

1 Introduction

Goals

This introduction answers the following questions:

- What is META-X?
- What is so special about META-X?
- In what areas can META-X be used?
- For whom has META-X been designed?
- What do you need to use META-X?
- What cannot be done with META-X?

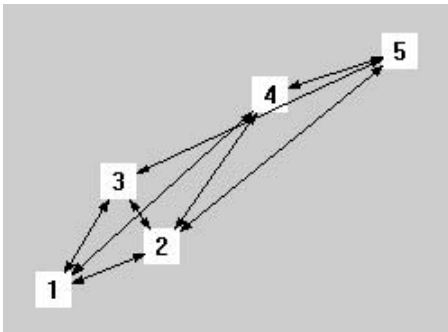
1.1 What Is META-X?

A metapopulation is defined as a ‘population of populations’ which go extinct locally and recolonize. META-X is a program which helps assess the probability of survival or the risk of extinction of metapopulations. The program implements a simple, generic model of a metapopulation. By choosing appropriate parameters, this model can be tailored to certain general questions or to real metapopulations in actual landscapes. Once this has been done, META-X comfortably supports all the steps of model-based population viability analysis (PVA).

The three basic terms set in bold type in this short description of META-X are explained in more detail below.

Metapopulation

A metapopulation is a group of two or more local populations or subpopulations which live on discrete habitat islands (patches).



Setup of a metapopulation

Although this fragmentation of habitat into discrete patches may be natural, nowadays it is caused for most species by human impacts. Very often, the subpopulations are not large enough to persist for a longer time, i.e. they are not viable. Sooner or later they will go extinct due to random fluctuations in environmental conditions and demographic processes (birth and death).

After a subpopulation has gone extinct due to random fluctuations, its habitat will still exist and may be recolonized by individuals leaving other patches which are still occupied by subpopulations. If the rate of recolonization is sufficiently larger than that of local extinctions, the whole metapopulation may persist much longer than even its most long-lived subpopulation.

PVA

Population viability analysis (PVA) targets three goals, which are closely interrelated:

1. Identifying and analyzing the processes and structures of (meta)populations which determine their risk of extinction. How do these processes and structures interact, and which process and which structural element of the landscape exerts the strongest threat to the metapopulation?
2. Quantifying extinction risk – because conservation and environmental management need ‘safety in numbers’ if they are to withstand other societal forces which may lead to the extinction of populations and species. Vague allusions to ‘too small’ habitats and ‘too high’ extinction risks are inadequate.
3. Management decisions which change the extinction risk of population on a rational basis. To this end, the extinction risks are quantified for all alternative decisions and ranked: which decision is likely to benefit the population most, and which decision will probably bring about the greatest threat to the population?

The main tool used by PVA to achieve these goals is ecological models.

Ecological Models

Ecological models are purposeful representations of problems or questions. They should not be interpreted as realistic images of nature but rather as tools for problem-solving.

Models emerge as soon as we consider a problem: certain aspects of reality are taken into account because they are considered essential, whereas other aspects are neglected since they are considered less important. Very often, models are used if information required to solve the problem is unavailable but the problem still has to be solved. Gaps in knowledge are taken into account by filling them with different assumptions and then exploring the logical consequences of these assumptions.

Since verbal and graphical models are hard to test for completeness and consistency, the models applied in PVA use the formal language of mathematics. For problems with a very simple structure, mathematical methods can be used to calculate results (e.g. to assess extinction risks) from the model. More frequently, however, computers are used. The ecological model is – as is also the case with META-X – translated into a computer program.

1.2 What Is so Special About META-X?

The special features of the model underlying META-X are:

- META-X concentrates on regional processes (recolonization, spatially correlated extinction of subpopulations) and therefore describes the local dynamics of the subpopulations in a highly aggregated way. This keeps the number of model parameters small.
- Spatial correlations of local extinctions can be taken into account.
- Peculiarities of the landscape, such as barriers to dispersal and corridors, and structures which affect spatial correlation, can be taken into consideration.

The special features of the concept behind META-X are:

- It supports the definition, handling and joint evaluation of comparative computer experiments. PVA does not aim to produce absolute assessments of extinction risks, i.e. individual numbers, but rather relative assessments. It is precisely this kind of relative, comparative assessment which is implemented in META-X.

The special features of the program META-X are:

- The input of model parameters is facilitated by wizards, i.e. step-by-step instructions on how to proceed. Parameters of external submodels may be imported.
- META-X allows the automatic variation of model parameters.

- A graphical Landscape Editor visualizes the landscape specified by the model parameters. The landscape editor allows the number and position of patches, the connections between patches and the properties of the subpopulations to be newly defined or modified.

The special feature of the results produced by META-X is:

- The use of the ‘intrinsic mean time to extinction’ as a basic measure to quantify persistence which can then be employed to calculate extinction risk for any time horizon. Other output quantities characterize the importance of each patch and the ability of the whole metapopulation to recover.

1.3 In What Areas Can META-X Be Used?

In Teaching

META-X is an ideal tool to teach and learn almost all aspects of metapopulation theory. A thorough understanding of this theory is now a must for ecologists and in particular for conservation biologists and planners. Teachers can use META-X to compile a course about PVA and metapopulations. Students can use META-X to practice or teach themselves PVA and metapopulation theory. The advantage of META-X for teaching and learning is that no skills in mathematics or programming are required to use META-X successfully.

In Empirical Research

Empirical studies of metapopulations are often saddled with the problem that conclusions about long-term dynamics are hard to achieve from short-term field studies or snapshots. Although under optimal circumstances, a tailored ecological model could be developed to solve this problem, there are usually insufficient resources (time, money, qualified personnel) to do so. META-X, however, can be used by empirical researchers by themselves. META-X allows hypotheses about the spatiotemporal dynamics of a metapopulation to be explored, along with the relative importance of different processes and structures in a landscape. This enables the limited information available to be integrated and extrapolated to achieve the best possible understanding of the long-term dynamics of the metapopulation. In turn, integrating empirical information and understanding will help subsequent empirical studies to be designed in a more focused, efficient manner.

In Biological Conservation and Planning

However, the main fields of application of META-X are biological conservation and planning. In addition to the lack of resources for developing tailored models and PVA being at least as high as in research, there are two more problems:

1. In most cases, even less information exists about the population in question than in empirical research.
2. Since PVA and metapopulation theory are relatively new approaches, there is still a lack of basic understanding of these approaches among conservation biologists and planners. So far, this lack of understanding has prevented the broader and more sophisticated application of these approaches.

META-X takes both these problems into account. Because of the first problem, META-X concentrates on regional aspects of metapopulation dynamics and thereby keeps the number of model parameters manageable. By using, for example, expert assessments of these parameters, complete PVAs can be performed. The uncertainty of expert assessment is taken into account by a concept which is basic to META-X, namely comparative experiments, i.e. META-X is designed to optimally support sensitivity analyses, the automatic variation of individual parameters and the comparison of scenarios. As an alternative to expert assessments, external submodels can be used to determine model parameters. META-X allows these parameters to be imported and is thus open to all kinds of external models and tools.

The second problem is solved by META-X providing (see above: 'In teaching') the opportunity to study PVA and metapopulations by oneself.

1.4 What Do You Need to Use META-X?

Successfully using META-X entails the following requirements:

- The hardware requirements are a personal computer with a Pentium Processor (or 100% compatible) with at least 133 MHz, 64 MB RAM, a hard disk with at least 15 MB free space, and a CD-ROM drive with at least 4x speed. The software requirements are: Microsoft Windows 95/98, Windows 2000, Windows NT 4.0 or Windows XP, and Microsoft Internet Explorer 4.0 or higher.
- You should be familiar with programs running on Windows 95/98/2000/NT/XP (windows, mouse-clicks, icons, dialog boxes, etc.). If this is not the case, this can all be learned in under half an hour by following the tutorial included with the various Windows operating systems.
- You should be familiar with the basic concepts, goals and methods of PVA. Only those who know and understand the goals and methods of PVA will be able to perform PVA and to benefit from META-X. If you do not have this knowledge, please read the Chapter 13 and, if necessary, the other literature

META-X®-Software for Metapopulation Viability Analysis

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