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Environmental Sciences' Advanced Modelling Techniques

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Commentary

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DESCRIPTION

Ecological modelling can help with the implementation of sustainable development, mathematical models, and systems analysis that describe how ecological processes can help with resource management. Sustainability, defined as the preservation of natural capital and resources, is a term that is increasingly being used as a guide for future development. Sustainability can be thought of in three ways: environmental, economic, and social. Environmental sustainability refers to the ability of the environment to support a defined level of environmental quality and natural resource extraction rates indefinitely. Economic sustainability refers to an economy's ability to support a defined level of economic production indefinitely, whereas social sustainability refers to a social system's ability to function at a defined level of social well-being and harmony indefinitely. The assessment of the sustainability of socio-ecological systems necessitates a systemic approach to address the close relationships between environmental and socioeconomic processes, and ecological modelling aids in the development of sustainable management plans for target ecosystems.

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Since the early days of ecological modeliing in the late 1970s, a variety of new model types have emerged, owing in part to the need to model more complex environments, greater integration among disciplines, and significant increases in computing power. Another query is, "How widely have these new model types been used in ecological modelling?" The general trend in ecological modelling has been for models to become more complex, with classical model types, particularly biogeochemical and population dynamic models, being integrated into more complex model frameworks that combine multiple model types. In other words, the principles underlying those models are

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being used as useful tools in the development of a variety of model types. This section does not cover statistical models. Statistics is regarded as a tool that can be used in ecological modelling to provide a more accurate process description. A model that is entirely based on statistics is referred to as a black box model because it lacks causality. This section discusses various types of ecological models that have a solid foundation in ecology science. For historical context, the applications of biogeochemical and bioenergetics dynamic models, as well as population dynamic models, predominated from 1975 to 1982. In the period 1975-82, fuzzy models, spatial distribution models, Structurally Dynamic Models (SDMs), and models based on catastrophe theory were used, but their application in ecological modelling was limited because they were new and untested tools. Because of increased modelling software availability and a greater need for those types of models in environmental applications, SDMs, Artificial Neutral Networks (ANN), and Individual-Based Models (IBMs) were more widely used from 2000 onward. The use of static models, such as food web models, is due to the widespread availability of application software that allows modelers to run large, complex simulations in a relatively short period of time—these models are especially useful for fisheries and other types of aquatic ecosystems.

Individual-based models are a useful approach for modelling ecological systems of interacting organisms. Individuals differ from one another in subtle ways and among themselves at various stages of their lives. Higher-level properties, such as populations, communities, and ecosystems, emerge from these individual interactions and interactions with their environment. IBMs are one way to capture this complexity because individuals within ecological systems have self-direction and the ability to adapt. Individual action is more detailed and flexible with IBMs than with the traditional compartment modelling approach.