Using Conceptual Models to Select Indicators for Wildlife Resource Values

FREP

Extension Note #16

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The *Framework for Monitoring and Evaluating Wildlife Resource Values*[1] under the Forest and Range Evaluation Program recommends demonstrating cause-and-effect relationships in a conceptual model to identify and support the selection of indicators. Conceptual models are an effective way to structure and communicate information about the interaction and influence of various factors. This is helpful both for selecting meaningful indicators and later in interpreting results.

Although this is an important step in the development of any monitoring project, it is especially important

(if not essential) for selecting indicators to evaluate the effectiveness of species-specific habitat management actions such as establishing wildlife habitat areas. Effectiveness is ultimately measured by how a species responds to implemented management actions. However, understanding a species response is complex and depends on many biological and anthropogenic factors. Evaluations of wildlife habitat management actions need to consider the complex interaction of these factors. In many cases, the relationships between factors are not well understood and require the formulation of predictions (hypotheses) regarding the interaction of factors and which factors will have the most influence. Conceptual models are an effective means of considering this complexity while acknowledging and documenting assumptions and areas of uncertainty. As such, these models can better inform and guide evaluations of wildlife habitat management actions.

This extension note briefly introduces conceptual models and recommends two approaches to support the selection of indicators for evaluating wildlife habitat management actions. It is a brief overview of a more detailed report (FREP Report # 24[2]) prepared by Brian Nyberg.

Conceptual models provide a scientific framework for the selection of indicators and interpretation of monitoring results.

Types of Conceptual Models

Conceptual models are of many types and can be classified according to how the information is structured (conceptual framework) and presented. In the context of informing indicator selection for evaluations of wildlife habitat management actions, four potentially useful conceptual frameworks exist: (1) Pressure-State-Response, (2) Ecological Causal Web, (3) Impact Hypothesis Diagrams, and (4) Logic Models.

Of these, the most relevant for identifying and linking indicators to evaluate wildlife habitat management actions is the Ecological Causal Web. This framework represents networks (webs) of linked ecological factors that relate species habitat attributes to a species population response.

Regardless of the conceptual framework employed, relationships can be presented in diagrams, tables, narratives, equations, graphs, or other mathematical models, or in any combination.

Recommended Approaches

Two approaches, based on the Ecological Causal Web framework, are recommended for guiding selection of indicators to evaluate effectiveness of wildlife habitat management: (1) the influence diagram, and (2) the Bayesian belief network. Each approach has advantages and disadvantages.

1 http://www.for.gov.bc.ca/hfp/frep/values/wildlife.htm

2 For more detail, see http://www.for.gov.bc.ca/hfp/frep/publications/reports.htm#rep24

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INFLUENCE DIAGRAM

The influence diagram, as the name suggests, is a diagram that shows the influence of selected factors (variables) on other factors. This is simply a "box-and-arrow" style of diagram. The "boxes" represent factors and the arrows represent influence and direction of influence (see Figure 1).

The influence diagram is an effective and common way of illustrating cause-and-effect relationships. It has the greatest effect when only the most relevant or influential relationships are included; otherwise, the diagram can become confusing. Influence diagrams are relatively easy to produce and often form the basis of more complex models.

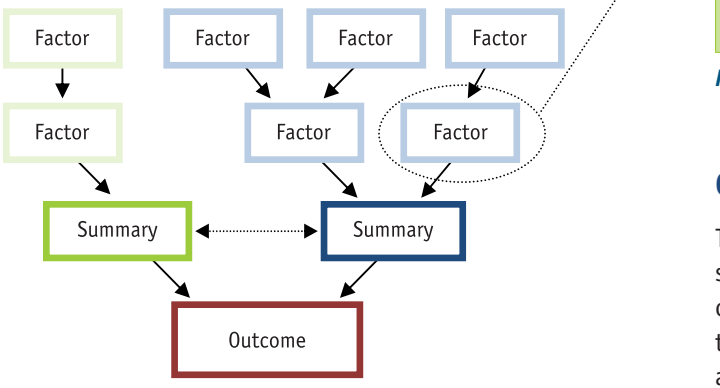

Figure 1. *Influence diagram.*

BAYESIAN BELIEF NETWORK

A Bayesian belief network (BBN) is also a network of boxes, referred to as "nodes," linked by arrows that show the influence of a node on other nodes. Unlike an influence diagram, a BBN is a quantitative model that uses Bayesian statistics to estimate the likelihood (probability) that a variable (node) is in a given state based on the state of linked variables. The state of each node is determined using conditional probability tables (see Figure 2). For evaluations of habitat management actions, nodes typically represent factors that most influence habitat condition, species population condition, and risk from human activities or natural disturbances.

Depending on the complexity, BBNs can require considerable effort to build and apply and require specific software and skills. Nevertheless, a BBN is a powerful tool because of the analytical capabilities offered by a quantitative model. Compared to other quantitative models, BBNs are quite flexible, enabling the integration of expert opinion with data.

When developing a BBN it is important to clarify what is known, what is not known, and under what situations the model is relevant (e.g., scale, area, ecosystem). Therefore, BBNs are commonly developed collaboratively with subject-matter experts and project teams. This approach results in a common understanding and support of the modelled relationships and the current state of knowledge, and provides certainty that the modelled relationships represent our best understanding of the system.

One of the greatest advantages of using a BBN is the knowledge that can result from the iterative process involved in testing and updating the model.

Input Factor	Factor	
	A	*B*
Present	0.6	0.4
Absent	0.3	0.7

States

Conditional Probabilities

Figure 2. *Conditional probability table for a node with two possible states (A or B) based on the state of the input node (present or absent).*

CHOOSING AN APPROACH

The approach selected will depend on the circumstances surrounding the monitoring project and the preferences of the evaluators. Although a BBN is a more powerful tool than an influence diagram, its use is not recommended in all cases because the level of effort required may not be warranted. An influence diagram is always a good place to start as it provides a solid foundation for further modelling, including BBNs. However, BBNs are rising in popularity as the number of skilled professionals increase and the software becomes more affordable.

	Influence Diagram	Bayesian Belief Network
Advantages	• Intuitive • Simple • Inexpensive • No special skills or software required	• Intuitive • Quantitative (analytical capability) • More extensive applications • Deals well with uncertainties
Disadvantages	• Can become too detailed and confusing • Descriptive only	• Requires more effort • Requires more knowledge • Requires skills or software

Figure 3. *Advantages and disadvantages of two approaches.*

Regardless of the approach selected, it is important to clearly recognize how much is known about the expressed relationships, to document reference materials, and to incorporate peer review.

Using a sound conceptual model to guide and inform the selection of indicators helps ensure meaningful data is collected. Such data is vital in conducting evaluations of the effectiveness of wildlife habitat management actions in British Columbia.

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