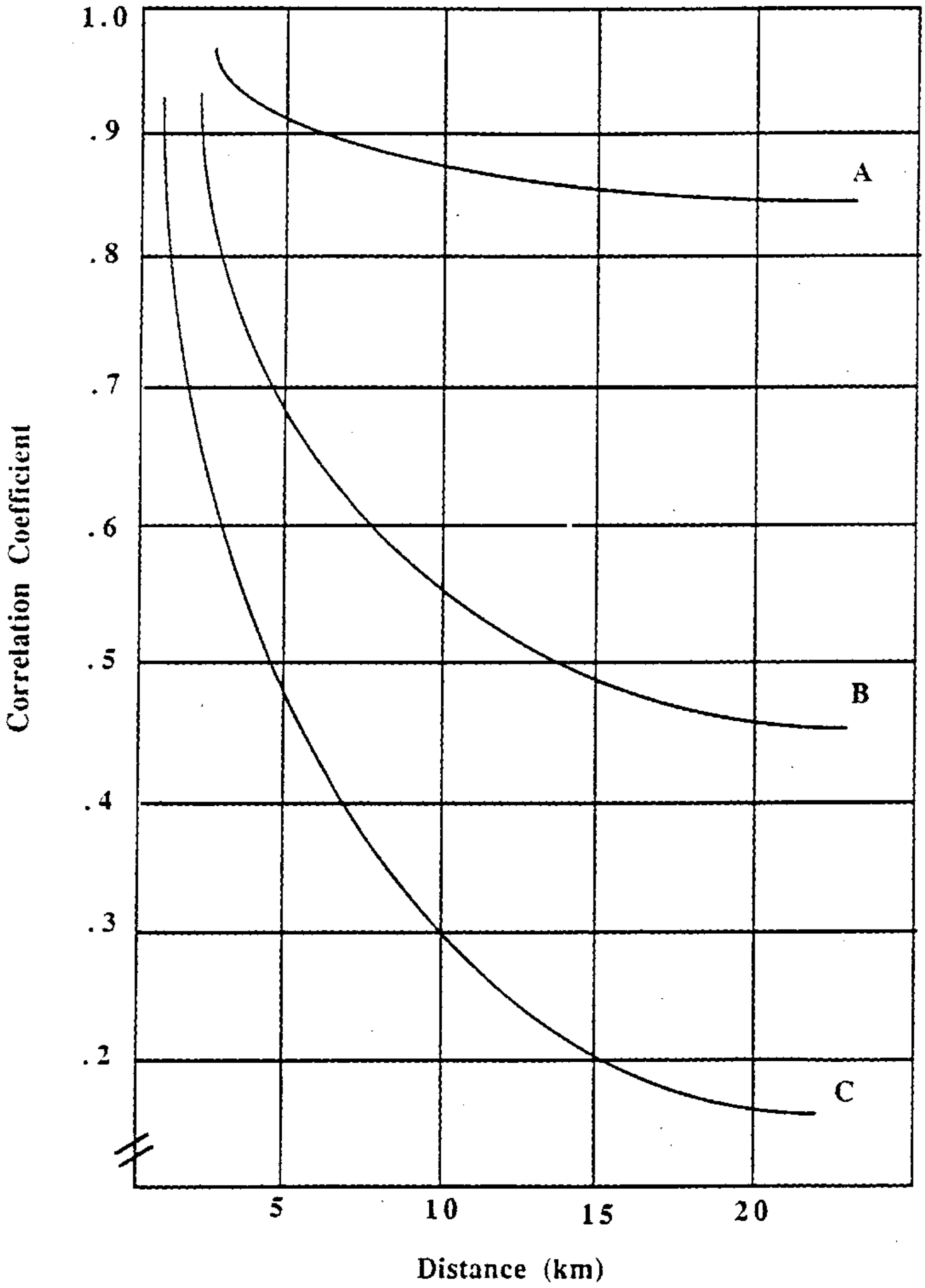
The focus in this paper is on ecological variability across space. Our first objective is to survey the meteorological literature on rainfall variability, emphasizing correlation-distance relationships rather than variation between years. For subsistence ranchers or farmers, with high discount rates, the intertemporal aspects of variability are probably less important than the areal distribution of rain within one growing season. Secondly, we will relate this empirical evidence to two risk spreading or spatial diversification models found in the economics literature. We conclude that common property regimes can be a rational response to ecological variability. Finally, we apply these understandings to Mexico's *ejido* system and the recent privatization reforms in this system.

Ecological Variability Over Space

Measures of average annual rainfall generally are used to characterize the ecology of a specific geographic region. While these aggregate statistics provide useful information for interregional analysis, they do not capture the nature of the variability within a region. Intraregional variability has been well understood by herders and farmers for millennia as an important source of risk. Yet the potential importance of spatial variability for land use decisions has remained in the background of property regime analysis.

Figure 1 presents three representative correlation-distance functions for rainfall. Empirically, these relationships are estimated from data obtained from a network of rain gauges over a watershed or other experimental area.

Figure 1: Representative Correlation-Distance Relationships for Rainfall



Pairwise correlations are tabulated for hourly, daily and/or monthly rainfall using $r_{ij} = r(d_{ij})$ where r_{ij} is the correlation coefficient between stations i and j and d_{ij} is the distance between the reporting stations or rain gages. Curves, similar to A, B, and C in Figure 1, then are fitted through scatterplots of the r_{ij}'s.

Three factors are influential in determining the shape and location of these spatial correlation relationships. First, latitude is a determinant of the relative mix between convective and frontal storms. Regions in higher latitudes have relatively more widespread frontal storms throughout the year which produce a correlation-distance function resembling A. Lower latitude areas where convective storms with high rain intensities for short periods of time are reflected in functions B and C.

A second determining factor is topography or relief. Orographic effects from mountain ranges and coastal influences produce spatial variability.[5] For example, location near mountains sharply rising from a valley floor may produce a rainfall pattern dissimilar to the one in the central valley only several kilometers away. Finally, the interval of observation increases, e. g. daily to monthly, the slope of the correlation-distance functions declines. For example, function C could represent the hourly rainfall relationships while B and A might reflect the daily and monthly data respectively. Special attention is given to these three factors in the following exploration of the meteorological evidence regarding spatial correlation.

Saskatchewan, Canada (Lat. 50 ° N)

McConkey, Nicholaichuk and Cutforth used data over a 34-year period from a combination of 11 rain gauges spaced 800-4400 m apart.[6] They evaluated spatial variability over this small area by storm and by month. The estimated spatial distribution function related to storms demonstrated a similar slope to the monthly function but with a lower intercept of two percent. Over a distance of 4,000 m the monthly spatial correlation values declined from 0.99 to 0.94. An extrapolation to 15 km produces a coefficient of 0.85, a gradual rate of decay over a moderate distance. These results are compatible with function A in Figure 1 and reflect precipitation relationships for relatively higher latitude regions.[7]

Illinois, U.S.A. (Lat. 40° N)

Insights into the spatial distribution of rainfall in the midwestern U.S. were obtained by Huff.[8] Using a network of 50 recording rain gauges over an area of 161 km^2, a 29-storm sample of 1-minute rainfall rates was obtained during the warm seasons of 1952 and 1953. Spatial correlation decayed very rapidly over instantaneous 1-minute rates. Within three kilometers correlation declined from 1.0 to 0.6. Over a distance of 16 km spatial correlations fell to 0. These results resemble relationship C in Figure 1. However, when total storm rainfall was correlated with the distance between rain gauges a completely different picture emerged. In this more temporally aggregated case the data resembled relationship A (Figure 1). Spatial correlation for total storm rainfall declined very slowly to a value of 0.8 after 16 kilometers.

Israel (Lat. 32° N)

Sharon has reported on the localness of rainfall in two areas of Israel: an area near the Gulf of Aqaba and the Jordan Valley.[9] In the arid southern region, daily rainfall data were obtained from five reporting stations within 25 km of one another. Data was gathered over a variable number of years (i.e. 2-9) depending on the station. Rainfall was found to be highly variable with respect to time (i.e. year to year) and space. For several years, one station reported receiving nearly its average annual total (23 mm) over a four-day period while the other stations during the same period received very little rain (0-3 mm). In this arid environment, correlation-distance functions decayed very rapidly. At 3 km a correlation coefficient of 0.9 was obtained while coefficients of 0.6, 0.5, and 0.25 were calculated at the 5, 10 and 15 km distances respectively. For daily observations these data reflect function C in Figure 1.

In the Jordan Valley study daily rainfall data from 92 stations over seven winter seasons (1960/61-1966/67) were analyzed. Spatial correlation functions generally maintained their relative slopes but shifted towards the origin as the location of the reporting station moved southward. For example, the spatial correlation at 20 km was approximately 0.7 at Jericho but nearly 0.9 at Ghor Fara which is 50 km to the north. Orographic effects may have been the contributing factor to greater precipitation uniformity in the northern area of the study region.

Southwestern U.S.A. (Lat. 32° N)

The Walnut Gulch Experimental Watershed utilizes a dense system of rain gauges (0.8 km radius per gauge) over an area of 176 km^2. Located on the northern edge of the Chihuahuan Desert, rainfall data from this station reflects general precipitation conditions in the southwestern United States and northern Mexico. Using 40 gauges for the period 1961-1972, researchers approximated a spatial correlation function for storms in the watershed.[10] At approximately 2 km correlation varied around a mean of 0.8 but fell rapidly to 0.6 and 0.2 at 5 and 10 km respectively. The authors failed to find any statistically significant orographic effect in the watershed within the 450 m elevation range. Significant localness in rainfall was attributed to the convective nature of the major rain producing storms during the monsoon-like season (July-September).

Tunisia (Lat. 35 ° N)

In this case, data were collected during 1982/83 from seven rain gauges over a 19.2 km^2 catchment area in a suburb of Tunis.[11] Spatial correlation relationships were developed for hourly, daily and monthly rainfall data. Hourly correlations between stations declined to less than 0 within 3 km; a correlation distance relationship much steeper than curve C in Figure 1. Daily and monthly correlation functions were less steeply sloped. These coefficients followed the now familiar pattern of decline from 1.0 to 0.6 over a distance of 6 km, thereby resembling relationship C.

Tanzania (Lat. 4° S)

Spatial patterns in rainfall in tropical Tanzania have been investigated by several researchers. Using an eight-year period, Sharon generated correlation coefficients related to distance for 14 rain gauges over a 30,000 km^2 area in northern Tanzania.[12] The decay over relatively short distances (< 20 km) was dramatic, with r declining from 0.8 at 5 km to 0.1 at 20 km. Sharon states,

> "What may be unique to the tropical area is the fact that a correlation that low applies to daily rainfall *in general* (Sharon's emphasis), and not only to a certain portion of selected raindays, as in higher latitudes. This reflects the predominant role of small-scale convection in the region dealt with. Still, if data for appropriately selected days would have been used here, the resulting correlation coefficients would be even lower, i.e. significant negative values would certainly have resulted" (p.213).

In a 56, 250 km^2 catchment area in central Tanzania, Jackson estimated spatial correlation coefficients for 25 stations.[13] Over a 25-year study period average monthly correlations between stations declined rapidly within the first 20 km. Spatial correlations for most months declined at least 30 percentage points over this short distance. Average monthly correlations varied from 0.3 in April to 0.7 in October. Jackson concludes his article by stating that, "The degree of local differences in rainfall variability patterns could be an argument in favour of fragmentation of holdings . . ." (p.285).

Jackson's general findings were supported later by research in coastal Tanzania.[14] Daily rainfall data were obtained from an extensive network of rain gauges in and around Dar Es Salaam. Spatial correlation values of $r < 0.3$ were realized within distances of less than 10 km. After 10 km the distance-decay relationship became relatively flat with correlation coefficient values ranging between 0.0 and 0.3.

In summary, the meteorological evidence indicates that rainfall variability over space is a fundamental characteristic of nature. The degree of variability is a function of latitude, storm patterns, and the topography of the region. This variability in rainfall across space may occur at critical flowering or growing periods in the crop or forage biological cycle. As a result, we should expect yield, and hence economic, variability to vary over space as well.

Spatial Diversification

Agricultural production worldwide is vulnerable to natural elements such as pests, rainfall, frost and soil quality. The localness of these ecological conditions is understood by farmers and herders in a wide variety of environments.[15] Just as investors diversify their financial portfolios to reduce risk and increase average returns, farmers and herders will attempt, when unconstrained, to diversify their yield portfolios over space to insure economic sustainability. As seen in the following two models, efforts by agriculturalists on extensive margin lands to diversify geographically can be a reasonable, if not rational, response to ecological variability.

A Statistical Model

Aggregation issues surround the use of area or regional data to reflect ecological or economic reality at the firm level. In the U.S., county and state data have often been used in policy analysis in the agricultural sector. Although this aggregate information may be the only available data, its use can seriously understate the level of variability experienced by the individual producer.

Nearly 30 years ago Eisgruber and Shuman developed a formal statistical relationship for aggregation bias.[16] Assuming all farm-level variances are the same $(\sigma_i = \sigma_2 = \ldots = \sigma_n = \sigma)$ for all n farms and that r, the correlation coefficient, represents an arithmetic mean of all cross-correlations, the aggregate variance is:

$$\sigma_A^2 = \left(\sigma^2 / p\right)\left[1 + (p-1)r\right] \qquad (2)$$

where p is the number of farms or plots. The aggregate variance is a declining function of p and as the correlation between farms declines, so does the degree of overall variability. Solving Equation 2 for p and differentiating with respect to r produces a negative relationship between correlation and the number of farms, holding all variances constant.

Spatial diversification to reduce ecological and economic variability would require an increase in the number of farms holding the average correlation-distance relationship constant. Correlation values approaching one reduce the incentive to diversify over space while lower correlation coefficients increase the difference between farm level variability (σ^2) and the aggregate measure. Therefore, there is more incentive to diversify geographically in the tropics of Tanzania or the deserts of Arizona and

Mexico, than in the plains of Canada. As the meteorological literature has shown, correlation between farms can fall dramatically over a 5 km range in some areas of the world.

A Behavioral Model

Historical evidence from England during the Middle Ages provides additional insights on the spatial diversification issue. McCloskey's research suggests that soil quality in parts of England varied highly over short distances.[17] When combined with other sources of biological and meteorological variability, yields likely varied markedly across plots as nearby as 5 km in any one season. So scattering of holdings allowed peasants in the English commons to diversify against the variation in yields.

According to McCloskey, an agent is interested in dividing A acres into p plots in order to reduce aggregate variance. The incentive for scattering can be demonstrated by a safety-first model where it is assumed that the agent chooses the number of plots in order to maximize expected yield, all subject to a probability of disaster constraint. The optimal number of plots (p*) is:

$$p^{*} = \left[\frac{I\sigma^{2}(1-r)}{\varepsilon c} \right]^{\frac{1}{1-\varepsilon}} A \qquad (3)$$

where I is valuation of insurance against disaster, σ^2 is yield variability, r is the correlation-distance relationship, c is a technical change parameter and ε is the elasticity of yield with respect to the number of plots.

An analysis of Equation 3 provides some insights regarding the complementarity between spatial diversification and common property regimes. As the tradeoff between expected yield and variance is valued more highly (I), one would expect a desire for more plots, i.e. risk-averse agents such as subsistence farmers or herders prefer scattering. Higher yield variability will produce a desire for more plots as will low correlation-distance relationships between plots. Where ε is small, as it would be on extensive margin lands, the incentive for more plots will be higher. Finally, increases in productivity reduce the incentive for scattering. Technological advances in crop varieties, fencing, irrigation and management practices generate sufficient yield levels, in an economic sense, from a relatively smaller number of plots. So as agricultural production becomes more modern, incentives will exist to reduce scattering and encourage enclosure and possibly, the privatization of the common lands.

The Case of Mexico's *Ejidos*

Current modernization efforts in Mexico's agricultural sector focus on the reform of the *ejidos* which control approximately 48% of the agricultural land in the country.[18] The *ejido* is a common property regime which has its roots in the indigenous past of Mexico. In the Aztec property regime, the *calpulli* land was held in common by villages but divided into family plots.[19] Much of this tenure system was ignored by the civil authorities as lands were reallocated to individuals, civic organizations and the Catholic Church throughout the colonial and post-independence periods. By the end of the *Porfiriato* (1876-1910), approximately 20% of the national territory was controlled by 50 families. One of the products of the Mexican Revolution (1910-1915), which was an agrarian revolution, was the partial return to a common property regime.

Current reform programs will legalize the renting and in some instances the selling of parcelized *ejido* lands to other farmers and investors. Corporations, both domestic and foreign, can now own these lands. The intent of these institutional changes is to modernize the *ejido* sector which is

30-50 percent less productive (measured as output value per hectare) than comparable private farms.[20]

Table 1 presents a geographical overview of the *ejido* system in Mexico. Well over 54% of the *ejidos* are found in the central or northern regions of Mexico. One-third of the *ejido* area is in the northern region (35.6 million hectares).

There are two types of *ejido* land: parcelized and communal. The parcelized lands generally are used for crop production. These lands remain with the family and are divided among the heirs, thereby producing unproductive minifundia in many instances. Communal lands, particularly in the northern half of the country, are unfenced property used for grazing and forestry purposes where open access can be a problem. It is noteworthy that parcelized lands as a percentage of total *ejido* lands range from a low of less than 1% in Baja California Sur to a high of 84% in Veracruz. Nationally, approximately 27% of the *ejido* lands are parcelized and subject to more rapid privatization. In the North Pacific region irrigated *ejido* land represent 45% of the agricultural lands in the region (not including communal lands). Yet this acreage represents only 5% of all *ejido* lands, parcelized plus communal. Only 3.5% of *ejido* lands at the national level are irrigated.

Meteorologically, there is no reason to expect correlation-distance functions for rainfall in Mexico to depart substantially from the literature reported earlier in this paper. Researchers at the Southwest Watershed Research Center, operated by the Agricultural Research Service of the U.S. Department of Agriculture, indicate that their data from the northern Chihuahuan desert is applicable to all of the North Pacific and North regions of Mexico.[21] These regions represent nearly 60% of the national land area controlled by *ejidos*. Published works specifically on northern Mexico support the proposition of significant rainfall variability across space.[22]

Given the predominance of common land in *ejidos* located in northern Mexico where high variability in rainfall prevails, McCloskey's behavioral model yields several insights into the likely outcome of new reforms of the *ejido* sector. First, it is clear that 95 million hectares will not be privatized, at least not in the foreseeable future. Only 27% of these hectares are parcelized, thereby facilitating the privatization process. The higher transaction costs of privatizing larger blocks of communal grazing lands will discourage investors. Secondly, non-irrigated *ejidos* which experience convective storms in the critical growing months of June, July and August will continue to favor the scattering under a common property regime. At least in the northern half of Mexico, we see no present economic incentive for investors to lobby the government to accelerate the privatization of communal lands. A single individual could capture the localness feature of rainfall by controlling a large expanse of grazing land, yet returns on investment in other areas of the economy will discourage such decisions. Thirdly, as noted earlier, the introduction of modern technology can encourage the enclosure of the commons. For this reason we anticipate that the irrigated *ejidos* will be the first *ejidos* to be privatized. In this case risk averseness is lowered, yield variability is reduced by supplemental irrigation, the use of fertilizer is more viable, and the incentive to produce high value crops is enhanced. In the irrigated *ejidos*, the optimal number of plots for economic sustainability is less than the number for economic viability in non-irrigated *ejidos*.

Table 1: Selected Physical and Socioeconomic Characteristics of Mexico's *Ejido* Sector

Region/State	Number of Ejidos	Percent(%) of Total Ejidos	Ejido Land Area(Ha.)	Ejidos as a Percent of Region/State Total Land Area(%)	Percent of Ejido Land Which is Parcelized(%)	Ejido Lands Which are Irrigated		
						Hectares	As a Percent of Region/State Agricultural Lands	Percent of Total Ejido Lands
North Pacific	**2,660**	**9.5**	**21,178,183**	**51.6**	**12.0**	**1,070,242**	**45.1**	**5.1**
Baja California Norte	218	0.8	5,113,394	73.1	4.4	145,560	63.4	2.8
Baja California Sur	95	0.3	5,051,06	68.8	0.4	21,350	94.1	0.4
Nayarit	387	1.4	2,118,246	78.5	2.1	126,184	22.2	6.0
Sinaloa	1,169	4.2	3,230,533	55.4	36.4	498,016	42.5	15.4
Sonora	791	2.8	5,664,948	31.1	8.0	279,132	74.0	4.9
North	**6,676**	**23.8**	**35,675,416**	**44.7**	**15.5**	**870,300**	**18.0**	**2.4**
Chihuahua	912	3.3	9,748,552	39.8	15.2	214,376	18.7	2.2
Coahuila	862	3.0	6,284,397	41.9	4.5	121,186	47.6	1.9
Durango	1,049	3.7	8,028,347	65.2	10.0	107,986	14.4	1.3
Nuevo Leon	594	2.1	1,868,555	28.8	13.0	38,114	16.9	2.0
San Luis Potosi	1,230	4.4	3,717,396	58.9	24.0	68,309	8.8	1.8
Tamaulipas	1,298	4.6	2,398,19	30.2	38.9	230,758	28.9	9.6
Zacatecas	741	2.6	3,629,978	49.6	25.1	89,571	10.0	2.5
Gulf Coast and Yucatan	**5,363**	**19.1**	**11,873,73**	**50.2**	**37.8**	**137,637**	**5.0**	
Campeche	344	1.2	3,115,750	61.3	18.3	9,089	2.7	0.3
Quitana Roo	270	1.0	2,743,286	54.6	12.4	3,359	1.0	0.1
Tabasco	694	2.5	1,011,991	40.1	65.6	1,743	0.8	0.2
Veracruz	3,337	11.9	2,840,561	39.6	84.1	73,382	5.6	2.6
Yucatan	718	2.6	2,162,147	56.3	24.4	50,064	8.9	2.3
South Pacific	**4,521**	**16.1**	**14,604,555**	**61.5**	**48.5**	**283,326**	**5.2**	**1.9**
Chiapas	1,714	6.1	3,130,892	42.2	63.5	52,316	4.1	1.7
Colima	147	0.5	289,291	55.7	66.0	31,257	30.7	10.8
Guerrero	1,172	4.2	3,771,753	58.7	50.2	75,000	5.4	2.0
Oaxaca	1,488	5.3	7,412,619	78.9	40.5	124,753	4.6	1.7
Central	**8,838**	**31.5**	**11,776,177**	**42.9**	**48.7**	**985,431**	**20.4**	**8.4**
Aguascalientes	182	0.6	240,297	43.9	43.4	33,043	31.9	13.8
Federal District	38	0.1	66,213	44.8	45.5	8	0.0	0.0
Guanajuato	1,383	4.9	1,154,565	37.9	54.8	200,642	31.5	17.4
Hidalgo	1,087	3.9	912,550	43.9	44.1	47,451	11.8	5.2
Jalisco	1,338	4.8	3,046,499	37.7	52.1	147,723	15.0	4.8
Mexico	1,112	4.0	1,068,096	50.0	59.2	96,567	16.6	9.0
Michoacan	1,749	6.2	2,692,184	44.9	43.8	263,925	26.7	9.8
Morelos	224	0.8	311,492	62.9	56.9	59,192	34.7	19.0
Puebla	1,125	4.0	1,545,634	45.6	43.0	80,673	12.8	5.2
Queretaro	359	1.3	547,76	47.8	31.1	42,275	25.4	7.7
Tlaxcala	241	0.9	190,883	47.5	78.8	13,932	99.9	7.3
National Total	**28,058**	**100**	**95,108,066**	**48.6**	**26.7**	**3,346,936**	**16.5**	**3.5**

Source: Instituto Nacional de Estadistica, Geografia e Informatica. Atlas Ejidal Nacional. Aguascalientes, 1988.

Concluding Remarks

Natural resource endowments matter in the study of property regimes. In part, existing property regimes are a human response to variable ecological conditions. Extensive margin lands, characterized by low mean productivity and high variances in yield, constrain the institutional choice set with respect to property regime choices. Community-oriented or risk-spreading regimes may be preferred to other institutional arrangements in these environments. In fact, this institutional response to ecological variability may be a rational and efficient response to existing resource conditions. Blanket condemnations of communally managed lands may reflect a limited understanding of the risky environment farmers and herders face in many areas of the world.

Notes

1. Wade, 1987, 1988; Stevenson, 1991.
2. Bromley, 1989, p. 15 argues that the functional relationship may be written as:

   Property Right =f(Economic Yield).

3. Bromley and Cernea, 1989 provide a useful overview of development issues with lands on the "extensive margin".
4. Sandford, 1983; Runge, 1986.
5. An orographic effect implies conditions where rain is produced when a mountain or mountain range deflects moisture-laden wind upward.
6. McConkey, Nicholaichuk and Cutforth, 1990.
7. See Hendrick and Comer, 1970 and Stol, 1972 for other higher latitude examples of correlation-distance relationships.
8. Huff, 1960.
9. Sharon, 1972, 1979.
10. Osborn, Lane and Myers, 1980.
11. Berndtsson and Niemczynowicz, 1986.
12. Sharon, 1974.
13. Jackson, 1978.
14. Sumner, 1983.
15. See Netting, 1976 and Guillet, 1981 for examples of this understanding.
16. Eisgruber and Shuman, 1963.
17. McCloskey, 1975, 1976.
18. Current coalition building behavior by *ejidatarios* is described in Wilson and Thompson, 1993. An in-depth evaluation of privatization efforts in Mexico's *ejido* sector is provided in Thompson and Wilson, 1992.
19. Rincon Serrano, 1980.
20. Yates, 1981. The case for privatizing the *ejido* sector has been recently challenged by Heath, 1992.
21. Weltz, 1992.
22. Hastings and Turner, 1965; Hastings and Humphrey, 1969.

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