# On the Feasibility of Quantitative Population Viability Analysis in Recovery Planning: Efforts to Bridge the Gap Between Theory and Practice

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**Abstract:** Quantitative population viability analysis (PVA) is applicable to, and essential for, many aspects of species at risk recovery planning and action; however, PVA itself is currently beyond the reach of most recovery practitioners mainly because of (1) a lack of empirical data, (2) a lack of (and lack of access to) appropriate tools, and (3) a deficiency in expertise and experience with different concepts, theories, and tools. On the other hand, our understanding of population viability is continuously improved by ongoing theoretical work and case study experience (e.g., the federal government's Interdepartmental Recovery Fund critical habitat project). As such, the gap between theory and practice seems to widen—an unacceptable trend in a period of dramatic species extinction and new legislative efforts to protect endangered species in Canada. This presentation provides guidelines for using quantitative PVA in a practical context. We show that population viability is likely to be constrained by a hierarchical set of limiting factors and threats. This insight, which is based on the relative importance of limiting factors on demographic processes, is translated into a decision tree for using PVA. We demonstrate that quantitative PVA does not necessarily require comprehensive data sets in order to be helpful for recovery actions. Additionally, we provide an outlook for a new generation of internet-based population viability assessment tools that will help identify and monitor the viability of endangered species and their dependency on environmental factors in Canada.

**Key Words:** PVA, population viability analysis, population modeling, critical habitat, tools, internet, PVA process, PVA guideline, recovery planning

## Introduction

This paper outlines the concept for a population viability assessment tool (PVAT) that will help narrow the gap between theory and practice. PVAT will be a tool for recovery action planning, ecological risk assessment, or conservation and official land use planning. It will use modern internet technology for analyzing the viability of populations based on quantitative demographic data and pre-computed population viability indicators. The core of PVAT will consist of two integrated databases. The first database will record and organize standardized, quantitative information on species' demography and life history (e.g., fecundity, survival). The second database will store a comprehensive set of pre-computed population viability indicators (e.g., minimum viable population size, extinction risk, probability of survival) for a wide range of demographic conditions and habitat configurations. These databases will be accessible over the internet.

The key features of PVAT will be on-line tools that can be used for rapid quantitative population viability analyses. This sophisticated objective will be achieved by linking information recorded in the two databases. Rapid PVA will be possible by using demographic data (database 1) as pointers for retrieving population viability information from the comprehensive set of predicted population viability indicators (database 2).

PVAT will allow demographic, quantitative knowledge for species at risk to be combined with most recent scientific PVA theories and methods. This will be achieved by using established and new simulation models (e.g., RAMAS, Vortex, Patch) for pre-computing a comprehensive set of population viability indicators for a wide range of demographic conditions. While this approach (usually called a factorial combination of various parameter values) is commonly used in theoretical studies, it is not feasible for, or accessible to, practical applications. PVAT will not replace the use of simulation models for PVA, but will provide a pragmatic shortcut to a comprehensive set of results obtained from such models.

The vision for PVAT is to facilitate research, communication, education, and knowledge transfer from theory to practice in favor of the fate of species at risk in Canada and elsewhere. PVAT will become the first integrated framework of this kind in the world and will provide Canada with a valuable tool and database to better understand the fate and options for protecting species at risk.

## Motivation

PVAT is a logical consequence of

- the current legislative demand to identify critical habitat for species at risk in Canada;
- the availability of theoretical concepts and practical tools for calculating population viability indicators;
- the existence, availability, and user acceptance of sophisticated internet technology;
- the identified need for organizing, standardizing, and integrating valuable demographic data and knowledge of species at risk; and
- the current lack of a central, accessible quantitative database for recording, monitoring, and exchanging information on species at risk in Canada.

The legislative demand arises from the *Species at Risk Act* (SARA, Bill C-5). Theoretical concepts, such as metapopulation ecology and landscape scale population ecology are acknowledged approaches in identifying and ranking factors that affect population viability. These concepts were, in part, developed with the help of spatially explicit population models. A few established tools (e.g., RAMAS GIS, Vortex, Patch) have been applied to a variety of population viability analyses across different taxonomic groups and are principally available for use in applied conservation ecology. Their proper use and interpretation of results, however, requires experience and a thorough understanding of the underlying theoretical concepts. This results in a relatively high usability threshold. PVAT will bridge this gap by providing access to population viability indicators obtained from these tools. PVAT will utilize modern internet technology to provide and control access to a wide range of potential users. The most urgent demand for PVAT, however, arises from the need to build a quantitative database for all information related to species at risk in Canada. A recent pilot study for delineating critical habitat for six endangered species in Canada (Interdepartmental Recovery Fund [IRF]) revealed an urgent demand for a consistent and consolidated database. To summarize, PVAT will simplify and encourage data organization and transfer of theoretical knowledge into practical information. It will furthermore grow into a comprehensive data pool from which further scientific projects can draw upon. Although PVAT will constitute a new innovative idea in the field of conservation ecology, it will not be the first to use this general approach. Similar systems, such as weather forecast and monitoring web sites, medical or disease information systems, and stock market analyses are abundantly available on the internet. It is, therefore, time to enable proven technology and concepts in favour of research and providing practical support to conservation ecology.

## Scientific Background

A few fundamental patterns emerged from recent research in spatially explicit population ecology. These patterns identify the relative importance of various factors and data on population viability. Table 1 provides a simplified overview of the main factors affecting population viability. These factors are ranked according to their relative importance to population viability, and they supplement each other with increasing rank order. The relative importance of these factors can also be translated into a decision tree (Fig. 1).

**Table 1. Constraints on population viability.**

| *Rank* | *Factor (constraint)* | *Affected by* | *Data for PVA* |
|---|---|---|---|
| 1 | Demographic potential (ratio between fecundity and survival) | Habitat quality (climate, predator/prey dynamics, competition, disturbance, human-related factors such as pesticide use and pollution) | Averages and variation in fecundity and survival |
| 2 | Habitat amount and population size | Human-related factors, disturbances, habitat loss, lack of complimentary habitat (summer-winter) | Spatial requirements (territory or home range size) and population density or abundance (census, surveys) |
| 3 | Habitat fragmentation | Human-related factors, disturbances | Dispersal and immigration rates |
| 4 | Matrix composition* (quality) | Human-related factors, agricultural and urban areas, roads and traffic | Dispersal behaviour and mortality in habitat and matrix |

*'Matrix' refers to the land surrounding and in-between habitat for a specific species. 'Matrix composition' refers to matrix heterogeneity or the proportion of land cover types within the matrix

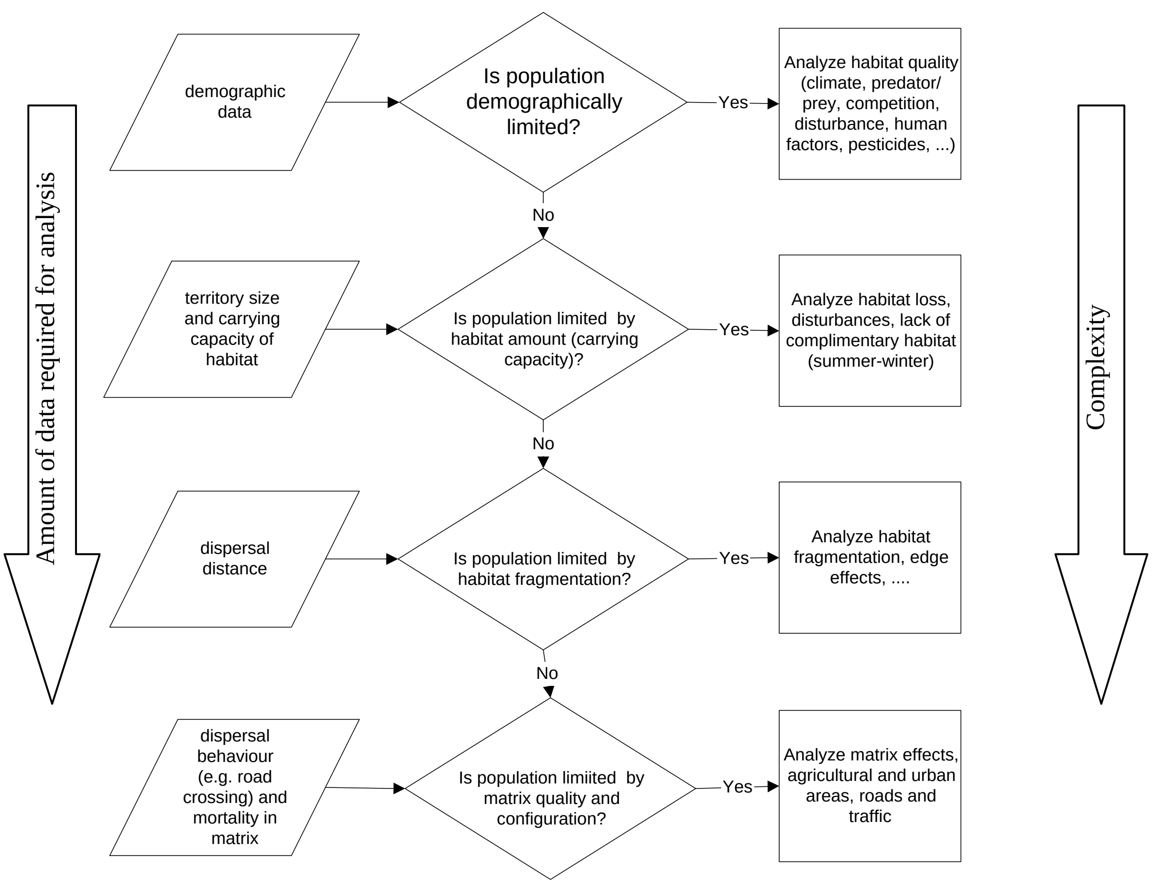


**Figure 1. Decision tree based on the relative importance of principal factors that affect population viability.**

If, for example, a population is not found to be demographically limited, the next important factor must be included in the PVA. This requires additional data and increases the level of complexity. Conversely, if a population is found to be demographically limited, lower ranking factors may not be important; therefore, they may not necessarily be included in the PVA. Instead, any further effort should focus on the reasons for the demographic limitation. This can often been achieved by comparing demographic data and environmental conditions across different populations of the same species. For example, PVA for the Acadian flycatcher in Ontario revealed the population was demographically limited. In contrast, populations of the Acadian flycatcher in southern regions of the United States were not found to be demographically limited. Comparison of fecundity and survival across different populations revealed that the breeding season in Ontario is shorter and permits only one clutch per year, whereas two clutches per year are successfully raised in southern regions. Climatic conditions are most likely the cause for this demographic limitation.

Another example relates to the yellow-breasted chat population in the Okanagan Valley, British Columbia. This population was found to be limited by habitat fragmentation. Results of a simple nonspatial population model indicated that the population was demographically viable. These results were inconsistent with the observed population size and abundance trajectory; therefore, we analyzed the habitat amount required to support a viable population and compared the result to the identified suitable habitat in the region. We found the identified suitable habitat was sufficient for supporting a minimum viable population; consequently, the population is not likely to be limited by habitat amount. We included habitat fragmentation in our analysis by adding dispersal distances in a spatially explicit metapopulation model. The results revealed that habitat fragmentation was a serious constraint on this population.

To summarize, population viability is affected by nonspatial and spatial factors. These factors rank similarly for many species based on their general relative importance to population dynamics. This pattern encourages a stepwise approach (from simple nonspatial to complex spatial) when analyzing population viability. Demand for demographic information increases with increasing complexity of the population model but is only necessary if the most important factors can be excluded as constraints on population viability. PVAT will use these theoretical insights and will provide tools to conduct stepwise quantitative population viability analyses.

## Implementation

A simplified overview of the principal components of PVAT is shown in Figure 2. PVAT will be an internet application; consequently, it will be accessible worldwide. It will allow the user to enter and retrieve data from two databases. The first demographic database will store quantitative, standardized information on species' demography, such as observed fecundity and survival rates. It will also allow that information to be linked to references of relevant publications, recovery team members, and time of posting. These data will be recorded over time allowing changes to be tracked by evaluating the data history. The second database will contain a comprehensive set of pre-computed population viability indicators. These data will be produced by simulating population dynamics for a wide range of demographic situations using a factorial combination of population model and landscape model parameter values. The dimension of these databases will depend on the number of parameters used in the simulation models. Each parameter corresponds to one dimension. Note that Figure 2 only shows three dimensions (fecundity, habitat amount, and time) for simplicity's sake. Computing the population viability indicators for a multi-dimensional parameter space will be one of the major challenges of this project. Computation time increases with model complexity and may become a constraint for populating this database.

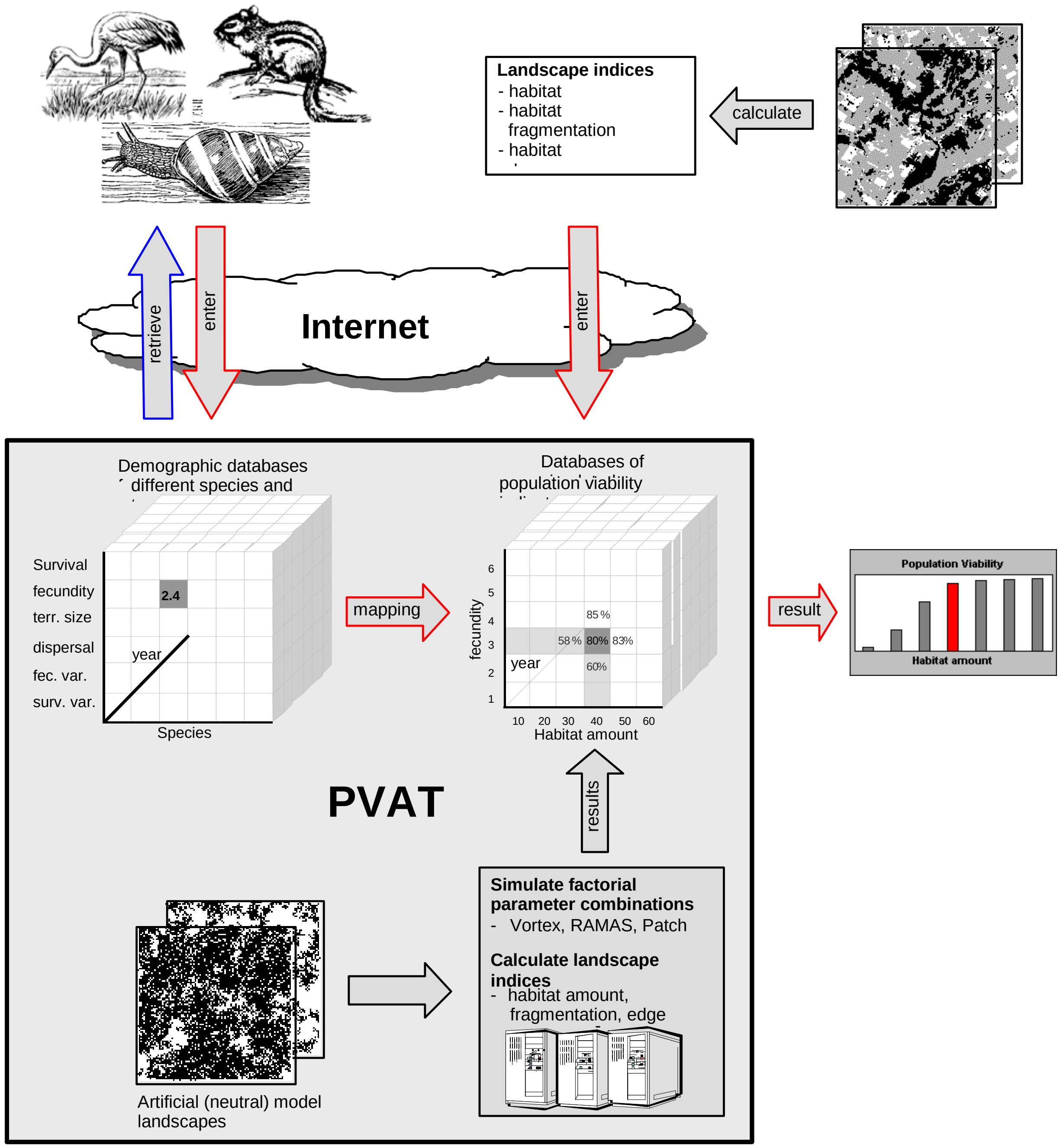


**Figure 2. Overview of the principal components of PVAT. The core of PVAT consists of multi-dimensional databases of pre-computed population viability indicators. These are results of simulating factorial combinations of demographic model parameters and habitat configurations. Habitat configurations are quantified using landscape indices. Dimensions of the databases correspond to model parameters. Providing a value for each dimension will return the corresponding PVA indicator. The demographic databases will be populated manually. PVAT will map demographic data and landscape indices to one of the indicator databases and return the nearest PVA indicator.**

## Outlook

PVAT will provide the foundation for a knowledge portal of information related to population viability analyses, conservation ecology, habitat suitability modeling, and more. The initial prototype can be extended by adding databases for tracking observed population abundances, saving and restoring PVA projects and experiments, and comparing observed with predicted population abundances. PVAT may be extended by a reporting tool that will allow changes in demographic and abundance data to be tracked over time. It may also provide links to relevant internet sites, tools, literature, and organizations.

PVAT has the potential to grow into a dynamic information portal. This process will largely depend on funding, user acceptance, input from stakeholders, scientists, and information technologists; therefore, it is impossible at this point to completely define the entire functionality of a finalized system. PVAT will, therefore, be implemented based on extensible modules. Implementation will adhere to modern principles in internet application development. The first step will be the development of a simple prototype, which will serve as a proof of concept. This prototype of PVAT will provide hands-on experience, elicit important user feedback, and facilitate communication about the potentials of PVAT; therefore, PVAT will be developed and extended over many phases. This will ensure acceptance, usability, scientific sophistication, and consequently, best possible return of investment.