



# Umwelt Collapse: The Loss of Umwelt-Ecosystem Integration

Timo Maran<sup>1</sup>

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## Abstract

Jakob von Uexküll's umwelt theory opens new perspectives for understanding animal extinction. The umwelt is interpreted here as a sum of structural correspondences between an animal's subjective experience, ecosystem, physiology, and behaviour. The global environmental crisis disturbs these meaning-connections. From the umwelt perspective, we may describe extinction as umwelt collapse: The disintegration of an animal's umwelt resulting from the cumulative errors in semiotic processes that mediate an organism and ecosystem. The loss of umwelt-ecosystem integration disturbs "ecological memory," which provides the ecosystem with adaptive modelling and self-design capacities. Making a distinction between core and mediated umwelts, and describing different types of umwelt collapse, are suitable methods for more detailed analysis. The concept of umwelt collapse enables the re-interpretation of extinction, from an internal perspective, as a semiotic breakdown. Such an approach may help us map scenarios of animal extinction, and may lead to successful compensation strategies in adapting to environmental change.

**Keywords** Umwelt collapse · Extinction · Ecological crises · Ecological memory

The current global ecological crisis influences practically every species on Earth. The effects range from overhunting and overfishing to the mediated impacts brought about by habitat decline, climate warming, and changes in ecosystems and food webs. The present study aims to analyze an outcome of the ecological crisis—animals' endangerment and extinction—from the perspective of Jakob von Uexküll's umwelt theory. I sought to answer the following questions: (1) how does the ecological crisis manifest in the changing relations between the animal umwelt and the ecosystem?; (2) how do umwelts collapse, and what mechanisms take part in this process?; and

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✉ Timo Maran  
timo.maran@ut.ee

<sup>1</sup> Department of Semiotics, University of Tartu, Tartu, Estonia

(3) what are the gains of interpreting endangerment and extinction from the umwelt perspective? Umwelt theory has seldom been applied to analyzing vulnerable species and extinction (with exceptions in Tønnessen, 2020; Smith, 2013; Mäekivi & Magnus, 2023). Umwelt thinking has much potential for supporting the threatened species, as it makes the animal's perspective central, which could lead to novel compensatory and co-evolutionary strategies. For instance, in Nature-based solutions, understood as making interventions inspired by nature to address ecological, social, and economic challenges, umwelt thinking can integrate animals' own knowledge and behavioral creativity to work against environmental degradation.

Jakob von Uexküll's umwelt theory has many aspects, ramifications, and interpretations (cf. Tønnessen et al., 2016; Kull, 2020b). As defined by Jakob's son, Thure von Uexküll (1982b: 87): "umwelt is the part of the environment of a subject that it selects with its species-specific sense organs according to its organization and biological needs. Everything in the Umwelt is labeled with the subject's perceptual and effector cues. Every subject is the constructor of its umwelt." The perceptual and effectual signs constitute "functional cycles" (*Funktionskreis*), which are the building blocks of umwelts. There are different functional cycles, the most essential ones being oriented towards food/resources, enemies, medium/environment, and partners. In zoosemiotics, Thomas A. Sebeok has interpreted the umwelt as an animal's model of its surrounding world (Sebeok, 2001: 195; cf. Kull, 2010b). In human-animal studies and environmental humanities, umwelt theory has been elaborated with regards to the subjective experience of an animal, and, as such, the umwelt becomes the animal's phenomenal presence in the world (Lestel et al., 2014; Tønnessen et al., 2018).

For ecosemiotics, while studying the ecological crisis and withering animal species, the completeness and fragility of umwelts come under the spotlight (Maran, 2020). The ecological aspects of umwelt are present throughout Jakob von Uexküll's (1982a) book "Theory of Meaning," most notably in concepts like a point-counterpoint duet, the tolerance of meaning, meaning-tones, and the composition of nature. He uses metaphoric and musical language to convey the idea that meanings organize contrapuntal relations across different species: "Each Umwelt forms a closed unit in itself, which is governed, in all its parts, by the meaning it has for the subject" (Uexküll, 1982a: 30). "Every animal, like every instrument, harbors a certain number of tones that enter into contrapuntal relationships with the tones of other animals" (Uexküll, 1982a: 63), and "the properties of the animal and the properties of its fellow actors harmonize in every case like point and counterpoint of a polyphonic choir" (Uexküll, 1982a: 69). Following Uexküll, *umwelt can be interpreted as the sum of structural meaningful correspondences between an animal's subjective experience, ecosystem, physiology, and behaviour*<sup>1</sup>. In environmental conditions, where species have evolved or developed for a long time, experience, affordances of the surrounding environment, physiological capacities, and behaviour correspond relatively well

<sup>1</sup> The proposed definition follows previous interpretations of the umwelt concept that highlight integration beyond the organism: Umwelt is "a set of relations an organism has in an ecosystem" (Kull, 2010a: 353), "interplay of stored genetic and epigenetic memory, experience and habits" (Švorcová et al., 2018: 272) or "the subjective world of an organism, enveloping a perceptual world and an effector world, which is always part of the organism itself and a key component of nature, which is held together by functional cycles connecting different Umwelten" (Tønnessen et al., 2016: 145).

to one another. During an ecological crisis and within environmental change, the connections between these different aspects of umwelt become unreliable and may break down.

## Umwelt and the Changing Ecosystems

To understand the effects of the ecological crisis on animals, we need to discuss the role of the ecosystem in relation to animal umwelt. An ecosystem is not just a system in which matter and energy flow, or a place where animals can find resources or a place to live. Instead, an ecosystem is a complex set of weak and robust sign-connections and feedback loops. The semiotic or informational nature of the ecosystem means that it retains dispersed memory about itself and its every inhabitant. This idea was expressed by the system-ecologist Bernard Patten, who considered the ecosystem a “model-making complex adaptive system,” wherein the internal model-making of living agencies, together with physical resources and the forces of natural selection, leads to active auto-evolutionary self-design (Patten, 1998: 151). The myriad of tiny regulatory hubs of recognition, communication, fitting in, and selective action, provide the ecosystem with the structure that memorizes the role and function of the species it includes. In ecology, a similar idea is expressed by the term “ecological memory<sup>2</sup>,” designating the effect that past states or experiences have on the present or future responses of the ecological community. Ecological memory consists of exogenous memory (the effects of past external factors) and endogenous memory (the effects of past states of the living system to the current states of the same system) (Ogle et al., 2015: 222). The patterns and affordances of the ecosystem keep the memory of an animal suitable for this habitat. For instance, the shady forest creeks of the Hiiumaa island in Estonia had kept the memory of the European minks that were released there after decades of breeding in artificial conditions. This re-wilding experiment in the Western Estonian islands was beautifully analyzed by Mäekivi (2021) and Riin Magnus (Mäekivi, & Magnus, 2023) as “umwelt reversion,” where the umwelt (diet, relations to humans) of the European mink in the suitable environment gradually returned to its earlier native state. From the umwelt perspective, the semiotic or informational correspondence between internal and external semiotic structures forms the core of the animal umwelt.

At the same time, ecosystem memory about its inhabitants is not static but dynamic, rich in fluctuations and mild disturbances (Nielsen et al., 2020: 146). What is specific about the ecological crisis is the scope and reach of changes in ecosystems. The ecosystem becomes an unreliable counterpart for the animal; its codes and regularities are too chaotic for an animal to make viable interpretations and build up a well-functioning body or living habits. It is easier to understand the interplay of static

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<sup>2</sup> Ecological memory stands close to the concept of “ecological inheritance”: “Each species prefers (has a habit to prefer) certain other species with its features, which it recognises and remembers. The existence of these species in an ecosystem renders it possible to inherit these relations, on the basis of memory, which directs their recognition and action capacity. This means that there is ecological inheritance” (Kull, 2010a: 348).

and dynamic relations between organisms and ecosystems when we make a distinction between short-term and long-term processes (see Table 1).

We may distinguish short-term and long-term memory structures both in animal organisms and ecosystems. Long-term structures (3 and 4 in Table 1) are similar what Tønnessen (2015) has called *core umwelt* – the physiologically-based centre of direct meaning-relations in animal umwelt and between an animal and the ecosystem<sup>3</sup>. Long-term structures are not understood here in the sense of genetic memory, but as memory in the relatively stable physical and physiological forms and patterns of both an organism and an ecosystem. As an example of the core umwelt, we may consider the correspondence between animal physiology and climatic factors. For instance, the ringed seals *Pusa hispida* are specially adapted for life in arctic oceans: they keep open breathing holes in ice by using their sharp front cloves, build snow lairs for giving birth to and nursing their pups, and have an annual pelage moult during which they need ice sheets to stay on (Von Duyke et al., 2020: 5597). The core umwelt changes slowly, and its point-counterpoint correspondences are especially vulnerable to ecological crises and environmental change. The disappearance of the arctic sea ice affects ringed seals tremendously as the duets of points and counterpoints between the animals' physiology and the physical properties of the sea ice become torn apart.

Umwelt core is surrounded by more dynamic and changing meaning-relations (1 and 2 in Table 1) that allow an animal to adapt and fit in with the environmental variations. Especially in omnivorous and opportunistic species, the abilities to encounter umwelt objects indirectly (via *mediated umwelt*, Tønnessen, 2015) are well developed. For instance, crows, jackdaws, and rooks have the necessary cognitive capacity and skills to notice, learn, memorize, and use local environmental affordances and resources. This provides flexibility between the internal and external semiotic structures that make corvids effective in inhabiting anthropogenic environments in cities (Delahaye, 2023).

In general, changes and incompatibilities that occur in mediated umwelts (1 and 2 in Table 1) can be more easily compensated and substituted. In contrast, loss of con-

**Table 1** Different temporal memory-structures in the organism-ecosystem complex

	Organism	Ecosystem
Short term structures ( <i>mediated umwelt</i> )	1. Search images, episodic memory, learning.	2. Environmental affordances, local patterns, and resources.
Long term structures ( <i>core umwelt</i> )	3. Physiology, embodied memory, cognitive archetypes.	4. Climate rhythms, land reliefs, ecosystem structures, etc.

<sup>3</sup> In Tønnessen's description, the core Umwelt encapsulates the experienced, direct encounters with other beings and objects. In the current interpretation, the "core Umwelt" is understood as stable and long term structures of the animal umwelt. Both interpretations make a connection with physiology. Tønnessen (2019: 416) further distinguishes the *minimal umwelt*, which is the basic umwelt structure formed under current planetary conditions: "Context of Umwelten is constrained by possible variations in physiology, and body plans—but also, more contextually, by the physiochemical conditions on Earth, and our astronomical circumstances concerning radiation, gravity, the composition of our atmosphere, etc."

sistency in the core umwelt is more difficult to handle. On the level of the mediated umwelt, an animal has much higher subjective agency in making meaningful connections by translating between different sources of information (Hoffmeyer, 2008), or fitting into the changing environment (Kull, 2020a). Semiotic processes enable the mediated umwelt to compensate for inconsistencies in the core umwelt. On an evolutionary time scale, the mediated umwelt is also a mechanism leading to niche-construction (Peterson et al., 2018). At the same time, new obstacles may emerge in the mediated umwelt due to erroneous recognition. Sea turtles mistaking plastic bags for jellyfish due to visual and olfactory cues and foraging them is one example of problems occurring in *mediated umwelts* (Schuyler et al., 2014).

The current global ecological crisis brings changes in deep rhythms and patterns of ecosystems that challenge umwelt structures and may lead to species extinction. Animal umwelts depend on predictable temperatures and seasonal patterns. These influence wintering and hibernation, seasonal migration and flight-ways, changes in competition between migratory and stationary species, and the availability and choice of food (as in a temperate climate, wherein available food is seasonally highly constrained). Especially in the temporal climate zone, many species are adapted for seasonal or climatic niches characterized by a specific set of temperatures, food, resources, and habitats (Zurell et al., 2018). Shifts in global temperatures cause some of these niches to shrink or partition, while species cannot change at a sufficient speed (Jezkova & Wiens, 2016). Change in temporal and climatic rhythms severely undermines animals' abilities to sustain coherent and functioning umwelts.

## Umwelt Collapse

From the umwelt perspective, animal endangerment and extinction are often not directly caused by environmental factors such as shrinking habitats, unavailability of food and shelter, and increased interspecies competition. Instead, extinction and endangerment can be seen as the failure of the semiotic processes taking place within animal umwelt, in conditions of rapid environmental change. Irregularities in the temporal and spatial patterns of ecosystems, errors in ecological codes, human-induced noise, and other disturbances, make it increasingly difficult for animals to sustain their umwelt structure. This gives us a ground to talk about *umwelt collapse as the disintegration of animal umwelt resulting from the errors in semiotic processes that mediate between an animal and the ecosystem*. The concept derives from the ecosemiotic interpretation of the umwelt as the sum of structural correspondences between an animal's subjective experience, ecosystem, physiology, and behaviour.

Umwelt collapse relates to ecological concepts like niche collapse (Pringle et al., 2019) and species collapse (Kleindorfer et al., 2014). For instance, Pringle et al. (2019: 58) describe the extinction of a lizard Green anolis (*Anolis smaragdinus*) in a small Caribbean island as niche collapse: "Fear-driven avoidance of predators collapsed the spatial and dietary niche structure that otherwise stabilized coexistence, which intensified interspecific competition within predator-free refuges and contributed to the extinction of green-anole populations on two islands." In niche collapse, different

factors become conflictive with one another in current ecological conditions, leading to the deterioration of the animal's ecological niche.

In *umwelt* collapse, the emphasis is put on semiotic processes – how meaning-relations between animal-internal and animal-external semiotic structures become dysfunctional and cause *umwelts* to disintegrate. There are probably different ways in which this may happen. *Umwelt* collapse can be induced by conflicts between different functional cycles, where fulfilling one basic functional cycle blocks executing the other. In degrading and defragmenting natural landscapes, social animals may suffer from inadequate social contact and communication with species-mates. Lack of contact may not only endanger the genetic diversity of the species, but also compromise its cultural memory and learning. For instance, human-induced environmental change—ecosystem fragmentation or the emergence of taxonomically related new species—may negatively influence animals' ability to learn their species identity via imprinting (Sih et al., 2011: 378). This could be interpreted as a conflict between partner and medium functional cycles.

As a second possibility, animals may use environmental entities as reference points in their codes. In such ecological codes, some aspect of an animal's memory, navigation, or cognition is attributed to the outer environment. As a known example, the honeybee dance code uses the sun's position as an external referent in the sky. Due to the sun's relative movement, the message communicated by ways of this code directs bees to separate places in the morning and afternoon. In the case of global environmental change, the environmental constants will stop corresponding to the internal meaning-structures in *umwelts*, and animals will not be able to find ecofields and resources to fulfill their biological needs (Farina, 2008). For instance, eels and other migrating fish that use oceanic currents as a reference system may not find their way if the direction, velocity, or temperature of water currents themselves change (Drouineau, 2018). Problems with ecological codes due to changing environmental constraints may be a source of *umwelt* collapse.

*Umwelt* collapse could also be caused by greater general stress determined by climate change or other anthropogenic environmental changes that make it difficult for an animal to keep up its coherent *umwelt* structure. To a certain extent, animals can compensate for different environmental stressors. If stress level rises, however, an animal may lose the ability to organize its perceptions and activities in a meaningful way. A suitable example of such meaning-collapse would be bee colony collapse disorder. Honeybee workers, affected by different environmental stressors, lose their ability to navigate and do not return to the hive. No single cause has been observed behind bee colony collapse disorder, but rather the inability of the bees to manage the numerous or many environmental stress factors (van Engelsdorp et al., 2010). "The number of stressor combinations rapidly becomes large, and exposure to stressors is hard or impossible to control with free-flying bees. Nonetheless, a strong argument can be made that it is the interaction among parasites, pesticides, and diet that lies at the heart of current bee health problems" (Goulson et al., 2015).

In *umwelt* collapse, animal extinction is understood as an internal subjective process related to various ways in which animals lose the ability to interpret their surrounding world meaningfully. We may imagine human suffering from Alzheimer's or dementia as a suitable metaphor to describe such a situation. "The reduced capacity of people with dementia to interact with the world may diminish the scope of their ontological niche" (Millett, 2011: 518). Signs and codes lose their reliability, and the connections between

internal and external meaning-structures fade. Animal species with collapsing umwelts may lose the ability to recognise familiar and necessary objects, but mismatch present things with previous search images, resulting in dysfunctional orientation and behaviour. The collapsing surrounding world seems “out of joints,” and an animal can no longer make sense of it.

## Conclusions

An animal species going extinct marks the end of a world, since each umwelt is a unique model of the world, a unique way of living. Extinction ‘is a curtailment of that species’ (bio)semiotic potential, where biosemiosis is understood as the production and communication of “significance” (Smith, 2013: 22). As Lestel (2013) has rightly noticed, each extinction event is an irreversible loss of experience and imagination. From an umwelt perspective, mass extinction can be experienced emotionally as hunger, social isolation, and confusion in myriad forms. Umwelt theory may help to notice this deprivation of meanings occurring on a global scale, as it focuses on animals’ subjective worlds and meaning-connections with ecosystems, instead of seeing extinction as a result of external ecological forces. Distinguishing between core and mediated umwelt, and between different causes of umwelt collapse, may help us map scenarios of animal endangerment and extinction. Different types of umwelt collapse may require different types of compensation strategies. Ecossemiotic interpretation leads to a better understanding of ecosystem degradation due to the interplay between organisms and ecosystems in ecological memory.

In general, higher human energy consumption in the Anthropocene and inserting more energy in the ecosystems are the primary ways to destabilize various species’ core umwelts. Extensive energy usage causes the relocation of matter, physical changes in ecosystems, and changes in climatic cycles. At the same time, engaging in semiosis with other species, making an effort in co-creative design, and living in dialogue may provide other species with new ways of inhabiting changing environments. Designing can be revised here as “a signifying activity, one that triggers behavioural possibilities for humans and other-than-humans while enacting and participating in the semiosphere” (Avila 2020: 43). Nature-based solutions, co-evolutionary development between human society and ecosystems, and environmental restoration, can do much to help nonhuman species adjust to and fit with environmental change (Herrmann-Pillath et al., 2022; Clement, 2021).

Constructing local environmental affordances with animal umwelts in mind could help nonhuman others to reach new meaning relations and behavioral novelties. In other words, such activities provide more possibilities for fitting and adapting through mediated umwelt. Enriching urban environments with affordances and resources for non-human species—natural soil, structures for shelter and nesting, passages, flightways, drinking-water, and other resources—are a few examples of how to aid non-human animals in fulfilling their biological functions and retaining umwelt consistency. The enrichments should entail sign patterns and aesthetics of non-human species as these allow non-humans to access the solutions proposed by humans. Umwelt analysis has the potential to counter species extinction as the animals’ own perspectives, meaning-making processes,

and umwelt structures, are put under central consideration. Future studies are needed on this topic.

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## Declarations

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