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Varieties of Interactions in Nature

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Introduction

This essay examines the parallels between the interactions of processes, of animals and of humans in ecological systems; it concentrates on disturbance and exploitation behaviour and contrasts them with the interference behaviour that characterizes the dominant human, industrial culture. Examples of each will be taken from wild ecosystems, forestry, animal cultures, archaic human cultures, and industrial culture. The word "interactions" is used, instead of words like "events" or "catastrophes," to describe the feedback and cyclic nature of actions.

Humanity is exploiting nature recklessly, without attention to the minimal health of ecosystems. Many ecologists, such as Eugene Odum (1971), have observed that complex communities have existed for thousands of years in relatively stable environments, even though these environments are characterized by regular disturbance and constant exploitation. These environments are now vulnerable to human interference (to be distinguished from disturbance or exploitation). Disturbance, by definition, is an event that can be caused by climate, biological entities or other actors. Exploitation is the normal use of a resource or of a species by another species, including the human species. This ecological definition differs from a sociological definition, "selfish" or unethical use," although it may suffer from negative connotations owing to associations with the latter. In contrast, ecological exploitation has a rejuvenating effect on populations. Exploitation is contrasted with interference, an activity that can degrade, destabilize or destroy entire ecosystems. Interference is not a form of disturbance, exploitation or competition; it is destruction without gain to any species. In the case of human interference, it is the destruction of the structures and processes of evolution for large-scale, one- species, short-term gain.

The interactions of living beings in ecological contexts may have positive and negative effects on themselves and other species, as well as constructive and destructive effects on ecosystems and the operation of biogeochemical cycles. Human interactions are also considered. The pandominance of ecosystems by humanity is related to the biological and cultural characteristics of the species. Ignorance and indifference are identified as major reasons for continued interference.

Interactions

Living organisms in a given area interact with the physical environment so that an energy flow leads to the defined trophic structures and material cycles that comprise an ecosystem, according to Eugene Odum. An ecosystem can be analysed into parts, including organisms, energy circuits, food chains, diverse patterns, nutrient cycles, development and evolution, and control. No organism can exist by itself or without participating in an ecosystem.

Organisms interact in a number of ways. Interactions can be positive, negative or neutral in effect. In neutral relations, for instance, neither population is affected; in competition each group adversely affects the other for resource use; in parasitic relations one benefits and the other is adversely affected; and, in mutual relations both benefit in a necessary relationship.

Competition was once considered the basic interaction between individuals and species. The better adapted organisms survived and reproduced; others died. However, cooperation is now known to be as effective a strategy as competition and as necessary. Survival of the fitter is correct only up to a point; beyond that it is survival of the more cooperative, as Konrad Lorenz has pointed out. Competition is necessary but limited. Cooperation is what creates communities. Both old studies (Reinheimer 1910, Kropotkin 1972) and new research (Fox 1974, Lorenz 1952) stress the primary importance of cooperation.

Some commentators feel that cooperation should replace competition as a primary interaction, and that positive interactions like symbiosis should be maximized. Of course, neither interaction can dominate without sad consequences. If all plants were symbiotic and none were competitive, we would have no trees or flowers. If every being were competitive and not symbiotic, multi-cellular beings would probably not have evolved.

Most interactions are not simple, but are complex and paradoxical, involving symbiosis and competition, which makes proper definition difficult. For example, predation is regarded as being where one population adversely affects another, but is dependent on the other, like parasitism. This is not so; predation benefits both. Predation is more of a mutual and less a parasitic relationship, especially with wolf-deer predation, for example. Since competition also regulates populations to some extent, according to Stanley (1971) and others, its effects are not entirely adverse. Furthermore, an interaction, like parasitism, that is negative on an individual level may have benefits on a species level. The predator/prey (or parasite/host) are not excluding opposites, but generate a whole unity, an autonomous domain where there is complementarity, stabilization and survival values for both species. The effect on a species, by disturbance, exploitation or interference, is also complex.

Exploitation

Animals and plants, algae, bacteria, fungi, live together in ecosystems. Living together involves many kinds of interactions, from competition and conflict to cooperation and mutualism. Interactions may be reciprocal or complementary. They may dominate or control. Interactions are multidimensional. A wolf, for instance, may howl to communicate or to restore proximity with a mate or for pleasure. Many animals, such as wolves and caribou, develop together over time, adapting to each other's strategies; Paul Ehrlich and Peter Raven (1992) refer to this mutual adaptation as coevolution. Coevolving systems never completely adapt.

Every species uses some part of other species or of the environment. This use is termed exploitation. Insects, diseases, and animals, more than being simply agents of mortality, are native components of complex food webs in ecosystems, and they contribute to the selection of species. In a Ponderosa pine forest in the Pacific Northwest, insects exploit trees; they pollinate some trees and overwhelm others, but rarely more than one per cent of a forest. Diseases exploit trees; they remove stressed trees - also probably a low percentage on the order of one per cent. Their effect on the long-term health of a forest, however, is positive.

Birds and mammals eat foliage and seeds; they also disseminate seeds. Mammals, the best regulated of more recent species according to Frank Golley (1975), change their habitats to suit themselves by chewing, digging and burrowing. Rodents can dislodge earth at a tremendous rate. In many cases, these activities improve the conditions for the growth of vegetation. Mammalian grazing promotes vegetative regrowth and the movement of seeds. Bison and prairie dogs were responsible for much of the character of the American plains. Rodent caches may account for a good percentage of pine seedlings; possibly fifteen per cent of a Ponderosa pine forest rises from such seed caches. Beavers and other rodents create their own microsystems. Wide-ranging caribou and wolves transfer energy between systems.

Predation increases the survivability of a prey species. Predation also increases the diversity of species, according to Steven Stanley, by limiting the most populous prey species. Rarely do predators kill all of the prey. Rarely do animals interfere with the operation of the biogeochemical cycles in the environment. The exploitation of the system by plants, insects and animals contributes to the health and continuity of the ecosystem. Exploitation is not chaotic; there are limits and rules.

Rules

Animals obey rules of behaviour. Many animal communities have codes of behaviour that regulate interactions. In birds and less complex mammals, these rules may be very rigid and predictable. With increasing brain complexity, however, learning takes a larger role. For example, young white-tailed deer in Idaho have to learn to cross highways. They appear to use rules of thumb (not the best phrase), finding a proper balance between safety and reasonable progress, between no traffic in sight and bumper to bumper congestion.

Animals like wolves have behavioural inhibitions against killing too many prey or killing their own kind, against coupling with a mated or disinterested female, or against attacking non-prey species. Animals that break such inhibitions are usually sometimes attacked or ostracized. In general, food is shared by all members of a wolf pack. Adults will regurgitate part of their food for adults who stay behind with juveniles. The members of a wolf pack cooperate bringing down an elk, but then compete for the choicest parts of the prey. Rules are not always strict; wolf mates raising pups may consciously deceive one another to get a break from the responsibilities, according to Michael Fox (1978).

The social structure of a wolf pack is most important. Breeding, playing, hunting, feeding and territoriality are tied to social structure. Wolf pups are taught how to behave and how to hunt. Much of the behaviour of wolves is directed at keeping the animal's status in the pack or to raising it. Quarrels take place often and the entire pack seems to take an active part. Actual battles, however, are rare. Ritualized squabbles result in few physical injuries. Wolves do kill each other, however. Wolves that behave strangely, such as epileptic pups or adults crippled in the chase, are sometimes killed by the pack. Disputes over the alpha position may end in death. Foreign wolves may be killed if they do not flee. Prey may be killed in excess during times of denning. Rules of encounter are complex and the outcome depends on numerous circumstances, such as the abundance of prey, the size and health of the pack, and stress; that is, the rules often depend on limits.

Limits

Mammalian behaviour is controlled and population regulated through the use of space in general. Most mammalian populations, wolves for instance, regulate their density well below the limits of the food supply, often by as much as fifty to seventy per cent. Territoriality limits populations, but populations can also be limited by specificity of prey or plant source, size of prey or plant populations, predators, natural events or even individual tastes.

Wolves in the Arctic disperse with the migration of the caribou. According to David Klein (1983), they prefer caribou to other often more easily obtained species, such as mice. This preference reduces their hunting efficiency, however.

The goals of an organism are limited by the life-images of its species. Each animal is a participant in a field of existence. Using its senses, each participant creates an image of nature, or world (*umwelt*, life-world, is the term used by von Uexkull), from the sensations that are meaningful to it. Each animal fits itself to its unique world as completely as it is able: simple animals to simple worlds, complex ones to well-articulated worlds. Each fits its place as well as it can. Konrad Lorenz, Michael W. Fox, and others have elaborated this kind of fitness in more detail.

Each organism is inseparably related to a place; breaking the bond may result in death. Organisms and places shape each other. This is true of archaic human cultures as well.

Traditional Ways of Archaic Societies

Most human cultures are located in a particular territory. This is especially true of the Campa, who live in a tropical forest in Peru, and for the Ituri pygmy, who live in a tropical rainforest in Africa. The features of their cultures are unique to their place. They literally could not live with images of desert or ocean, like the Taureg of the Sahara or the Samoans of the Pacific. The very circumstance that makes each culture unique, being in a unique place, ensures that it can fit a place. This fitness ensures a limitation of exploitation.

Particularly in agricultural societies, cultures are gauged closely to seasons. The culture makes the world manageable by limiting it. A local culture is also tuned to the limits of the local ecology, within the knowledge of interactions; the long-range ecological consequences of drainage, irrigation or overexploitation can contribute to the success or failure of a culture. Many, but not all, archaic cultures are a form of fitness and limitation. Most archaic groups try for adaptation before domination. For instance, according to Gerardo Reichel-Dolmatoff (1971), the goal of the Desana Indians is the cultural continuity of their society in its place in the rainforest.

The Chipewyan Indians in Northern Canada occupy the same territory as wolves and compete for the caribou, although their niches are not identical. Both social systems are adjusted to the hunting of barren ground caribou. Chipewyan hunters depend on animals other than caribou, which migrate out their Indian grounds. The cultural decision to hunt caribou as the primary item of subsistence, however, has produced many similarities between the two species in their utilization of land and in the formation and distribution of social groups. The cultural decision to hunt caribou results also in a population density lower than what would result through other decisions regarding the utilization of resources.

For hunting, Chipewyan use dog teams, snowshoes, and boats to increase their mobility and rifles and bows to supplement the traditional spears. The strategy of the Chipewyan, according to Henry Sharp, is to kill caribou at any opportunity. They increase their opportunities by walking aimlessly, watching, and driving the caribou, although the Chipewyan expend less energy by watching and ambushing. Wolves follow the more active strategy because of their increased and superior mobility. Both species adopt a pattern of dispersing and concentrating with the caribou. The basic choices regarding subsistence patterns, social organization, demography, terrain usage and yearly cycles are made on the basis of the internal logic and structural characteristics of the two cultures (wolves do have culture, in the general anthropological sense, according to Sharp and Fox).

Although the two species do not compete directly, both Chipewyan and wolves are predators that put pressure on caribou populations. Sharp suggests that the commitment of both to caribou hunting is ecologically inefficient, since both species could spend more energy on secondary sources of food. For the Chipewyan, a deliberate "underutilization" of moose, rabbit, grouse, birds and fish, is the result of cultural values, including their willingness to live below the carrying capacity of the local environment, a characteristic of most hunting/gathering societies. The complex practice of drying caribou meat, and the reciprocity of their kinship system, i.e., caribou, are better bases for future relationships. The cultural decision to hunt caribou as the primary item of subsistence has produced a unique pattern in the utilization of land and in the formation and distribution of social groups. Wolves also underutilize their resources.

Regardless of cultural order or cooperative interactions, part of the process of life is uncoordinated, unfitting, disorderly, unbalanced and destructive. Therefore, suffering often occurs. Suffering is an unavoidable part of disturbance or exploitation. We cannot intervene in every case, nor can we eliminate the possibility of suffering. We cannot maximize the self-realization of every being, and we cannot make evolution into a perfectly functioning machine; the functionless features of evolution are part of the process, but we can protect the process. The mode of operation of nature consists of a rhythm of dissolution and reformation. The extravagance and beauty of the natural world features many more species in an ecosystem than would be necessary if exploitation alone were its organizing principle.

Disturbance

Disturbances in nature are regular but unpredictable events. Disturbances are caused by geological events, climatic events, physical processes and biological agents. Hurricanes, for example, cause disturbances, as do volcanic eruptions, windstorms, tidal waves, disease outbreaks, and acid rain.

Disturbance is what causes change in an ecosystem. On a small scale, a single tree falling over is a disturbance. Although an individual dies, species continue. Mortality is a normal part of the life cycle of the forest. The disturbance may be necessary for the ecosystem to continue to mature; for example, according to David Perry (1994), without windthrown spruce that expose mineral soil seed beds, the northern forest ecosystem would shift to bogs.

Disturbances, if sufficiently regular, become a "known" feature of the ecosystem. In Florida, some species such as Cypress, need the complete inundation provided by hurricanes to remain healthy. Yet, even catastrophic disturbances like hurricanes rarely damage more than five per cent of a forest; the 1938 hurricane in the eastern U.S. blew down less than four per cent of the trees.

As the frequency of a disturbance increases, the forest becomes adapted to the disturbance; even pine plantations in the southeastern United States that are managed with controlled burns are less damaged by lightning-caused wildfires. Many disturbances in forests, such as insect explosions or fires, kill low percentages of trees.

After long periods without a major disturbance, however, a catastrophic disturbance becomes more likely. Where wind and fire are absent, for example, the probability of insect and disease outbreaks increases. By trying to prevent one kind of mortality, ecosystem managers often establish conditions for another kind.

Fire is regarded as catastrophic. In some ecosystems, for instance tall grass prairies in Illinois, fire is required to suppress competition from trees. In some forests, such as lodgepole pine in Washington state, fire is required for the cones to open and the trees to regenerate. Forest fires rarely damage more than ten per cent of the whole forest. Even the Yellowstone fire of 1988, still regarded by some as a tremendous disaster according to "Smoky the Bear" policies of prevention (resulting in dead material forming fire ladders), caused limited damage as it leapfrogged along, leaving healthy untouched stands that became the source for the regeneration that is now being observed.

A typical percentage of death is the normal condition of an ecosystem, necessary for its renewal. The rate of death per year in an old forest is remarkably consistent at about one to two per cent, even with wind storms, fires, disease outbreaks and animal damage.

In some cases, a larger percentage of the forest is affected. For instance, high elevation balsam fir forests are subject to bands of dieback that progress up the slopes parallel to the contours of slopes. These "fir waves" seem to be triggered by cold winds striking exposed forest margins. A new stand regenerates where the trees have been killed.

Disturbance may change the direction of maturity in an ecosystem, but it also is stimulating for those species adapted to it. Disturbance may continue succession or it may deflect it, according to Bormann and Likens (1979). Because of the range of scales and intensities with disturbance, it is a complex concept.

Disturbances that are not part of the history of an ecosystem may cause irreversible changes to the system, because the system has not evolved a defence or response mechanism to such a rogue disturbance. A meteor strike would be such a disturbance, especially if the landform were altered by a crater. Human disturbances, in the form of acid rain or clearcutting, are both novel and threatening. If they are small enough or rare enough, however, the ecosystem may rebound.

Very large-scale disturbances, such as volcanic eruptions or meteor impacts, can destroy entire ecosystems or disrupt global biogeochemical cycles. However, such very large-scale disturbances are rare, and the ecosystems often have thousands or millions of years to become re-established, although changed.

Interference

Although rare large-scale or novel disturbances can interfere with ecosystem processes, the term "interference" is reserved for constant large-scale or novel effects. The destruction of ecosystem processes in nature by the action of one or more species is rare; any species that did so would become extirpated or extinct, unless it was not dependent on a single ecosystem, as is the case with wolves. Many commentators have accused mammals, wolves for instance, of overkilling their prey. It is fairly well established now, by David Mech (1981) and others, that wolves will take prey in excess of their immediate needs. This behaviour has been interpreted as useful in maintaining not only the wolf but also secondary predatory and scavenging populations, for example, foxes and ravens. Indian informants are aware of this aspect of the wolf's excess kill, but they attribute to the wolf sufficient foresight to kill an excess of caribou near the den site in order to have an adequate food supply when the caribou are absent. Regardless of the wolves' intent, excess kills of caribou by wolves seem to be linked to the pup-rearing part of the pack that follows behind, as well as providing some food for the reverse seasonal migration; wolves can eat the remains of kills that are up to a year old.

Like wolves, human beings, as part of the process, interact with the individuals of other species or with entire species. Human beings are mammals who, as George Woodwell (1968) puts it, live in a biosphere whose essential qualities are determined by other species. Mammals are bound by biological requirements that must be met if a population is to survive.

Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way from other mammals, simplifying patterns of energy and chemical exchange and solidifying themselves at the end of many food chains as a dominant species. (A dominant is a species with greater influence than any other in its biotic community, changing the lives of other species and the character of the habitat.)

Human populations have increased exponentially, with billions in giant urban ecosystems. Agriculture has produced monumental yields, but only at the cost of tremendous erosion and great subsidies of fertilizers and pesticides. Dams have been built all along rivers, and riverine forests have been cut, altering rivers and fishing grounds. Changes have been made without regard to the long-term impact on the ecosystem or on its human population. We dominate entire ecosystems.

Pandominance

By its influence of all ecosystems, humanity has become a pandominant species. As such, humanity reclaims, overgrazes, clears, depletes and wastes at a scale that interferes with the stability, processes and existence of many systems. One of the ecological consequences of human activity is the degradation of wild habitats for human developments and the introduction of novel elements into the biosphere - elements that have not been added slowly over time as the result of natural processes.

The biomass of the human species probably exceeds the biomass of any nondomestic mammalian species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is far greater than the human biomass and consumes much of the same food as humans, including milk, fish and grain. The domination of humanity is related to other characteristics as well: its large annual population increase (over two per cent), high structural organization (of information and matter) and high energy use (globally thirteen times the total of all other mammal equivalents).

This dominance has major effects on ecosystems: Transient perturbations in energy relations (from oil spills and burning); chronic changes/shifts of systems (from dams, irrigation and chemical wastes); species manipulation (from the import and export of exotics); and interference competition with wild species. None of these effects are exclusive to humans as a species, but human effects are excessive, rapid, compounded and very large-scale. Humanity has upset the balance of nature in favour of its own needs. Animals, plants and habitats are being destroyed because of short-sighted, short-term economic interests.

Human beings have contributed to the extinction of species and to the destruction of ecosystems. Human hunters are hypothesized to have wiped out most of the large mammalian species of the Pleistocene through over-hunting, not for future food, but because of the style of hunting, e.g., by driving herds over a cliff. There are other instances. In the 1880s, soldiers and cowboys slaughtered buffalo as a political strategy to reduce the resources of Native peoples. Farmers and loggers destroyed the dense forests of Ohio and other states. Settlers and industrialists in the Amazon are destroying vast tracts of rainforest, as part of a political strategy to move peasants out of cities. Industrial forestry in the Northwest is content to take a high percentage (well over ninety per cent) of a forest for wood and pulp, destroying the basis for the continuity of the forest, as well as for all beings that depend on the old-growth, fungi and physical properties of the forest.

Human exploitation at the tremendous physical scale that occurs in industrial states is different from exploitation by other species, because it results in the destruction of the entire system, the very basis for renewal of a system that human beings (as well as other species) need for life. Human actions are damaging global biogeochemical cycles, such as the carbon or nitrogen cycle. For instance, deforestation, burning, wetland loss and industrial processes are releasing massive quantities of carbon dioxide into the atmosphere, which disrupts the carbon cycle. Although the destruction of large species, from whales to frogs, has a dramatic effect on ecosystems, the destruction of microbes, which generate oxygen and recycle nutrients, has a critical impact on the entire food web. These actions are global, like a large volcanic eruption, but, unlike a volcanic eruption, they are constant and hourly. These human activities are best referred to as interference.

Industrial Ways

The cosmologies of archaic cultures have been limited to historical places and by human perception, tradition and technology. Modern technological cosmology, beyond being another kind of order (more linear and abstract), is wrongly considered the evolutionary successor to traditional cosmologies. It is displacing them rapidly, although we cannot afford to suppress the diversity of thought necessary for adaptation to the diversity of environments or to eliminate ecosystems and the societies adapted to them.

Our modern problems reflect an unbalanced and immature image of the earth, the earth as a machine, for instance. People sometimes constructed their worlds from preconceived notions, and many of these worlds did not survive, because they could not adapt to the environment. Our modern cultures are defective for this reason. The modern attitude toward nature as a resource has resulted in pollution and depletion of resources. It has allowed humans to overpopulate their habitats. Recent productivity studies indicate that the optimum sustainable human population is far below the current world population (Wittbecker 1983).

Even worse, decisions regarding resources are still made exclusively on short-term economic rationalizations and lead to material shortages and environmental degradation. The crises of environmental degradations are crises of cultures. Monocultures of the industrial kind lead to "dedifferentiation," that is, the decomposition and destabilization of complex structures. A species or culture that destabilizes its ecosystem through misbehaviour risks its own extinction. Human beings make changes to ecosystems that endanger themselves.

Humanity, as calculated by Norman Myers (1984) and others, is using more than forty per cent of the ecosystem productivity of the entire earth. Humanity influences virtually every ecosystem to some extent, destroying some, interfering directly with many, and exposing the rest to exotic chemicals and materials. Species normally use a percentage of system productivity without disrupting the processes of production. The human species interferes with the processes.

Based on limited scientific and cultural perspectives, humanity fails to value those beings and communities for which no use is known. But, as Aldo Leopold (1949) notes, the majority of the beings in nature have no human uses. Even ecologists cannot think of uses for many large birds and mammals. The real danger is genetic loss, which is frequently grossly underestimated. As wild areas grow smaller, even wild species interbreed. As species are lost, the ecosystems become simpler or start to collapse.

Discussion

The problems of ignorance and inappropriate images are multicultural, ecological and cosmological, and must be solved on those levels; the entire activity of culture is guided by metaphors. Metaphors emphasize likenesses between living things and languages (or human constructs). A metaphor furnishes a label and emphasizes similarities. It not only defines and extends new meanings, but redescribes domains seen already through one metaphoric frame.

New metaphors already exist for interactions in an ecosystem. These include: 1) a process view (A. N. Whitehead 1920's) in which organisms are dynamic structures that are immanent and simultaneous with the process, rather than consequences of natural selection of past random mutations; 2) a field concept (C. H. Waddington 1960s) for development, emphasizing dynamic transformation (form as organized spatio-temporal domain), in contrast with the particulate concept of an organism, understood in terms of group dynamics, rather than selective advantage or cost/benefit; 3) self-organization (Franceso Varela 1970's) or autopoiesis, which refers to the dynamic self-producing and self-maintaining activities of living beings that incorporate materials through physiological processes; and 4) reciprocally constrained construction (R. D. Gray 1980's), according to which the organism and environment are co-implicative, co-defining, and co-constructing in a process of self-assembly, where the self is the organism/environment system.

Combining metaphors, we can see that organisms put together (enfold) structures based on historical patterns, and move (unfold) through a filter of limits, like minnows through a fish net, rather than behaving as interchangeable units competing for resources. These metaphors could form the basis of a new image for humanity, where we are an integral part of food chains and part of an organic cycle of birth and death. We humans need to recognize that we automatically participate in everything, and that we cannot not participate by choice. Participation starts at the quantum level and extends through the ecological and cultural. Human nature does not find meaning in an absurd world, but discovers its structure through interaction with the surrounding order. Human identity exists partly in relation to nature; the destruction of ecosystems may lead to the destruction of human identities mediated through cultures.

A culture that fits a local ecology is adapted and more likely to survive. Fitness is a way of reducing negative effects to make cultures more flexible and longer lived. An understanding of ecology, with an emphasis on limits, can lengthen the life of a culture, but ecology is not enough. Good metaphors are necessary, as are good rules of behaviour.

New Human Rules

Human beings have no complete guidelines to interacting with other species in an ecological context. Cultural ethics are usually restricted to some members in a local ecosystem; such ethics are assembled inductively, from experiences from living in specific places. Philosophical ethics have been traditionally restricted to the human species and human situations. The areas of concern of ethics are not broad enough; their foundations are not deep enough. Philosophical ethics is the ethics of the human species living alone, without wild animals or plants in modified ecosystems. An ecological ethics has been developing.

Aldo Leopold proposed a land ethic, dealing with human relationships to land, plants and animals. This land ethic was a sense of ecological community between humanity and other species. "When we see land as community to which we belong, we will use it with love and respect." Such an ethic would change the human role from master of earth to plain member of it. Predators are members of the community; and no special interest group has the right to exterminate them for the sake of benefit for itself. This attitude is important for habitat protection. Leopold describes the extension of ethics as "actually a process in ecological evolution. Its sequences may be described in ecological as well as in philosophical terms. An ethic, ecologically, is a limitation on freedom of action in the struggle for existence. An ethic, philosophically, is a differentiation of social from anti-social conduct. These are two different definitions of one thing. The thing has its origin in the tendency of interdependent individuals or groups to evolve modes of cooperation."

The extension of ethics to animals and land is an ecological necessity with human pandomination. This extended ecological ethics defines a social conduct that is a mode of cooperation and, ultimately, symbiosis. Leopold argued that voluntary limitations of freedom are necessary in a complex world of which we remain incredibly ignorant.

Extensions of ethics are developed in response to problems that arise from increasing knowledge. Science has phenomenally increased our knowledge of physical and biological processes. It has now become the basis of our moral code, but it cannot very long be a science divorced from feeling and art if that code is to help us survive. To do this science requires aesthetic perception as well as disciplined thinking and feeling. As there is a rational component to ethical judgments, so there is an intuitive and emotional one, as well. An ecological ethics suggests that humans avoid tampering with complex evolved systems, not because they are good, but because they are the basis of life at this stage of development. Ecological ethics is situational, because ecology is the study of changing systems. It is pluralistic, as Stone notes, because of the variety of entities involved. The morality of the act is determined by the current state of the system. Adaptive modes should conform to ecological patterns. An ecological ethics is based on attributes of ecosystems and human compliance with ecological laws. The aim of an ethic must be harmonious with the whole population of living beings.

An ecological ethics is a set of rules for living together with other beings (in fact, the word "ethics" is derived from the Greek word *ethos* meaning "custom," which itself came from the Sanskrit word *svadha* for one's "own doing." Since it was used in the plural, it meant "doing together"). It is based on ecological knowledge, grounded "in the breadth of being," in Hans Jonas' words (1974), founded on principles discovered in existence. An ethics based on ecological knowledge places human behaviour in vital social and biological communities in nature. The frame of reference of ethics is enlarged, as Albert Schweitzer predicted (1957), leading to appropriate behaviours in a larger context, through reverence for life. Skolimowski and Callicott (1980) recommend a reverence for life ethic. We must develop specific rules to live with other species, more formal than isolated cultures like the Campa and more comprehensive than modern cultures like the French or German.

Ecological ethics is a series of rules for living together. Most sets of ethics make the rules easy to follow. They emphasize the differences (relativism) or similarities (absolutism) of human beings only; or of the individual or the group; or of good feeling, reason or desire. But ethics has to confront the individual, embedded in a community, located in a bioregion, on earth. And, the rules really are not as easy as human systems have presented. Schweitzer made them too difficult, with a constant valuing, but neither are they that difficult. An ecological ethics can be detailed only on a local level, even when it uses a global strategy.

An ecological ethics is not distorted by human needs and wants when it argues for the preservation of animals and habitats themselves, because they are, as they are. Because of the uncertainty of human actions, ethics has to encompass the far past and distant future. No one knew that when DDT killed mosquitoes, it would concentrate in the food chain to kill birds. Values are time dependent, and ecological time can be very long indeed. The futures we invent are viable, only if compatible with constraints imposed by evolutionary past. An ethics that requires a long-range responsibility also requires a new humility, since technological power exceeds the ability to foresee its consequences. An ecological ethics recognizes the moral obligation to leave the world habitable for future generations.

Rights seem to follow the expansion of the sphere of ethics, as formal statements of intuitive knowledge. But codifying rights is more difficult, especially for philosophers, who tend to limit rights with a series of restrictions. Paul Shepard (1974) says the argument is not new, and that its application is ambiguous because "unlimited rights" will conflict with human interest. But, there are two bad assumptions: that human interests are not ambiguous - they are - and that animals will be granted unlimited rights - they will not.

The strongest argument for rights is interrelatedness in communities, which is the basis for assigning rights to nature. Garret Hardin (1977) considers interrelatedness, but interprets it narrowly. He considers rights as rules of competition; every right is a ploy in the struggle for existence, and every right implies an obligation to furnish it. This is good as far as it goes. However, life is more than competition; it involves cooperation and play. Rights are formal rules for living together. It is foolish not to assign rights to animals, plants and the earth because of contractual formalities. The reverence for all beings is concerned with the right functioning and right numbers in the right places, according to standards of health and quality of life.

One problem with the current legal system is that all nonhuman beings are given the status of inferior human beings, legal incompetents, thus keeping humans in a guardian role. A new legal category is needed that would respect the existence, competence and excellence of natural beings. Christopher Stone (1974) recognizes that the judicial system has granted rights to a variety of inanimate holders, trusts, corporations and nations, for instance. The legal system already operates with fictions, so the extension to natural entities should not present an insurmountable problem.

To be sure, formal rules should to be altered to account for unconscious, interdependent beings. Current legislation on animal experimentation and protection implicitly recognizes the right to life and to a healthy habitat. Laws are needed to protect entire habitats of animals and plants from human interference.

We act by intuition and feelings. Like the inductive creation of cultural ethics, we are building a framework of intuitions, feelings, theories and principles. The whole is recognized as a valuable end by hunters and actors, as well as by scientists and politicians. The framework is supported by principles and theories developed by ecologists and philosophers, by the working rules of conservationists and activists, and by specific instances from cultural traditions as well as from the industrial paradigm (determined to become its own worst enemy as well). Stone considers that these things are only part of the framework. In *The Laws*, Plato has the Athenian say to a youth that all things are ordered with a view to the preservation of the whole, each portion contributes to the whole, and every other creature is for the sake of the whole. Ethics has expanded in wholes, from the family, to the human community, and to nature, on which everything depends. With Ervin Laszlo (1971), ethics encompasses all systems in the universe.

Observing Ecological Limits

Life involves a vast number of interacting structures. Living consists of complex behaviours whose limits are defined empirically. The earth is suitable for life, because of three limits: (1) solar radiation has stayed within certain limits for four billion years; (2) the biogeochemical cycles of oxygen, carbon, nitrogen, phosphorus, sulfur, water have stayed within certain limits; (3) the environment has been constant enough for organic evolution, but variable enough for natural selection to operate.

Animals and plants stay within limits of an ecosystem; for instance, Klein concludes that caribou populations are limited by food supply. Wolves are sometimes limited by stress. Trees are limited by water supply.

Traditional cultures have often stayed within the limits of an ecosystem. A sense of place, with its beings and features, is necessary for information on how to live, get food and stay dry. The ecological benefits of rootedness are that people will take care of a place if they realize they are going to be there for a long time. Having a place means that the inhabitants have stock in it and participate in its unfolding, through planting and caring. Detailed understanding of the plants in a locale allow gathering of food and medicine. People in place - people in unique surroundings - acquire a sense of community, share a set of values and concerns, and reap physical and spiritual benefits.

Practising Noninterference

Exploitation, in the ecological sense, is necessary and beneficial to biological populations. A machine metaphor approach, with its assumptions of interchangeability and quantity, apparently has difficulty distinguishing between exploitation and interference. An ecological metaphor, which is more receptive and reverential, may be more appropriate to understanding organisms and nature in general. Such an approach would stress noninterfering observation rather than controlling manipulation.

Applied to nature, human intelligence discovers the significance of natural rules of interaction and exploitation. The reverence for beings as they are results in the rule of noninterference (Wittbecker 1984). A rule of noninterference states that human beings ought to avoid behaviour that disrupts essential ecological processes or destroys biotic communities. As Paul Taylor (1986) states his rule of noninterference, it requires a "hands-off policy" for whole ecosystems and biotic communities; the rule stated here is concerned with limited and sustainable exploitation of ecosystems already shaped to some extent by human activities. Many other ecosystems, perhaps covering fifty per cent of the land area of the planet, would be reserved by law for predominately natural ecosystems or adapted first nations. Noninterference also means "letting be" (after Martin Heidegger), or "letting alone" in the words of E. O. Wilson (1984). Noninterference is not indifference, which is diffuse. It is caring. Noninterference will not lead to chaos, poverty or stagnation. It permits the rational exploitation of resources.

We need to practise the rule of noninterference so that all beings can enhance their lives and habitats. The rule of noninterference can be derived from the rule of nonviolence (or taoist nondoing, a metaphoric expression for the nonbeing of nature), or even from English Common Law, which is well-established in Western law. It includes a precept: "Use what belongs to you in such a way as not to interfere with the interests of others" (*Sic utere tuo ut alienum non laedas*). This rule could be defined by positive laws and by negative restraints on behaviour. This attitude would entail using what is necessary, exploiting some ecosystems completely, changing a place to fit human aspirations, and killing plants and animals for sustenance. But, it would also mean limiting humanity and its technological effects, limiting human use to local impacts, and letting other beings live without interference. It is not necessary to dominate or terraform the earth completely. Humanity could contain itself to a small percentage of the planet's surface and ecosystems and only visit or ignore the remainder.

Conclusion

Interference has been a rare phenomenon on earthly ecosystems; it has happened in the past as the result of global catastrophes, such as meteor impacts. Now, interference, as opposed to more limited and predictable disturbances or exploitations, is threatening the stability of all ecosystems. It is dangerous to interfere with the processes of ecosystems because it disrupts the communities on which other species, and ultimately human communities, depend. Furthermore, in the deepest sense, it violates the idea of living together with other species on the planet. The proper relationship of humanity with nature includes competition and exploitation and mutualism, but not interference.

We kill millions of animals in laboratories to ensure our safety; we kill billions of plants and animals for food and clothing and products while indulging in the sentimental preservation of some individuals of other species. Animals do not need to be saved from natural death, a great regulator of life, but from unnecessary suffering, experimentation and premature extinction. The world would not be a better place without sharks, silverfish, rats, cockroaches or hyenas. They need their own places. The places, entire ecosystems, need to be saved. If we diminish variety in nature, we debase its stability and wholeness. To save ourselves, we must preserve and promote the variety of nature.

A start has been made. Ethics now considers almost every human being and human interaction. The restriction of ethics to exclusively human modes of existence, however, leads to a troublesome isolation. Human beings are not separate from their social and biological communities and these communities are embedded in ecological contexts with biogeochemical processes. Human communities are one of many communities that make up an ecosystem. Human ethics describes only a small part of the rules for living together in communities, perhaps only the self- conscious part. Ethics must be extended to the entire framework and to the surrounding communities in the framework, without which there would be no human health or wealth. Through our efforts, we understand that communities of other beings have their own values and rules for living together. It remains for us to integrate and codify human rules that recognize the values and rights of other beings to live in healthy ecosystems and that limit human use of those ecosystems.

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