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Abstract

Ecopath with Ecosim is designed for straightforward construction, parameterization and analysis of mass-balance trophic models of aquatic and terrestrial ecosystems. Focus is on using the models for fisheries management, and a suite of tools are included for this aim. This help system describes how to obtain, install and use the Ecopath software system written for personal computers using the Windows environment. Brief accounts are given of the theory behind the models developed using Ecopath with Ecosim.

The Ecopath mass-balance modelling system is built on an approach initially presented by J.J. Polovina for estimating biomass and food consumption of the elements (species or groups of species) of an aquatic ecosystem. Subsequently it was combined with various approaches from theoretical ecology, notably those proposed by R.E. Ulanowicz, for the analysis of flows between the elements of ecosystems. However, the system has been optimized for direct use in fisheries assessment as well as for addressing environmental questions through the inclusion of the temporal dynamic model, Ecosim, and the spatial dynamic model, Ecospace.

Since its initial development in the early 1980s, the mass-balance approach incorporated in the Ecopath software has been widely used for constructing food web models of marine and other ecosystems. This has led to a number of generalizations on the structure and functioning of such ecosystems, relevant to the issue of fisheries impacts. Some of these generalizations have revisited older themes, while others were new. Both sets of generalizations have impacted on the development of the Ecopath approach itself. Herein, the description of the average state of an ecosystem, using Ecopath proper, also serves to parameterize systems of coupled difference and differential equations, used to depict changes in biomasses and trophic interactions in time (Ecosim) and space (Ecospace).

The results of these simulations can then be used to modify the initial Ecopath parameterization, and the simulations rerun until external validation is achieved. This reconceptualization of the Ecopath approach as an iterative process, which helps address issues of structural uncertainty, does not, however, markedly increase its input requirements. Rather, it has become possible, through a semi-Bayesian resampling routine to explicitly consider the numerical uncertainty associated with these inputs.

Real ecosystems are more complicated than the mass-balance fluxes of biomass in Ecopath, however large the number of functional groups we include in our models. Real ecosystems also have dynamics far more complex than represented in Ecosim. The issue to consider, when evaluating the realism of simulation software, is, however, not how complex the software and the processes are that are represented therein. Rather, the question is which structure allows a representation of the basic features of an ecosystem, given a limited amount of inputs. On such criterion, it was obvious that a major deficiency of the Ecopath with Ecosim approach was its assumption of homogenous spatial behaviour. This has been remedied through the development of Ecospace (Note that in Walters et al., 1999 Eq. 13, the sign for the T' factor was reversed by mistake.), a dynamic, spatial version of Ecopath, incorporating all key elements of Ecosim.

The Ecopath with Ecosim software has been distributed to more than 3000 registered users in 124 countries, and more than 200 publications utilizing it have appeared in the scientific literature. See ?www.ecopath.org for an update.