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Cultural Capital and Natural Capital Interrelations

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Cultural Capital and Natural Capital Interrelations

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Abstract

The importance of natural capital and the relationships between natural capital and human-made capital are of fundamental interest in ecological economics. But a consideration of these two kinds of capital alone fall short of providing the essential elements for the analysis of sustainability. A more complete conceptualization of the interdependency of the economy and the environment requires attention to social/cultural /political systems as well. We use the term cultural capital to refer to factors that provide human societies with the means and adaptations to deal with the natural environment. Cultural capital, as used here, includes factors such as social /political institutions, environmental ethics (world view) and traditional ecological knowledge in a society. The three types of capital are closely interrelated. Natural capital is the basis for cultural capital. Human-made capital is generated by an interaction between natural and cultural capital. Cultural capital will determine how a society uses natural capital to create human-made capital. Aspects of cultural capital, such as institutions involved in the governance of resource use and the environmental world view, are crucial for the potential of a society to develop sustainable relations with its natural environment.

Introduction

There has been considerable conceptual progress in combining conventional economics with conventional ecology towards achieving ecological economics (e.g. Costanza et al. 1991). For example, the fundamental importance of life-support functions of the natural environment (Odum 1975) for economic development and sustainability has gained recognition in economics as well as in ecology. Ecological economists have distinguished between *natural capital* and *human-made capital* and have come to regard human-made capital and natural capital as fundamentally complementary. Natural capital and its derived goods and services have been considered as the preconditions or the basis for economic development. Ecological economists recognize that it is not possible for human ingenuity to create human-made capital without support from natural capital (e.g. Daly 1990).

However, it is not possible to analyse sustainability by focusing only on these two factors, natural capital and human-made capital. For a more complete conceptualization of economy-environment relations, a third dimension is needed, what we refer to as *cultural capital.* From a systems perspective, the three types of capital are strongly interrelated, and need to be considered together as the essential elements for the analysis of sustainability. In this chapter, we start by describing the three kinds of capital and their interrelations, the systems view of some of these relationships; self-regulation in social systems as described in the literature of common property (common pool) resources; and finally, ways of enhancing cultural capital towards sustainability.

Three Types of Capital

Human-made capital is capital generated via economic activity, through human ingenuity and technological change; the produced means of production. This a common definition of capital in economic textbooks.

Natural capital consists of three major components 1) non-renewable resources such as oil and minerals that are extracted from ecosystems, 2) renewable resources such as fish, wood and drinking water that are produced and maintained by the processes and functions of ecosystems, 3) environmental services such as maintenance of the quality of the atmosphere, climate, operation of the hydrological cycle including flood controls and drinking water supply, waste assimilation, recycling of nutrients, generation of soils, pollination of crops, provision of food from the sea, and the maintenance of a vast genetic library. These crucial services are generated and sustained by the work of ecosystems (Odum 1975; Folke 1991).

Ecological economists argue that a minimum condition for sustainability is to maintain the total natural capital stock at or above the current level (e.g. Daly 1990). An operational definition of this condition for sustainability means that:

- the human scale must be limited within the carrying capacity of the remaining natural capital
- technological progress should be efficiency increasing rather than throughput-increasing
- harvesting rates of renewable natural resources should not exceed regeneration rates
- waste emissions should not exceed the assimilative capacity of the environment
- non-renewable resources should be exploited, but at a rate equal to the creation of renewable substitutes.

The multifunctionality of natural capital needs to be acknowledged in this respect, including its role as integrated life-support systems. Only through maintenance of an integrated, functional ecosystem can each environmental good and service be assured: such goods and services cannot be managed one by one as independent commodities. Humans reduce natural capital because of our capability to invent technical substitutes for those functions, generally forgetting that such substitutes require environmental goods and services from other ecosystem - substituting natural capital in one place requires natural capital from elsewhere - and because of imperfect understanding of the life-support functions on which society depends. It is the significance of this understanding that we discuss in terms of cultural capital.

Cultural capital refers to factors that provide human societies with the means and adaptations to deal with the natural environment and to actively modify it. Different societies have evolved different ways to deal with the environment; the concept of nature, for example, is culture-specific (Hjort af Ornäs and Svedin 1992). The diversity of ways to deal with the environment, i.e., cultural diversity, is a significant part of cultural capital, and perhaps as important to conserve as biological diversity (Gadgil 1987).

Also included in cultural capital is how people view the natural world and the universe, the *source* of these values or cosmology (Skolimowski 1981); environmental philosophy, values and ethics, including religion (Leopold 1949; Naess 1989); local and personal knowledge of the environment, including traditional ecological knowledge (Johannes 1989). An important dimension is the organization of human societies by the evolution of various kinds of resource management institutions, defined as "the conventions that societies establish to define their members' relationships to resources, translate interests in resources into claims, and claims into property rights" (Gibbs and Bromley 1989, p. 22). These institutions, both formal and informal, governmental and non-governmental, dealing with the use of resources or any aspect of the natural environment, are part of cultural capital (Ostrom 1990).

We have used the term "cultural capital" for the lack of a better term. As an alternative term, we considered using "adaptive capital" to emphasize that we are referring to all of these factors important to ecological economics from an evolutionary, mainly cultural evolutionary sense. But the term would have been inadequate to capture the systems perspective that we present here, in which organisms not only adapt to, but also actively modify their environment. This concept, referred to as autopoiesis (Varela et al. 1974), is a key to a systems perspective because it emphasizes a cyclic relationship necessary for the analysis of sustainability. In this cyclic relationship the system boundaries and the components necessary for the development of the system are the result of the system's own actions, in which the components mutually shape each other. Recursive processes of this type are necessary for the evolution of all ordered systems (Jantsch 1980).

Various authors have grappled with the issue of a missing variable in ecological economics. Bormann and Kellert (1991), for example, have focused on ethics as the relevant variable, and considered "ecology, economics and ethics as parts of a whole, of an interconnected circle." Daly (1980) has used the term "moral" to refer to the important social dimension; Daly and Cobb (1989) have distinguished between moral capital and physical capital in reference to ethics and community. But ethics or "moral capital", as terms, are too limited to cover some of the other essential social considerations such as institutions.

No doubt all of the above terms, including cultural capital, are inadequate. But it is difficult, if not impossible, to find a term that would sufficiently cover all aspects of the human societal/ethical/political dimension. These areas fall into a number of different fields of social sciences and humanities (including philosophy, theology, anthropology, sociology, geography and political science); there is no common technical literature that binds them. Yet from a systems point of view, they are clearly related as they all pertain to adaptations dealing with natural systems of which human systems are a part. Together they shape the way in which society interacts with its environm ent, and defines and uses natural capital.

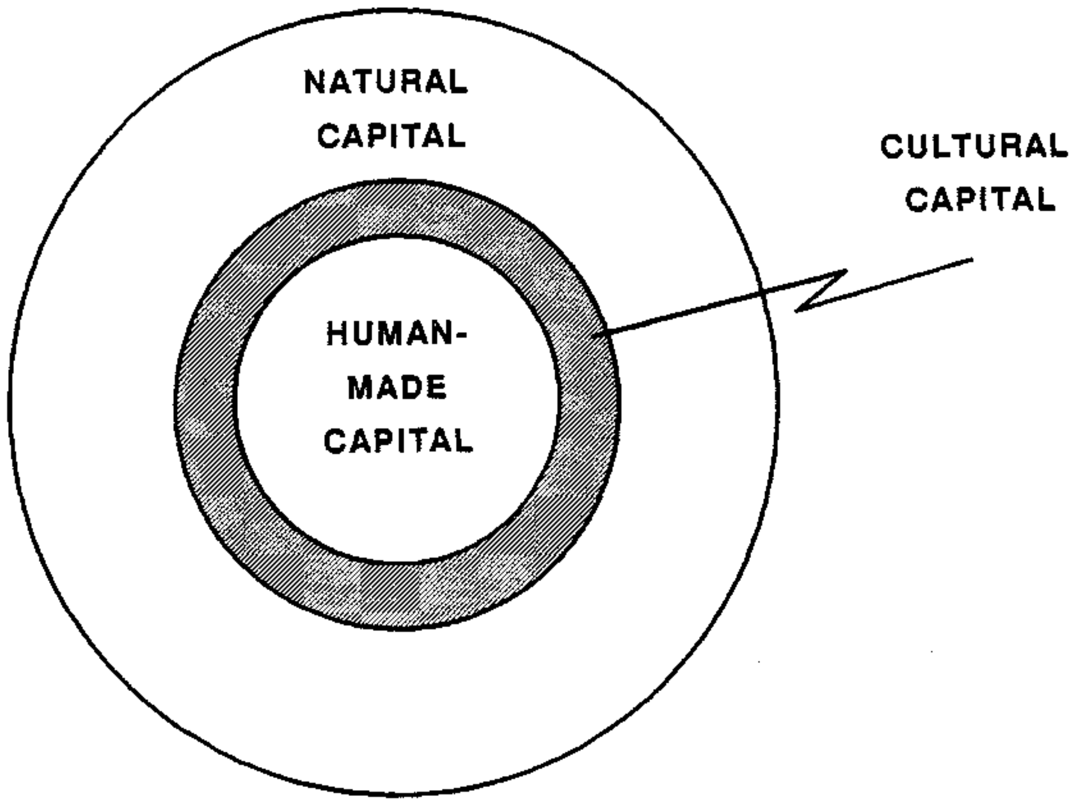

Figure 1. Cultural capital is the interface between natural capital and human-made capital.

There exists a fundamental interrelation between natural capital, human-made capital and cultural capital. In simplest terms, cultural capital is the *interface* between natural capital and human-made capital (Fig. 1). Our world view, values, knowledge and institutions shape the way in which we treat the environment. If ecological economics "addresses the relationships between ecosystems and economic systems in the broadest sense" (Costanza 1989, p. 1). then this interface is part of the proper field of study of ecological economics. A more complex view of the interrelationships among the three kinds of capital is provided in Fig. 2. Natural capital is the basis, the precondition, for cultural capital. Human-made capital is generated by an interaction between natural and cultural capital. Human-made capital, in turn, may cause an alteration of cultural capital. Technologies which mask the society's dependence on

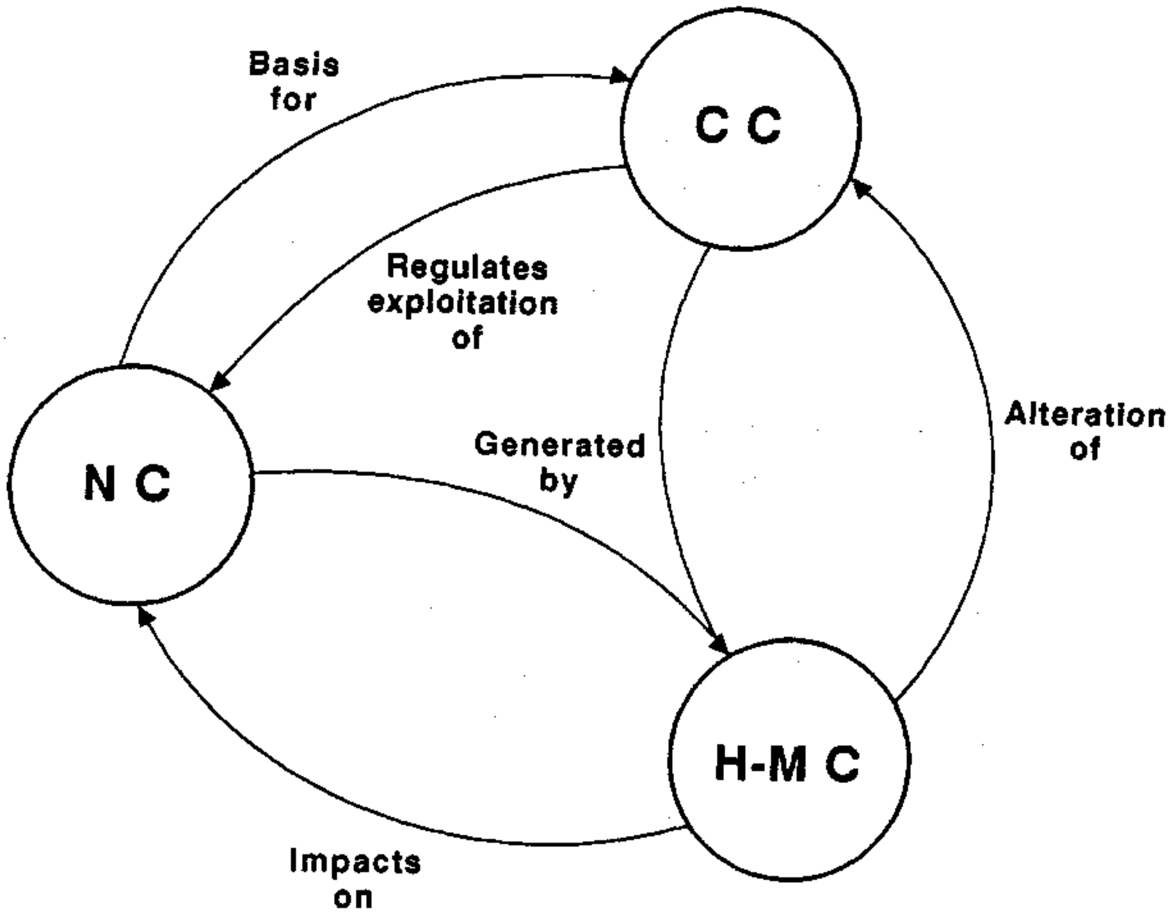

Figure 2. First-order interrelationships among natural capital (NC), human-made capital (H-MC) and cultural capital (CC).

natural capital encourage people to think that they are above nature. The more extensive this change, the more of similar type of technologies will be developed and the more impacts on natural capital there will be. Positive feedbacks between cultural capital, and human-made capital are established which enhance this trend. There will be resource depletion and environmental degradation to feed an industrial society that requires ever-increasing amounts of raw materials, and that generates ever-increasing amounts of waste. Therefore, cultural capital will to a large extent determine how we use natural capital to "create" human-made capital. Thus, human-made capital is never value-neutral. Technologies that we develop are not simply tools that can be put to good or bad use - they reflect our cultural values, world view and institutions.

Systems Ecology and Human Ecology

First, consider the systems view of the environment. The structure and function of the ecosystem is sustained by synergistic feedbacks between organisms and their environment. The physical environment puts constraints on the growth and development of the biological subsystem which, in turn, actively modifies its physical environment to enhance its chance of survival. The focus of the evolutionary perspective is on the incessant process by which organisms adapt to and co-evolve with their environment. The ecological system as a whole is seen to be in a dynamic process of self-organization and self-maintenance (homeostasis). Solar energy drives the use of matter for self-organization, and complex, interdependent hierarchical structures evolve. It is this self-organizing ability, the resilience, organization, and vigour of the ecosystem that generates and sustains the goods and services which form the necessary material basis for human societies.

Now consider the systems view of the human-environment relationship. The structure and function of the ecosystem is sustained by synergistic feedbacks between human societies and their environment. The physical and biological environment places basic physical constraints on the growth and development of the human subsystem. For example, the population growth in a certain area would be limited by the carrying capacity of the environment. The human subsystem, in turn, actively modifies its physical and biological environment: carrying capacity of an area may be decreased through the degradation of life-support systems, or increased by organizing differently or using new technology that works with the environment (e.g. Mitsch and Jörgensen 1989). The self-organizing ability and homeostasis of the ecosystem is paralleled by the self-organizing ability and homeostasis of the human subsystem. These adaptations, in turn, shape the way in which society defines and uses natural capital.

The systems view of the human-environment interrelationship in human ecology is not nearly as well developed as the systems view in ecology, but there are some notable works (e.g, Jantsch 1980, chapter 9). One of the more helpful examples for our purposes of systems view applications in human ecology is the concept of *co-evolution.* Human-environment interactions may be viewed as a co-evolutionary interrelationship in which the two sides change one another continuously by mutual feedback. This is the logical extension into the human subsystem of an evolutionary concept that has been in common use in ecology at least since the 1960s (Ehrlich and Raven 1964).

Historically, the world can be seen as consisting of a "mosaic of co-evolving social and ecological systems" (Norgaard 1987). In each part of the mosaic, the human subsystem selected for species that fulfilled its needs, and itself evolved under the selective pressure of having to use natural capital sustainably. "Co-evolution is a local process," Norgaard (1987) pointed out, "specific to local cultural knowledge, technology and social organization." Thus, these local human subsystems are a significant starting point for discussion of coupled biological/cultural evolution in ecological economics.

A major impediment to the development to a full systems view of human-environment relationships is our heritage of a reductionistic science world view which excludes humans from the system to be studied (Clark 1989). Many ecologists have been reluctant to extend the notion of mutually interactive relations to the study of human ecology, concentrating instead on other species. Other environmental scientists merely study the impacts of humans on the environment, a one-way relationship, effectively treating human systems as exogenous to the ecosystem.

Common Property Systems and Institutions

Another example of systems view application to human-nature interrelationships is the common property approach. The literature on common property resources is of special interest to ecological economics because it deals with experiences in the sustainable use of resources across many different cultures and geographic areas (McCay and Acheson 1987; Berkes 1989; Ostrom 1990). Much of the literature has appeared since 1985; the International Association for the Study of Common Property (IASCP) was established in 1989, with annual meetings after 1990. The newsletter of the IASCP network, the Common Property Resource Digest, had a circulation of some 4 000 as of 1992. What accounts for the phenomenal development of interest in common property resources?

Like the International Society for Ecological Economics (ISEE), the IASCP is interdisciplinary and represents new alliances amongst old players from established disciplines. Concentration on property rights, resource management institutions and social self-regulating mechanisms, has allowed specialists in fisheries, water resources, forestry and land resources to discover new approaches across old disciplinary boundaries. It has provided a coherent, practical approach to problem solving. The parallels between ISEE and IASCP do not end there. These two international, interdisciplinary alliances also show convergent development towards the objective of sustainability.

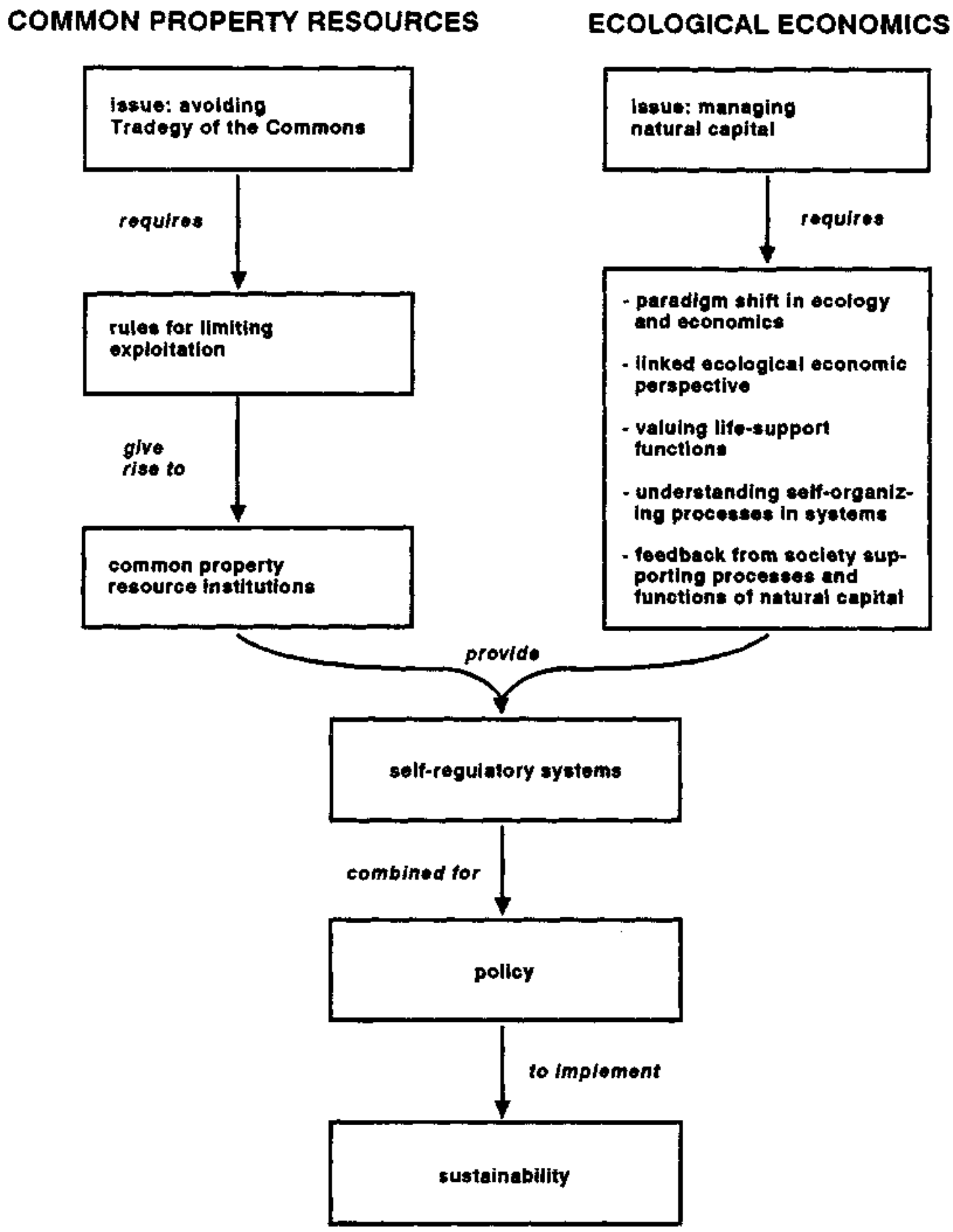

Figure 3. Convergent developments in the fields of Common Property Resources and Ecological Economics.

Figure 3 outlines the development of the fields of common property and ecological economics. The starting points are quite different but not mutually exclusive: in the case of common property, the emphasis is on avoiding or solving the "tragedy of the commons" (Hardin 1968). In the case of ecological economics, the emphasis is on conserving and valuing natural capital. The central issue in the case of common property, requires the development of rules (and their enforcement) for limiting exploitation to levels that are sustainable. This in turn requires attention to resource management institutions, both governmental and other. In the case of ecological economics, the central issue requires a paradigm shift in discipline boundaries to allow for the development of a linked ecology-economics perspective wherein social systems are regarded as subsystems of the overall ecosphere. Costanza et al. (1991) have provided a detailed comparison of ecological economics with conventional ecology and economics.

The common property literature deals largely with the local resource base directly. The usual emphasis is on the local community of resource users and their informal institutions. A major finding of the common property literature is that much of effective management occurs at the local level, and tends to be community-based, both for rule-making and rule-enforcement. By contrast, the ecological economics literature is not concerned with community-level processes explicitly. These processes are often masked by activities at the national, regional, international levels, such as economic growth, development projects and pollution.

Whatever the differences in emphasis and scale, common property and ecological economics fields converge because they are both concerned with self-organization and self-regulatory systems. In the common property area, negative feedback to keep resource exploitation within the limits of sustainability is provided by communal institutions, government institutions or private property regimes (or co-management regimes representing various combinations of the three). In the case of ecological economics, the study of self-regulation of ecosystems, especially with regard to life-support functions, is a priority area. The study of market processes and incentives in the aid of sustainability is another major area. Self-regulatory systems in the use of natural capital do not seem to receive as much attention; in terms of scale, the emphasis appears (implicitly) at the national and international levels, and on specific natural capital problems such as those involved in acid rain, eutrophication and particular ecosystems such as wetlands.

Perhaps the main lesson from the common property literature is that, given a resource management problem, a group of people often organize themselves to deal with it in a manner similar to the formation of a "bucket brigade" to put out a fire in a rural neighbourhood. Communal management of resources also has the advantage of reducing transaction costs. The evolution of rules and self-regulatory mechanisms within the group has adaptive significance for sustainability and survival, and can arise over a time period of as little as ten years (Berkes 1986), and may endure over centuries (Ostrom 1990). Conceptually, it is not surprising to find self-organizing capabilities in social systems, similar to those in ecosystems. In both ecological economics and common property frameworks, human systems are subsystems of ecosystems, and if our premises are correct, should follow the same laws of general systems theory (von Bertalanffy 1968).

Many of the earlier studies of common property systems involved isolated communities. More recent work, such as Ostrom's (1990), focus largely on common property use in contemporary settings, such as ground water use in California and coastal fisheries in Turkey and Atlantic Canada. Of particular interest from a sustainability viewpoint are ultra-stable systems.

A number of such long-enduring, self-organized and self-governed common property institutions have been analyzed by Ostrom (1990). Examples include communal land tenure in high mountain meadows and forests in Törbel, Switzerland; common land management in Hirano and area villages in Japan; and the *huerta* irrigation system in the Valencia area and elsewhere in Spain. From these and other cases, Ostrom (1990 p. 188) has derived a set of variables which were shown to be important for sustainable resource management outcomes, as opposed to "tragedies of the commons":

- the total number of decision-makers or functional units,
- the minimum number of participants necessary to achieve the collective benefit,
- the discount rate used or length of perspective,
- similarity of resource use interests and technology used, and
- the presence of leadership.

Many simpler common property systems involve on the order of a hundred users. More complex systems, organized hierarchically, function with thousands. For example, the number of irrigators in Spanish *huertas* may be some 13,000. Such systems seem to start with small numbers of local resource users which later federate into larger units. In the case of irrigation systems, users may be organized hierarchically from the smallest canals to the main branch of the river, so that the system that eventually evolves may be four layers deep (Ostrom 1990, p. 189). Can more layers be added? Or what are the prospects for a bottom-up hierarchical organization that regulates resource use all the way to the global level?

Common property institutions run into jurisdictional problems, user-group conflicts, and the barrier of national laws and regulations that often contradict them. Thus, for practical purposes, local rules are not likely to extend to international or even national levels. What is more feasible, however, is the possibility of making consistent rules simultaneously at various levels of organization. Global commons have not been the focus of the recent common property literature, but the use of common property institutions for the solution of regional and international resource management problems has started to receive attention (e.g., Bromley 1991). In addition, the experience from common property research has direct implications for the structure of international rule-making. Principles of successful commons use at the local level seem to have their parallels in the international arena, thus stimulating comparative work between common property scholars and international affairs scholars (E. Ostrom, Indiana University, and R. Keohane, Harvard University, pers. comm.).

Enhancing Cultural Capital

It is likely that to approach sustainability at the global level will require investing in cultural capital as well as in natural capital. Figure 4 summarizes some of the ways in which cultural capital may be conserved and enhanced.

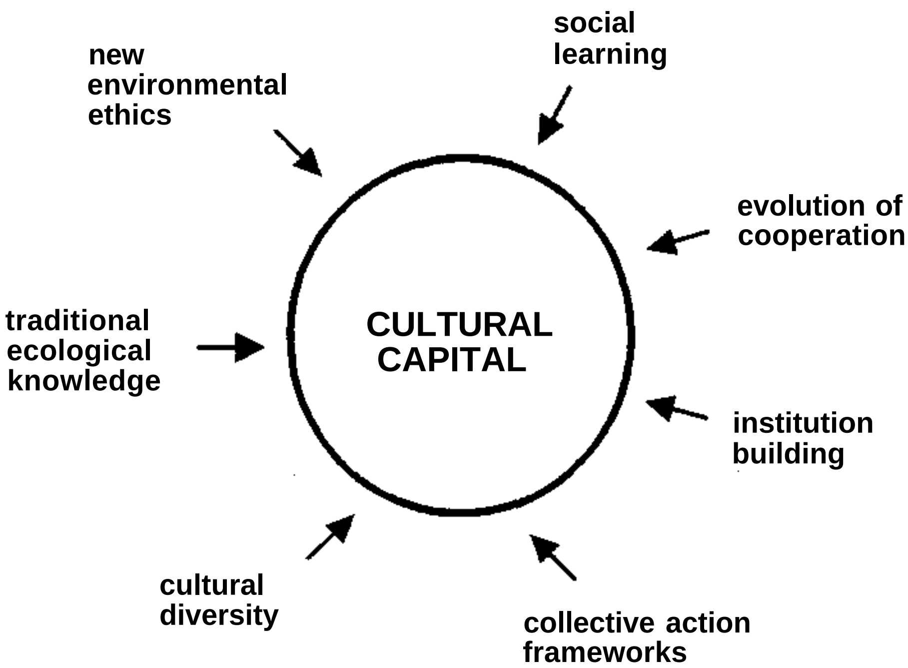

Figure 4. Conserving and enhancing cultural capital towards self-organization for sustainability.

Cultural diversity

Diverse cultures hold the key not only to diverse adaptations to the environment, but also to a diversity of world views that underpin these adaptations. The "dominion over nature" world view, emerging in part from the values and perspectives of the Industrial Revolution, is best geared for the efficient exploitation of resources as if they were boundless, but not for the sustainable use of natural capital (Gadgil and Berkes 1991). With only a limited number of dominant world views, the chances of finding sustainable patterns will be diminished. Thus, as Gadgil (1987) observed, human cultural diversity and biological diversity go hand-in-hand as prerequisites for long-term sustainability. Cultural diversity may be considered a pool of social system adaptations spanning many millenia, a "library" from which a new science of sustainable resource management can borrow. Cultural diversity is no doubt important for its own sake as well, but our emphasis here is on cultural diversity as key to adaptations and knowledge to enable the sustainable use of the environment.

Traditional ecological knowledge

Indigenous knowledge has received a great deal of attention in the fields of agriculture, pharmacology and ethnobotany. More recently, the importance of indigenous ecological knowledge has been recognized for the management of tropical forest, arctic and subarctic, marine coastal, mountain and dryland ecosystems (Johannes 1989; Posey and Balee 1989; IUCN/UNEP/WWF 1991). Traditional systems of communal resource use have been the main ways in which resources have been managed in human history. If these traditional systems had not been sustainable for the most part, we would not have any resources left today to speak about. Indigenous knowledge has proved useful for supplementing scientific information, assisting development planning and impact assessment studies, and helping design resource management systems. For example, the aquaculture and integrated farming systems of ancient China, Egypt and Hawaii show remarkable diversity and ecological sophistication (Ruddle and Zhong 1988; Costa-Pierce 1987). The experience with integrated farming and aquaculture in ancient cultures provide clues for the identification and management of feedbacks for sustainable modern aquaculture (Folke and Kautsky 1992).

Institution-building

One of the reasons for the degradation of natural resources is the degradation of institutions that once provided for their use. For example, the destruction of Hawaii's traditional land tenure system by colonialists in 1848 precipitated the decline of the traditional ecosystem-based land use system *(ahupua'a),* with its integrated farming and aquaculture systems. Decline of fishpond complexes was such that some 98 or 99 percent of the earlier production was eventually lost (Costa-Pierce 1987). How can the lost production be recovered? Traditional production systems may be replaced by new production systems and traditional institutions by the building of new institutions. Or alternatively, institution-building may use elements of traditional institutions if these are still relevant for the solution of resource management problems in hand, as in the case of wildlife co-management in James Bay (Berkes et al. 1991). A current institution-building issue, and a very major one, concerns Eastern European countries. Central state mismanagement of resources, coupled with the virtual elimination of private property and communal property regimes, have left these countries with an unenviable task of institution-building. In general, institution-building is relevant to natural capital conservation from the local to the international scale, and includes such challenges as building international institutions to deal with global atmospheric change effectively.

Collective action

When a number of individuals (or countries) have a common or collective interest, unorganized individual action will often be insufficient to advance that interest. The problem is one of organizing: How to get the independent actors to adopt coordinated strategies to obtain higher benefits for all. This is the key problem behind the theory of collective action (Olson 1965), and it also underpins a variety of social traps (circumstances in which rational individual choices are inconsistent with long-term or collective interests), including the "tragedy of the commons" (Costanza 1987). Users of common property resources such as fish, forests and water are interdependent on one another, as are countries fighting international pollution problems. Much of the observed self-organization among common-property users may be explained in terms of collective action frameworks (Wade 1987). The concept of *interdependency*,with all the feedback loops that it implies, has been in widespread ecological use for decades. It is equally applicable in human ecology, and is the basis for the development of common property institutions at all levels from the local to the international.

Evolution of cooperation

The dilemma in the "tragedy of the commons" is that there is no mechanism in Hardin's (1968) version of the theory, to reconcile rational individual interest with the collective interest. In reality, the recent common property literature indicates the prevalence of social self-regulatory mechanisms in constraining individual behaviour (Feeny et al. 1990). There are sophisticated and ingenious social controls, enforced by mutual consent of community members, on interdependent resource users such as farmers along an irrigation network; these have been documented in great detail by such scholars as Wade (1987). Cooperation confers selective advantage, at the ultimate (or evolutionary) level of causation, to a society of interdependent individuals. But how does cooperation evolve in the first place? Various mechanisms are potentially available, but a particularly promising model is Axelrod's (1984) game-theory approach, based on reciprocity and a repeated Prisoner's Dilemma game. In addition, the Folk-theorem of game theory (Friedman 1986) has unraveled how individuals *in their own interest* may evolve a variety of social norms that will support sustainable uses of resources. These arrangements are fragile, however, and their robustness very much depends on the condition under which these systems evolve (Dasgupta and Maler 1991).

Finding a Prosperous Way Down to Sustainability

The present high levels of seemingly limitless natural capital use is a historically unique phenomenon that is a product of the Industrial Revolution. In the context of the history of the human species, it is a very thin slice of time. For most of their existence, human societies have lived with biophysical limits. A generalized picture of natural capital use over recent human history may indicate more-or-less sustainable levels of utilization of various resources until the Industrial Revolution, followed by sharply increasing use, peaking at the global scale perhaps sometime in the 20th or 21st century. Most ecologists and many ecological economists would probably argue that, on the whole, we have overshot the sustainability levels of our resource base (Fig. 5).

Possibilities for resource substitutability and technological change notwithstanding, most would agree that physical growth cannot continue indefinitely. If so, we are nevertheless uncertain as to (a) whether we have reached the peak of the curve, (b) where the limits really are, and (c) whether the peak will be followed by a collapse and how far. Since not too many people would like to revert to a pre-Industrial Revolution way of life, there is obvious interest in finding a prosperous way down to sustainability; that is, along the lines of A instead of B or C in Figure 5.

Many systems developed during the industrial era are, at the current level of human population and activity, unsustainable and inefficient from a biophysical perspective. They are throughput systems which require large amounts of resource inputs often imported from distant areas. At the same time they generate waste and pollutants

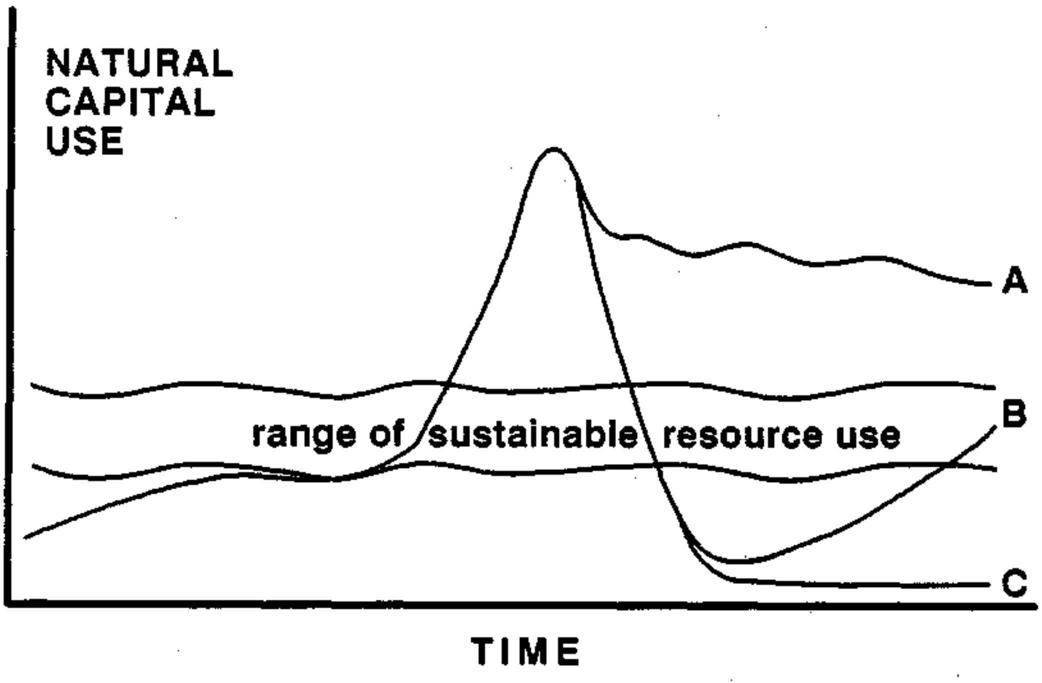

Figure 5. Natural capital: depletion or sustainable use? What level of sustainability?

concentrated in time and space. Throughput systems lack feedbacks for a sustainable use of resources and the environment. They have not been developed for integration with the processes of ecosystems on which they ultimately depend.

Intensive salmon farming is an example of such systems. The salmon are densely reared in cages, which requires huge imports of feed pellets continuously "pumped" into the system, as well as inputs and support from an industrial infrastructure. The salmon culture would have no chance of surviving without these inputs. In addition, large ecosystem areas are needed to produce the salmon food. In fact, that ecosystem area is about 50 000 times larger than the surface area of the cages, or 1 km^2 per tonne of salmon produced. The concentration of large quantities of imported resources in a limited area generates much waste, which creates severe environmental impacts that threaten the survival of the industry itself (Folke and Kautsky 1989). If such an industry expands (and this is equally true for other industries behaving in a similar manner) the limits to growth will appear that much earlier.

A necessary condition for sustainability is that the functions of natural capital be supported, rather than disrupted, by feedbacks from society. In the case of salmon farming, creating a more diverse system by managing feedbacks between the farm and its surrounding ecosystem would turn waste into new resources, such as seaweeds and mussels (Folke and Kautsky 1992). Such "new" resources would serve as valuable products, both at the salmon farm and in society. Recycling of waste into new resources would also minimize impacts on the environment, and considerably reduce the system's dependence of inputs from large ecosystem areas. The culturing system would be much more self-sufficient. Such approaches, referred to as ecological engineering (Mitsch and Jörgensen 1989), would build the capacity for the management system to work in synergy with ecosystem processes. As well, reducing the spatial scale of the operation makes it more suitable for communal control and management.

Through discoveries of new energy sources (manily fossil fuels) throughout the industrial era, which made it possible to exploit minerals and other non-renewable resources, the expansion of the human sub-system accelerated. The cultural capital components of accumulated knowledge and human ingenuity found these new sources of natural capital which released the direct constraints set by the natural environment. Throughput production and consumption behaviours were made possible during this rapid and creative expansion phase because of this additional (but non-renewable) natural capital.

In a natural system, feedbacks from the environment directs the system towards restructuring resource use from a throughput behaviour towards a more complex and sustainable use pattern. Quantitative growth is replaced by qualitative improvements, simply because of necessity. We would argue that many of the self-regulatory social and behavioural patterns that exist in local communities have evolved in a similar way. We would further argue that the increased attention to sustainable development at the national and international levels is a reflection of environmental feedbacks as limits are approached. The question is whether humanity will be able to respond to these feedbacks rapidly enough to find and adopt sustainable development pathways. Successful transition requires creating conditions conducive for such pathways, under which we will deal with three topics.

Ethics of sustainability

The way in which resources and environment are managed depends on our values. As it is clear enough that we have not been managing our natural capital sustainably over the last two centuries or so, some of our values need to be modified. The current Western world view of the environment has a complex background rooted in our religious, scientific and industrial history (Clark 1989; Skolimowski 1981). We need to restore a semblance of the "community of beings" world view of ancient pantheistic traditions; this may be useful in curing widespread alienation from nature. Everenden (1985) has suggested that humans are akin to aliens from space because they, in most Western cultures, have a self-identity distinct from the world around them. The root of this aberration, according to Everenden, is our cultural emphasis on objectivity. Skolimowski (1981) has argued further that our cosmology is based far too much on empiricism and scientism. It is too mechanistic and analytic; it is not sufficiently based on humanistic notions and morality toward nature (Skolimowski 1981). Developing an ethic of sustainability, taking into account these considerations and re-integrating people with nature, is a challenge for using our cultural capital creatively.

Hierarchy of systems

The issue of the speed of change in values leading to sustainability is obviously crucial. Some authors have pointed out that natural systems may be seen as consisting of a hierarchy of nested subsystems, with a two-way flow between levels (e.g. Norton 1990). The discrete functional components of the ecosystem may be operating at different scales. The higher levels may be operating at a time scale that is slower than that of the lower levels. Norton (1990) analysed Leopold's (1949) land ethic and interpreted his *Thinking Like a Mountain* as a metaphor for thinking in larger time frames: "He recognized that human individuals consider their actions in short frames of time whereas the mountain - the larger ecological community - must 'think' in the longer frames of ecological time" (Norton 1990).

The effective time scales in social-ethical change in this context and how they relate to time scales in natural systems is an area in which little is known. Suffice to say that social systems, like natural systems, *are* organized hierarchically. However, the potential for change at the higher levels (e.g. national and international) is *not* necessarily slower than that at the lower levels (e.g., community). Given the global media coverage and electronic communications of our age, the potential of rapid change at the highest levels is very great. (Effective political action at the global environmental level, however, is yet another story). The image of the "global electronic village" has been with us for the last few decades. However, this term conveys the sense of a mass society alienated from nature (gesellschaft rather than gemeinschaft). The image that we much rather prefer is that of a "community of communities" (Daly and Cobb 1989).

Social learning

A concept that is difficult to define precisely, social learning carries the sense of a "self-educating community" (Milbrath 1989, p 88). It refers to learning that takes place at the level of the population or society, rather than at the individual level. It is a learning process at an altogether different time scale; it carries great promise as a way in which cultural capital can be put to work for sustainability. The classical cases of social learning in sociobiology concerned the spread of learned adaptive behaviour. The general finding was that the adaptive behaviour at first spread very slowly, gathering momentum as it spread to a certain critical number of individuals. When that critical threshold was reached, however, the behaviour was learned very quicky - explosively - by the rest of the population.

Applied to human societies, analogies may be found with regard to smoking and the avoidance of cholestrol-rich food. The spread of individual behaviours consistent with sustainability principles (e.g., family planning, recycling waste, sorting of household toxic substances, avoidance of pesticides in the garden, bicycling to work) may follow similar pathways. But these individual behaviours may not be sufficient in themselves to bring about sustainable society. Community and corporation-level behavioural change may also be necessary. There are national-level "behaviours" as well, such as assessing the potential impact of development projects before they are built, encouraging the development of energy policies based on renewable resources, and natural capital accounting. These also seem to be spreading but have not yet reached the "take-off" stage internationally. It may be suggested that incentives for social learning towards sustainability may be provided by episodic events such as the Chernobyl accident, the Rhine chemical spill, the death of seals in the North Sea - shocks to the value system to stimulate change. Furthermore, the behaviour of critical nodes in the social system such as media, international banks and others, serve an important role in the process of social learning.

Conclusions

There are no pristine environments on earth untouched by human influence. Even Antarctica is affected by pollutant fallout and ozone-layer thinning. The positive approach for ecological economics is not to bemoan the human influence on the natural environment, but to adopt a systems view of human-environment relationships to trigger measures that would stimulate social, as well as ecological, self-regulatory patterns for sustainability. Policies of sustainability need to recognize the importance of *institutions,* at the various levels in the "community of communities", and the lessons available from the common property literature which deals with the organization of sustainabilty across various cultures, resource types and geographical areas.

Institution-building, collective action, cooperation, and social learning towards a new environmental ethic are some of the ways in which social self-organization may help us adapt rapidly enough to meet the constraints of sustainability. We need institutional structures which are adaptable. Cultural diversity and traditional ecological knowledge are part of the cultural capital into which society needs to invest to provide the raw material for the process of sustainable development. Successful transition to sustainability requires building the capacity for the environmental-socio-political system to change. Sustainable development is a continuous process and not a state; it is never achieved once and for all, but only approached. As such, it can only be reinforced, not attained. Sustainable development calls for maintenance of the dynamic capacity to respond adaptively, which is a property of all successful species and societies. It is not meaningful to measure the absolute sustainability of a society at any point in time. "Our concern should be more with basic natural and social processes, than with the particular forms those processes take at any time" (Robinson et al. 1990).

We need to learn to live with uncertainties and surprises, and be prepared for them. We can use the great creative activity of the current energy-rich world and the pervasive information network that we have developed to find "a prosperous way down" to sustainable steady-state societies (Odum 1988). To rethink and reconstruct a new science that is better adapted to deal with the interdependencies among natural capital, human-made capital and cultural capital, the systems perspective will be of great value to the field of ecological economics.

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References

Axelrod, R. 1984. The Evolution of Cooperation. Basil Blackwell, New York.

Berkes, F. 1986. Local-level Management and the Commons Problem: A Comparative Study of Turkish Coastal Fisheries. Marine Policy 10: 215-229.

Berkes, F. (ed.). 1989. Common Property Resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London.

Berkes, F., George, P. and Preston, RJ. 1991. Co-management. The Evolution in Theory and Practice of the Joint Administration of Living Resources. Alternatives 18 (2): 12-18.

Bormann, F.H. and Kellert S.R. 1991. Ecology, Economics, Ethics. The Broken Circle. Yale University Press, New Haven.

Bromley, D.W. 1991. The Law, Agency and Global Climate Change Report to the United States Agency for International Development, Washington, D.C. 55 pp.

Clark, M.E. 1989. Ariadne's Thread: The Search for New Modes of Thinking. St. Martin's Press, New York.

Costa-Pierce, B.A. 1987. Aquaculture in Ancient Hawaii. BioScience 37: 320-331.

Costanza, R. 1987. Social Traps and Environmental Policy. BioScience 37: 407-412.

Costanza, R. 1989. What is Ecological Economics? Ecological Economics 1: 1-7.

Costanza, R., Daly, H.E. and Bartholomew, J.A. 1991. Goals, Agenda, and Policy Recommendations for Ecological Economics. In: R. Costanza (Editor), Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York. pp. 1-20.

Daly, H.E. 1980. The Steady-State Economy: Toward a Political Economy of Biophysical Equilibrium and Moral Growth. In: H.E. Daly (Editor), Economics, Ecology, Ethics: Essays Toward a Steady-State Economy. Freeman, San Francisco, pp. 324-356.

Daly, H.E. 1990. Toward Some Operational Principles of Sustainable Development. Ecological Economics 2: 1-6.

Daly, H.E. and Cobb, J.B. 1989. For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future. Beacon Press, Boston.

Dasgupta, P. and Mäler, K.-G. 1991. The Environment and Emerging Development Issues. In: Proceedings of the World Bank Annual Conference on Development Economics. The World Bank., Washington. pp. 101-131.

Ehrlich, P.R. and Raven, P.H. 1964. Butterflies and Plants: A Study in Coevolution. Evolution 18: 586-608.

Everenden, N. 1985. The Natural Alien. University of Toronto Press, Toronto.

Feeny, D., Berkes, F., McCay, BJ. and Acheson, J.M. 1990. The Tragedy of the Commons: Twenty-Two Years Later. Human Ecology. 18: 1-19.

Folke, C. 1991. Socio-Economic Dependence on the Life-Supporting Environment. In: C. Folke and T. Kåberger (Editors), Linking the Natural Environment and the Economy. Kluwer Academic Publishers. pp. 77-94.

Folke, C. and Kautsky, N. 1989. The Role of Ecosystems for a Sustainable Development of Aquaculture. Ambio 18: 234-243.

Folke, C. and Kautsky, N. 1992. Aquaculture with its Environment: Prospects for Sustainability. Ocean & Coastal Management 17: 5-24.

Friedman, J.W. 1986. Game Theory with Applications to Economics. Oxford University Press, Oxford.

Gadgil, M. 1987. Diversity: Cultural and Ecological. Trends in Ecology and Evolution 2: 369-373.

Gadgil, M. and Berkes, F. 1991. Traditional Resource Management Systems. Resource Management and Optimization 8: 127-141.

Gibbs, C.J.N. and Bromley, D.W. 1989. Institutional Arrangements for Management of Rural Resources: Common-property Regimes. In: F. Berkes (Editor), Common Property Resources. Belhaven, London. pp. 22-32.

Hardin, G. 1968. The Tragedy of the Commons. Science 162: 1243-1248.

Hjort af Ornäs, A. and Svedin, U. 1992. Cultural Variation in Concepts of Nature. GeoJournal 26: 167-172.

IUCN/UNEP/WWF 1991. Caring for the Earth. A Strategy for Sustainable Living. World Conservation Union, Gland.

Jantsch, E. 1980. The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution. Pergamon Press, New York.

Johannes, R.E. (ed.) 1989. Traditional Ecological Knowledge: A Collection of Essays. World Conservation Union, Gland.

Leopold, A. 1949. A Sand County Almanac. Oxford University Press, Oxford.

McCay, B.J. and Acheson, J.M. (eds.) 1987. The Question of the Commons: The Culture and Ecology of Communal Resources. The University of Arizona Press, Tucson.

Milbrath, L.W. 1989. Envisioning a Sustainable Society: Learning Our Way Out. State University of New York Press, Albany.

Mitsch, W.J. and Jorgensen, S.E. (eds.) 1989. Ecological Engineering: An Introduction to Ecotechnology. John Wiley and Sons, New York.

Naess, A. 1989. Ecology, Community and Lifestyle. Cambridge University Press, Cambridge, U.K.

Norgaard, R.B. 1987. Economics as Mechanics and the Demise of Biological Diversity. Ecological Modelling 38:107-112.

Norton, B.G. 1990. Context and Hierarchy in Aldo Leopold's Theory of Environmental Management. Ecological Economics 2: 119-127.

Odum, E.P. 1975. Ecology: The Link Between the Natural and Social Sciences. Second Edition. Holt-Saunders. New York.

Odum, H.T. 1988. Living with Complexity. In: The Crafoord Prize in Biosciences 1987. Crafoord Lectures, The Royal Swedish Academy of Sciences, Stockholm, Sweden. pp. 19-87.

Olson, M. 1965. The Logic of Collective Action. Harvard University Press, Cambridge, MA.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge, U.K.

Posey, D.A. and Balee, W. (eds.) 1989. Resource Management in Amazonia: Indigenous and Folk Strategies. Advances in Economic Botany, vol. 7 (special issue).

Robinson, J., Francis, G., Legge, R. and Lerner, S. 1990. Defining a Sustainable Society: Values, Principles and Definitions. Alternatives 17 (2): 36-46.

Ruddle, K. and Zhong, G. 1988. Integrated Agriculture-Aquaculture in South China: The Dike-pond System of the Zhujiang Delta. Cambridge University Press, Cambridge, U.K.

Skolimowski, H. 1981. Eco-Philosophy. Boyars, London.

Varela, F.J., Maturana, H.R. and Uribe, R. 1974. Autopoiesis: The Organization of Living Systems, Its Characterization and a Model. Biosystems 5: 187-196.

von Bertalanffy, L. 1968. General System Theory: Foundations, Development, Applications. George Braziller, New York.

Wade, R. 1987. Village Republics: Economic Conditions for Collective Action in South India. Cambridge University Press, Cambridge, U.K.

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