This is a preprint version of the paper:
Maran, Timo (2017). On the Diversity of Environmental Signs: A Typological Approach. Biosemiotics DOI 10.1007/s12304-017-9308-5.
There are some differences in wording and pagination. The final publication is available from the journal web-page:

https://link.springer.com/article/10.1007/s12304-017-9308-5

Timo Maran

On the Diversity of Environmental Signs: A Typological Approach

Abstract. Environmental signs as physically manifested signs that we and other animals perceive and interpret in the natural environment are seldom focused on in contemporary semiotics. The aim of the present paper is to highlight the diversity of environmental signs and to propose a typology for analysing them. Combining ecosemiotics and the pragmatist semiotics of C. Peirce and C. Morris, the proposed typology draws its criteria from the properties of the object and the representamen of the sign, and of their relationships. The analysis distinguishes eight basic types of environmental signs and provides examples of these from the natural environment. The typology also integrates existing concepts of *environmental affordances, ecofields, phonetic syntax, sign fields, ecological codes, meta-signs* and others. In addition to basic types of environmental signs, compound environmental signs are discussed with three types of these distinguished: (1) environmental meta-signs; (2) ecological codes; and (3) environmental-cultural hybrid signs. Further study of compound environmental signs could lead to reconceptualising relations between linguistic and pre-linguistic semiosis.

Keywords: environmental signs; natural signs; ecosemiotics; typology; index; hybridization

In semiotics, there are several typologies and terminological distinctions to organize conventional signs, that is, signs intentionally used in human communication and culture. Rather little attention has been paid, however, to characteristics and types of environmental signs understood here in a loose sense as signs that we and other animals perceive and interpret in the natural environment.[1] It almost seems that the issue of physically manifested signs of the environment has been expelled from the conceptual framework of modern semiotics. However, "environmental sign" has been employed, for instance by Almo Farina et al. (2011: 1263), to indicate the use of acoustic information. Antonios D. Mazaris and colleagues underline the diversity of channels where environmental signs occur: "In order to truly comprehend the cognitive landscape of the organisms we need to incorporate other layers of environmental signs [besides visual signs]" (Mazaris et al. 2009: 818). Gordon. W. Hewes (1994: 140) used the term "signs in the environment" for analysing the semiotics of tracks and tracking, and "environmental cues" has been broadly used, for example, by Riin Magnus (2016: 280), Asghar T. Minai (1984: 159) and by Elina Vladimirova and John Mozgovoy (2003). A partly overlapping concept with environmental signs is that of "natural signs", deriving from St. Augustine's legacy and being often characterized as given or primary signs that are present without intentional communication. Anton Sukhoverkhov (2012: 154) describes natural signs as having correlation between signifiers and signifieds and notes that also "the term 'natural signs' is not well-established and widespread in modern semiotics, where it deserves more attention". Indeed, most handbooks and general introductions to semiotics do not include a dedicated entry on the natural sign (Eco 1976; Nöth 1990 and Clark 1978 being exceptions here). For instance, David S. Clark (1978: 50) has suggested a novel concept of *natsign* for denoting signs that are based on interpreters' earlier experience about the correlation between the sign and what it signifies and that do not need linguistic mediation.

Conceptually, the general framework of the present paper is ecosemiotics, which can be understood as "a branch of semiotics that studies sign processes as responsible for

[1] What is the natural environment in semiotic terms is a complex issue on its own. For this paper, I describe this through three characteristics — environment: (1) includes multitudes of Umwelts of organisms of different species and interactions between them; (2) contains physical forces, structures and resources that can be objects of interpretation, that can constrain interpretation or be a context for interpretation; (3) provides conditions for the multisensory and multi-layered semiosis from tactile to symbol-based semiosis.

ecological phenomena" (Maran and Kull 2014: 41). Earlier, ecosemiotics has also been defined, for instance, as "the study of sign processes which relate organisms to their natural environment" (Nöth 2001: 71) or as a semiotic discipline investigating "human relationships to nature which have a semiosic (sign-mediated) basis" (Kull 1998). It may also be said that "ecosemiotics is concerned with the semiotic processes that relate to or address the broader context of living biological processes" (Maran 2017: 5). Contemporary ecosemiotics is thus a part of a broader consensus about the necessary integration of biosemiotics and cultural semiotics (Favareau et al. 2017).

A reader may wonder whether the frame of reference advocated here to approach environmental signs is a realist/physicalist one and how such a perspective could fit into contemporary biosemiotics. I will explain: my viewpoint is rather in line with multi-constructivist approach (Maran 2017: 3; Jaroš 2016), according to which semiotic structures have certain objectivity independent from the cognition, but at the same time they are also objects of interpretation and thus depend on an organism's Umwelt, cognition (and culture). In such a view, the primary focus of research would be on analysing correspondences and discrepancies between different layers of semiotic process. The final object of the present analysis is the *environmental sphere* that obtains its "reality" from the involvement of countless organisms that are constantly interpreting and remaking the world they inhabit. This comes close to the idea of *natural constructivism* according to which "recursively generative physical interactions up and down system levels also function as sign relations in the co-ordination of the system of the organism with its surround" and "signs 'count' in the world — not just in our 'minds' — they organize the percepts, and thus the actions of animals — and these actions have genuine, consequential, material effects" (Favareau 2008: 518). Now, extrapolate these semiotic interactions of natural constructivism over numerous species in their evolutionary connectedness and history, include the resources and other tangible counterparts of semiosis in all their relevant relations, and you will get a source and criteria of the objectivity of environmental signs.

In this paper, I prefer the concept of "environmental signs" over natural signs (and alternatives) to emphasize the connection with ecosemiotic subject matter (as natural signs can be present in various domains e.g. in human physiognomy and nonverbal communication). In terms of Peircean semiotics, environmental signs are

predominantly indexical, that is, they rely on continuity (Sebeok 2001: 64) — on the causal or physical relation between the sign (representamen) and its object. Peirce notes that the "index is physically connected with its object; they make an organic pair, but the interpreting mind has nothing to do with this connection, except remarking it, after it is established" (Peirce 1998: EP 2:9, c. 1894). The interpreter needs to have access to such signs for semiosis to occur, but interpretation has a secondary importance in determining the conditions and content of the semiosis.

Many authors have developed helpful discussions on signs in the environment. Introducing ecosemiotics, Winfried Nöth (2001: 71) describes it as the "study of *environmental semioses*, i.e. the study of sign processes which relate organisms to their natural environment". Thomas A. Sebeok (2001) has discussed indexical signs as a type in his six species typology of signs. He further lists "symptom, cue, clue, track, trail" as synonyms of index and brings several examples from animal and environmental communication (traces and tracks of animals, the dance code of honey bees, the behaviour of a tropical bird called the greater honeyguide, *Indicator indicator*, who has a habit to guide honey badgers and several other mammalian species to bee nests). Charles S. Peirce gives a classification of indexical signs by distinguishing between designators and reagents (Peirce 1931–1958: CP 8:368 fn23, this corresponds to the distinction between degenerate and genuine indexes)[2], both of which can also be found in environmental semiosis. Designators are signs that point to something in the environment and can be exemplified by the dance code of honey bees, whereas animal tracks would be reagents or genuine indexes as signs based on a causal connection. Further, several authors have studied animal tracks in the semiotic framework (Hewes 1994; Vladimirova and Mozgovoy 2003; Vladimirova 2009). Natural signs also form an important part of reconsidering the connection of human language and the environment, the tradition in which works of the Scottish philosopher Thomas Reid stand as an important milepost (Reid 1764; cf. Sukhoverkhov 2012).[3]

[2] In some typologies, reagents can be further divided between tracks and symptoms (see Johansen, Larsen 2002: 32).
[3] Relevant to the present topics is also work done in architectural semiotics on "object semiotics", as a study of structural and functional relations between elements forming an architectural space (Krampen 1979: 6–20).

Both everyday experience and studies in ecosemiotics prove that there is a variety of signs in the environment. One could take into consideration, for instance, the difference between animal tracks and seasonal signs, such as the melting of the snow. Animal tracks are specific patterns that have a strict casual connection with the animal that has left them and have therefore also a particular and well-limited sign relation to the object. The melting of the snow, on the other hand, is a process manifested in many physical and perceivable changes of snow turning into water. The object of the melting snow, presumably spring or a seasonal change, is an ambiguous, more compound object than a singular entity. There are clear differences between these examples, and ecosemiotics as well as general semiotics would benefit from a clearer typological understanding of possible types of environmental signs. My goal in the present paper is not, however, to craft a new sign typology *per se*, but the proposed typology should rather be considered as a method to shed light on the diversity of environmental signs and to initiate discussion for finding conceptual and methodological tools for analysing these.

Bases of the Typology of Environmental Signs

Environmental signs as depicted in this paper depend much on the relation between object and representamen and are related with underlying physical regularities. Correspondingly, a possible typology should also focus on these aspects and their accessibility to the interpreter. What we basically describe here are different possibilities for indexicality to emerge and to be constituted in the natural environment – or as T. Reid has expressed this: "connections established by nature and discovered by experience or observation, and consequences deduced from them" (Reid 1764: 88). In my typological account, I will loosely follow the Peircean-Morrisian semiotic framework. I do not incorporate, however, the role of the interpretant and interpretation into the analysis (for the role of the interpretant in indexical signs, see West 2013: 112ff.). I am also not strictly excluding the role of interpretation, as the way that humans and other animals relate with the environment clearly depends on their Umwelt structures, used communication codes, cultural and social contexts and their interpretative freedom. My impression is, however, that in present semiotic discussions, interpretation often tends to mask underlying

environmental relations, and it would be more fruitful to analyse environmental signs in this stage by leaving the interpretational dimension aside and to take a more object oriented focus.

Proceeding from the Peircean understanding of index, the proposed typology takes into account four dimensions of sign, two of which focus on the characteristics of representamen and object separately, and two on the relationship between the representamen and the object in its formal manifestation and as being perceived by an interpreting organism. In discussing characteristics of the representamen and the object, the attention is paid to their particularity or generality — a question that has been important for the semiotics of Charles Morris (e.g. Morris 1971a: 59–63 distinguishes five sources of generality in semiotic process). More specifically, the four bases of the typology are: 1) attachment of the representamen and its object; 2) accessibility of the sign relation; 3) particularity of the representamen; 4) particularity or generality of the object. These dimensions are not exclusive to each other but can be combined, producing several particular types of environmental signs.

1. Attachment of the representamen and its object. The attachment of the representamen and its object is a dimension that shows distance or connection between a sign and its object. On one extreme, signs can be *embodied* in their objects as is the case, for instance, in James J. Gibson's *environmental affordance*, where the environment has perceivable characteristics that have immediate relations to particular properties of the environment that are usable by the organism (Gibson 1986: 127). Quite a similar concept appears to be A. Farina's *ecofield* that operates in larger ecological structures and takes into account the Umwelt structures and motivations of animals (Farina and Belgrano 2006). *Embodied sign* also stands close to what Michael Polanyi has called *existential meaning* as the meaning in itself or due to the context and not because the sign denotes some separate object (Polanyi 1962: 94). We can also say that such signs follow the metonymical logic of *pars pro toto* and are indexical for that reason. At the other end of this dimension, a sign can be *detached* from its object. A suitable example would be traces and tracks of animals. Animal tracks as signs are spatially detached from the animal as their object, and they are also *disconnected*, in the sense that they can change – for instance, fade – in the environment independently from their objects. In the case of a detached sign, we can

also talk about the *sign vehicle* (Morris 1971b: 96) as a special carrier of the sign that is distinct from the object. In the case of detached signs, the sign relation connecting the representamen and the object can be based on different types of logic — causal relation, physical proximity, temporal proximity, spatial direction — and according to this, several subtypes of signs can be further distinguished. In detached signs, the representamen should include a certain indication that would allow connecting this with the object (in contrast to the embodied signs, where co-existence could establish the connection).

2. Accessibility of the sign relation. In the Peircean index, the object has a great influence upon the sign: "I define an Index as a sign determined by its dynamic object by virtue of being in a real relation to it" (Peirce 1997: SS 33, 1904). At least according to Peirce's realist view, there is an ontologically based connection between the dynamical object and the representamen, and accordingly there is a possibility to distinguish between this connection and the sign as perceived by an interpreting organism. These two poles of the environmental sign – ontological and epistemological – may unfold in different ways, by providing a set of combinations.[4] The ontological aspect of the sign relation between representamen and object is often accessible to the interpreter – that is, the interpreter has a perceptual access to both the representamen and the object, or he/she/it has knowledge (cognitive access) of what the object of the sign is or could be. At the same time, there are also cases where the interpreter does not have a good perceptual access or understanding of the object. In C. Morris's terminology, this difference corresponds to the distinction between *vague* and *precise* signs.[5] In the case of vague or inaccessible signs, the sign-relation may not even appear to the interpreter (so that one will not arrive at interpretation at all). But there may also be intermediate cases where the interpreter recognizes the sign-nature or *signness* of the representamen but is not able to connect this with the (dynamical) object of the sign as the source of, the cause of or a thing continuous to it.

[4] W. Nöth explains this twofold relation as follows: "The sign vehicle (A) and the referent (B) in this type of natural semiosis are related in two ways. At an extrasemiotic level, the level of natural events, A is the effect of the cause B. At the semiotic level, the effect A becomes an index or symptom which an interpreter connects by inference to B" (Nöth 1990: 86).

[5] "A sign is *vague* to a given interpreter to a degree that its signification does not permit the determination of whether something is or is not a denotatum; so the extent that sign is not vague it is *precise*" (Morris 1971b: 97).

Such incomplete sign relations appear to be quite common in environmental semiosis. One can consider here, for instance, so called "fairy rings" – regular circular shapes of darker or higher grass in vegetation or mushrooms growing in the circle. These phenomena have amazed people for a long time and inspired many folk narratives about supernormal agents. The cause and the presumable object of the sign, a mycelium of fungus growing centrifugally, is not easy to detect without special scientific knowledge and equipment. What is perceived by the interpreter is a representamen (symmetrical circular structure) that is open to be connected with a secondarily conceived object or process (providing thus great freedom for interpretations). Similarly, we may suppose that mammals often detect a smell in the environment that they recognize as strong and distinct, but are probably not able to determine its source and origin. This may be especially true for olfactory communication that is very dependent on environmental conditions and often does not provide good information about the location of the emitter. In human environmental semiosis, peculiar landscape formations are often recognised as having a signness or sign-nature (detected but incompletely understood sign relations) that is not possible to refer back to any specific origin or object. In such cases, the missing aspects of the sign will be often compensated by human cultural narratives (e.g. stories of trolls, giants and other supernatural beings). Basically, what we see is how underlying indexicality in the environment and partially perceived sign relations in environmental structures create an open and creative space of interpretations.

3. Particularity of the representamen. A representamen can be formed by a single percept, feature, object or body in the environment, but it can also have a multiple character. In the latter case, it can be formed by a group, series or sequence of single elements or objects. The location and structure of such elements may vary, and the specific configuration may have a specific meaning.[6] More complex cases of group-

[6] For ecosemiotics, C. Morris' interpretation of the concept of "meaning" appears to be suitable. This includes not accepting any narrow definition – meaning is not "considered as one thing among other things, a definite something located somewhere"; it is not in the designatum (leading to realism), in the interpretant (leading to conceptualism), or in the sign vehicle (leading to nominalism) (Morris 1971a: 57). Rather, "meanings are not to be located as existences at any place in the process of semiosis but are to be characterised in terms of this process as a whole" (Morris 1971a: 57). From this basis, Morris accepts the subjectivity of meaning (interpretation), which at the same time is compatible with treating every meaning as potentially intersubjective (due to rules and generality of usage) leading to the possibility to study meanings by objective analysis (Morris 1971a: 58-59). For ecosemiotics, a most fascinating perspective is extending this intersubjectivity to the domain of environmental sphere and to interspecies semiosis.

wise representamens could be denoted as *natural syntax*, where the natural signs have a text-like character and where a pattern or rhythm of the sequence can provide knowledge about the object. This appears to be true about sounds and songs of birds – the complexity of which has been denoted as *phonetic* or *phonological syntax* by Peter Marler (1977) – but the same appears to be valid about the material structures of the environment. For instance, shape, size, distance from each other, rhythm and orientation of animal footprints can provide a lot of information about an animal's speed, motivation and intentions. Based on the type and speed of animal movement, field guides distinguish track patterns, such as walking, trotting (distinguishing side trot and straggle trot), pacing, lopes, gallops and different types of jumps (Liebenberg et al. 2010: 33–50). Tracks have direction and course, and they can be read and interpreted either along the direction of animal movement or counter to it.[7]

We can also imagine situations where the representamen is not just manifold but fuzzy – being rather a vague and hard to define group of features or elements. Also, in such a case, the question regarding the limits of the representamen – that is, from the multitude of percepts in the environment, what forms a meaningful whole? – does not have a clear answer. If we are to think about the features that we use to recognize a particular ecological community (for instance, a swamp forest), then these include relief and water level, vegetation growing in the herb layer, the species and size of trees, etc. In different examples of the particular ecological community (as a swamp forest), these characteristics will vary; thus, the interpretation is not derived based on any specific single representamen but rather on the group of fuzzy features that form the representamen for this particular sign relation. In the animal world, a similar example can be found in navigation. In the case of migrating birds, for instance, a set of landmarks, information about the location of the sun, fixed stars and magnetic poles, the infrasound of oceans — the specific set differs in different species — can be combined into a sign relation that refers to the "right direction" of flight as an object (cf. Chernetsov 2016; Wallraff 2005).

4. Particularity or generality of the object. Similarly to the representamen, the object in the environmental sign can also be either specific or general/manifold. In the case of concrete objects, there is a specific agent or agency to which the representamen

[7] Interpretation of an unfolding course of a hiking trail by humans could be considered another example of this kind (cf. Lekies and Whitworth 2011).

refers to or that has induced the sign relation. Examples of sign relations with such concrete objects include classical examples of indexes and natural signs, such as pairs of thunder and lightning, smoke and a fire, footprints and an animal, etc. In cases where the object of the environmental signs is general/manifold, there could be different underlying causes. Natural agents, processes and effects themselves may be very complex, mediated and developing through the different stages. This is true for dynamic processes in ecosystems, such as soil erosion, drought, desertification, etc. Although signs (representamens) of such processes may be clearly perceivable and limited, the actual causal relations that have induced the signs may be very complex and combine both natural and human agencies (consider, for example, desertification or climate change). In human language-based semiosis, there is a tendency to use some common term to denote such manifold objects, and often such cultural cover-up appears to have obtained the role of immediate object in the environmental signs for humans. Here one can think of natural signs referring to seasonal changes, such as those that mark the arrival of the spring. What is the exact object to which the representamen refers is not easy to determine (this discussion will be developed further in the final section of the paper). Also the signs with general/manifold objects appear to bring along a wide space of interpretation (at least for the human species): the interpreter may build on the indexical sign relations differently, and thus such incomplete environmental signs are open to creativity and symbolicity.

Eight Types of Environmental Signs

The dimensions of environmental signs described above allow different combinations, not all of which will appear in the actual environment. The exclusion of some combinations is due to logical restrictions in combining different bases of typology that limit the number of possible types: (1) if the sign is embodied, its representamen and object need to be particular; (2) if the sign relation is inaccessible, the nature of its object (particular or general/manifold) cannot be determined. Taking into account these restrictions, it is possible to construe the space of the possible semiotic configurations that results in eight types of signs (see table 1).

Table 1. A typology of environmental signs

Type of sign	**Example**
1. Embodied sign	
1.1. Inaccessible embodied sign	Quicksand or mud hole in swamp
1.2. Accessible embodied sign	Slope, cliff or other perceivable element of the terrain
2. Detached sign	
2.1. Inaccessible detached sign	
2.1.1. Inaccessible detached sign with particular representamen	A “fairy ring”
2.1.2. Inaccessible detached sign with manifold/vague representamen	Perception of a location in the forest as dangerous or mystical
2.2. Accessible detached sign	
2.2.1. Accessible detached sign with particular representamen	
2.2.1.1. Accessible detached sign with particular representamen and object	Distinct footprint of an animal
2.2.1.2. Accessible detached sign with particular representamen and general/manifold object	Eroding soil
2.2.2. Accessible detached sign with manifold/vague representamen	
2.2.2.1. Accessible detached sign with manifold/vague representamen and particular object	Trace of an animal
2.2.2.2. Accessible detached sign with both general/manifold representamen and object	Natural sign set indicating the arrival of the “spring”

Let us illustrate the logic of the table with an example of the “fairy ring” that was discussed above in the section “Accessibility of the sign relation”. A “fairy ring” would belong to the type 2.1.1. “Inaccessible detached sign with particular representamen” based on the following considerations: (1) the representamen – a circle of mushrooms or grass is perceivable as a “particular” entity, (2) the object or the cause of the sign is not perceivable for most interpreters; therefore, the sign

relation is “inaccessible”, and (3) the “relation is detached” due to the spatial separation between the object (mycelium) and the ring of mushrooms.

Paying attention to different types of signs in the environment as distinguished above endows a better understanding and analysis of environmental semiotic relations in both humans and other animals. Deriving from the typology, the concept of detached signs makes mediated communication possible, where humans and animals use the physical environment as a medium of communication by inscribing and reading information from the environment. Both territorial markings in various animals and environments altered to reflect the identity of humans groups are examples of this process. Detached signs are also related to an ecosemiotic understanding of *semiocide* (Puura 2013; Maran 2013) — where damaging the physical environment destroys semiosic and communicative processes that have their detached objects in the environment. Analysing manifold representamens in the environment makes it possible to notice that the environment may include complex signs with internal structure and syntax. This means that both humans and other animals make sense of their environments in complex ways, as we do when delimiting and naming the specific biological communities — for instance, to describe a swamp forest — or as other animals do when they use the set of environmental characteristics to determine whether the specific area is suitable for the living place. The presence of inaccessible sign relations indicates the possibility that indexicality can be opened, that environmental signs can lay ground for an open sphere of interpretations from where new signs can emerge. Thus, the existence of general/manifold objects directs attention to the complex relations between environmental signs and language based signs of human culture and the interpretation space present therein. All in all, a more detailed understanding of environmental signs would allow us to develop a better analysis of environmental use and conflict by humans and other animals.

Possibilities for Compound Environmental Signs

Basic environmental signs described in the typology above lay the groundwork for bringing forth more complex sign configurations in the environment. In the following, I would like to discuss three possibilities for compound environmental signs that

might emerge: (1) environmental meta-signs; (2) ecological codes; and (3) environmental-cultural hybrid signs. In the first case, the compound sign emerges as a hierarchical arrangement of the single environmental signs. In the second case, the compound sign is a result of the combination of significational and communicational activities of animal species, and in the third case, environmental signs and symbolic signs of human language merge to produce hybrid sign complexes.

Compound environmental signs can be found in cues and landmarks that a human or other animal uses when orienting in a familiar environment. We may assume that environmental sign complexes exist for animals — such as ants, bees, rodents, doves, elephants and others — that have been shown to be capable of performing complex orientation tasks (see Golledge 1999; Reznikova 2007: 118–131). In the home range, environmental signs are interpreted in the context or *sign field* that informs animals: "of the environmental conditions, as well as the state of ecological systems. [...] A sign field represents informative and communicative interaction between mammals and their environment" (Vladimirova and Mozgovoy 2003: 3; see also Vladimirova 2009). We can also consider such semiosis to be dynamical and related to animal motivations. That is, based on animal motivation (e.g., escaping from a predator or finding a mate), certain elements in the environmental sign complex become emphasized and meaningful: "An elementary movement can be a response to the perception of sign field objects (external cues) or to inner stimuli determining the dominant motivation of an animal" (Vladimirova and Mozgovoy 2003: 3). In addition, there appear to exist signs that operate on a more general level, influencing the interpretation space of any singular environmental sign in the sign field. As proposed by Jamie L. Kruis, such general signs can be called *meta-signs* (Kruis 2013) – that is they are (1) "based on repetition of a significant change in the environment" and (2) "systematically reorganise the internal sign relations of perceived environmental structures" (Kruis 2017: 250). J. L. Kruis exemplifies environmental meta-signs with water level in river rafting, which changes in a complex way the interpretation of rapids, rocks and other elements in the river. A suitable example of the environmental meta-sign for animals could be snow coverage. Access to the affordances and embodied signs of the terrain, smells and animal traces completely changes depending on whether the land is covered by snow or not. Even the meaning of animal coloration may radically change – camouflage colouring may turn out to be

conspicuous and vice versa, as evident in hares, weasels and other mammals that change between summer and winter fur. Accessibility of the environmental resources differs radically, and hence also the meanings of cues and signs that indicate their availability. In environmental meta-signs, it is the changing combination between different signs in the environment itself that influences the possibility of interpretation, and therefore environmental meta-signs appear to obtain a similar role to linguistic structures in human communication and texts.

Secondly, compound environmental signs can emerge when significational activities (perceiving and interpreting environmental signs) and communicational activities (code-based message exchange between sender and receivers) of animals become integrated. Inasmuch as the environment is used in intraspecific and interspecific communication as a medium, the distinction between signification and communication blurs, and information exchange between animals could also include or rely on features of the physical environment (e.g., arrangement of stones, trees, water bodies and other objects in the physical environment). The merger of communication and signification appears to pave a road to the consistency of sign relations in interspecies communication. I have explored this idea earlier under the concept of *ecological code* (Maran 2012):[8] "An ecological code rests on indexical relations, as it is in these that representamen–object relationships surpass and remain independent of any specific interpreter" (Maran 2017: 130). At the same time ecological codes are distributed and open: "the involved species have different perceptual organs, Umwelten and relation to the environment. Therefore, no single individual or species has full perception of an ecological code. […] Every single species and organism involved in an ecological code has a partial variation of the convention" (Maran 2012: 150). An example of the ecological code is birds' morning chorus, where a complex polyphony rises from different bird species singing in turns and looking for pauses to tune in (Malavasi and Farina 2013; Farina et al. 2015; Farina et al. 2016). Such a natural convention combines properties of local terrain and flora (where birds can situate how sounds spread and fade) as well as volume and frequency of the geophonic or technophonic sounds.

[8] Consortium "as a group of organisms connected via (sign) relations, or groups of interspecific semiosic links in biocoenosis" is another example of community level signs complex (Kull 2010: 347).

A third example of compound environmental signs is the hybridization of human cultural and environmental signs. In the common semiotic understanding, the distinction between natural and conventional signs is sharp, and these sign types do not overlap or intertwine. Natural signs are often described by being motivated or involuntarily present, whereas conventional signs are arbitrary (no motivational relationship between the form and content) or are intentionally presented by senders. If, however, we look more closely to human language signs that refer to environmental phenomena, such presumptions turn out to be questionable. Let us take up an example of the seasonal change – the arrival of the spring – that was discussed before under the topic of the particularity/generality of the object of environmental signs. In the temperate climate zone, the number of cues, such as the melting of the snow, the arrival of migratory bird species, and the emergence of early flowers, flies, ants and bumblebees can all be representamens referring to the beginning of the spring. At the same time, the question as to what is exactly the object of these representamens, what they refer to, is not so easy to answer. What is this "spring", how to interpret it? Should we limit our understanding with some conventional definition of the word, as: "The season after winter and before summer, in which vegetation begins to appear, in the northern hemisphere from March to May and in the southern hemisphere from September to November"?[9] Or should we include in our understanding of "spring" also the abovementioned perceptual signs of the seasonal change? If so, then there is a reason to distinguish between an astronomical (the period from the vernal equinox to the summer solstice) and a phenologic spring (based on the arrival and life activities of seasonal species etc.), which, depending on the year, can be apart by several weeks. An expression like "the spring is late" would make sense only in case where these different layers of interpretation are juxtaposed. Furthermore, inasmuch as it is related with the appearance of the early blossoms, the spring emergence of insects and amphibians and the arrival of migratory birds does not depend on just human convention but is related to the interpretations made by other living organisms. When is the right time to return to nesting grounds? When is the water warm enough for spawning? As the human interpretation of the spring at least partly depends on the interpretations done by other living organisms, seasonal change also transforms from being a cultural convention into a natural or ecological

[9] https://en.oxforddictionaries.com/definition/spring (accessed 25.08.2017).

convention and is hence a compound environmental sign.[10] My aim here is not to undermine linguistic content and the cultural or social context of the conventional signs that are clearly present and can be exemplified by comparing the depictions of seasonal change present in different languages and cultures. What I am arguing is against the independence of human cultural conventions from the semiotic and communicative processes of the environment, where life activities of other species have an essential role. Hybrid cultural-environmental signs should rather be considered as multi-layered or semi-transparent semiotic phenomena, where patterns of the environment, semiotic activities of other species and cultural interpretations of humans become loosely intertwined.

Conclusions

The present paper discussed the diversity of environmental signs by using four basic criteria that focused on the object, the representamen and their relationships. The analysis further distinguished eight basic types of environmental signs and provided examples of these from the natural environment. It was demonstrated that environmental signs, by having an often simple or degenerate structure, are open to become included in the more complex sign types. In addition, the possibility of compound environmental signs was discussed, and three types of these were distinguished: (1) environmental meta-signs; (2) ecological codes; and (3) environmental-cultural hybrid signs. These three types of compound signs appear to support one another as they all relate to the conventionality that is able to pass beyond the limits of a single sign system. In denoting environmental phenomena, humans tend to label complex and ambivalent environmental signs (that have a manifold or vague object or representamen) with a single denominator on the symbolic level. But such a drive towards communicational efficacy should not be an excuse for excluding the environmental aspects that make up a part of and constrain these sign relations. Understanding types and properties of environmental signs appears to be crucial for analysing supportive or conflictive relations between humans, other animals and their environment.

[10] Perhaps the danger to interrupt this natural convention was also the true strength behind the metaphoric title of the Rachel Carson's book *Silent spring* (Carson 1962).

Acknowledgments

The research for this article was supported by the institutional research grant IUT02-44 and by the individual research grant PUT1363 “Semiotics of multispecies environments: agencies, meaning making and communication conflicts” from the Estonian Research Council. I express my gratitude to the anonymous reviewers of *Biosemiotics* for their constructive feedback.

References

Carson, R. (1962). *Silent spring*. Boston: Houghton Mifflin.

Chernetsov, N. S. (2016). Orientation and navigation of migrating birds. *Biology Bulletin*, 43(8), 788–803.

Clark, D. S. (1987). *Principles of semiotic*. London: Routledge and Kegan.

Eco, U. (1976). *A theory of semiotics*. Bloomington: Indiana University Press.

Farina, A. & Belgrano, A. (2006). The eco-field hypothesis: Toward a cognitive landscape. *Landscape Ecology* 21(1), 5–17.

Farina, A., Ceraulo, M., Bobryk, C. Pieretti, N., Quinci, E. & Lattanzi, E. (2015). Spatial and temporal variation of bird dawn chorus and successive acoustic morning activity in a Mediterranean landscape. *Bioacoustics* 24(3), 269–288.

Farina, A., Lattanzi, E., Malavasi, R., Pieretti, N. & Piccioli, L. 2011. Avian soundscapes and cognitive landscapes: theory, application and ecological perspectives. *Landscape Ecology* 26(9), 1257–1267.

Farina, A., Pieretti, N., Salutari, P., Tognari, E. & Lombardi A. (2016). The application of the acoustic complexity indices (ACI) to ecoacoustic event detection and identification (EEDI) modeling. *Biosemiotics* 9(2), 227–246.

Favareau, D. (2008). Understanding natural constructivism. *Semiotica* 172(1/4), 489–528.

Favareau, D., Kull, K., Ostdiek, G., Maran, T., Westling, L., Cobley, P., Stjernfelt, F., Anderson, M., Tønnessen, M. & Wheeler, W. (2017). How can the study of the humanities inform the study of biosemiotics? *Biosemiotics* 10(1), 9–31.

Gibson, J. J. (1986). *The ecological approach to visual perception*. Hillsdale: Lawrence Erlbaum.

Golledge, R. G. (eds.) (1999). *Wayfinding behavior: cognitive mapping and other spatial processes*. Baltimore: The John Hopkins University Press.

Hewes, G. W. (1994). Evolution of human semiosis and the reading of animal tracks. In: Nöth, W. (Ed.). *Origins of semiosis, sign evolution in nature and culture* (pp. 139-149). Berlin: Mouton de Gruyter.

Jaroš, F. (2016). Cats and human societies: A world of interspecific interaction and interpretation. *Biosemiotics* 9(2), 287–306.

Johansen, J. D. & Larsen, S. E. (2002). *Signs in use. An introduction to semiotics*. London: Routledge.

Krampen, M. (1979). *Meaning in the urban environment.* London: Pion.

Kruis, J. L. (2013). Reading the river: Exploring new applications of 'text' and 'language'. In: *Program and Abstracts. Centre of Excellence in Cultural Theory: VI Autumn Conference: Embodiment, Expressions, Exits: Transforming Experience and Cultural Identity. Tartu, October 30–November 1, 2013*. (p. 42) Tartu: University of Tartu.

Kruis, J. L. (2017). Shoshone as a text: a structural-semiotic analysis of reading the river as a whitewater raft guide. In: Kannike, A. Tasa, M., Västrik, E.H. (Eds.), *Body, personhood and privacy: Perspectives on the cultural other and human experience*. *Approaches to culture theory 7.* (pp. 245–265). Tartu: University of Tartu Press.

Kull, K. (1998). Semiotic ecology: Different natures in the semiosphere. *Sign Systems Studies*, 26, 344–371.

Kull, K. (2010). Ecosystems are made of semiosic bonds: consortia, umwelten, biophony and ecological codes. *Biosemiotics* 3(3), 347–357.

Lekies, K. S., & Whitworth, B. (2011). Constructing the nature experience: A semiotic examination of signs on the trail. *The American Sociologist* 42(2-3), 249–260.

Liebenberg, L., Louw, A., & Elbroch, M. (2010). *Practical tracking: a guide to following footprints and finding animals.* Mechanicsburg: Stackpole Books.

Magnus, R. (2016). The semiotic challenges of guide dog teams: the experiences of German, Estonian and Swedish guide dog users. *Biosemiotics* 9(2), 267–285.

Malavasi, R., & Farina, A. (2013). Neighbours' talk: Interspecific choruses among songbirds. *Bioacoustics: The International Journal of Animal Sound and Its Recording*, 22(1), 33–48.

Maran, T. & Kull, K. (2014). Ecosemiotics: main principles and current developments. *Geografiska Annaler: Series B, Human Geography* 96 (1), 41–50.

Maran, T. (2012). Are ecological codes archetypal structures? Maran, T., Lindström, K., Magnus, R., Toennessen, M. (eds.), *Semiotics in the wild. Essays in honour of Kalevi Kull on the occasion of his 60th birthday* (pp. 147–156). Tartu: Tartu University Press.

Maran, T. (2013). Enchantment of the past and semiocide. Remembering Ivar Puura. *Sign Systems Studies* 41(1), 146–149.

Maran, T. (2017). *Mimicry and meaning: structure and semiotics of biological mimicry*. (Biosemiotics 16). Springer.

Marler, P. (1977). The structure of animal communication sounds. In: T.H. Bullock (Ed.), *Recognition of complex acoustic signals (Report of Dahlem workshop)* (pp. 17–35). Berlin: Dahlem Konferenzen.

Mazaris, A.D., Kallimanis, A. S., Chatzigianidis, G., Papadimitriou, K., & Pantis, J. D. (2009). Spatiotemporal analysis of an acoustic environment: interactions between landscape features and sounds. *Landscape Ecology* 24(6), 817–831.

Minai, A. T. (1984). *Architecture as environmental communication*. Berlin: Mouton.

Morris, C. (1971a). Foundations of the theory of signs. In Morris, C. (Ed.), *Writings on the general theory of signs* (pp. 13–71). The Hague: Mouton.

Morris, C. (1971b). Signs, language, and behavior. In Morris, C. (Ed.), *Writings on the general theory of signs* (pp. 73–397). The Hague: Mouton.

Nöth, W. (1990). *Handbook of semiotics*. Bloomington: Indiana University Press.

Nöth, W. (2001). Ecosemiotics and the semiotics of nature. *Sign Systems Studies* 29(1), 71–81.

Peirce, C. S. (1931–1958). *Collected papers of Charles Sanders Peirce*, 8. Vol, vols. 1-6, eds. Charles Hartshorne and Paul Weiss, vols. 7-8, ed. Arthur W. Burks. Cambridge, Mass.: Harvard University Press.

Peirce, C. S. (1997). *Semiotic and significs: The correspondence between Charles S. Peirce and Victoria Lady Welby*. Edited by C. S. Hardwick and J. Cook. Bloomington: Indiana University Press.

Peirce, C. S. (1998). *The essential Peirce. Selected philosophical writings*. Vol. 2 (1893-1913), ed. Peirce Edition Project. Bloomington: Indiana University Press.

Polanyi, M (1962). *Personal knowledge: Towards a post-critical philosophy*. Chicago: The University of Chicago Press.

Puura, I. (2013). Nature in our memory. *Sign Systems Studies* 41(1), 150–153.

Reid, T. (1764). *An inquiry into the human mind on the principles of common sense*. 3rd ed. London.

Reznikova, Z. (2007). *Animal intelligence. From individual to social cognition*. Cambridge: Cambridge University Press.

Sebeok, T. A. (2001). *Signs: An introduction to semiotics*. 2nd. ed. Toronto: University of Toronto Press.

Sukhoverkhov, A.V. (2012). Natural signs and the origin of language. *Biosemiotics*, 5, 153–159.

Vladimirova, E. (2009). Sign activity of mammals as means of ecological adaptation. *Sign Systems Studies* 37(3/4), 614–636.

Vladimirova, E., & Mozgovoy, J. (2003). Sign field theory and tracking techniques used in studies of small carnivorous mammals. *Evolution and Cognition* 9(1), 1–17.

Wallraff, H. (2005). Beyond familiar landmarks and integrated routes: goal-oriented navigation by birds. *Connection Science* 17(1-2), 91–106.

West, D. E. (2013). *Deictic imaginings: Semiosis at work and at play*. Springer.