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Zentrum für Literatur- und Kulturforschung Berlin

The »Ecosystem« Concept in the Political Ecology Discourse

Benjamin Bühler

In the 20th century, the term »ecosystem« was one of the most important concepts for the biological discipline »ecology.« Originally coined by the English botanist Arthur G. Tansley in an article from 1935, it is now a well-established term. The authors of the textbook *Ecology* write, the ecosystem concept »has become a powerful tool for integrating ecology with other disciplines.«[1] But this only addresses the scientific resonance of the term.[2] In the 1970s »ecosystem« also became an important concept for the environmental movement, for the term »ecosystem« describes nature as a whole entity, in which all things are linked together, forming a network of biotic and abiotic factors. In this sense, the »ecosystem« concept also took on a key role in the political ecology discourse.

This article begins with a look at the political ecology discourse, and then focuses on the formation of the »ecosystem« concept. The terminological development of the term turns first to the linguistic definition of »ecosystem« before looking how the ecosystem became an established concept by transforming the object »lake« into the scientific object »ecosystem.« Sections four and five further pursue the role of the ecosystem concept in the environmental discourse, based on the metaphor of »spaceship earth« on the one hand and of the »closing circle« on the other. Finally, the article contextualizes the »ecosystem« concept in conjunction with Claude Lefort's concept of »the political.«

As we will see, the political impact of the »ecosystem« concept inheres in the very term itself for it describes a wholeness that human beings are inevitably a part of even as their actions alter or disturb with the ecosystem fundamentally. In other words, human beings are both inside and outside of the »ecosystem« at the same time. This paradoxical situation is inevitably constituted by the concept »ecosystem«, which is understood as a (nearly) closed system. Hence solutions to environmental problems aim at reintegrating human beings into the closed circle of the global ecosystem through technical constructions or through adapting to natural processes.

1 Michael L. Cain/William D. Bowman/Sally D. Hacker: *Ecology*, Sunderland, MA 2008, p. 414.

2 For more details on the history of the ecosystem concept, see: Frank Benjamin Golley: *A History of the Ecosystem Concept in Ecology. More than the Sum of the Parts*, New Haven/London 1993.

1. Political Ecology

Ecology is neither just a scientific discipline nor simply a metaphor in the environmental movement. As Hans Magnus Enzensberger points out, ecology is a hybrid, in which scientific and socio-scientific categories and methods are mixed together, without the consequences of this mixture having received adequate theoretical reflection.[3] The sociologist Niklas Luhmann writes that there is no social subsystem »ecology.« Instead, there are just interferences between social systems like law, science, or politics that are connected to ecology.[4] Thus, one can conclude, ecology has no defined position in these social systems, meaning that ecology is located in the space *between* social systems. Also the ecologist Ludwig Trepl points out that the term »ecosystem« describes a hybrid »leading science« (»Leitwissenschaft«) with a methodologically and ideologically hybrid character:[5] Ecology describes an assemblage of different sciences (biology, chemistry, physics, toxicology, etc.), technologies (solar engineering, recycling, etc.), moral concepts, lifestyles, and political attitudes.

Against this background it makes sense to call this »hybrid« a discourse following Michel Foucault's use of the term. The political ecology discourse is, therefore, arranged according to specific objects (e.g., the earth, the population), enunciative modalities (e.g., manifestos, programmatic texts), political interventions (e.g., protests, definition of critical values, programs), institutions (e.g., political parties like The Green Party; IPCC), and concepts (e.g., Lebensqualität/quality of life; sustainability, ecosystem).

Real things and events, like radioactive substances, the threat of wide-spread animal extinction or large quantities of plastic in the sea, are central topics in political ecology; nevertheless, this discourse is organized by products of the imagination, above all by fictions of the future and of wholeness. These fictions can appear in different shapes and genres. The future is often represented by graphs, as for example in the prominent study for the Club of Rome, *The Limits of Growth* (1972), which developed a computer model for unrestrained population growth with limited resources. Manifestos like *A Blueprint for Survival* (1972) are also an important genre with an appealing character. There are also literary models like Ernest Callenbach's utopian novels *Ecotopia* (1975) and *Ecotopia Emerging* (1981), or Margaret Atwood's dystopian novels *Oryx and Crake* (2003) and *The Year of the Flood* (2009), as well as movies like Richard Fleischer's *Soylent Green* (1973) or Roland Emmerich's *The Day After Tomorrow* (2004). New assemblages of different sciences might also be mentioned, for example, industrial ecology tries to improve the flow of materials in industrial systems and is therefore based on a promise about future conditions. In an important article on this approach, Robert Frosch and Nicholas F. Gallopoulos presented a model of the »industrial ecosystem« as analogous to biological ecosystems: »In such a system the consumption of energy and materials is optimized, waste generation is minimized and the effluents of one process – whether they are spent catalysts from petroleum refining […] or discarded plastic containers from consumer products – serve as the raw material for another process.«[6]

Visions of future scenarios do not merely illustrate possible developments to come; they also govern politics of the present: Statements about climate change initiate the implementation of new energy technologies; novels or publications like the *Whole Earth Catalog* inspire social movements (or at least try to). The philosopher Hans Jonas, to name an example from yet another field, developed an ethics for the future in his well-known book *The Imperative of Responsibility: In Search of Ethics for the Technological Age* (in German: *Das Prinzip Verantwortung*, 1979), which emphasizes the responsibility of coming

3 Hans Magnus Enzensberger: »Zur Kritik der politischen Ökologie«, in: *Kursbuch* 33 (1973), pp. 1–42, here p. 1.
4 Niklas Luhmann: *Ökologische Kommunikation. Kann die moderne Gesellschaft sich auf ökologische Gefährdungen einstellen*, Opladen 1986.
5 Ludwig Trepl: *Geschichte der Ökologie. Vom 17. Jahrhundert bis zur Gegenwart. Zehn Vorlesungen*, Frankfurt am Main 1987, p. 226.
6 Robert Frosch/Nicholas F. Gallopoulos: »Strategies for Manufacturing«, in: *Scientific American* 261 (1989) 3, pp. 94–102, here p. 94.

generations and culminates in the call for a new Machiavelli in as the political sphere proper begins to enter its twilight. These are just a few select instances that show how political acts and decisions are based on scenarios about the future.

Ecology's imaginary force also demonstrates itself in the concept of complex wholeness, in expressions like the »biosphere«, »ecosphere«, »ecosystem«, »spaceship earth«, or »life support system«. Therefore, it is no surprise that the 1972 photograph taken from Apollo 17 of the earth as a »blue marble« became the initial symbol for the environmental movement as it was starting in the 1970s. Furthermore, the idea of the »Anthropocene«, which is currently being discussed intensively, is based on a fiction of wholeness, namely, the earth as a »biosphere«.[7]

This scientific-political imagination constitutes, organises, and legitimates the political ecology discourse. It is constituted of scientific statements, medial representations; it is structured by narrative and rhetoric forms; and it represents a regulating factor for political acts. The history of the concept »ecosystem« must be analysed within this framework.

2. The emergence of the ecosystem concept

Arthur G. Tansley was an English botanist as well as co-founder and president of the British Ecological Society. In his article »The Use and Abuse of Vegetational Concepts and Terms« (1935), he discusses concepts describing plant formations. He contradicts the articles by John Phillips, a follower of the botanist Frederick Clements. Clements and Phillips describe plant formations as »complex organisms«, following the Jan Christian Smuts' holism theory. Tansley disagrees with the analogy between plant formations and individual organisms. By extension, Tansley aims to pinpoint the object of the emerging science of »ecology« by discussing other possible concepts for thinking of organism collectives. That means that the object of scientific study has to first be conceptualized on »linguistic grounds«.[8] Until it was grounded in language, there could be no such discipline as ecology.

Tansley dismisses expressions like »complex organism« and »quasi-organism« because of the analogy to the individual organism. He rejects »biocoenosis« because of the focus on equilibration, and »biotic community« because it implies certain equality among its members, but animals and plants, Tansley argues, are not common members of anything except the organic world. In contrast, he proposes the term »system«:

> *But the more fundamental conception is […] the whole* system *(in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome – the habitat factors in the widest sense. Though, the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment with which they form one physical system. […] Our natural human prejudices force us to consider the organisms (in the sense of the biologist) as the most important parts of these systems, but certainly the inorganic factors are also parts – there could be no systems without them, and there is constant interchange of the most various kinds within each system, not only between the organisms but between the organic and the inorganic. These* ecosystems*, as we may call them, are of the*

7 Paul J. Crutzen/Eugene F. Stoermer: »The Anthropocene«, in: *Global Change Newsletter* 41 (2000), pp. 17–18.
8 Arthur G. Tansley: »The Use and Abuse of Vegetational Concepts and Terms«, in: *Ecology* 16 (1935), pp. 284–307, here p. 296.

most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom.[9]

The components of an ecosystem therefore include animals and plants in addition to physical factors like temperature, salinity, the composition of soil, and rainfall. Tansley also develops a new concept of climax. For Clements, a plant formation develops according to the growth of an individual organism, but Tansley now uses this new term to counter Clements' claim: »The climax represents the highest stage of integration and the nearest approach to perfect dynamic equilibrium that can be attained in a system developed under the given conditions and with the available components.«[10] Ecosystems are thus self-regulating and self-organizing systems, which seek to achieve a state of dynamic equilibrium.

Human beings are also components of ecosystems. By introducing sheep and cattle into a region, humans alter the ecosystem: They kill carnivores in order to protect his herds, and together with the animals they create an ecosystem whose »essential feature is the equilibrium between the grassland and the grazing animals.«[11] These »anthropogenic ecosystems« differ from ecosystems that develop independent of human interference, while the essential formative processes of the vegetation remain the same, »however the factors initiating them are directed.«[12] With Tansley we arrive at the conclusion that humans are a component of ecosystems like plants, animals, and physical factors. In this vein, Tansley casually annihilates the difference between nature and culture; for him, there are just ecosystems. Already in the earliest formulations of the »ecosystem« concept, one recognizes the foundations of what will later become actor-network-theory.[13]

The »ecosystem« concept isolates systems for the purpose of study, »so that the series of *isolates* we make become the actual objects of our study, whether the isolate be a solar system, a planet, a climatic region, a plant or an animal community […].«[14] The concept constitutes ecology's object, but it is an artificial, technical object.[15] Tansley argues that this type of isolation is necessary for ecological study – yet, as we will see, this concept also implies the possibility of manipulating ecosystems.

Tansley draws distinctions between different systems corresponding to orders of stability: There are exceptionally stable systems like atoms or chemical elements with a low atomic number. But ecosystems also consist of unstable components (climate, soil, organisms) and they have permeable borders. Components from other ecosystems can become invasive, and certain components from one ecosystem might emigrate to other systems.[16] Consequently, ecosystems are »extremely vulnerable« and unstable. That means the state of equilibrium in ecosystems is also unstable. And although there are ecosystems that have maintained themselves for thousands of years, Tansley points out that the equilibrium in ecosystems is regularly subject to change. In this respect, his claims anticipate current debate: Above all nature protection advocates often argue that a special state of nature has to be conserved, but from an ecological viewpoint one might also argue that all ecosystems are changing all the time. An ecological equilibrium is always a »stable instability« or a »discordant harmony«.[17]

9 Ibid., p. 299.
10 Ibid., p. 300.
11 Ibid., p. 304.
12 Tansley: »The Use and Abuse of Vegetational Concepts and Terms« (note 8), p. 304.
13 Bruno Latour: *Politiques de la nature. Comment faire entrer les sciences en démocratie*, Paris 2004.
14 Tansley: »The Use and Abuse of Vegetational Concepts and Terms« (note 8), p. 300.
15 »The isolation is partly artificial, but is the only possible way in which we can proceed.« Ibid., p. 300.
16 Ibid., p. 301.
17 See e.g. Daniel Botkin: *Discordant Harmonies. A New Ecology for the Twenty-First Century*, Oxford 1992; Josef Reichholf: *Stabile Ungleichgewichte. Die Ökologie der Zukunft*, Frankfurt am Main 2008.

With his formulation of the ecosystem concept (especially in his use of system in the physical sense), Tansley gave a new discipline its object of study: »[…] nobody denies the necessity for investigation of all the components of the ecosystem and of the ways in which they interact to bring about approximation to dynamic equilibrium. That is the prime task of the ecology of the future.«[18]

Tansley's article operates on a linguistic and theoretic level, where it remained for him, as he himself did not use the concept in his experimental scientific work. To ensure the success of the ecosystem concept, empirical studies were still needed to show how the new concept could be applied.

3. From the lake to the ecosystem

The predestined object for such a study would prove to be a lake, which is a relatively closed system by nature. Scientists want to make observations and undertake experiments under controlled conditions, so they can study the relations between different organisms and between organisms and their physical environments. But such scientific studies cannot really be done in a laboratory, which is why a nearly closed and complex thing like a lake has a high heuristic value. However, it is not as simple as that. Ecological knowledge cannot simply be gathered from the lake. Instead, the lake is transformed into an ecological object. This transformation of a natural thing into a scientific object is also due to the emergence of the system as a concept. Parallels in the conceptual history of the system and history of ecological research on lakes culminate in the implementation of the »ecosystem« concept and in the emergence of the »New Ecology«.[19]

Stephen A. Forbes was one of the first scientists to conceive of a lake as a scientific object. In his article *The Lake as a Microcosm* (1887), he outlined how the organisms in a lake live almost independently from the land and how the equilibrium in a lake is more complete than the equilibrium on land. The lake would be »a microcosm within which all the elemental forces are at work and the play of life goes on in full, but on so small a scale as to bring it easily within the mental grasp.«[20] It would not be possible to study just one species in a lake because whatever happens to that one species has consequences for the total assemblage in the lake. If a researcher examines the black bass, he will have to include all the other species that depend on the existence of the black bass in his research. He has to further include the conditions that all these species depend on as well as the competitors of the black bass and all the conditions they depend on. Forbes also already accounts for human beings, as when he examined lakes in Illinois, which are protected »from the filth and poison of towns and manufactories by which the running waters of the state are yearly more deeply defiled.«[21]

There was a consensus between researchers that the lake was predestined to become the object of biological research, but there was a debate concerning the methods of that process, namely, regarding how the lake is described as a unified whole. In this context, the German limnologist August Thienemann supported Forbes' article, but he does not adopt the term »microcosm«. Instead, Thienemann introduces the terms »Lebensraum« and »Lebensgemeinschaft«. Like Tansley, he stresses the fact that the equilibrium in a system is the result of the enormous number of interrelations between the members of the living community (»Lebensgemeinschaft«).[22] He also states that this equilibrium is »unstable« because of the

18 Tansley: »The Use and Abuse of Vegetational Concepts and Terms« (note 8), p. 305.
19 See, for example, Eugene P. Odum/Howard T. Odum: *Fundamentals of Ecology*, Philadelphia 1953.
20 Stephen A. Forbes: »The Lake as a Microcosm«, in: *Bulletin of the Scientific Association* (Peoria, IL) 1887, pp. 77–87, here p. 77.
21 Ibid., p. 78.
22 August Thienemann: »Lebensgemeinschaft und Lebensraum«, in: *Naturwissenschaftliche Wochenschrift* 17 (1918), pp. 181–290.

dynamic conditions in the »Lebensraum«, which he explains as being shaped by chemical, physical, and geographic factors.[23]

Thienemann defined limnology in his article, *Die Bedeutung der Limnologie für die Kultur der Gegenwart* (1935), as a scientific discipline, whereby limnological thinking is basically just another name for holistic thinking. Thienemann choses the lake as an object of study because it represents a complete whole. That is to say, the object lake constitutes the concept of wholeness and by this process the lake is transformed in a scientific object. To paraphrase Hans-Jörg Rheinberger: The inscription of scientific concepts transforms the natural lake into the lake as an epistemic thing.[24]

Given this process of transformation, the diagrammatical representation of the lake is also important to take into consideration. In his article »Nahrungskreislauf im Wasser« (1926), Thienemann concludes that we have to face the difficulty of establishing order amidst the chaos of all the factors in a lake. One complicating aspect here is that every individual factor affects the entire »Lebensgemeinschaft«, and at the same time the conglomeration of factors taken together constitutes an individual factor which, in turn, affects the parts of the system.[25] The representation of these relations in words would be nearly impossible, so Thienemann produces the following diagram.[26]

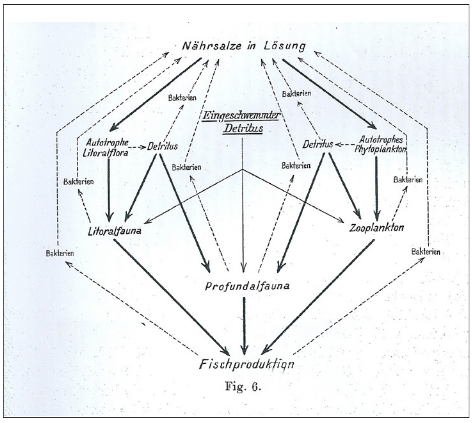

Diagram 1: Nahrungskreislauf in einem See nach Thienemann 1926

The diagram shows the direction of the composition and decomposition of organic substances and reveals how human interventions disrupt the circulation of substances. But Thienemann emphasizes that the diagram cannot show all the interrelations – the circulation of substances is too complex.

The notion »system« appears as a solution to the problem of finding an appropriate description for ecological complexity. Here the lake is not just a field of application, but as an object it also constitutes the very concept of a system and illustrates it at the same time. This can be seen in an article by the German zoologist Richard Woltereck on the specificity of the »Lebensraum«, feeding habits, and body forms of *Cladocera*. For Woltereck, the lake is an irreplaceable object.[27]

In his description of the lake as a complete whole, Woltereck refers to the concept of *Gestalt* by way of *Die physischen Gestalten in Ruhe und im stationären Zustand* (1920), published by the German gestalt-theorist and psychologist Wolfgang Köhler.[28] In his book, Köhler tries to apply the psychological holistic concept of *Gestalt* to the fields of physics, chemistry, and physics. Köhler was convinced that this application would only be possible in biology, especially for the description of organisms; in this respect, the *Gestalt* concept served as a holistic alternative to concepts developed by mechanists and vitalists.[29] In opposition to Köhler, Woltereck applies the concept of *Gestalt* not on an individual level but rather on the level of the population. He concludes that ecological *Gestalt*-systems,

23 In the 1930s and 1940s, Thienemann conceptualized this approach as a national-socialist, »Blut und Boden« ideology, which made a strong impression on the German sense of »ecology« and the image of nature in Germany for a long time after 1945. For more on this issue, see: Thomas Potthast: »Wissenschaftliche Ökologie und Naturschutz: Szenen einer Annäherung«, in: Joachim Radkau/Frank Uekötter (eds.): *Naturschutz und Nationalsozialismus*, Frankfurt am Main 2003, pp. 225–254.

24 Hans-Jörg Rheinberger: *Experiment, Differenz, Schrift. Zur Geschichte epistemischer Dinge*, Marburg an der Lahn 1992.

25 August Thienemann: »Der Nahrungskreislauf im Wasser«, in: *Verhandlungen der Deutschen Zoologischen Gesellschaft* 31 (1926), pp. 29–79, here p. 36 f.

26 Ibid., p. 57.

27 Richard Woltereck: »Über die Spezifität des Lebensraumes, der Nahrung und der Körperformen bei pelagischen Cladoceren und über Ökologische Gestalt-Systeme«, in: *Biologisches Zentralblatt* 48 (1928), pp. 521–551, here p. 539.

28 Wolfgang Köhler: *Die physischen Gestalten in Ruhe und im stationären Zustand. Eine naturphilosophische Untersuchung*, Erlangen 1920.

29 Benjamin Bühler: *Lebende Körper. Biologisches und anthropologisches Wissen bei Rilke, Döblin und Jünger*, Würzburg 2004, pp. 75–88.

which include organic and inorganic factors, display the same qualities as physical systems, for example, like a conducting medium, through which electric current flows.[30]

4. Quantifying the »ecosystem«

While ecology does appear to have immediate relevance as an experimental field for holistic concepts, its inception has other important facets. The early researchers on ecological questions (zoologists, like Woltereck, or botanists, like Tansley) had to build consensus because the concept used to describe ecological wholeness was also the very definition of the emerging new discipline of ecology. To be sure, there was a tendency to employ the concept of a system in a physical sense, following the use of concepts like organic community or biome (both terms excluded abiotic factors), and microcosm, *Lebensraum*, *Lebensgemeinschaft*, or *Gestalt*-system. Ecology was, however, able to establish itself as a concept in no small part due to the possibility of quantitatively measuring the relations in an ecosystem. Two examples help to show how the concept was thusly reinforced:

Alfred Lotka's book *Elements of Physical Biology* (1926, in 1956 published with the title *Elements of Mathematical Biology*) aimed at a quantification of biology in general. Lotka formulated equations to calculate the evolution of systems and demonstrate the conditions of equilibrium within systems. Lotka points out that the evolution of systems is irreversible, and thus the law of evolution would be nothing other than a reiteration of the second law of thermodynamics: Evolution increases entropy. But this approach is not without problems in biological systems:

> *To attempt application of these methods to the prime problems of organic evolution is much like attempting to study the habits of an elephant by means of a microscope. It is not that the substance of the elephant is inherently unfitted to be viewed with the microscope; the instrument is ill adapted to the scale of the object and of the investigation.*[31]

To adapt the scale, Lotka examines biological entities such as atoms or molecules and looks at population density, population pressure, and population growth. At the level of the population, he can alter his systems of equations to correspond better to the scale of biological entities. In this way, the relations between organisms also became a matter for his study of mathematical biology. Lotka chose to focus on aquatic life so as to be able to include the human impact on the relations between organisms from the beginning. Aquatic life would moreover help illustrate an economic account of natural sciences. Lotka does not mention the concept of ecology or ecosystem, but he comes to conclusions that are similar to those of Forbes and Thienemann: If one is interested in the eating habits of animals or humans, it will not suffice to look just at the individual organism. The »economic biologist« has to give consideration to entire food cycles: »Food chains, were we able to trace them through their entire course, would undoubtedly be found to form closed cycles or a network of cycles.«[32] It is from this vantage point that Lotka then attends to the mathematical description of water, oxygen, carbon, and nitrogen cycles.

But the most important case study behind the establishment of the term »ecosystem« was Raymond Lindeman's work on the Cedar Creek Bog in Minnesota. The result of this work, which he started in the 1930s, is the article »Trophic-Dynamic Aspects of Ecology« (1942), which remains important to this day. In the article, Lindeman draws connections explicitly to Tansley's ecosystem concept. He further

30 Woltereck: »Über die Spezifität des Lebensraumes« (note 27), p. 541.
31 Alfred Lotka: *Elements of Mathematical Biology*, New York 1956, p. 39.
32 Ibid., pp. 176 and 183.

points out that a lake is »a primary unit in its own right«.[33] In this unit, the differences between living organisms (as parts of the »biotic community«), dead organisms, and inorganic nutrients (as parts of the »environment«) would seem arbitrarily. Lindeman recapitulates different positions held by others, such as Clements and Thienemann, but when it comes to interpreting data from the field of dynamic ecology, he prefers Tansley's term »ecosystem«. In doing so he surpasses Tansley by applying the abstract concept to concrete data that he collected in his study on the lake. By reformulating biological quantities in terms of energetic quantities, he was able to highlight the productivity of the ecosystem:

> *In the following pages we shall consider the quantitative relationships of the following productivities: λ_0 (rate of incident solar radiation), λ_1 (rate of photosynthetic production), λ_2 (rate of primary or herbivorous consumption), λ_3 (rate of secondary consumption or primary predation), λ_4 (rate of tertiary consumption). The total amount of organic structure formed per year for any level λ_n, which is commonly expressed as the annual »yield«, actually represents a value uncorrected for dissipation of energy by (1) respiration, (2) predation, and (3) post-mortem decomposition.*[34]

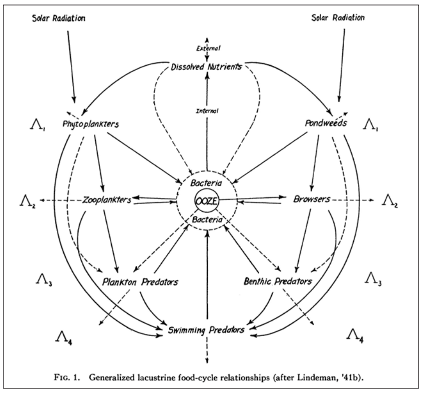

Diagram 2: Ecosystem after Lindeman

The details of Lindeman's approach are not pertinent to the contexts that this article explores. The quantification of biological relations through the concept of ecosystem, however, is highly significant to our discussion. Lindeman is then able to translate his data from its linguistic, descriptive form into a diagram.

Lindeman's diagram shows the energetic relations between different levels (λ). The presentation of related elements within a closed entity means that we are dealing with a diagrammatic representation of an ecosystem. In contrast to Thienemann's graph, Lindeman's diagram depicts the object itself as interchangeable. The lake that provided the data for Lindeman's diagram is transformed into a scientific object or, in other words, into a technical object.

The explosive character of Lindeman's article manifests itself in his arduous efforts to get it published.[35] He gave his article to the journal *Ecology*, but two experts, Chancey Juday and Paul Welch, advised against its publication in the journal because, according to them, Lindeman's article referred to a lake as an »imaginary object«, and it lacked sufficient data. It was only after George Evelyn Hutchinson's intervention, the leading figure in the US in the field of limnology, that the article was finally published in the journal. As Hutchinson pointed out, he would prefer an article with far-reaching hypotheses, which could be tested with actual data and which could be generalized, to the endless number of papers that present data without ever referring to each other. Lindeman's transformation of a lake into a system of energetic quantities thus became the symbol for the theoretical turn in ecology. Researchers like Eugene Odum and others then proceeded to develop the New Ecology.

But against this background it is not surprising that the ontological status of the »ecosystem« was called into question. For example, an article from 1981 entitled »Do Ecosystems Exist?« further asks: Are *ecosystems* assemblages of species? Or are they »cybernetic systems« or »information networks«?[36] What should be clear at this point in our historical overview of the concept's development is that »ecosystems«

33 Raymond L. Lindeman: »The Trophic-Dynamic Aspect of Ecology«, in: *Ecology* 23 (1942), pp. 399–417, here p. 399.
34 Ibid., p. 403
35 For the following see: Robert E. Cook: »Raymond Lindeman and his Trophic-Dynamic Concept in Ecology«, in: *Science* 198 (1977), pp. 22–26.
36 Carl F Jordan: »Do Ecosystems Exist?«, in: *The American Naturalist* 118 (1981), 2, pp. 284–287, here p. 284.

are scientific objects thanks to the precedent set by early researchers who established the lake as an object of study. But the borders of ecosystems are artificial, and, as Tansley puts it, to get an ecosystem one has to *isolate* factors from other factors arbitrarily. Yet the scientific necessity of creating clear lines of demarcation contrasts with how the ecosystem concept also eliminates the difference between nature and culture: Odum writes in his book *Ecology* that an ecosystem is a network of components and processes that »include humans and human-manufactured machines, units, or organization such as industry, cities, economic exchanges, social behaviour, and transportation, communication, information processing, politics, and many others.«[37]

The ecosystem concept has two further important aspects: First, an ecosystem is a whole that can be described mathematically. Second, this mathematical description does allow for the technical manipulation and construction of artificial ecosystems. Given these two aspects, the discipline of ecology (as New Ecology) then takes a political turn.

5. Life support systems: Spaceship earth

As this article has shown, the »ecosystem« concept does not just describe specific collectives of biotic and abiotic factors, but gives way to the imaginary construction of a completely regulated space. In the eyes of ecosystem researchers, this space can also be constructed and manipulated. For example, Odum describes the earth as a bio-regenerative life-support-system or as »spaceship earth«.[38]

The metaphor of »spaceship earth« was popularised by Buckminster Fuller's book *Operating Manual for Spaceship Earth* (1969). The space of a spaceship suggests that all factors contained within it can be controlled. As Fuller writes, this idea works as a global regulative model, and he introduces the term »synergy« to describe the complex interrelations in the closed system of the »spaceship«.

According to Fuller, »spaceship earth« has not yet received a proper operating manual. »We are learning how we safely can anticipate the consequences of an increasing number of alternative ways of extending our satisfactory survival and growth«.[39] The idea is that prognoses about the future provide the framework for operating the spaceship earth in the present. Consequently, regeneration and sustainability become main concepts because, as Fuller writes in 1969, we should not waste resources like fossil fuels. The expression spaceship earth is a metaphor for ecological wholeness that connects fictions about the future with technical solutions for environmental problems. As the historian of science Sabine Höhler writes: »As ›Spaceship Earth‹ was fused with ›System Earth‹, the planet became a habitat based on cybernetic principles. The global environment was conceptualized as functioning by means of technology-driven control systems, similar to the control systems integrated into space capsules. Ecosystems sciences regarded the environment as an economy of efficiently cooperating parts, composed and operated like a machine.«[40] The spaces in spaceship earth or system earth can be fully governed.

The project Biosphere 2 is an interesting example of an attempt to implement this idea of the total regulation of a closed space.[41] Biosphere 2 is a building in the desert of Arizona, built in 1991. The founders of the project were members of the Institute for Ecotechnics, founded in 1969. They described themselves,

37 Eugene Odum: *Ecology*, New York 1963, p. 17.

38 Eugene Odum: *Ecology and Our Endangered Life-Support-Systems*, Sunderland, MA 1989, pp. 1–7.

39 R. Buckminster Fuller: Operating Manual for Spaceship Earth, New York 1969, p. 53.

40 Sabine Höhler: »›Spaceship Earth‹: Envisioning Human Habitats in the Environmental Age«, in: *Bulletin of the German Historical Institute* 42 (Spring 2008), pp. 65–85. Online issue: www.ghi-dc.org/files/publications/bulletin/bu042/065_nocartoon.pdf (15.11.2014).

41 See also: Sabine Höhler: »The environment as a life support system: the case of Biosphere 2«, in: *History and Technology* 26 (2010) 1, pp. 39–58.

using Fuller's language, as »social synergists« and they all came from the environmental movement. As Jane Poynter, a member of the first group in Biosphere 2, wrote: »We were creating a new way of life for a new civilization based on the notion of social synergism.«[42] The idea behind Biosphere 2 was to build a spaceship earth that connected the technology of life support systems with a new way of living.

Biosphere 2 was a total closed system and contained different ecosystems like a desert, ocean, rain forest, marsh, and also an agricultural area with goats and chickens, which provided the food for the first eight members who lived in Biosphere 2 for two years. Plants, in turn, provided the organisms with the necessary oxygen. In Biosphere 2 all things were parts in a recycling process, and indeed, recycling served as a basic guiding principle for the program: First, Biosphere 2 showed on a small scale that we, too, can live on the basis of self-regenerating systems in Biosphere 1, i.e., the earth. Second, it demonstrated an entirely new way of living based on the principle of recycling; and third, the project was meant to be the basis for the prospective colonization of space.[43]

In the end, Biosphere 2 failed: Oxygen was absorbed by the concrete walls, so that the concentration of carbon dioxide rose to a dangerous level for the inhabitants. An ant species, *Paratrechina longicornis*, also called the crazy ant for its erratic movements, propagated and displaced other species. There were also social conflicts between the inhabitants. But even in its failure the project produced scientific results.[44] A second group also lived in Biosphere 2 for six months in 1994, and Colombia University used the building for experiments to climate change from 1996 to 2003.[45]

The project Biosphere 2 is, therefore, the materialisation of the metaphor »spaceship earth« as well as of the concept »ecosystem«: It is a closed system based on recycling that is inhabited by a collective of humans and non-humans. The political impact of the project lies in its relation to the future. The sociologist Robert Merton's concept of »suicidal prophecy« helps to analyse the logic of this temporal relationship: »The suicidal prophecy […] alters human behavior from what would have been its course had the prophecy not been made that it *fails* to be borne out. The prophecy destroys itself.«[46] In the case of spaceship earth/ Biosphere 2, a pessimistic scenario of the future legitimates and organizes political actions in the present, as with the consumption of resources for example. These actions are supposed to assist in avoiding the pessimistic future by initiating another, »better« future scenario.

Odum also disputed the role of such a suicidal prophecy: In his more popular work, *Ecology and Our Endangered Life-Support-Systems* (1989), he notes that though we cannot forecast coming developments precisely, it would be helpful to devise a spectrum of potential outcomes. The most important aspect would be that »we might be able to do something now to reduce the probability of an undesirable future«.[47] Therefore, preventative measures have to be expansive. Too much population growth might result in the wasteful use of resources, and shortages would then lead to social problems. In this respect, it is imperative that science, economics, and politics work together. For Odum, a fundamental change in the social order is necessary, something that can only be achieved through »strong political leadership«.[48]

In a certain sense all eco-apocalyptic narratives are »suicidal prophecies«. This applies especially for literary fiction. For example, Margaret Atwood's series of interconnected novels, *Oryx and Crake* (2003), *The Year of the Flood* (2009) and *MaddAddam* (2013), together create a future scenario of a society that is

42 Jane Poynter: *The Human Experiment. Two Years and Twenty Minutes inside Biosphere 2*, New York 2006, p. 91.
43 Ibid., p. 64.
44 See, for example, the issue of *Ecological Engineering* 13 (1999) with the special topic: *Biosphere II*.
45 For further information, see the homepage http://www.b2science.org/ (15.11.2014).
46 Robert Merton: »The self-fulfilling prophecy«, in: *Antioch Review* 8 (1948), pp. 193–210, here p. 196. The analogous concept is the self-fulfilling prophecy: »The self-fulfilling prophecy is, in the beginning, a false definition of the situation evoking a new behavior which makes the originally false conception come true.« Ibid., p. 195.
47 Odum: *Ecology and Our Endangered Life-Support-Systems* (note 38), p. 257.
48 Ibid., 262.

totally organized by science and technology on its way to an ecological catastrophe. Atwood characterizes the dystopia genre in the essay »Writing Oryx and Crake« in this way: »Like *The Handmaid's Tale*, *Oryx and Crake* is a speculative fiction, not a science fiction proper […]. As with *The Handmaid's Tale*, it invents nothing we haven't already invented or started to invent.«[49] So the dystopia does not exhibit the future present but the present future and opens a space for other possible developments. It works as a space for thought experiments about the future. In »Writing Utopia« Atwood writes, »The details then, vary, but the Utopia-Dystopia as a form is a way of trying things out on paper first to see whether we might like them, should we ever have the chance to put them into actual practice. In addition, it challenges us to re-examine what we understand by the word human, and above all what we intend by the word freedom.«[50]

Fictions about the future are not only spaces, in which we can imagine prospective developments and potential applications of scientific technology: They also enable political interventions. In the words of Atwood, »Dystopias are […] like […] dark shadows cast by the present into the future. They are what will happen to us if we don't pull up our socks.«[51] Like Fuller, Odum, or the members of the Institute of Ecotechnics, Atwood tries to translate the imaginary versions of the future into concrete political actions.

6. Recycling enforced: The closing circle as social form

The metaphor »spaceship earth« illustrates how a technical form becomes a model for the social. In the environmentalism of the 1970s there were other approaches, in which natural cyclic processes became models for the social. As one can see in Enzensberger's article »Zur Kritik der politischen Ökologie« (1973), these approaches also use the term »ecosystem«. Enzensberger claims that the object of political ecology are feedback systems or, better, disruption cycles that are interconnected in various ways.[52] Ultimately, Enzensberger thinks, we should orientate ourselves towards the agricultural society of Mao Tse Tung's China. His idea is, thus, not to construct a spaceship earth but to include human beings in natural cycles.

One of the most important books for environmentalism in the 1970s was written by the molecular biologist Barry Commoner. In 1971 he published *The Closing Circle: Man, Nature, and Technology*, which landed him on the title page of *Time*.[53] Commoner did not criticize population growth and technology as such, instead he was crucial of scientific and technological reductionism. As a countermovement, he emphasized the importance and necessity of establishing ecology as a leading science:

> *We are in an environmental crisis because the means by which we use the ecosphere to produce wealth are destructive of the ecosphere itself. The present system of production is self-destructive; the present course of human civilisation is suicidal.*[54]

49 Margaret Atwood: »Writing Oryx and Crake«, in: Margaret Atwood: *Writing with Intent. Essays, Reviews, Personal Prose: 1983–2005*, New York 2005 [1989], pp. 284–286, p. 285.

50 Margaret Atwood: »Writing Utopia«, in: *Margaret Atwood: Writing with Intent. Essays, Reviews, Personal Prose: 1983–2005*, New York 2005 [1989], pp. 92–100, p. 95.

51 Ibid., p. 94.

52 Hans Magnus Enzensberger: »Zur Kritik der politischen Ökologie«, in: *Kursbuch* 33 (1973), pp. 1–42, p. 4.

53 For more details on the work of Commoner, see: Michael Egan: *Barry Commoner and the Science of Survival. The Remaking of American Environmentalism*, Cambridge, MA 2007.

54 Barry Commoner: *The Closing Circle. Nature, Man, and Technology*, New York 1971, p. 294f.

In Commoner's view, ecology becomes a science of survival. As a form of knowledge about complexity, ecology ought to become the leading principle behind structuring and ordering technological, economic, and social processes. If this does not happen, we will not survive.

Commoner is not alone in his understanding of ecology. Aldous Huxley, author of the dystopian novel *Brave New World* (1932), wrote a work in 1963 with the title *The Politics of Ecology – the Question of Survival*, in which he emphasizes:

> *Ecology is the science of the mutual relations of organisms with their environment and with one another. Only when we get it in our collective head that the basic problem confronting twentieth-century man is an ecological problem will our politics improve and become realistic. How does the human race propose to survive and, if possible, improve the lot and the intrinsic quality of its individual members?*[55]

Commoner addresses precisely this interspace between the science of ecology and ecological politics by focusing on the public. He does not call for an expertocracy (as Hans Jonas does for example), but for public participation. First, people have to be informed about problems that they otherwise have not heard about. Second, establishing a critical consciousness is necessary in order to encourage responsible behaviour. Commoner advocates for a partnership between scientists and citizens. It would be the responsibility of scientists to present scientific facts to the public in an accessible form, so that they might discuss these facts within their own social sphere. The discussion is not just about data, but more importantly about value judgements, which are not determined by scientific facts: »These are matters of morality, of social and political judgement. In a democracy they belong not in the hands of 'experts', but in the hands of the people and their elected representatives.«[56] For Commoner the environmental movement leads to a renewal of democratic culture. In this sense, he endorses public debate about the risks of technology (like nuclear plants) and about the public's participation in political decisions concerning the use of high-risk technology.[57]

According to Commoner, the real reasons behind environmental problems still have to be acknowledged by the public and presented for discussion. Unlike Huxley or Paul Ehrlich's thesis of the »population bomb«, Commoner does not see population growth as the cause of the problems: »Of course if there were no people in the country there would be no pollution problem, but the fact of the matter is that there simply has not been a sufficient rise in the US population to account for the enormous increase in pollution levels.«[58] More important than population growth is the interruption of natural cyclic processes, as humans have converted »endless cycles« into linear events.[59] This process of interrupting natural cyclic process has to be reversed, and to do so ecological concepts have to be transformed into political ones. For in the end the survival of humankind depends on the fundamental transformation of the means of production and consumption. When Commoner speaks of ecology, he means a science of survival: »If we are to survive, we must understand why this collapse now threatens«.[60] His book is concerned with questions about which human activities have effected life cycles and why they have done so.[61]

55 Aldous Huxley: *The Politics of Ecology. The Question of Survival (An Occasional Paper on the Free Society)*, ed. By the Center for the Study of Democratic Institutions, Santa Barbara 1963, p. 6.
56 Commoner: *The Closing Circle* (note 54), p. 198.
57 Egan: *Barry Commoner and the Science of Survival* (note 53), p. 8.
58 Barry Commoner: »Untitled Talk, Harvard University, 21. April 1970 (Barry Commoner Papers, LoC, Box 36)«, cited in: Egan: *Barry Commoner and the Science of Survival* (note 53), p. 119.
59 Commoner: *The Closing Circle* (note 54), p. 12.
60 Ibid.
61 Ibid., p. 13.

The social consequences of this idea (to use the figure of a closing circle as model for the social) have to be developed through future scenarios – and this task falls under the expertise of literature. For, on the one hand, fictions of the future give us an opportunity to think about alternative futures; on the other hand, literary texts serve as regulative fictions, which imply that they have the function of shifting present social and political processes in a specific direction, either according to suicidal prophecies or towards a more desirable future.

The most prominent examples of ecological utopias are probably found in Ernest Callenbach's novels *Ecotopia* (1975) and *Ecotopia Emerging* (1981), which both refer to Commoner's book *The Closing Circle*. In fact, the motto of *Ecotopia* is a quotation from Commoners book: »In nature, no organic substance is synthesized unless there is provision for its degradation: recycling is enforced.«[62] Accordingly, the key to founding the new state of Ecotopia lies in recycling, that means, in the institutionalization of »stable state life systems«. An »Assistant Minister« outlines this principle with the example of food production: »In short, we have achieved a food system that can endure indefinitely.«[63] The society is based on recycling, ergo a closing circle, and so it can endure forever. For example, one report from Ecotopia[64] addresses the theme »Their Plastics and Ours«: When plastics are used in Ecotopia, they, of course, come solely from biological sources and not from fossil fuels. In strictly keeping to this fundamental principle, human beings are also recycled: »At any rate, when they feel their time has come, they let it come, comforting themselves with their ecological religion: they too will now be recycled.«[65]

The relation to the project Biosphere 2 is evident. The social synergists dreamed of space colonization made possible through the constructing stable state systems with the help of technology, and the founders of Ecotopia dream of a state without pollution and the depletion of valuable resources. Whether by technical means or by natural means, in both cases the idea of a closed system is the central point of reference. Stable state systems are at this juncture nothing more than the very concept of an ecosystem translated into social and political terms.

7. Conclusion

The »ecosystem« concept has to be read in the context of the discourse on political ecology. It is a key concept in this discourse for several reasons: First, it establishes the discipline of ecology by constituting its very object of study. Second, it lends a form to the wholeness of ecological objects (a lake, a city, the biosphere). Third, it supplies the ecological discourse with technical input: Ecosystems are constructed systems that can be quantified and regulated. Fourth, an ecosystem is a type of »closed system«. These closed systems are, in a political sense, internally complex organized entities, but their relation to their outside ought not be overlooked. Indeed, the enemy of environmentalists often takes on the unspecified shape of some adversarial outside force.

The political sense of »ecosystem« does not just lie in topics like the pollution of rivers; rather it aims at the total social order of human beings. To better grasp this sense of »politics«, the French philosopher Claude Lefort's distinction between »politics« and »the political« is useful. Politics denominates a subsystem

62 Ernest Callenbach: *Ecotopia. The Notebooks and Reports of William Weston* [1975], ed. Klaus Degering, Stuttgart 1996, p. 3.

63 Ibid., p. 48.

64 The main protagonist is a journalist, who travels to Ecotopia. The novel alternates between his reports about different themes (education, economics) and his personal impressions from his diary.

65 Callenbach: *Ecotopia* (note 62), p. 299.

in a society, opposed to the non-political, like economics, law, aesthetics, or religion.[66] In contrast, the concept of »the political« denominates not a part of society, but the »putting into form« (*mise-en-forme*) of social relations, which first requires an engendering of sense (*mise-en-sense*). Then, a *mise-en-scène* of social relations follows, which gives a society a »quasi-representation of itself«.[67] This »quasi-representation« then forms the social, puts it into form.

Lefort's distinction allows us to align environmental politics with »politics« in the first sense, and the concept of ecosystem in the political ecology discourse with »the political« in the second sense: Hence, the »ecosystem« aims to put the social into form, in other words, to transform the social into a closed system by natural or by technical means.

66 Claude Lefort: *Fortdauer des Theologisch-Politischen?* Vienna 1999, p. 36.
67 Ibid., p. 39.

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