Under the Sign of Nature: Explorations in Ecocriticism

Ecocritical Theory

NEW EUROPEAN APPROACHES

Edited by Axel Goodbody and Kate Rigby

UNIVERSITY OF VIRGINIA PRESS CHARLOTTESVILLE AND LONDON

University of Virginia Press

Printed in the United States of America on acid-free paper

First published 2011

9 8 7 6 5 4 3 2 1

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Ecocritical theory : new European approaches / edited by Axel Goodbody and Kate Rigby.
p. cm. — (Under the sign of nature: explorations in ecocriticism)
Includes bibliographical references and index.
ISBN 978-0-8139-3135-7 (cloth : alk. paper) — ISBN 978-0-8139-3148-7 (pbk. : alk. paper) — ISBN 978-0-8139-3163-0 (ebk.)
1. Ecocriticism—Europe. I. Goodbody, Axel, 1950– II. Rigby, Catherine E.
PN98.E36E36 2011
809'.9336—dc22

2011011294

Contents

HANNES BERGTHALLER

Cybernetics and Social Systems Theory

Aldo Leopold's *A Sand County Almanac* opens with a walk in the hills of southwestern Wisconsin, in January, during a brief spell of thaw. The narrator follows the track of a skunk: "[It] leads straight across-country. . . . I follow, curious to deduce his state of mind and appetite. . . . In January one may follow a skunk track . . . with only an occasional and mild digression into other doings. . . . There is time not only to see who has done what, but to speculate why."[1]

The narrator thus resolves to shift his interest from the *facts* of nature (which, in his role as a scientist, he has been trained to observe) to the *purposes* which went into their making. The first chance to apply this different mode of observation offers itself up when the narrator encounters a field mouse:

> Why is he abroad in daylight? Probably because he feels grieved about the thaw. Today his maze of secret tunnels, laboriously chewed through the matted grass under the snow, are tunnels no more, but only paths exposed to public view and ridicule. Indeed the thawing sun has mocked the basic premises of the microtine economic system! The mouse is a sober citizen who knows that grass grows in order that mice may store it as underground haystacks, and that snow falls in order that mice may build subways from stack to stack: supply, demand, and transport all neatly organized.[2]

It requires little acumen on the reader's part to recognize the "microtine economic system" as an allegory of the kind of narrowly utilitarian relationship to the land which will be the chief target of Leopold's criticism in the *Almanac*—here exposed to the light of reason by the sun of his satirical prose. What complicates such a reading, however, is the fact that Leopold is writing not only as a satirist, but also as an ecologist: while the field mice are figurally humanized, they are also literally a part of the "wild nature" which

Leopold elsewhere sets in opposition to precisely that type of human behavior which the mice here serve to allegorize. If humans, as he charges, are blind to their environment, the same is true of the field mice—and of most other inhabitants of this landscape as well, as becomes apparent in the rest of the section "January Thaw." The field mouse falls prey to a hawk whose vision of his environment is no less myopic: "The rough-leg has no opinion why grass grows, but he is well aware that snow melts in order that hawks may again catch mice. . . . [T]o him a thaw means freedom from want and fear."[3] The pattern is then reiterated by a rabbit and an owl. The only creature that seems to defy such an analysis of its motives in terms of self-interest is the narrator's guide, the skunk. It is with him that the section concludes: "The skunk track leads on, showing no interest in possible food, and no concern over the rompings or retributions of his neighbors. . . . Finally the track enters a pile of driftwood, and does not emerge. I hear the tinkle of dripping water among the logs, and I fancy the skunk hears it too. I turn homeward, still wondering."[4] With this brief, imagined moment of shared perception, Leopold subtly drives home the self-reflexive point of "January Thaw": having contemplated the blindness of those other members of the "land community," the narrator is confronted with the possibility of his own blindness—a blindness that he, like them, would be unable to see.

Leopold died in the same year that the *Almanac* was published. He thus did not live to think through the implications of the paradox which he had so lucidly encapsulated in its opening chapter: that man is both "a part of" nature and, at the same time and insofar as he is able to observe it, "apart" from it[5]—a paradox which threatened to destabilize the very conceptual foundation of the new ethics Leopold was expounding. Like Adam Smith's market, the "land community" was assumed to function the way it did only because its various members pursue their own self-interest blindly, their conflicts ordered into a larger harmonious whole through the action of an ecological equivalent of Smith's invisible hand—whose working is attested to, in "January Thaw," by the neat way in which the respective blindnesses of mouse and hawk complement each other. Yet man, in order to become a member of this land community, would have to act unlike all its other members by knowingly subordinating his interests to those of the whole—thereby rendering moot the original definition of the land community as a *self-regulating* system. Throughout the book, Leopold's narrative voice thus oscillates between the hope for a secure vantage point from which humans and their environment could be cognized and described as a totality, and the belief that such aspirations are precisely what is wrong with humanity. In one paragraph, the "land community" may thus appear as a scientific fact, while in the next it is presented as something that will truly come into being only once humans learn to see it.

Cybernetics

Just as Leopold was finishing the *Almanac*, an interdisciplinary group of researchers had begun to work out a new conceptual framework to tackle problems of a very similar kind. In 1946, these researchers came together for a series of conferences entitled "Circular-Causal and Feedback Mechanisms in Biological and Social Systems" and now remembered, in honor of the organization which funded them, as the Macy Conferences. The members of this group came from a wide range of fields including medicine and physiology, mathematics, engineering, experimental physics, anthropology, economics, ecology, and zoology. The goal they pursued was sympathetic to Leopold's project: they, too, were looking for a way to bridge the gap between the humanities and the natural sciences, but whereas Leopold had been increasingly drawn toward the language of ethics and aesthetics, this group began by searching for new mathematical formalizations. One of their primary aims was to understand how complex systems are able to maintain their internal balance against fluctuations in their environment, and ultimately to find new scientific explanations for purposive behavior.

The belief that such explanations were now finally within reach rested on recent developments in the field of engineering, namely on the methodical exploration of the principle of feedback. The most popular example for mechanisms based on this principle is still the thermostat, which keeps a room's temperature constant by measuring its difference from the desired temperature and accordingly switching the heating system on or off; in other words, the output of the system (the room's temperature) is "fed back" into the system to regulate its subsequent operations. Similar homeostatic mechanisms were known to be at work in biological organisms, which also face the problem of maintaining certain variables (such as the sugar content of the blood or the osmotic pressure of bodily fluids) within bounds, or in ecosystems, where the numbers of predators and their prey would mutually control each other (as expressed in the Lotka-Volterra equations).[6] The properties of such a system could not be explained by breaking it down into its constituent parts—rather, it was the way in which these parts were interrelated, the organizational *patterns* which bound the components into a whole, which gave rise to "teleological" behavior. It was Norbert Wiener who coined the term *cybernetics* to designate the study of such self-regulating systems, and this nomenclature already indicated the larger hopes attached to the field: in classical Greek, a "kybernetes" is the pilot of a ship, and

cybernetics was to enable scientists not only to "steer" the dynamics of complex systems of all kinds, but also to design machines that could steer themselves.[7]

Another one of the Macy group's paradigmatic objects of study was the nervous system. It was in this context that they encountered paradoxes logically analogous to those Leopold had run into with his land ethics and were forced to realize that the hope of "controlling" such systems had been overly optimistic. On the one hand, the nervous system was clearly amenable to a description in terms of circular causality and feedback loops. However, it turned out to be impossible to determine a direct correlation between external stimuli and the internal states of the system. Not only does the sensorium of living organisms rely on the principle of indifferent coding—that is, light, warmth, sound, and all other physical stimuli are all equally transfigured into electrochemical impulses;[8] most of the system's connections are not even to the sensory cells at all, but between the elements of the system (that is, the neurons). The nervous system can thus be considered as "closed" in terms of information, even as it is "open" in terms of energy: while it is nourished by the body, its internal states are not determined by the latter. The system computes new sensory input with its internal states in order to produce representations of the environment, but these representations cannot in any significant sense be said to have been *caused* by the environment—rather, they are a function of the system's earlier internal states. Most importantly, the nervous system can never compare its representations with objects in its environment, but only with *further* electric potentials as they appear within the system; in other words, it is utterly blind to everything in its environment that does not come in the form of an electric impulse.

Second-Order Cybernetics

The radical consequences of this model became apparent as soon as one took seriously the implication that the scientists who had generated this description of the nervous system had been able to do so only by virtue of their possessing nervous systems in the first place. In other words, they were not only "apart from," but also "a part of," the reality they were studying, and thus subject to precisely those limitations which they had described in their object of study. This clearly violated one of the basic precepts of scientific epistemology, namely, that "the properties of the observer must not enter into the descriptions of his observations."[9] The very idea of scientific objectivity had been founded on this principle of self-exemption, but in this context it was now exposed as a mystification. If cognizing systems are constituted like the nervous system, they can *only* refer to their environments by *simultaneously* referring to themselves; put differently, in the terms of the aprioric perfect familiar from Derridean deconstructivism: hetero-reference is *always already* auto-reference. The fact that such systems are radically closed off from their environments could no longer be seen as an obstacle to cognition; rather, this separation now had to be understood as the very condition of its possibility: the nervous system can "see" the world *only because* it is also blind to it. This realization required the reformulation of a number of concepts that had been central to the first wave of cybernetics. Information, for instance, could no longer be conceived as something that was present in the world "out there" and then transferred *into* the cognizing system; rather, it had to be seen as produced by distinctions that the system makes *internally*, by the act of selecting those elements of the environment which are relevant to its continuing self-reproduction. Consequently, communication could not be conceptualized as an "exchange" of information. When one person waves to another, what travels between them is not information, but a visual *signal*—which is "converted" into information only once the person waved to interprets it as an attempt to communicate (and the countless possibilities for misunderstanding make evident that the information which the wave is said to "carry" cannot possibly be intrinsic to it).

What all this amounted to was that the very idea of a singular "reality" or a total "environment" had to be given up. Environments and realities always come in the plural; as cognitive constructs, they are relative to an observer—indeed, they are *constituted* by the act of observation, which is necessarily blind to its own enabling conditions. Observing other observers within her environment, and observing that they cannot see what they cannot see, an observer can deduce that the same must be true for herself. She can thus shift her interest from the properties of the world as it is in itself ("*what* does the observer see?") to the properties of the observer who has brought it forth ("*how* does the observer see?"); she can proceed, as Heinz von Foerster was to put it, from the cybernetics of observed systems, that is, first-order cybernetics, to the cybernetics of observing systems, that is, second order-cybernetics[10]—and this, one may add, is the conceptual move implicit in the opening chapter of Leopold's *Almanac*. Such "second-order observations," however, cannot escape their own constitutive blindnesses: When Leopold's narrator observes the field mice and distinguishes between the environment as they see it and the environment as it "truly" is, he cannot at the same time determine whether the distinction he thus applies is *itself* "true" to the environment—or whether it subjects him to limitations analogous to those of the mice; he can only do so in *subsequent* observations, which again will be unable to see what they cannot see.

For the sake of convenience and with some justification in the chronology of their development, I have sketched out these ideas with the nervous system as my chief illustration. However, their range of application is much wider than that. Among the most significant developments which built on these insights was the work of the logician George Spencer Brown and of the biologists Humberto Maturana and Francisco Varela. In his book *Laws of Form*, published in 1969, Spencer Brown developed a "calculus of indications" which conceptualized observation as the act of drawing distinctions, and the latter as the formal basis for the logical description of all possible types of relationships. Drawing on Spencer Brown's new calculus, Maturana and Varela applied the principles of operational closure and self-organization to the workings of biological organisms, describing them as *autopoietic*, that is, self-producing systems. Autopoietic systems close themselves off from their environment in order to maintain their own structure; they draw energy from their surroundings only in order to maintain the boundary that separates them from the environment. What occurs within this boundary is thus no longer determined by the chains of cause and effect that prevail outside, but by the previous states of the system itself, that is, by its history. Again, the properties of an autopoietic system cannot be explained by analyzing its components in isolation from the network of operations through which these components reproduce themselves. This process is circular, in that the system's structure is produced by its own operations, which are themselves conditioned by the structure. In the case of a cell, for example, enzymes are produced in order to metabolize nutrients, which are used to reproduce the DNA, which controls the production of enzymes in order to metabolize nutrients, and so forth. The only way in which the environment can directly determine the operations of such a system is by destroying it.

These were, of course, not the only developments that came out of early cybernetics. It also provided points of departure for new inquiries in numerous other fields such as ecology,[11] economics,[12] psychology,[13] physics,[14] as well as cognitive science, mathematics, and artificial intelligence.[15] While cybernetics had been launched as an interdisciplinary research agenda, it thus quickly turned into what can be called a metadiscipline, or as Ernst von Glasersfeld was to put it in the "Declaration of the American Society for Cybernetics" in 1981, "a way of thinking, not a collection of facts."

Niklas Luhmann's Theory of Social Systems

Rather than trying to sort out the many divergent paths which cybernetic thought has taken since the 1960s, I focus now on what is arguably the most sustained, provocative, and philosophically ambitious attempt to fully unfold the implications of second-order cybernetics and to synthesize the various strands of systems theory into a single, coherent theoretical architecture —namely the theory of social systems as it was developed by the German sociologist Niklas Luhmann. If Anglophone ecocritics have heard about Luhmann, it is most likely in connection with the single publication that he devoted explicitly to the subject of environmentalism, a book entitled *Ökologische Kommunikation* (*Ecological Communication*), which was published in 1986, in the heyday of Germany's green movement. The most immediate effect of this book was to turn the theory of social systems into a red rag for most environmentalists in Germany. Luhmann acknowledged the threat of ecological crisis, but he charged the movement with fearmongering and moral stridency. He answered the question which formed the subtitle of the volume—"Can modern society adapt itself to ecological dangers?"—largely in the negative. Yet Luhmann refused on principle to advance any comprehensive solutions, pronouncing as the goal of his inquiry not the remediation of environmental problems but the "avoidance of unnecessary excitement."[16] Lest these pronouncements seem willfully provocative, it will be necessary to consider them in the context of Luhmann's theory as a whole.

The basic building blocks of social systems theory are operationally closed, self-organizing, autopoietic systems such as they had been conceptualized by Maturana and Varela. However, Luhmann generalizes and radicalizes the concept. Not only biological organisms, but the individual consciousnesses which some of the latter "possess" *and* society as a whole can be described in these terms, although the operations through which they reproduce themselves do not involve biochemical components. Rather, they consist of meaningful events—mental events or "thought" in the case of consciousness, communication in the case of society.[17] What applies to biological systems also applies to psychic and social systems: their elements never occur as isolated phenomena, but only as links in a continuous sequence of similar events. As with the cell, the circular processes through which the elements of these systems reproduce themselves depend on a continuous "structural coupling" with an environment from which they are, however, also strictly separated. Structural coupling is thus the concept that takes the place of causality in the description of system/environment relations, and refers to the arrangement which allows a system to produce "resonance" with its specific environment. Consciousness cannot occur without a brain; if the brain dies, consciousness ceases. Yet neurological states can, as such, never "enter" consciousness but only "irritate" it. The same applies to society; it is structurally coupled with psychic systems,[18] but there is no transfer of patterns from consciousness into communication or vice versa (the same applies, mutatis mutandis, to psychic [illegible]

environments). Communication is therefore not, as early cybernetics would have it, the transmission of information from a sender to a receiver; it is an autopoietic process that determines by itself which parameters in the surrounding world are relevant to it, and becomes indifferent to the rest. It is this combination of closure and selective opening through which the system maintains itself as a system.

This is the basis for one of the most provocative claims of systems theory: humans are, Luhmann argues, not a part of society—rather, they constitute its environment. Furthermore, what we are accustomed to designate as a "human individual" is in fact not an "in-dividual" at all—it is not an indivisible unity, but rather a composite of several, structurally coupled systems which serve as each other's environment: psychic systems (consciousnesses) are the environment of social systems (communication), neurological systems (brains) are the environment of psychic systems, biological systems (i.e., human bodies) are the environment of neurological systems. Each of these systems is an "emergent" phenomenon, an explanation of which requires that we attend to the autopoietic process through which its components reproduce themselves. Accordingly, if we want to understand how society works, it is only of limited use to look at individual humans, bodies, or consciousnesses—rather, we have to examine the autopoiesis of communication.[19] Against this background, it should be apparent why Luhmann is skeptical with regard to the environmentalist project: humans are simply not in a position to impose their designs on society. They cannot "control" communication—communication can only change itself.

There is yet another serious obstacle to any attempt at social control. According to Luhmann, modern society is characterized by "functional differentiation," that is, it has evolved several distinct subsystems which perform specific social functions. Among these systems are law, politics, science, religion, and the economy. Each of these is an operationally closed, autopoietic system of communication in its own right, for which the other subsystems serve as intrasocial environments. These subsystems reproduce themselves by the use of specialized codes of communication—for example, legal/illegal for the law, true/false for science, payment/nonpayment for the economy—which they use to observe and distinguish themselves from the rest of society. "Communication" must not be confused with natural language—science, for example, would obviously be hard put if it had to rely only on language to establish the truth or falsity of a proposition, and mere words could hardly replace money. To increase the likelihood of successful communication, all of the function systems have therefore developed what Luhmann refers to as "symbolically generalized communication media," for

example, money (for the economy), power (for politics), or jurisdiction (for the law). Each of the function systems creates its own reality, and none of them is in a position to control the operations of any of the others—there is no hierarchy between them, and they cannot be mapped onto each other: truth cannot buy you a sandwich, and a profitable crime is still a crime.[20]

The breakdown of the communist command economy is an obvious example for the problems that arise when the code of one system is forcefully imposed on that of another. Yet Luhmann is no Adam Smith: there is no invisible hand that would harmonize the actions of the function systems. As a mode of social organization, functional differentiation is not better or worse than any of the other modes of organization for which there are historical precedents.[21] Neither is Luhmann a traditional Darwinist: the fact that modern society is more complex than its predecessors by no means implies that it is better adapted to its environment—from a perspective within society (and, in terms of communication, there are no others), all we can say is that thus far, it has been able to continue its autopoiesis.

Not all communication takes place within the function systems—in most everyday conversations, for example, we do not distinguish whether what the other person says is legal or scientifically true; but that is also the reason why such conversations are so easily discontinued. As Luhmann puts it, the function systems "float on a sea of small-scale systems that are continuously newly built and then dissolved."[22] On the larger scale of social evolution, these ephemeral types of communication do not leave much of a trace. If a communication is to be of lasting consequence, it must use the code of one of the function systems. This is indeed the chief problem with which environmentalism has struggled, because the language it uses to describe both itself and its objects often does not meet this requirement. While it is quite possible to voice "mountain-like" thoughts[23] and to demand that society pay attention, it is naïve to expect that this will produce the desired consequences, as Aldo Leopold himself was fully aware. All of the different function systems have reacted to the attempts of the environmental movement to remodel society in accordance with ecological criteria. But they have done so on their own terms, namely by developing green subdiscourses which in effect subverted the movement's universalist aspirations: the system of politics reacted with environmentalist parties and the creation of new government agencies; the law with environmental legislation; the economy with organic food stores, "greenwashing," and carbon-credit systems; (Catholic) religion with declaring Francis of Assisi the patron saint of ecology; science with new environmental studies programs and, more recently, with the creation of a new subdiscipline of literary

studies: ecocriticism. In each of these cases, the effects have been first and foremost on the respective function systems themselves—they have made a difference in communication, and only secondarily on the ecological environment.

Ecocriticism as Second-Order Observation

Now, what does all of this imply for ecocriticism? First of all, and most generally, it should be understood as a call to intellectual humility. This might sound somewhat surprising, coming from a thinker whose project was a "supertheory" aiming at universal applicability. Yet the crux of social systems theory and second-order cybernetics is that *all* observer positions come with a blind spot, and that it is precisely their blind spots which condition whatever purchase they have on the world. Luhmann was always quick to point out that social systems theory was itself nothing more than a theoretical option: it offers a vantage point from which old problems can appear in a new light (and without which some newer problems would perhaps not become visible at all). What it does *not* offer is an Archimedean point from which we could unhinge the social order—nor even the assurance that, though society may be beyond saving, at least we are not among the duped. As Hans-Georg Moeller writes, a "supertheory reflects on the fact that it and its validity are its own product—and is therefore absolutely contingent."[24] We need not do systems theory, and even if we do, we do not need to do it all the time. As a theory about society, social systems theory can produce a description of society that can claim to be scientifically true. But because it communicates within the function system of science, it cannot control what kind of resonance it will produce *outside* of that system. Therefore, it is not in a position to offer practical solutions for the ecological problems which society faces (although it is able to explain very well why those who have claimed to be able to do so have, by and large, fared so poorly). Systems theory does not deny that such practical solutions are necessary (and when Luhmann talks about the dangers facing modern society, ecological problems are always high on the list). It only denies that a theory, of whatever stripe, can be of much help in this respect. Social systems theory thus asks us to accommodate ourselves to the fact that what the environmental movement has been saying about nature applies just as much to society: we can never know it fully, and it is essentially beyond rational control.

Metaphorically speaking, one might therefore say that an engagement with systems theory can have the beneficial effect of a spasmolytic: It could help ecocriticism to accept its limitations as a necessary prerequisite for the production of a distinct kind of knowledge—in other words, to accept that

what ecocritics do is read texts and write about them, not campaign for new environmental legislation or plug tailpipes. Only to the extent that ecocriticism is something other than the academic wing of the environmental movement can it render that movement a service which is perhaps more valuable than general consciousness-raising or the recruitment of new personnel. Rather than insist on the factuality of the ecological crisis (as environmentalists must), ecocritics might take seriously the question why the argument that the ecological crisis really is real has gained so remarkably little traction—and to ponder the possibility that where it did, the reasons for this might be found *within* society, and not in its environment (which also means: not in individual consciousnesses). Taking the position of a second-order observer, ecocriticism can examine how environmentalism (or another organization or social system) observes, which distinctions it uses in order to unfold the paradoxes these distinctions necessarily entail—it can try to see what environmentalism must lose from sight in order to see what it sees and to do what it does.

A glance back at Leopold's *A Sand County Almanac* may indicate how such an interpretive practice might proceed. The chief distinction the text employs is that between the "wild" and the "social," and it subordinates the latter term to the former—it is those qualities of the social which preserve a measure of wildness that are to be considered most valuable. However, the distinction reenters on *both* of its own sides: not only is there a "wild" side to the social, but the wild itself also displays social characteristics. What allows Leopold to nevertheless uphold the distinction and to use it in order to pass plausible judgments is the deployment of a set of tropes that is not only deeply embedded in the liberal tradition, but that was also part and parcel of the struggle against totalitarianism in which U.S. Americans at the time saw their country engaged. In the *Almanac*, the preservation of wild nature is the preservation of a space where the individual must take complete responsibility for its actions, and thus of a core repository of quintessentially American values. Human encroachments on wilderness, on the other hand, are consistently aligned with totalitarian ideology, as when modern farming is denounced as aiming at "a sort of Pax Germanica of the agricultural world."[25] A similar intertwining of "properly" ecological subject matter and concerns about social organization in a more general sense can be seen in many other key texts of the environmental movement.[26] From a perspective informed by social systems theory, such semantic parallels cannot be dismissed as merely ornamental—they are at the very heart of the matter, showing, as they are, that ecological communication is one of the modes in which society observes itself.

NOTES

1. Leopold, *Sand County Almanac*, 3–4.

2. Ibid., 4.

3. Ibid.

4. Ibid., 5.

5. Cf. Fritzell, "The Conflicts of Ecological Conscience," 139.

6. All these examples illustrate the principle of negative feedback, which was initially at the center of attention; the principle of positive feedback was explored only in the course of the 1950s.

7. The more immediate reference was, of course, to the "governor" of James Watt's original steam engine, the most consequential application of the principle of negative feedback in modern engineering.

8. As such, this was not a new discovery—it had already been made by the German physiologist Johannes Peter Müller in the middle of the nineteenth century.

9. von Foerster, "Cybernetics," 7.

10. Ibid., 8.

11. Central in this respect is the work of the brothers Howard T. Odum and Eugene P. Odum. For an overview, see Odum, *Systems Ecology*. James Lovelock's Gaia hypothesis and Lynn Margulis's work on the role of symbiosis in evolution are also strongly informed by systems theory (cf. Lovelock, *Gaia*; and Margulis, *Symbiotic Planet*).

12. Cf. Kenneth Boulding's *Evolutionary Economics*. It was also Boulding who had coined the catchphrase "Spaceship Earth" in 1965—a metaphor which neatly captures the view of earth as a closed system.

13. Most notably the research conducted at the Mental Research Institute at Palo Alto, the results of which were summarized in 1967 by Watzlawick, Beavin, and Jackson in *The Pragmatics of Human Communication*; the driving force behind much of this work was Gregory Bateson, *Steps to an Ecology of Mind*.

14. Most famously Ilya Prigogine's work on dissipative structures (cf. Prigogine and Stengers, *Order out of Chaos*).

15. Hofstadter's *Gödel, Escher, Bach* remains by far the most entertaining introduction to these developments.

16. Luhmann, *Ecological Communication*, xviii.

17. For a summary of Luhmann's account of meaning, which is heavily indebted to the phenomenology of Husserl, cf. Moeller, *Luhmann Explained*, 65–70.

18. And society is coupled *only* with psychic systems: "there can be no physical, chemical, or purely biological interferences with social communication" (Luhmann, *Einführung*, 123, my translation)—only events that have first passed through the "needle's ear" of consciousness can have effects on communication.

19. If these claims seem stark and counterintuitive, it is useful to recall what we know of humanity's evolutionary history. *Homo sapiens* as a biological species has been in existence for about 100,000 years; only in the last twentieth part of this time span has the evolution of larger social structures really taken off. If social evolution was determined by the biological properties of humans, this time-lag would present a considerable

conundrum; if we grant that society consists not of biological entities, but of communications, and that it therefore possesses a dynamic that is entirely its own, the incongruence between biological evolution and social evolution is a matter of course.

20. Wolfe, *Animal Rites*, 200.

21. The major other forms of social organization which Luhmann contrasts with functional differentiation are stratified differentiation (e.g., feudalism), segmentary differentiation (as in tribal societies), and center-periphery differentiation (as in many premodern empires); these forms are rarely found in "pure" forms, and in many regions of modern world society, functional differentiation is complemented by other modes of social organization.

22. Quoted in Moeller, *Luhmann Explained*, 30.

23. cf. Leopold, *Sand County Almanac*, 137ff.

24. Moeller, *Luhmann Explained*, 200.

25. Leopold, *Sand County Almanac*, 199.

26. For example, in Rachel Carson's *Silent Spring* or in the works of Edward Abbey and Gary Snyder. Cf. Bergthaller, *Populäre Ökologie*.