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Second order cybernetics and semiotics in ecological systems—Where complexity really begins

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ABSTRACT

Complexity in ecology arises not merely from number of components and the direct interactions – such as flows – between them alone. We may talk transactions in general and consider that they may be both material and immaterial in character. Our concerns here simply will be of the latter kind. Ecological sciences of today have troubles in coming together to find ways to address the fact that we do not really understand how to tackle the issues treated under the term of complexity and how properties arise. At the same time biological system at all levels of hierarchy are ontic open, which means that the number of possible combinations of their components at any level reaches numbers that exceeds what can possibly be realized in time or space even if considering the total number of particles in the universe. This means that the very character of this sort of complexity alone provides a feature that ensure development and evolution that at low level of hierarchy is entirely random, indeterminate and non-directional (Nielsen and Ulanowicz, 2011. Ecological Modelling, 222, 2908) but simply inherent in a heterogenous system together with its extrinsic relations in terms of hierarchical organisation, thermodynamics and informational dependencies (Nielsen, 2000. Ecol. Modelling, 135: 279; Nielsen, 2007. Ecol. Complexity, 4, 93; Nielsen, 2009. Cybern. Hum. Knowing, 16, (1–2), 27). At higher levels of hierarchy biological systems are still ontic open but are met with different and increasingly stronger, more specific constrains. Biological systems are not only formed and shaped by constraints from the inside-outward but external constrains are also imposed by imperatives set by the surrounding environment. Thus they are not truly autonomous but are rather systems that receives a strong influence of outside-inward gradients what can be considered a downward causation. A great part of realisation and more important the cybernetics of these forms of existence involves transfer and decoding of information and in the end that the system exhibit adequate responses to a given situation. Such phenomena are widely known as biosemiotics processes. The same is valid to ecosystems as long as we consider conditions that allow us to interpret them as embedded forms. For some other focal levels – like that of population – the semiotics seems to take over a great deal of the cybernetics, but due to the autonomous part of the steering we have to deal with these systems within a framework of seconder order cybernetics. As we move up ro another form of hierarchy – namely that of more and more advanced organisms – it seem that the semiotics adds up to yet another type of ontic opennes that involves a second order, cyber-semiotic system (Brier, 1996. Syst. Res., 13, (3), 229; Brier, 2013a. Toronto Studies in Semiotics and Communication. University of Toronto Press, 498 pages). At the uppermost levels we find advanced structural societies, not only the well know examples of ants nests, bee hives but also large scales ecosystems like the Serengeti that seem to be more or less driven by interpretational processes, such as for instance the yearly cycle of wandering of the gnu/wildebeest. It is therefore likely that we need to integrate semiotics in our existing scientific models but only a few modelling approaches if any include this type of transactions in them not to say the possibility to do so. A framework to assist in the development of such type of model is presented.

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1. Introduction

Ecosystem have over the recent decades be acknowledged as systems demonstrating an overwhelming complexity. Not only are we dealing with complexity in the form of number of components, but with and increasing focus on transformations and transactions

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in ecology—a focus needed for energetic, material as well as information in the system. In addition, we are also facing an increased complexity in terms of a time dependent phase-space that is much more incomprehensible than hitherto believed. For instance doing a calculation on the number of possible interactions of an ecosystem such calculation will most often result in numbers that reach *immense numbers*, sensu Elsasser (1983, 1998) as demonstrated (Jørgensen et al., 2007, chapter 3). Although a brief introduction will be given here please refer to Rubin (2005), Ulanowicz, (2009), Nielsen and Ulanowicz (2011), and Nielsen and Emmeche (2013) for a further, broader explanation and discussion on consequences to this.

Not only are we facing this number of quantitative complexity, number of components and interactions. We also face a qualitative complexity of the system. The components will change according to external, the environment in which they are embedded, as well as internal influences in a dialectical manner. Components reacting with the externals may in turn affect the state of their environment. A clear example on global, regional and local scale may be the fact that the way we as humans have behaved since the industrial revolution now shows to have great impact on our future life conditions by feedbacks from the environment on us. I do not here only speak of local feedbacks like the decrease in precipitation which often is the result from deforestation but also more global about "reactions" such as the possible increase in greenhouse effect, ozone layer depletions, atmospheric transport of DDT and gas exhaustions from power plants and cars, not to mention the effects of the vast amount of chemicals that have now introduced as seemingly a necessary part of our everyday lives.

When considering the number of interactions we as humans have with nature, this is maybe not what we really think of as complexity sensu strictu. Complex, in the sense of complicated, yes, because our ways of interfering with nature are many. Just think of the more than 100,000 chemical substances we seemingly consider it necessary to use in our everyday lives in order for us to exist. The use of chemicals and handling of wastes from society is a complicated problem but it is a complication that must and can be handled. And that the way we treat nature should in some way have an influence back on us is probably not such a big surprise any longer.

Accepting such a dialectic perception, or (a more mechanistic "action–reaction" for those who prefer this picture) of the world is probably acceptable to most scientist of today. Never the less, the latter form, in particular in its dialectic formulation of interactions between the components of the system seems much more and more difficult to comprehend.

Meanwhile, the complexity of the system is not only a result of its ontological components, but also due to the phenomenological features of the components. To this understanding we need to comprehend the role of ontic openness, propensities (second order) cybernetics and semiotics much better.

Thus, having just made the parallel between the forcing functions and the sequential response of the ecosystem to the action–reaction scheme often found in textbooks on physics it needs to be stressed that we deal with no one to one reaction scheme in this biological and thus also not in an ecological context. The imposed flows affecting the system may be random or even chaotic in character but the reaction is inherently indeterminate and not deductable from even probalistic science.

The systems response will be a change in cybernetics that is not necessarily following a definite goal function, but will rather change with history as cognitive properties, interpretory systems, information storage, knowledge, experiences, and consciousness develops.

The point to be made here to ecology is that while the regulation, the cybernetics of the (eco-)system is usual incorporated somehow in its original form – i.e. as *first order cybernetics* of Wiener (1948) – in most of our models, both the ones we programme and the ones we have in mind. But when it comes to the integration of more recent concepts like the *second order cybernetics* of von Foerster (1974, 1981, 2003) or even combining the perspectives given by this introduction with the semiotics of C.S. Peirce the attempts of introducing such approaches to the understanding of ecosystems the attempts become rather limited. Attempts have been made to integrate this even further with the principles of *autopoiesis* introduced by Maturana and Varela and the sociological views of Luhmann has lately been presented by Brier (2013a) thereby building a synthetic framework of information science in its widest sense which allows a common interpretation of semiotics in physical, biological and societal system (Brier, 1996, 2013b).

It is important to take such attempts seriously as it is clear that at least part of the elements and resolutions presented by the above authors has something to offer by introducing new views on ecosystems. Systems ecologist are likely to be ready to follow and agree with much of the argumentation as regulation of the systems is already included in our everyday work. So it is not regulation but rather how the regulation comes by and how it serves to constrain our systems that will meet some opposition here.

It is the purpose of this paper to initiate a discussion on how to add such perspectives in present ecological modelling. It is also the opinion that the role of the various systems may vary a lot throughout the biological hierarchy. Therefore different levels demand a different strategy of the developed models in order to reveal the role of different inferences. This is to be examined in order to improve biological models in general.

In fact the awareness of ontic openness, together with the recognition agency in the fundamental units of models,—organisms, which take on habits in the form of higher level of regulation based on bio-semiotics – internally as well as externally – may well lead to a fundamental rethinking of the way we model. The phenomenon of semiotic habits finds an analogue in the concept of *scaffolding* used by Hoffmeyer (2014). Semiotics enter the biological world as a "continuum" over all levels – a *semiome* – but varies in character between hierarchical levels. In relation to this work it could be argued that scaffolding becomes increasing important with level.

2. The missing metaphysics

First of all, it important to identify if at all something is missing in the present state of perception of nature that models in general reflect today. With a very few exceptions the opinion of this author is – that provided we do want to bring ecological modelling further, for instance to make progress in terms of raising the predictive value or gaining even more insights in nature and life by the use of models – we need to integrate several of the concepts and theoretical foundations presented in the above.

Many of the scientific disciplines have as indicated been put together in the metaphysical discipline known as *cybersemiotics* (Brier, 2013a,b). Meanwhile, for the development of ecological modelling and understanding in such a direction it is important to take a stance to which of the compositing disciplines will be important relatively to each other and at what level. It is likely that this aspect will vary in accordance to hierarchical level, purpose of the model and the interaction with society it is supposed to describe.

All in all the present state of ecological models do not include knowledge enough—nor are the way we formulate models oriented towards integration of cybernetic and semiotic perspectives and the model language we use do (therefore?) not include the facilities to easily include all these issues at the same time. For a first step of clarification we must somehow increase our awareness of these insufficiencies.

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