RESOURCE NOTES

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Population Viability Analysis - General Principles and Applications

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Background

Why Population Viability Analysis is Important to Ecological Stewardship

Ecosystem approaches to natural resources management are often thought to represent a shift away from single species management. The ecosystem management paradigm, however, does not exclude research and management for individual species population viability. Rather, ecosystem management reinforces the need to view individual species within the context of the ecosystems that sustain them. Population viability analysis is a valuable and sometimes indispensable tool in understanding the role of species in ecosystem processes.

Population viability analysis (PVA) is the study of all factors that may cause a species to go extinct. Population viability analysis is important to ecological stewardship for several reasons. First, PVA is a relatively rigorous way to identify cause and effect relationships in conservation biology. PVA has accelerated our understanding of basic ecological relationships and underlying patterns in the distribution and abundance of living things. Second, PVA can help to monitor the health and integrity of ecosystems. For example, PVA for certain "keystone species" — organisms, such as salmon, that interact with a range of other species and vital ecosystem processes — may help to identify key factors or trends that affect the integrity of the ecosystem. Third, by focusing on the most limiting factors to a species' survival, PVA can help to identify the most effective management actions to protect endangered species. Without well-executed PVA's, mistaken assumptions in species recovery plans can lead to the waste of precious time, money, and public support.

Discussion

What is Population Viability Analysis?

The principle motivation behind the development of population viability analysis is to assess the threats to a species' survival, and to intervene before population declines become inevitable. It is a structured, systematic, and comprehensive examination of the interacting factors that place a population or species at risk. To estimate the likelihood that a population will persist for some chosen time into the future (often a hundred years), PVA requires the careful evaluation of data, such as reproduction rates, genetic characteristics, and geographic range requirements, generally by the use of mathematical analyses and computer simulations.

Key Findings

Population viability analysis requires a sophisticated understanding of the biology of the species in question. Still, there are several basic considerations that can help the researcher and the natural resource manager to better understand the role of PVA in ecological stewardship.

Many factors affect the persistence of a species — not all are of equal importance. The most important factors, such as habitat loss, are called "deterministic" because they make populations of a species isolated and rare in the first place. Secondary factors, such as severe weather events or predation, may contribute to the demise of a species but are rarely the ultimate cause.

Over the short term, deterministic factors should get most of our attention. Secondary factors, such as demographic stochasticity, are usually symptoms of deterministic factors. PVA can help to identify which deterministic factors have the most impact on a species.

Simple statistics, such as population size and habitat area are not enough to understand the ability of a species to persist. It is crucial to have a sense of spatial and temporal relationships between habitat and demographic factors. PVA — whether quantitative or qualitative — should never be undertaken without a fundamental understanding of a species' ecology. Poorly executed PVAs can lead to misleading conclusions, inappropriate management prescriptions, hasten rather than avert a species extinction, or lead to costly and unnecessary actions for a species not in jeopardy.

There is no single "best" approach for conducting a PVA. The format for a given PVA is dictated by data availability, the degree to which the species ecology and life history are understood, knowledge of risk factors, and management goals.

To be useful PVAs should be directly linked to risk factors that are under the control of management. Population viability analysis is useful only to the extent it helps to solve management problems. The results of a PVA should inform managers on what actions can be taken to reduce threats to a species persistence.

When should PVA be used?

PVA should be used when a species is believed to be declining. Species listed under the Endangered Species Act (ESA) in the United States are obvious candidates, and a new listing may trigger local demand for PVA by resource managers. PVA is often used to help determine whether a species should be considered for listing (and conceivably for de-listing).

A "coarse-filter" screen may be the best way to select species for PVA. The best approach to selecting species for analysis may be to simply screen all species within the planning area for viability concerns. A set of relatively simple criteria developed for the World Conservation Union (IUCN) Species Survival Commission can be used to determine which species are the best candidates for PVA. These criteria include population size, number, isolation, and habitat area trends. Other factors could include specific life history traits (e.g., reproductive rates), habitat specificity, and trends in abundance and distribution.

PVA may also be a proactive tool. For example, multi-species PVA is being used to help prioritize habitat restoration efforts and design monitoring systems in the Pacific Northwest. PVA could also be useful in making decisions about how to control invasive exotic species.

What are the basic requirements?

The most basic requirement is to know what data are needed. This will vary depending on the species, area of analysis, and the management goal. Data on population size and dynamics, habitat area and dynamics, and risk factors are essential. PVA models can help to explicitly identify what information is needed.

The next step is to find data. For some species, data may already have been collected by other researchers. For many species, some or most data will not exist. Information on population status, in particular, is key but available for only a limited number of species. For either quantitative or qualitative methods, some data will likely have to be collected for the first time.

Basic awareness of population dynamics, genetics, and spatial and temporal dimensions of population change are essential. There is no substitute for basic knowledge of population biology, genetics, ecosystem processes, and conservation biology. This knowledge is a prerequisite for conducting a PVA even as software programs (e.g., VORTEX, RAMAS, ALEX, etc.) make PVA more accessible.

PVA efforts should involve collaboration between researchers with both field and theoretical knowledge about a species.

PVA is not a casual undertaking. Managers and researchers should have an appreciation of the resources needed to conduct rigorous analysis.

Limitations of PVA

PVAs often depends on incomplete knowledge. We do not have basic population and life history information on most species. For many species where data and knowledge are limited, it may not be appropriate to use rigorous PVA methodologies since the risk of misleading results is high. Qualitative forms of assessment, expert opinion workshops for example, may be alternatives.

PVA does not predict the fate of a species. PVA is a probabilistic rather than a predictive tool. It focuses on the factors that are most likely to limit the persistence of a species over time.

Conclusion

Population viability analysis can be a valuable and practical tool in natural resource management. It is not practical or possible to conduct a PVA for most species in a given management situation. In general, it is advisable to focus on species that are known or thought to be vulnerable to extinction or extirpation. A variety of existing categories can be used to identify species that may be good candidates for PVA. These include species currently listed under the ESA as threatened or endangered, species ranked as G1, N1, or S1 in The Nature Conservancy/ Natural Heritage system, restricted range or especially endemic species, species that are exhibiting chronic or precipitous population declines, including those not currently ranked as threatened or endangered.

There are a range of methods that analyze the risks faced by a species over time. Six steps provide a basic framework — regardless of the method — for analyzing population viability in the ecosystem management context:

1. Select species of concern
2. Describe population status
3. Describe risk factors
4. Identify suitable habitat amount, distribution and trends
5. Describe relationship of population dynamics to habitat dynamics
6. Assess likelihood of species persistence.

Most examples of PVAs found in the published literature are atypical — that is they are for the relatively few species (<5%) for which we have good data. It is important to recognize that data for most species is sparse. This requires either a concerted focus to collect missing data (often a costly and time consuming proposition) or the use of more qualitative approaches.

Managers rarely have all the information needed to conduct fully quantitative PVAs. Managers must then rely on simpler techniques that are less rigorous and possibly less reliable. Alternative approaches to quantitative assessments include the use of expert opinions, habitat inventories, and basic information on current population status. With all methods, extensive documentation and use of a logical process are key to credibility.

Additional Source of Information

Noon, B.R., R.H. Lamberson, M.S. Boyce, and L.L. Irwin. 1999. Population viability analysis: A primer on its principal technical concepts. In: Ecological Stewardship: A Common Reference for Ecosystem Management. K. Johnson et al. (eds). Elsevier Science Ltd., London

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