Resource competition and violent conflict

Cross-cultural evidence for a socio-ecological approach

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Abstract. The present paper provides a statistical test of alternative theories related to the resource scarcity hypothesis in anthropological conflict research. Existing demographical, ecological, and evolutionary theories are criticized for conceptualizing scarcity as an one-dimensional phenomenon. An alternative "socio-ecological" model is developed, in which the distribution of scarce goods plays a key role. The power of the discussed models in explaining ten different forms of violent conflict management is examined by applying a hierarchical logit-analysis. The results provide strong support for the socio-ecological approach.

Introduction

The idea that scarce resources may be one factor leading to warfare or other forms of violent conflict has been discussed for a long time in the social and political sciences alike. In cultural anthropology, this topic has attracted special attention with the rise of the cultural-ecological paradigm in the 50's and 60's (Ferguson 1984). A great many of scholars began to focus on this relationship, and the majority of their rather detailed case studies provide strong support for this argument.[1] Since then, some cross-cultural work has followed, where these assumptions have been tested on a regional or worldwide scale. Most of these studies arrived at a confirmation of the hypothesis, thus implying that the connection between warfare and such phenomena as rising population densities or food stress can be accepted even as a statistical law.

Up to now, however, no attempt has been made to assess the theoretical compatibility of the different approaches. Furthermore, the existing hypotheses have never been tested simultanously using the same sample. This will be done in the present paper.[2] I will start with a short review of existing cross-cultural studies dealing with resource scarcity as a cause of violent conflict. In trying to overcome some theoretical weaknesses of previous attempts, a new theoretical perspective is developed in the second section. It will be statistically tested against the previous explanations thereafter, using a hierarchical logit-analysis.

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[1] For an exhaustive bibliography on these studies see Ferguson and Farragher (1988).

[2] Preliminary versions have been presented at the DFG-Conference "Theory construction and comparative research on violent conflict in Third World Countries: Nomothetic explanations versus ideographic descriptions" (Bonn, November 1989) and the annual meeting of the Society for Cross-Cultural Research (Claremont, March 1990).

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Review of previous explanations

Cross-cultural studies on the topic can roughly be classified into three categories, according to the major causal force underlying their explanation. I will refer to them as the demographical, ecological, or evolutionary explanations.

By "demographical" I mean those hypotheses conceptualizing scarcity as a density-dependent phenomenon. The relationship between population density and warfare has first been statistically examined by Ember (1982) in his critique of a previous work of Sillitoe (1977). For Sillitoe's sample of 28 societies in New Guinea, Ember comes to the conclusion that war is the result of landshortages, brought about by population pressure.[3] Ember (1982) could also demonstrate a significant relationship between food shortages (another measure for population pressure, which shall indicate that carrying capacity has been reached) and warfare for a world-wide sample of 15 societies. In a later study with a world-wide sample of 70 cultures, however, this result turned out to be not significant (Ember and Ember 1984).

Sometimes scarcity caused by natural, density-independent factors (like drought) is supposed to compel people to go to war. Such an "ecological" argument is presented by Ember and Ember (1984), who show (again for a sample of 70 societies) that food shortages, created by natural disasters, will cause external warfare. On the other hand, no relationship could be found between ecological factors such as the spatial distribution of resources and the presence of blood feuds within a society, an argument developed by Black-Michaud (1975) and tested by Fleising and Goldenberg (1987).

Finally, one study takes an evolutionary perspective in seeing scarcity as a result of increasing technical and societal differentiation (Leavitt 1977). The evolution of societies is expected to be related both to external and to internal war. For external war the argument is more or less identical to the demographical explanations. The reasoning behind the explanations for internal war is, that the maldistribution of resources leads to interest conflicts within the society, which will be violently resolved. The four propositions are confirmed by the statistical tests (n = 132): as societies evolve, the frequency of external warfare, riots and civil wars increase, while the frequency of feuds, due to the diminishing importance of kinship in more modern societies, declines.

The socio-ecological approach

The main shortcoming of the three types of explanations is their unidimensionality. Scarcity is designed to be either ecological, demographical or distributional in origin. Hence, both the ecological and the demographical perspective neglect that resources can be unevenly distributed in society, while Leavitt's cross-cultural test of the evolutionary argument, contrary to the highly elaborated theoretical framework (see

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[3] But see Hanser (1985) for a critical discussion of the land-shortage hypothesis for New Guinea.

Johnson and Earle 1987), does not incorporate the crucial variables of the other two perspectives. None of them takes into consideration that different types of social organization may solve the problem of scarcity in different ways. This one-dimensional point of view has still another consequence, as it obscures the fact that causal relationships may exist between the central variables of the different approaches. If this should be the case, statistical tests denying this fact may easily produce false correlations or may even be unable to unmask existing ones.

Technically spoken, a distinction has to be drawn between (1) the causal relationships of the independent variables pertaining to the three approaches, and (2) the causal effect these independent variables have on violent conflict.

Causal relationships between the independent variables

The central independent variables of the three approaches are population density, food stress and social stratification (see Table 1). A bundle of hypotheses exists about the causal relationships between them, which will be briefly discussed below.

Table 1. Independent variables

SCCS	Variable	Quellen	Source
64	Population density (persons per sqm)	1 = 1 per 5 sqm 2 = 1 per 1–5 sqm 3 = 1–5 4 = 1–25 5 = 26–100 6 = 101–500 7 = over 500	Murdock & Wilson 1972
678	Food stress	1 = food constant 2 = occasional hunger 3 = periodic or chronic hunger 4 = starvation	Sanday 1981
270	Class stratification	1 = absence among free men 2 = wealth distinctions 3 = elite 4 = dual (hereditary aristocracy) 5 = complex (social classes)	Murdock 1967

Population density and social stratification. Among evolutionary theorists it is a commonly shared view that rising population densities lead to social stratification (Johnson and Earle 1987: 16–18; Dumond 1972; McNetting 1972: 235; Hammel and Howell 1987: 147). According to these studies, population growth, which is viewed to be an inherent trait of human und animal populations alike, causes population pressure. Human societies face this situation by intensifying their production. This allows the generation of surplus, which is the basis of stratification. A positive relationship between the two variables can be expected even if rising population densities are not valid as a measure of scarcity, as suggested by some scholars.[4] According to a hypothe-

[4] For a more lengthy discussion of this topic see Wittek 1990: 56–58.

sis elaborated in organization theory (Blau 1970; Mayhew et al. 1972) and adopted by legal anthropology (Podolefsky 1987), increasing system size heightens the probability of quarrels in the social system. This creates "a need for stronger judicial mechanisms" (Podolefsky 1987: 582). The development of these mechanisms is thought to be related to unequal access to resources (Brown and Podolefsky 1976).

Food stress and social stratification. McNetting (1972) has examined this relationship for some African peasant societies. He argues, that the permanent threat of famine through natural desasters creates a feeling of fear and insecurity in the minds of the peasants. As "people want to believe that those conditions most vital to their existence are in some way subject to their will" (McNetting 1972: 236), the institution of the "priest-chief" develops. He is thought to be able to make rain and to ensure the fertility of the soil. According to McNetting, this institution marks the beginning of social stratification.

Population density and food stress. The relationship between these two variables lies at the core of the demographical explanation, but has never been tested cross-culturally. If population density is a measure of population pressure, it should be the cause of food shortages (Ember 1982). On the other hand there is no doubt about the fact that frequent food shortages also limit population growth. Malnutrition increases the mortality rate and lowers the fertility rate of a population (Swedlund 1978: 150f.; Jochim 1982: 181). Thus, a negative feedback can be expected between the two variables.

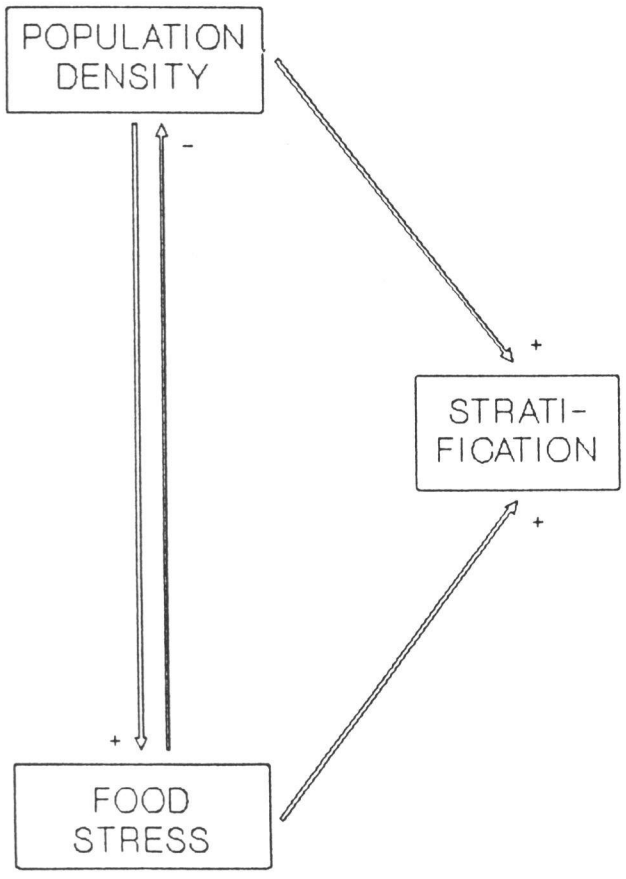

Fig. 1. Hypothetical relationships

The model. The postulated relationships can be integrated into a three-variable model, which is graphically represented in Figure 1. In the following two sections, I will first discuss two socio-ecological models of scarcity, and then discuss their role within a multivariate, socio-ecological explanation of violent conflict.

Socio-ecological models of scarcity

The basic distinction to be drawn is that between partial and total scarcity. Partial scarcity occurs in societies practicing restrictive modes of distribution. The result is, that not all members will be equally affected by a shortage, and some succeed in securing a larger part of the remaining goods than the rest. On the other hand, total scarcity is a trait of societies with flexible modes of resource distribution.[5] In the face of a shortage, these societies share the remaining goods in a way that scarcity will be evenly distributed among all members of the social system. Shared poverty is a more common term for this situation (Browning 1970: 80). Networks of reciprocity or redistribution (Brookfield 1970: 148; Jochim 1981: 191) may be means to establish it and often provide a very effective "life insurance" (Durham 1976: 392f.; Lomnitz 1977) until the situation gets better again.

Thus, this socio-ecological perspective on scarcity makes explicit what can be called the "distribution of scarcity". It contains as least two dimensions: changing demographical or environmental factors on the one hand, and societal mechanisms regulating the distribution of the diminished supply of goods on the other. With the variables at hand for the present study, two such models can be constructed.

In relating population density to social stratification, a causal mechanism may be derived which Durham (1977) has termed the "Combination Model". In this model, partial scarcity is regarded to be a product both of rising population density and unequal distribution of resources. The reasoning behind it is a social system within which a high per capita resource availability can be maintained only by a few individuals or groups. With total resource availability remaining constant, population growth will produce resource scarcity for the poorer members of the social system.

The second model results in combining ecological (density-independent) forms of scarcity and social stratification, and will be referred to as "Combination Model II". Here, food stress will lead to partial scarcity in stratified societies, while unstratified ones will exhibit total scarcity.

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[5] The distinction between distributional flexibility and restriction has been developed by Brookfield (1970).

Socio-ecological models of violent conflict

The preceding discussion was concerned with the different types of scarcity. Now, the question remains to be answered how these different types of scarcity are related to violent conflict. As a starting point for the construction of testable hypotheses will serve the distinction between partial and total scarcity.

First, partial scarcity is the result of unequal access to resources. A society exhibiting this trait can be seen as consisting of two or more subgroups, which make up different positions in a hierarchical system. It is these subgroups whithin which values and expectations regarding the access to resources are shared (Boone 1983; Schmink 1982; Little 1987). They can be regarded as the main institutional setting determining group formation and subsequent violent collective action, especially if scarcity occurs. The reason is that a subgroup ranking low in the hierarchy can be expected to adopt other, different strategies than its privileged counterpart. To leave the sphere of influence of the dominant group may be one solution for the commoners, and in fact fission seems to have been the most common reaction to such situations (Hammel and Howell 1987; Jochim 1981: 192; Maude 1973: 178). If no empty lands are available, violent conflict with the goal to secure more resources may be the alternative. Here, three different types of violent conflict can be distinguished, regarding to who will initiate aggressive acts. First, the dominant elite may try to forcefully expel the weaker part of society (Jochim 1981: 192; Little 1987; Schmink 1982). Second, the poorer strata may try to coercively drive out the elite (Schryer 1987; Friedrich 1970). These two forms refer to violent conflict within the society. The third option is external violent conflict (Mitra 1971: 101). This may be a probable solution if either the dominant elite of the commoners consider themselves too weak to accomplish the expulsion of the other group, that is, the costs of such an action would be much higher than its benefits. As the weaker subgroup's need to solve the resource deficiency remains, it may regard aggression against neighbouring groups as the less costly alternative. On the other hand, as such an action will lower the threat of loosing their own positions, the dominant group will strongly support, if not even instigate such attempts (Boone 1983: 81):

> "(...) territorial expansion does not necessarily arise as an adaptive response to solve productive deficiencies facing the population at large: expansionist warfare often results from attempts by individuals or coalitions to maintain control by directing the competition of their immediate subordinates away from themselves and against neighbouring territories".

Second, total scarcity has been attributed to groups with distributional flexibility. Here, every member of the society has to suffer deprivation to the same extent. But the diminished supply may be sufficient to make a living for a longer time than the deprivated part of a society with partial scarcity could afford. Hence, the resort to collective violent action will become necessary only if the total supply of the resources in question is too low to guarantee every member at least the minimum share necessary for

survival. This will occur at a much later stage than in "restrictive" societies, and may be unnecessary at all, if the resource base could recover during this time.

From what has been said up to now, one general hypothesis can be derived: Societies marked through partial scarcity will have more violent conflict than societies with total scarcity. With regard to the two models of scarcity and the independent variables used to measure them, this assumption has to be specified as follows:

(1) Societies with food stress and social stratification will fight more often than societies with food stress and no stratification.

(2) Societies with high population densities and social stratification will fight more often than societies with high population densities and no social stratification.

If we add these two hypotheses to the postulated relationships between the independent variables as stated above, a four-variable model is the result. It is graphically depicted in Figure 2.

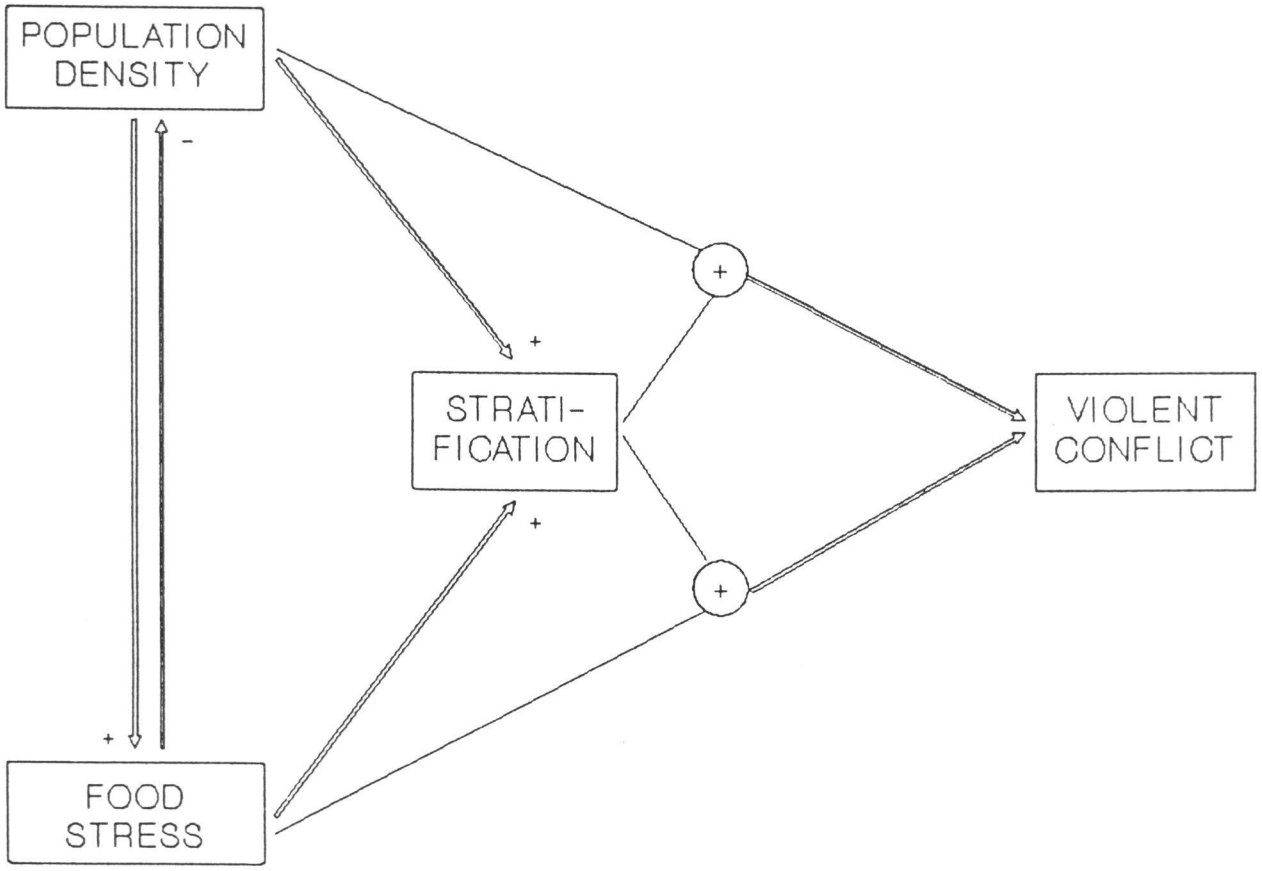

Fig. 2. Socio-ecological model of violent conflict

Statistical tests

Both the type of hypotheses and the type of data at hand determine the choice of the appropriate statistical method. In the present case, the method should take into consideration the interrelationship of the independent variables and the categorical measurement level of variables. Though for dichotomous dependent variables these condi-

tions could principally be met by regression analysis (Langeheine 1986: 172), the dichotomous dependent variable normally lacks two conditions necessary for the application of ordinary regression: "(1) constant variance (homoscedasticity) and (2) a normal distribution at each level of the independent variables" (Swafford 1980: 665). Log-linear models do not need that assumption and thus are the appropriate tool for the tests to be conducted here.[6]

A log-linear model is an additive function of effect parameters which estimate the variation of the cell frequencies. Depending upon how much information of the original cell frequencies are used (what marginals are fitted), every model tries to generate expected frequencies which should reproduce the original data in the contingency table as exactly as possible. The significance of a model can be determined by using the Likelihood-Ratio-Chi-Square value.[7] A model "fits" the data if p lies between .10 and .35 (Knoke and Burke 1986: 31) – that is, we are looking for non-significant results. It is possible that various models fit the data. In this case, it has to be determined whether a specific model significantly increases the fit of another model. This can be done by subtracting the L^2 of the two models (as well as their degrees of freedom, df). The difference is called ΔL^2, and can again be tested for significance. Here, the conventional significance criterion is employed ($p<.05$). While a log-linear model does not distinguish between dependent and independent variables, a logit model does. Here, the criterion to be explained is the logged odds[8] of the expected frequencies of the dependent variable, which is called the logit (Phi):

$$\Phi = \mathrm{Ln}\,(e_{1jk}/e_{2jk}) = b^{\Lambda} + b_j^{AB} + b_k^{AC} + b_{jk}^{ABC}$$

This expression normally is depicted in the fitted marginal notation as (ABC), meaning that in a three variable model, both B and C have an effect on the dependent variable A. On the other hand, (AB)(C) would mean that C has no effect.

The model shown in Figure 2 can be tested in consecutively fitting a logitmodel for each dependent variable.[9]

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[6] See Langeheine (1986) and Knoke and Burke (1986) for good introductions into and ample bibliographies to the topic.

[7] $L^2 = 2 \sum f_{ij} \ln (f_{ij}/F_{ij})$ with f_{ij} = original Frequencies and F_{ij} = expected Frequencies.

[8] "An odds is the ratio between the frequency of being in one category and the frequency of not being in that category" (Knoke and Burke 1986: 9).

[9] Strictly seen, the model is a non - recursive path model. The test of non - recursive path - models via logit - models requires assumptions that are not met here (Langeheine 1986: 166). But it can be interpreted as a recursive path model, if the two variables with the feedback are seen as exogenous variables. This condition is valid here, because "a partial relationship between two variables, controlling for a variable that is causally subsequent to the two, is meaningless, whether the relationship is estimated by means of OLS regression or log - linear techniques" (Gillespie 1978: 722).

[10] Note that the analysis conducted here assumes the models to be hierarchical, that is, higher order hypotheses always include all lower order effects. Thus, the test of the relationships social stratification – food stress, social stratification – population density has to include the previous subtable of population density – food stress, even if both have been found to be independent (Knoke and Burke 1986: 44).

Causal relationships among the independent variables

The first relationship to be tested is whether population density (P) and hunger (H) are dependent. This is not the case, as the independence model (P)(H) fits the data well with $L^2 = .04$ and $df = 1$. As a consequence, both variables should not be connected by any arrow in our model. The next step is to test the relationship between these both variables and stratification (S).[10] Here, the independence model (PH)(S) clearly does not

Table 2. Logit-models for the independent variables

Model	Fitted marginals	L^2	df	p
1	(PHS) "Sat. mod."	.00	0	–
2	(PH) (S)	18.56	3	.000
3	(PH) (PS)	3.93	2	.140
4	(PH) (HS)	16.16	2	.000
5	(PH) (HS) (PS)	.96	1	.327
6	(PH) "Sat. mod."	.00	0	–
7	(P) (H)	.04	1	.104

fit the data, indicating that there is indeed some relationship between stratification and the other two variables. It remains to be determined whether both variables have an effect on stratification or only one of them. Model 3, which proposes only population density to have an effect, fits the data well with an $L^2 = 3.93$ and $df = 2$. Will the addition of the relationship between food stress and stratification, as proposed by model 5, significantly improve the fit? As the difference between the Likelihood-Ratios of the two models with $\Delta L^2 = 3.93 - .96 = 2.97$ for $df = 2 - 1 = 1$ turns out to be not significant ($p>.05$), we conclude that the addition of the relationship between food stress and stratification is not necessary. Thus model 3, which fits the two marginal tables (PH)(PS), is accepted, meaning that only one of the four relationships postulated in theory does in fact exist. Neither the main premise of the demographical explanation – that higher population densities ultimately cause food shortages – nor McNetting's "priest-chief" hypothesis could be supported. The remaining relationship between population density and social stratification may be interpreted according to the system-size argument. The next step consists of testing the effects of the independent variables on the ten conflict variables (see Table 3).

Internal violent conflict

As can be seen from Table 4, the independence model fits for all of the four variables measuring internal violent conflict. This means, that neither population density, nor food stress, nor stratification, nor any interaction between them is significantly related to these variables. None of the proposed explanations, be it demographical, ecological, evolutionary or socio-ecological, is able to predict under what circumstances violent collective actions will take place *within* societies or political communities.

Table 3. Dependent variables

SCCS Variable/Study	Code
(Ross 1983)	
Frequency of conflict	1 = endemic: a reality of daily existence (physical violence, feuding)
767 in the local community	2 = high: conflict present, but not a pervasive aspect of daily life
768 between communities of the same society	3 = moderate: disagreements do not result in high violence
	4 = mild or rare
773 Internal warfare (between communities of same society)	1 = frequent, occuring at least yearly
774 External warfare (with other societies)	2 = common, at least every five years
	3 = occasional, at least every generation
	4 = rare or never
(Nammour 1974, follows Otterbein 1970)	
Frequency of	1 = continual
891 internal warfare	2 = frequent
892 external warfare	3 = infrequent
(Nammour 1974)	
909 Subjugation of territory or people	1 = present
910 Collection of tribute	2 = absent or not mentioned
911 Acquisition of land	
912 Plunder	

Table 4. Logit-models for internal violent conflict

Model	Fitted marginals	L^2	df	p
2	(PHS) (V767)	8.03	7	.330
2	(PHS) (V768)	3.44	7	.841
2	(PHS) (V773)	5.13	7	.643
2	(PHS) (V891)	6.18	7	.519

External war

The two variables measuring the frequency of external warfare have different points of reference. While Ross (V774) determines external warfare if two *societies* fight with each other, Nammour (V892) coded the *political community* as the war leading unit. This may be the reason why the analysis yields different results. While the independence model fits for V774 ($L^2 = 6.86$, df = 7, p = .443), it does not for V892, if one accepts p = .10 as the significance level that should be reached to accept a model (Table 5). In subsequently adding one of the three effects (models 3,4,5), only stratification substantially reduces the L^2 of the independence model ($\Delta L^2 = 12.19-5.35 = 6.84$ with df = 7−6 = 1 is significant at $p<.01$). As none of the subsequent models including additional effects significantly improve the fit, the model chosen for this dependent variable is model 5 (Figure 3).

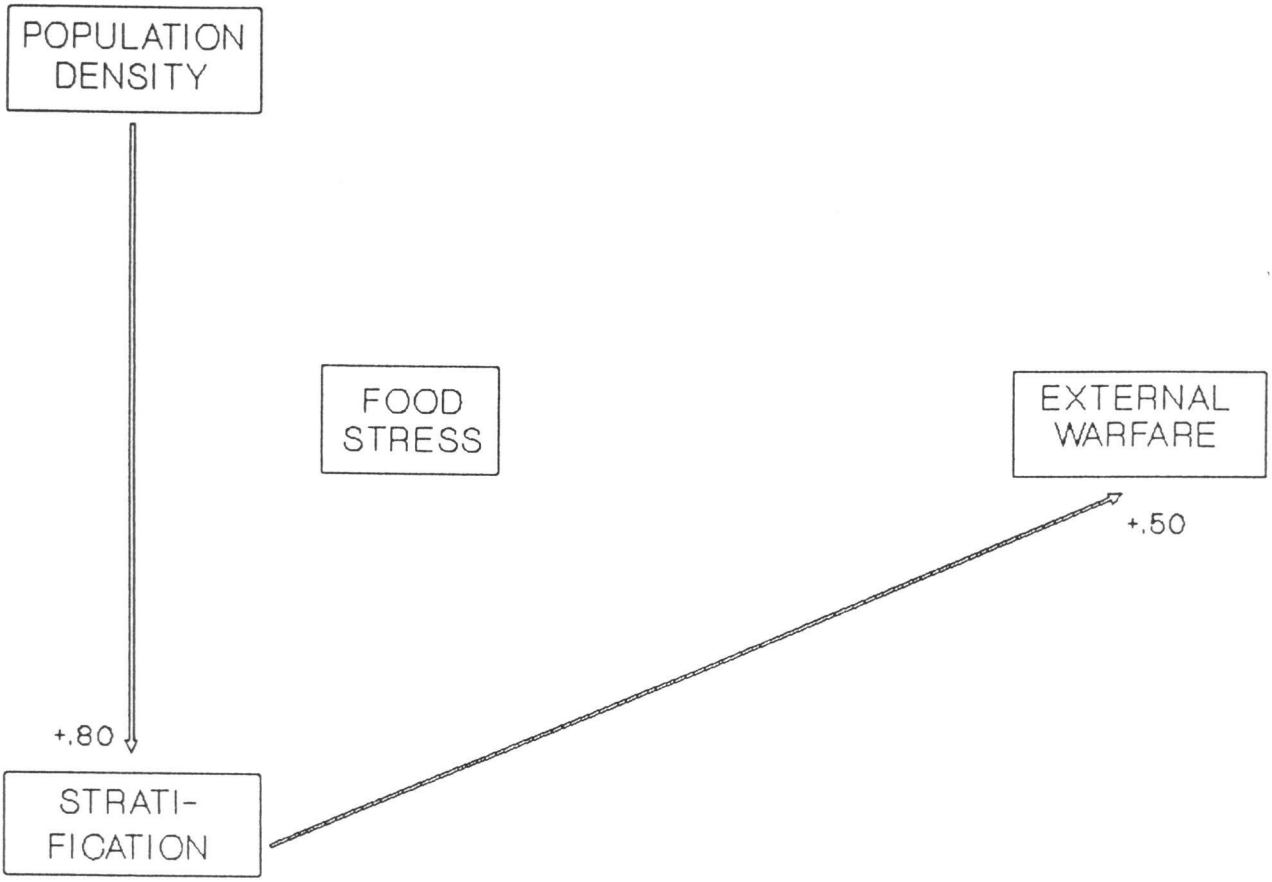

Fig. 3. Logit-model for external warfare

This model postulates that neither population density nor food stress have direct effects on external warfare. Stratified societies will go to war more often than unstratified ones, and though a stratified society is more likely to have high population densities, its warfare behavior is independent of population density. That is, the chance that a stratified society with high density initiates warfare is not higher than that of a stratified society with low population density.

These results indicate, that both the demographical and ecological explanations can be rejected with regard to external warfare. The same is true for the evolutionary approach, as long as it sees population growth as the major cause of external warfare. Strictly speaking, even the socio-ecological models do not hold in the way they have been formulated above. No demographical or ecological stimuli are necessary to mobilize a stratified society to take the arms. However, the empirical results are congruent with the interpretation of these external wars as the attempt of dominant individuals or groups in directing the competition of the commoners away from them. This makes sense also if no acute shortages do exist.

Subjugation of territory or people

Comparing the models with only one main effect, no doubt arises that model 5 has the best fit of them (Table 5). With $p = .122$, it would also reproduce the data well. How-

ever, the fit is significantly improved when another main effect – population density (model 7) – is added ($\Delta L^2 = 10.07-4.30 = 5.77$ with $df = 6-5 = 1$, $p<.025$). As the inclusion of additional effects does not further increase its fit, it is the appropriate model to choose (Figure 4).

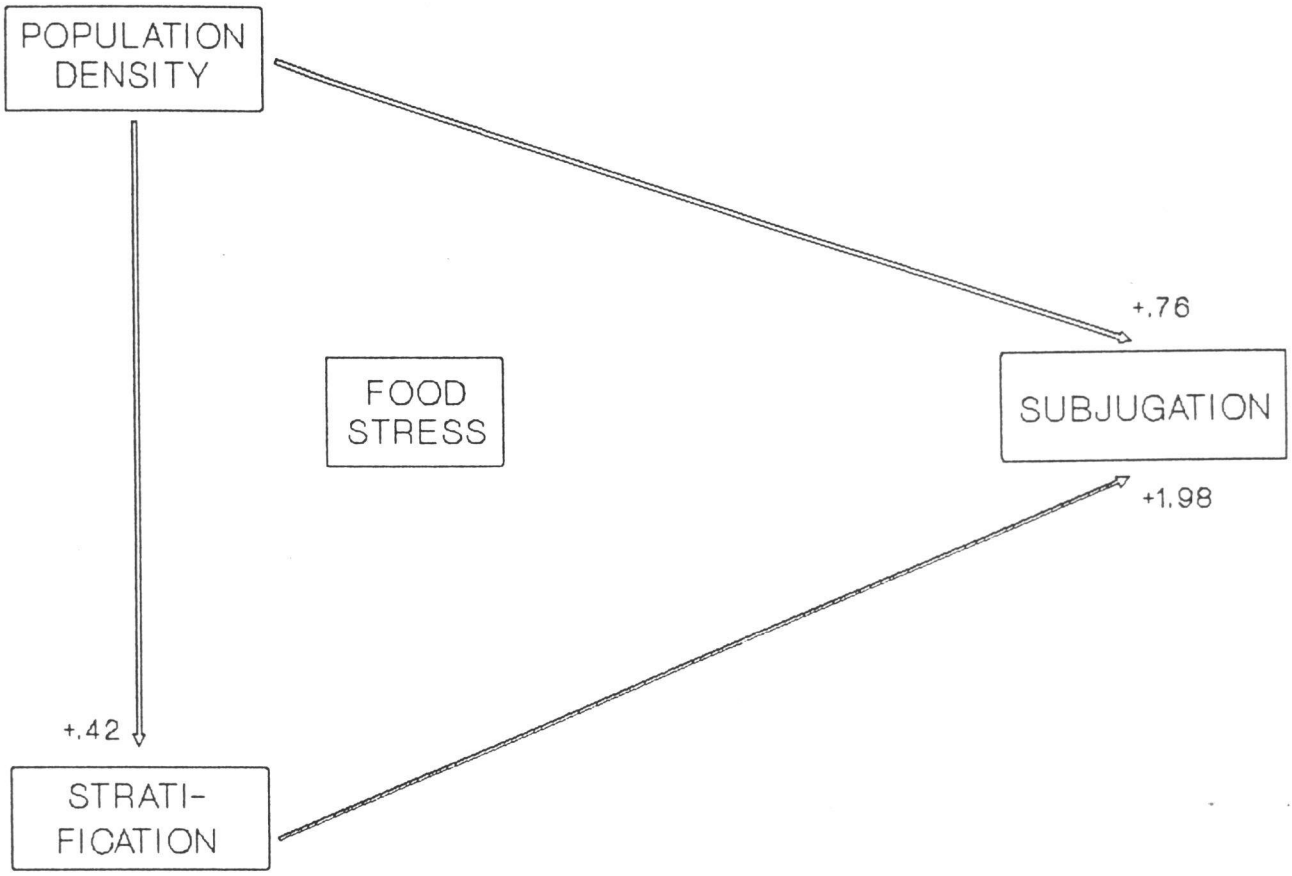

Fig. 4. Logit-model for subjugation of territory

Thus, the logged odds on practicing the subjugation of territory or people are raised by high population densities and the presence of social stratification. Both of them affect the dependent variable, net of the effects on each other. A look on the beta coefficients in Figure 4 shows, that the effect of social stratification is extremely high und two and a half times as strong as the effect of population density.

With regard to the causal effect of social stratification, the interpretation given for external wars may hold also for this dependent variable. Furthermore, the effect of stratification on subjugation of territory or people is nearly four times as high as its effect on external wars. Thus, stratification is a much better predictor for subjugation than for external warfare.

Collection of tribute

For this variable, the same model holds as for external war (model 5), meaning that the

Table 5. Logit-models for five dependent variables

No	Model	Fitted marginals	df	External war		Subjugation		Tribute		Acquis. of land		Plunder	
				L^2	p	L^2	p	L^2	p	L^2	p	L^2	p
1	Saturated Model	(PHS*)	0	.00	–	.00	–	.00	–	.00	–	.00	–
2	Independence Model	(PHS) (*)	7	12.19	.095	54.71	.000	17.23	.016	12.09	.098	28.31	.000
3	Demographical Model	(PHS) (P*)	6	10.98	.098	36.48	.000	16.84	.010	12.06	.061	22.88	.001
4	Ecological Model	(PHS) (H*)	6	9.66	.139	54.69	.000	15.48	.017	11.96	.063	22.83	.001
5	Evolutionary Model	(PHS) (S*)	6	5.35	.499	10.07	.122	4.09	.664	11.43	.076	28.11	.000
6		(PHS) (P*) (H*)	5	8.66	.123	36.48	.000	15.15	.010	11.93	.036	16.67	.005
7		(PHS) (P*) (S*)	5	5.34	.375	4.30	.506	3.47	.628	11.20	.047	20.85	.001
8		(PHS) (H*) (S*)	5	3.82	.576	8.50	.131	3.46	.629	11.19	.048	22.82	.000
9		(PHS) (P*) (H*) (S*)	4	3.81	.432	2.14	.710	2.78	.596	10.95	.027	15.57	.004
10	"System-size-Model"	(PHS) (PH*)	4	8.52	.074	35.93	.000	15.14	.004	11.94	.018	4.86	.303
11	Combination Model I	(PHS) (PS*)	4	4.51	.341	3.35	.340	2.26	.688	9.69	.040	18.33	.001
12	Combination Model II	(PHS) (HS*)	4	2.68	.612	7.35	.062	2.07	.556	4.22	.377	20.22	.001
13		(PHS) (PH*) (S*)	3	3.78	.286	2.07	.558	2.70	.440	10.93	.012	2.65	.449
14		(PHS) (PS*) (H*)	3	2.83	.419	1.33	.723	1.45	.694	9.51	.023	12.54	.006
15		(PHS) (HS*) (P*)	3	2.66	.447	1.25	.741	1.47	.689	3.76	.289	13.34	.004
16	Combination Model I & II	(PHS) (PS*) (HS*)	2	1.79	.409	.45	.797	.07	.964	2.03	.363	10.79	.005
17		(PHS) (PH*) (HS*)	2	2.35	.309	1.17	.558	1.47	.480	2.75	.253	2.56	.278
18		(PHS) (PH*) (PS*)	2	2.74	.254	1.12	.571	1.42	.493	9.50	.009	.56	.757
19		(PHS) (PH*) (PS*) (HS*)	1	1.25	.264	.00	.977	.00	.929	1.79	.181	.52	.473

effect of social stratification is sufficient to explain the data (Table 5). Furthermore, this effect is more than two times as high as on external war (Figure 5).

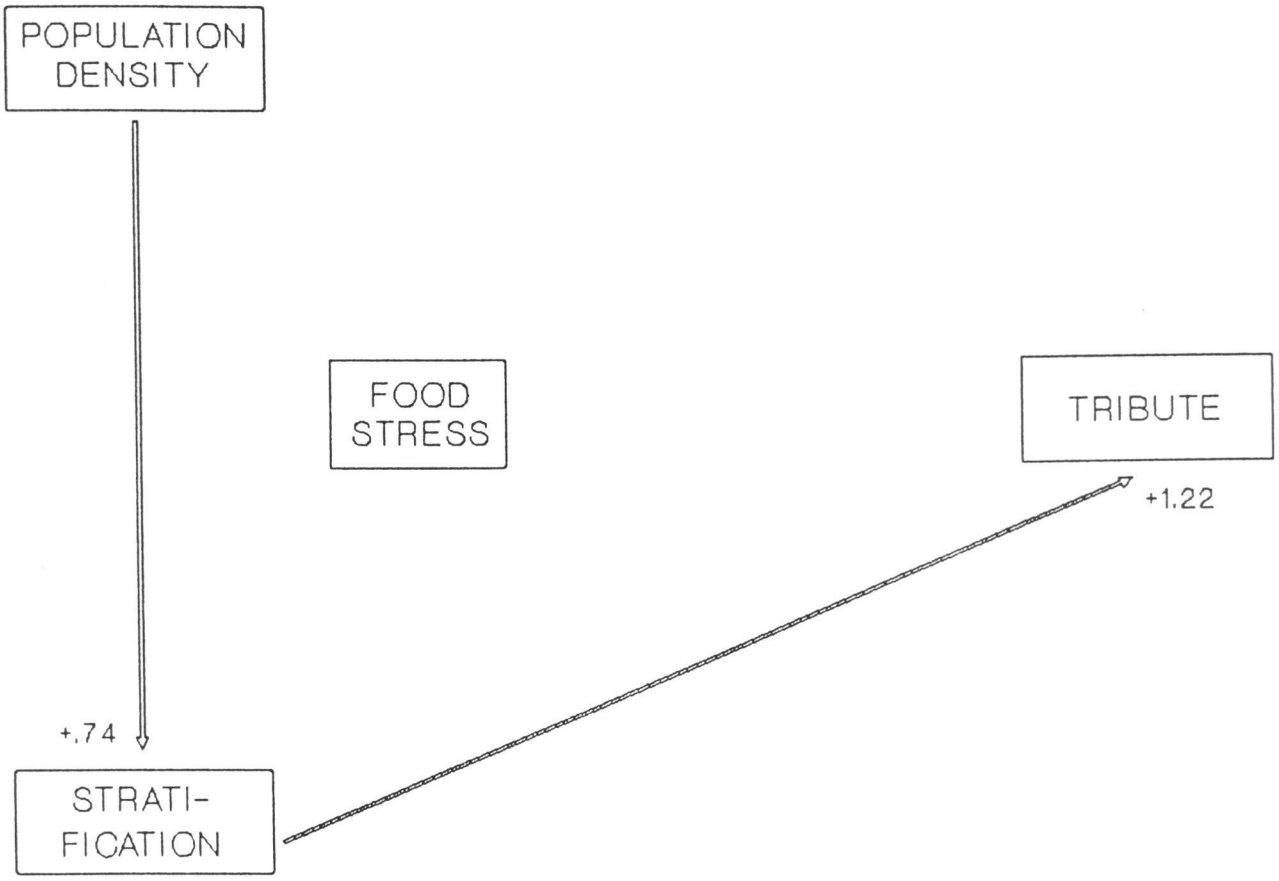

Fig. 5. Logit-model for collection of tribute

Acquisition of land

This dependent variable is perhaps the most important for a test of the land-scarcity-hypothesis. If a society in fact fights wars because of land scarcity, one would expect that these wars are aimed at the appropriation of land to get rid of the shortage.

With p = .098 for model 2, we reject the hypothesis of no interaction between the three independent variables and the acquistion of land as a motif of warfare. As can be seen from Table 5, none of the models containing only main effects (models 3 to 9) fit the data. Thus, at least one interaction effect between the independent variables will be necessary to explain the data. The most parsimonious models with interaction effects are models 10–12. Of these, only model 12, which contains the interaction between hunger and social stratification (HS*), yields an acceptable fit. It may be concluded, that those interactions involving population density – (PH*) and (PS*) – are not necessary to explain the independent variable. Neither does the addition of the main effect of population density (model 15) significantly reduce the L^2 of model 12 (ΔL^2 = 4.22–3.76 = .46, with df = 4–3 = 1). Thus, model 12 is the final model (Figure 6).

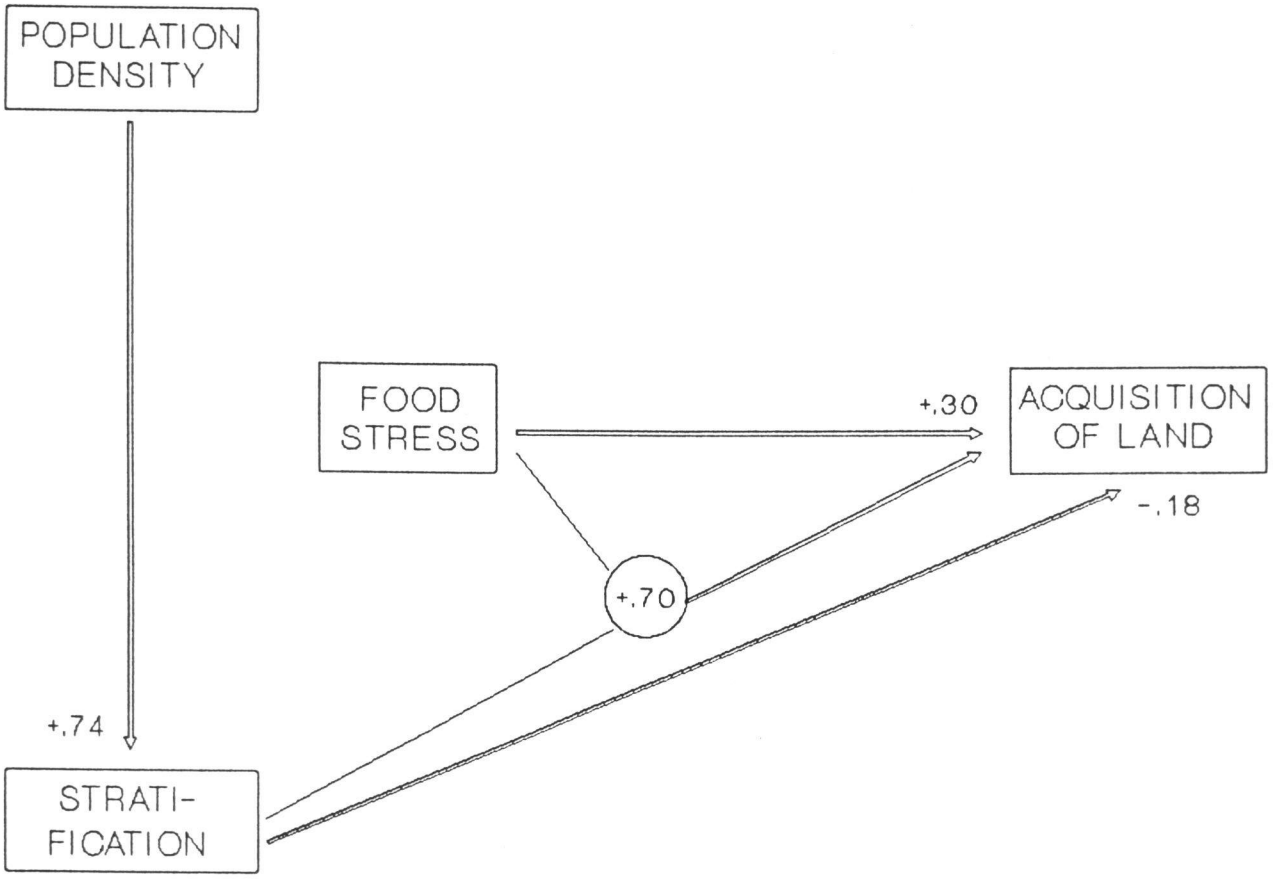

Fig. 6. Logit-model for acquisition of land

As it contains the interaction between hunger and social stratification, and the beta-coefficient for this interaction is positive for stratified societies with food stress, Combination Model II is supported. This result may be interpreted as follows: (1) The presence of food shortages raises the probability of fighting for land more for stratified societies than for unstratified ones. (2) The presence of food shortages raises the probability of not fighting for land more for unstratified than for stratified societies. Thus, societies practicing flexible distribution may indeed be able to successfully cope with famines so that violent conflict will not become necessary. Partial scarcity – a result of restrictive types of distribution – is more likely to be a cause of aggressive appropriation of productive land.

It follows further, that for this type of violent conflict the demographical explanation has to be rejected. Wars aimed at the acquisition of land can be explained without the resort to population density as an independent variable.

The single effects of stratification and hunger are rather weak in comparison to the interaction effect. Taken alone – that is, holding constant either stratification or hunger – the presence of stratification lowers the acquisition of land ($\beta = -.16$), while the occurence of hunger raises it ($\beta = +.22$). This may be interpreted that food scarcity in fact acts as the crucial impetus for stratified societies to seize new land.

Warfare for plunder

While the preceding variable measured the acquisition of land this variable examines whether the acquisition of portable goods is a goal of warfare. Here, too, none of the models with only main effects fit the data (Table 5). This is not the case, however, on the next level. Model 10, containing only the interaction effect of population density and hunger on plunder (PH*), has an excellent fit with p = .303. As the further addition of a main effect (as proposed in model 13, for example) will not significantly improve the fit, model 10 is the one to be selected (Figure 7).

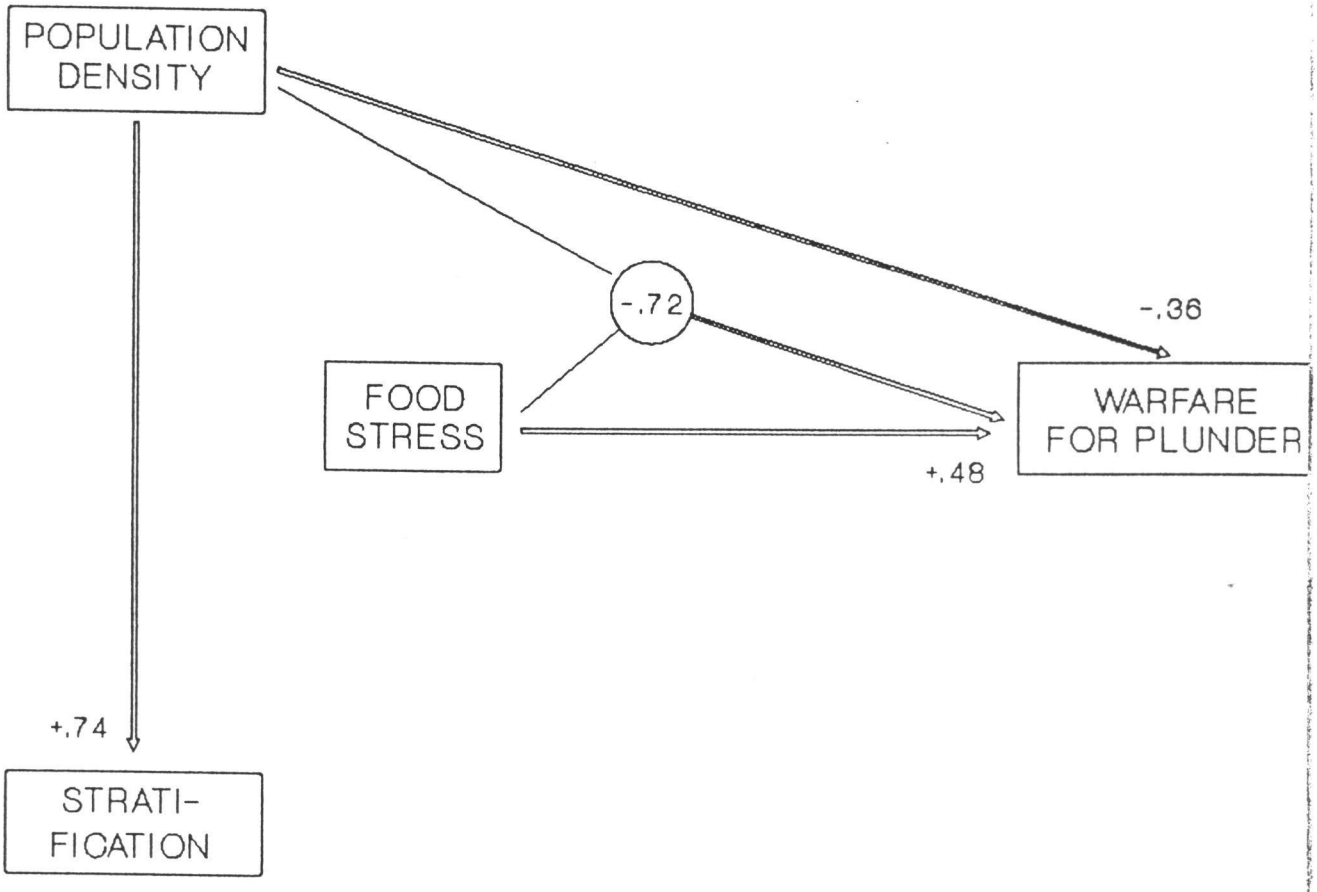

Fig. 7. Logit-model for warfare for plunder

This is a very interesting result, since it equals the rejection of a socio-ecological explanation of plunder. As can be seen, plunder can be predicted without resort to social stratification. Moreover, the uncovered interaction effect of population density and hunger at first glance even promises to support the demographical explanation. However, this promise turns out to be a false one. The beta-coefficient is negative both for the interaction effect (PH*) and the main effect of population density (P*), while it is positive for hunger (H*). Thus, the presence of food shortages raises the probability of warfare for plunder more for societies with *low* population density than for societies with high density. Finally, it should be added that the single effect of food stress on the dependent variable is somewhat stronger than the single effect of population density,

and more than twice as high in this model than in the preceding one for land-acquisition. The interaction effects in both models are equally strong.

Statistical power of the models

Statistical power (or, the control of the ß-error) is a long neglected topic in anthropological research (Schweizer and Lang 1989). The statistical power of a test is defined as 1−ß. ß is the beta-error, that is, the probability of rejecting the alternative hypothesis though it is true. E.g. if the level of the ß-error is considered to be 10%, the power of the test is 1−ß = 90%. In other words: the probability that the hypothesis is true is 90%. The power of a log-linear model depends upon four parameters: sample size, degrees of freedom, the specified α-level and a critical effect size "w". "W" measures how strong the alternative hypothesis deviates from the null-hypothesis. A log-linear model *exactly* fits, if w = 0. Cohen (1988: 224) distinguishes small (w = .10), medium (w = .30) and large (w = .50) w values, and suggests w = .10 for strong tests. As this would make necessary a sample size of over 1500 cases to attain 90% power at α = 5%, more liberal effect sizes have to be accepted when working with the SCCS.

Table 6. Power of six models for W = .30 and α = 5%

Models	N	u = df	Power
Independent variables	135	2	85%
Landacquisition, Plunder	125	4	75%
Subjugation	125	5	70%
Tribute	125	6	70%
External war	117	6	65%

Table 6 shows the power of the six logit-models for w = .30 and α = 5%, approximately determined according to the power tables in Cohen (1988: 259). Thus, with more than 75% the logit models for the acquisition of land and plunder yield more power than the other models for violent conflict. This power value comes close to 80% with α = 5%, which Cohen suggests as a convention. It can be concluded, that at least for these two dependent variables as well as for the interaction of the independent variables, the statistical results are robust enough to warrant the acceptance of the discovered models.

Discussion

Some comments are necessary with regard to the role of the variable "population density" in the respective models. First, the fact that plunder is conducted by low-density societies with food shortages contradicts the assumption of the demographical explanation. This result indicates that population density cannot be taken as a measure of

population pressure or land scarcity in cross-cultural comparisons. I argue that this type of violent conflict is the least costly type of aggression (and often the last choice) low density societies may have to secure more food: it is confined to the appropriation of movable property, and thus can be conducted by small raiding parties. Second, the positive relationship between population density and the subjugation of territory or people should not be taken as a confirmation of the demographical explanation. This type of violent action implies the enlargement of the aggressor's territory, but as the subjugated are not driven out of their lands, the man-land ratio remains the same for both territories. Hence, no release of population pressure takes place, as implied by the demographical explanation. Here, a system-size perspective can be adopted, too. To subjugate a people means to have the necessary man-power – that is, administrative functionairies like collectors of tax or tribute, a standing army or police etc. – to exert long-time hegemonial control over it. Thus, high density societies have an opportunity that low density societies are lacking. System size, then, sets the frame for the type of violent conflict a society may choose. It is clear, however, that system size as such is

Table 7. Correlations between ten conflict variables

		768	773	774	891	892	909	910	911	912
	tau	.52	.43	.08	.24	.03	.06	.05	.26	.28
767	n	89	85	84	82	81	84	84	84	84
	p	.00	.00	ns	.00	ns	ns	ns	.01	.01
	tau	–	.78	.24	.46	.10	– .02	– .01	.08	.45
768	n		84	83	81	80	83	83	83	83
	p		.00	.01	.00	ns	ns	ns	ns	.00
	tau	–	–	.28	.53	.20	.04	.05	.11	.44
773	n			82	77	76	79	79	79	79
	p			.00	.00	.02	ns	ns	ns	.00
	tau	–	–	–	.13	.53	.03	.17	.32	.34
774	n				76	76	78	78	78	78
	p				ns	.00	ns	.01	.00	.00
	tau	–	–	–	–	.14	– .04	.00	.04	.19
891	n					146	155	155	155	155
	p					.03	ns	ns	ns	.01
	tau	–	–	–	–	–	.12	.20	.23	.39
892	n						153	153	153	153
	p						.05	.00	.00	.00
	tau	–	–	–	–	–	–	.29	.05	– .11
909	n							168	168	168
	p							.00	ns	ns
	tau	–	–	–	–	–	–	–	.20	.19
910	n								168	168
	p								.01	.01
	tau	–	–	–	–	–	–	–	–	.16
911	n									168
	p									.02

not sufficient as a cause for the subjugation of a neighboring group. Further research will have to uncover possible interaction effects of this variable and other ones not considered here.

Finally, some remarks are necessary about the interdependencies between the dependent variables. It should be kept in mind, that only one of the five models discussed above relates to a collective violent *action*. The other four originally have been designed to measure the material *motives* of warfare (Nammour 1975: 268) – though a neat distinction between the two will certainly not be possible with regard to the sources in the SCCS.

Table 8. Logit-equations for five models

Subjugation	Φ_{11}^*	=	b^*	+	$b_1 P^*$	+	$b_1 S^*$	
		=	−2.34	+	0.768	+	1.974	
		=	0.399	=	Ln (17.36/11.64)			
Tribute	Φ_1^*	=	b^*	+	$b_1 S^*$			
		=	−2.450	+	1.226			
		=	−1.224	=	Ln (10/34)			
External war	Φ_1^*	=	b^*	+	$b_1 S^*$			
		=	0.504	+	0.532			
		=	1.036	=	Ln (31/11)			
Acquisition of land	Φ_{11}^*	=	b^*	+	$b_1 H^*$	+	$b_1 S^*$	+ $b_{11} SH^*$
		=	−1.980	−	0.178	+	0.228	+ 0.692
		=	−0.356	=	Ln (14/20)			
Plunder	Φ_{11}^*	=	b^*	+	$b_1 H^*$	+	$b_1 P^*$	+ $b_{11} PH^*$
		=	0.606	+	0.470	−	0.350	− 0.726
		=	0	=	Ln (18/18)			

Index:

P = Population density (V64) (dichotomized at the median)
1 = high (categories 5–7)
2 = low (categories 1–4)

H = Hunger (V678) (dichotomized at the median)
1 = high (categories 2–4)
2 = low (category 1)

S = Stratification (V270) (dichotomized; category 3 "elites" has been omitted, as it contains only 3 cases)
1 = stratified (categories 4, 5)
2 = not stratified (categories 1, 2)

* = Represents the dependent variable in each model

Φ = Logit (natural logarithm of the expected odds of the dependent variable)

b = Beta-coefficient, can be interpreted as the unstandardized beta-coefficient of ordinary regression analysis

The statistical results demonstrate that scarcity is no cause of *internal* violent collective action, which would be a very valuable insight by itself. Such a conclusion implies, however, that the appropriation of resources as a goal of warfare means plundering or seizing the land of *other* societies or political communities. Table 7 shows, that this is not the case. Plunder is significantly related to all other forms and material motives of violent conflict, except the subjugation of territory or people, and especially the correlations with internal violent conflict are very high. On the other hand, the acquisition of land is significantly related primarily to external warfare. As already suggested above, the subjugation of territory or people can be regarded to be conceptually distinct from all other variables besides the collection of tribute.

Conclusion

The aim of the present study has been a test of alternative theories related to the scarcity-hypothesis in anthropological conflict research. None of the previous explanations, based on one-dimensional concepts of scarcity, could be confirmed by the data. On the other hand, the socio-ecological explanation developed in this paper proves to be valid for an explanation of the crucial dependent variable, the acquisition of land. Further, three other types of violent conflict or its motives – external warfare, subjugation of territory or people and collection of tribute – turned out to be determined primarily by internal societal antagonisms, rather than demographical or ecological factors. Only plunder may be predicted whithout taking into consideration social stratification. However, the appropriate model contains an unexpected interaction effect, which has not been foreseen by the socio-ecological argument and which runs counter to the causal mechanisms underlying the demographical explanations.

While the present study could demonstrate the general validity of a socio-ecological explanation of violent conflict, the results are far from complete. The measurement of distributional flexibility or restriction had to recur on an existing and rather approximate measure, social stratification. Some new variables have been constructed which shall provide more fine grained measures of this phenomenon as well as for land-scarcity, and coding is currently underway.

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