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Industrial Ecology’s Hidden Philosophy of Nature:
Fundamental Underpinning to Use Nature as Model

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2 Keywords

Analogy; Ecological Economics; Industrial Ecology; Learning from Nature; Metaphor; Nature as Model; Paradigm; Philosophy of Nature; Philosophy of Science
3 Summary

In its scientific sense, industrial ecology represents an emerging transdisciplinary field of studying industrial systems and their fundamental linkage with natural ecosystems. As a short form, industrial ecology is called the “science of sustainability”.

At the bottom of industrial ecology there is a refreshingly different perspective of understanding nature as model in comparison with other scientific disciplines and concepts of understanding nature e.g. in terms of “sack of resources”, “biophysical limit”, “something outside”, “surrounding”, or just “environment” as opposed to industrial systems. The keynote of industrial ecology’s specific perspective of understanding nature is to balance the development of industrial systems with the constraints of natural ecosystems, analogous to an “industrial symbiosis”. This perspective does not merely spring from a persistent craving for balancing natural ecosystems and industrial systems but is based on a persuasive analogy between nature - seen as matured cyclical economy on the one hand - and industry taken as a whole - interpreted according to a living systems approach on the other.

Indeed, metaphorical application of nature and natural ecosystems are intuitively appealing and smartly sounding. Surely, metaphorical usage and analogy provide valuable insights as an eye-opener. Certainly, metaphorical usage and analogy also lead to new facets of interpreting nature, perhaps for learning from nature in order to contribute for solving our environmental problems.

However, the currency of metaphors and analogies themselves does not imply automatically general acceptance and proper usage. More detailed, according to common scientific standards of philosophical awareness, metaphorical usage and analogy are assigned to the context of discovery. Metaphor and analogy are actually fundamental to our way of thinking, and
indeed, they may deliver unexpected insights and they may prove to be a window for surprising and refreshing vistas. However, even if metaphor and analogy are interpreted indispensable to science, it does not follow that all metaphors and analogies are indispensable.

Moreover, they are by no means appreciated as appropriate methods or or legitimate instruments for the context of justification. To be a little more precise, according to common epistemological standard, usage of metaphor and analogy become more or less provocative and - probably - misleading without being made clearly and transparent. In the famous words of Alfred Marshall (1966, 314): “It is well to know when to introduce them, it is even better to know when to stop them off”. Moreover, from an philosophical point of view, they need substantial underpinning by convincing arguments. Further, in avoiding the danger to comprise a “Trojan Horse” within industrial ecology science, its non-mainstream perspective of understanding nature as model requires solid foundation.

At first glance, it is this unusual and non-mainstream perspective of understanding nature as model, its frequently metaphorical use, based on a proclaimed compelling analogy that industrial ecology may cause surprise within the scientific community. Thus, as an emerging scientific discipline, industrial ecologists as its proponents are probably often challenged by critics, sceptics, hard-liners and other mainstream-scientists to conceptualise and underpin their characteristic understanding of nature: Some of them may argue that industrial ecology is just loosely based on natural ecosystems. Resulting from this, they may trouble that industrial ecology seems vague and mired in its own ambiguity and weakness. Some others may state that from an philosophical point of view industrial ecology seems to be in its infancy, only at the beginning of a voyage of epistemological exploration. In addition to such criticism, there are some indus-
trial ecologists who sense that a consolidated theory-building is only emerging.

Due to this challenge, industrial ecologists made few initial efforts to strengthen and elucidate their background assumptions concerning nature and to underline their apparently problematic employment of nature as model. Based on these initial industrial ecology efforts and in pursuing to gain greater conceptual clarity, an approach of nature as model is presented. This approach aims to contribute for laying a general solid underpinning of industrial ecology’s hidden philosophy of nature.

Although such a voyage of philosophical exploration obviously does not take place in a broader sense, elucidation about “meta industrial ecology implications” seems to be still significant because it represents an essential element of scientific task and duty. There are at least three main reasons that industrial ecologists should pay attention to matured insights of philosophy of science and philosophy of nature:

- Firstly, reasoning on philosophical questions is nothing exclusively for professional academic philosophers but to every scientist, engineer, ecologist, economist etc. who does research and takes responsibility contributing to shape towards sustainability at large. Thus, it is up to industrial ecologists themselves being philosophically aware. Primarily it is their turn and they are able to reason on philosophical aspects.

- Secondly, clarifying meta industrial ecology implications is nothing really “outside” industrial ecology. Undeniably, there is no need to import these implications from outward into industrial ecology science because they are already internal, always implicit, and usually inherent.

- Thirdly, background assumptions and essentials of industrial ecology are defined or - as a minimum - influenced by philosophical aspects. Thus, it is a serious question of basic categories and actually of industrial ecology’s
reputation as emerging scientific discipline to take care of philosophical awareness.

Of course, scientists and economists have frequently drawn heavily from biological analogies and metaphors as linguistic equivalent - in particular from organism-analogy, evolution-analogy, fractal-firm-analogy, brain-analogy, and bionics-analogy - in order to illustrate and point out the understanding e.g. of economic phenomena. However, nature as model regularly causes more than surprise. Hence, with regard to industrial ecology, it seems necessary to provide a fundamental underpinning for this unusual perspective focusing on four main reasons:

- The first reason is that to protect nature as model against inflationary use of biological analogies and poetic metaphors as merely rhetoric or picturesque note in economic literature.

- The second reason is that to prevent cosmetic reference to nature only as fruitful metaphor, for example, as it is often done by management consultant companies.

- The third reason is that to critically examine references to nature and reasoning based on nature. It is not going to romanticise nature or to equate nature just with a “holy world of harmony”, “biological community”, or “familiar cooperation”.

- As a larger goal, the fourth reason is that to emphasize the vital relevance of nature for industrial ecology in order to contribute towards sustainability at large.

Summed up, we surely will progress in our thinking by basing our ideas of an area in the unknown on using metaphors and analogies drawn from an area of the known. However, we should be aware that in reasoning by metaphors and analogies there are pitfalls and shortcomings to be avoided, i.e. usage of metaphors and analogies are proper and legitimate
and - probably - highly helpful, as long as what is involved is primarily the elucidation of the sense of a given proposition. If we try to use them for proving a proposition or even to establish a presumption in its favour, we will be lead into more or less grave errors.

4 Goal and Scope

The goal is to contribute for laying a fundamental underpinning for industrial ecology in its scientific sense, in this case especially for its use of nature as model. Therefore an impressive battery of philosophical arguments is provided bringing to bear against the sort of probably raised fallacies and facile or hasty proclaimed critics by sceptics, hard-liners, and mainstream-scientists who often overlook industrial ecology’s stimulating role towards sustainability.

In industrial ecology nature is usually interpreted as model explicitly or at last implicitly. However, despite the fact that there are already some initial contributions dealing with the role of the natural ecosystem metaphor and analogy in industrial ecology, industrial ecology obviously seems to require further efforts in order to underpin and conceptualise its non-mainstream interpretation of nature. As a result, there is urgent need for research on industrial ecology’s underlying philosophical assumptions.

The tangible objective is twofold:

- firstly, as a larger goal, to make philosophical thinking quite accessible to industrial ecologists while its content is of interest to professional philosophers;
- secondly, more precisely, the contribution aims (i) to protect “nature as model” against inflationary use of biological analogies as merely rhetoric, (ii) to shield industrial ecology from sceptics, and (iii) to avoid it against obvious shortcomings.
5 Content

The contribution is divided into two sections: In the first introductory section, the relevance of nature for industrial ecology is outlined by a comprehensive classification framework (typology) that proves useful to survey the substantial differences of understanding nature within the field of different scientific fields, in particular within different environmental economic schools.

The major second section deals with basics of philosophy of science and philosophy of nature in industrial ecology:

- At first, industrial ecology is outlined by a framework of basic characteristics in order to highlight the substantial differences in comparison to traditional perspectives of understanding nature as object or limit.

- Then, industrial ecology's hidden philosophy of nature is uncovered to demonstrate the seemingly unproblematic use of nature as model. Based on this, the dialectic principle of thesis, antithesis and synthesis is applied in order to settle the dispute between sceptics' and protagonists' viewpoints concerning nature as model. It is emphasised to be aware of its hypothetical status, i.e. nature provides a minimum representing a perhaps useful heuristic of smart solutions, evolutionary strategies, and ecological principles. However, nature by no means represents an all-inclusive checklist that could guarantee sustainability or ethical fairness itself. This sophisticated perspective of understanding nature as hypothetical model correlates with a groundbreaking study “Environmental Report 1994. For Environmentally Sound, Sustainable Development” of the German Council of Environmental Advisors (Rat der Sachverständigen für Umweltfragen, SRU 1994) who stated very clearly that every effort of hyper-interpreting nature is quite problematic: Indeed, such efforts of understanding nature e.g. as “partner”, “stakeholder”, “master”, “teacher” etc. probably offer valuable insights. However, they still remain rhetoric or private beliefs of noble-minded ecologists.
but they could not serve a general acceptable perspective towards sustainability at large. Consequently, these efforts should be treated carefully, or when evidently deficient, just rejected.

Next, it is outlined that nature as model can serve as a paradigm for industrial ecology. More detailed, an elementary architecture of industrial ecology science is presented, the term “paradigm” is illustrated, and major impacts on industrial ecology are outlined. Following the Kantian understanding, nature as model looks like a regulative idea providing a helpful heuristic that can be employed for guiding industrial ecology’s research program.

The conclusion may support a final pleading to use nature as model in industrial ecology:

- On the one hand, understanding nature as model is not only pointing to the limits of nature as scarce source, finite sink, and fragile self-organised cycle. Limits usually imply reduction, restriction, avoidance, diminution, and minimisation. Limits imply respect tending to be understood in a negative sense just containing negative connotations. However, nature as model contains positive connotations. It may serve as a paradigm in order to guide industrial ecology’s research program.

- On the other hand, understanding nature as model provides substantial enhancement of traditional perspectives of understanding nature as object and limit. With this in mind, perhaps the industrial ecology specific perspective of understanding nature as (hypothetical) model may transcend classical perspectives of traditional scientific fields e.g. of environmental economic schools which are still highly influenced by neoclassical environmental and resource economics and its one-sided mechanistic understanding of nature as “sack of resources”.
In all, the appeal of nature as model not merely springs from a persistent craving for balancing nature’s ecosystems and industrial systems. Profoundly considering that nature as model is more than fashionable rhetoric and smart theoretical idea, industrial ecology research should be advanced and turned into practice.

6 Methods
According to the above-mentioned goal and scope, industrial ecology’s implicit philosophical aspects are situated in the centre. Four major philosophical methods are applied: (i) classification-framework (typology) to specify the interpretation of nature; (ii) dialectic principle of thesis, antithesis, and synthesis to settle the dispute between sceptics’ and protagonists’ viewpoints concerning nature as model; (iii) basics of anthropology to explain how it is even possible to understand nature by science in general, in particular by industrial ecology, and to look to nature for a model by reflexive manner; (iv) epistemologically based architecture of industrial ecology science to demonstrate that the reflexive interpretation of nature as model represents a paradigm serving as helpful heuristic and influencing industrial ecology’s research and practice.

7 Results and Conclusions
It is possible to elucidate industrial ecology’s hidden philosophy of nature by reflexive manner. An impressive battery of philosophical arguments is presented to underpin industrial ecology’s perspective of understanding nature as model. Consequently, it seems plausible and useful to learn from nature, i.e. industrial ecologists can selectively apply nature’s smart solutions, evolutionary strategies, and ecological principles for balancing natural ecosystems and industrial systems.
The keynote is to be aware of nature's hypothetical status. Thus, nature as model provides a minimum that can be considered when we already know what we are looking for, i.e. we need something like a regulative idea that constitutes nature and natural ecosystems' phenomena as relevant objects for solving our environmental problems. Even then, we could look on nature for a model searching for smart solutions, evolutionary strategies, and ecological principles which might seem appropriate for us in order to solve our environmental problems. Nature does not provide unequivocal orientation. Hence, nature as model can not provide an all-inclusive checklist that guarantees sustainability or ethical fairness itself.

Metaphorically, nature as model provides valuable insights as an eye-opener. From this rhetoric sense we can learn by gaining inspiration and encouraging creativity to derive ecological innovations. However, additionally to linguistic aspects, nature as model can also serve as paradigm. This paradigmatic sense includes rhetoric use as metaphor but broadens the interpretation as smart biological analogy and exceeds the connotation as picturesque note by far. Nature as model is seen as regulative idea that offers a helpful heuristic guiding industrial ecology's research program. Such a regulative idea plays a dominating role that is (i) to arrange our way of thinking, (ii) to organise our imagination of phenomena, and (iii) to govern our decision-making.

8 References


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9 Transparencies

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Industrial Ecology’s Hidden Philosophy of Nature
Fundamental Underpinning to Use Nature as Model

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1 Industrial Ecology: Hidden Philosophy of Nature (I)

<table>
<thead>
<tr>
<th>Author</th>
<th>Reference to nature understood as model explicitly or at least implicitly</th>
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<tbody>
<tr>
<td>Frosch/Gallopoulos (1989, 94)</td>
<td>“IE would function as an analogue of biological system”</td>
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<td>Tibbs (1992, 2 and passim)</td>
<td>“IE takes the pattern of the natural environment as a model”</td>
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<tr>
<td>Simons (1993, 131)</td>
<td>“Learning from nature by taking private lessons in ecology”</td>
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<td>Graedel (1994, 24)</td>
<td>“The ideal anthropogenic use of materials would be one similar to the biological model”</td>
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<td>Socolow (1994, 4)</td>
<td>“Nature is the measure of man; nature “as the principal shaper of global activity”</td>
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<td>Andrews/Berkhout/Thomas (1994, 471)</td>
<td>“Nature is instructive to explore in some detail what an industrial ecosystem could involve”</td>
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<td>Richards/Allenby/Frosch (1994, 3, 8)</td>
<td>“Natural ecosystems as no waste ecology”</td>
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<td>Allenby/Cooper (1994, 343)</td>
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<td>Graedel/Allenby (1995, 10)</td>
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<tr>
<td>Wernick/Ausbel (1997, 7)</td>
<td>“IE implies that models of non-human biological systems are instructive for industrial systems”</td>
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<td>Ausbel (1998, 1)</td>
<td>“IE asks whether nature can teach industry ways in mimicking waste”</td>
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<td>Manahan (1999, preface and 93)</td>
<td>Nature as cyclical economy without waste</td>
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<td>Cleveland (1999, 149)</td>
<td>It is characteristic for IE “to look to the natural world for models of efficient use of resources”</td>
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<td>Allenby (1999, 43)</td>
<td>“The concept of industrial ecology is based here on the biological analogy”</td>
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<td>Ehrenfield (2000, 237)</td>
<td>“Natural ecosystems offer the only example of long-lived, robust, resilient living systems”</td>
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<tr>
<td>Journal of IE (2000, 1)</td>
<td>IE “looks to the natural world for models”</td>
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<td>Korhonen (2001, 57)</td>
<td>“Ecosystems are masters of recycling … ecosystem metaphor provides a sustainable model”</td>
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<tr>
<td>NTNU (2001)</td>
<td>“Nature as a teacher” and “learning from nature”</td>
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</tbody>
</table>
Internal industrial ecology topic

- Manahan (1999, 2) concedes that industrial ecology "is loosely based" on natural ecosystems.

- Korhonen (2000, 11) says that industrial ecology’s "theory is only emerging".

- Fuchs/Mazmanian (1998, 193) emphasise a premature stage: "Progress in our understanding of greening has been hampered by a lack of theoretical and methodological rigour".

Provisional result (1)

- In industrial ecology nature is employed and used as model explicitly or at least implicitly,

- often phrased in terms of a metaphor and frequently based on a proclaimed compelling analogy between natural ecosystems and industrial systems.

- This perspective is refreshingly different from traditional ones, e.g. in terms of "sack of resources", "biophysical limit", "something outside", or just "environment".
2 Philosophical Prerequisites to Understand Nature by Industrial Ecology (I)

Why dealing with philosophical prerequisites?

- Epistemological awareness is an element of industrial ecology’s scientific task and duty
- Meta-industrial-ecology-implications are already **internal**, always **implicit** and usually **inherent**
- Clarifying background assumptions becomes **relevant and essential** for industrial ecology’s **reputation** as emerging scientific discipline

2 Philosophical Prerequisites to Understand Nature by Industrial Ecology (II)

Meaning of Philosophy

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<thead>
<tr>
<th>Typical philosophical questions</th>
<th>Main realms of philosophy</th>
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<td>What can we know?</td>
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<td>What may we hope?</td>
<td>Philosophy of religion</td>
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<tr>
<td>What (who) is man?</td>
<td>Anthropology</td>
</tr>
</tbody>
</table>
Authors dealing with philosophical prerequisites

- Bourg (2000): Industrial ecology and its philosophical and political meanings
- Ehrenberg (2000): Industrial ecology as paradigm shift or normal science
- Keitsch/Erkman (1998): Philosophical reflections on industrial ecology and appropriate methods in research and curriculum
- Isenmann (1998; 2000, 2001): Philosophical facets of industrial ecology e.g. (i) understanding nature, (ii) paradigmatic shift, (iii) architecture of industrial ecology science, (iv) learning from nature

Authors dealing with the role of metaphor and analogy

- Allenby/Cooper (1994): Understanding Industrial Ecology from a Biological Systems Perspective
- Sagar/Frosch (1997): A Perspective on Industrial Ecology and Its Application to a Metals-industry Ecosystem
- Commoner (1997): The Relation between Industrial and Ecological Systems
Epistemological role of metaphor and analogy

- Intuitively appealing and smartly sounding (e.g. for didactic and educational purposes)
- Providing valuable insights as “eye-opener” (e.g. for encouraging creativity and gaining inspiration)
- Leading to new facets of understanding nature (e.g. for learning)
- Common epistemological standard (Reichenbach 1891-1953):
  - appropriate for the context of discovery, but
  - by no means for the context of justification
  - because: “genetic fallacy”, i.e. mixing genesis with validity, danger of a “Trojan Horse”

Nature as construction and interpretation

- “Nature” does not automatically or clearly speak to us. Nature appears to us in several ways of mediation.
- Epistemology: According to Kant (1781, KrV, 198): Every effort of understanding nature implies a construction and an interpretation by humans.
- Anthropology: In line with Löw (1990) and Zwierlein (1997): The pivot for understanding nature is a “logical anthropomorphism”. 
### 2 Philosophical Prerequisites to Understand Nature by Industrial Ecology (VII)

**Industrial ecology as means for interpretation**

- **Application**: Conceptual framework containing three layers

| Meta-Theory: Epistemological interest in nature | Orientation by nature |
| Theory: Comprehension of nature | Nature as model |
| Practice: Dealing with nature | Learning from nature |

### 2 Philosophical Prerequisites to Understand Nature by Industrial Ecology (VIII)

**Industrial ecology as means for interpretation**

- **Application**: Conceptual framework containing three layers

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<th>Perspective 2</th>
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<td>Nature as object</td>
<td>Nature as limit</td>
<td>Nature as model</td>
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<td>Dealing with nature (practice)</td>
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<td>Care of nature</td>
<td>Avoiding to use nature</td>
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<td>Epistemological interest in nature (meta theory)</td>
<td>Interference into nature</td>
<td>Conservation of nature</td>
<td>Respect for nature</td>
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<td></td>
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<td>Orientation by nature</td>
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<td></td>
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<td>Incorporated efficiency of nature</td>
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Provisional result (2)

- Based on matured insights of philosophy of science and philosophy of nature,

- industrial ecology can be seen as (probably) **appropriate scientific means** to interpret nature by and into our language.

- It’s perspective on nature is guided by three characteristics:
  - **epistemological interest** in nature (orientation by nature)
  - **comprehension** of nature (nature as model)
  - **way of dealing** with nature (learning from nature)
3 Conclusion: Implications for Industrial Ecology (I)

Five major insights

1. IE: Nature as model, used metaphorically, based on analogy
2. IE: Lack of effort (i) to uncover its hidden philosophy of nature and (ii) to underpin its metaphorical understanding ⇒ philosophical elucidation
3. IE: Appropriate scientific means to interpret nature by and into our language
4. Philosophical prerequisite: Awareness of the hypothetical status of nature as model
5. IE: Substantial enhancement for understanding nature

3 Conclusion: Implications for Industrial Ecology (II)

My larger goal

⇒ to provide an impressive battery of philosophical arguments bringing to bear against the sort of probably raised fallacies and facile proclaimed critics by sceptics.

- not rejecting industrial ecology’s hidden philosophy of nature at all, but:
  ⇒ to elucidate still hidden background assumptions
  ⇒ to encourage awareness (i) that “nature as model” is always hypothetical and (ii) its use needs conceptual underpinning
10 Further Studies


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