THE COMMONS BREAKDOWN IN MAYALAND: CAUSES, CONSEQUENCES, AND CRITICAL RESPONSES

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ABSTRACT

Much work on how humans manage their common-pool resources, such as forests, has been framed in terms of Hardin's parable of the commons, where "rational" calculation of gains and losses for individual decision makers leads inexorably to overuse and ruin of resources. While this dilemma is often cast as one where cooperation is doomed in any confrontation with competition, case evidence is mounting of "real-world" local commons having endured over the ages. From a cognitive vantage, findings in decision theory suggest that people are often more concerned with reducing risk than maximizing gain. Especially in fragile ecosystems, where feedback on the effects of resource mismanagement is readily apparent, mechanisms for sharing risk may be the rule, not the exception. Moreover, as long as actors maintain intimate relations with one another and their environment, they appear less likely to aspire only to self gain at the expense of others. They are also less prone to treat non-substitutable, "context-sensitive" ecological resources as completely divisible and substitutable "context-free* items, like money.

Yet, often overlooked in general models of environmental management - including commons studies - are the underlying roles of information and communication. For actors seldom uniformly share knowledge of resources, nor is such information generally transmitted without "noise" or modification. To remedy this oversight, we have begun using techniques to elicit the "mental models" that allow differential access to ecological information within and between distinct cultural groups acting in the same territory. These models are intended to reflect people's "tacit theories" of ecology. The information elicited targets conceptions of the causal role of species relationships, as well as edaphic and climatic zones, in "making the forest live" and on short- and long-term relationships between human activities and species viability. We have also begun modeling the "social networks" that communication of such information is likely to follow within and between groups in order to explore the implications of communication networks for commons management among groups.

Our underlying theoretical presumption is that commons problems result principally from breakdowns in the ways communities locally manage their common resources, not from an original lack of commons solutions. The looming tragedy is that even the most long-standing local commons do not seem able to survive the advent of an expanding global market economy rooted in the logic of maximizing individual gain. A central issue is why this is so and what it means for any attempt to extend the lessons of local commons to the avoidance of global tragedies. At present, no formal or practical solution exists to the problem of "upscaling the commons," perhaps in part because no long-term empirical studies of the problem yet exist.

With this in mind, we have chosen as the empirical focus of our research the long-term development of biological and cultural diversity in the Maya area of Mesoamerica. Although many commons cases involve low-density populations, with low but constant-levels of productivity there appears to be no intrinsic limit on the size, density or productivity of successfully cooperating groups under conditions of environmentally reliable information, manageable channels of communication and sufficiently long time horizons. Maya civilization is a case in point.

Lowland Maya forests comprise one of the world's richest areas of biodiversity that has been under a continuous tradition of intensive cultural management spanning millenia. The United Nations has declared it "Humanity's Patrimony," and has the area as a cornerstone of the UN Biosphere Reserve Program. Mayaland offers a natural laboratory for the first long-range analysis of the cognitive and cultural dimensions of the commons breakdown in a key zone of biodiversity. Also motivating this focus is the imminent extinction that threatens the area's rich biodiversity and millenial resource-management culture. That is why the US State Dept., the World Bank and many of the world's largest non-governmental organizations (NGOs) have given the area highest priority in their global attempts to preserve vital ecologies through "debt-for-nature" swaps and "sustainable development" programs. Still, a vicious cycle of deforestation and ecological degradation, community breakdown and political conflict spirals on downwards (e.g., the recent Zapatista rebellion in Chiapas and a renewal of violence in Guatemala). This poses a direct threat to regional stability, and is of increasing concern to the United States and the United Nations.

THE COMMONS BREAKDOWN IN MAYALAND - **Scott Atran**

1. Introduction. This outlines a current field project, which I am running with Douglas Medin (a psychologist at Northwestern U.) and Bobbi Low (an evolutionary biologist at U. of Michigan) . The focus is on 4 questions that have not been integrally addressed in prior work on common resource management: 1) What is the structure and content of local ecological knowledge that enables successful commons management? 2) What is the character of communication networks that make possible assimilation, distribution and implementation of the information? 3) To what extent is loss of local knowledge and disruption of communication networks related to a breakdown of the commons? 4) What cultural, psychological, biological, demographic and geographic factors facilitate or impede more global upscalings or mergings of local commons?

A motivating theoretical claim is that commons problems result principally from breakdowns in the ways communities locally manage common resources, not from an original lack of commons solutions. Yet, even the most long-standing local commons do not seem able to survive the advent of an expanding global market economy rooted in the logic of maximizing individual gain. A central issue is why this is so and what it means for any attempt to extend the lessons of local commons to the avoidance of global tragedies.

The project targets 3 sites: northern Peten, southern Campeche, eastern Chiapas. At each site three groups of actors differ on important axes in terms of ecological information available and communication networks mobilizable. Each has a native Maya population: Itza, southern Yucatec, Lacandon. Each harbors Maya speakers recently displaced into the area by political and economic events: Kekchi in Peten, Tzeltal and northern Yucatec in Campeche, and Tzeltal, Tzotzil and Choi in Chiapas. Spanish-speaking Ladino immigrants also reside at each location. Finally, national and international NGOs are transforming these areas into UN Biosphere Reserves to sustain La Selva Maya as "Humanity's Patrimony": The Maya Biosphere in Peten, The Calakmul Reserve in Campeche, the Montes Azules Biosphere in Chiapas. In each site, the forest comprises a common-pool resource. Thus, for example, all members of the "Comunidad Lacandona" - including the 500 Lacandon, 3000 Chol and 5000 Tzeltal who live in this 314,000 hectare commons - may hunt, plant and harvest the forest, but not outsiders.

We have started work in Peten, and will go to the Yucatan later this year. If funding and logistics allow, we also plan to work with the Brent Berlin-ECOSUR project in the Lacandon. That project examines health and nutrition status as a key indicator of successful human adaptation and sustainable commons management, and critically complements our work. In the Maya case, nutrient deficiencies in human populations, deforestation and conflict are positively correlated in the archaeological record, and this correlation may also signal areas of commons breakdown today.

2. Commons Breakdown: Human Nature or Historical Nurture? From a cognitive standpoint findings in reasoning and decision theory indicate that people untrained in economic or business theory are often more concerned with reducing risk than maximizing gain (Kahneman & Tversky 1979, Hardin 1982, Payne et al. 1993, Weber 1994). In fragile ecosystems, where effects of resource mismanagement on a people's margin of survival are readily perceptible, mechanisms for sharing risk may be the rule, not the exception. Food sharing is common among peoples who hunt (Kaplan & Hill 1985) and fish (Nietschmann 1972). Collective resource management may have cultural (e.g., religious) support even when "basic needs" are not guaranteed (Rappaport 1968, Sheng-ji 1985).

Among agriculturalists risk-reduction often involves risk-sharing and diversification strategies (Atran 1985a, Goland 1993), such as scattering and periodic redistribution of multicrop plots among cultivators or tending and harvesting multiple forest species and their products according to common terms of appropriation. Such diversification strategies necessarily involve complex systems of cooperative behavior and exchange, if only to coordinate scheduling in the common territory. Some former subsistence economies have successfully sustained CPRs with rising populations by mixing both subsistence and commodity production, and by pooling labor and costs for technological improvements such as tractors and irrigation systems (Aswad 1971, Ostrom 1994).

From an evolutionary perspective, empirical evidence and formal arguments for "reciprocal altruism" among human and non-human species in sharing and accessing scarce resources are now accumulating (Cosmides & Tooby 1989). Robert Axelrod (1984) and his associates (Axelrod & Hamilton 1981, Axelrod & Dion 1988) have shown that if a Prisoners' Dilemma game is played repeatedly (the iterated PD, or IPD), there is greater benefit in cooperation, providing there are mechanisms to detect cheaters. If one considers benefits from an evolutionary standpoint, as points of inclusive fitness (Trivers 1971), then this discriminating cooperative strategy would be able to invade and eventually dominate a population of noncooperators. From a historical vantage, some commons management schemes may have sustained fragile ecosystems for centuries, if not millenia.

Examples include variants of the Middle East "commons" (masha'a), which occupied a broad belt between the desert and sown from Morocco to Baluchistan well into this century (Atran 1986). In Western Europe, related systems endured until forced enclosure (15th-18th centuries, Darby 1940) and survived even longer in Eastern Europe (Stahl 1969). As in the Middle East, forced privatization or State domination of former commons lands often led to alienation of lands to outside absentee owners and to political factionalism, armed conflict and the break-up of villages and village life (Atran 1985a, Fraser 1973).

2.1. The Maya Case. Lowland Maya agro-forestry represents another set of long-enduring, but highly endangered, commons solutions (Nations & Nigh 1980, Remmers & De Koeijer 1992, Atran 1993a). In Yucatan, there is concerted effort to dissolve the last vestiges of indigenous collective tenure (i.e., the ejidos now falling victim to the recent abrogation of Article 27 of the Mexican Consitution in conformity with the recommendations of the World Bank and IMF). In Chiapas, conflict threatens to engulf the "Comunidad Lacandona," which is caught between its struggle to preserve the forest commons, the angry demands of land-hungry immigrant farmers (with Zapatista army support), and large landowners who prefer that the State redistribute Lacandon forest lands - not their's - to armed peasants. In Guatemala's Peten, most former Itza ejido lands have been declared a State Reserve from which Itza are excluded, while lands closest to Itza settlement (Municipio San José) have been sold to absentee landowners from Guatemala City and abroad.

Although the Itza, who ruled the last independent Maya polity, were reduced to corvée labor after their conquest in 1697, their forests continued to thrive. Since 1960, when Tikal and other ejido lands were first alienated from the Itza, half the forest cover of Peten (which includes 35,000 km2, about 1/3 of Guatemala's territory) has been cleared. Remaining forests in northern Peten have been declared "The Maya Biosphere" (including most former Itza ejido lands); however, satellite imagery shows that deforestation has only increased (USAID in Atran 1993a, Steven Sader in Conservation International 1994:2). In Spring 1994 Guatemala's government, in conjunction with USAID and some of the area's more than 40 NGOs, awarded part of the Biosphere (San Miguel) as a "managed commons" to Ladinos (sureños) recently settled into this former logging camp. Rules of commons management will be decided by "experts," guided by conservation theories informed by western economics, and "in consultation" with "locals" who have little forest or commons experience.

Gómez-Pompa and Kaus (1992) note an underlying conviction of many planners that is congruent with the US Wilderness Act: namely, that "nature" is best left "undisturbed" by human presence (but if that presence is inevitable then it is best managed by western conservation and economic theory). This conviction, while comprehensible from the vantage of those witnessing urban and industrial disruption of the environment, is not consonant with fact that no major ecological zone (apart from polar regions, the deep sea and high mountain peaks) has been "undisturbed" by humans for long periods over the last few thousand years. Neo-tropical forests were likely more intensively exploited before European contact (Roosevelt 1990) , and biodiversity has arguably suffered by the reduction in indigenous involvement.

Most stable CPR systems studied thus far are typically small-scale societies that: speak a common language, involve kin groups

and other long-term stable reciprocators, and generate low but constant levels of productivity (Low & Ridley in press). Little wealth and social hierarchy provides little incentive or impunity to cheat. Larger, more diversified societies seem more exposed to CPR breakdowns, and generally require more elaborate monitoring and sanctioning institutions. But in principle there is no set limit on population density and production of wealth in successful CPR management. An example may be the the Classic Maya, whose numbers exceeded present-day (largely immigrant) inhabitants of the region by an order of magnitude, and who managed their milieu without destroying it for a time at least an order of magnitude greater than current rates of deforestation allow. This is relevant to our study, assuming ample overlap between present and past Lowland Maya agronomy (Marcus 1982, Gomez-Pompa et al. 1987, Lentz 1991, Rice & Schwartz 1992).

3. **Significance of Project to General Conditions on Commons.** Case studies suggest that for a CPR to be successfuly managed at least 3 conditions must be met: a) The group can identify and exclude outsiders so that local appropriators do not face a risk that benefits produced by their efforts go to those who do not share in those efforts ("closed access," Ciriacy-Wantrup & Bishop 1975); b) encounters between "players" in a cooperative game are "open-ended" to the extent that they believe they might encounter any potential partner indefinitely many times lest shirkers go free ("the shadow of the future," Axelrod & Dion 1988); c) there is a shared cultural medium for identifying resources and assigning them "values" (Stern 1978) so that individuals can reliably communicate costs, benefits and intentions to others in negotiative situations ("referential system," Cosmides & Tooby 1992).

Different groups - local Maya, immigrant communities (both Maya and Ladino) and non-governmental organizations (NGOs) - have converged on forests in Lowland Mexico and Guatemala. Each appears to have distinct views of how the forest worls (the ecology of the region), what actions would destroy it, how the forest should be used, how (and among whom) its resources should be shared, and which of its resources are most valuable. This creates a situation in which the three conditions necessary for stable cooperation - closed access, shadow of the future, and shared referential system - are likely to be violated in between-group interactions. If the economic and evolutionary theories are correct, this bodes ill for the survival of these forests as common pool resources.

Suppose, for example, that cultures determine the value of exchange items (e.g., costs and benefits), and also institutionalize mechanisms for a common memory of the history of transactions (e.g. social reputations). Then what happens when those cultures are "invaded" by people or market items which do not partake of those values and institutions? Studies of both local (Rappaport 1968, Kottak 1992) and global (Cairncross 1992, World Bank 1993) economies indicate that such "arbitrary" effects on

value systems lead to a rapid breakdown of traditional resource management and negotiating strategies. If so, then how can cooperative understanding and action occur with respect to common resources in a "multi-cultural" society, a multi-national world or a global market economy?

What happens to local management strategies that are based on "traditional" belief that there is no temporal limit to cooperation (e.g., where parents imagine a life for future generations similar to their own, Mead 1970) , when outside organizations attempt to impose fixed time-tables to show their benefactors short-term results for "sustainable development" projects? What happens when governments propose fixed-term concessions on resource extraction? Studies of finite, iterated prisoner's dilemma situations indicate that a logic of "backward induction" prevails, with "rational" actors foregoing cooperation because it does not pay in the last round, and hence cannot pay in the next to last round, and so on back up the series (Luce & Raiffa 1957, Hardin 1982, White 1994). If so, then how can modern economic planning possibly support a commons?

3.1 **Information and Communication.** Prior study suggests general constraints on information and communication. In particular, issues of reliability and scale appear to underlie successful CPR management. Kinship (Hamilton 1964) is potentially a strong predisposing factor toward sustained cooperation: individuals are somewhat less likely to defect on kin than non-kin, and the costs if a relative defects are often less than if a stranger defects (in the first case, the defector's profit goes to a relative). Non-kin who interact repeatedly and have some "voice" in decision-making also appear less likely to defect (Ostrom 1990) . In well-controlled social-dilemma experiments, Ostrom (1990) and her colleagues (Ostrom et al. 1992) have shown that the ability to communicate alone leads to marked improvement in commons-like outcomes. What we seek to study is what kind of information is communicated, and through what channels.

For example, preliminary field study suggests that native Maya remaining in the forest (Itza, Yucatec-part, Lacandon) may best statisfy the 3 conditions owing to a high "cultural consensus" on local knowledge (in the statistical sense of Romney, Weller & Batchelder 1986) and "dense" communication network (statistical sense of Scott 1988). Immigrant groups, both Maya (Kekchi, Tzeltal) and Ladino, view the forest as "up for grabs" (agarrada de nadie) and violate condition (a) on closed access. But immigrant Maya may do so because they lack information about the forest, whereas Ladinos also lack integrated social network and cultural idiom to boost circulation of, and consensus on, information acquired. This implies Maya immigrants may be more apt to acquire relevant information if it can be translated into a cultural idiom that promotes consensus (see Keckhi-Itza exchange in Atran 1993b). From a cognitive vantage, translation may be easier if it is "story-

based" information embedded in folk narrative, rather than the sort of "fact-based" information usually provided by governments and NGOs (Lévi-Strauss 1970, Kintsch 1980, Gergen & Gergen 1986, Schank 1990). Our tests explore this proposition.

Governments and NGOs may readily violate (b) and (c). Condition (b) is prone to violation by fixed-term agenda, especially those that follow the short-term (3-5 year) planning and budgeting schedules typical of most "sustainable development" efforts. But even middle-term (20-40 years) extractive concessions generally fail to meet condition (b). Luce and Raiffa (1957) have shown, by backward induction, that cooperation is not rational in a finite game of social exchange ("Prisoner's Dilemma[11]) because cooperation does not pay in the last round, and hence cannot pay in the next to the last round, and so on back up the series.

It is not that native peoples who do manage successful commons reflectively envisage unlimited economic horizons. Rather, local knowledge and practice may incorporate a generation-long "shadow of the future" that cyclically stretches over indefinitely many lifetimes. As Margaret Mead (1970) noted, in "traditional society" parents imagine a life for their children like their own, and children conceive of a life like their parents'. In this sense, few, if any, "traditional" societes survive; however, the insight that knowledge of time, space and information content is more or less faithfully reproduced across generations may still describe cases of successful local commons.

An example: UNESCO and World Wildlife agents visited the recently created Bio-Itza (an indigenously managed 36 km2 forest), proposing an aid package on condition that Itza allow experiments in "selective management and cutting" of mahogany and tropical cedar. This was to be an "ecologically correct" alternative to the logger's practice of "high grading" (extracting valuable species without regard to ecosystemic consequences) in that only narrow swaths would be cleared of all but desired species and additional mahogany and cedar seedlings would be placed in the clearings. In a filmed encounter Itza objected, arguing that clearing would let wind and sun dry protective vegetation on the barks of valuable fruit trees in areas adjacent to the clearings. When the UN and NGO visitors argued that "20 years of selective cutting in Costa Rica shows it works," the Itza countered with: "you need a lifetime to see what wind and sun will do to the bark of a chicle tree."

In a community vote, the Itza rejected the aid offer. In our testing of mental models we will seek to determine in more systematic fashion what local peoples think will be the long-term causal consequences of various outsider schemes for the forest, and compare these with the outsiders' own predictions. This will establish an alternative conceptual basis for "ground-truthing" these schemes in years to come.

Condition (c) is prone to violation by "marketing the forest" schemes (e.g., Clay 1988), which arbitrarily reassign value to selected indigenous resources on the basis of criteria over which local people have little control. This can disrupt systems of local reckoning and exchange (making some values contingent on outside markets and introducing noise into the local referential system). It also risks repeating the abuses of "extractive" economies, such as rubber in Amazonia (Bunker 1984) and chicle production in Mayaland (Schwartz 1990), by profoundly reorganizing indigenous labor and ecology to supply a market whose collapse may leave local society and nature without the means necessary for either to reproduce itself.

From a cognitive standpoint, failure to appreciate limiting conditions (b) and (c) on commons management seem to relate to different ways of appreciating what it takes for the forest to live. For example, a workshop was recently organized in Peten by the U.S. State Dept. (MAB/USAID) and the Central American Commission on Development (CCAD) to address the "conservation and management needs" of "The Maya Forest." The workshop, which was attended by this project's PI and the major NGOs (MacArthur, Ford, etc.) and government agencies in the "Maya Tri-State Region" (Mexico, Guatemala, Belize), targeted as "key issues": "Tri-national coordination," "legal harmonization and enforcement," means "to facilitate access to information" between NGOs and governments. "strengthening local organizations," "research," and "markets and trade" (Dept. of State Publ. 10082, July 1993). Although World Bank representatives were "urged to incorporate input from local resource users," no local users were present to provide input. It was simply assumed that NGOs "can help build the capacities of [local] groups... to promote sustainable forest development" by providing "proper technical and financial support."

Nevertheless, in the 3 years since the "Maya Biosphere Reserve" was instituted with the help of several millions of dollars in USAID and NGO funds, deforestation has risen. The only discussion of the forest itself concerned proposals to market a few native species, such as xate (Chamaedorea sp.) and chicle (Manilkara achras), and to introduce foreign species, such as sheep and iguanas, to feed the immigrants, and hybrid corn to increase yields. There was no mention of risk posed by introduction of new species into a little-known ecosystem, or of hundreds of species exploited by native Maya whose properties and value are unresearched.

By contrast, when we asked Itza how to preserve the forest, their responses were geared largely to current human activities and species interrelationships. For example, providing tapirs watering holes in the dry season so that they would not wander from protected areas and be shot by hunters; sanctioning farmers who failed to make adequate fire breaks around certain trees, such as the incense tree (Protium copal) whose delicate bark is

particularly susceptible to fire-generated heat; monitoring ramon trees (Brosimum alicastrum) against uncontrolled foraging of leaves for livestock fodder, so that the fruits of the trees would continue to be available to numerous mammal and bird species that feed on them; etc.

Still, except for the tapir and jaguar which are especially threatened, Itza continue to hunt mammal species in a manner consistent with the predictions of foraging theory, that is, to maximize their short-term harvesting rate. Hunting decisions that are costly in terms of short-term harvest-rate maximization, yet increase the sustainability of the harvest are eschewed (e.g., not allowing the most likely progeny-producing specimens to go free). By the criteria of foraging theory, this suggests that Itza are more "opportunist" than "conservationist" (Alvard 1993, Johnson 1989) . But there are possible objections to these criteria, and others used to determine species viability in conservation policy (e.g. the US Endangered Species Act). Concentration on single species or quantities of species and species populations may not adequately capture the ways people conceive and maintain species viability. Among Itza, for example, ending to ramon trees may be a much more efficient way of managing viable relations with the numerous animal species that depend on it, rather than monitoring individual species. Our methods are designed to identify such "indicator" species of local knowledge and their ecological roles.

4. **Methodology.** A major anthropological criticism of data-analytic models developed by other social scientists is lack of attention to information content and the varying contexts for interpreting content (local "meaning," Ford 1976, Shweder 1992).

4.l **Anthropological "Ground-Truthing"The** idea of "parachuting" into a field site for intermittent periods of a few weeks of testing is rejected on grounds that both the explanatory hypothesis and its putative explanation may be irrelevant to how others actually conceive and deal with the world. Purported "failures" by people on tasks designed without the benefit of prior cultural insights may reflect more the insufficiency of the experimenter's premises for treating local cases of the issue at hand (Cole & Scribner 1974, Hutchins 1980, Atran in press a). For example, it is hardly plausible that community actors actually remember the history of all transactions in the society so as to calculate the credibility of potential partners in social-dilemma experiments. Rather, people may monitor culturally-determined "reputations," which only participant observation can identify.

4.2 **Analytic Tools.** We employ standard ethnobiological, archaeological and ethnohistorical methods (Berlin et al. 1974, Ford 1978, Flannery 1982, Atran 1993, Hunn 1977, Breedlove & Laughlin 1992, Sabloff & Henderson 1993, Zent 1994). All elicitations are in the informant's native language. In addition, we use 3 modeling techniques originated by psychologists,

sociologists and anthropologists, respectively: 1) mental models (Collins & Gentner 1982), 2) social network models (Scott 1988), and 3) the cultural-consensus model (Romney et al. 1986) . Mental models, is a technique for simulating how people conceptualize physical systems, such as electric circuits (Collins 1985), economic links (Salter 1986) and, in our case, ecological relationships (cf. Kaplan & Kaplan 1982, Kearney 1983). It does this by dividing a system into a set of states and calculating the strength and distance of the links between states. Then informants are asked to change one state and predict what will happen to others. This converts the graph into a causal grid and provides it inferential power not possible with static networks or mental frames (Minsky 1975) and scripts (Schank & Ableson 1977).

Social network models is a data-analytic technique for mapping social structural ties, such as those of corporate organizations (Galaskiewicz and Krohn 1984), kin and non-kin groups (Wellman 1990) and, in our case, networks of resource and information dependency (whose contents are revealed by participant observation, Ford 197 6). It does this by highlighting the presence, direction and strength of relevant ties between actors using graph theory and multidimensional scaling (Coleman 1964, Doreian 1970). The cultural-consensus model (CCM), is a factor-analytic method for computing levels of agreement and disagreement in the structure and distribution of information within and across populations - for example in assessing degrees of consensus about diverse kinds of ecological information and expertise (e.g., experts who typify the consensus versus those with highly idiosyncratic knowledge - Boster & Johnson 1989, Atran 1994).

4.2.1 **Mental Models.** An example of our use of mental models begins by asking informants from each group to imagine that they are sharing their beliefs on "what is most necessary for the forest to live" with a newcomer who has just moved into the area and who is neither familiar with the forest nor has thought much about the issue. Informants are then asked more specifically : (x) What is "most necessary" that people do for the forest to live? (y) What animals and plants are "most necessary" for the forest to live? (z) What (kinds of) water and earth are "most necessary" for the forest to live?

In pre-tests we found that each of the lists usually contained 7-20 items per person. Accordingly, we compile 3 composites list of 15 items each - {xl,..., xl5}, {yl,...,yl5} and {zl,...,zl5} - for each group of informants based on the items most frequently cited. The next step is to write down each item named in the composite lists on an index card. For each informant, one card is selected at a time and the informant asked: "If people do not do x, then what will happen to the other items?" or "If y disappears, what will happen to the other items?" or "If z is not available, what will happen to the other items?" Although using name cards with nonliterate (Maya) informants may seem to **place** unusual **demand on**

(paired-associate) memory, we have found to the contrary that informants sort fairly large numbers of stimuli (e.g. 44 mammals, 42 reptiles) without needing to be reminded of the names associated with symbols on the cards. We have found no significant differences on sorting tasks between literate and non- literate informants who use the cards as mnemonic icons (Atran 1994,in press b).

All responses are then coded in a common representation and vocabulary. The representation is a path in a directed graph (digraph), and the vocabularly a set of 45 terms. Consider the question: "What happens if ramón disappears?" and the sample response: "people will have to plant more corn (they can't eat ramón fruits) the white-fronted parrot will eat more of everybody's corn (it can't eat ramón) and people will burn down more forest (to plant corn); the coatimundi will have to somewhere else for food and will be harder to hunt, and the jaguar will come into the village looking for pigs and chickens (no coatimundis to eat) and be shot; the earth on the hilltop (u-pol witz') (where shallow-rooted ramσn grows) will go, there will be no more (ramσn) to make gruel (sa') for the priostes (religious functionaries) to pray, etc.."

Let "ramón" be yl, "protect from fire" xl, "jaguar" y2, "protect (karst) hilltop" zl, and "pray" x2. Coatimundis and white-fronted parrots are excluded from the list as not highly relevant to the forest's survival for the informant's cultural group, although their relevance in this case is indirectly captured through causal links to items that are highly relevant, forest fires and the jaguar. The above response path would be coded: (yl-xl-y2-zl-x2...).

Numbers are assigned to the "causal strength" of links between items, with 2 simplifying assumptions: 1) links are unsigned (the causal relations between all items are positive functions); 2) the longer the chain between items, the more attenuated the causal effect. Concerning 1): inverse causality could occur between certain items; for example, eliminating ramσn could conceivably help to improve the competitive advantage of certain other valuable trees. An informant's knowledge of this would be preserved in the transcript and qualitative analysis of responses, but not in the quantitative analysis. Concerning 2): there is no guarantee that the temporal sequences generated by the responses correspond to the informant's "true" conception of causal chains. Overall, however, temporal sequence in elicitation or recall may be taken as a rough index of perceived causal strength (McGuire 1968).

For each informant, graphs are represented as matrices (Salter 1986). Each matrix entry signals the strength of the directed link from row concept to column concept. Each item has a link to every item that follows it in a causal chain: the fewer links intervening between 2 items, the higher the absolute value of directed link strength. Items between which no causal links are elicited are

strength. Items between which no causal links are elicited are assigned value "0" for "no effect.[11] Matrices are factor-analyzed. The first principal component captures each item's causal strength: the more frequently an item is mentioned earlier in causal chains, the greater (the absolute value) of its weight in the first component. For each informant, the first 4 principal components comprise a multidimensional simulation of the causal structure of the items, from which we expect different unverbalized but "tacit" theories to arise among informant groups.

ALthough our pilot studies have only just begun, we anticipate group differences in mental models of what human activities and species interrelationships are necessary for the forest to live. For example, NGOs may view the forest ideally as an uninhabited wilderness and think of human involvement in terms of minimizing the disturbance caused by human participation. But the ideal of "minimal disturbance" may be coupled with an understanding of the forest as a set of relatively independent entities or populations, with the "proposed solutions" potentially having anything but minimal consequences. By contrast, we expect native Maya to have models of the forest that are more richly ecologically interactive. Furthermore, their models likely include human beings participating in agro-forestry practices that historically have functioned to maintain the CPR.

Displaced Maya may have preserved some of the social structure for cooperative stragegies; but we predict that they will lack the ecological knowledge and the associated local practices needed to prevent the forest's destruction. Ladinos may view the forest as an open resource to be exploited in an extractive manner. **The critical point is that mental models serve as a guide to action. Incommensurable models and understandings of the rain forest are likely a major obstacles to cross-group communication and cooperation.**

There is also the prospect of within-group expertise or gender differences, owing, e.g., to the greater occupation of men with hunting and farming and women with certain types of herbal curing and forest-related artisanry. Such differences may reveal a cognitive division of labor, as well as areas of overlap, that are important to successful CPR systems. **Where such cognitive divisions of labor exist, social networks can help to reveal how diverse information is coordinated and a cultural consensus reached in matters relevant to CPR management.**

4.2.1.1 **Further Cognitive Mapping.** The full set of 45 index cards representing the "cultural" response to (x), (y) and (z) are placed in alphabetical array on a table before each informant for a free-pile sort. The informant is asked to: "Please put those items together that go together to make the forest live." No restrictions on size or number of piles is given. An aggregated tabulation of item groupings formed by each group of informants is

constructed. This takes the form of a triangular matrix whose cells contain the frequency with which members of the group put together each pair of items.

The matrix is analyzed by a number of straightforward techniques to detect patterns of consistency in how each group combines items. In addition, the responses of each member of the group are converted into a single column of 2-valued pairwise judgments ("1" for a pair of items that "go together" and "0" otherwise), and the columns correlated and factor-analyzed to determine levels of cultural "competence" and "consensus" in informant responses (see CCM below). We expect native Maya groups to have higher levels of consensus (the first latent root accounting for more of the variance) and competence (higher first factor scores for individuals) than other groups.

4.2.1.2 **Story-Based versus Fact-Based Models.** Although most information aids that accompany conservation and development projects are fact-based, research indicates that stories have advantages over factual description for conveyance and retention of causal information (Bartlett 1932, Lévi-Strauss 1970). Stories often build from prior knowledge (Anderson et al. 1987); they use vivid images (Clark & Paivio 1987) and episodes (Tulving 1973, Bruner 1990) that elicit attention and personal involvement; they provide redundant meanings to materials, which allows people to drop details fail to bolster overall causal integration (Garner et al. 1991); they permit retention of potentially relevant but ill-fathomed information so that it can be worked on later (Sperber 1987). Suppose, as we expect, native Maya informants respond with richly interconnected narrative interpretations of the relationships between sorted items and that NGO informants respond with lists of factual descriptions. Then we should be able to see which account is the more communicable and persuasive to the groups that both the native Maya and NGOs believe most threaten the forest by their actions, namely, the immigrant groups.

After the free-pile sort, native Maya and NGO informants are thus asked: "How would you explain to a newcomer why the items go together in that way to make the forest live?" Responses are recorded, transcribed and verbally re-represented to the Maya and Ladino immigrant groups. The immigrant informants are presented with different, randomly chosen versions of the complete response set of native Maya and NGO informants. Following presentation of one native Maya scenario and one NGO scenario to each immigrant informant we will perform 2 tasks. The tasks are counterbalanced among informants.

In task 1 we ask informants to "tell what you heard" to another member of the same immigrant group who has not yet been exposed to any of the versions. This enables us to evaluate which source of information is more vivid and memorable (Allport 1954). In task 2 we ask the informant: "After what you've heard, do you

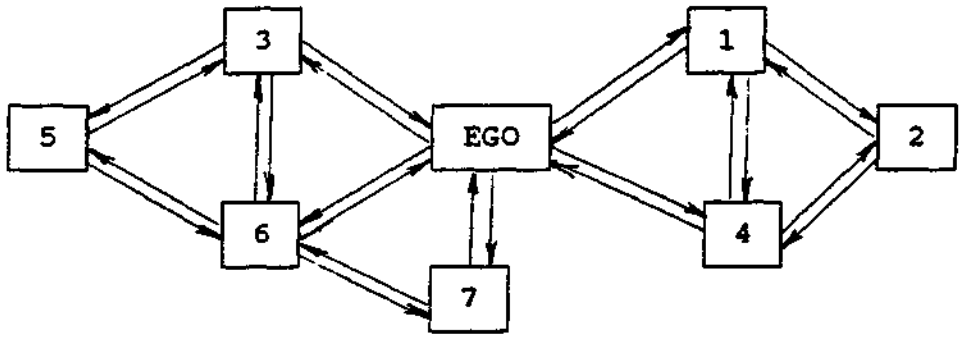
think any differently about what is most necessary for the forest to live?" How?" This allows us to evaluate integration of new information to prior belief and knowledge (Wisniewski & Medin 1994) . We also ask the immigrant informants to tell us: "What is important to you in what you just heard?" "What do you believe is true?" "What do you believe is not true?" We expect immigrants to assimilate native Maya information better than NGO information, and immigrants to do so better than Ladino immigrants.

4.2.1.3 **CPR Monitoring.** We ask informants for each (x): "How do you know if people don't do (x)?" and "If people don't do (x) what should be done to them?" Answers should allow us to discern between-group differences in the kinds of CPR monitoring and sanctioning strategies there are, and within-group differences as to the level of consensus that exists over their use. We predict that only native Maya and NGOs will have elaborated strategies that enjoy a high cultural consensus, but that only the NGO set will be highly institutionalized and rule-bound.

4.2.2 **Social Network Models.** Consider figure 1 from a pre-trial. EGO is an an informant asked to identify in order of importance the 7 persons outside the household that are "most necessary" for EGO. Each person listed is scored for: a) social role (kin, workmate, friend, etc.), b) location (same/other neighborhood, village, province, place of origin as informant), c) frequency of contact (e.g. twice daily = 720/yr.), d) type of dependency (moral, political, material [labor, money, food, tools, etc.]). For each person named, EGO was asked to indicate which of the other persons named that person depends on. To EGO's right are three of EGO's kin who depend on EGO and on one another (double lines represent mutual dependency). To EGO's left are persons identified as "friends" who depend on EGO and on one another, but not on EGO's kin. Below EGO is a person identified as a "workmate and friend" who only depends on EGO and one mutual friend (spatial positioning is arbitrary).

Because there are 8 points including EGO, it is logically possible for them to be connected through 56 lines. In fact they are connected by only 28 lines, so this particular graph has a density of 28/56, or 0.5, indicating that only half of all possible connections are present. Wellman (1979) and his colleagues (Craven and Wellman 1973, Wellman 1990) found that personal networks of 4-8 intimate relationships are readily elicited, but the density of those networks can vary significantly across cultures and across different populations within a culture. For example, a sample of 845 residents of East York in Toronto yielded a mean density of 0.33, but a similar survey in rural Tanzania (Kigoma) yielded 0.76.

Figure 1



In graph theory, density is the ratio of actual number of lines in the graph to the number that would be present if all points were connected to all others. Density measures are used to identify the existence of "clusters" in a graph. A cluster is a relatively densely-connected clump of points within a larger, and less dense, graph. In figure 1, two clusters stand out: one of kin and one of friends. Notice that if figure 1 is viewed as a potential information network, then the clusters have a highly redundant feedback structure, with multiple routes of transmission from and to the same individuals, and the probability of fairly concordant feedback developed through mutual exposure over time. If most of community is densely interconnected, then information concerning commons management should also be highly redundant. In such cases, we might expect multiple channels and opportunities for monitoring and sanctioning, hence little need to develop highly specialized institutional safeguards (watchmen, land courts, etc.).

Such "core" networks of direct contacts represent only a small portion of a person's "extended" social network. By asking, in turn, the highest and lowest ranked persons named by EGO (that live within a day's reach) for the 7 persons they most depend on, we have a better appreciation of EGO's potential contacts. There is no a priori limit on a person's extended contacts (e.g., chain letters) ; but it is generally the case that the longer the chain through which contacts are mediated the less likely they are frequent or important sources of information. Nonetheless, the less redundant, more open sets of relationships should tend to provide more diverse kinds of feedback from sources that do not mutually interact, as well as access to a wider range of less redundantly mediated contacts (Granovetter 1973) .

Thus, two axes of importance to the flow of common resources and information are the variety of ties (e.g., kin, non-kin) and their scope (e.g., intimate, distant). For example, research in Canada and Tanzania indicates that the variety of intimate ties allows access to more diverse arrays of resources and information, while heavy involvement with kin retains connections to a somewhat

solidary system. This may be relevant to the case of native Maya. In addition, distant connections can facilitate greater flexibility in adapting to new resources and information and greater feedback from and access to the larger society. This may be pertinent to the case of immigrant Maya. However, without also a dense "core" of intimate ties to redundantly sustain the circulation of this new knowledge, it may be easily lost and prove ultimately unassimilable as with displaced urban poor (Hammer 1983). This may be germane to the Ladino case. If these are the cases, then it arguably makes sense for NGOs to continue to assist Ladino groups in "stengthening local organizations and communities" but not the already densely organized Maya groups.

3.2.2.1 **Ecological Networks.** Similar procedures elicit people's conceptions of species interrelationships. For example, we ask: (i) What 5 forest animals and plants not found in the village (kaj. pueblo) or farm (kol, milpa) are "most necessary" for people to live (and why)? For each of the kinds named, what are the 4 forest animals or plants that are "most necessary" for it to live (and why)? etc. We also ask: (ii) Which 5 animals and plants outside the home and farm most depend on people to live (and why)? For each of the kinds named, what are the 4 forest animals or plants that most depend on it to live (and why)?

For each informant, responses to (i) and (ii) are represented as separate fishnet graphs with single lines, and then the results combined into a single fishnet graph with single lines representing "parasitic" relationships and double lines representing "symbiotic" relationships. In this way, we can spot clusters of well-connected nodes around important "indicator" species, such as ram6n for the Itza. For the combined graph of each informant, it is logically possible for the number of nodes (named kinds) to range from 5 to (2 X 5! =) 240, and for the combined total of a group of, say, 20 informants to range from 5 to (20 X 2 X 5! =) 4880. In fact, we know from previous study that no group has ready knowledge of more than 100-1000 kinds (Atran 1990, Berlin 1992). But within this factually possible range, with the CCM (see below) we explore the scope and degree of consensus in understanding ecological relationships within and across populations.

For example, we find that, individually and collectively, native Maya name more items than all other groups (including NGOs) . Native Maya will also recognize more "symbiotic" relationships and show greater agreement between individuals in the items and relationships represented. It is also possible to target particular species interrelationships: for example, to determine how much consensus there is on whether people think ramɔn is important for other species.

3.2.3 **The Cultural-Consensus Model.** There is evidence that knowledge associated with "core domains" of human cognition, such as folk biology, spreads within a population in rapid, extensive

and lasting fashion owing to an affinity of such knowledge with basic (possibly innate) cognitive dispositions (Atran & Sperber 1991; Wellman & Gelman 1992). By contrast, where the distribution of opportunities to learn is patchy, then the amount of knowledge shared by randomly chosen pairs of individuals should be shaped more by their social relationship than by general cultural knowledge. For example, among the Aguaruna (Peru) only a few women cultivate rare manioc varieties, so only they and their kin have ample opportunities to visit gardens and learn varieties (Boster 1986b). Understandings of the rain forest ecology may represent an important intermediate case.

The issue of whether the local knowledge of different groups is affected by different belief systems and patterns of information-transmission is examined by analyzing agreement and disagreement in judgments of human/species relationships. A mathematical tool well-suited to this task is the "cultural-consensus model" of Romney et al (1986) . Although the CCM was developed with an eye to practical issues such as how many informants are needed to establish a consensus, it has proven to be a powerful conceptual tool for asking other questions as well.

4.2.3.1 **Determining consensus**. The model assumes widely-shared information is reflected by a high concordance, or "cultural consensus," among individuals. To the extent some individuals agree more often with the consensus on a set of related questions, they are considered more "culturally competent" than others with respect to that set. Mathematical estimation of individual knowledge levels, or competencies, is derived from the pattern of inter-informant agreement on the first factor of a principal component analysis provided that: i) there is a single factor solution such that the first latent root (largest eigenvalue) is large enough in comparison to all other latent roots so that it alone accounts for a significant amount of the variance; ii) most individual scores on the first factor are strongly positive, while no first-factor scores are strongly negative.

Thus, the pattern of correlations among informants should owe entirely to the extent to which each knows the common (culturally relative) "truth." The mean of all first factor scores gives an overall measure of consensus. If there is a common consensus, differences in knowledge should be reflected in the competence parameter. For example, we might expect local Maya to show higher competence scores (owing to their greater experience with the local flora and fauna) than the recently displaced Maya.

The CCM can be run separately for each group or in a combined analysis. We anticipate some general cross-group agreement but also systematic disagreement. Failure of the CCM takes the form of negative correlation of answers for some subsets of the items and the ratio of the first eigenvalue to the second not being high. The idea is that if different subgroups have different knowledge or

beliefs, then subsets of items that tap these knowledge differences will produce negative correlations. Weller (1984) gives examples of the CCM's power to reveal similarities and differences (cf. Nakao & Romney 1984) . She found a single cultural consensus for beliefs about contagiousness of diseases but clear violations of the CCM for beliefs about their remedies. We expect decreasing cross-group agreement as questions shift from the status of individual species to ecological and causal relationships. Boster and Johnson (1969) found that despite lack of significant differences in competence levels between expert and novice fisherman on first factor scores, second factor scores were significantly different. Moreover, the pattern of first and second factor scores correlated strongly with a propositional analysis: experts and novices both relied primarily on morphological criteria in making similarity judgments among fish, but only the experts also used functional criteria to a significant extent in judging similarity (cf. Atran 1994).

4.2.3.2 **Sample size.** The CCM includes an algorithm for assessing how many informants must be sampled from a population with a given average competence in order to determine the cultural consensus with a specified degree of confidence: e.g., if the average cultural competence is 0.7, then a minimum of 5 informants is necessary to classify 80% of informant answers with a 95% confidence level within true-false or multiple-choice formats. Because judgments in our data set have no fixed-response format, the original fixed-format consensus model is only a rough, but reasonably correct, indicator of needed sample size given sufficient numbers of data points (Romney, pers. comm.). Results from our another of our projects on folk-biological classification suggests high inter-informant agreement among native Maya and that as few as 2 groups of 5 subjects from each gender can yield a consensus.

5. **Content in Decision Making.** As indicated above, models of cooperation and commons management typically assume that: actors uniformly share local knowledge; they can communicate this without "noise" or misunderstanding; and they do in fact understand sufficiently well how the ecosystem works and what consequences follow from each act. Many "real-world" cases, however, violate one or all of these assumptions, although current decision-making models of commons management and environmental resource also do not adequately factor these crucial "asymmetries" in local knowledge that can make or break a commons culture.

Accordingly, our methods are aimed at discovering: (1) networks of cooperation and the communication channels these create; (2) what individuals in each group believe about the forest's resources and causal links between these resources (i.e., their "mental models") of the ecological situation); (3) the extent to which the mental models of individuals within a culture overlap; (4) the extent to which the mental models of individuals in different cultures overlap; (5) the extent to which any of these

mental models is a veridical reflection of the ecological situation.

These discoveries, in turn, should inform construction and use of decision-making models. For example, one prediction is that the less connected the species are in mental models of biodiversity, the more likely the resource will be treated as a context-free, substitutable item like money. Of course, this prediction will be modified by more specific factors: if an organism subsists on either of two species, then they are mutually substitutable; however, keystone species that exhibit more dependency links with other species will be less substitutable. Another prediction is that the denser the social network, the less uncertainty there is apt to be in distributive solutions, because the more redundant are the distributive paths. The denser the social network, the less the uncertainty introduced by the time factor where the reliability of social actors is involved; however, the greater actors' knowledge of biodiversity and resource interdependency, the greater the uncertainty introduced by time where reliability of resources is involved. Again, general predictions will be modified by details: a complex, well-buffered system is more likely to be resilient than a simple system dependent on a single variable resource.

7. **Conslusion. The Commons Breakdown: Causes, Consequences and Critical Responses.** The rapid globalization of the market economy is causing the equally rapid destruction of even the most longstanding commons regimes. The entry into a local commons system of even one highly market-valued item can lead to the wholesale replacement of all context-sensitive values (ecological resources) with context-free values (monetary market items), and of ecological rationality (sustaining resource use) with economic rationality (maximizing individual payoffs). This, despite the fact that economic health ultimately depends on ecological viability. As **a** consequence, "the commons tragedy" spreads contagiously as a social virus from mind to mind and from population to population - with the market as its carrier - to menace global survival.

Economic rationality avoids confrontation with ecological rationality by supposing that no resource is critical because any resource is ultimately divisible and substitutable; hence, all resource use is ultimately boundless. Related to the globalization process, three negative and interdependent cognitive correlations operate to maintain this illusion:

1) The greater the expansion of the resource pool beyond local space and knowledge, and the greater a population's conceptual "alienation" from actual conditions of appropriation and use, the less there is readily perceived feedback and appropriate reaction to the consequences of resource abuse (DeYoung & Kaplan 1988).

2) The greater the socio-political commitment to growth over steady-state economics, and the greater "the invisible hand" of

self-interest is imagined to reach beyond present spatial or technological frontiers in order to sustain growth, the fewer the perceived bounds on potential resource abuse (Daly 1991).

3) All things being equal (e.g., constant relative values of resources), then: from the finite-term perspective of self gain, the longer the time horizon on resource use, the greater the preference for up-front rewards and the less the perceived value of the resource over the long term (Prelec & Lowenstein 1991) .

True, there is today a dawning realization that some common resources, such as endangered species, are biologically and culturally irreplaceable, and that other critical resources, such as ozone or neo-tropical forests, may well be indispensable to humankind. But short of a total ban on the use of endangered resources and the abuse of critical ones, it is unlikely that these resources will survive. This is because the greater the mobility and displacement of a population, and the more "diluted" its social networks and ecological knowledge, the less social resolve and conceptual resolution there will be in regard to resource problems.

In principle, there is likely to be a distributive solution to the exploitation of even the most endangered species (e.g., a sustainable harvest ‚tropical cedarwood or rhinocerus horn); however, the greater 'the contact and competition among different value systems (cultures) , and the greater the "noise" introduced by conflicting scenarios of resource structure (mental models), the less likely any distributive solution to resource use can be agreed upon and sustained. Consider, for example, the overriding social value of cattle ownership and grain production in hispanic culture, regardless of economic or ecological value. This leads to maximization strategies for grasses and cereals, and militates strongly against native calculations that concentrate on tree tending as a way to optimize use of biodiversity.

In the absence of strict and clear agreement on how to share a rapidly dwindling resource base, the commons tragedy looms as inevitable. The "zero-option" has the advantage of offering such strict and clear agreement (cf. Princen, manuscript). The conceptual simplicity of a total ban works to cut bureaucratic costs and loopholes. Granted that no ban is guaranteed to be permanent, even temporary enforcement can allow time for a reconceptualization of the resource's value in the consumer market (substituting its moral or aesthetic value in the global ecology for its use value in an extractive economy) . It also gives the local community a chance to develop productive strategies that can provide distributive solutions based on clear and pressing knowledge of costs and benefits. For critical resources, where loss is irreversible and the consequences of such loss are unpredictable, the logic of optimization is wholly specious and any compromise runs the risk of catastrophy. Accordingly, two policy recommendations this project is likely to support are:

1) Institution of a total ban on clear cutting (high grading or selective cutting) in the Maya forest. This should be a proviso of continued US government commitment to the "debt for nature swap" that established the Maya Biosphere Reserves in the first place. Deforestation has only increased despite massive infusion of "sustainable development" funds. This dubious effort involves considerable USAID financing in conjunction with perhaps the highest ratio of NGO participation to any area of the planet (with over 40 registered NGOs in Flores, Peten - a town less then 1 km2 - and including some of the largest NGOs in the world) .

2) Redirecting government and NGO involvement away from setting fixed-term agendas for resource use (leading to iterative prisoner's dilemmas), "marketing the forest" schemes (leading to highly vulnerable extractive economies) and "top-down" social engineering, including organization of "grass roots" participation in pre-planned projects (leading to disruption and collapse of traditional information networks necessary to sustain forest and society) . Current proposals for a establishing a consortium of NGOs within the "information superhighway" promise only to perpetuate and deepen the patron-client relationships between outside organizations and local communities. This is because only the NGOs would be directly connected to one another. Outside organizations would thereby amplify their power to mediate and "represent grass roots needs," instead of allowing local peoples to directly represent themselves to one another.

A new role would be to assist local communities who know how the forest works to directly network information pertinent to their mutual survival. This involves active NGO participation in the exchange, through the channeling of information to local peoples that can help them cope with the disorienting suddeness of forcible immersion in the global market. The focus on physical capital, and a few marketable but ecologically disconnected items, does not help (cf. Ostrom 1994). More often than not, a rapid infusion of money, whether from the market or foreign assistance, rapidly destroys the traditional values attached to resources, knowledge of resources, their ecological integrity and the social life geared to their use.

Largely disenfranchised within their own nations, but possessing the human capital necessary (but no longer sufficient) to sustain local forests and forest society, Maya communities do seek and require aid in transforming their accumulated knowledge and skill into global "political capital." A better task of NGOs and foreign aid, then, may be to internationalize the voice and plight of local commons. For it is a distinct possibility that systems of local management are the only demonstrable means of sustaining limited resources. The problem would be to develop ways for these systems to conceptually link up and coordinate actions. At least this is a problem we can hope to address. The alternative is to confront the looming tragedy with nothing to start with, save a prayer to learn something . .. fast.