

Northumbria Research Link

Citation: Goodfellow, Paul (2019) Eerie Systems and Saudade for a Lost Nature. Arts, 8 (4). p. 124.
ISSN 2076-0752

Published by: MDPI

URL: <https://doi.org/10.3390/arts8040124> <<https://doi.org/10.3390/arts8040124>>

This version was downloaded from Northumbria Research Link: <http://nrl.northumbria.ac.uk/40835/>

Northumbria University has developed Northumbria Research Link (NRL) to enable users to access the University's research output. Copyright © and moral rights for items on NRL are retained by the individual author(s) and/or other copyright owners. Single copies of full items can be reproduced, displayed or performed, and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided the authors, title and full bibliographic details are given, as well as a hyperlink and/or URL to the original metadata page. The content must not be changed in any way. Full items must not be sold commercially in any format or medium without formal permission of the copyright holder. The full policy is available online: <http://nrl.northumbria.ac.uk/policies.html>

This document may differ from the final, published version of the research and has been made available online in accordance with publisher policies. To read and/or cite from the published version of the research, please visit the publisher's website (a subscription may be required.)




**Northumbria
University**
NEWCASTLE



UniversityLibrary

Article

Eerie Systems and Saudade for a Lost Nature

Paul Goodfellow 

Department of Arts, Northumbria University, Newcastle NE1 8ST, UK; paul.goodfellow@northumbria.ac.uk

Received: 10 August 2019; Accepted: 13 September 2019; Published: 24 September 2019



Abstract: This paper considers Art's engagement with the socio-ecological systems in operation in the world. Drawing from both environmental and art history, this paper employs the Deleuzian concept of the fold to suggest three overlapping periods of ecological-systems awareness over the past sixty years. This paper demonstrates how we have shifted our attention from a material engagement with the Earth to a primary engagement with systems which describe and simulate the Earth. This shift in attention to secondary information and an enfoldment within systems, defined as the *Post-Systems Condition*, manifests in the aesthetic quality of the eerie and a profound sense of saudade or longing for a lost nature.

Keywords: saudade; eerie; virtual; systems; fold; nature; simulation

1. The Folds, Saudade and the Eerie

This paper considers art's understanding and engagement with the socio-ecological systems in operation in the world. Drawing from both environmental and art history, this paper employs the Deleuzian concept of the fold to suggest three overlapping periods of systems engagement within culture to question whether our conception of Earth has been extended or obscured by our increased understanding of the ecological, social and cybernetic systems in operation. This paper demonstrates how we have shifted our attention from a material engagement with earth systems to a primary engagement with simulations of these systems. This shift in focus from the material to the virtual produces the aesthetic experience of the eerie, whilst simultaneously inducing a profound sense of saudade, or longing for a lost nature. The terms nature, eerie and saudade and the concept of the fold are introduced, before being applied to the three temporal folds within culture, and how these are played out in the co-evolving dimensions or folds of ecology, systems and art¹.

The concept of nature is employed in this paper to denote an out-of-date understanding of the Earth and earth-systems. Nature suggests an external and romantic location to be visited, which is somehow separate from our mental, social, cybernetic and technological systems we employ to describe the Earth. This discussion of nature is understood in relation to the human impact on the Earth-systems which has been variously defined as the Anthropocene, Capitalocene, Plantationocene and Chthulucene (Demos 2017, pp. 85–112). Drawing from Timothy Morton's dark ecological thinking, this paper proposes that we extend our understanding of nature to encompass all human and machine activity. Morton describes this perspective as an 'ecology without nature' (Morton 2012, p. 10), stating,

This ghostly Nature inhibited the growth of the ecological thought. Only now, when contemporary capitalism and consumerism cover the entire Earth and reach deeply

¹ Some of the ideas contained in this paper, and in particular the *system folds*, and the concept of the *Post-System Condition* are refinements of ideas originally developed in the author's practice-based Fine Art PhD. The author is a practising artist, but has a background in geography and environmental science and has experienced first-hand the disorientation of working with complex environmental information systems.

into its life forms, is it possible, ironically and at last, to let go of this nonexistent ghost. Exorcise is good for you, and human beings are past the point at which Nature is a help. Our continued survival, and therefore the survival of the planet we are now dominating beyond all doubt, depends on our thinking past Nature. (Morton 2012, p. 5)

Nature may also refer to the self, as a distinct psychic system, the boundaries of which are being eroded through the encroachment of technological systems. Consequently, there are both perceptual and psychological costs in the erosion of the concept of nature.

Mark Fisher defines the *erie* by contrasting it with the weird suggesting the weird is constituted by a 'presence of *that which does not belong*', and 'a teeming which exceeds our capacity to represent it' (Fisher 2016, p. 61). Weird, he suggests is a condition expressed in science fiction, and we could point to the proliferation of zombie and pandemic films as examples of unimaginable excess. In contrast, the *erie* occurs either 'when there is something present where there should be nothing, or [...] there is nothing present when there should be something' (Fisher 2016, p. 61). Fisher gives the example of a bird's cry, which could be read as *erie* if we feel there is something supernatural, or beyond natural in operation, see Figure 1. He describes this as the 'failure of absence', as it denotes an alien presence which compels speculation (Fisher 2016, p. 61). The second form of *erie*, 'failure of presence' is the experience ruins and abandoned structures have on the psyche, as we are confronted with evidence of loss. These two understandings of *erie*, as 'the failure of absence' and the 'failure of presence' will be employed to understand our contemporary *Post-Systems Condition*, which is haunted by the cybernetic and technological extensions of nature.



Figure 1. Loading ice at Nuuk Port and Harbour, Greenland, for Ice Watch in Copenhagen, 2014. Photo: Group Greenland. © 2014 Olafur Eliasson. Used by permission.

The term *saudade* is employed to capture our emotional response to nature and Earth, the subject of our desire, as it changes in both physical and perceptual terms due to the stresses of the Anthropocene: mass extinction, climate heating, and the encroachment of systems. Félix Neto and Etienne Mullet produced a thorough analysis of the term *saudade* and drew together the following definitions of this complex word (Neto and Mullet 2014, p. 661). *Saudade* is a Portuguese term, which has no direct English equivalent, but António Braz Teixeira defined it as 'the desire of the loved thing or the loved creature, turned painful by the absence of it. It is at the same time the desire and the pain it causes' (Teixeira 2006, p. 30), whilst the *Novo Dicionário Compacto da Língua Portuguesa* defines *saudade* as the

'melancholy caused by recalling something good that one was deprived of' (Morais 1990). In contrast with nostalgia, which sentimentalises the past, *saudade* has a more complex temporality as Eurico Figueiredo states, 'Saudade is past and also future The past through the desire is present and future' (Figueiredo 1991, p. 17).

The concept of the fold also has appealing flexibility and a multi-dimensional quality, and as with other Deleuzian concepts such as the *rhizome* and *assemblage*, facilitates a description of things, which are either perceptually just out-of-research, or difficult to pin down with precise terms. The concept of the fold appears in several of Deleuze's books and in particular the texts on Leibniz, *The Fold* (Deleuze 1993) and *Foucault* (Deleuze 2006). Simon O'Sullivan suggested that these books involve a folding or 'doubling' of Deleuze's thought 'into' the thoughts of the subject (O'Sullivan 2005). This notion of the doubling of thought is performed in this paper, as ecological systems and art historical perspectives are folded together.

Underpinning the fold is Deleuze and Guattari's concept of the *plane of immanence* developed in *A Thousand Plateaus: Capitalism and Schizophrenia* (Deleuze and Guattari 1988) and this can be understood as a description of the infinite of all things which have existed, will exist and could exist (Marks 2010, p. 5). Relative to this infinite plane folds can be understood as folds or creases, to the surface of the plane which offer vantage points or axial markers from which we can apprehend distinct aspects of infinitude. In discussing Leibniz, Deleuze demonstrated how the *plane of immanence* is not divided into discrete parts through the consideration of individual phenomena, but instead retains an overall cohesion. As he states,

The division of the continuous must not be taken as of sand dividing into grains, but as that of a sheet of paper or of a tunic in folds, in such a way that an infinite number of folds can be produced, some smaller than others, but without the body ever dissolving into points or minima. (Deleuze 1993, p. 6)

Likewise, when we consider observable temporal patterns in the evolution of art, ideas, technologies, information, or even the psyche, we can think in terms of folds of time, as opposed to waves. As a wave denotes an overarching movement of molecules, as the whole body of water swells in a particular direction. In effect, a wave operates in much the same way as sand, but with lower viscosity, and consequently, the crest of the wave, will recede and move depending on the underlying currents and leave no trace. In contrast, the crest of a fold locates the emergence of an idea, and this does not contradict other ideas and developments which will emerge within adjacent folds. Thus, the concept of the fold is closer to geological folds of rock than to the wave-like movement of water. Deleuze addressed this distinction stating,

Particles are "turned into folds," that a "contrary effort changes over and again." Folds of winds, of waters, of fire and earth, and subterranean folds of veins of ore in a mine. In a system of complex interactions, the solid pleats of "natural geography" refers to the effect first of fire, and then of waters and winds on the earth. (Deleuze 1993, p. 6)

In geological terms, the peak of folded rock, the 'axial ridge' becomes the fold, and these can reveal or obscure other layers of material on the geological plane. Thus, we can imagine how things can be unfolded to be revealed, and equally how something can be consumed by a fold, or enfolded. This paper discusses three overlapping temporal folds of ecological-systems awareness within culture and how these are played out in the three co-evolving fields or folds of ecology, cybernetics and art.

Co-evolution is a concept drawn from ecological thinking, and this concept is invoked here to imagine the dialectical relationship between ecological thinking and culture. Within ecology, *co-evolution* describes how the health and sustainability of a species depend on their ability to adapt or *co-evolve* with their environment and other species. As David Pitt states, 'Co-evolution leads to selection pressures through interactions that establish structure between species, whether symbiotic, parasitic, predatory or competitive' (Pitt and Samson 2012, p. 19).

This paper imagines how the *co-evolution* of ecology, cybernetics and art thinking have been simultaneously symbiotic, parasitic, predatory and competitive, as culture has at first accommodated system thinking, and ultimately been enfolded within systems. These co-evolving fields are each cultural and systemic descriptions of things which are understood to be operating in the material world and can be summarised as follows: *Ecological Thinking* and the model of the ecosystem is the world of ideas that correspond to the external material world and is an attempt to describe the interactions taking place between the organic and inorganic materials of the Earth; whereas *Cybernetics* is an attempt to model the operations of machines, digital systems, and the flow of information; finally, *Art* and *Art History*, in systems terms, is a structural description of the artwork and the role of art in society. All three areas are thus active descriptions of how we observe and make sense of the flows of material and information.

This cultural understanding of systems is derived from Niklas Luhmann and his structural analysis of society in *Social Systems* (Luhmann 1995), and the role of art within society in *Art as a Social System* (Luhmann 2000). Luhmann describes how the artwork functions within culture and makes the key distinction between our personal *psychic systems*, or systems of consciousness and the *social system*, or systems of communication. *Psychic systems* describe the individual actor and how the 'self' and consciousness are emergent qualities arising from the complex interactions between internal and external stimuli on the nervous system and brain, whereas the *social system* is focused on the communication between actors within society and is operating at a more abstract level. Luhmann suggests that art has a unique function within *social systems* and in principle, has the potential to communicate internal perceptions between these closed psychic systems (Halsall 2008, p. 59). Although in practice, Luhmann argues art is the Sisyphean project of the artist in seeking to externalise, and therefore communicate the complex operations of their own *psychic system*.

Luhmann's work highlights the tension between our mental models of the world and the external material world. This tension between the material and the mental returns us to Deleuze as he employed the term fold, as a way of breaking down simple binary categories such as what is material, the material processes of the Earth, and what is mental or socially constructed: our ecological, cybernetic and cultural descriptions of what we observe. For example, an artwork such as Robert Smithson's *Spiral Jetty* (1970) is both material and mental as it exists as both a massive earthwork located in Utah but has been extended over time to include numerous forms of documentation, drawings and writing, including the 1972 text *The Spiral Jetty*, (Smithson and Flam 1996). Additionally, as the earthwork is difficult to access due to its remote location, the work has predominantly existed in the mind of the audience, independent of any direct experience of the material form. Consequently, an adequate description of *Spiral Jetty* must include a description of both the material objects and the wider invisible flows of information which contribute to the work.

To deal with this material-mental duality, Deleuze employed the metaphor of a house containing two floors to accommodate the separation of the material world from the world of ideas (Deleuze 1993, pp. 100–20). The ground floor is the material fold containing all organic and inorganic materials, whereas the upper floor is the mental fold containing all ideas, including our engagements with the material world, and in so doing, enfolds the materials of the lower floor. This can be understood in relation to the artwork *Spiral Jetty* as the artwork is distributed across both the material and the mental and the idea of the work enfolds and extends across all the material. This is not to say that the material aspect of the work, the rock and salt crystals which form the earthwork are fully described through these observations. Instead, mental enfoldments are narrative devices to make sense of the things we experience.

Graham Harman warns against treating material things as purely narrative or relational devices, as objects will always exceed their description (Harman 2016, p. 7). Harman employs the term 'withdrawn' to acknowledge that the material world can never be fully described, or 'exhausted' by a system or processional description as *Spiral Jetty* can be described in art historical terms as well as environmental, ecological and geographical terms, without ever being fully described by them. *Spiral*

Jetty, the artwork, is enfolded in these mental descriptions but is never exhausted by them. This quality of inexhaustibility may even suggest the reverse is true and the material fold ultimately enfolds the mental, as all mental activity has a material basis. Likewise, as our material world is extended by computational descriptions of the world, so we become enfolded by the cybernetic and virtual. This is the case whether we understand these as an extension of the material world, through the processing of bits of information, or the mental world through the exchange of ideas. Thus, as we increasingly understand our experiences as ecological, in this expanded sense, so we must also understand that we are enfolded within systems. To understand this *post-system condition*, we must consider the systemic awakenings that have taken place within culture and how they have peaked as folds within Art. This paper now considers Art's engagement with the three distinct folds of systems within culture.

2. Roots of Systems Thinking

The three system-infused histories of ecology, cybernetics and art merged in the 1960s and laid the foundations for Systems Art, and these convergent histories are mapped here. Prior to this period, culture had oscillated between systemic or holistic descriptions of the world and mechanistic descriptions of the experienced world. Prior to the dominance of 'western science', more integrative and holistic narratives explained the complex operations of the world. These included various forms of Animism, reflected in Shintoism, Hinduism, Buddhism and the concept of Gaia. These holistic descriptions contrast with the early mechanical Cartesian descriptions of the 'world-as-machine', in which things could be described as distinct observable objects. This mechanistic view of the world, expressed by Galileo, Bacon, Descartes and Newton focused on the material properties of things, such as the weight, shape and movement of objects and how these characteristics could be quantified and described using mathematics (Capra and Luisi 2014, pp. 19–30). Other observable characteristics of objects, such as sound, taste, smell and beauty, which could not be measured in this way were ignored as subjective and unreliable. These persistent and affective affirmations of lived experience disrupted such a measured description of life, and biological life ceased to be explainable in purely mechanistic terms with the discovery of the cell). Modern cell theory developed through Rudolf Virchow's research into their underlying structure and function defining them as the 'fundamental unit of life' (Capra and Luisi 2014, p. 37). He demonstrated that cells were independently alive and as such to understand life at the scale of the plant, animal, or human one had to understand the interactions of the cells within. The cells could therefore be understood as a complex system; and the life of the plant, animal, or human was an emergent property of that system (Capra and Luisi 2014, pp. 230–33).

This expanded understanding of life emerged in the late nineteenth century when biologists began to study organisms, not in isolation, but in terms of their community and environment (Capra and Luisi 2014, pp. 66–68). This integrated perspective can be traced to Darwin's work on evolution, as he explicitly articulated the interconnectedness of things in *On the Origin of Species* in 1859 (Darwin 2011). As Susan Flader notes, 'to Darwin [...] belongs the principal credit for describing the complex functional interrelatedness of organisms and environment and the tendency of the evolutionary process to elaborate and diversify the biota to produce what ecologists today speak of as a system in dynamic equilibrium' (Flader 1994, p. 5).

In the 1940s, Ludwig von Bertalanffy built on this understanding and described the *open system* and his *General Systems Theory*, which established systems thinking more broadly within science, and in turn led to cybernetics, and applications in computing. Bertalanffy's proposed that each living system could be understood as a 'whole' made up of interdependent parts, which were kept in dynamic balance or equilibrium, which he termed *Fliessgleichgewicht* or 'flowing balance'. He stated,

We find systems which by their very nature and definition are not closed systems. Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, a building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so-called steady state which is distinct from the latter. (Bertalanffy 1968, p. 39)

In parallel to the ecological and systems understanding of the material world, other forms of relational thinking emerged, which were dealing with the more abstract areas of language and information. For example, Ferdinand de Saussure's *Course in General Linguistics* (1916), described the underlying rules of language (De Saussure and Harris 2013), whilst the field of cybernetics shifted from the description of systems which were kept in balance through the exchange of material to systems which were focused on the exchange of information. Cybernetics grew from the work of Claude Shannon, Norbert Wiener and Gregory Bateson and was focused on the non-material transmission of information and 'concerned with a different level of description, concentrating on patterns of communication, especially in closed loops and networks. Their investigations led them to the concepts of feedback and self-regulation, and then, later on, to self-organization' (Capra and Luisi 2014, p. 87). Although cybernetics was originally conceived within a machine environment, the definition of the machine was fundamentally different from Descartes' earlier clockwork description of the world. The key text on cybernetics Shannon and Weaver's *Mathematical Theory of Communication* (1949) defined 'communication' through the key concepts of message, signal and noise (Shannon and Weaver 1998). Shannon demonstrated that in order to define a 'mathematical theory of information communication signals must be treated independently of the meaning of the message' (Capra and Luisi 2014, p. 93). Thus, in this context 'information,' does not mean meaning, but the measure of non-randomness, of a signal- with the end goal of information theory being the reduction of randomness or noise relative to signal or the 'signal-to-noise ratio'. This understanding effectively separated the medium from the message, which became a fundamental tenant of conceptual art in the late 1960s.

Cybernetics and systems thinking shifted significantly with the biological research of Humberto Maturana and Francisco Varela and in particular the concept of 'autopoiesis' articulated in *Autopoiesis and Cognition: The realization of The Living* (Maturana and Varela 1980). The concept of autopoiesis or 'self-making' demonstrated the underlying processes at work within biological systems so that the system remained in balance. This understanding helped explain the dialectical interdependence or 'structural coupling' between the cells and the body and how life is an emergent quality of these relationships (Maturana and Varela 1980). Katherine Hayles described this revised understanding as cybernetics' 'reflexive turn', summarising their work as follows:

Organisms respond to their environment in ways determined by their internal self-organization. Their one and only goal is continually to produce and reproduce the organization that defines them as systems. Hence, they not only are self-organizing but also are autopoietic, or self-making. (Hayles 1999, p. 10)

Hayles notes that although these systems are self-sustaining, the definition of the system is a construction of the observer, developed as a way of explaining the complex relationships observed in the world. As Hayles notes,

Information, coding, and teleology are inferences drawn by an observer rather than qualities intrinsic to autopoietic processes. In the autopoietic account, there are no messages circulating in feedback loops, or are there even any genetic codes. These are abstractions invented by the observer to explain what is seen; they exist in the observer's "domain of interactions" rather than in autopoiesis itself. (Hayles 1999, p. 138)

As the inferences we draw from observations are products of the mind, and we employ system descriptions of the world as a way of making sense of what we see. The earth can be explained in terms of biological and environmental systems operating at different scales, but these are relative explanations, which are subject to our senses and understanding, and the external world remains removed from these imaginary systems. With this understanding, this paper considers three distinct folds of time from an art historical perspective, and how our relationship with the material Earth and the concept of nature has been extended and obscured by system descriptions.

3. The 'Primary Systems' Fold, (1960–1980)

The first fold operated between 1960 and 1980, a period which saw the growth in systems thinking, as Pamela Lee observed, 'Psychology and modern religion; anthropology and urban planning; business management, cognitive science and the ecological movement: all find their place under the Systems umbrella' (Lee 2006, p. 65). This included the development of *Systems Art*, which was a synthesis of Conceptual Art, Minimalism and the application of rules or systems in the production of work.

Much writing on the history of Systems art has focused on the cybernetic roots and specifically the influence of Shannon and Weaver's *Theory of Communication*. This is most starkly employed in the work of Nam June Paik, which explicitly performs the 'media and message' dichotomy at the heart of information theory. One can though see several other key influences that converged within Systems art of this period. A line can be traced through the formal approaches that ran from Suprematism and Constructivism, through to Abstract Expressionism, as these movements can be understood in terms of process. Likewise, artists such as Josef Albers, Alfred Jensen, and Ad Reinhardt and their application of colour theory can be understood as precursors to a more explicit rule-based painting (Glimcher 2005), whereas the diagrammatic paintings of Hilma af Klint demonstrated a hermetic quality, which suggests an underlying esoteric system akin to the later Systems Art of Jack Burnham. More broadly, Fluxus and Neo-Concretism applied rules in the production of work, in ways that expanded the artwork and anticipated art in explicitly relational terms.

These influences converged within art in the 1960s as artists engaged with systems in several distinct ways including cybernetic systems, rule-based systems, social systems and environmental systems. Cybernetic art spearheaded by the artist Roy Ascott and the artist-curator Jack Burnham focussed on information systems and the flow of information, whereas the rule-based art of Sol LeWitt, Agnes Martin, Robert Ryman and Jeffrey Steele investigated the aesthetic application of rules and repetition (Glimcher 2005). Other artists such as Hans Haacke, Adrian Piper and Vito Acconci engaged with systems on critical, social and political levels.

Above all of these system engagements, it can be argued that the dominant systemic understanding within art derived from the nascent ecological movement, which was built on ecological and biological concepts and non-western holistic systems such as Buddhism. In particular, the *Primary Systems* fold can be understood in relation to the emerging ecological concepts of the 'Whole Earth', 'Gaia' and 'Spaceship Earth' taking hold in the popular imagination. This ecological awakening within the wider culture can be traced to several widely read texts which understood the world in systemic terms. Rachel Carson's *Silent Spring*, (1962), discussed the agricultural-capitalist systems adverse effects on the wider ecosystem (Carson 2000). James Lovelock's seminal text *Gaia* (1979), drew from the traditional animistic concept of Gaia to define the Earth as both self-sustaining and sentient (Lovelock 2016), whilst Buckminster Fuller's *Operating Manual for Spaceship Earth*, (1969), imagined the planet as a system and employed the metaphor of a spaceship (Fuller 2008). Fuller's part-ecological and part-technological description of the *whole* earth alone in space reflected NASA's efforts to document the planet from space. Firstly, with the *Earthrise* photograph taken from Apollo 8 in 1968 and, later the *Blue Marble* in 1972, from Apollo 17. In imagining the Earth in this hybrid ecological-technological terms, Fuller anticipated the current turn within humanities towards an expanded understanding of the ecological-technological entanglement described in the writing of Erich Hörl (2017).

A range of work developed during this period which can be described in environmental, biological and ecological terms. The artwork as 'environment' emerged through the work of Allan Kaprow and his environmental installations, which were not strictly sculpture, but an occupation of space, in the way nature occupied space (Nisbet 2014, pp. 15–22). By contrast, the large-scale Land Art of De Maria and Michael Heizer, for example, was not engaging with the expanded ecological subject but with the material world as it became mapped and mined by NASA, aerial photography and industry in the 1960s. Thus, from a contemporary perspective, these large-scale works were not ecological, but instead reflected the material conditions impacting the Earth during this period. In particular, the *Earthrise* and *Blue Marble* photographs from space fixed the Earth as a material object and potential resource,

but they also laid the foundation for a more nuanced and ecological relationship with the material planet in the future.

David Wills has suggested, 'blood and soil are the two poles of every anthropo-ecological impulse', and artists were drawn to these two scales of ecological activity during this period (Hörl 2017, p. 237). In contrast to the environmental Land Art of the 1960s, which were grounded in soil Mary Kelly's work in the 1970s, *Antepartum* (1973) and *Post-Partum Document* (1973–1979), were grounded in blood and personal biology. As Kelly's work demonstrated a more personal and ecological relationship with nature, which started to emerge at the end of the 1960s, whilst the concept of simulation and its relationship to ecological thinking was demonstrated in De Maria's move from the external earthworks, to his gallery installations and with Smithson's concept of the *Nonsite*. These works operated as a form of simulation as they made an explicit correlation between the gallery installation and the external environment.

Thus, many of the ecological systems-based works moved from a direct engagement with the subject, the material earth to information about the subject. This transformation within art from object to concept and from material to information was both anticipated and described by Jack Burnham in his *Artforum* essays: *Systems Aesthetics* (1968), and 'Real-time Systems' (1969), (Burnham et al. 2015), and was later documented by Lucy Lippard in *Six Years: The Dematerialization of the Art Object from 1966 to 1972* (Lippard 1973). This shift from the material subject to information about the subject was also foregrounded in several important exhibitions including *When Attitudes Become Form* (1969), *Information* (1970), and *Software: Information Technology* (1970). The works exhibited in these shows extended beyond the simple idea of a discrete art object to actively include other elements such as associated writings, the gallery spaces and the audience. The morphology of these increasingly complex artworks could not be described in simple objective terms but required a systemic or even ecological description.

Environmental Science was also founded on systems thinking, and ultimately an informational understanding of the world, and this can be traced to Eugene Odum's *Fundamentals of Ecology* (Odum 2017), first published in 1953, in which Odum argued that both the ecological world and social worlds co-evolved 'toward greater complexity, interdependence, and self-regulation' (Hagen 2008, p. 708). This cooperative perspective was though increasingly challenged during the close of the 1970s when the Darwinian ideas of competition and self-interest were reasserted. This individualist perspective was established in Garret Hardin's *The Tragedy of the Commons*, (Hardin 1968), and followed by Richard Dawkins' *The Selfish Gene* in 1976 (Dawkins 2016), and Eric Pianka's *Evolutionary Ecology* in 1982, (Pianka 1997), which foregrounded competition over cooperation. This shift in tone effectively ended the optimism, and in retrospect technological naivete, of the 1960s, as culture shifted to the fragmentary culture of the self in the 1980s.

4. The 'Open Systems' Fold, (1981–2000)

The competitive perspective of Pianka's *Evolutionary Ecology* resonated with the free market, and atomised politics of the *Open Systems* fold personified by Margaret Thatcher's economic policies, the privatisation of societal infrastructure and the deregulation of the financial markets. This shift in thinking was most clearly understood and articulated by François Lyotard in *The Postmodern Condition*, (1979), in which he argued that society was increasingly fragmented by different interest groups, modes of discourse and narratives (Lyotard 1984). Lyotard challenged the view that science 'represented the totality of all true knowledge', arguing instead that knowledge and narratives are employed by specific interest groups to achieve certain goals at different societal levels (Hopkins 2000, pp. 198). Thus, the disparate narratives which emerge in society cannot be threaded back together to form a single coherent 'grand narrative' such as Science or Modernism. Lyotard argued that the presence of these discordant and contradictory narratives suggest that the grand narratives have not so much been lost through fragmentation, but never truly existed (Hopkins 2000, pp. 198–99).

The emerging plurality of science was acknowledged and facilitated in this period with the increased use of computer models, which eroded simple singular narratives. Large environmental

computer information systems, for example, began to organise and map vast quantities of spatially coordinated data and environmental science shifted from simple ecological stories to the flat ontologies of relational data, which facilitated multicursal speculation. Thus, a conceptual and physical break emerged between our engagement with the world and the information we employ to describe it. At the heart of this was the destabilisation of authorship, as ecologists and geographers started to manipulate data and computer models without the direct affective experience of the source materials. This shift from a primary relationship with the material Earth to a secondary relationship with information about the Earth was facilitated and encouraged through a confluence of technology and culture. From a technological perspective, the role of computer processing power, relational databases, Hypertext and the Internet have allowed and even forced the user to access data in ways that could not be imagined or even intended by the original authors. Whilst from a philosophical and literary criticism perspective, Roland Barthes, Jacques Derrida and Umberto Eco developed the thinking tools to liberate the text from singular interpretations. Fundamentally, the *Open Systems* fold marked the shift in attention from the material object to the processes and relationships acting upon and through the object. Thus, the focus shifted from the subject Spaceship Earth, or nature to its simulation in computer models and information systems.

George Landow described how the open navigation proposed in literary theory and computer systems functioned in a surprisingly similar way, as both shifted the power from the author to the reader or end-user to finish or create the work (Landow 1991, p. 2). In *S/Z* Barthes described this combinatory approach as 'unfinished textuality', as words and images are freed to be infinitely reconfigured (Roland 1991). This destabilized the authorship of the work as the reader could have an equivalent or equal relationship to the text as the original author and would be free to navigate and extract their own personal meanings from the work. Hypertext and other relational methods of reception, such as environmental models and information systems, are in effect an implementation of Barthes ideas, as originally described in *The Death of the Author*, (1967) in which he argued that the text is independent of the author (Barthes 1987, p. 185). Two points, derived from Barthes' observation of the author and text, can be applied to the technological changes taking place in Environmental Science during this period. Firstly, the new images and information can be understood as 'emerging' from these systems, and consequently reflect the structure of the system, rather than the original subject. Secondly, the powerful environmental models and information systems must be understood in the same way that Barthes understood the open works. That is, the information generated from these systems can and should be read independently of their biographical roots due to the complex range of source material. Consequently, these systems are not designed for a single fixed reading but offer an open navigation and a *rhizomatic multiplicity* of narratives, to use the terms of Deleuze and Guattari (1988).

Thus, although these systems were designed to describe the external world, the Earth, the primary experience elicited from the system is the simulation (of the Earth). On one level, the sense of removal or distance from the Earth is inevitable as any description of the external world that moves beyond the affective lived experience is a form of mental translation or simulation. Accepting this limitation, it can be understood that these environmental information systems offer a simulation of a simulation. In such systems, Baudrillard suggested that the issue was no longer one of misrepresenting a withdrawn reality, but the 'fact that the real is no longer real.' (Baudrillard 1994, p. 13). Thus, although these profoundly sophisticated models of the world had effectively decoupled from the material Earth, they were not artificial descriptions, but simulacra, existing in their own terms and thus extended reality.

Likewise, arts' engagement with the world moved from a primary engagement with the earth, and earth systems to a more reflexive and second-order engagement with the sign systems employed to describe our material and social relationships. This was demonstrated with the shift from the art object to art processes and from artist to audience as Post-structuralism and Post-Modernism became the dominant cultural discourses. Like the models emerging in climate and environmental science, the artwork became unanchored from its biographical roots. Artworks expanded beyond the singular object to form complex systems which demonstrated unexpected affiliations and emergent qualities.

Umberto Eco encapsulated this expansion of the artwork in the concept of the *Open artwork*, which he described as:

Open in that it proposes a wider range of interpretive possibilities, a configuration of stimuli whose substantial indeterminacy allows for a number of possible readings, a “constellation” of elements that lend themselves to all sorts of reciprocal relationships. (Eco and Robey 1989, p. 84)

The open and reconfigurable artwork aligns with Lyotard assessment that without the grand narrative of Modernism the art market and capitalism became the grand narrative replacement and aesthetic, and commodity production became inextricably linked. This shifted the focus from the art to the wider art world, and the artworks became reconfigurable market commodities or signs within the wider art system. Drawing from Baudrillard, Lyotard described this reconfiguration and appropriation of art within the wider system as ‘schizophrenic’, as the work had become divorced from its *referents* or roots, for both the artist and audience (Hopkins 2000).

The critics Hal Foster and Craig Owens distinguished between two approaches employed by artists in the negotiation of this more fragmented postmodern landscape. Firstly, there was the ‘postmodernism of reaction’, in which artists redeployed signs from the wider art and social systems in an ironic and cynical way and David Hopkins cites Sigmar Polke and David Salle and their mixing of unrelated signifiers of found imagery, pattern and abstraction as key examples. Secondly, there was the ‘postmodernism of resistance’ which critiqued society by analysing and describing the social and political systems in operation and Hopkins cites Jenny Holzer and Barbara Kruger, who employed the language and sign systems of advertising to critique the political and capitalist systems (Hopkins 2000, p. 200).

By the 1990s, a group of artists, including Liam Gillick, Pierre Huyghe and Philippe Parreno began to address systems in institutional critique terms directly. Their work, described as the ‘Relational Turn’, was influenced by the relational thinking of Nicolas Bourriaud and his text *Relational Aesthetics* (Bourriaud 1998) which analysed the systemic relationships operating at different scales within society. Thus, artists during this period found new ways to reimagine how they may engage with things in the world, and in the process, the linear narratives of art history were disrupted. Technology was a key disrupter, particularly in the areas of reproduction, reconfiguration and communication. An argument could be made that technology had an even more significant impact than Post-Structuralism and Post-Modernism as it was adopted uncritically, fundamentally changing our relationship with the planet and each other. At the time, technology was seen as giving the individual power to connect and thus demonstrated the postmodern paradox of simultaneous atomisation and relation.

5. Post-Systems Condition, (2001–Present)

The Primary fold introduced systems into mainstream culture, and we reflected upon their value in both spiritual and utility terms as they extended our understanding of the holistic nature of the world and our place within it. Ecological systems, biological systems and social and political systems unfolded and helped explain our relationship to nature, our communities and our productive tools, such as art. During the Open fold system technologies, such as information systems and critical tools such as the Open Artwork allowed us to further understand the power of systems to alter and critique the operations of the material and social worlds. These digital and mental tools afforded individual freedoms to operate within systems, decoupling the author from the text. We felt empowered by these tools, both technologically and critically; but as we absorbed and remixed the images, texts, and art of others, we too were being absorbed within the system folds. As our relationship with technology and systems started to evolve and mutate and this can be understood as an insidious emergent quality of the complex systems operating within culture. As the more people engaged with systems-based processes, such as databases, and the Internet, the experience shifted from unfolding (empowering) systems to enfolding (disempowering) systems. That is, the tools that had originally been designed to decouple

the author from the text and allow freedom of navigation had autopoietically ‘structurally coupled’ the participants to the wider system. In the same way that Maturana described the interdependence of cells to the body, so the individual has been symbiotically enmeshed within the dominant systems of society (Capra and Luisi 2014, pp. 135–36). This change in relationship marks the third and final systems fold in which we become enfolded and engulfed within systems, in ways we cannot control at the individual (cellular) level. This enfoldment induces an eerie undercurrent of anxiety, and the dominant feeling of the Post-System Condition is one of *saudade*, for things we have lost and a future we may never see.

The art of the *Post-Systems Condition* demonstrates this condition of *saudade* with work documenting the material loss of species and habitats, as well as the psychological loss of self, as we become distributed across the Internet. These new engagements with the physical, cybernetic and psychic systems in operation were documented first by Lev Manovich (Manovich 2001) and have since been expanded in the writing of Gene McHugh (McHugh 2011), Omar Kholeif (Kholeif 2018), and Hito Steyerl (Steyerl and Berardi 2012). Manovich described ‘Post-Media Aesthetics’ and a ‘post-net’ culture which assumed access to and exchange with the Internet (2001), whilst Post-Internet art, introduced by Olson and McHugh on their blog, Post Internet, (2009–2012), was employed to describe the conditions of millennial art. Post-Internet art tends to exhibit an explicit nostalgia for the aesthetics of the 1990s and in particular the colours and the visually crude motifs of early computer graphics. Much of this work reflects the artist’s complicity with the technology and the ‘social’ systems they participate within as they produce, consume, circulate and recirculate images on the Internet. Consequently, they perform or reflect the recursive and self-absorbed role of the subordinated consumer within image systems, social systems and Late Capital; a state anticipated by Guy Debord with his concept of the spectacle. As Martin Jenkins summarises,

The spectacle is a social relation between people that is mediated by an accumulation of images that serve to alienate us from a genuinely lived life. The image is thus an historical mutation of the form of commodity fetishism. (Debord 2009, p. 24)

The critical and art historical reception to the *Post-Systems Condition* has included a reassessment of early Systems Art, which includes, from a British perspective, two significant exhibitions: *Open Systems: Rethinking Art c. 1970*, at Tate Modern (De Salvo 2005) and the *Systems Art Symposium* at the Whitechapel Gallery (2007). There have also been several texts which have reconsidered systems thinking within art, including: *Chronophobia, On Time in the Art of the 1960s* (Lee 2006), *Art, Time and Technology* (Gere 2006), *The Art of Systems, Art, History and Systems Theory* (Halsall 2008), *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness* (Ascott 2008), and *White Heat Cold Logic: British Computer Art 1960–1980* (Brown et al. 2009), *Systems* (Shanken 2015), *Ecologies, Environments, and Energy Systems in Art of the 1960s and 1970s* (Nisbet 2014) and *Systems we have loved* (Meltzer 2013), which discusses the affective, emotional, and the eerie quality of systems enfoldment.

Beyond the critical reappraisal of Systems Art and systems thinking within art, there have been two significant theoretical developments during the *Post-Systems Condition*, which simultaneously oppose and confirm each other, thus performing the complex material-mental (systems) dialectic at the heart of contemporary culture. Firstly, there has been a re-evaluation of the relational models proposed by Gregory Bateson, Luhmann, Deleuze and Latour, which foreground the flow of information, relationships and systems. Secondly, there has been a growth in Object-Oriented Ontology and Speculative Realism which reasserts the material basis of reality.

The ‘Systems’ turn is both a response to the present conditions and a re-evaluation of thinkers who anticipated many of the morphological aspects of a systems-based culture which foregrounds process and information flows. Thus, the work of Bateson, Luhmann, Latour and Deleuze has been reemployed to understand and describe the complex systems in operation in the material and social worlds. Of particular note is the renewed focus on the writing of Gregory Bateson and his two important texts *Steps to an Ecology of Mind* (1972), and *Mind and Nature* (1979) and his synthesis of cybernetics

and ecological thinking which feel both prescient and contemporary. One of the key contributions of Bateson was the definition of information as the 'difference that makes a difference', stating,

Perception operates only upon difference. All receipt of information is necessarily the receipt of news of *difference*, and all perception of difference is limited by threshold. Differences that are too slight or too slowly presented are not perceivable. (Bateson 1979, p. 29)

In addition to Bateson's understanding of difference in biological and social systems, Niklas Luhmann's demonstrated how social systems, including the art system, are kept in balance through the exchange of information, whilst Assemblage Theory, developed by Gilles Deleuze and Félix Guattari (Deleuze and Guattari 1988), and Actor-Network Theory, proposed by Bruno Latour (2007) offer alternative and expansive relational models to describe observed material and informational flows. These tools, in contrast to the strict morphological models employed in Environmental Science (to account for causal observations), allow for a higher level of abstraction and can thus describe complex patterns within the folds of space and time.

In contrast to these relational models which foreground information and process the second theoretical response to the *Post-Systems Condition* has been the inverse position in which different forms of materialist thinking are put forward within philosophical, cultural and political frameworks to counter the alienating effects of relativism and virtualisation. These include the realist philosophies of Object-Oriented Ontology, and Speculative Realism and the materialist thinking of Donna Haraway, Jane Bennett and Karen Barad which traverse philosophy, politics and material culture.

Object-Oriented Ontology and Speculative Realism developed through the work of Levi Bryant, Iain Hamilton Grant, Graham Harman, Timothy Morton, Steven Shaviro, Isabelle Stengers, and particularly Quentin Meillassoux's *After Finitude* (Meillassoux and Badiou 2009). Underpinning this realist thinking was Francois Laruelle's *Principles of Non-Philosophy* (Laruelle 2013), in which he argued that everything that is real exists together, and this includes all material things and all thoughts (Malik et al. 2015, pp. 18–19). Thus, all thoughts we have about the Earth, including systems descriptions of the Earth and the concept of nature, operate within the boundaries of what is real. Therefore, the artist or ecologist cannot step outside this system, so that the real may be described from the outside. This perspective has been employed within Art, not solely as a critique of relational or textual descriptions of the world, but as a way of re-grounding our experiences in a world that is becoming increasingly virtual due to technological simulations.

Morton's writing captures something of the paradox inherent in this position, as however much we believe the world to be a withdrawn material reality existing beyond our senses, we cannot avoid the eerie sensation that it can only be experienced as either a presence or absence. Morton deals with this material-relational paradox with the concept of the 'mesh' which he describes as 'the interconnectedness of all living and non-living things' (Morton 2012, p. 28). Contrasting the term *Mesh* with the term *web*, which he disregards due to its technological and Internet associations Morton draws from a dictionary definition of a mesh as 'a complex situation or series of events in which a person is entangled; a concatenation of constraining or restricting forces or circumstances; a snare' (Morton 2012, p. 28). Morton notes that the two key aspects of the mesh are the entanglement of things, and the space between things, stating, 'interconnection implies separateness and difference', which are by definition relational terms (Morton 2012, p. 97).

6. Lost Natures

Bridging the gaps, excavating the fissures and disrupting the simple duality between the realist turn (of Meillassoux, Bryant and Harman), and the systemic models (of Luhmann, Deleuze and Latour), is the materialism of Donna Haraway (1991, 2008, 2016), Jane Bennett (2010), and Karen Barad (2007). Their work, sometimes presented as the 'Materialist Turn', (as in the stuff of matter), offers a heterogeneous assemblage of ideas—each exploring different ways to move beyond the binary choice between an inaccessible material world or its relational nature. This can be traced back to

Haraway's *Simians, Cyborgs and Women: The Reinvention of Nature* (1991), in which she describes nature as a 'system of production and reproduction'. Underpinning this systems-material understanding is the acknowledgement that dominant descriptions of the world are predominantly Western, male and anthropocentric, and largely ignore the actions and experiences of non-human actors and marginalised human actors.

This perspective is political, captured in the question posed by Haraway in *Staying with the Trouble*: 'What happens when human exceptionalism and the utilitarian individualism of classical political economics become unthinkable in the best sciences across the disciplines and interdisciplines?' (Haraway 2016, p. 57). Haraway has answered this through a reimagining of the present, not as staging post of the Anthropocene or the Mass Extinction Event, but as a plane, an extended present tense which is concerned with and inextricably connected to everything. She describes this as the *Chthulucene*, a portmanteau of two Greek words—*khthon*, (or Chthonic), which means 'of the earth' and *kainos*

[which] means now, a time of beginnings, a time for ongoing, for freshness. Nothing in *kainos* must mean conventional pasts, presents, or futures. There is nothing in times of beginnings that insists on wiping out what has come before, or, indeed, wiping out what comes after. (Haraway 2016, p. 2).

Thus, *Chthulucene* describes a world of interconnections: kinships between species and things such as the symbiotic relationship between forest and mycorrhizal (fungi) networks, but also kinships across networks and communities which are invisible to the traditional metrics found in science and the humanities. This understanding can be applied to an orphaned dugong named Marium labelled 'the nation's sweetheart' by Thailand's Department of Marine and Coastal Resources. Marium died in August 2019 from an infection caused by ingesting plastic, and the sorrow expressed at her loss can be woven together into such a network, extending beyond the local community to implicate the petrochemical industries which produced the plastic. This reciprocal and active understanding of nature is also demonstrated in the writing of Bennett who states, 'humans are always in composition with nonhumanity, never outside of a sticky web of connections or an ecology' (Bennett 2004, p. 365).

Bennett proposes the political and ecological concept of 'Vibrant Matter' to describe the vitality of things, which are usually described as dormant in scientific, philosophical or social descriptions of the world (Bennett 2010). She describes an 'energetic vitality inside each' thing; when seen operating within an assemblage, 'objects appeared as things, that is, as vivid entities not entirely reducible to the contexts in which (human) subjects set them, never entirely exhausted by their semiotics' (Bennett 2010, p. 5). This description of the lively object is incredibly useful as it transcends the object-system or matter-energy dialectic by acknowledging that the individual objects' vitality is both an essential characteristic and symbiotically bound to the wider system, network or assemblage. As Bennett states,

[T]here is no need to choose between objects or their relations. Since everyday, earthly experience routinely identifies some effects as coming from individual objects and some from larger systems (or, better put, from individuations within material configurations and from the complex assemblages in which they participate), why not aim for a theory that toggles between both kinds or magnitudes of "unit"? One would then understand "objects" to be those swirls of matter, energy, and incipience that can hold themselves together long enough to vie with the strivings of other objects, including the indeterminate momentum of the throbbing whole. The project, then, would be to make both "objects" and "relations" the periodic focus of theoretical attention, even if it remained impossible to articulate fully the "vague" or "vagabond" essence of "thing" or any "system." (Grusin 2015, p. 228)

Bennett's argument, supported by our daily experience of the world, is that we do not need to choose between objects or the systems within which they operate. We do not, for example, need to choose between the glacier-as-object or the glacier-as-system (the accumulation and ablation of snow and ice)—as a glacier is experienced as both a massive material object and a set of glacially slow processes.

Thus, this hybrid object-systems perspective philosophically sits somewhere between the two extremes of the real, but inaccessible material world and the correlational world experienced by the senses.

Although all three positions contribute to our understanding of the world, they do not fully address the perceptual and in particular the phenomenological disorientation at the heart of the *Post-Systems Condition*: the loss of nature. As prior to the expansion of computational science there was a simple triangulation taking place between the observed material world, the observed forces operating in the world, and the models developed to describe the interplay between these observations. These models were largely perceptible by a single mind, and thus there was a congruence between the internal model of the world contained within the psychic system and the models shared between individual minds in the science community or wider social systems. Consequently, regardless of whether we ever truly experience the true nature of nature, there was a shared and necessarily simplified model of its operations.

This situation changed in the 1990s with the widespread implementation of computation in the Earth sciences, as each field of study built ever more sophisticated models which would perceptibly exceed the grasp of the individual mind. These computational models were then combined to produce ever more complex simulations of Earth systems, such as climate change models. As stated, the issue being raised here is not the degree to which these models accurately reflect the operations of the Earth, but the degree to which they obscure or transform our personal experience of nature. This can be understood through the employment of two concepts: the simulacra and the hyperobject developed by Baudrillard and Morton, respectively.

This can be illustrated by considering a simple and hypothetical model which tracked the retreat and eventual loss of the Okjokull glacier in Iceland through the measurement and mapping of ice reduction. Such a model is not designed to predict future environmental change but accurately represent the changes which have occurred. Consequently, there is a level of equivalence between the sign (the measurement), and the material reality, even though Baudrillard suggested such an equivalence was an idealised aim (not reality), of such a model (Baudrillard 1994, p. 6). The perceptual problem arises when the complexity of the model causes a break between the sign (data), and the thing being described. Baudrillard described how descriptions of the external world lose their equivalency as they become more complex, stating that ‘simulation envelops the whole edifice of representation itself as a simulacrum’ (Baudrillard 1994, p. 6). He described this shift from equivalent sign to simulacra taking place in the following stages:

- it is the reflection of a profound reality;
- it masks and denatures a profound reality;
- it masks the absence of a profound reality;
- it has no relation to any reality whatsoever: it is its own pure simulacrum.

(Baudrillard 1994, p. 6)

Thus, as the models and system descriptions of the world increase in complexity, they shift from a material foundation to computational foundation and consequently operate as simulacra which reflect the underlying algorithms, not the original subject. They, in effect, operate as independent complex systems and exhibit emergent and unexpected behaviour generating new information, not about nature, but about the operations of the simulation. The primary relationship is therefore not with nature but the simulation.

This shift can also be understood through the employment of Morton’s concept of the hyperobject, as something which is perceptually out-of-reach due to its complexity (2013). Morton developed the hyperobject to describe vital objects (or systems), which operate across huge spatial and temporal scales and cannot, therefore, be directly touched even though we experience their influence. Morton developed this concept as a way of apprehending the scale and complexity of Global Warming. Paradoxically, the models developed to simulate and anticipate global warming have become hyperobjects themselves

as they too exceed our understanding. Consequently, the edifice of science and particularly Climate and Earth Sciences have created models which exceed our understanding and therefore operate as simulacra or hyperobjects. Thus, the more we have modelled and simulated nature, the more it has perceptually and phenomenologically been obscured. The more data we have, the greater the sense that nature has been lost. Didier Debaise captured this state when he suggested the ‘concepts we deploy, the abstractions we construct, our very modes of thought, are no longer able to deepen and develop our experience of nature; they only obscure its meaning’ (Hörl 2017, p. 151).

The true nature of nature is obscured in media-information terms also. This is illustrated by Al Gore’s widely reproduced graph from the film *An Inconvenient Truth* (Guggenheim 2006), which depicted the correlation between the concentration of Carbon dioxide in the atmosphere and global temperature. In semiotic terms the graph operated as both an ‘index’, correlating Carbon dioxide concentration and global temperature and as ‘symbol’ of Global Warming. This film, and in particular the graph, became an important cultural moment in the mainstream discussion of global warming and may have contributed to personal shifts in recycling or more responsible air travel. The counter-argument is that the film effectively neutralised the underlying message of climate heating through an oversimplification and over circulation of the presented information. This reading of the film draws from Baudrillard’s claim that a message transported through information will be exhausted through over circulation (Baudrillard 1994). In particular, the focus on a single gas—Carbon dioxide—may obscure the causes of these changes which derive from the complex interplay between the Earth systems, social systems and technological systems. As Franklin Ginn suggests, the problem of ‘carbon dioxide has been fetishized to stand in as ‘the problem,’ masking the underlying causes of inequality and politics’ (Ginn 2015, pp. 351–52). Inequality, for example, cannot be explained by a 0.001% change in atmospheric Carbon dioxide. If *An Inconvenient Truth* simplified the problem the sequel to this film *An Inconvenient Sequel: Truth to Power* (Cohen and Shenk 2017), simplified the solution, as the focus shifted onto renewable energy and how capitalism and technology (conveniently), saves the planet: *deus ex machina*. As Fisher notes, ‘Environmental catastrophe features in late capitalist culture only as a kind of simulacra, its implications for capitalism too traumatic to be assimilated into the system’ (Fisher 2009, p. 18).

Thus, science, computation and the media contribute to the dominant feelings of the *Post-Systems Condition*, which is a profound sense of saudade for a lost nature, a lost future and lost self and the eerie feeling that we are caught within a system or simulation. For as we understand the complexities and interrelations between the natural world and the social world, our romantic understanding of nature, as a distinct location to be visited and protected melts away. We feel saudade, for the lost species, lost glaciers and lost habitats, but we also feel saudade for the lost idea of nature. As Morton states, ‘Nature elegy is a paradox, as it’s about losing something we never really had: losing a fantasy, not a reality’ (Morton 2012, p. 105). Thus, we may feel saudade for the simple narratives of the past which described nature in terms of a sentient-Gaia or a spaceship-Earth, as the more we understand the operations of the Earth, the more it has perceptually dematerialised, becoming eclipsed by its virtual simulation in data. As Morton states,

On the one hand, our world expands as our knowledge grows. But on the other hand, it shrinks: things are “less” than we thought they were. We discover that our more detailed understanding of how things connect with each other results in a loss of a sense of reality. A void opens up in our social and psychological space. (Morton 2012, p. 36)

Art has responded to the perceptual loss of nature in two interconnected ways. Firstly, there are artists who have sought to reassert our kinship with the Earth and its inhabitants, creating work which materially reconnects human culture with the wider ecosystems. This includes Olafur Eliasson and his expanded studio practice, Björk Guðmundsdóttir’s *Biophila* Education project and Simon Faithfull’s material engagement with the Earth as sculptural object. Secondly, there are artists who are challenging the encroachment of eerie systems either by reflecting upon or disrupting our entangled state. Art has a crucially important role in disrupting the technological-capitalist (systems) culture,

which has led to the converging crises of the Mass Extinction, Climate Heating and the loss of self. In particular, art needs to find new ways for us to live and affectively experience the material Earth, whilst challenging the psychologically unsustainable boundaries of our extended virtual realities. Artists, for example, Jon Rafman, Shana Moulton, Theo Triantafyllidis and David O'Reilly actively engage with the complexity and virtual nature of information on the Internet, social media and Google Earth to create works which reflect life in these information ecosystems. Jean Robertson suggested that artists operating within these digital spaces are, 'pioneers in helping us to confront what it means to live in a world of accelerated information flow from multiple channels and to find ourselves entranced by manufactured virtual worlds' (Robertson and McDaniel 2012, p. 17). O'Reilly, for example, created an immersive computer simulation game, *Everything* (O'Reilly 2017), which allows the participant to explore and procedurally generate virtual worlds whilst simultaneously listening to an audio archive of the philosopher Alan Watts discussing our entanglement with biological and ecological systems. This work exhibits the aesthetic experience of the eerie; operating as both an eerie absence of the material world and the eerie presence of the virtual. The work also instils a profound sense of saudade as the Watts recording from the 1970s describe a hopeful kinship with an idea of nature which has already been lost—replaced with a simulation.

There is also an eerie absence in Olafur Eliasson's photographs, for example, which record the receding glaciers of Iceland over the past twenty years, or satellite images which starkly map the deforestation of the Amazon. Conversely, there is an eerie presence in the photographs of starving polar bears searching for food in Siberian towns, as this vividly illustrates the breakdown of natural nature. Or the footage of Harambe, a 17-year-old silverback gorilla, who was shot dead on the 28 May 2016, as he tried to protect a child who fell into his pen at the Cincinnati Zoo. These images are too painful to view as they force us to acknowledge that Harambe was sentient, and expressed kinship with the boy despite our lack of care for Harambe and his lifeworld.

Ironically, at the point at which we start to understand that sentience extends across species, we feel saudade for a lost *self*. There is consequently an underlying pathos in contemporary culture, for lost cybernetic innocence, as the boundary of what is *self* and what is the wider system has become obscured. Luhmann observed that communication operates within *social systems*, whilst the *self* operates as a discrete *psychic system*. However, as we have become enmeshed within social networks and the increasingly fabricated simulations of ourselves online, the boundary between what is self and what is the wider social system becomes blurred.

The focus on social media and the constant reconfiguration of *self* is eerie in the two senses defined by Fisher. Firstly, there is a 'failure of absence' as there is an alien presence which compels speculation, as we look at our idealised simulation as a form of apparition or haunting. These algorithmically enhanced images are haunted; not in reference to the supernatural but the virtual, as they present a picture of the *self* which has never materially existed. Fisher described this haunted state as the 'agency of the virtual', or 'that which acts without (physically) existing' as these algorithmic images present a simulacrum' (Fisher 2016, p. 12). This also demonstrates a 'failure of presence', as the socially-networked *self* exists without a body or direct affective experience of the world. This eerie condition is demonstrated in the work of the artist Rachel Maclean, for example, *Feed Me* (2015), which confronts how the self is fractured and distributed through social media. Such work addresses the contemporary condition of externalising the *psychic system*, whilst constantly looking at the broken mirror of social media to see how much of the *self* remains.

We also feel saudade for lost futures, as the *Post-System Condition* decentres time and projects an atemporal multiversal reality. In contrast to the first two folds which imagined a future in either material terms, (Land Art), or social terms, (Relational Aesthetics), the *Post-System Condition* has obscured the axis of time. In the past, there was a sense of moving forward, progressing and a cultural *Fliessgleichgewicht* or flowing balance, whereas the contemporary landscape is a plane, on which everything is equally available. Manuel Delanda described this atemporal plane as the 'flat ontology' (Delanda 2013, p. 51). Thus, if everything or its digital simulation is made available to us by algorithms,

Artificial Intelligence and the Internet, how can the past be differentiated from the present and how can the underlying production rules be determined to create the future?

7. Conclusions

To some degree, our personal experience of the *Post-System Condition* depends on whether we were born before these cybernetic systems enfolded the Earth or after such technologies were commonplace, as each generation of artist experiences the enfoldment of systems and the perceptual loss of nature in fundamentally different ways. Artists of the 1960s will have a strong foundation in nature which predates nature's translation through text and technology, whereas artists of the 1990s are a generational bridge between the old world of material and conceptual clarity and the new world of technological-textual mediation. In contrast, artists born after 1985 have always had access to and operated within this expanded cybernetic territory, and digital information is often the primary source of material for their work. Thus, young artists of the *Post-Systems Condition* experience the *plane*, not of immanence but the Internet, and any *saudade* they may feel is for the immediate past where the cybernetic landscape was perceptually finite. As Hito Steyerl, an artist who emerged in the 1990s lamented,

The 1990s were about decoding and understanding these relations but now it's more about how to be immersed without drowning, or to be embedded without falling asleep and happily surrendering control of your feelings to a pervasive military-entertainment complex. (Heiser 2010)

These folds can be understood simultaneously as a period of time and a fold within human understanding. Thus, although each generation of artists experience the world and nature in a historically located manner, the ideas and perspectives generated by each fold remain equally available on the plane of ideas and the Internet.

Contemporary Art is engaging with the flat ontology of the internet and finding new ways to re-imagine our relationship with Earth Systems and nature. An example of this is Jason Rhoades' *The Creation Myth* (1998), which could lay claim to being the first artwork of the *Post-Systems Condition*. In this complex installation, a jumble of readymade consumer products, Rhoades explored both creationist and evolutionist creative 'myths' through the exploration of ecological, cybernetic and artistic systems; see Figure 2. The work has been understood as a portrayal of the mind and body as functional systems, and how these are continually extended and renewed through the circulation of materials within the wider ecosystem (Schaffner 2014, pp. 56–59).

Thus, if we return to Deleuze's concept of the fold and the house with two floors, where the ground floor is the material fold, and the first floor is the mental fold—*The Creation Myth*—the material artwork on the ground floor is enfolded by these mental descriptions from the upper floor, but crucially it is never exhausted by them. *The Creation Myth* is a material object which is an attempt to describe the model of the world in the mind of Rhoades, but not only does the work fail to fully describe what is in the mind of the artist, any description of the artwork fails to fully describe the withdrawn reality of the artwork also. Consequently, *The Creation Myth* demonstrates the Sisyphean task of triangulating between our affective experience of the material world, our interior world, (*psychic system*), which tries to make sense of our experiences and our shared social world, (*social system*), where we try and communicate this understanding.

The final example is Olafur Eliasson's global installation project, *Ice Watch*. In this ongoing project, the artist has collaborated with the geologist Minik Rosing to retrieve blocks of ice which are breaking off the main ice sheet at the Nuup Kangerlua fjord and falling into the sea. These blocks have then been shipped to several cities including London, Copenhagen and New York, to create temporary installations of ice. The London installation (2018), consisted of 30 blocks arranged together in the space between the Tate Modern Gallery and the Thames river. The audience could walk between and

directly interact with the blocks as they slowly transformed into water before running into the ground or evaporating into the atmosphere; see Figure 3.



Figure 2. Jason Rhoades, *The Creation Myth*, 1998/2015. Installation view. BALTIC Centre for Contemporary Art, Gateshead, UK. Friedrich Christian Flick Collection, Berlin. Photo: Colin Davison. © 2015 BALTIC Centre for Contemporary Art. Used by permission.



Figure 3. *Ice Watch* by Olafur Eliasson and Minik Rosing. Supported by Bloomberg. Installation: Bankside, outside Tate Modern, 2018. © 2018 Olafur Eliasson. Used by permission.

This is an interesting work as it performs the *Post-Systems Condition* of simultaneously engaging with the material world whilst implicating it in extended forms of simulation. The work engages with the environmental systems in operation, as the blocks are created by the action of climate

heating, and they melt in situ due to local environmental conditions. The work demonstrates the audience's entanglement with these environmental factors on three substantive levels. Firstly, the climate change of the Anthropocene is driven by human actions, and consequently, the audience is implicated as 'human'. Secondly, as residents of the city, the audience contributes to the local environmental conditions or 'urban heat island' which increases the local ambient temperature. Thirdly, on a personal level, the heat from the body as the individual touches the ice increases the melting process. Thus, this work powerfully demonstrates our entanglement within the environmental and climatic systems, which operate at the perceptual scales of the individual, community and planet. Consequently, the audience is entangled with the artwork and wider environment, which the artwork both describes and participates in—the audience is structurally coupled with the fate of the blocks of ice and the wider planetary climate system. As Lee notes,

Second-order cybernetics rests with the idea that the person who engages the system fundamentally alters it, or perhaps more radically put, constructs it, by virtue of the language used to describe its operations or ask its questions. The system is "autonomous" insofar as it is implicitly "constructed": it is what von Foerster refers to as "cybernetics of cybernetics." (Lee 2006, p. 66)

This understanding adds a level of nuance to our complicity, as although there are undoubtedly complex environmental systems in operation, our understanding of them is filtered through our senses and the tools we employ, (art and science) to describe our observations of the world. Thus, the imagined subjects of the artwork: *nature*, the Anthropocene or Climate Heating are mental simulations of the withdrawn reality. Consequently, the artwork can be understood as a simulation of a simulation and demonstrates Baudrillard's precession of simulacra, whereby the real and imaginary collapse together, and we are potentially lost somewhere between the two. As Morton suggests,

The ecological crisis makes us aware of how interdependent everything is. This has resulted in a creepy sensation that there is literally no world anymore. We have gained Google Earth but lost the world. "World" means a location, a background against which our actions become significant. But in a situation in which everything is potentially significant, we're lost. (Morton 2012, p. 30)

Returning to Deleuze's concept of the house with two floors, we can apply this to our relationship with *nature*, as the Earth in all its complexity is never completely mapped or obscured by our attempts to describe it through art and science and it will continue to exist without our observations. This quality of inexhaustibility points to a fundamental question. Is the material world becoming enfolded within our increasingly sophisticated descriptions and simulations, meaning that our experienced reality is predominantly mental and informational? Or is the material world merely extended by our information-driven, cybernetic and virtual activities and does our experience of these things reaffirm our grounded material nature?

The *Post-System Condition* traps us in an ever-expanding web of secondary experience and reconfigured digital signals which are divorced from the blood and soil realities of a stressed Earth. Thus, to break free from the digital simulations of both ourselves and the planet, we need to expand our notion of ecology to confront 'our ecologically endangered society to name what it cannot fathom, represent, or experience; a metaphor around which our whole society might revolve, as it were—one that would reorganise our knowledge and our discourses ecologically' (Hörl 2017, p. 4). That is, an ecological understanding of the world, including the operations of art, must expand beyond the organic material descriptions of the world to accommodate the informational, technological and virtual. Hörl captures this transformational thinking as "Cyberneticization crystallizes as Environmentalization" (Hörl 2017, p. 10). That is, if nature's true nature is informational, then we need to think relationally in order to observe and feel the flows of its energy.

Funding: This research received no external funding.

Acknowledgments: I would like to thank Olafur Eliasson, and the BALTIC Centre for Contemporary Art for permission to reproduce the photographs in Figures 1–3. I would also like to thank the reviewers and editors for their valuable comments.

Conflicts of Interest: The author declares no conflict of interest.

References

- Ascott, Roy. 2008. *Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness*, 1st ed. Berkeley: University of California Press.
- Barad, Karen. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press.
- Barthes, Roland. 1987. *Image Music Text*, new ed. London: Fontana Press.
- Roland, Barthes. 1991. *S/Z*. Translated by Richard Miller. New York: Farrar, Straus & Giroux Inc.
- Bateson, Gregory. 1979. *Mind and Nature: A Necessary Unity*. New York: Dutton.
- Baudrillard, Jean. 1994. *Simulacra and Simulation*. Translated by Sheila Glaser. Ann Arbor: University of Michigan Press.
- Bennett, Jane. 2004. The Force of Things: Steps toward an Ecology of Matter. *Political Theory* 32: 347–72. [\[CrossRef\]](#)
- Bennett, Jane. 2010. *Vibrant Matter: A Political Ecology of Things*. A John Hope Franklin Center Book. Durham: Duke University Press.
- Bertalanffy, Ludwig Von. 1968. *General Systems Theory*. New York: George Braziller.
- Bourriaud, Nicolas. 1998. *Relational Aesthetics*. France: Les Presse Du Reel.
- Brown, Paul, Catherine Mason, Charlie Gere, and Nicholas Lambert, eds. 2009. *White Heat Cold Logic: British Computer Art 1960–1980*. Cambridge: MIT Press.
- Burnham, Jack, Melissa Ragain, and Hans Haacke. 2015. *Dissolve into Comprehension: Writings and Interviews, 1964–2004*. Cambridge: MIT Press.
- Capra, Fritjof, and Pier Luigi Luisi. 2014. *The Systems View of Life: A Unifying Vision*. Cambridge: Cambridge University Press.
- Carson, Rachel. 2000. *Silent Spring*, new ed. London: Penguin Classics.
- Cohen, Bonni, and Jon Shenk. 2017. *An Inconvenient Sequel: Truth to Power*. Film. Los Angeles: Participant Media, Paramount Pictures.
- Darwin, Charles. 2011. *The Origin of Species*, 1st ed. London: William Collins.
- Dawkins, Richard. 2016. *The Selfish Gene: 40th Anniversary Edition*, 4th ed. New York: OUP Oxford.
- De Salvo, Donna, ed. 2005. *Open Systems: Rethinking Art C. 1970*, 1st ed. London: Tate Publishing.
- De Saussure, Ferdinand, and Roy Harris. 2013. *Course in General Linguistics*. Bloomsbury Revelations. London: Bloomsbury Publishing.
- Debord, Guy. 2009. *Society of the Spectacle: Written by Guy Debord*, 2009th ed. Eastbourne: Soul Bay Press.
- Delanda, Manuel. 2013. *Intensive Science and Virtual Philosophy (Bloomsbury Revelations)*. London: Bloomsbury Academic.
- Deleuze, Gilles. 1993. *The Fold: Leibniz and the Baroque*. Oxford: Athlone Press.
- Deleuze, Gilles. 2006. *Foucault*, reprint ed. London: Continuum.
- Deleuze, Gilles, and Félix Guattari. 1988. *A Thousand Plateaus: Capitalism and Schizophrenia*. Athlone Contemporary European Thinkers Series; Oxford: Athlone Press.
- Demos, Thomas J. 2017. *Against the Anthropocene: Visual Culture and Environment Today*. Berlin: Sternberg Press.
- Eco, Umberto, and David Robey. 1989. *The Open Work*. Translated by Anna Cancogni. Cambridge: Harvard University Press.
- Figueiredo, Eurico. 1991. *Psicanálise da Saudade [Psychoanalysis of Saudade]*. Lisboa: O Jornal.
- Fisher, Mark. 2009. *Capitalist Realism: Is There No Alternative?* Winchester: O Books.
- Fisher, Mark. 2016. *The Weird and the Eerie*. London: Watkins Media Limited.
- Flader, Susan L. 1994. *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude Toward Deer, Wolves and Forests*, 2nd rev. ed. Madison: University of Wisconsin Press.
- Fuller, R. Buckminster. 2008. *Operating Manual for Spaceship Earth*. Edited by Jaime Snyder. Oslo: Lars Muller.
- Gere, Charlie. 2006. *Art, Time and Technology*, English ed. Oxford and New York: Berg Publishers.

- Ginn, Franklin. 2015. When Horses Won't Eat: Apocalypse and the Anthropocene. *Annals of the Association of American Geographers* 105: 351–59. [CrossRef]
- Glimcher, Marc. 2005. *Logical Conclusions—40 Years of Rule-Based Art*. New York: Pace Wildenstein.
- Grusin, Richard, ed. 2015. *The Nonhuman Turn*. Minneapolis: University of Minnesota Press.
- Guggenheim, Davis. 2006. *An Inconvenient Truth*. Hollywood: Paramount Classics.
- Hagen, Joel B. 2008. Teaching Ecology during the Environmental Age, 1965–1980. *Environmental History* 13: 704–23. [CrossRef]
- Halsall, Francis. 2008. *Systems of Art: Art, History and Systems Theory*, 1st new ed. Bern and Oxford: Verlag Peter Lang.
- Haraway, Donna. J. 1991. *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Free Association Books.
- Haraway, Donna. J. 2008. *When Species Meet*. ISSR Library. Minneapolis: University of Minnesota Press.
- Haraway, Donna J. 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Experimental Futures. Durham: Duke University Press.
- Hardin, Garrett. 1968. The Tragedy of the Commons. *Science* 162: 1243–48. [PubMed]
- Harman, Graham. 2016. *Immaterialism: Objects and Social Theory*. Malden: Polity Press.
- Hayles, N. Katherine. 1999. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, 74th ed. Chicago: University of Chicago Press.
- Heiser, Jörg. 2010. 'Analyze This'. Frieze. Available online: <https://frieze.com/article/analyze?language=de> (accessed on 6 August 2019).
- Hopkins, D. 2000. *After Modern Art 1945–2000*. Oxford History of Art. Oxford: OUP Oxford.
- Hörl, Erich. 2017. *General Ecology: The New Ecological Paradigm*. Edited by James Edward Burton. London: Bloomsbury Academic.
- Kholeif, Omar. 2018. *Goodbye, World!: Looking at Art in the Digital Age*. Berlin: Sternberg Press.
- Landow, George P., ed. 1991. *Hypertext: The Convergence of Contemporary Critical Theory and Technology*. Baltimore: The Johns Hopkins University Press.
- Laruelle, Francois. 2013. *Principles of Non-Philosophy*. London: Bloomsbury Academic.
- Latour, Bruno. 2007. *Reassembling the Social: An Introduction to Actor-Network-Theory*, new ed. Oxford: Oxford University Press.
- Lee, Pamela M. 2006. *Chronophobia: On Time in the Art of the 1960s*. Cambridge and London: MIT Press.
- Lippard, Lucy. 1973. *Six Years: The Dematerialization of the Art Object from 1966 to 1972*. Westport: Praeger.
- Lovelock, James. 2016. *Gaia: A New Look at Life on Earth*. 2 Reprint editions. Oxford: OUP Oxford.
- Luhmann, Niklas. 1995. *Social Systems*. Edited by Timothy Lenoir and Hons Ulrich Gumbrecht. Palo Alto: Stanford University Press.
- Luhmann, Niklas. 2000. *Art as a Social System*. Translated by Eva M. Knodt. Stanford: Stanford University Press.
- Lyotard, Jean-Francois. 1984. *The Postmodern Condition: A Report on Knowledge*. Theory and History of Literature. Minneapolis: University of Minnesota Press.
- Malik, Suhail, Christoph Cox, and Jenny Jaskey. 2015. *Realism Materialism Art*. Berlin: Sternberg Press.
- Manovich, Lev. 2001. *The Language of New Media*. Leonardo (Series); Cambridge: MIT Press.
- Marks, Laura U. 2010. *Enfoldment and Infinity: An Islamic Genealogy of New Media Art*. Leonardo (Series); Cambridge: MIT Press.
- Maturana, Humberto R., and Francisco J. Varela. 1980. *Autopoiesis and Cognition: The Realization of the Living*, 1980th ed. Dordrecht and Boston: Springer.
- McHugh, Gene. 2011. Post Internet. Available online: Lulu.com (accessed on 24 September 2019).
- Meillassoux, Quentin, and Alain Badiou. 2009. *After Finitude: An Essay on the Necessity of Contingency*, reprint ed. London and New York: Continuum.
- Meltzer, Eve. 2013. *Systems We Have Loved: Conceptual Art, Affect, and the Antihumanist Turn*. Chicago and London: University of Chicago Press.
- Morais, António de. 1990. *Novo Dicionário Compacto da língua Portuguesa (New Compact Dictionary of Portuguese Language)*, 6th ed. Mem Martins: Editorial Confluência.
- Morton, Timothy. 2012. *Ecological Thought*, reprint ed. Cambridge and London: Harvard University Press.
- Neto, Félix, and Etienne Mullet. 2014. A Prototype Analysis of the Portuguese Concept of Saudade. *Journal of Cross-Cultural Psychology* 45: 660–70. [CrossRef]

- Nisbet, James. 2014. *Ecologies, Environments, and Energy Systems in Art of the 1960s and 1970s*. Cambridge: MIT Press.
- O'Sullivan, Simon. 2005. *Art Encounters Deleuze and Guattari: Thought Beyond Representation*. Renewing Philosophy. Basingstoke: Palgrave Macmillan UK.
- Odum, Eugene. 2017. *Fundamentals of Ecology*, 5th ed. Australia: Cengage Learning.
- O'Reilly, David. 2017. *Everything*. Computer Game. San Francisco: Double Fine Productions.
- Pianka, Eric R. 1997. *Evolutionary Ecology*, 5th ed. New York: Benjamin Cummings.
- Pitt, David, and Paul R. Samson. 2012. *The Biosphere and Noosphere Reader: Global Environment, Society and Change*. Abingdon: Taylor & Francis.
- Robertson, Jean, and Craig McDaniel. 2012. *Themes of Contemporary Art: Visual Art After 1980*, 3rd rev. ed. New York and Oxford: Oxford University Press.
- Schaffner, Ingrid. 2014. *Jason Rhoades: Four Roads*. University of Pennsylvania, Institute of Contemporary, Kunsthalle Bremen, C. Kraus, and Baltic Centre for Contemporary Art. Munich: Prestel Publishing.
- Shanken, Edward A. 2015. *Systems*. Cambridge: MIT Press.
- Shannon, Claude E., and W. Weaver. 1998. *The Mathematical Theory of Communication*. Champaign: University of Illinois Press.
- Smithson, Robert, and Jack Flam. 1996. *Robert Smithson: The Collected Writings*. Documents of Twentieth-Century Art. Berkeley: University of California Press.
- Steyerl, Hito, and Franco Berardi. 2012. *The Wretched of the Screen*. Berlin: Sternberg Press.
- Teixeira, António Braz. 2006. *A Filosofia da saudade [Philosophy of Saudade]*. Lisboa: Quidnovi.



© 2019 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).