Beyond Uncertainties: Some Open Questions about Chaos and Ethics

Teresa Kwiatkowska

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BEYOND UNCERTAINTIES
SOME OPEN QUESTIONS ABOUT CHAOS AND ETHICS

TERESA KWIATKOWSKA

ABSTRACT

Lately, a new language for the understanding of the complexity of life (organism, ecosystem, and social system) has been developed. Chaos, fractals, dissipative structures, self-organization, and complex adaptive systems are some of its key concepts. On this view, reality is not the deterministic structure that Newton envisaged, but rather, a partially unknown or at least unpredictable world of multiple possibilities. As the horizon of our knowledge of natural realities expands, the emergent comprehensive perspective requires a radical reconstruction of both the concrete structure upon which human life is materially built and the symbolic structure that reason has schemed.

Out of the multiplicity of relations emerges a new set of metaphors to describe our minds, our universe, and ourselves. The view of nature, where the aspects of indeterminacy make evident the role the observer plays in the construction of an account of reality, calls for a new ethics to respond to the nature of complex systems and to constitute us purposefully in response to the natural environment. The chaos theory, which defies perma-

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Direct all correspondence to: Journals Manager, Indiana University Press, 601 N. Morton St., Bloomington. IN 47404 USA journals@indiana.edu

nence, durability, and equilibrium, generally means renouncing the idea of defeating nature or controlling it completely. Instead, it confronts us as partners in the human-nature dialogue with the need to change the style and the type of discourse, the questions we want to ask, and the answers. The nebulousness of our future makes dialogue the fundamental element connected with the ethos of responsibility for humankind today and tomorrow.

The questions raised by unforeseen consequences of human decisions are, finally, moral questions. They are questions of choices, which look to the standards of values for their answers. However, such global standards are not recognized. The ecological perspective of life, particularly the interactive openness to the environment or "otherness" through which the unknown, novel, and creative forms or functions can arise unexpectedly, "heralds new metaphysic, a new logic, and a new ethic" derived from the self-organizing systems marked by change, heterogeneity, and multiplicity.

This paper originated in feelings of doubt, an uneasiness with the current moral code, normative principles of action, and inadequacy, which becomes particularly obvious when confronted with our inability to cope with the pressing environmental problems facing us today. It might be both our ethics and the thinking and methods of natural science, which are often the accumulation of "unrelated anecdotes," as Simon A. Levin[1] describes. The physical and biological realities are not easily explained and are definitely not easily "manageable" by simplistic models constructed within the isolated disciplines. New concepts and a coherent theoretical framework are desperately needed at a time when ecological knowledge is increasingly required to comprehend and resolve global environmental problems. Erroneous interpretative frameworks create illusions and generate unnecessary limitations in our possibilities to forestall potentially hazardous environmental consequences.

Clockwork models of the universe, raised in Cartesian thought to the status of philosophy, together with the Newtonian image of the world, led to the belief in a clockwork world. Deterministic mathematical models induced the belief in a deterministic world.[2] One overwhelming paradigm emerged. The way to modify nature was through differential equations. Consequently, Ian Stewart asserts that "a process of self selection set in, whereby equations that could not be solved were automatically of less interest than those that could" (Stewart 1989, 39).

The "scientific nature" favored a particular class of phenomena, namely, linear ones; all chaotic features, dysfunctions, disharmonies, and internal inconsistencies were eliminated from theoretical studies and experimental techniques. The very limited usefulness of nonlinear systems sealed their fate; until there was a practical use for nonlinear systems, the linear case was treated as the only important one. Similarly, ecological theory has tended to portray nature as something akin to large Newtonian systems (highly structured, ordered, and regulated) capable of returning towards its original constant state if disturbed.[3] From the vague notion of the uniformity of Nature came the belief that all experience can be comprehended under general nonconflicting theories obeying rational requirements and a tendency toward stable concepts and norms.

The dominance of nature grew closely related to the evolution of exact sciences in a modern sense. The principles of mechanistic physics were generalized in order to form the basis of a comprehensive metaphysical system embracing methodical rules for the expansion of domination over nature. "Mathematical manifold," as Edmund Husserl[4] described this idealized nature, achieved a higher ontological status than the living world.

In the search for a stable, rational pattern for the sake of predictability or security, chance was deemed inappropriate within the explanatory scheme of classical mechanics. Correspondingly, the patterns used to describe or predict the behavior of the world (prevailing in the industrial societies) were wholly based on the possibility of transforming nature on the basis of models founded on the total prediction of the effects of human actions.

> These models implied the negation of the spreading effect of perturbations and therefore the existence of non-additive interactions between elements. This allows the reduction of predictions to the direct and immediate effect of the single change.[5]

Hence, we made arrangements that allowed us to control our lives and our nature in a manner likely to produce only a minimal departure from the preceding stages.

REFRAMING FOR THE FUTURE

> "The way to achieve a harmony with nature is first break free of old metaphors and embrace new ones so that we can lift the veils that prevent us from accepting what we observe."[6]
>
> D.Botkin

Many contemporary theories that shed new light on the various physical and natural phenomena require radical reconstruction of large areas of our knowledge and values. The new theories introduce a new order into the domain of the phenomena, which they describe, and which were ordered in a different way by their predecessors. What is usually necessary is to look at the problem from a completely different perspective. But even seemingly small changes could mean the rejection of a cosmology held sacred and the basic reconstruction of the entire worldview based on this cosmology.

Whereas the theoretical reinterpretation is extremely complex and hardly discernible to anyone but the specialists, it is even harder to change concepts that become part of everyday language and a part of value systems to justify our "rational" actions.

Intellectual constructs such as epicycles, laws of motion, or ecosystems may either be deep truths about nature or clever delusions. One of the lessons of biology is, for instance, that habitats and ecological systems are not entities. One system emerges and overlaps with another without clear boundaries. Their extent is defined by the scale of observation. Moreover, the individualistic nature of responses to the environment means that what we call a community, or ecosystem, is really just an arbitrary subdivision of a continuous gradation of local species assemblages.

Recent findings in life sciences suggest that natural systems exhibit irregular dynamics (randomness, chaos, stochastic fluctuations, etc.) that make them different from the essentially stable or balanced units perceived not so long ago by biological theories. Research in nonlinear analysis indicates that chaotic disturbances are normal. Historical studies of forests and other ecosystems suggest that species and environmental context fluctuate chaotically and that species do not simply reach permanent or even long-term ideal adaptations with their environment. In multi-species models chaos seems even to be the rule rather than the exception. William M. Schaffer wrote:

> In particular it would no longer make sense to think of such systems in term of balance between intrinsic forces, forever searching out some mythical attracting point, and environmental vagaries perturbing the system away from it. [7]

The results of the investigations so far show evidence of low dimensional chaos in ecology; yet, those results need to be qualified, for in all cases the time series are very short. However, the view of inherent randomness in nature is supported by the fact that chaotic behavior is being, in fact, found in a wide number of biological systems ranging from host-parasite interactions, at the population level, to cardiac rhythm, olfactory perception, and so forth. Natural systems seem to have no difficulty switching from one state into the other, from laminar flow into turbulent flow, from a regular heartbeat to an erratic heartbeat, from predictability to unpredictability. Uncertainty seems to be inherent at the local scale as well as at the level of the system as a whole with regard to the long trajectory of its evolution. [8]

Once detected, the concept of chaos that runs counter to conventional perceptions about the way nature works may change our view of the natural world. Essentially, its underlying dynamics will be deterministic; nevertheless, to varying degrees the system's properties will appear to involve a random variable.[9] (The description of the universe remains deterministic, as is the case in Newtonian dynamics, but with a predisposition for disorder, complexity, and unpredictability.) The great discovery of chaotic dynamics is that apparently patternless behavior may become simple and comprehensible if you look at the right picture. Randomness and stochasticity do not replace regularities in the hierarchical pattern of spatial and/or temporal variations in ecosystems. As Douglas Hofstadter pointed out:

> Nature presents us with a host of phenomena which appear mostly as chaotic randomness until we select some significant events, and abstract from their particular, irrelevant circumstances so that they become idealized. Only then can they exhibit their true structure in full splendor.[10]

One thing is certain. Biological systems from communities and populations to physiological processes are governed by nonlinear mechanisms. Nonlinear systems may exhibit irregular time evolutions and sensitivity to small changes in initial conditions. Given the network nature of living systems, and the fact that little changes can abruptly bring about the choice of new equilibrium, every human action can be seen as a chain of spreading reactions to follow. What lies beneath the recognition of that unity called human being and its environment can lead to the formulation of a new approach to nature and to the emergence of the axiological patterns accordingly, in view of the long-term effects and the possible consequences of our rational decisions and actions.

Uncertainty as to the severity of ecological, social, and economic disturbance, arising from potential environmental change, added to the openness of networks and systems that defy prediction, questions the ways we act upon nature. Even if indeterminacy does not reside in objective nature, but only in our subjective interpretations of natural phenomena, the future states of the universe are in a certain sense "open." Nature acquired an ability to bring forth something entirely new.

Would the ontological interpretation of chaotic systems (ontological indeterminacy rather than epistemological ignorance) be helpful not only to describe the world we are living in, but also to influence the way we are acting in this world? Seeing the world of complex and flexible character whose processes are open to the future, would it affect our motives, our behavior, and our value system?

In the past, everything had its name and place in a world of great accuracy, for people were prejudiced in favor of the perfect regularity of mathematically designed machine. Now, the creative, evolutionary, and spontaneous world possesses attributes whose effects are still impossible to comprehend; a tremendous scale of space and time and the complexity of natural systems. It admits an infinite number of possibilities. The answer to the question, which of these possibilities will be carried out where and when still remains one of nature's closest kept secrets.[11] As it has happened with the climatic systems, our improving understanding of nature, rather than decreasing uncertainty, can reveal the universal sources for unpredictable behavior and surprise.

It will undoubtedly take a great deal of time for humans to get adjusted to the theoretical consequences of contemporary science that seem to violate common sense, tie the loose ends of a new view of nature, and commence a new relationship between man and the universe. It is not just a matter of terminology. It is a matter of understanding, of recognizing and avoiding the kind of mistakes about nature that we inherited. Suddenly, the human being has become an active party in the drama of existence. The human being, as the biologist Charles Birch indicated,

> is not the same person independent of his or her environment. The human being is a subject and not simply an object pushed around by external relations. To be a subject is to be responsive, to constitute oneself purposefully in response to one's environment.[12]

Released from our restrictive role as spectators in the universe, we are allowed freedom and perspective to see ourselves as part of a much greater living system and learn to act accordingly.[13] Incomplete knowledge does not diminish the concern for the consequences of our behavior in the social or the natural world. The "chaos theory" generally means renouncing the idea of defeating nature or controlling it fully. At the same time it can encourage a self-critical and open attitude required to foster a dialogue, where rational decisions relying on the solid facts and predictions from the natural sciences are impossible.

To accept the new conception of nature is to accept a different philosophy of life. Current values and behaviors, easily understood within mechanistic framework, lose relevance in the broader context of complex systems. As a part of the interwoven totality of nature, forever making order from chaos, and forever free to do something new to recognize itself, when necessary, we have to abandon the idea of a heartening future in favor of an idea of the future as a necessary yet unexpected consequence of our daily creativity. As Jack Cohen and Ian Stewart suggested:

> We could be in the position of the hilltop beetle, just on the verge of extinction, blissfully unaware that a mathematical fiction in the space of the possible is about to become reality. And the really nasty feature is that it may take only the tiniest of changes to trigger the switch. This is emphatically not a fantasy. It is respectable way of expressing some of things we know about climate change. . . . [T]he universe is always ready to realize an unexpressed potential. Mathematical fictions can bite.[14]

Whatever logic is to be found in this world springs from the human encounter with its natural environment. The problem of change, conditioned by what we do not know and are unable to see, is that for which we are constantly searching. Most people, however, would rather continue with familiar, seemingly secure living conditions. Still, mistaken perceptions of nature's *modi operandi* govern our thoughts and therefore our practical, societal actions. No individual has what might be called a scientific view of the whole world, only portions of it; and these moreover, are always incomplete. When it comes to action, we draw only on those areas of science that seem relevant, thus science is translated into technology, fragments of the whole that only serve conscious purpose. When we suspect some threat from the environment, we can dip into science for counterarguments but we seem unable to extract from science the alternative to the kind of linear, reductionist thinking that no longer can address the problems of modern world.

Advancing scientific understanding will produce knowledge that can be used to fulfill certain social goals (a generation of new information or new technologies). Understanding the spontaneous dynamics of the world embodies the potential for an immense impact on the social, economic, and political conduct. It is, however, a very difficult task to directly relate, for instance, high-energy physics, number theory, chaos theory, or theoretical ecology to specific social goals. The recent puzzle of environmental changes made the understanding of the physical and biological sciences more frustrating than ever. Therefore, perhaps, our search for novelty is greatly limited to seeking new methods (technologies) and means of incorporating our conventional attitudes. In most cases we make our decision by automatically applying the traditional norms of our culture. This is a misconception. To deal with the problems of today and tomorrow we must not use today's conventions, technologies, and scientific means of solving yesterday's problems; we must start with a basic understanding of many key characteristics of life; not by redefining but rather by formulating new problems. We have to develop sensitivity and alertness in order to be able to interpret rapidly changing complex field of interactions, and have the ability to create new messages not based on the attitudes of the past but relative to the changing, unpredictable image of the natural world. As the famous biologist Robert May has repeatedly urged:

> not only in biological research, but also in the everyday world of politics and economics, we would be better off if more people realized that simple nonlinear systems do not necessarily possess simple dynamical properties.[15]

PARADISE LOST

> "Indeed, because we're part of the universe, our efforts to predict it may interfere with what it was going to do."
>
> Ian Stewart

When we search for the simple rules of the apparent complexity we want more that just finding the comprehensible laws that can work for us; we want to know what they imply about our place in the universe and the possibility of organizing one's life around known and predictable behavior of nature. We simplify the behavior of nonhuman environments in order to comprehend it within human scale effects in both space and time.[16] The operation of many elements in physics, biology, or ecology cannot be tested "in the wild"—we deal with a visualized, simplified world. Ecologists, like many other researchers, were routinely reducing difficult nonlinear problems to less complex linear approximations. Stewart L. Pimm wrote:

> "The reasons why ecologists have tended to ignore complex dynamics, was that the dynamics seemed to be no more than mythical beasts that were fun to imagine and draw but that had unknown habits and were unlikely to ever be convincingly identified."[17]

The traditional view was that science would solve problems and that we could proceed with, if not with a certainty, at least with a trustworthy quantification of the odds upon which to base decisions. The scale of human induced environmental change and the spatial and temporal complexity of natural systems have destroyed this hope. From the local and discrete to the complex and global we are uncertain of the nature and causes of environmental change, the severity of long term impacts and the processes that underlie natural systems. Global climate change and changes in the concentrations of greenhouse gases may have major effects on the vegetational patterns at local and regional scales; in turn, changes that occur at very fine scales ultimately will have impacts at broader scales.[18] The challenges, such as prediction of ecological causes and consequences of global climate change, require the interfacing of phenomena that occur on very different scales of space, time, and ecological organization.

What is more, the observer, be it any organism, including human beings, imposes a perceptual bias, a filter through which the system is viewed. Niels Bohr, introducing the idea of complementarity, suggests that the term "reality" is in part a socially and subjectively constructed concept. On this view reality is not the deterministic structure Newton visualized, but rather part of a partially unknowable or at least unpredictable world of multiple possibilities. What we called reality is revealed to us only through the active construction in which we participate. On that account, Ilya Prigogine and Isabelle Stengers indicated that:

> We can no longer accept the old a priori distinction between scientific and ethical values. This was possible at a time when the external world and our internal world appeared to conflict.[19]

The openness exhibited by chaotic systems provides the possibility of reconciling physics with our basic experience as human beings of responsibility and agency in facing an open future in which we play our part in bringing it forth. Can science, that is, the factual content of science be applied to generate an ethical code? This suggestion is usually rejected because it raises the *is* to an *ought*. One of the greatest barriers for the development of a new set of values is precisely that perceived levels mismatch. Moral inferences cannot be drawn from mere facts (norms can never be derived from empirical assertions alone), nor are facts ever loaded with prescription. Moral inference and prescription require first an *interpretation* of facts so that the existence of certain norms can be *derived* from a descriptive context containing value assertions, but this very context cannot by itself be used to justify rules of conduct.[20]

Scientific investigation of the physical world, the ethical investigation of our moral experiences, each of these inquiries has its own domain of data and its own consequent autonomy, yet each has a close relation to the other as they both seek a rationally motivated understanding of what is going on. Emerging out of the new culture is, according to John Brockman,

> a new natural philosophy, founded on realization of the importance of complexity, of evolution. . . . There is a new set of metaphors to describe ourselves, our minds, the universe, and all of the things we know in it.[21]

Most of the static concepts embodied in the prevailing perception of a stable and balanced nature, find their counterpart in a dynamic description, hence, they require new interpretation.

Typically, complex environmental problems were, and still are, disentangled to single issues that are dealt with separately, yet when it comes to the questions about order and disorder, decay and creativity, emergence of patterns, and life itself, the whole cannot be explained in terms of the parts. However, the failure to predict does not mean failure to understand or to explain. Indeed, if we are confident we know the equations governing a chaotic system, then we could be confident we understood its behavior, including our incapacity to predict.[22] The possible scenarios (regarding, for instance, future climate change or the mechanisms underlying the maintenance of biodiversity) should not be taken as predictions or forecasts; they should be used to spark new sensitivity in dealing with environmental challenges.

Yet old dreams die hard. We are perfectly aware of a sense of crisis, which characterizes the end of a familiar intellectual tradition we have been committed to for at least three centuries, a dream of an all comprehensive theory grown out of impartial observation which embrace Humans and Nature. Time and again, over several centuries, the need for trusting a coherent system of universal theories upon life, both natural and social has arisen. This unshaken rationality of a structure regulated by a set of definite principles had to eliminate all the chaotic dissonance and dysfunction. In their abstractness and universality the ethical prescriptions resemble the axioms of Euclidean geometry. They exist in their own independent realm expressing divine will or moral law.[23]

By an amazing paradox, modern science shifts the stress to what is elemental and chaotic. The acceptance of the idea that we might benefit by viewing nature as characterized by chance and randomness is a deep and unsettling change. We have to learn that there are no ultimate cognitive or ethical criteria of a universal scope. We live surrounded by randomness under the pressure of unsteady options. This breakthrough compelled us to change the style and type of discourse in the Humans-Nature dialogue, the questions we want to ask, and the answers we want to receive. New ways of comprehending the world require indeed prudent moral reasoning while facts are uncertain, values in dispute, stakes high, and decisions urgently needed.

Predictive problems give rise to epistemic barriers hindering our ability to anticipate the sequences of our activities. On the one hand, we cannot help but be less confident of the outcome of our mastering and changing Nature. The realization that it is necessary to consider the uncertainties that may affect a given situation makes people contemplate the effects of their decisions much more carefully. One problem arises because of the ability of technologically driven action to outstrip human powers of calculating the consequences on the basis of different scenarios, thereby challenging standards of responsibility.

On the other hand, because deterministic chaos in natural and cultural realms serves to create and to destroy, we cannot foresee the way it will operate. But ignoring the future, in the sense of disregarding the consequences for reason of uncertainty, it is not and cannot be a legitimate approach, for it may seriously hamper the conditions of our survival on the planet Earth. Therefore, the moral dimension contained in the scientific view of nature might be more significant than the question of the accuracy of predictions as such. While the resolving power of any analytical framework will be limited, the resolution of environmental issues including sustainability will remain firmly moral and political.

PARADISE REGAINED?

Through its creative fusion of ancient and modern perspectives[24] of the ways of the world, philosophical metaphors involving complex interactions, as well as oppositions between order and disorder, the chaos theory opens up a broader panorama on the classical question of free will and moral terms. Metaphorically, the chaos theory liberates creativity. Living systems obviously have a potential to create new responses to unprecedented situations. Should we not explicitly include this property while considering humanity?

Traditional ethics seek linear behavior of *x* consequences and *y* effects. Tragic heroes of Greek dramas were charged with great crimes, sins, and vices with the corresponding catastrophes and sufferings. Laws and concepts were invented by human societies to control individual and collective behavior; they proscribe certain activities and prescribe punishments for disobedience. The models commonly used in the social realm rendered every measure wholly reliable. The obvious consequence of the rejection of variability as being dangerous and difficult to control was the induction of the unique "rational" and therefore optimal model of social organization. However, all the details of our lives can be positively and negatively influenced by unlimited number of variables and a small change in one variable can have a disproportional effect on others, without any possibility of predicting future interactions.

Chaos theory with its stress on the sensitive dependence on initial conditions may have nothing to do with individual morality, but everything to do with the subsequent course of events. Therefore, we strongly suspect that the importance attributed to ethical considerations may not be independent from what are perceived as possible consequences for humankind. We want to play the God-games, yet we are subject to chaotic forces, uncertainties, and random disruptions that make all the difference in the successive events. The physical laws of the world that govern natural phenomena (like earthquakes, bio-geochemical cycles, plagues, AIDS, etc.) can permanently influence our subjective consciousness, for, as Richard Dawkins observes, "cultural relativism stops for all passengers on a plane struck by lightning." [25]

Should we not look for a metaphysical and axiological expression of the complexity, unpredictability and self-organization? It is, however, a long way from considering impressive possibilities of chaos theory to talk about our moral universe. Its metaphorical relevance to moral values may not be immediately apparent. Likewise, we are perfectly aware of the tendency to extend the precepts of modern science into the fields where there is no rigorous justification for doing so (as it is obviously the case of this paper). Yet, any viewpoint as to how ethical norms can arise within the complexity of interconnectedness must address, at least implicitly, the question of physical and biological reality itself. To understand the ethics of the environment without understanding Nature's *modi operandi* is like trying to know the good of a thing without knowing what kind of thing it is.[26]

The metaphors, ideas, and concepts that come under the heading of chaos raise questions, but can they trigger a new ethical response? It is undoubtedly attractive; one of its premises is to intertwine the traditional moral oppositions between order (good) and chaotic (bad, evil). We can perceive the interaction of positive and negative forces of chaos and order, good and evil, harmony and conflict, kindness and wrath as different manifestations of complex systems. Various environmental decisions [27] suffice to illustrate that in the present ecological and evolutionary times, good does not necessarily spring from goodness, and evil does not necessarily beget evil.

People interpret new discoveries in terms of what is important to them. The messages we receive from science help us to unveil secrets of nature's structure and organization. They can change the face of the Earth literally and metaphorically. Once you understand how the system works, you do not remain a passive observer; you can attempt to control the system. Within modern decision and policy-making processes, the knowledge about a system is selected accordingly to its ability to design strategies of control and manipulation, which means squeezing physical and biological data into a frame that might not be appropriate.

Thus, it is clear that any suggestion of change in our "environmental practices" involves far reaching modifications in perceptions, in institutions, and in society. A first step towards a change may be a recognition that "wilderness really does mean chaos, and not the slightly saccharine kind of harmony that ecologists used to imagine."[28]

ETHICS UNDER GLASS

It has become a commonplace for those who speak and write about global environmental problems to stress the importance of values motivating people to assume the responsibility for the world around them and call for a "new" environmental ethics. Usually, we automatically apply the traditional norms of a respective culture that involve some general rules of moral theory, or of different, competing moral theories. These theories whose norms are hardly agreed upon [29] offer different answers, some leaning toward the "others," some stressing the autonomy of human being. There are many general rules though there is little consensus. So when the conflict between several norms arises we have to undertake a rational analysis. Facing ethical ambiguities on one side, unclear scientific foundations together with the lack of fundamental data on the other, should we rely on the vagaries of a coin tossing, uninformed discussion, nebulous ethical notions,[30] or possibly slightly better scientific analysis?

There is no pathway from science to ethics, culture, and other humanistic concerns like human rights, population problems, and poverty that cannot be considered apart from environmental issues. Neither biology nor physics provides a reliable set of specific ethical norms. Yet, all these considerations have substantial relationships with life sciences, if we want our decisions not to be made in an informational vacuum. Ernst Mayr recently wrote:

> An ignorance of the findings of biology is particularly damaging whenever humanists are forced to confront such political problems as global overpopulation . . . the depletion of nonrenewable resources, deleterious climatic changes, increased agricultural requirements worldwide, the destruction of natural habitats.[31]

Our way of successfully dealing with problems of environmental deterioration will depend to a considerable extent on our understanding of the causes and consequences of the puzzling phenomena of our world. The only way to resolve it is not by ignoring the scientific foundation for judgments about environmental welfare but to apply ecological thinking not just on behalf of conservation but with respect to all our dealings with the environment.

However, in life sciences a plurality of causal factors combined with probabilities of the change of events often makes it very difficult, if not impossible, to determine the cause of any given phenomena, not to mention its consequences. Science does not offer unifying solutions nor produce clear-cut predictions upon which decisions and actions can be based. It mirrors the complexity and diversity of the subject studied.

When several options are available, it inevitably involves value judgment and enables us to make the ethically most appropriate choice. The capacity of judging the alternatives in ethical terms and choosing what is morally good depends on the individual capacity to calculate the consequences of our rational actions and the will to accept individual responsibilities for the results. F. J. Ayala once mentioned three necessary conditions for ethical behavior. First, the ability to anticipate consequences of one's own actions; second, the ability to make value judgments; and third, the ability to choose between alternative courses of action.[32]

Only science can grasp the intricate interactions that take place in the complex system of global environment. Yet, science alone cannot account for what we do know about life as it is lived and as it can be conceived of being lived in the future. Although science can give us a description of natural patterns in terms of processes that produce them and can explain the function and structure of living systems, it cannot explain the inner logic of our dealing with the natural world. We need an ethical theory to account for these factors. Ethics helps us to come to an understanding of issues to which science is unable to provide answers, to which science answers "chance," or to which answers of science do not convince or satisfy.

Just as we cannot understand a work of art merely in terms of the characteristics and chemistry of paint, we cannot understand the functioning of the natural whole in terms of the physical, chemical, and biological properties. All these characteristics also require an explanation in terms of ethical causes. To this extent we are free, not from the biological understanding, but to add levels of meaning and plasticity and expression to this knowledge. The history of evolution teaches us that life is always capable of expressing and elaborating new and unexpected potentialities. We can never predict what these will be, but we can know that they may always occur.

Try as we may, we cannot get away from values. Much of the environmental policy analysis is conducted in the policy languages of science, economics, and law. These languages are assumed to be ethically neutral but are in fact laden with a variety of contextual and methodological ethical positions. If not explicitly identified, decisions may be based on ethical criteria that are in conflict with the position of the environmental concern. However, building the ethics into decision making first requires making a careful articulation of value choices an explicit part of the process.

A great many books and articles try to design a new ethics[33] that will provide a solid ground for environmental concerns. Yet, it still proves equally problematic as does traditional morality when it comes to devising specific normative recommendations for decision making. Most existing environmental ethics, moreover, is based on the earlier ecological science, and is thus "out of date."[34] If we are to develop any ecologically centered approach to nature, the transformation of ecological science from its earlier period based on notion of succession, ecosystem and ecological balance/ order to the present-day emphasis on disturbance and chaos, is a key to an ethical response.[35]

When old categories turn into old keys, which do not fit into new locks, and we have to accept the unsolvable nebulousness of our future, prudence and responsibility should guide our way "along an almost impassable road, where the ground may at any moment shift beneath our feet."[36]

Our acceptance of risk means the acceptance of dialogue with nature. As Carolyn Merchant pointed out, "Because nature is fundamentally chaotic, it must be respected and related to as an active partner through a partnership ethics."[37] The expression, "partnership," is an ideological term indicating a view that we should all strive for a common goal, for example, a new balance in which both humans and nonhuman nature are equal partners, neither having the upper hand, yet cooperating with each other. Both humans and nature are active agents.[38]

So far so good, however, if normative problems are to be approached in the spirit of realism, one has to scrutinize the partnership at some distance. A number of crucial arguments for a partnership approach have been raised in a narrower, humans-bound context.[39] In order to make fundamental moral progress and put on a par our interests with the interests of animals and nonsentient beings, we need to "dialogue with nature," to transform what first appear as obstacles into original conceptual structure providing fresh insights into the relationship between human beings and nature.[40]

Besides, for any ethical code to be effective, to lead to the right choice, requires contextual flexibility, for absolute prescriptions rarely solve ethical dilemmas in our dealings with the natural world whose essence is change, chance, and variability. It is not that the moral directives cannot in principle be pursued except by placing them in a specific context, but they are most naturally fruitful in that context. The strength of an ethical idea lies in its applications, in its ability to command our consent.

Whatever ethical stance we uphold, human-centered or nature-centered,[41] we have to be humble enough not to get carried away with the unique righteousness and infallibility of our own pet scheme, and flexible enough to work with science in order to adapt our ideas to a changing knowledge. We have to understand ethics not in its modern narrower sense as a theory of moral obligations, but as a Socratic reflection on how life as a whole is to be lived. Any normative approach to scientific inference that seeks to validate one answer in response to complex uncertainty is, in my opinion, a parody of a would-be rational human decision making process. Making right choices involves tradeoffs between multiple values, the blending of a commitment to human justice and the love for nature in many practices that combine dynamics of biological and cultural evolution. The greatest challenge is to choose wisely. As Stuart Kauffman wrote, "If we find renewed concern about the untellable consequences of our best actions, that is wise. It is not as though we could find a stance with either moral or secular certainty. . . . All we can do is be locally wise, even though our best efforts will ultimately create the conditions that lead to our transformations to utterly unforseeable ways of being. We can only strut and fret our hour, yet this is our own and the only role in the play. We ought, then, play it proudly but humbly."[42]

NOTES AND REFERENCES

1. Simon Levin 1992. "The Problem of Pattern and Scale in Ecology." *Ecology* 73(6): 1943–1967, 1944.
2. Ian Stewart 1989. *Does God Play Dice; The New Mathematics of Chaos*. London: Penguin Books, 39.
3. See Daniel B. Botkin 1990. *Discordant Harmonies: A New Ecology for the Twenty-first Century*. New York, Oxford: Oxford University Press; Claudia Pahl-Wostl 1995. *The Dynamic Nature of Ecosystems*: *Chaos and Order Entwined*. Chichester, New York, Brisbane, Toronto, Singapore: John Wiley & Sons.
4. Edmund Husserl 1970. *The Crisis of European Science: A Transcendental Phenomenology* (trans. by David Carr) Evanston: Northwestern University Press.
5. Marcello Built 1995. "Complexity Concepts and Environmental Education," in *History of European Ideas*, vol. 21, no. 1, 32–36, p.33.
6. D. Botkin 1990. *Discordant Harmonies: A New Ecology for Twenty-First Century*. New York: Oxford University Press, 189.
7. William M. Schaffer 1985. "Order and Chaos in Ecological Systems." *Ecology* 66 (1):93–106.
8. See Nina Hall (ed.) 1991. *Exploring Chaos: A Guide to the New Science of Disorder*,. New York, London: W. W. Norton.
9. It is ruled by simple, comprehensible laws, but it is unpredictable. "A system that displays sensitivity to initial conditions is said to be *chaotic*. Chaotic behavior obeys deterministic laws, but it is so irregular that to the untrained eye it looks pretty random. Chaos is *not* just complicated, patternless behavior; it is far more subtle. Chaos is *apparently* complicated, *apparently* patternless

behavior that actually has a simple, deterministic explanation. " Ian Stewart 1995. *Natures' Numbers: The Unreal Reality of Mathematical Imagination*. Basic Books, A division of Harper Collins, 113.

10. Douglas R. Hofstadter 1989. *Gödel, Escher, Bach: An Eternal Golden Brand*. New York: Vintage Books, A Division of Random House.
11. Ecosystems may seek some kind of equilibrium, but that equilibrium bears no resemblance to the traditional idea of "balance of nature." See Claudia Pahl-Wostl 1995, *The Dynamic Nature of Ecosystems*, op.cit.
12. Charles Birch 1988. "The Postmodern Challenge to Biology," in *The Reenchantement of Science*, David Ray Griffin. Albany: State University of New York, 69–78, 70–71.
13. Contemporary science no longer views the universe as a collection of material points in instantaneous external relations; the world is an interdependent, unitary, and space-time whole. Life is understood as complex, creative unity organized at distinct levels (molecules, cells, organisms, populations, ecosystems, biosphere) in such a way that modifying one element may eventually affect the entire system; each systemic shift can propel an interlaced network in a radical new direction.
14. Jack Cohen and Ian Stewart 1995. *The Collapse of Chaos: Discovering Simplicity in a Complex World*. London: Penguin Books, 212.
15. Robert May 1993. "The Chaotic Rhythms of Life," in Nina Hall (ed.) *Exploring Chaos: A Guide to the New Science of Disorder.* New York, London: W. W. Norton.
16. Simon A. Levin, Bryan Grenfell, Alan Hastings, and Alan Perelson 1997. "Mathematical and Computational Challenges in Population Biology," *Science* 275: 334–45.
17. Stewart L. Pimm 1991. *The Balance Of Nature? Ecological Issues in the Conservation of Species and Communities*. Chicago: University of Chicago Press, 101.
18. See Simon A. Levin 1992. "The Problem of Pattern and Scale in Ecology." *Ecology*, 73 (6):1943–1967, p. 1950.
19. Ilya Prigogine and Isabelle Stengers. 1984. *Order out of Chaos: Man's New Dialogue with Nature.* Flamingo: HarperCollins, 312.
20. See John R. Searle 1969. *Speech Acts, Cambridge University Press, & The Naturalistic Fallacy Fallacy*, 132–136, 182–197. By being an inhabitant of the global community one is committed to the observation of certain rules, for instance, the simple but powerful criterion of group survival which operates even in the present chaotic situation.
21. John Brockman (de) 1996. *The Third Culture.* Simon & Schuster, Touchstone, 20.
22. S. Kauffman 1995. *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*. New York: Oxford University Press, 17.
23. See Colin McGinn 1997. *Ethics, Evil, and Fiction*. Oxford: Clarendon Press.

24. Traditional ideas of uncertainty, diversity, and ambiguity that seemed to lead nowhere should be dusted off while exploring what Mandelbrot called the "trash cans" of philosophical thought.
25. Richard Dawkins 1991. "Mad Molecules," in *The Sunday Times*, 12 November, section 6, p.12; Richard Dawkins 1987. *The Blind Watchmaker*, New York: W.W. Norton.
26. Andrew Oldenquist 1990. "The Origins of Morality: an Essay in Philosophical Anthropology." *Social Policy and Philosophy*, 8(1) Autumn, 121–40.
27. Eduard O.Wilson 1984. *Biophilia*. Cambridge, Mass.: Harvard University Press.
28. James Gleick 1993. "Chaos and Beyond," in John Holte (ed.) *Chaos: The New Science*. University Press of America, 123.
29. Most of the proposals made within the *anthropocentric* trend of environmental ethics are based either on Kantian argument of duty and rights or on the utilitarian tradition of J. Bentham and J.S. Mill.
30. *Good, justice, and truth* have long been accepted as outstanding values, though no one seems to be able to agree on what is *just*, what is *good*, and what is *fair*. The same problem arises within the *nonanthropocentric* or *intrinsic* value approaches to environmental ethics. The concept of *inherent* or *intrinsic* value has been frequently discussed, yet, it is not at all clear where do ethicists locate the moral values of nature.
31. Ernst Mayr 1997. *This is Biology: The Science of the Living World*. Cambridge Mass.: Belknap Press of Harvard University Press, 39.
32. F.J. Ayala 1987. "The Biological Roots of Morality." *Biology and Philosophy* 2: 235–52.
33. See J. Baird Callicott 1995. "In Search For Environmental Ethics," Warwick Fox (1995) " A Critical Overview of Environmental Ethics," *World Future*, vol.46, 1–22.
34. Donald Worster 1997. "The Ecology of Order and Chaos," in Char Miller and Hal Rothman (eds.) *Out of the Woods: Essays on Environmental History*. Pittsburgh: University of Pittsburgh Press.
35. More recently, the ethics of integrity accepts the "precautionary principle" to limit a certain kind of human intervention in the natural world due to its either negative or unpredictable impact on the ecosystem. (See Laura Westra 1994, *An Environmental Proposal for Ethics: The Principle of Integrity*, Lanham, Md.: Rowman, Littlefield.) However, with recent shifts in ecological science it is becoming more difficult rather than easier to develop concepts such as ecological integrity.
36. John D. Caputo 1993. *Against Ethics*. Bloomington: Indiana University Press, 4.
37. Carolyn Merchant 1995. *Earthcare: Women and the Environment*. New York: Routledge, 221.
38. ibid. 218.
39. P. Chatterjee 1996. "Partnership in Action," *The Urban Age* 4(2):14; E. Carlson 1997. "The Legacy of Habitat II," *The Urban Age* 4(2):1,4–6; I. Erlander 1998.

Partnerships and Urban Governance: Towards an Agenda for Cross-National Comparative Research, Paris: ISSC-UNESCO/MOST.

40. Ilya Prigogine 1996. *The End of Certainty:Time, Chaos, and the New Laws of Nature*. New York, London, Toronto, Sydney, Singapore: Free Press.
41. See J. Baird Callicott 1995. "Environmental Ethics: An Overview," in *Encyclopedia of Bioethics*, rev.ed., Warren T. Reich (ed.), Macmillan Reference, Simon & Schuster.
42. Stuart Kauffman 1995. *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*. New York, Oxford: Oxford University Press, 30.