14. Risk and uncertainty in the 'original affluent society': evolutionary ecology of resource-sharing and land tenure

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Introduction

Ecological anthropology has as its primary goal the development of a body of theory capable of generating explanations for cross-cultural and historical variation in human social behavior — that is, explanations that have a more than local application. In pursuing this task, anthropologists have always leaned heavily on theoretical developments in biological ecology, with varying results (Vayda and Rappaport 1968: Orlove 1980; E.A. Smith 1984a). The ecological orientation has been particularly strong in anthropological analyses of societies whose economies are based on foraging or simple agriculture. The studies of foraging societies in the 1960s and 1970s were characterized by reliance on the very simple but initially useful concepts of 'cultural ecology' developed by Steward (1955) and those he influenced (for example, various contributors in Lee and DeVore 1968b; Bichierri 1972). While this approach is still in current use, more recent analyses of hunter-gatherer economies have emphasized the political and dynamic aspects of these systems, and place more reliance on paradigms from Marxism, economics, and evolutionary ecology (for example, Barnard 1983; Leacock and Lee 1982; Schrire 1984; Williams and Hunn 1982; Winterhalder and Smith 1981). This chapter draws its theoretical inspiration from the latter two paradigms, though, unlike many commentators, I do not see these as being so estranged from at least some varieties of Marxism (an argument that I do not have time to develop here).[1]

1. An earlier version of this chapter was presented at the Wenner-Gren Conference on 'Risk and Uncertainty' organized by Elizabeth Cashdan and myself. I thank the participants, especially Bruce Winterhalder, Cashdan, Hillard Kaplan, and Dave Stephens, for their helpful comments. Rob Boyd, Cashdan, Tim Ingold, and Nicolas Peterson offered detailed comments on the manuscript, for which I am grateful. Michael Taylor stimulated me to take a more systematic approach to strategic interaction, which I'm afraid is barely begun here.

While ecological analysis of the interaction between organisms and aspects of their environment is often limited to relatively short-term, homeostatic approaches, beginning with Charles Darwin's work it has been clear that the theory of natural selection can powerfully illuminate the ways in which living creatures adapt to their environments. Accordingly, in recent decades large segments of ecology and evolutionary theory have merged into a single discipline termed 'evolutionary ecology' (reviewed in Pianka 1983; May 1981; Roughgarden 1979). More recently, aspects of economic theory, particularly neoclassical decision models and game theory, have been borrowed or reinvented in attempts to deal with certain aspects of the evolutionary ecology of animal behavior (Krebs and Davies 1984 provides the best single review).

The early work in behavioral ecology involved deterministic models (in the mathematical sense of the term) that assumed — for simplifying purposes — that actors possess perfect information, and were concerned only with the *average* payoff of different choices; but more recent work has paid increasing attention to uncertainty and risk (concepts discussed below). In addition, evolutionary ecologists have come to realize that whenever fitness is frequency-dependent (for example, due to social interaction), the simple notion of optimality must be replaced with the strategic notion of game-theoretical equilibrium or evolutionary stability (Dawkins 1980; Maynard Smith 1982). Anthropological applications of evolutionary ecology have primarily drawn on the simpler 'classical' models of deterministic optimization (review in E.A. Smith 1983b), but there are good reasons for suggesting that the theory of risk and uncertainty developed by economists and evolutionary ecologists, as well as the theory of strategic games or evolutionarily stable strategies, be incorporated within ecological anthropology.

What are these reasons? First, as I argue in detail below, there are several phenomena, widespread among hunter-gatherers and of considerable anthropological interest, that cannot be fully understood without invoking risk, uncertainty, and strategic interaction: sharing of food, information and other resources, as well as certain patterns of land tenure and intergroup relations.[2] While the importance of these factors has long been recognized in an intuitive way, the position taken here is that anthropological emulation of the more rigorous and systematic treatment of risk and uncertainty developed in economic and ecological theory will significantly improve our explanation of why

2. There are a number of phenomena in non-market societies where consideration of the impact of risk and uncertainty would provide useful analytical elements. Among such topics that are *not* examined here are production strategies, demography and political organization. Furthermore, in keeping with the focus of this volume and the conference that spawned it, the substantive analysis is restricted to societies with foraging economies (though I see no compelling theoretical basis for restricting the general approach in this manner).

these social and ecological practices take the forms they do, and vary in the manner they do, from one time and place to another. Second, many anthropologists have criticized the use of ecological and economic models for ignoring the impact of imperfect information and subsistence risk, as well as the importance of social constraints on individual choice (see discussion in E.A. Smith 1983a). I hope to show that, to a large extent, these criticisms can be blunted without giving up the demonstrable virtues of simple, precise, and testable models anchored in general evolutionary and economic theory.

In fact, my argument is that by paying greater attention to the impact of risk and uncertainty on individual choice, one is compelled to pay explicit attention to social interaction and structural constraint. This means that two quite distinct attributes of that perennial whipping-boy, Economic Man — his omniscient focus on the Main Chance, and his Robinson Crusoe-like individualism — are dialectically linked, such that abandoning one undermines the other. Yet, as should be clear in what follows, I do not adopt the dominant stance of contemporary sociocultural anthropology in rejecting the analytical utility of general premises of economic choice and ecological adaptation, putting in their place historical indeterminacy and epistemological relativism. The model of the strategic actor that replaces Economic Man herein is humbler in information endowment and buffering abilities, and more constrained by those summed actions of others that we term 'society'; yet I contend she or he has attributes and takes actions that are illuminated in unique and powerful ways by the abstract models of evolutionary ecology and economics.

This chapter is organized as follows: the next section briefly states the central theoretical assumptions employed, and defines the main characteristics of risk and uncertainty as developed in economics and evolutionary ecology. The following section uses this theory to analyze variation in land tenure, interband visitation rights, and resource exchange as strategies of risk reduction. The final section examines the effect of uncertainty on such strategies, in particular the problems for evolutionary stability and collective provisioning of goods raised by sharing and visiting rights, and offers a reassessment of current views on these issues. Throughout the last two sections, I endeavor to bring out the commonalities and contrasts between the arguments derived from evolutionary and economic theory, and those developed for the most part independently by anthropologists; however, I caution that space and time constraints present me from offering a comprehensive or even extended review of the anthropological literature on these topics.[3]

3. Recent reviews focusing on these topics to one degree or another include Barnard (1983), Cashdan (1983; 1985), Hayden (1981), Ingold (1980), Kaplan and Hill (1985), Layton (1986), E.A. Smith (1981; 1985), Wiessner (1982), Winterhalder (1987 and in press), and Woodburn (1982a).

Evolutionary ecology, economics and risk: some general points

Central theoretical assumptions

In common with a growing body of investigations in anthropology, this chapter adopts the general theoretical orientation of evolutionary ecology in analyzing variation in human social behavior. The central (not necessarily unique) tenets of this approach can be stated rather baldly as follows:

(1) Methodological individualism. Social and ecological processes at the level of groups and populations can be analyzed most fruitfully as the result of the actions and motives of the component individuals making up these larger groupings.
(2) Optimization. Many properties (goals, attributes) of individuals can best be understood using the theory of natural selection; selection favors strategies of behavior that exhibit maximum *fitness* (replication rate) or *evolutionary stability* (cannot be outcompeted in a population of interacting strategies) relative to competing strategies.
(3) Deductive modeling. Simple, abstract models are useful tools for generating expectations with broad generality; general theory is often best constructed in a 'piecemeal' manner, by combining these simple models and empirical tests into larger sets of theories and findings.
(4) Phenotypic strategies. Most behavioral strategies, while influenced by inherited instructions (genes or culture), take the form of 'decision rules' or conditional strategies rather than being automatic, invariant actions.

Though this is not the proper place (and there is not room) to explicate and defend these principles in detail, some expansion and clarification is called for. The first tenet stated above, that of methodological individualism, may strike many readers as unproblematic, if unremarkable. It holds simply that

> all social phenomena (their structure and their change) are in principle explicable in terms of individuals — their properties, goals, and beliefs. This doctrine is not incompatible with any of the following true statements. (a) Individuals often have goals that involve the welfare of other individuals. (b) They often have beliefs about supra-individual entities that are not reducible to beliefs about individuals . . . . (c) Many properties of individuals, such as 'powerful', are irreducibly relational, so that accurate description of one individual may require reference to other individuals (Elster 1982: 453).

But even so, methodological individualism entails a set of procedures and an explanatory logic rarely followed by anthropologists, and is in fact actively resisted and disparaged.[4] The alternative view — that sociocultural variation is best explained in terms of functional consequences for supra-individual entities (communities, societies, cultures, even ecosystems) — has been the more common anthropological position, although atheoretical description or intuitive eclecticism (a bit of self-interest here, a batch of group functionalism there) is even more common.

There are two advantages to the stance of methodological individualism (in addition to the arguable advantage of being explicit and consistent about one's assumptions and procedures!). (1) Since (barring future revelations) supra-individual entities lack will or consciousness — that is, since there is no existing basis or mechanism for imbuing social change (or stasis) with its own motive power or rationality — the characteristics and dynamics of such entities must be explained in terms of the actions of conscious, individually motivated actors *or* in terms of some process of evolutionary change (which also normally requires attention to the properties of individuals). This means that explanations in terms of supra-individual function, while they may often be empirically supported, must necessarily be logically incomplete. In order to avoid spurious explanations, then, we must develop 'micro-foundations' that account for social structures and dynamics in terms of the properties and interactions of individuals (given their endowments and environmental context). (2) Adopting the stance of methodological individualism frees the anthropologist to adapt theories and models from economics and evolutionary biology (including game theory), or to invent new ones partaking of the same methodological individualist procedures. This is no panacea, but I submit that there is no comparably rich and methodologically sound source of explicit, testable theory.

To briefly anticipate some probable objections: against (1), it is often argued that methodological individualism supposes that actors always pursue their own material self-interest, but that this is belied by the

4. One currently popular rationale for rejecting methodological individualism (MI) is the charge that it reflects (and functions to support) conservative or bourgeois conceptions of the social order. Two brief comments on this: (1) While neoclassical economics is officially wedded to MI, and neoclassical economics is often used to support a conservative political agenda, bourgeois ideology *in general* does not generally involve (nor does it require) MI. Indeed, I submit that conservative political arguments more frequently hinge on a group-level functionalism, or at least on a poorly supported 'invisible hand' argument (see text, *infra*), than on MI *per se*; in any case, explicit adherence to MI can seriously undercut conservative arguments on the social value and progressive improvement resulting from unconstrained competition (for one such critique, see Hirshleifer 1982). (2) Those who assume that the class functionalism and anti-MI stance of classical Marxism is unproblematic should consult recent challenges to that stance emanating from within Marxism itself (especially Elster 1982; 1985; Roemer 1982a; 1982b). As this literature convincingly argues, the virtues of MI in providing solid explanatory 'micro-foundations' for larger patterns of historical and political process are available to all but the most dogmatic Marxists, and need not be monopolized by supporters of the bourgeois status quo.

cross-cultural evidence for altruism, ascetism, collective solidarity, and so on. To the contrary, methodological individualism by itself entails no specific assumptions about the *content* of individual goals and actions — that, indeed, is its signal lacuna, and the reason it is a methodological (rather than theoretical or empirical) element, which must be supplemented with theory that does predict something about the content of goals and actions. Both proponents and opponents of (1) frequently assume that one can move directly between individual preference and collective outcome, but this is often — perhaps usually — mistaken. Individual actions have many unintended consequences, some of which may be unperceived or (if the costs they impose fall either on someone for whom the source actor has no concern — 'externalities' — or fairly equally on the social group as a whole — 'collective bads') ignored by the source, even if harmful. Such consequences are not the goals of the actors who produce them, though they may have a considerable or even critical effect on the collectivity. More important, there are strong theoretical and empirical reasons for expecting that individual preference is often thwarted or constrained by the preferences and powers of others; as a consequence, one needs specific theoretical tools (such as game theory) to follow the often twisted path between individual intention and social outcome, though — as methodological individualism would predict — it is generally easier to follow the path from source (individual actors) to destination (social structure or process) than the reverse. Finally, against (2) it is often argued that anthropologists should not borrow theory from other fields (such as economics), and certainly not from natural sciences (such as biology); while admitting that in specific instances such borrowing can be inappropriate or even disastrous, I see no valid a priori grounds for adhering to such a prohibition.[5]

The use of optimality theory in analyzing ecological and behavioral phenomena is a complex and controversial topic, and there is a large body of literature covering theory, empirical results and critiques.[6]

5. There are two styles of argument against such interdisciplinary borrowing, one opposed in general, and the other opposed specifically to biology as a source of understanding human social behavior. The former often cautions that the donor discipline will set the agenda for the borrowing discipline (see Keene 1983). This claim, if true, is only a valid criticism if such an agenda is inferior to the existing one. In any case, it seems quite artificial to hold up a historically specific, transitory, and not necessarily rational division of contemporary Western academia as some sort of Platonic ideal or optimal arrangement; such an argument seems especially ironic when it comes (as it so often does) from Marxists or cultural determinists. The second stance, critical of biology, is in my experience usually based on a misinterpretation of what the application of evolutionary biology to humans entails. The notion that ecological models developed by biologists are necessarily 'mechanical' (Lee 1979: 434) in denying human consciousness a role, or that they focus on purely material processes and hence leave out intentionality or socially-informed motivations (Ingold, this volume), are examples of such misinterpretations, as I argue further in the text.

6. I refer the reader to the now classic papers collected in Sober (1984 — esp. Maynard Smith 1978; Gould and Lewontin 1979), the recent conference proceedings edited by Dupre

Evolutionary ecology and optimality theory have become so intertwined in recent years (at least in analyses of behavior) that there is a danger of putting the cart before the horse, and forgetting that optimization and game theory are really just techniques — albeit powerful ones — for constructing and testing evolutionary explanations (Maynard Smith 1978). Since Darwin, natural selection has been recognized as the primary engine of evolutionary change, and hence as a critical element in any naturalistic attempt to explain the diversity of living things. Since natural selection favors variants with greatest relative fitness (replication rate), and since fitness is a correlated feature of phenotypes designed for effective survival and reproduction, it is quite understandable that biologists should have turned to techniques such as optimality theory in order to formalize their predictions about evolutionarily successful design. But to repeat, in evolutionary explanations these techniques have no justification or theoretical status independent of this broader aim; they are means, not ends in themselves.

In evolutionary biology, an optimal strategy is the one of a set of feasible alternatives that yields the highest fitness (to its possessors) in comparison with other strategies, and is hence the one favored by natural selection acting on individual variants (though other evolutionary forces, such as group selection or drift, can in principle override this selective advantage). An evolutionarily stable strategy (ESS) is 'uninvadable' by alternative strategies, and is used in place of optimality whenever the fitness payoff to any strategy depends on its frequency (commonness or rarity) in the population. Put another way, optimality models are simpler, and thus preferred *if* (and only if) the payoff to any actor does not depend on what other actors in the population or social group are doing; otherwise, an ESS model is needed.

An ESS yields higher fitness relative to competing strategies when the population is at *equilibrium* (has ceased evolving with respect to the set of strategies in question); but, in contrast to simple optimality, an ESS may not be the strategy that started off with the highest fitness payoff, and the ESS equilibrium may even be a *mix* of strategies. ESS/game theory is an important tool for grasping the critical role of methodological individualism in framing explanations of social phenomena. Game theory shows us *why* we can expect that (1) some socially beneficial results will be by-products of the action of self-interested individuals (the 'invisible hand' theorem), but also why it is

(1987) and the several anthropological review articles on the topic (Foley 1985; Jochim 1983; Keene 1983; E.A. Smith 1983a; 1987; Winterhalder 1981 and in press; and J.F. Martin 1983 v. Smith and Winterhalder 1985). Almost all of the anthropological papers concern optimal foraging models, which accounts for the common misconception that all optimality theory in evolutionary ecology deals with feeding; however, I suspect that optimality and game-theoretical analyses of human mating systems, demography, and politics are destined to overtake foraging applications.

that (2) even when individuals all prefer some collective outcome, they may not be able to realize it through social interaction (the 'back of the invisible hand' theorem — Hardin 1982). (These game-theoretic insights are illustrated with ethnographic examples below.)

Optimality and ESS models provide formal techniques for analyzing the likely outcome of natural selection (or rational choice) in specific ecological and social contexts. I have discussed the rationale for employing simple, abstract models in studying complex social and ecological phenomena elsewhere (E.A. Smith 1983a), and will not repeat that discussion here. Let me simply state that while I agree that such models — and indeed any abstract representations of reality — are imperfect caricatures of actual processes, only the most radical form of empiricism would reject them on those grounds. Of course ecological models omit elements that are present in reality; a model by nature represents a hypothesis about which few of a vast array of factors are major determinants of the particular phenomena of interest. Any particular such hypothesis may be wrong, but the strategy itself is not thereby discredited. The important issue is whether the models assist us in our attempts to understand general patterns in the real world. That question cannot be answered in advance of the systematic application of such models (unless it can be shown that the models are either logically flawed, or make assumptions that lack even a rough correspondence to reality).

Finally, there is the question of the applicability of evolutionary theory to human social behavior. Out of the rather troubled sea resulting from all the ink spilled on this matter, I would pluck three points germane to this chapter. First, there is no need to see a narrow kind of genetic determinism either as being required to justify use of natural selection theory, or as following from it; both cultural inheritance and individual decisions can be given a place in the scheme (E.A. Smith 1983a; 1983b; Boyd and Richerson 1985; Durham 1988). Evolutionary ecologists do not expect that selection typically shapes the behavioral strategies of a population by acting on specific genes that link to specific behaviors; rather, the expectation is that genetic variation (and hence selection) influences behavior by modifying the expression of what are termed 'decision rules' (see Krebs 1978) or conditional strategies (Dawkins 1980). Such strategies involve (1) environmental assessment, (2) cognitive processing (which can in principle be as complex as a given creature's brain will allow) and (3) alternative courses of action chosen (either consciously or not) on the basis of the expected fitness payoffs. In effect, the models assume that selection has designed organisms to say 'If the environment or payoff matrix looks like X, then do Y'. This is a far cry from most anthropologists' notion of 'genetic determinism'. In the human case, not only is cognition extremely complex, involving what we intuitively perceive as consciousness and intentionality, but selection and evolution act through a cultural channel that is independent in some senses from the genetic channel.[7]

Second, evolutionary arguments are necessary components of any full account of variation in human behavior. There exists a long-standing reluctance — understandable in the face of the distortions and falsehoods of racism and 'social Darwinism' — to employ natural selection explanations to account for our own behavior. In avoiding Darwinism, social science has been able to point to two causal agents — conscious choice and cultural inheritance — as alternative design agents that are unique, or at least uniquely developed, in our species. But ultimately, these both require an evolutionary underpinning: choice must be based on preferences, and utilize cognitive machinery, that were inherited (culturally or genetically) by the actor; and cultural constructs are themselves subject to evolutionary change, including natural selection (Boyd and Richerson 1985). The incompleteness of rational choice or cultural inheritance as explanatory schemes thus provides a justification for applying evolutionary theory, and particular techniques such as optimization models, to human social behavior.

Third, most of the principles discussed in this chapter have clear analogues in other fields of inquiry, including especially neoclassical economics; what is specific to the evolutionary approach is the attention to *fitness consequences of strategic action*, rather than criteria such as wealth or subjective utility. Much of the reaction against evolutionary ecology within anthropology dwells on the uniqueness of human action, but the critics frequently fail to realize that the propositions they are arguing against are in many cases at least shared with certain traditions in social science, and sometimes directly derived from them. This does not make these propositions correct, of course, but it does deflect the charge that they must be wrong because they are based on an understanding of non-human species.

What are risk and uncertainty?

The concepts of risk and uncertainty are associated with stochastic processes — that is, variation in outcomes that cannot be controlled by the decision-maker. Following Knight (1921) and Hey (1979), Stephens and Charnov (1982) have suggested the following analytical distinction be made between risk and uncertainty: problems of risk concern the effects of stochastic variation in the outcome associated with some decision, while uncertainty refers to the lack of perfect information that afflicts decision-makers. As Stephens and Charnov recognize, in the real world many decision problems may include both risk and uncertainty; yet theory-building requires that we simplify the world in useful ways, and a separate consideration of risk and uncertainty is such a useful simplification.

Thus, whereas some decision theorists define the distinction between risk and uncertainty in terms of psychological states — does the actor have any probability estimates of the outcome, subjective or not? — the perspective adopted here (see also E.A. Smith 1983a) views this distinction in more instrumental terms. Risk then refers to the degree of stochastic variation in decision outcomes, while uncertainty refers to the stock of information that an actor has. Exactly how to define and measure risk is a matter of some controversy (see, for example, Roumasset *et al.* 1979; Hey 1981), but all technical definitions involve some measure of statistical dispersion.[8] Many decision problems may involve both risk *and* uncertainty, but problems of 'pure risk' do not necessarily indicate uncertainty on the part of the actor. Under conditions of risk, an actor may have a good notion of the probability distribution of outcomes for different choices, or may even know the outcomes with certainty, but must still deal with the fact that the value of the outcomes varies. Hence differential riskiness can affect the utility of different outcomes even when information is perfect, as long as the actor cannot use this information to eliminate risk altogether.

Economic and ecological theory leads us to expect actors to be risk-*seeking* under some conditions, but a comparable desire for increased uncertainty is not expected. Accordingly, actors may respond to risk by attempting to avoid it or to buffer it or (in certain cases) by seeking more of it; they respond to uncertainty by attempts to reduce it via collection of more information. In each case, the cost–benefit trade-off that defines the optimality problem differs: for problems of risk, the trade-off is between the mean value of an outcome and the variation in this value, and the optimum is determined by the shape of the actor's utility (or fitness) function; with uncertainty the trade-off is between the value of additional information (in raising, for example, the mean value of the outcome) and the cost of obtaining this information through search or social interaction. These basic distinctions between risk and uncertainty as I use the terms here are outlined in Table 14.1.

7. The question of when cultural evolution will parallel genetic evolution (but proceed at a faster rate), and when it will follow trajectories that deviate widely from those predicted by fitness maximization or ESS considerations, is as yet a difficult and unanswered one (Boyd and Richerson 1985; Durham 1988; Flinn and Alexander 1982; Pulliam and Dunford 1980). Part of the procedure for answering this question should involve systematic testing of predictions from evolutionary ecology, with no dogmatic bias for or against its applicability to human behavior. That is the position I have taken in my own work, including this chapter, although I personally feel that significant and lasting deviations from these predictions probably do occur as a result of cultural evolution, and will prove important in future analyses.

8. Note that an alternative definition of risk — the probability of coming home empty-handed, or more generally the probability of falling below some minimum threshold — differs from the technical meaning adopted here (cf. Winterhalder 1987: 383f.). As should become clear once the risk model has been presented, risk in the colloquial sense can be subsumed under the technical meaning, but technical risk can persist even when the payoff mean or range lies above some viability or expectation threshold.

Table 14.1: Contrasts between strategies dealing with risk and those dealing with uncertainty

	Risk	Uncertainty
Measured in units of:	'Income' variation	Information
Optimal strategies maximize expected value of outcome?	No	Often yes
Can actors ever benefit from increased levels?	Yes	No
Adaptive response:	Avoid, buffer, or seek out	Reduce via collection of information
Effect of complete information:	Possibly none (risk may persist)	Uncertainty eliminated or greatly reduced
Optimality trade-off:	Mean v. variation in income	Benefits of information v. cost of obtaining

In the following two sections I consider how economic and ecological theories that incorporate the concepts of risk and uncertainty and employ evolutionary game theory can be used to explain variation in hunter-gatherer social behavior involving land tenure and property rights, exchange of resources, and closely related aspects of social relations. While all these topics have concerned anthropologists for some time, they have rarely been considered within the unifying perspective of decision-making (or selection) under conditions of risk and uncertainty.[9]

Environmental risk and resource-sharing

Risk and sharing

Foraging is often an inherently risky and uncertain proposition: risky because for many resources (especially large game) capture often eludes the forager, and because when it is successful there may be a temporary glut; uncertain because the location, abundance, ripeness,

9. The work of Wiessner (1977; 1982) and Cashdan (1985) is notable in its systematic attention to the impact of risk on the social behavior of foragers. While inspired by their work, I have adopted my theoretical framework from evolutionary ecology and ESS/game theory, in contrast to Wiessner and Cashdan, who employ economic insurance theory. The resulting convergences as well as divergences are a matter not taken up directly here.

or behavior of the resource may be unpredictable over the short or long term. Dealing only with risk, we can ask how any actor might in fact reduce risk from variable foraging outcomes. There would appear to be five distinct (but not mutually exclusive) options: (1) alter foraging practices (for example, select less risky prey); (2) store resources on good days and consume these stores on bad days; (3) exchange some portion of resources for durable goods and exchange the goods for resources at some future time, in a manner similar to (2); (4) pool resource harvests with a sharing network prior to consumption; and (5) move to a locale with either lower variance in foraging returns, or a higher mean return. All of these options are ethnographically described for hunter-gatherers, often in simultaneous combinations, although (1) is harder to demonstrate and is less likely to be important on theoretical grounds (Winterhalder 1987); here, I am primarily interested in (4) and (5), but will touch on (3) at relevant points.[10]

Following standard practice, I refer to option (4) — engaging in reciprocal resource transfers through pooling and redistribution of individual harvests — as 'sharing'. The degree to which hunter-gatherers engage in sharing of food and other resources has long been noted (see, for example, Marshall 1961; Sahlins 1968), and the notion that hunter-gatherer economies are generous, sharing economies has become part of the conventional anthropological wisdom. Various explanations for this observation have been advanced. Some of these, such as the argument that foragers possess an ethic of 'generalized reciprocity', focus on the psychological or moral significance of sharing practices; these strike me as tautological, or at least highly limited in explanatory power. Others, such as the suggestion that sharing rules are a 'leveling device' impelled by an egalitarian ideology, draw attention to the political mechanisms by which sharing is maintained, but do not address the ultimate causes of sharing *per se* (nor of the egalitarian ideology that enforces it, for that matter).[11]

10. For discussion of the conditions favoring one option over another, see Wiessner (1977), Binford (1980), Cashdan (1985), Ingold (1983), Kaplan and Hill (1985) and Winterhalder (1987). To those who might think that storage is invariably an effective means of risk reduction, thus calling into question the basis for my argument concerning sharing as a means of risk reduction, let us remember that storage entails a number of costs that need to be subtracted from its benefits. These include the labor costs of effective preservation (which vary according to the type of resource, environment — for example, temperature and humidity — and technology, see Binford 1980), the costs of defending stores against thievery or forceful seizure, and the potential cost of reduced mobility which can tie foragers to their stores rather than releasing them for possibly more efficient foraging opportunities elsewhere. I do not doubt that these costs are often less than the benefits of storage, or even that the net benefits of storage often exceed those of alternatives, but the costs do need to be kept in mind, and may account for the existence of alternative, more social forms of risk reduction (such as sharing, exchange, and mobility) despite their enforcement costs.

11. I want to make myself perfectly clear here, as the original passage in the 'conference version' of this chapter was overstated, and occasioned some criticism. I do not deny that many foragers (but certainly not all — see Gould, 1982, for example) possess an ethic of widespread, if not quite 'generalized', reciprocity. But to point to such an ethic is not to

Even more common and long-standing in anthropology is the view that sharing among hunter-gatherers is an adaptation to periodic scarcity, a form of 'collective insurance against natural fluctuations' in both productive ability and available resources (Ingold 1980: 144; see also Dowling 1968; Lee 1968; Woodburn 1972; Yellen and Harpending 1972; and others). Ingold's (1980: 145) summary of the received view is exemplary: 'Were each hunter to produce only for his own domestic needs, everyone would eventually perish from hunger. . . . Thus, through its contribution to the survival and reproduction of potential producers, sharing ensures the perpetuation of society as a whole'. I will refer to this argument as 'the received view'. We are now ready to consider the contribution formal theory from evolutionary ecology can make to understanding hunter-gatherer sharing practices.

A simple model of risk

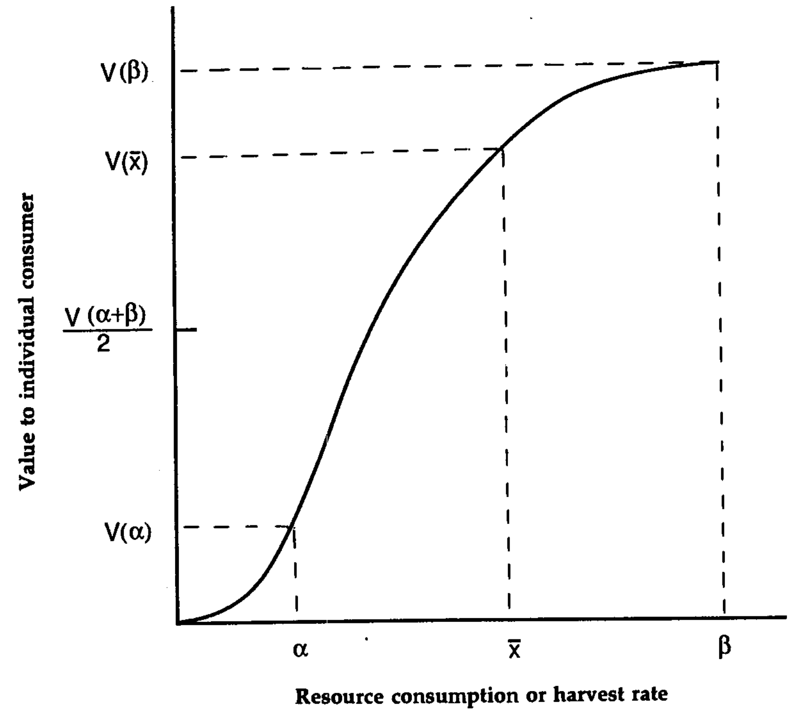
As noted above, the concept of risk is associated with stochastic variation in the outcome of some choice or action. But this variance can only have psychological or material significance — can only, in a sense, *become* risk — if there is a nonlinear relationship between the material outcome itself and the value of the outcome (measured psychologically in terms of subjective utility for economic analyses, or in terms of fitness consequences for evolutionary analyses). More specifically, when the nonlinear function relating outcome and value is accelerating (curves upwards), the actor should be risk-seeking (gaining greater utility or fitness from outcomes with greater variance, all else being equal); if the function is decelerating (curves downwards), we expect risk-averse preferences (see Figure 14.1).[12]

While most of the ecological work on risk has focused on production

explain its existence, nor the sharing behavior it may help motivate. In other words, such an ethic — like any culturally transmitted value or belief — is but one (intermediate) element in a longer causal chain. On the matter of 'leveling devices', as has been pointed out by others (notably Cashdan 1980), this view fails to explain variation in extent of sharing, or the rise and eventual dominance of nonegalitarian, nonreciprocal social formations. In some cases, it also tends to rely on a functionalist or social-teleological point of view. Again, I do not deny that such mechanisms exist — indeed, I give them a prominent role in my discussion of 'enforcement' (*infra*) — only that their identification provides a sufficient explanation for the existence of sharing practices.

12. The general theory of risk preference was first developed by Bernoulli, and then formalized by von Neumann and Morgenstern (1944). Application to ecological and evolutionary contexts can be found in Schaffer (1978), Caraco (1980), Real (1981), Rubenstein (1982) and Stephens and Charnov (1982). In adapting this concept to problems in evolutionary ecology, biologists have generally substituted the notion of 'fitness' for that of utility, with the proviso that natural selection designs organisms to respond to risky situations in a manner that maximizes their expected fitness. Since the actual psychological mechanisms that individuals use in making decisions may best be captured by some proximate goal equivalent to the economist's concept of utility, the necessary presumption in all of this is that there is a strong positive association between fitness and utility — something that is easy to assume, but hard to demonstrate as of yet.

Figure 14.1: A risk reduction model of resource-sharing



Note: For any actor, the rate of resource harvest is assumed to be a random variable with a symmetric distribution whose mean is $\bar{x}$ and whose range (or standard deviation) is from α to β. With a diminishing marginal value curve (see text), those actors who pool their resources and then consume equal shares will realize a higher and more certain value, equal to $V(\bar{x})$, than those who consume their own resources at the stochastic rate determined by the harvest rate distribution, whose expected value equals $V(\alpha + \beta)/2$. For an accelerating value function (e.g., below the inflection point on the sigmoid curve shown here), the converse results hold (see text).

or consumption decisions of individual foragers — which prey types to harvest, which patches to utilize, and so on — some attention has been given to the effect of risk preference on social interaction. One case in point involves the role of risk in favoring systems of reciprocal exchange. The first formal treatment of this problem is that of Schaffer (1978). The essential features of the model are these (E.A. Smith 1987; see, for similar treatments, Rubenstein 1982; Kaplan and Hill 1985; Winterhalder 1987):

(1) A set of actors (two or more), who are at least sporadically in contact with each other, independently obtain resources (income)

which they can either consume individually or share to some degree.

(2) Each actor is subject to stochastic variation in rates of resource income, measured over some relevant period (such as a day).
(3) This variation is to some degree unsynchronized between actors (that is, the interactor correlation in resource income during each time period is less than unity).
(4) For any actor, the marginal value of resources consumed over the relevant period exhibits diminishing returns, at least over some frequently-realized portion of the fitness or utility function.[13]
(5) Actors seek to maximize the total expected value (utility or fitness) obtained from consumption, over the long run.

With these assumptions, the classical results of risk theory apply (Figure 14.1). Specifically, actors should be risk-averse (this maximizes expected value), and will even pay some premium (for example, in lower mean income) to obtain the benefits of reduced risk.[14]

Clearly, the risk model presented above can be viewed as a formalization of the received view that hunter-gatherers share food in order to even out fluctuations in their food supply and avoid the threat of starvation. But there are two primary ways in which theory from evolutionary ecology can be employed to modify or add to the received view. First, the formal risk model provides a general theoretical framework for predicting the advantages and disadvantages of sharing — in other words, a means of explaining the degree of variation in sharing from time to time and place to place, even from resource to resource; and it does so in a manner that is subject to quantitative (and hence more exacting and powerful) empirical test. Second, evolutionary game

13. This is perhaps the most difficult assumption in the list to verify. But I believe it plausibly applies to most hunter-gatherers, and indeed to people everywhere much of the time. Stated baldly, it assumes that the more one has of most things, the less pleasure or benefit one derives from additional amounts. In slightly more cautious language, the assumption states that the use-value of any material resource will decline at the margin, such that past some point each additional unit of resource will be 'worth' less and less to the consumer, where 'worth' is measured in terms of satisfaction (psychological utility) or effect on fitness (relative ability to survive and reproduce). This may not be true of certain non-material resources (such as religious knowledge or political prestige), and it may not apply to certain roles in a capitalist economy (for example, profit-maximizing firms), but I submit it is the most reasonable assumption we can make for the use-values of resources, such as food, raw materials and water, with which I am concerned in this chapter. At the same time, the general risk model allows for the opposite assumption — that marginal value accelerates, as in the lower-left segment of Figure 14.1 — and, as noted in the text and caption, predicts risk-seeking preferences in that case. Again, this is plausible for many use-values at the *lowest* consumption rates: the first few grams/hour of food consumed by a starving man, or liters/hour of water by a dehydrated woman, for example, will make much higher contributions to their utility and fitness than will higher and higher rates of consumption.

14. Specifically, actors should be willing to pay any amount less than $[V(x)]-[V(\propto+\beta)/2]$, which is equal to the difference in value (utility or fitness) between risk-free consumption rate and the mean risky consumption rate (E.A. Smith 1987: 238, n. 11).

theory specifies the additional conditions required for sharing to be perpetuated in a social group, and points to the possible evolutionary rationale for such phenomena as the egalitarian ethos, the conflict and bickering that sometimes surround resource distribution, the 'demand sharing' noted by N. Peterson (1986), and gift-exchange or other conventions structuring sharing alliances. In doing so, it rejects the social functionalism or teleology implicit in the second sentence of Ingold's summary, and in similar accounts that point to survival of the social group as the function of sharing practices.

On the first point, the ethnographic record reveals clearly that there is considerable variation in the degree of sharing and reciprocity from one hunter-gatherer society to another, and even from one type of resource to another within these societies (E.A. Smith 1981; Hayden 1981; Gould 1982). Some of this variation may be due to ecological causes (variation in characteristics of the resources or the way in which they are harvested), and some may be due to political factors (differences in the ways in which decisions and agreements are reached and enforced). This suggests that we should continue to search for the root causes of variation in reciprocity and sharing in the *interaction* between ecological context and political process. In any case, successful explanation of the why and when of sharing practices cannot ignore variation, but instead needs to account for it.

The risk model suggests the following ecological determinants of variation in the costs and benefits of sharing: (1) degree of variation in foraging success (some resources, such as game, are more likely to exhibit high degrees of stochasticity in yield); (2) package size and perishability (large values of either increase the marginal decline in the value of solitary consumption); (3) degree of interforager correlation in harvest success (Winterhalder 1987), which in turn is affected by such factors as environmental patchiness and foraging group size. In the simplest case, where each actor has the same expected income rate and returns to the same central location during each period (for example, to camp), and where the correlation in foraging success between foragers is low (zero or negative), direct pooling and equal sharing of the pooled catch may be very effective in reducing risk (Winterhalder 1987). It should be quite feasible to obtain sufficient data on these factors in order to test the explanatory force of the risk-reduction hypothesis of sharing in any given case. Kaplan and Hill (1985) provide the only rigorous test of what they call the 'variance reduction' hypothesis yet published (see also Hames n.d.). They show that among Ache foragers in Paraguay, riskier resources (those with greater package size and higher variance in availability across family units) are shared to a significantly greater extent, and that such sharing increases the nutritional well-being of most band members (though not equally).

It is also worth stressing that the risk model (Figure 14.1) also predicts that when resource income is very low, actors will be risk-seeking and avoid sharing (see note 8 above); this prediction is especially strong when expected resource income is below the minimum required to sustain life (Stephens and Charnov 1982). Hence, the model predicts the conditions under which sharing should diminish or cease even when resource income is variable and times are hard; this is not something the received view can accommodate, let alone explain, at all.[15]

The sharer's dilemma

The simple risk-reduction argument for sharing sketched above fails to consider any *cost* to sharing. But presumably sharing practices exact costs of various sorts, including both 'maintenance' costs (such as transporting resources to a central place, living in larger groups, and so on) and 'enforcement' costs (to prevent or reduce failure to reciprocate on the part of past recipients of one's aid). Leaving aside maintenance costs, which are comparatively straightforward (though not unimportant), let us consider enforcement costs, and take up the second component in our reevaluation of the received view of sharing. Assuming that ecological conditions are such that a system of sharing will reduce risk, what additional conditions are required to ensure that it will arise and persist? This takes us into the realm of politics; here, game theory is a most useful tool (see also Kaplan and Hill 1985; E.A. Smith 1985).

In simplest form, the payoff matrix for the sharing game might look as follows[16]:

15. Further discussion of the logic of risk-seeking preferences can be found in E.A. Smith (1983a), as well as in the references listed in note 12 (above). I am familiar with ethnographic evidence from the North American Arctic that supports the prediction of diminution or cessation of sharing during times of extreme scarcity (for example, Graburn 1969: 37f., 73f.; Riches 1982: 71f.), but have not made a systematic search of ethnographies from other areas. Ingold (1980: 149ff.) argues against such a claim, but I find his evidence quite incomplete or even irrelevant (for example, prevalence of domestic cannibalism over extra-domestic forms may simply reflect opportunity, especially if other households have dispersed, or it may reflect fear of revenge from non-kin; it certainly does not in itself indicate that extra-household sharing persists). Ingold's more general argument that sharing will peak in times of 'famine' and 'plenty' — given in a diagram (ibid.: 147) as well as the text — seems to conflate the benefits of information sharing and cooperative search when a mobile concentrated resource (such as caribou) is hard to locate (Wilmsen 1973; E.A. Smith 1981: 43f.; Heffley 1981) with those of food sharing *per se*. It also demonstrates the pitfalls that face analyses innocent of methodological individualism: for if 'famine' or 'plenty' apply indiscriminately to the condition of the social group, then there is no motivation for sharing, which requires interindividual *differences* (some individuals facing 'famine', others facing 'plenty' at a given point in time) in order for anyone to benefit from it.

16. By convention, payoffs are simply rank-ordered from highest (4) to lowest (1); those in the upper left of each cell apply to the row player (whose play is given on the left side of the matrix), while those in the lower right of each cell apply to the column player (at the top of the matrix). In the present matrix, the payoffs to row and column are symmetrical, but this is not a general requirement of the method.

	Share	Hoard
Share	3 / 3	1 / 4
Hoard	4 / 1	2 / 2

The rank ordering for the matrix is based on two assumptions: (1) the net benefits (in risk reduction) if both actors share are greater than the net benefits of hoarding; (2) unilateral hoarding (the 'free-rider' option) provides all benefits and no costs, while unilateral sharing (the 'altruist' option) provides all costs and no benefits.[17] The first assumption is derived directly from the risk model (Figure 14.1), while the second assumption can be restated colloquially as follows: most individuals would rather get something (their share of another's catch) for nothing (hoarding their share, at least within their household), all else being equal (specifically, if there are no costly sanctions — short- or long-term — that will be imposed for such selfish behavior). The second assumption is bound to disturb many anthropologists — I confess it bothers me. Yet notions of selfless hunter-gatherers who share even when they could get away with hoarding are in conflict with ethnographic data too numerous to cite here (some examples are given in N. Peterson 1986), as well as violating general expectations from evolutionary theory. If strict self-interest is unlikely to be universal and unyielding, generalized altruism is even less plausible.

Setting such arguments aside, we are faced with the finding that our exercise in game theory predicts it will never pay to share! If the other actor is altruistic or foolish enough to share, one wins the maximum payoff from hoarding, whereas if the other actor is equally selfish, hoarding pays worse, but still better than sharing. This result demonstrates the danger of functionalist thinking — just because it would be beneficial to society as a whole (less abstractly, to the sum total members of a society) to cooperate, this does not mean that self-interested actors will do so; and those that are optimistic enough to try it are vulnerable to victimization by the unscrupulous. Even if we posit an initial starting point of a society of sharers, the introduction of just one hoarder may eventually upset the applecart. If based on rational choice, the sharing strategy will see its gains eroded by hoarding, and its

17. NB: for both assumptions, 'benefits' and 'costs' refer to those received by the single actor adopting the strategy referred to, *not* to the joint or average benefits and costs.

practitioners will be tempted to switch; if based on cultural inheritance, the sharing strategy will dwindle (less resources to convert into offspring who follow the sharing ethic) and natural selection will eventually ensure that the hoarding strategy inherits the earth — unless checked by some other factor.

The sharing matrix given above is in fact an example of the classic game matrix known as the 'prisoner's dilemma' (PD). The PD payoff structure is widely viewed as the worm in the apple of social cooperation. But the pessimism generated by such a view may be unwarranted. The PD matrix is based on a game where the players interact only once, or if more than once then at random without memory; hence there is no opportunity for cooperation and reciprocity to pay. Once the sharing game is domesticated by allowing for (1) repeated interaction, (2) memory of past interactions, and (3) sanctions against unilateral selfishness by future selective refusal to share with such 'cheaters', the outcome can be quite different. Such an 'iterated PD' or 'PD supergame' may lead to a stable population of cooperators, with a few selfish cheaters thrown in but held in check by the force of frequent sanctions (Trivers 1971; Taylor 1976, 1987; Axelrod and Hamilton 1981; Kaplan and Hill 1985). In the present case, one obvious sanction involves suffering the effects of being denied a share of the collective pot.

This discussion of the sharing game, simplistic as it is, serves an important role in sharpening our thinking about the collective provisioning of a 'public good' such as generalized reciprocity. Two important conclusions suggest themselves: (1) truly generalized reciprocity (that is, altruistic or indiscriminate sharing) is unstable and will be undermined by free-riding, *even when it provides the greatest good for the greatest number*; (2) the existence of collective goods is therefore dependent on a system of monitoring, ongoing expectation of reciprocity, and costly sanctions against free-riders. The first point, if empirically verified, underlines the need for methodological individualism in explaining social phenomena (such as sharing), and further challenges the persistent group-level functionalism that views sharing (among other phenomena) as a means to ensure societal reproduction or to maximize or optimize population density.[18]

The second point stimulates the search for the socio-political mechanisms hunter-gatherers might employ to restrict sharing to those who are likely to reciprocate, and to detect and punish free-riders who would take unfair advantage of the ethic of generosity. While ethnographies are full of anecdotal examples of such mechanisms, only Wiessner (1977), to my knowledge, has given us a detailed and convincing set of data bearing on this matter. Briefly, her work shows that, among the !Kung — those supposed archetypes of generalized reciprocity — sharing of certain resources is hardly generalized or automatic, even among kin; instead, sharing partners are carefully selected, cultivated, and monitored, and failure to reciprocate when capable is cause for termination of the sharing bond.[19] However, Wiessner's data bear only on sharing of non-food items, and hence leave the question of the adequacy of the game-theoretical analysis of hunter-gatherer food sharing unanswered for now, even for the !Kung.

18. Examples are numerous, but include Piddocke (1965) on North-west Coast Indians, Sahlins (1974) on the (reformed) domestic mode of production, and Spielman (1986) on exchange between egalitarian societies as a means to ensure survival and maximum population density. In each case, the functionalist error lies in assuming that a result — collective benefits widely or evenly shared — is a sufficient explanation for the individual actions that are the proximate cause of those benefits (for a general discussion of functionalism, see the superb treatment of Elster 1982; 1983, chap. 2).

Sharing between bands

As noted above, two important variables determining the advantages of sharing (that is, of pooling risk) are the degree of risk experienced by each actor (expressed by the daily variance in food harvest) and the degree of asynchrony in resource income between actors. How might these variables relate to intra-band versus inter-band sharing? Whereas short-term asynchrony may be common among the members of a single local band, prolonged asynchrony, with more marked fitness effects, may often be much greater between members of *different* bands. That is, within a given region, the asynchrony of foraging success over a period of several days or weeks should often increase as the *distance* between any two individuals sampled increases. I expect this to be so because of such factors as patchy rainfall, movement of game, and stable habitat differences in seasonal production or resource availability. Increasing asynchrony as a function of distance implies that risk reduction through sharing should be greatest if conducted over longer distances. Yet the costs of such sharing, especially transport cost, should also increase with distance, particularly under the conditions of low population density and foot transport characteristic of many hunter-gatherers. This means that risk reduction through sharing of resources may often be most costly precisely where it would be most effective — between rather than within local hunter-gatherer bands.[20]

19. Four central findings emerge from Wiessner's work: (1) sharing networks are formed from dyadic components — the relationships between pairs of individuals are the fundamental units; this makes the two-person game, as opposed to a more complicated *n*-person game, a reasonably appropriate model; (2) individuals choose their partners in a way that will ensure ties to diverse natural and social resources; close kin with meagre or redundant resources may be passed over in favor of more usefully situated individuals; (3) *hxaro* — a form of conventionalized sharing — provides a continual check on partners' willingness to reciprocate, hence on the ongoing reliability of reciprocity bonds that may only occasionally be activated for major support, in times of critical need; (4) failure to reciprocate either at conventional (*hxaro*) or critical levels is cause for breaking of ties, and also leads to gossip and reluctance on the part of others to share resources with the unreciprocating individual.

20. Analytical (Winterhalder 1987) and empirical (Hill and Hawkes 1983) results indicate

Under these conditions, there would be a potential selective advantage to the development of some means of reducing risk other than interband resource transfers. Put another way, many hunter-gatherers — even those living in a region characterized by fluctuations in resource availability that decrease in synchrony as a function of distance — may find long-distance (interband) sharing too costly (in transport time and effort) in relation to its benefits (of risk reduction). The obvious alternatives are (1) local storage, and (2) movement of *people* (rather than goods) between local groups.[21] These each have their own costs and advantages, of course (for those of storage, see note 10 above). The second alternative — moving foragers between groups — is the one that concerns me here. Ethnographers have often remarked on the extensive visiting and frequent residential shifts noted among band societies, and a number have suggested that this characteristic of fluid local-group composition can be explained as an adaptation to equalize the consumer/resource ratio in situations where local resource availability fluctuates markedly and asynchronously (see Lee 1972; Yellen and Harpending 1972). In such a formulation, an extensive network of kin ties and other alliances combined with a communitarian attitude serves to ensure that all have equal and undivided access to the land and its fruits.

Again, the risk model can be used to formalize the received view, with the advantage of making it subject to greater logical and empirical examination. (It also allows one to formulate an explanation for the *absence* or underdevelopment of mobility between bands in situations where variance in resource harvest is low, and/or synchrony in harvest is high.) Specifically, the model predicts that systems of reciprocal access to local foraging areas by members of different local bands would reduce risk under the following set of circumstances:

(1) diminishing marginal fitness to increased resource harvest over at least some portion of the fitness function;
(2) fluctuations in local resource availability substantial enough to make the benefits of risk aversion outweigh relocation costs;
(3) asynchrony (low temporal correlation) between local areas in such fluctuations, resulting in frequent reversals in their ranking by per capita resource availability;
(4) relatively high transport costs (for example, due to low population density and reliance on foot transport);
(5) relatively high storage costs (direct processing costs, indirect costs of defense, and/or opportunity costs for reduced seasonal mobility).

From the perspective adopted here (evolutionary ecology and methodological individualism), however, this kind of account appears rather naive. For while the preceding list may be sufficient to define the techno-environmental constraints favoring systems of reciprocal access between members of local bands, we need to consider social constraints as well. (Indeed, if individuals and groups always cooperated to achieve mutually beneficial goals, our task of explaining social behavior would be much simpler than it is![22])

My basic point is that, even if we can show that communal or reciprocal access would benefit individuals by reducing risk, it does not necessarily follow that such a system of land tenure will evolve or persist. As with resource-sharing within a band, reciprocal access between bands raises issues of monitoring and enforcing reciprocity, and of avoiding the material and evolutionary costs of indiscriminate altruism; it also raises some new issues involving the coordination of two sets of foragers. In particular, I suggest we need to pay attention to the costs to members of the host group of allowing visitors access to the local foraging area. The two main costs I want to consider are: (1) the potential cost that visitors who are allowed access to resources will not reciprocate, and hence of the necessity to maintain controls against possible cheating; and (2) the effects of visitor-foraging on host-foraging efficiency. In the following section, I argue that these problems can be illuminated by viewing them in terms of uncertainty and

that pooling of the harvest by a surprisingly small number of individuals will be effective in reducing risk at the level of the local band. This finding might appear to suggest that any further sharing between bands, such as discussed here, would be of little value. However, I do not think this necessarily follows, given the expanded temporal and spatial scale I envision with interband sharing. The diminishing returns to sharing *within* the band reflect the effects of sampling from a single population of foraging outcomes, on a daily basis. If, as assumed here, both the difference in mean foraging success and the asynchrony in outcome is greater for members of different bands than for those of the same band, especially when measured over periods longer than a day, interband sharing might still markedly reduce risk even after the benefits of sharing within each band had been exhausted.

21. A third alternative would be to amalgamate local groups at a large, centralized camp that could sample (forage over) an area extensive enough to include the necessary range of resource fluctuations, and then pool the catch (or at least information on resource locations) at the central place. This might be a viable hypothesis to explain the occurrence of large camps at certain seasons (such as the winter-sealing villages of Inuit [E.A. Smith 1984b: 78f]) or the settlement pattern of Caribou-eater Chipewyan (J.G.E. Smith 1978; Sharp 1977; Heffley 1981), but this strategy quickly runs into the same cost problems discussed for interband sharing. As band size and foraging radius expand to map onto more asynchronous resource patches, the mean cost of traveling to resource patches and bringing resources back to camp rises at an increasing rate (for example, because those foragers ranging farthest afield must stay overnight or longer, or can only carry back a portion of their catch). Hence this alternative should face approximately the same constraints as a strategy of interband sharing, and reach its adaptive limits almost as quickly under conditions of low population density and foot transport.

22. A parallel form of naive functionalism has been prominent in explaining resource transfer between local groups among densely populated hunter-gatherers (see Piddocke 1965; M. Harris 1974). In this case as well, the analytical task is not just to show that such resource transfers would be beneficial, but that they would not be subject to the forms of cheating and evolutionary instability that often plague the provision of collective goods (see note 18).

information, and by employing the strategic logic of evolutionary game theory.

Uncertainty and reciprocal access

Land tenure diversity

The 'undivided access' view of hunter-gatherer land tenure presumes that there are no social barriers to resource utilization throughout a region — in effect, that the region is one vast commons. As discussed below, there are ethnographic examples approximating such a system. But there is also abundant ethnographic evidence that different systems of land tenure commonly occurred among hunter-gatherers, even among those meeting the usual requirements of 'egalitarian' or 'band society'. Yet the anthropological literature reveals a persistent tendency to deny the diversity of hunter-gatherer systems of land tenure, and a repeated insistence that communal ownership, or indeed absence of ownership, is not only widespread but of the essence for hunter-gatherers.[23] An excellent example is provided by Ingold's (1980: 161) unqualified statement — apparently arrived at through deduction rather than induction — that 'the hunting economy is based on the principle of undivided access to productive resources, including both the land and its fauna'.[24]

One alternative approach that allows for diversity in hunter-gatherer land tenure focuses on the ecological factors affecting the 'economic defendability' (J. Brown 1964) of different resources, and attempts to predict the presence or absence of territoriality in terms of the spatio-temporal *density* and *predictability* of key resources (Dyson-Hudson and Smith 1978; Richardson 1982). In this view, territorial exclusion is expected whenever resource density and predictability is sufficient to make the benefits of exclusive use outweigh the costs of defense.[25]

23. In the past, the opposing normative view — that hunter-gatherers were mostly or universally territorial — also had wide currency, and practised a similar denial of the ethnographic reality of alternative systems, such as communal tenure: see Dyson-Hudson and Smith (1978: 21) and M.K. Martin (1974) for summaries of and references to this literature. Perhaps because of repeated demonstrations that claims of territoriality or private land ownership were often based on faulty readings of the ethnographic data, many anthropologists came to believe that no such systems existed aboriginally, and that therefore all hunter-gatherers had fluid systems of land tenure *on the ground*, despite what they might appear to have as expressed in native ideology or ethnographic misinterpretation.

24. Exceptions to this portrait that are blatant enough, such as cases of explicit territorial boundaries and violent defense of same, have often been seen as pertaining only to societies with high population density, greater socioeconomic complexity, and low mobility — in a word, not band societies at all (see Fried 1967; Leacock 1982).

25. A conceptually similar idea is expressed in Blurton Jones's (1984) model of resource transfer as a form of 'tolerated theft' (see also Maynard Smith and Parker 1976; Moore 1984). Here, individuals may allow others to have some resources that are already harvested if the cost of defending them is higher than the benefit of exclusive use. According to Blurton Jones, one way this could arise is under conditions of diminishing marginal value of

Conversely, since relatively scarce and unpredictable resources do not 'pay' for territorial defense, foragers under these conditions are expected to treat land and unimproved resources more or less as a commons.

The economic defendability model has the virtue of testability (as shown in the animal ecology literature, reviewed in Davies and Houston 1984), and for hunter-gatherers it seems neatly to explain why territorial systems are found primarily in areas with high population density, since this indicates both lower defense costs for monitoring a territory and (under a Malthusian view of population equilibrium) a denser resource base. However, there are some problems with the model. First, in terms of the territorial cases, the model does not specify how local-group territories — a collective good — could result from the action of self-interested individuals. Second, hunter-gatherer societies lacking explicit territorial ownership rarely seem to treat local foraging areas as a commons. Rather, in such societies local groups frequently have ideologies of land ownership and attempt to control access to the resources surrounding them. These controls generally involve requirements that visitors gain permission to use the resources in a local area from the 'owners' of these resources. Because of these sorts of observations, it has been alleged that some degree of territoriality is ubiquitous among hunter-gatherers (N. Peterson 1975; 1979).

In retrospect, the economic defendability model is too restricted in scope to capture the diversity found in hunter-gatherer systems of land tenure. Part of the problem here lies in that model's failure to deal explicitly with the political mechanisms governing access to land. Although there is insufficient room to develop the conceptual scheme or review the ethnographic data fully here, let me outline a framework for describing variation in hunter-gatherer land tenure. Briefly, I suggest we view this as forming a continuum punctuated by the following ideal types:

(1)	(2)	(3)	(4)	(5)
COMMONS—	RECIPROCAL ACCESS—	TERRITORIALITY—	PRIVATE	PROPERTY
(common property)	(communal property)	(local-group ownership)	(kin-group ownership)	(individual ownership)

In system (1), land is treated as a commons and there is no enforce-

resource consumption (for example, as given in Figure 14.1). If intruders have less resources than residents (are lower on the fitness function), they should be willing to incur a higher marginal cost in contesting additional resources than the residents would be willing to incur in defending them. The equilibrium resource division equalizes the marginal net benefits to the contestants. As in the economic defendability model, no reciprocity is implied.

able control over access or over unharvested resources (though in fact there may be coordination of land use and resource harvests, reached by consensus — see below). Among others, some western Shoshone (Steward 1938), the Hadza (Woodburn 1972), and some Batek (K. Endicott 1988) approximate this ideal type. System (2), as noted above, is widespread, and is particularly well described for Australian societies and Kalahari San.[26] Two features of system (2) are of central interest here: reciprocal access between members of land-owning groups is highly developed; and transfer membership, which grants property rights, is relatively easily negotiated. In contrast, system (3), while exercising a form of communal property ownership quite similar to (2), is characterized by much stronger controls on local-group membership, and a corresponding reduction in reciprocal access as well. The north-west Alaskan Inupiat Eskimo case described by Burch (1980; 1988) approximates this ideal type. Systems (4) and (5) both involve private ownership by well-defined subsets of a local group; reciprocal access may be present to some degree, perhaps comparable to system (3). Examples of (4), involving kin-group ownership of land and unharvested resources, are particularly well known for certain North-west Coast Indians (review in Richardson 1982), while individual ownership of unharvested resources is described for a number of Californian Indian groups (see Gould 1982).

Again, I want to emphasize that I view hunter-gatherer land-tenure systems as lying along a continuum, and the labeling of types and enumeration of their characteristics is heuristic rather than typological in intent. An additional caveat is that particular societies may well exhibit a *mix* of these systems, with different resources or sections of land falling at different points along the property–rights continuum.[27]

Let us return to system (2) — communal ownership with reciprocal access — and the failure of the economic defendability model to address it. Focusing on this latter problem, Cashdan (1983) has recently argued that social controls implied in this system bring the explanatory adequacy of the economic defendability model into question. Specifically, she argues that evidence from four regional populations of San hunter-gatherers indicates that the greater the unpredictability of resources, the tighter are the social controls on visitor access to local

26. For Australians, see Myers (1982) on Pintupi, N. Williams (1982) on Yolngu, Altman and Peterson (1988) on Arnhem Landers, and N. Peterson (1975; 1979) on Western Desert Aborigines; for Kalahari San, see Lee (1972; 1979), Wiessner (1977; 1982), Barnard (1979), and Cashdan (1983).

27. The frequent occurrence in Australia of system (1) or (2) with respect to subsistence resources and harvesting sites, but system (3) or (4) with respect to sacred localities, may be a good example. A mixed system is equally possible for subsistence resources alone (Dyson-Hudson and Smith 1978: 33ff.). For example, among the Owens Valley Paiute, Steward (1938; 1955) reports a division of land into local-group territories, reflecting a system (3) for gathering purposes, but a rule allowing pursuit of game across boundaries reflecting a system (1) commons.

resources. Following Peterson (1975), Cashdan terms these controls 'social boundary defense', and contrasts this with what she terms 'perimeter defence' or what I would prefer to call 'spatial defense', the form of territoriality treated in the economic defendability model.[28] She concludes that whereas the economic defendability model may be a valid explanation for systems of perimeter defense, it fails to explain the occurrence of territorial systems that employ social boundary defense because it ignores the information-sharing capabilities of human beings, and the need to manage access to resources even when these are scarce and unpredictable.

It seems to me that there are two issues here, one semantic and the other analytic (E.A. Smith 1983c). The primarily semantic issue — that is, whether it is confusing or not to lump spatial defense and social boundary defense under the same category of 'territoriality' — can be set aside here (but see note 28 below). The more important claim that spatial defense and social boundary defense are functional equivalents, in the sense of realizing the same adaptive ends in controlling access to local resources, deserves further examination.

Uncertainty and reciprocal access

In a system of spatial defense, residents find the benefit of exclusive use sufficient to justify the costs of excluding competitors. There is no reciprocity between residents and outsiders (though with cooperative spatial defense — that is, group territoriality — there is reciprocity *within* the group, a problem not analyzed here). In denying others access to one's resources, one clearly reduces the incentive for those others to provide one with access to any resources they may control.[29] In contrast, hunter-gatherers who practice social boundary defense characteristically *do* allow outsiders access, but *only* after they have asked permission. Evidence from a number of groups, including that discussed by Cashdan for the San, indicates that this permission is

28. The term 'perimeter defense', employed by Cashdan but not by Dyson-Hudson and Smith, is somewhat misleading. The definition of 'territoriality' adopted by the latter is 'an area occupied more or less exclusively by an animal or group of animals by means of repulsion through overt defense or advertisement' (E.O. Wilson 1975: 256). The existence of well-defined boundaries is implied but not really required; but defense of the *perimeter* itself is certainly neither implied nor required. Thus, for example, the case described by Burch (1988) involving territorial defense but not perimeter defense, qualifies as territorial by the above definition, even though in Cashdan's terminology it would be called a perimeter defense system to distinguish it from a system of social boundary defense.

29. As noted earlier in the text, I am aware that system (3) territoriality may include some amount of reciprocal access involving members of other groups (often utilizing specific kinship ties). My claims are that such reciprocity is much less common than in societies with a system (2) form, and that the circumstances in which it occurs are much more restrictive, *because* — for the ecological reasons specified in the economic defendability model — most of the time residents stand to lose much more from allowing access, and can expect to gain much less from obtaining it themselves in the future.

rarely denied outright — indeed, to do so without very good justification (beyond the stated social fact of ownership) would be to invite anger and perhaps even violence on the part of the visitors. In return for granting permission, owners can expect to be granted rights of access when they visit their former guests.

Thus, the spatial defense system is at base one of non-reciprocal exclusion; the social boundary system one of non-exclusionary reciprocity. Both involve 'control over access to local resources', but by very different means and to very different ends. How then can we account for the development of systems of social boundary control on access to local resources? I think the answer lies in the increased uncertainty that uncontrolled access to foraging areas would entail. This uncertainty has two aspects: (1) the threat that those allowed access will fail to reciprocate in the future (the free-rider problem); and (2) the threat to foraging efficiency posed by uncoordinated resource depletion by 'residents' and 'visitors'.

On the first point, it is appropriate to recall the earlier analysis of the 'sharing game'. The sharing of land (and unharvested resources) differs in a number of ways from the sharing of harvested resources, but the basic payoff structure is plausibly still the same:

	Share	Exclude
Share	3 / 3	1 / 4
Exclude	4 / 1	2 / 2

Again, the structure is that of a prisoner's dilemma, with the selfish ('exclude') strategy dominant over that of sharing.[30] And again, this

30. Although I am purposefully keeping the game-theoretical analysis exceedingly simple here, two caveats are in order. First, there are good grounds for thinking that payoff structures other than the prisoner's dilemma are often more germane to analysis of social cooperation (Taylor and Ward 1982). For an example close to home, the 'labour contribution' game — should an individual contribute to the collective pot with his or her foraging labor? — is more plausibly viewed in terms of the 'chicken' (also known as 'hawk/dove') payoff matrix than the PD one. In chicken, free-riding is constrained by the very low payoff for bilateral selfishness (in the present case, by no one going foraging because they do not want to feed the lazy); hence, the predicted outcome is a *mix* of cooperation and selfishness. Second, although I am limiting the present discussion to two alternatives (and a 2×2 matrix), game theory is capable of dealing with more complex games (for example, an evolutionary game between three different land tenure systems, or games with more than two actors — '*n*-person games').

outcome can be reversed if the interaction is repeated (with indefinite future expectation of same), but only if free-riders (guests who refuse to reciprocate as hosts) face suitable sanctions (such as future exclusion).

What is the evidence that systems of reciprocal access do involve the features suggested by the iterated prisoner's dilemma? First, I would argue that the very fact of requiring permission before allowing visitors to utilize the residents' resources is a way of keeping tabs on the balance of reciprocity, and hence on the ongoing stability (or lack thereof) of the particular partnerships involved. Failure to secure 'permission' from residents makes it harder for residents to update information on the balance of reciprocity between members of different bands. This additional information cost is unilateral (falling on the residents only), but it could motivate the residents to impose higher sanctions on intruders who are discovered, sanctions that might be greater than the intruders are willing to pay. The fact that permission is rarely denied to prospective visitors has been read by some as an indication that the requirement is purely symbolic, a mystification of the underlying system of undivided access. But another interpretation is that it is rarely denied because the existence of the requirement motivates people to behave in a way that will keep their good name as reciprocators, and prevent their future exclusion as 'poor credit risks'. (This is certainly an area that would benefit from more detailed modeling *and* ethnography.)

Second, there is some evidence that residents can develop sufficient experience to judge the reliability of potential guests as future hosts. Again, Wiessner's (1977; 1982) study is exemplary in its discussion of the ways in which individual !Kung San engage in long-term efforts to maintain ties of reciprocity with individuals in other bands, and to monitor the ability and willingness of these partners to reciprocate in times of need. She presents detailed evidence indicating that !Kung systematically cultivate exchange partners and affines over a broad region (partners are hyperdispersed) and then use these relationships to facilitate residence change when local resource fluctuations warrant it. Although as yet all too rare in the ethnographic literature, this approach provides an avenue for explaining fluid group composition as an individually-adaptive strategy for responding to risk under conditions where reciprocal access to (sharing of) unharvested resources is ongoing. It improves upon the received view by focusing attention on *individual* costs and benefits, rather than effects such as 'higher carrying capacity', and by providing an explanation for the existence of controls on access as well as frequent movement between areas.

As noted earlier, I think there is a second selective factor promoting a system of controlled reciprocal access, one involving the role of information in foraging efficiency. Hunter-gatherers, like other species of foragers, spend considerable time and effort in monitoring the changing availability of resources within their local area. This information requires updating, and is always less than perfect, but the complex communication made possible with language, coupled with the active information-sharing that occurs at the central place (camp), gives human foragers a density of information that undoubtedly surpasses that of any other species. Ecological theory predicts that foragers exploiting relatively ephemeral resources, or resources whose quantity greatly exceeds the requirements of a single forager, may be expected to develop active information-sharing at a central place (E.A. Smith 1981; Waltz 1982; Clark and Mangel 1986).[31]

If the local area is treated as a commons, however, this information will be degraded — that is, uncertainty will increase. Foragers from other camps who do not 'check in' with the residents will deplete local resources in a manner that cannot be predicted by those residents. This will lead to inefficient allocation of foraging effort by 'residents' and 'intruders' alike, as they unknowingly visit patches that have recently been exploited by others, or even to direct interference from simultaneous but unplanned use of the same patch.

In summary, these arguments suggest that social controls over access to local resources involving reciprocal access could be evolutionarily stable under the following conditions:

(1) Residents possess much more information about the location and abundance of local resources, and recent and current allocation of foraging effort, than do visitors (likely to be the case in situations characterized by moderate fluctuations in key resources and relatively slow resource renewal).
(2) Uncoordinated search exacts a penalty of interference and inefficiency through overcrowding of foraging effort above the equilibrium that would result with greater information.
(3) Today's visitors are likely to be tomorrow's hosts (for reasons discussed in the previous section).
(4) Residents can impose effective sanctions (such as failure to share information, denial of access, gossiping, and so on) against those who cheat (that is, either fail to ask permission or fail to reciprocate).

It is worth reiterating that under this formulation, social controls offer benefits to both residents and visitors (as Cashdan 1983 recognizes). Residents can reduce the uncertainty concerning foraging opportunities by monitoring their guests' foraging efforts, suggesting

31. This is one explanation for the very existence of local bands among hunter-gatherers, as well as such phenomena as camp 'leaders' who act as clearing-houses for information about the distribution of foraging effort by camp members — that is, as coordinators of such effort with advisory but not coercive powers (E.A. Smith 1981: 44f.).

foraging locations for these guests that minimize interference, and gathering information from them at the central place. Guests can benefit from obtaining the access at low cost (that is, avoiding hostile confrontations if caught 'poaching') and from the information-sharing available at their hosts' camp.

Of course, this is not likely to be a case of simple mutualism, and there is no doubt ample opportunity for misinformation and manipulation to occur. The game-theoretical conditions for cooperation, and the exact equilibrium defined by costs and benefits to each party, need to be worked out in much more detail than is done here. However, if one keeps in mind that such interactions are embedded in long-term reciprocal and repeated movements of individuals between locations in an asynchronously fluctuating environment, the costs of providing false information to guests, or denying them access altogether, are considerable.[32] This is not to deny that such exclusion may at times occur. At one extreme, if resource availability is no better in the residents' local area than back at the visitors', it may be in both parties' interests for the visitor to look for a better situation elsewhere. In addition, there may well be conflicts of interest — and of opinion — within the resident band regarding acceptance of a new member, depending on kinship and partnership ties to different residents.

My general point is that social boundary controls, while certainly affecting regional access to resources, are perhaps best viewed as ways of reducing the uncertainty that would arise if movement and resource utilization were anarchic. The lower the correlation in resource availability between adjacent regions, the more demand for reciprocal access, and hence the more likely elaborate devices will evolve to control this access and reduce the uncertainty it could bring. While clearly not a system of rigid territorial exclusion (which, following Dyson-Hudson and Smith 1978, I would still expect to encounter in areas with relatively dense and predictable resources), neither is it the simple system of undivided access envisioned in many portrayals of band society, which would turn the bush into a commons with uncertain yields for all.[33]

32. As discussed in note 25, an alternative explanation of reciprocal access as 'tolerated theft' would argue that residents allow visitors access if the *immediate* costs of excluding them are higher than the *immediate* benefit of exclusive use of local resources. Aside from the fact that this interpretation overlooks the competitive advantage that a large number of residents has over a (usually) smaller number of visitors, it obviously predicts rather different cost–benefit conditions for the occurrence of visitors' access, and cannot account for the role of personal ties or past reciprocity in establishing the right to such access.

33. One question not analyzed here is what conditions would select for a true commons (undivided access) system. Resource factors favoring such a system probably include extreme degrees of unpredictability in spatial location and abundance, which would select for high mobility and extremely opportunistic exploitation of ephemeral resource patches (Dyson-Hudson and Smith 1978).

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