Science for Policy

Research findings in brief

Project 4.4.8 & 4.4.10

Threatened Species Recovery Hub

National Environmental Science Programme

STEPS: Software for spatially and temporally explicit population simulations

In brief

Understanding and predicting how species populations change over time and in response to certain drivers is essential to their effective conservation management. Existing software options for modelling populations of species had functional limitations or other shortcomings that prevented their wide uptake. We responded by developing a free application, called STEPS, that meets this need.

STEPS is a highly functional software option that can be used by conservation managers, researchers and analysts to run reproducible spatially explicit simulations of species' population dynamics. It can also be used to predict how species' populations respond to drivers as varied as fire, disease, climate change, land-use change, landscape features, heat waves and predation. It is written in the widely used R language, that is open-source, flexible and runs on multiple platforms.

To demonstrate its functionality, we applied STEPS for a species of conservation concern, the greater glider; however, its modelling approach could equally be applied to the management of overabundant or pest species.

Background

The populations of species change across time and space in response to environmental factors, human activity and conservation management actions. Understanding and predicting how species populations will change in response to these drivers is fundamental to a wide range of ecological actions and interventions.

Researchers and conservation managers need to be able to model the effects of multiple factors that affect species' population dynamics, including the amount, quality and features of habitat (e.g., the effects of climate and land-use change), one-off disturbances or catastrophes (e.g., fire, flood) and factors influencing survival and breeding that vary in space (e.g., disease, physiological constraints, predation).

As such, a wide range of practitioners need to be able to access a suitable modelling application. Prior to this project no freely available, well-documented, cross-platform software existed that could perform spatially explicit population modelling with broad functionality and the flexibility for expansion.

What we did

We examined the current software offerings to determine their shortcomings.

Some software had already been reviewed in the literature, and we combined information from these reviews with the knowledge and experience that our team had gained with other software. We also searched for and tested software packages that had not been reviewed in the published literature.

We then set about creating a software package that addressed the limitations we identified in the existing tools, basing our standard functionality on methods widely used in the practice of spatially explicit population modelling.

Research aims

We aimed to develop a population simulation software tool that offered broad functionality and could be freely available to help conservation managers to simulate changes to populations of threatened species over space and time.

Greater glider.
Photo: David Cook Flickr CC BY-NC 2.0

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steps

Cited material

This factsheet summarises the key findings of the following paper:

Visintin, C., Briscoe, N.J., Woolley, S.N.C., Lentini, P.E., Tingley, R., Wintle, B.A., Golding, N. 2020. STEPS: Software for spatially and temporally explicit population simulations. *Methods in Ecology and Evolution* 11: 596– 603. https://doi.org/10.1111/2041-210X.13354

Key findings

Our survey of existing software found that the best, most feature-rich candidate package ran in only a single operating system (Windows), was inflexible to customisation and was very expensive. Other freely available software packages also ran in a single operating system only, presenting an obstacle to their wider use. Software options that were both freely available and had cross-platform functionality performed poorly in terms of the level of their documentation or the quality of their user interfaces.

These major limitations created an opportunity to develop software that would be more useful and receive greater uptake by practitioners working across disciplines.

As a team of ecologists and statistical modellers, we responded to the challenge by creating a freely available, multi-platform, flexible software program with broad functionality. We developed a software package that overcomes these limitations, STEPS, at The University of Melbourne in 2018–19, and published a paper about the work in early 2020 (see citation above).

STEPS models spatial changes in species populations in response to drivers of distribution and abundance such as climate, disturbance, landscape dynamics and the ecological and physiological requirements of species.

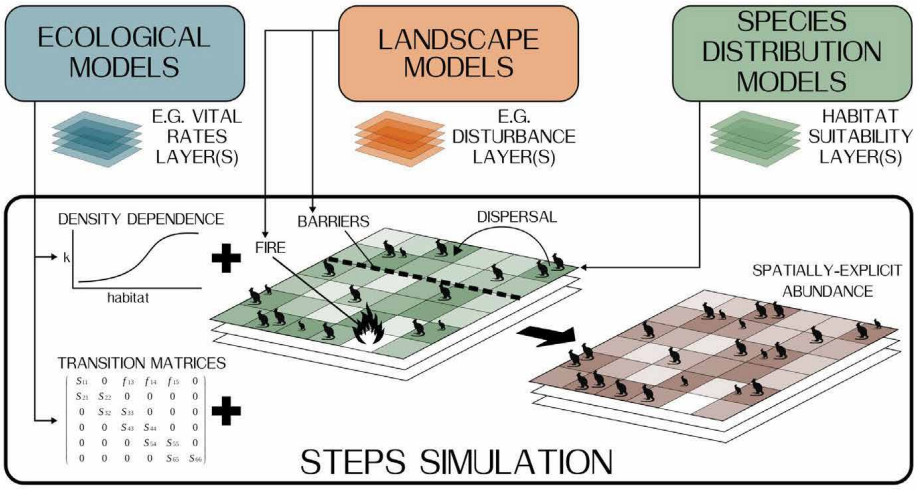

Figure 1. STEPS is run on a grid-based architecture, which enables the easy integration of spatial products (grids) from other modelling software, including climate, landscape, physiological and disturbance information.

To illustrate the functionality of STEPS, the paper includes an example for greater gliders (*Petauroides volans*). For this species, we show how STEPS can be used to simulate population responses of the glider to changes in forests and their management with the types of data commonly used in ecological analyses. However, STEPS can be used for any species of interest to managers, including overabundant or pest species.

STEPS includes useful features found in existing software packages and can share data with them. For example, it can readily incorporate a range of spatial factors such as habitat suitability, and vegetation dynamics and disturbances (see Figure 1). It produces integrated and transparent analyses within the one platform, and shows how species' populations change over space and time.

It is written in the language of the widely used statistical software R. STEPS has a modular design that will allow for extensions by future researchers: it offers both ready-to-use, built-in functionality as well as featuring a modular design that will enable extensions by advanced future researchers for custom analyses through defining their own modules.

Applications

We hope that the software will appeal to and be widely used by practitioners, academics and naturalists worldwide to study the persistence of species on a dynamically changing planet.

STEPS is currently being used by researchers and conservation analysts to determine drivers of species decline and test wildlife management strategies, and we anticipate that it will offer significant value also to environment and wildlife managers from a broad range of disciplines.

We have included tutorials in version 1.0.0 on the functionality of the software to facilitate its use and also maintain a repository of all source code. Further, we plan to launch a website where users can share custom modules that increase the functionality of the software.

Further Information

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