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## **Semiotics in Ecology and Environmental Studies**

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### ***Introduction***

There are fundamental similarities and connections between ecology and semiotics. Both disciplines derive from the same episteme of systemic or structural thinking established in the late nineteenth and early twentieth centuries. Both classic ecology and semiotics (semiology) have also viewed their research objects as possessed of structural organization. In 1935, Arthur G. Tansley proposed the concept of the ecosystem as the structural and functional system of organisms and the environment they inhabit. In a similar way, early semiotics saw language (but also mythologies and literature) as intrinsically organized and comprised of elements and their relations (e.g. in the semiology of Ferdinand de Saussure and the structural anthropology of Claude Lévi-Strauss). Both fields have given a principal ontological position to relations and go to great lengths to study relations. In ecology, ecological relations such as predation, parasitism, competition, herbivory, and so on, have been the principal entities of research. Meanwhile, in Peircean semiotics a main object of study – the sign – is understood as a mediated relation.

There are also many examples wherein semiotic theories and concepts have been included within ecology and environmental studies. The adoption of semiotics within ecology has aided in foregrounding information and communication processes in nature, and also in articulating the relations between human culture and ecosystems. This chapter provides an overview of semiotics in population, community, and ecosystem ecology, and also overviews various usages of semiotics in environmental

studies, as well as describes the ecosemiotic paradigm as an explicit synthesis of ecology and semiotics.

In the second half of the twentieth century, the influence of ecology and other biosciences on the humanities became noticeable. This movement led to the development of various novel paradigms (media ecology, cultural ecology) that adopted ecological concepts (environment, ecosystem, symbiosis), and also led to the rise of interest towards environmental issues as research objects (e.g. in ecocriticism and environmental history). In semiotics, the introduction of the concept of the semiosphere by Juri Lotman (2005) as a sphere of sign processes in a loose metaphoric relation with the biosphere, and the adoption of the Umwelt concept originally coined by Jakob von Uexküll (1982) in biosemiotics to denote species-specific perceptual worlds, are some markers of this development. Furthermore, there have been sub-disciplines in semiotics that have come close to the subject matter of ecology because of their interest in spaces, spatial relations, and artefacts (e.g. urban semiotics, Krampen 1979). The interrelations between the biosciences and the humanities culminated in the development of the environmental humanities at the beginning of the twenty-first century, which as of now forms a contemporary context for interpreting the relations holding between semiotics and ecology. Besides these general developments, in the second half of the twentieth century specific paradigms of zoo-, eco-, and biosemiotics emerged with the aim of bridging different fields of biology and semiotics, and with an ambition towards interdisciplinary syntheses. With its longer history, biosemiotics has been especially active in making many semiotic concepts accessible to ecology. It is also worth noting that several people working in the field (e.g. Kalevi Kull, Almo Farina, Riin Magnus) have professional involvement both in semiotics and ecology.

For the most part, the historical influences between ecology and semiotics appear to be unidirectional – ecological concepts have been adopted by different paradigms of the humanities, but very seldom do we find cases wherein semiotic concepts and methods have been used in ecology (although the number of such works has been growing in recent decades). So what, in principle, could the role of semiotics be in ecology and environmental studies, and why should we aspire to such a synthesis? Based on a review of the literature, the following main motivations for incorporating the semiotic approach into ecology can be distinguished:

1. Including animal agency in the understanding of ecological processes. The question of how animals perceive, select, and modify their environments is relevant for a number of ecological topics, such as protecting habitats for endangered species or controlling pest damage in medicine, agriculture, or forestry (e.g. Shaw et al. 2013). Including the animal perspective is mostly achieved by applying Uexküll's Umwelt theory or its elaborations (such as the landscape of fear, Bleisher 2017, or environmental continua, Manning et al. 2014).
2. Including human communicative and cultural processes in the subject matter of ecology. This is especially relevant for topics where environmental processes depend on human culture or behavior. For instance, studies of urban ecology or semi-natural ecosystems would remain incomplete without the inclusion of the human cultural component, due to the effect that humans have in shaping these environments (e.g. Hess-Lüttich 2016).
3. Bridging the sciences and the humanities for the purpose of enriching the theory, conceptions, and methods of ecology, or for envisioning the synthesis of the ecologies and the humanities into one sphere of knowledge. This approach is often related to the process of proposing new concepts for ecology (e.g. propagating the informational, cybernetic, or cognitive approach, Farina et al. 2005; Farina & Pieretti 2013), or for building new methodological frameworks (as in ecosemiotics).

Upon examining how semiotics has been conceptually included in ecological studies, there are several methods of concept-building which can be distinguished: existing ecological concepts are reinterpreted by adding some semiotic content (e.g. *semethic interaction*, *semiotic niche*, applying semiotic concepts directly within ecology: signs in the form of *environmental signs*, a code as an *ecological code*); original concepts that have derived from the theoretical synthesis of semiotics and ecology (*eco-field*, *sign-field*) are proposed; or concepts which have a broader interdisciplinary usage and have been naturalized both in semiotics and ecology (*Umwelt*, *affordance*) are used. As it stands, all of these conceptual tools have been proposed by different authors, often one concept at time and based on diverse disciplinary insights.

Integrating ecology and semiotics seems promising as a number of dedicated research methods have been provided and applied as part of their synthesis. For

instance, Italian semiotician and landscape ecologist Almo Farina has developed the method of *ecofield* analysis that combines Uexküll's Umwelt theory with the spatial description of landscapes and the allocation of resources. The ecofield is a meeting point of an animal's biological needs and the properties and resources of the landscape. "The term eco-field is the contraction of the words 'ecological field', and means the physical (ecological) space and the associated abiotic and biotic characters that are perceived by a species when a functional trait is active." (Farina & Belgrano 2004: 108). In addition, Farina proposes describing organism-environment relations as a Need-Function-Ecofield (or interface)-Resource sequence (Farina 2012: 23) wherein functions and resources are mediated by a semiotic component—the ecofield—that animals need to perceive and interpret correctly in order to make use of resources. Ecofield analysis has been practically tested by Roberto Pizzolotto (2009) in a study of the distribution of Carabid beetles in various natural and anthropogenic habitats in Italy. He concludes that the "eco-field is a valuable approach for developing tools to reveal natural trends, and that the study of life strategies as descriptors of an organism's perception of the natural environment may lead to a practical application of the eco-field hypothesis [...] eco-field is not merely an eco-mathematical model; its ecological dimensions result from the life histories and interactions of living organisms. The eco-field has been strictly related to species traits, which are one of its determining characteristics when species interfere with perceived ecological factors" (Pizzolotto 2009: 146).

Another more established method is Kalevi Kull's distinction between 0-, 1-, 2-, and 3-nature as different levels of environmental mediation in the nature-culture continuum. "Zero nature is nature itself (e.g., absolute wilderness). First nature is the nature as we see, identify, describe and interpret it. Second nature is the nature which we have materially interpreted, this is materially translated nature, i.e. a changed nature, a produced nature. Third nature is a virtual nature, as it exists in art and science." (Kull 1998: 355). Kull's typology is an effective conceptual tool for analyzing semi-natural communities, hybrid natures, and the interrelations between culture and nature. The typology has been applied in organizing the intertwining of culture and nature in sacred landscapes (Heinapuu 2016) and herbal medicine (Sõukand 2005). Other proposals for semiotically-motivated research methods are the Naturesyns model (Møller 2009), Ecological Repertoire Analysis (Maran 2020), and Anxious Semiotics (Whitehouse

2015). The presence of several original research methods also signals the strength of the synthesis between ecology and semiotics.

### ***Population ecology and species conservation***

In ecology, a division is often made between population ecology and ecosystem ecology, while in-between these major ecological schools we may locate community ecology. In population ecology, the research interests are in the demographics of different species, a species usage of resources, and the relations they have with other species living in the same habitats (ecological relations). Population ecology also has a strong link with conservation biology, predicated on the question of what requirements are needed for the given species to thrive. In the study of animal populations, semiotics can be employed in various ways. First, (bio)semiotics can be used to explain the ecological role of animal morphology – what meanings an animal can achieve in ecological relations. Kalevi Kull has emphasized the role of organic form as a constituent of ecosystems: “production of ecosystem as the result of multiple ‘organic design’ by the organisms living in the ecosystem.” (Kull 2008: 3213). Animal form has had a central focus in the German-language biological tradition, e.g. in the work of Adolf Portmann (animal appearance), and has more recently been elaborated in Czech biosemiotics under the concepts of *semiotic co-option* and *semantic organs* (Kleisner 2015). An important principle of this approach is understanding that animal form is semiotically open and able to gain new meanings, and that these can become engaged in new ecological relations.

Several authors at the crossroads of ecology and semiotics have contemplated the semiotic mediatedness of organism-environment relations. Aside from Almo Farina’s *ecofield* concept (described above), Jesper Hoffmeyer (2008) has proposed the *semiotic niche* concept to emphasize the many properties and resources of the ecological niche which are presumed to be involved for the interpreting subject. For instance, in making use of an environment for nesting, a bird like the chaffinch needs to recognize a suitable location for nesting, secure the territory from rivals, and build a nest from twigs, moss, and other vegetative material (on the semiotic aspects of niche construction, see Peterson et al. 2018). Here an animal obtains an active role in creating a correspondence between its own genetic and bodily information and environmental information. In ecological studies, an animal’s individual connection to the

environment is often discussed under the Umwelt concept (e.g. in landscape ecology, Manning et al. 2014; in sensory ecology, Jordan, Ryan 2015).

With regards to the ecological relations holding between species, the semiotic approach is mostly related to the role of communication in ecological relations. It is generally accepted in ecology that the availability of information and communication may have quite a significant effect on ecological relations (Schmidt et al. 2010). Interspecies communication may have an effect on habitat selection, migratory routes, accessibility, food preferences, and so on. “The evidence is strong that interspecific information transfer influences the distributions of animals relative to each other, as evidenced by the number of studies [...] Information flow between species can influence the position in space and time of different species, whether it be temporary groups around a predator or resource or stable associations between species in mixed-species groups or between species with shared territorial locations.” (Goodale et al. 2010: 359). The semiotic approach may shed light on these aspects in more specific ways, including how the particular messages, codes, and media that are used in animal communication influence ecological and interspecies relations.

The semiotic approach in ecology also helps to decipher how the physical environment acts as a medium in the message exchange between species. Russian ecologists and semioticians Elina Vladimirova and John Mozgovoy (2003, also Vladimirova 2009) have proposed *signal field theory* to describe the type and abundance of animal tracks and traces in a given area, and thereafter use the latter as the basis on which to analyze the diversity of meaning-relations in the environment. Sign field analysis has also enabled the characterization of the *semiotic intensity* of the environment, inasmuch as a number of functional classes of environmental objects provoke reaction on behalf of the animal.

Focusing on the semiotic mediatedness of the animal-environment relationship is important for animal conservation and species protection, as it is in animal Umwelten wherein the environment becomes usable for other animals. Distinctions and categorizations between “structural habitat units (e.g., land cover types) as perceived by humans may not represent functional habitat units for other organisms” (Van Dyck 2012: 144). The Umwelt approach allows for better scrutinizing the accessibility of environments for animals in the face of various anthropogenic effects like anthropogenic niche construction or human interference in information processing (Van Dyck 2012). It may also be that human-altered environments inhibit animals not

because of the lack of some resource, but because of the deficient competencies of animals in recognizing their resources. For instance, if the abundance of prey species diminishes quickly, will a predator be capable of finding and developing a novel image of prey, as has been noticed in black-footed ferrets with regards to the declining prey populations of prairie dogs (Candland 2005)? The Umwelt-centered view will lead to different responses and countermeasures as regards environmental change. Besides protecting physical environments and land areas, attention needs to be on working with animal Umwelten in order to provide animals with necessary cues for orienting in the environment, or for altering animal Umwelt by training them to survive in novel environments (Van Dyck 2012; Shier 2016). In several works, Morten Tønnessen has elaborated on Umwelt theory to make it more suitable for analyzing the changing relations between an animal and its environment (the concepts of *Umwelt transition*, *Umwelt trajectory*, Tønnessen 2009, 2014). Umwelt theory may also be a valuable tool in more general strategies of nature protection as it makes it possible to describe and value the environment from the perspective of different non-human species (e.g. in regard to wolves, Tønnessen 2010; Drenthen 2016).

### ***Community ecology***

Community ecology focuses the combination, distribution, and dynamics of species in local biological communities or ecosystems. Here the semiotic approach may be included to untangle the role that semiotic processes such as interspecies communication, animal cultures, and ecological heritage, play in shaping the biological communities. Semiotics can further target specific communicational conventions that are used in biological communities. An example of such an approach can be found in Sánchez-García et al. (2017), wherein various relations of bark beetles in the forest ecosystem have been analyzed using eco-field networks (representamen networks). According to this study, relevant information is shared among forest species via the combination of various scents that together comprise the communication medium of *odourtope*.

Kalevi Kull has proposed the concept of the consortium, which emphasizes the basic semiotic structure of biological communities. A consortium is a “group of organisms connected via (sign) relations, or groups of interspecific semiotic links in biocoenosis.” (Kull 2010: 347). It may be that in the evolution and development of the community structure, semiotic processes like habitat choice, recognition, and learning

play a major role. This is the idea behind the concept of *ecological fitting* wherein organisms themselves select and adjust their location and relations with the resources, species mates, and other species within the ecosystem (Janzen 1985; Kull 2020). According to the *ecological fitting* hypothesis, species' co-existence in biological communities does not result from the long-term co-evolution of the species, but results from more rapid processes of relational fitting. An example of such a fitting process can be habitat preference, which is based on the risk assessments that animals make concerning the presence of predators (such descriptions of the environment have been called landscapes of fear, Bleicher 2017). By looking for, and finding, a good spot to inhabit, individuals belonging to various species, are, in fact, creating the composition of the biological communities.

Jesper Hoffmeyer (2008) has proposed describing ecological relations and food webs by foregrounding semiotic relations and by applying the ideas of semiotic habituation and symbolization. He has proposed the concept of *semethic interaction* to describe the way existing patterns, structures, and routines tend to become sources of interpretation between species: "Whenever a regular behavior or habit of an individual or species is interpreted as a sign by some other individuals (conspecific or alter-specific) and is reacted upon through the release of yet other regular behaviors or habits, we have a case of semethic interaction" (Hoffmeyer 2008: 189). To give an example, the blossoms of daisies, dandelions, and other plants transmit messages about the presence of nectar to flies, butterflies, and other insects; the habits of pollinators to visit colorful plants is in turn used by the crab spiders *Thomisidae*, who lurk in blossoms; and the crab spiders' habit of sitting in the blossoms is made use of by the parasitic mud dauber wasps *Sceliphron sp.*, many species of which are specialized in catching spiders. Semethic interactions form cascades of linkages based on habits and the recognition occurring between different species in biological communities (e.g. in predator-prey networks).

There are several approaches in ecology that aim to study the spatial organization of biological communities (e.g. landscape ecology, acoustic ecology). Spatial ecological analysis often uses large-scale modelling and applies it to big data sets. For instance, in acoustic ecology, hundreds of microphones can be simultaneously used to map the changing patterns of biophonies, geophonies, and technophonies. Here semiotics can be included as a method of organizing and categorizing data. Farina and colleagues (2016) have proposed an *Ecoacoustic Event Detection and Identification*



(EEDI) method wherein properties and meanings attributed to earlier events are combined with computerized analyses of datasets. The methods allow for analyzing soundscapes in large land areas and in long-term monitoring programs.

In addition to organismal activity and semiotic interactions, we may also assume broader communicative conventions and codes arising in local communities. The idea of interspecies communicative conventions has been proposed by several authors and designated by many terms: *acoustic codes* (Malavasi et al. 2013), *ecoacoustic codes* (Farina 2018a), *ecological codes* (Kull 2010; Maran 2017a). Malavasi and colleagues (2014) argue that birds' songs establish cross-species conventions (acoustic codes), and that these conventions allow birds themselves to regulate their density in biological communities. By listening, adapting, and tuning in to the morning chorus, individual birds receive information about the crowdedness of the habitat and location of unoccupied areas and resources. Maran (2017a) has proposed a broader interpretation of *ecological codes* as partially shared and distributed interspecies conventions wherein the code incorporates both environmental and communicational aspects, and wherein every participant uses a partial variation of a code. The further distinction in ecological codes can be made between: “(1) distribution codes, where animal activities and communication through the process of self-assembly organize the spatial and temporal organization of the animals; (2) significational codes, where an environmental affordance is perceived and interpreted similarly by various species that results in shared or non-random use of the corresponding resource; (3) identity codes, where the ecological code is centred on a species or group that has significance or is charismatic to a broad number of species in the given ecological community; (4) symbolic codes, where the code is centred on the specific patterns of colour (or another modality) that have a shared meaning for a number of species; and (5) archetypical codes, where the ecological code is centred on the meaning relation that is valid for a broad number of different species due to the general physiological, ecological or behavioural constitution of the organisms.” (Maran 2017a: 130–131). Examples of ecological codes include eyespots, yellow-black coloration, hissing, and other warning signs. The presence of ecological codes opens up possibilities for complex interspecies regulation in ecosystems.

### ***System ecology***

System ecology studies the large-scale structure of ecosystems by paying attention to the distribution and movement of matter and energy (described as pools, flows, trophic levels, bioproduction, etc.). According to this objective, system ecology has developed a complex body of mathematical methods to model ecosystems. On this scale of generalization, the semiotic activity of organisms as well as the dynamics of populations is usually considered as a variation below statistical relevance. At the same time, it has been proposed that besides webs of energy and matter, ecosystems also consist of information networks. “Strong positive feedbacks in information processing can define or reinforce levels of organization—from a cell to an individual to symbioses all the way to an ecosystem and the biosphere [...]. Information stored at higher order levels of organization, such as social groups, communities or ecosystems, can be used by lower level systems, such as individual organisms and cells. In this way, information processing occurs across scales of space and time, and can create and maintain physical or energetic structures” (O'Connor et al. 2019).

System ecologists Bernard C. Patten and Eugene Odum (1981) have argued that this informational layer consisting of an enormous number of local feedback cycles is the main reason why ecosystems retain their relatively stable structure and do not disperse into myriads of chaotic events. They further describe informational processes that allow for the connection of different entities and layers of the ecosystem as mapping—processes which correspond to iconic representation in semiotic jargon—and amplification, in which a small causal trigger can have a major output effect on account of semiotic mediation. The informational layer of the ecosystem mostly comprises the activities of organisms which through homeostasis and self-preservation aim for stability at the local level. This property of living systems to retain their organization has been called *coherence* by Robert Ulanowicz (2010), who connects the latter with communication and biosemiosis. Through the feedback organismal regulation may cumulate in a more general system-wide regulation (lasting population densities or community structures). In some cases, however, also the non-living environment may become an agent carrying system-wide information (Lévêque 2003: 96). An example of such process would be the seasonal changes in coastal ecosystems, wherein the change of chemical composition (pH, DH, organic compounds) in water signals the beginning of the reproduction cycle for a variety of species.

The semiotic regulatory layer of the ecosystem has been termed an information network (Patten & Odum 1981) or communication network (Lévêque 2003: 95). Danish

system scientist Søren N. Nielsen (2007) has rightly recognized the semiotic character of this layer and proposed that it should be called *semiotype* in parallel to genotype and phenotype. Nielsen has argued for the inclusion of the semiotic approach in ecological modelling that would take into account the role of meaning-making (qualities) at different levels of ecological systems. Following Bernard C. Patten (1990), organismal meaning-making can be included within ecological models as input and output *environs* (formalized but phenomenological equivalents of Uexküll's Merkwelt and Wirkwelt). Nielsen suggests that system ecology would benefit from including the understanding of second-order (cybernetic) systems, which are underdetermined, partly autonomous, ontically open, and reactive (Nielsen 2016). Nielsen has further proposed that the particular approach could be named *ecosystem semiotics* and that "in order to understand the action of humans toward our environment and fellow/companion species on our planet, it is very important to have a further look on and improved understanding of the semiotic processes in the ecosystems" (Nielsen 2007: 100).

Semiotic regulation in the ecosystem is contextual and cumulative; it includes and combines patterns and perceivable properties of the inanimate environment with the perception, interpretation, and behavioral action of single organisms together with their memory, experience, and evolutionary past, as well as the communication networks in and between species. This makes the semiotic layer of the ecosystem very difficult to rationalize by conventional scientific methods. The numerous tiny acts of meaning-making organize and regulate the ecosystem in its every joint and connection, forming a complex multilayered network (Nielsen 2016). Describing these indirect regulating hubs in semiotic terms is notably present in the works of eminent system ecologist Bernard C. Patten. He has considered the ecosystem as a "model-making complex adaptive system," wherein the internal model-making of living agencies together with physical resources and the forces of natural selection lead to the active auto-evolutionary self-design (Patten 1998: 151). In a more global, biospheric sense, the semiotic regulatory layer of the ecosystem can be described as the (bio)semiosphere, following Jesper Hoffmeyer: "the semiosphere is a sphere just like the atmosphere, the hydrosphere, and the biosphere. It penetrates to every corner of these other spheres, incorporating all forms of communication: sounds, smells, movements, colors, shapes, electrical fields, thermal radiation, waves of all kinds, chemical signals, touching, and so on. In short, signs of life. (Hoffmeyer 1996: vii)."

### *Environmental studies*

Environmental studies is a denotation for a broad interdisciplinary field that combines the approaches of the humanities, social sciences, environmental sciences, and biology for studying human interactions with the environment. There are various possibilities for using semiotic theories in environmental studies. In this overview, I will cover approaches that focus on human communicational or cultural relations with the environment and that afford the environment with some realist or agential properties. I exclude numerous works wherein semiotic theories have been applied for analyzing environmental representations as objects within media discourses (e.g. Douglas, Veríssimo 2013; Dobrin 2018), as well as poststructuralist criticism (mostly departing from the philosophies of Deleuze, Foucault, Baudrillard, but see Beever's 2013 critical synthesis) of Western societies that occasionally include environmental topics. An adjunct field that has some overlap with semiotics is ecolinguistics as developed by Arran Stibbe (2012; 2015) and colleagues to critically scrutinize the functioning of language in ecological crises.

In the works of several authors we find the aspiration to integrate perspectives of ecological science and the humanities into a non-dualistic interdisciplinary framework. Often such endeavors derive their motivation from semiotics. Combining semiotics and Actor-Network Theory (ANT) has been proposed for the non-dualistic treatment of culture-natures (Ivakhiv 2002; Maran 2015; Jepson et al. 2011). Adrian Ivakhiv has called his ANT-inspired approach *multicultural ecology* and described this as a “perspective that acknowledges the cultural embeddedness of any and all ideas nature, accepts the coexistence of multiple cultural-ecological practices, and gestures, at least in a preliminary way, a normative dimension by which such practices can be compared and evaluated” (Ivakhiv 2002). It is worth noting that ANT as originally developed by Bruno Latour was influenced by Greimas' actant analysis and has also been called “material semiotics” (Law 2008).

Another surface of syntheses lies between semiotics and multi-perspectivist anthropology (mostly deriving from the works of Eduardo Viveiros de Castro). In this tradition, Eduardo Kohn (2007, 2013) has studied the relations between humans, domestic animals, and wild animals in South American nature-cultures by combining local cosmologies with the Peircean typology of signs. According to this approach, humans and other animals are grounded by iconic and indexical semiosis which creates the united *ecology of selves*. In a similar way, Nils Lindahl Elliot (2019) has applied

Peircean categories in analyzing tourist experience in tropical America, considered in terms of the degrees of mediatedness organizing the perception and observation of wildlife. On the opposite side of the Earth, Almo Farina has found inspiration from traditional Mediterranean agricultures in suggesting the *rural sanctuary* model for promoting the co-existence of small-scale economy, local cultures, and biological diversity. The rural sanctuary “is defined as an area where farming activity creates habitats for a diverse assemblage of species that find a broad spectrum of resources along the season [...] A Rural Sanctuary represents an ecosemiotic agency in which human eco-fields and animal eco-fields interact.” (Farina 2018b: 139). Farina emphasizes the positive impact of human activities on other species as traditional agriculture often makes landscapes patchier and more heterogenic.

There are also approaches that undermine the boundaries of human material or literary culture by aiming to build a direct synthesis between culture and the environment. This view is expressed by medievalist Alfred K. Siewers in his vision of an *ecosemiosphere* that “literally means an ecological bubble of meaning (borrowing the term “semiosphere” from semiotics)” (Siewers 2014: 4), wherein the term “extends earlier definitions of specific symbolic cultures as semiospheres, or meaningful environments, into physical environments” (Siewers 2011: 41). Deriving from the works of Juri Lotman, Kati Lindström (2010) has suggested that the landscape may enter into a dialogic relationship with culture by providing perceptual markers that act as a second code of communication. Such a relationship leads to enhanced cultural autocommunication and thus enhances cultural creativity. Kadri Tüür (2009, 2016) has argued for overcoming the representational view of nature and using the concept of biotranslation for describing relations between animal meaning-making and literary depictions. It is noteworthy that semiotics has been influential in many applied fields of environmental studies such as landscape studies (Abrahamsson 1999; Lindström et al. 2011; Claval 2005), ecological restoration (Rochford 2017), ecological design (Ávila, 2020), and environmental education. In environmental education especially, communicating and mediating environmental knowledge to students is a practical concern, as in the case of learning about plants and other organisms that are very different from humans (Affifi 2013). In this context, *environmental literacy* with a semiotic emphasis on interpretation has been used both as a theoretical concept (Stables, Bishop 2001), and also for encouraging the practical skill of reading traces and tracks (Lekies, Whitworth 2011).

There are a number of critical concepts which denote the collapse of nature-cultures or the negative effects of human activities on the meaning-making of other species. Ivar Puura's (2013) concept of *semiocide* describes "a situation in which signs and stories that are significant for someone are destroyed because of someone else's malevolence or carelessness, thereby stealing a part of the former's identity." Examples of semiocide are the replacement of natural meadows with golf courses or primeval forests with mono-cultural plantations. A similar critical concept to describe harmful semiosis is that of *semiotic pollution*, as in the effect of excessive light or sound signals produced by modern human civilization to other life forms (Posner 2001). Semiotic pollution may disturb the code, contact, message, participants, and other aspects of the sign process. German semiotician Ronald Posner draws our attention to the parallel between chemical contamination and semiotic pollution as both increase physiological stress in biological organisms. In some cases, the environmental object may also demonstrate *dissent* or non-concordance with the human interpretation. The concept of dissent was used in this context by Australian semiotician David Low (2008), who emphasized the necessity of including the environment as a semiotic subject into the study of environmental communication. According to his view, environmental processes enter into environmental communication as dynamical objects of the sign in the sense of C.S. Peirce. For example, the pollutants in water act as dynamical objects, whereas their perceived characteristics and effects act as immediate objects of the sign. In such situations, people search for the correspondence between dynamical and immediate objects – that is, they adjust and adapt their sign-mediated knowledge towards the environmental processes themselves.

In another type of dynamic interaction, cultural norms are projected onto nature and the material environment through human activities. Here, cultural oppositions like city and forest or native and non-native may through applied rules and actions influence the structure of biological communities (Magnus, Remm 2018; Maran 2015). Prisca Augustyn (2013) has further demonstrated the role of language structures (framing, metaphors, oppositions) in the human understanding, appreciation, and manipulation of nature. Semiotic modelling provides a tool to explicate the grounds of human understandings of the environment, and to playfully rearrange these by altering the grounds of modelling (Maran 2020, forthcoming). On a more general scale, the type of semiosis dominant in culture may also influence culture-nature relations and local ecologies. Alf Hornborg (1996; 2001) has demonstrated how the dominance of abstract

sign systems may lead to *ecosystem dissolution*. He has distinguished between sensory, linguistic, and economic signs, and has shown how each subsequent sign type becomes more detached from the practices of human living within the ecosystem. Using the example of native South American peoples, Hornborg has shown that adoption of abstract economical sign systems becomes a main reason for the dismantling of local nature-cultures. As seen from this overview, semiotics is mostly applied in environmental studies for establishing a common framework in the study of nature-cultures, or for critical treatment of human effects on the environment.

### ***Ecosemiotics***

Ecosemiotics (also semiotic ecology) is an explicit synthesis of ecology and semiotics that started to develop in the 1990s. The concept was originally proposed by German semiotician Winfried Nöth (1996), although there is also a prehistory with earlier variations of the name used in the early 1990s (ecological semiotics, environmental semiosis). In the development of ecosemiotics, it is especially professor Kalevi Kull of the Tartu School who has had a leading role (for an overview, see Maran 2018). Over the years, many authors have explicitly elaborated ecosemiotics, including Almo Farina, Timo Maran, Morten Tønnessen, Riin Magnus, Alf Hornborg, Ernst Hess-Lüttich, Alfred K. Siewers, Kadri Tüür, and Matthew Clements. Depending on the author, the scope of ecosemiotics has been understood as having either a more humanitarian or scientific focus. For instance, ecosemiotics has been defined as “the study of sign processes which relate organisms to their natural environment,” (Nöth 2001: 71), “a branch of semiotics that studies sign processes as responsible for ecological phenomena” (Maran, Kull 2014: 41), or as the semiotic discipline investigating “human relationships to nature which have a semiotic (sign-mediated) basis” (Kull 1998: 351).

In the twenty-first century, ecosemiotics has gained more disciplinary unity and developed a shared framework that covers both semiosis in the biological realm and cultural representations of nature. For instance, Kalevi Kull has described the aim of the field holistically: “The role of semiotics for ecology is to constitute a certain theoretical frame that would allow to approach, without any dualism, the analysis of semiosphere as the natureculture whole. This includes description and explanation of natural emergence of meaningfulness in organic communication, and of the communicative basis of organic forms and relations.” (Kull 2008: 3211). Deriving from

the more recent concepts of socio-ecological systems (Bodin 2017) and biocultural diversity (Sobo 2016), we can claim that ecosemiotics studies semiotic processes present in and responsible for constituting local biocultural wholes (or nature-cultures). Contemporary ecosemiotics can be characterized as treating sign processes taking place on many different levels of the biosemiosphere: from the potential of the environment to evoke semiosis, to the meaning-making and communication of animals, to semiotic networks in ecosystems, up to cultural representations and the symbolization of nature in culture (cf. Maran 2020, forthcoming). Ecosemiotics has categorized environmental semiosis and signification (elaborating concepts of perceptual affordance, tacit signs, environmental meta-signs, Maran 2017b) and combined these with cultural representations of nature (under concepts like nature-text, environmental-cultural hybrid signs, Maran 2017b, 2020). As Morten Tønnessen (2020) has demonstrated, ecosemiotics is also effective across various scales of generality in its study of both local and globalized semiotic processes. This broad scope allows ecosemiotics to analyze very different objects (nature writing, eco-cinema, urban trees, alien species, medicine plants, etc.) by pinpointing interactions, cross-effects, and hybridizations between different levels of semiotic phenomena.

Maran and Kull (2014) have brought out eight main principles of ecosemiotic research:

1. The structure of ecological communities is based on semiotic bonds;
2. Changing signs can change the existing order of things. Living organisms change their environment on the basis of their own images of that environment;
3. Semiosis regulates ecosystems. Meaning-making both stabilizes and destabilizes them;
4. Human symbolic semiosis (with its capacity of de-contextualization) and environmental degradation are deeply related;
5. Energetically and biogeochemically, human culture is a part of the ecosystem. Semiotically, culture is both a part and a meta-level of the semiotic ecological network;
6. The environment as a spatial-temporal manifestation of an ecosystem functions as an interface for semiotic and communicative relations;
7. Narrative description is inadequate for the description of ecological semiosis;



8. The concept of culture is incomplete without an ecological dimension. A theory of culture is incomplete without the ecosemiotic aspect.

These principles are comprehensive in the sense that they have a broad focus which covers the semiotics of ecological relations as well as the semiotics of human connections with ecosystems, and in a metalevel role covers the ecological dimension within the humanities.

Aside from its usage in environmental humanities and education science, ecosemiotics has also found applications in practical ecological research. The ecosemiotic approach appears to be very suitable for analyzing semi-natural environments and hybrid natures. For instance, Low and Peric (2012) have applied ecosemiotics in analyzing human agency in the distribution of weeds and the related construction of meanings, Maran (2015) has started from ecosemiotics in his survey of the spread and cultural interpretations of novel species (golden jackal, *Canis aureus*), and Magnus and Remm (2018) have provided an ecosemiotic analysis of the distribution and cultural history of urban tree species. Morten Tønnessen (2020) has recently elaborated on Umwelt theory in his analysis of the change in Amazonian culture-natures by focusing on two species of monkeys, the red howler monkey (*Alouatta seniculus*) and the blackheaded squirrel monkey (*Saimiri vanzolinii*). Marcos S. Karlin (2016) has further applied ecosemiotics for mapping the resilience of the local semiosphere by juxtaposing locally- and globally-available species knowledge in Salinas Grande, Argentina. Based on the examples above, ecosemiotics appears to be practically usable in various case studies and applied to various research objects. The development of ecosemiotics in the last twenty-five years is an encouraging sign for the viable synthesis of ecology and semiotics.

### ***Perspectives and challenges***

Semiotics appears to possess strong potential for contributing to the ecological sciences, owing to a robust analytical framework that covers informational and communicational processes in both the biological realm and human culture. There are encouraging examples of such integration (e.g. research done by Almo Farina), but the broad-scale synthesis of ecological and semiotic research is a task still to be undertaken. In working towards this synthesis, the following challenges must be addressed:

1. Developing a non-structural semiotics that would include conceptual tools and research methods for working with heterogenic, open, dynamical, and potentially unlimited systems. Compared to human linguistic and cultural systems that have been the model object for semiotics, ecosystems are special due to the presence of a vast number of species and energetic and material openness. Analyzing such systems would require a critical revision of semiotic methodology.
2. Elaborating the frame of analysis to cover processes with different semiotic complexity. The success of applying semiotics in ecological research appears to depend on methods that can address the interrelations of different types of semiotic processes (e.g. environmental affordances, signification, animal communication, cultural representation, meaning-making and symbolization in human discourses). Some progress has been achieved in this integration, especially in ecosemiotics, but there is still progress to be made.
3. From an ecological perspective, a critical question appears to be how to include and integrate qualitative descriptions and animal phenomenal perspectives into existing ecological methods and conceptual systems. There are topics where this integration has been quite successful (ecoacoustics, theory of niche construction), but on a broader scale integration still needs to be achieved.

There are ongoing detrimental processes to our planet—climate change, species loss, accumulation of waste—that urge science to find new and effective ways to address environmental problems. Part of this challenge is bridging the natural sciences with the humanities, and on the object-level bridging biodiversity conservation with human discourses and meanings. In this context, developing the synthesis between ecology and semiotics is an endeavor both timely and very necessary.

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