# EFFECTIVENESS MONITORING GUIDELINES FOR ECOSYSTEM RESTORATION

# Final Report

**Submitted to:**

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# Executive Summary

This document provides a conceptual framework and guidelines for *effectiveness monitoring* (EM) of restoration projects. It reviews the rationale for conducting effectiveness monitoring, and describes the sequence of steps involved in designing, implementing and summarizing the results of EM.

*Effectiveness monitoring* addresses the question of how successful a project ultimately is at restoring the ecosystem or component parts. It involves assessing restoration progress in relation to initial objectives, and refining treatment prescriptions, where required, to increase their effectiveness. EM is a critical component of an adaptive management approach to ecosystem restoration. Fundamental questions addressed by EM include the following:

1. Is the restoration work achieving the desired objectives for the targeted ecosystem and/or its component parts?
2. Can restoration methods and techniques be improved to optimize recovery of the ecosystem and/or its component parts?
3. What modifications are possible to improve the cost-effectiveness of the work?

The appropriate level of EM will depend on the nature of the restoration project. *Routine evaluation* involves rapid data collection at low cost, using mainly qualitative methods to compare one or a few response variables before and after treatment. It is appropriate for restoration projects with straightforward objectives and established methods applied to a small or homogeneous area over a limited time period. *Intensive evaluation* requires more in-depth quantitative monitoring over a longer time frame at a higher cost. The latter would only be conducted for selected projects (or at a subset of sites that are part of a large project or *program)* where a quantitative assessment of restoration success is critical in order to obtain feedback for future restoration efforts. This might be the case where (i) a restoration treatment is applied over large areas with potentially far-reaching management implications; (ii) restoration involves using new, innovative or poorly documented techniques; or (iii) several activities, steps or treatments are involved and a quantitative measure of comparative or interactive effects is desired.

Effectiveness evaluations should be designed and initiated prior to the commencement of any restoration work, in order to ensure valid pre- and post-treatment comparisons. Designing and implementing an effectiveness evaluation for a particular project involves the following steps: determine EM objectives; select an appropriate monitoring design and level of evaluation; identify project constraints (e.g., budgetary, logistic, personnel); refine EM objectives, identify key response variables to monitor; design monitoring protocols; implement EM; implement restoration prescription(s); analyze, summarize and interpret monitoring data; and report and communicate findings. Each of these steps is discussed with reference to specific examples of terrestrial ecosystem restoration.

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# Acknowledgements

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# Introduction

## Objectives And Scope

This report was originally conceived to benefit the (now-defunct) Forest Renewal BC Terrestrial Ecosystem Restoration Program (TERP), but the tenets apply to any restoration project, regardless of funding source or location. Good effectiveness monitoring will evaluate whether projects are ultimately restoring ecosystems and their component parts, and whether there is a need to refine current restoration treatments or practices to increase their effectiveness. Fundamental questions addressed by effectiveness monitoring include the following:

1. Is the restoration work achieving the desired objectives for the targeted ecosystem and/or its component parts?
2. Can restoration methods and techniques be improved to optimize recovery of the ecosystem and/or its component parts?
3. What modifications are possible to improve the cost-effectiveness of the work?

This document provides a conceptual framework and general guidelines for the design of an effectiveness monitoring (EM) component for all operational (on-the-ground) restoration projects. It reviews the rationale for conducting effectiveness evaluations and describes the sequence of steps involved in designing, implementing and summarizing the results of EM. As such, this document will be of interest to anyone conducting, seeking funding for, or administering restoration projects. Recognizing the diversity of potential restorationists and ecosystems to be restored, an attempt has been made to develop EM guidelines that are clear, usable by a diverse audience with varied capacities, flexible enough to apply to a range of treatment types, and applicable to a variety of ecosystems found province-wide.

## What Is Effectiveness Monitoring And Why Is It Important?

Ecosystem restoration is a relatively new field incorporating techniques from a variety of other disciplines, and a conceptual framework to approach restoration in practice is now developing (Hobbs and Norton 1996; Hobbs and Harris 2001). Underlying any successful restoration initiative is a sequence of systematic steps (as adapted from Hobbs and Norton 1996):

1. Identify the processes underlying the degradation or decline;
2. Define suitable *a priori* restoration goals and objectives based on a reference ecosystem, historic range of variability, and/or desired future condition;
3. Develop treatment prescriptions to reverse or ameliorate the degradation or decline at a spatial and temporal scale appropriate to the problem;
4. Implement treatment prescriptions and monitor to ensure that they are adhered to;
5. Identify and monitor key system variables and other easily observable measures of treatment success;
6. Review and summarize monitoring output, assess progress of restoration relative to initial goals, and make adjustments, if necessary; and
7. Communicate findings and incorporate into future planning and management strategies.

Monitoring increases our understanding about ecosystem function and response thresholds and provides insights about which practices are effective. Monitoring of restoration activities has not been emphasized in the past and there has been a tendency to repeat treatments without questioning their efficacy or applicability to different biogeoclimatic zones (Clewall and Rieger 1997). This leaves restoration practitioners with little opportunity to critically evaluate the success of currently used treatments.

*Effectiveness monitoring* (EM) addresses the question of how successful a project ultimately is at restoring the ecosystem or component parts, relative to its initial goals and objectives (Noss and Cooperrider 1994; Morrison and Marcot 1995). It is the process (embodied in steps 5 and 6 above) of identifying and monitoring key indicators of ecosystem response to evaluate the success of a restoration initiative. Restoration progress is assessed in relation to initial objectives, and treatment prescriptions may be refined or modified, where required, to strive for more acceptable results. EM is a critical component of an adaptive management[1] approach to ecosystem restoration, or to any other resource management activity (Taylor *et al*. 1997; Morrison 2001). Monitoring feedback is used to modify or refine restoration practices, and promote improved restoration success over time. It may also result in greater efficiency and lower costs associated with future project planning, implementation, and/or evaluation (Figure 1). Monitoring findings can also influence a funding agency to modify or refine its goals and strategic funding priorities over time (Figure 1).

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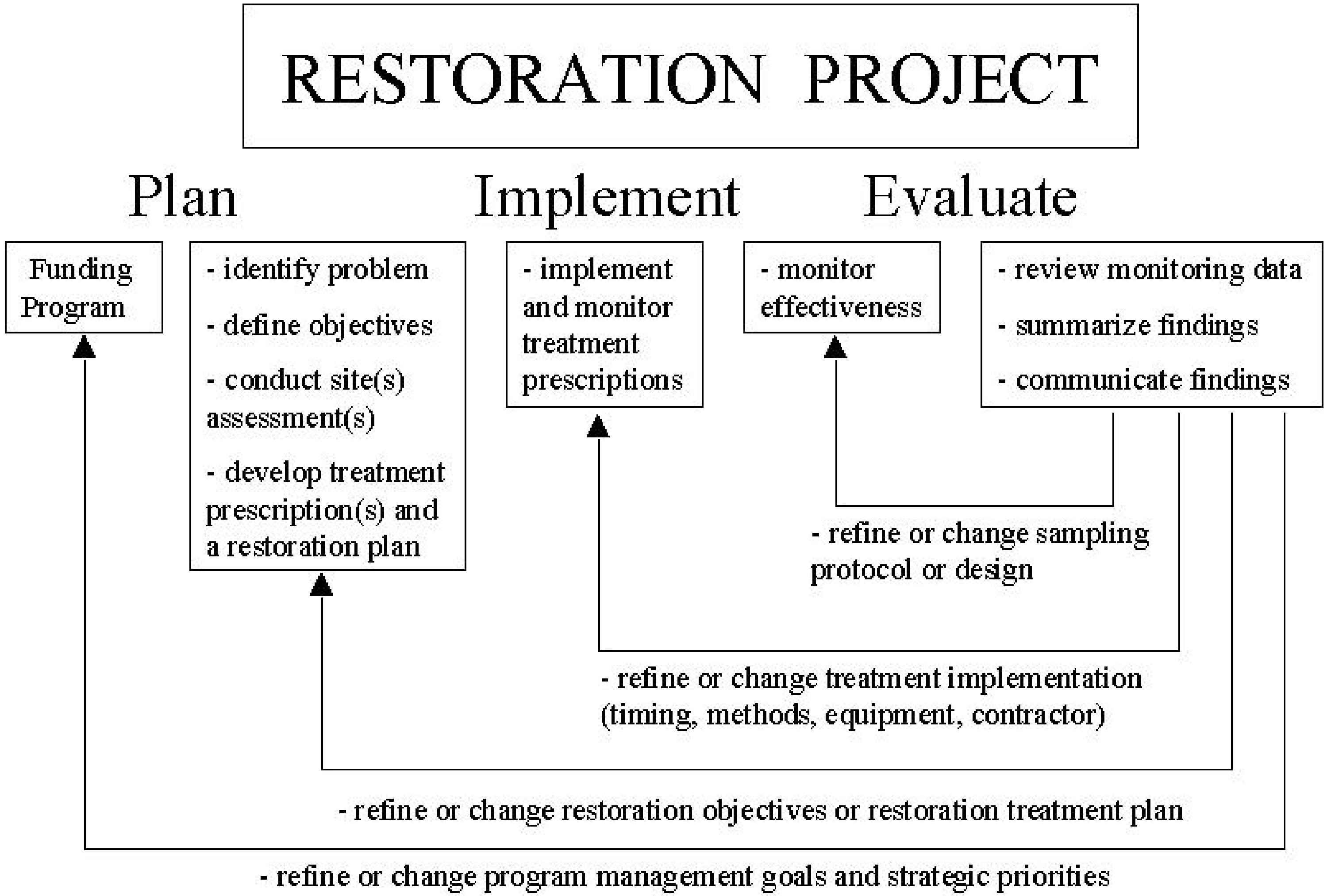
[1] Adaptive management is "a systematic approach to improving management by learning from the outcomes of management interventions" through "careful design, monitoring, evaluation and feedback" (see Taylor *et al*. 1997).

Figure 1. The role of effectiveness monitoring within an adaptive management framework to ecosystem restoration (modified from Gaboury and Wong 1999).



EM differs from *implementation monitoring* (IM), which answers the question of how well (or accurately) treatments were carried out (in terms of conditions, standards or targets complied with, activities completed, and resources expended), relative to a restoration prescription. Nevertheless, EM findings may be difficult to interpret or apply within an adaptive management context if IM is not conducted concurrently. Using restoration of open forest and grassland habitat with prescribed fire as an example, there is often a poor fit between predicted and actual fire behavior. If actual fire behavior is not monitored and quantified during treatment implementation, unexpected post-burn ecosystem responses measured during EM may be difficult to interpret and factor into an adaptive management framework. Therefore although effectiveness monitoring is the focus of these guidelines, it is acknowledged that restoration success is contingent on both the *appropriateness* and the *accuracy* of a particular treatment. Restoration plans developed for specific projects should provide details on how both types of monitoring (IM and EM) will be addressed as part of an adaptive management approach to ecosystem restoration.

# Effectiveness Evaluation Framework

Effectiveness evaluations can be conducted at varying levels of intensity, depending on restoration project complexity (e.g., the specific nature of the work proposed, the number of steps or activities involved in completing it, the size of treated site(s), the time frame of the work, and the associated costs). The range of effectiveness evaluation possible is shown in Figure 2. This figure parallels the framework and terminology developed for effectiveness evaluations under the Watershed Restoration Program (Gaboury and Wong 1999), with a few modifications. The level of effectiveness evaluation is shown as a continuum ranging from *Routine* to *Intensive* evaluations. Also shown in Figure 2 are the concepts of *Inspection* and *Validation.* Inspection involves field- or office-based assessment by administrative staff to ensure that the terms and conditions of a restoration contract are satisfied. *Validation* entails pure and applied research to formally test hypotheses or assumptions underlying the development or design of restoration treatment(s). This will often involve comparative testing of restoration treatments with controls and some level of replication to reduce variation.

*Routine evaluation* will usually apply to restoration projects with relatively straightforward objectives and established methods that are applied to a relatively small or homogeneous area over a limited period of time. Such evaluation involves rapid data collection at low cost, using mainly qualitative methods (e.g., photo-points, a visual estimate or a rating system) to compare

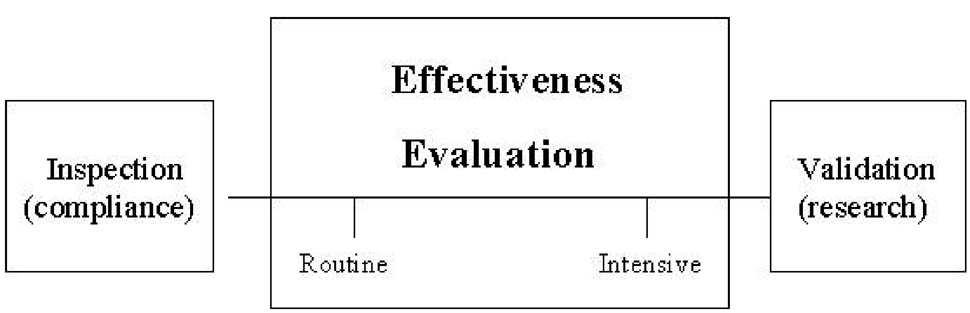



Figure 2. A conceptual framework showing the range of possible effectiveness evaluations.

one or a few key response variables before and after restoration works are completed. Routine evaluation provides an indication of the extent of ecosystem recovery and current site condition. It will also serve to identify sites where more detailed evaluation is required. In the case of a restoration project involving noxious weed removal through hand pulling over a small uniform area, a routine effectiveness evaluation would be most appropriate. It might entail monitoring weed and native vegetation species cover through qualitative assessment (e.g., pre- and post-treatment photographs taken at permanent photo-points). If little is known about the efficacy of hand-pulling to reduce the relative abundance of the weed species being targeted, then a low-level quantitative assessment (e.g., measurement of percent cover and weed species density in marked sampling plots established along a random transect) may be warranted.

*Intensive evaluation* requires more in-depth quantitative monitoring and analysis over a longer time frame at a higher cost. Such an evaluation provides a quantitative assessment of pre- and post-treatment site condition and ecosystem recovery based on measurement of several key response indicators. The latter can be useful to refine future treatments or to select the best treatment where several are available. An intensive evaluation would only be conducted for selected projects or at a subset of sites that are part of a large project or "*program*"[2]. For example, intensive evaluation would be required where a quantitative assessment of restoration success is critical in order to obtain feedback for future restoration efforts. This might be the case where (i) a restoration treatment is applied over large areas with potentially far-reaching management implications; (ii) restoration involves using new, innovative or poorly documented techniques; or (iii) several activities, steps or treatments are involved and a quantitative measure of comparative or interactive effects is desired. Intensive evaluation would be appropriate where fire-maintained ecosystem restoration is conducted over a broad area with the long term goal of re-introducing fire and its associated mosaic of grassland and open forest habitats, structural attributes and plant and animal communities (see Brown *et al*. 2001; Machmer *et al., in prep*.). Such an evaluation would involve pre- and post-treatment monitoring of several ecosystem response variables (e.g., extent and spatial distribution of open forest and grassland habitats; density, cover and composition of overstory and understory vegetation; presence or density of selected habitat attributes such as veteran trees, large snags and coarse woody debris, or particular forage species, etc.). These variables would have to address multiple spatial and temporal scales. To ensure that the hypotheses and assumptions underlying the restoration program are sound and scientifically defensible, concurrent research would also be required (Tiedmann *et al*. 2000; Lehmkuhl *et al*. 2001).

In the case of restoration projects that share aspects described under both *routine* and *intensive* evaluations, some intermediate level of effectiveness evaluation may be most appropriate.

# Designing Effectiveness Evaluations

Designing, implementing and summarizing the results of an effectiveness evaluation for a particular restoration project involves considering and integrating a number of factors or steps.

[2] A restoration *program* is considered a coordinated restoration effort involving treatment(s) application over large areas and/or at multiple sites to achieve a common objective (e.g., NDT4 ecosystem restoration in the East Kootenay Trench; Gary Oak ecosystem restoration in coastal British Columbia).

These are outlined in Figure 3 and discussed in this section. It is important to note that effectiveness evaluations should be designed in tandem with restoration goals and objectives, and prior to the commencement of any restoration work. This is critical to ensure valid pre- and post-treatment comparisons.

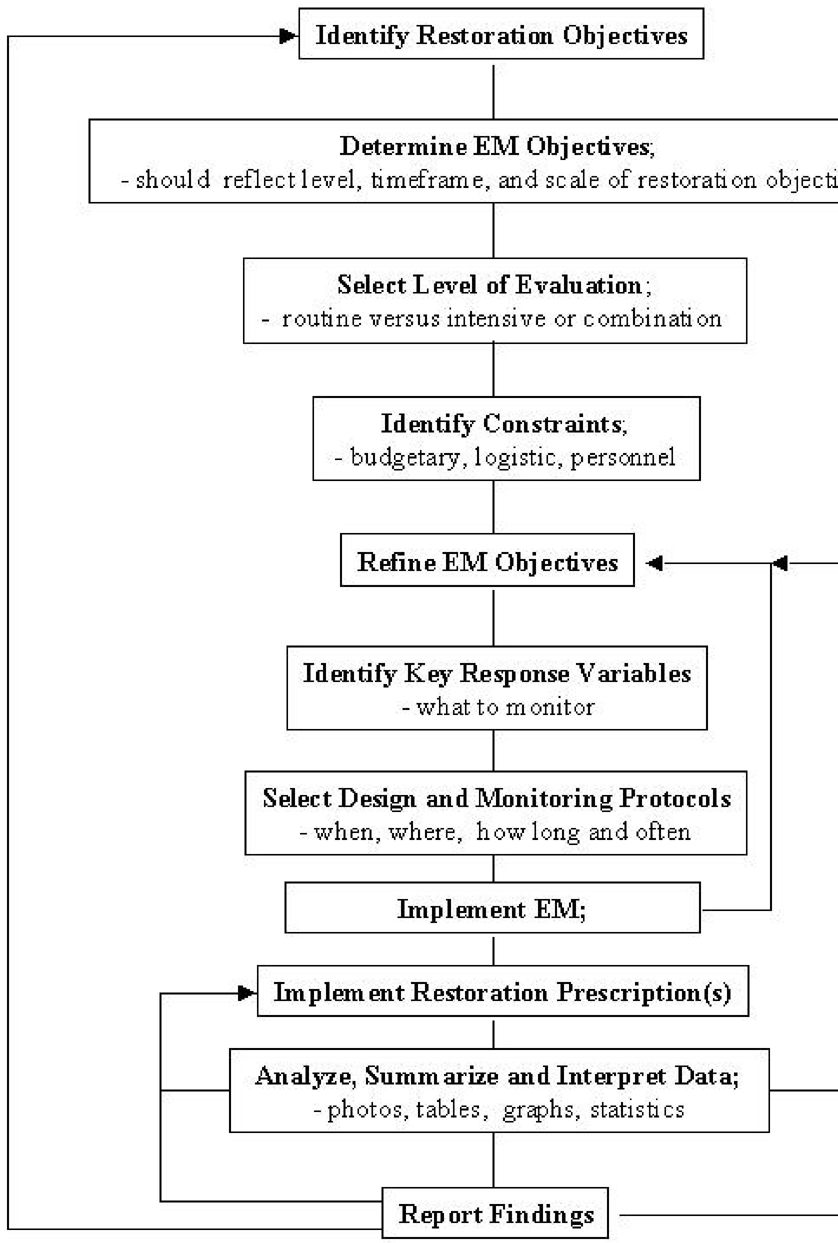
## Determine Effectiveness Monitoring Objectives

Restoration objectives are formal statements regarding the actions required in order to achieve the project goals. Irrespective of the nature of the restoration project, objectives should be explicit, measurable, and have a designated time element (Clewall *et al.* 2000). They must also be based on sound ecological information from a reference ecosystem, or determined from the historic range of variability and/or desired future conditions for an ecosystem. EM objectives need to relate very clearly back to the restoration objectives in terms of the level of restoration proposed (i.e., ecological processes, component/habitat, or species level of organization), and the expected timeframe for ecosystem recovery (i.e., short versus long term).

Where restoration is focused on the re-establishment of an ecosystem process, the change in the process may be measurable as soon as the work is complete, however the "trickle down effect" to finer levels of organization (i.e., component/habitat and species) may take many years. For example, removal of a dyke may restore the natural hydrologic regime to a downstream cottonwood riparian bottomland, resulting in resumption of seasonal flooding events. However, functional recovery of a particular vegetation community or wildlife species associated with that habitat may take much longer. An effectiveness evaluation that gages the success of the restoration should identify and measure response indicators at appropriate levels of organization, and over realistic timeframes. In the example above, pre- and post-treatment measurement of seasonal water levels over the short term (3 years) might begin to address effectiveness at the process level. Monitoring of cottonwood (and other flood-resistant) seedling establishment and growth over an intermediate time frame (5 years) might provide an initial indication of cottonwood riparian habitat recovery. To ensure that the restoration is functionally successful over the longer term (5-10 years), monitoring and comparison of key wildlife species dependent on cottonwood riparian habitat (e.g., Beaver, Gray Catbird, Black-headed Grosbeak, Veery, Northern Waterthrush; Egan *et al*. 1997) might also be appropriate.

Where restoration focuses on repairing the habitat of a particular species at risk, an effectiveness evaluation would seek to monitor use of the restored habitat by the species over the longer term, acknowledging that there may be some delay between habitat recovery and species re-occupancy (Scott *et al*. 2001). Other response variables that are known to be of importance to the species should be monitored over the shorter term. For example, where a small lake previously used for nesting by Western Grebes has recently become too shallow, dry and densely vegetated (due to upstream water control for irrigation), restoration may involve increasing water flows to historic levels after manually thinning vegetation growth. Grebes require stable water levels with a supply of shoreline emergent vegetation for successful breeding. An effectiveness evaluation for this project might involve pre- and post-treatment comparisons of lakeshore water levels and emergent vegetation cover or density during the breeding season, as well as direct monitoring for grebe nesting activity over the longer term. Some concurrent monitoring of small fish prey may also be warranted, to ensure that food is not a limiting factor.

Figure 3. Steps in the design, implementation,and summary of effectiveness evaluations (adapted from Gadboury and Wong 1999).



## Select Appropriate Level of Evaluation

Developing EM objectives for a restoration project or program involves striking the right balance between the cost of monitoring relative to the level of detail required to evaluate restoration success based on *a priori* restoration objectives. Selecting the most appropriate level of intensity will involve consideration of the following:

- the amount of funding available to conduct the physical restoration work – effectiveness evaluation costs (development, implementation, and evaluation) should reflect overall project costs; they should typically not exceed 10% of the total project budget;

- the degree of overlap with other EM initiatives for similar projects – where EM data (and pitfalls to avoid) are already available to evaluate the success of a comparable restoration treatment, then intensive monitoring may not be required;

- the complexity of treatment(s) proposed to meet objectives – projects involving more complex treatments (i.e., treatments with several steps or comparisons of alternative treatments) are more likely to require intensive evaluation;

- the level of ecosystem organization (i.e., ecosystem processes, components or habitats, communities or species) addressed by the restoration objectives – projects addressing coarser levels of organization with a "trickle-down" effect may require more intensive evaluation using more response variables to address multiple levels of organization;

- the time frame of the restoration work – restoration projects taking place over several years with a number of steps to completion are likely to require repeated and more intensive evaluation;

- the spatial scale of the restoration work – restoration projects applied over a large area and/or at a number of sites are more likely to require intensive evaluation at a site or subset of sites treated;

- the level of risk or uncertainty associated with a restoration treatment – treatments that are new, innovative or poorly-documented should have a higher priority for intensive evaluation; and

- the expected benefit gained through intensive evaluation (in terms of the potential broad-scale application of the method to other degraded sites in the landscape) – projects whose findings have the potential to be widely applicable to subsequent restoration initiatives should be given greater priority for intensive evaluation.

## Identify Constraints

In designing an effectiveness evaluation, constraints pertaining to the project budget, logistics and available personnel must be identified and will determine whether an effectiveness evaluation design is feasible and realistic. Identifying response variables that are readily measured, at a low cost, with minimal need for specialized equipment or training of personnel is essential, to ensure that monitoring is cost-effective relative to the information gained (Hobbs and Harris 2001).

## Refine Effectiveness Monitoring Objectives

After integrating constraints with restoration project objectives and level of evaluation, effectiveness monitoring objectives can be refined. Only those objectives that are considered critical to answer the question of whether a project was an ecological success (and that can be addressed with a reasonable level of effort and cost) should be followed up.

## Identify Key Response Variables

Inherent to any monitoring program is deciding what to monitor in relation to initial objective(s). A response variable (also called "performance standard" or "success criteria") provides evidence based on monitoring in accordance with a prescribed protocol of whether or not (or to what degree) an objective has been attained. Ecosystem restoration incorporates practices and monitoring methods from a variety of disciplines (e.g., earth sciences, ecology, forestry, agriculture, hydrology, geomorphology, conservation biology, etc.) and the wide range of potential response variables used to measure success cannot be listed here. However in general, effectiveness evaluations must be able to detect change, so the best response variables are those that are very closely linked to the restoration objective (Hobbs and Harris 2001). For example, if the objective in a grassland restoration project is to reduce the percent cover of a noxious weed species by 50%, then EM should measure the percent cover of that weed before and after treatment. Whenever possible, response variables that can be empirically quantified (rather than subjectively determined) should be chosen, to facilitate objective interpretation.

Selecting appropriate response variable(s) to address a particular objective requires an understanding of the ecosystem. In some cases, several good response variables may be identified, and some sort of ranking may be required to pick the best one(s), based on cost, ease, accuracy, timing, frequency, subjectivity of measurement, and duration for expected response. In the case of a restoration project using tree girdling and pheromone baiting as techniques to kill trees and restore cavity-nesting bird habitat to a second-growth forest devoid of snags (see George and Zack 2001), several response variables are possibilities. These include: the number (or proportion) of treated trees occupied by incubating birds, the number (or proportion) of treated trees producing young, the mean reproductive success of birds occupying cavities, or simply the number (or proportion) of treated trees with cavities. In terms of time and effort spent monitoring, the latter measure would be the easiest and most cost-effective, since it relies only on observation of fresh sign, rather than animals themselves.

In some cases, meaningful response variables that are cheap and easy to monitor are hard to identify and surrogate variables may have to be used. This is often a problem with restoration involving wildlife/wildlife habitat (George and Zack 2001; Smallwood 2001), where proof of functional success in the restored habitat (e.g., breeding success) is needed, but wildlife presence/absence or relative abundance measures are used as a surrogate (Noon *et al*. 1999). Surrogate measures such as "indicator species", "umbrella species", or "guilds" are often monitored, rather than the populations or habitats of all individual species in a restored area. There are costs and benefits associated with this approach and there should be very strong empirical evidence that supports indicator use for an ecosystem parameter (Block *et al*. 2001).

## Select Design and Monitoring Protocols

To detect change that may be attributable to restoration treatment, one or more response variables must be compared before and after the restoration work is accomplished. This is called a time-series design (Green 1979) and if a difference is detected, then it is suggestive of a treatment effect (note that a difference due to natural temporal variation cannot be separated from a treatment effect with this approach). This type of monitoring design is considered sufficient for routine effectiveness evaluations.

In some cases, it may be worthwhile to collect “before-after” monitoring data at an unrestored site (i.e., “control”), in addition to the treatment site(s). This “quasi-experimental” design (Before-After-Control-Impact; BACI) permits detection of a restoration effect independent of natural temporal variation (Underwood 1994; Block *et al*. 2001). The latter may be necessary in cases where restoration proceeds over several years and natural temporal changes extraneous to treatment are very likely. If treatments are replicated at more than one site (i.e., BACI with replication), then one can distinguish temporal from spatial variability and expand the scope of inference to other areas in addition to those treated (Block *et al*. 2001). The latter may be useful in the case of a large project spanning a large spatial and temporal scale, where the monitoring findings have broad management implications to other areas (see Machmer *et al., in prep*.).

If the work is perceived as a continuum or as part of an ongoing program (rather than a single project with discrete beginning and endpoints), then periodic monitoring during restoration may be desirable, to improve final restoration outcomes through monitoring feedback and adaptive management (Clewall and Rieger 2001).

Within those general designs of “before-after”, “before-after-control-impact, and “before-during-after” monitoring, a number of sampling questions should be considered. Some general guiding principles are provided below in terms of where, when, how long, and how to monitor.

***Where to monitor?***
In rare cases, a restoration site may be small and homogeneous enough to permit complete coverage of the area for a particular response variable (e.g., cover or abundance of a noxious weed or rare endemic plant may be easily estimated or measured directly over a small area). However, some form of sampling is typically required and the sample “population”, number of sample “units” (i.e., plots, transects, quadrats, stations), allocation of those units (i.e., size, shape and distribution), and overall sampling design (i.e., simple random, systematic, or stratified) depend on the amount of variation in the response parameter.

A detailed discussion of sampling design and statistical considerations is beyond the scope of these guidelines. Such information is available on the Resources Inventory Committee website (http://www.for.gov.bc.ca/ric/pubs) and in various texts and reference materials (Cochran 1977; Bonham 1983; Cooperrider *et al*. 1986; Jones 1986; Krebs 1989; B.C. Ministry of Environment, Lands and Parks 1992; B.C. Ministry of Environment, Lands and Parks and Ministry of Forests 1995, 1998; Zar 1998).

***When, how often and how long to monitor?***
The choice of timing, frequency and duration over which data should be collected is influenced by the characteristics of the response parameter, the restoration and monitoring objectives, extrinsic and intrinsic factors that influence the parameter, and the resources available to conduct monitoring. If the parameter monitored changes with time of year, month or day (e.g., high water levels, seed rain of a weed, fruiting of a mushroom, breeding or activity of an animal), then the most appropriate time for monitoring must be established. Once decided, every effort should be made to standardize timing in order to eliminate confounding sources of variation that are dependent on weather, season, time of day, or other time-related phenomena.

After restoration work is completed, some ecosystem, habitat/component or species-level changes may be delayed in their onset or protracted in their response. In designing monitoring protocols, it is critical to consider the estimated duration for a particular monitoring parameter to respond to treatment(s). The timing and frequency of monitoring should be established with the latter in mind and may require adaptive adjustment over time, depending on initial monitoring results.

In a broader sense, the time scale for ecosystem recovery should also be considered, although it is difficult to predict (Hall and Howarth 2000). Where possible, information on time to ecosystem recovery (with comparable restoration treatment in a similar ecosystem) should be sought before designing restoration objectives and EM protocols. Restoration plans often underestimate the time required for ecosystem recovery (Holl and Howarth 2000) or attainment of specific response thresholds. This can result in loss or lack of monitoring funds and undermine the potential for monitoring feedback and adaptive management to occur.

***How to measure?***
Standardized monitoring methods and protocols appropriate to a broad range of response variables can be downloaded from the Resources Inventory Committee website (http://www.for.gov.bc.ca/ric/pubs) or ordered in hard copy format from the Queen's Printer B.C. Government Publications Centre (Telephone: 1-800-663-6105). There are a number of excellent sources of monitoring information covering a wide variety of terrestrial resources (B.C. Ministry of Environment, Lands and Parks 1992; B.C. Ministry of Environment, Lands and Parks and Ministry of Forests 1995, 1998a,b; Luttmerdig *et al*. 1990). Irrespective of the methods used, it is important that these methods are standardized to ensure repeatability of data collection, and valid comparisons before and after treatment. Hall (2001) provides a comprehensive summary of methods for ground-based photographic monitoring.

## Implement Effectiveness Monitoring

Prior to implementing EM, the objectives, level of evaluation, response variables and monitoring protocols for EM should be summarized in the restoration plan for a particular project. By doing so, it will become obvious during the planning phase whether specialized personnel or equipment are required to complete the planning, implementation or evaluation of EM. In cases of routine evaluation, little specialized training or equipment may be necessary to undertake the required monitoring, other than adhering to the restoration plan and to general monitoring methods and standards. In cases of more intensive evaluation, some worker training, assistance or advice from natural resource professionals or statisticians may be required to ensure that effectiveness evaluations are successful and yield meaningful results. Some monitoring equipment may also need to be purchased or rented for a particular project and this would need to be planned and budgeted for early on.

Irrespective of who conducts effectiveness evaluations, it is important that all monitoring locations (e.g., photopoints, plots, transects, quadrats, stations, etc.) be permanently marked and readily located (e.g., global positioning system air-photos, etc.). This will facilitate re-location and monitoring after the restoration prescription is implemented.

Once effectiveness monitoring has been conducted and data are available for evaluation, early monitoring findings may suggest adaptive modification to additional planned treatments (Figure 3). For example, where two alternative treatments are used to re-vegetate a slide area, if one shows measurable success whereas the second shows no response, consideration should be given to only using the successful treatment in subsequent restoration efforts.

## Analyze, Summarize and Interpret Monitoring Data

Data summary for a routine evaluation would consist of a comparison of key response variable(s) before and after restoration treatment(s). The latter could be shown in photos, graphs, tables, charts, or using descriptive statistics (frequencies, proportions, mean, variance, etc.), if the data are quantitative. Where monitoring is repeated periodically in conjunction with restoration treatment, graphical displays showing the change in key response variable(s) over time (possibly relative to a nearby untreated control site) are useful. A post-treatment response variable could also be compared to that of a reference ecosystem or bio-standard as an indication of ecosystem recovery.

Intensive evaluations (potentially with multiple treatments, replication and controls) will generate quantitative data. The latter should be summarized using descriptive statistics (e.g., mean and variance by treatment/site) and shown in graphical or tabular format to facilitate interpretation. Statistical analysis can be used as a tool to objectively evaluate the significance of treatment(s) effects and compare the effects of alternative treatments. To gage success, treatment outcomes can also be compared with data for an established reference ecosystem, or with a known bio-standard.

## Report Findings

Findings of effectiveness evaluations should be an important component of all restoration project reports. This report would include a description of EM objectives, type and design of evaluation, key response variables, and monitoring protocols. EM findings should also include a discussion of the following:

- a summary of monitoring data and any analyses;

- an assessment of the short term success of restoration treatment(s) relative to stated objectives (based on EM data and other evidence gathered to date);
- recommendations for change or refinement to project restoration objectives, treatment prescriptions, treatment implementation, monitoring objectives and protocols to improve overall success;
- comments on cost-effectiveness of restoration and possible improvements; and
- recommendations (i.e., locations, timing, frequency, duration, methods) for continued EM, including more intensive evaluation, if warranted.

Extension of EM findings and recommendations is a critical link in the adaptive management approach adopted here. A written "summary" should be prepared for each restoration project (this would briefly describe its objectives, treatment prescriptions, results, and main IM and EM findings), so that this information is readily accessible to other restoration practitioners. This summary can be posted as a publication on the Natural Resources Information Network (NRIN) (http://nrin.siferp.org/). More detailed effectiveness evaluation reports may be appropriate for the online Journal of Ecosystems and Management (http://www.siferp.org/JEM/). Both of these services are managed by the Southern Interior Forestry Extension and Research Partnership (SIFERP) in order to promote information sharing by resource managers in B.C. Other extension possibilities include presentation at workshops or conferences, posting of project findings on other websites, submission as a research summary or other unpublished report to interested agencies or organizations, and publication in a hard-copy peer-reviewed journal.

## Other Considerations

The cost of designing, implementing, and summarizing routine evaluations (a minimum requirement for all on-the-ground projects) should be factored into overall project costs. In the case of intensive evaluations, a separate funding request and cost estimate for the EM component may be warranted. This is because the duration and associated cost of intensive evaluation (i) is likely to extend well beyond the completion of all on-the-ground work, and (ii) will be influenced by the results of initial monitoring findings.

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# Appendix I:

## Generic Outline of an Effectiveness Monitoring Plan

**1. Information Review:**

This section would review existing information regarding restoration planning, approaches, objectives, practices and initiatives targeting the ecosystem/habitat or habitat component under consideration. It would also review ongoing, planned and completed monitoring initiatives and data available for the type of restoration that is being proposed. Monitoring needs, gaps and options would be discussed (particularly in the case of large-scale projects that have province-wide relevance, and for which considerable information is available).

**2. Ecosystem Restoration Objectives:**

This section would provide restoration objectives for the restoration site(s) being targeted and provide a detailed rationale based on sound ecological information (i.e., from a reference ecosystem, determined from the historic range of variability, and/or desired future conditions).

**3. Effectiveness Monitoring Objectives:**

This section would list and provide a brief explanation for effectiveness monitoring objectives. The latter would reflect the restoration objectives developed above, as well as consideration of the appropriate level of evaluation for the project and associated constraints (e.g., budgetary, logistic, personnel).

**4. Monitoring Design, Response Variables and Protocols:**

This section would describe an overall monitoring design, as well as specific response variables and monitoring protocols (how, where, when, how long and how often) to address each monitoring objective formulated above. It should also provide a clear rationale for selection of all response variables.

**5. Analysis, Summary and Interpretation of Monitoring Data:**

This section will provide details of how interim and final monitoring data and deliverables will be stored, analyzed, summarized and interpreted. It should also present a tentative schedule for completion of these phases.

## 6. Summary of Findings and Adaptive Management:

This section should describe how the findings of this project will be communicated and shared with identified target audience(s). It should also explore how interim and final project results/deliverables could potentially be applied within an adaptive management context.