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RESTORATION AS A SCIENTIFIC PROBLEM IN ECOLOGY

Ecology has become dramatizing. Biodiversity is declining in many areas, but the massive sixth wave of mass extinction is not yet in sight. Alongside the increase of protected areas, restoration has emerged as a key means to achieve established desirable targets in global biodiversity. Restoration is an important measure in rehabilitating damaged areas, but broadly understood, large-scale restoration requiring significant investments needs consideration from a scientific perspective.

The fundamental problem of ecology is the desire to consider it a normative science. Several key terms are inadequately described or defined. Although ecology should be based on collected observed data, it has become a virtual science. In the absence of new information, old data is being recycled, and researchers often have not even been out in the field. Ecology should be experimental, but it branches out to study microcosms or virtual models, sometimes far from reality (Lévèque 2013). Researchers are increasingly guided by various ideological and conservationist movements because they are often frustrated due to slow progress in biodiversity conservation.

Due to the lack of essential long-term policies for analyzing action in ecosystem functions and its consequences, research has become fragmented not being sufficiently relied on systematic data collection and evaluation of existing experiments (Mayr 1997). In the evaluation of the soundness of science, the number of references tends to be more important than the content of the articles. The same data can also at times yield different results in the work of analysts (Gould et al. 2024). As a result, the level of substantive scientific dialogue is inadequate.

Fortunately, ecology has not lost its place in science. While previously the basic concepts focused on maintaining the "balance of nature," the current key concepts are variation and heterogeneity. Ecosystem functions were in the past understood as deterministic, but it is now clear that they are stochastic processes, significantly influenced by chance and changes in conditions (Lévèque 2022).

Ecosystem ecology deals with living species which occur in an environment where they undergo change. Global ecology deals with the entire biosphere including its limitations and possibilities for life. At the center of everything is the human in the ecosystem, as humans have influenced nature almost globally. It is a coexistence where certain species have been favored for their economic, aesthetic, or ethical qualities, and others have been eliminated because they were perceived as harmful. This process, which has lasted for thousands of years, continues today (Lévèque 2013).

Ecology covers a large number of different branches of science, each addressing various specific questions. The resulting fragmentation of research has made synthesizing almost impossible, as there is both too much and too little information (cf. e.g., Wilson 1999).

Dramatization is the other nature of ecology

The starting point in the dialogue has been that human activity causes irreversible effects on nature and, if measures are not taken immediately, the loss of biodiversity will endanger

human existence in the world. Dramatization has become the second nature of environmental ecology because otherwise the attention it receives would remain marginal. Dramatization benefits researchers and environmental organizations in securing funding resources. The atmosphere of catastrophic fear that has been created has been seen as a sign of wisdom.

Prominent researchers have made varying different quantitative predictions about the loss of species and the sixth wave of mass extinction which will lead to a collapse of life on Earth. However, the emergence of new species and the adaptability of endangered species have not been sufficiently considered. Alien species also evoke strong passions rather than relying on factual information.

It is generally thought that pristine or "original" nature is something that humans have not changed; something that has always remained in its steady state without alteration. Nature is thus perceived to exist independently of humans and human actions. However, the difference between "natural" and "artificial" is not clear, as many "natural" environments are human-created or at least influenced by human activity. The degree of "naturalness" has been a subject to fierce debates, especially in the case of forests.

The basic concepts of ecology include the balance of nature, which is associated with uniqueness and harmony, a state where each species has found its own place. However, this concept of a permanent balance does not correspond to reality, as species constantly compete for space and nutrients by adapting to environmental changes (Mayr 1997). A stable and resistant state cannot be scientifically defined, although it still intuitively influences the foundation of conservation philosophy (Lévèque 2013).

The basic assumption of restoration is that the ecosystem will return (or be restored) to its former state when external disturbances are eliminated. This assumption is also incorrect, as ecological systems develop in their own trajectory. In reality, adaptation to modified conditions occurs, but not as a return to an "initial" state that, furthermore, is often even unknown.

Ecology as a science cannot decide what is "Good" and "Bad"

An ecological state can be "good," "bad," or something in between. In politics, the aim is, of course, to achieve a "good" state. Several theoretical definitions of a "good" state have been presented in the literature, but their generality on the one hand and complexity on the other limit their practical application (Lévèque 2013).

It has proven easier to judge when the state of an ecosystem is ecologically "bad." However, in management, criteria need to be defined according to which "bad" has changed to "acceptable". Ecology as a science cannot, therefore, decide what is "good" and what is "bad."

It is even more difficult to make predictions about where restoration measures will lead to. In practical work, the most promising option may be to maintain the most desired features of the ecosystem. Given that different aspects of ecosystems are often contradictory, they must be prioritized in decision-making, while at the same time also minimizing costs.

Ecology increasingly relies on modeling

The development of ecological research has largely occurred through the introduction of new concepts. Unfortunately, these are often not clearly defined. They are typically developed by generalizing the results that are based on specific studies in given locations. Their associated limitations for generalization are not necessarily duly considered. As in all science, there is a common tendency to prove that the models underlying scientist's hypotheses are correct even though negative results could often be more valuable for scientific advancement.

Ecology as a science has increasingly focused on model development. Models are fundamentally abstractions that simplify reality, as they do not take into account external environmental factors (Mayr 1997).

Modeling is based on causality. It is almost impossible to identify a specific reason in a long chain of biological reactions due to the interactions between the multiplicity of factors in the ecosystem. Although models are useful tools to prove hypotheses, to assess causalities and for prediction, their strengths do not necessarily get better with increased sophistication.

For the generalization of results, more empirical knowledge about the functioning of ecosystems under different conditions would often be necessary. For example, it is assumed that the more species there are, the more stable and important the ecosystem function is. On the other hand, it is also assumed that the productivity and value of an ecosystem is diminished as species diversity decreases. Such generalizations are not valid, although they are proposed as universally applicable scientific facts (Lévêque 2013).

It is often assumed that the ecosystem will collapse, if a single species disappears. This is a common deterministic assumption of ecosystem fragility. However, many ecosystems are robust and flexible and many different species found in them perform the same functions. Flexibility and genetic adaptation are typical characteristics of biological communities (Mayr 1997).

Setting a specific goal for achieving a combination of ecosystem services is difficult because their values differ. There is also a question about the strategy to be applied: improvement through management interventions or a laissez-faire approach leaving matters to nature itself. Additionally, it is necessary to clarify whether human-created or modified ecosystems should be restored, even if they are not "natural" or if they are not visibly degraded (Lévêque 2022). The generalized use of a baseline or reference situation (as specified in the EU's restoration law) therefore loses its meaning both in theory and practice.

The end does not justify the means in ecology either

Society did not wait for the development of ecological principles and guidance when farmers, herders, foresters, fishermen, and other practitioners applied their accumulated knowledge in practical ecosystem management. Today, ecologists tend to define and generalize principles and methods of operation based on new concepts, models, and site-specific scientific results. "New scientific" knowledge is considered necessary as previous practices have led to "destruction of nature." Unfortunately, researchers seem to duly recognize neither the limitations of generalization in the diversity of field conditions nor the uncertainties associated with the results of proposed measures.

Even less realistic is the belief that ecosystem changes can be achieved in a short period of time, as required by the EU's restoration law. This is intellectual dishonesty as it is clear that effects of restoration typically occur over decades or even centuries.

It is also clear that there are no simple and universal laws in nature that can be applied to a biologically very heterogeneous region like the European Union or even to individual member states with vast biological variation.

Ecology should help us strengthen the ability to recognize the limitations of science and distinguish opinions from research results. Otherwise, it is difficult for the layperson to understand what is scientific and what is ideological. At present, the end often seems to justify the means, as shown for example by alarming predictions of global species extinction.

The relationship between climate change and biodiversity are still inadequately known. In contrast, the causes of biodiversity degradation are better known: they are overexploitation of natural resources, habitat loss due to land use changes, climatic variation, and pollution. The underlying causes lie in social behavior, political choices, and distorted economic incentives. They all require further research. The means available to us to improve the state of biodiversity also require more research drawing on the experience accumulated over decades.

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