Effectiveness Monitoring of Forest Management Guides
Strategic Direction
Guide Effectiveness Monitoring
Strategic Direction

Robert Rempel\textsuperscript{1,2}, Jim Baker\textsuperscript{2}, Glen Brown\textsuperscript{3}, Joe Churcher\textsuperscript{4}, Michael Gluck\textsuperscript{5}, and Brian Naylor\textsuperscript{4}

\textsuperscript{1}Centre for Northern Forest Ecosystem Research
Ontario Ministry of Natural Resources
955 Oliver Road
Thunder Bay, ON
Canada P7B 5E1

\textsuperscript{2}Applied Research and Development Branch
\textsuperscript{3}Science and Information Branch
\textsuperscript{4}Forests Branch
\textsuperscript{5}Species at Risk Branch

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SUMMARY

This document outlines the strategic direction for effectiveness monitoring of forest management guides (referred to as Guide Effectiveness Monitoring (GEM)). GEM evaluates “outcomes” and relies on hypothesis-based monitoring to test how well directions in the guides produce intended results. This is in contrast with broad-scale cumulative effects monitoring programs that are designed to monitor changes occurring across the province resulting from many causes (including forest management operations). The term “effectiveness” implies testing a specific hypothesis, whereas the term “effects” implies investigating unknown consequences.

The legal obligation for GEM is derived from the 2003 Environmental Assessment Act Declaration Order Conditions 30, 31, and 38f. These conditions tie GEM projects more closely to the guide documents, and require effectiveness monitoring for all forest management guides. As well, the conditions require the involvement of the Provincial Forest Technical Committee in all stages.

Forest management guides operate within the context of the Crown Forest Sustainability Act (CFSA 1994). Meeting the intent of the CFSA means the principal goal of the guides is to maintain ecosystem services by conserving ecological integrity by emulating natural disturbance patterns and processes while minimizing adverse effects. Consequently a key prediction is that across spatial scales and over time, Community Structure, Population Trends, and Ecological Processes will be similar between habitats that have arisen from natural disturbance versus habitats that have arisen through application of the forest management guides. From a study design perspective, the principal comparison for evaluating effectiveness is between forests that have arisen from natural disturbance processes versus those that have arisen through application of the forest management guides. This results in a critical restriction for a statistically valid study design.

This document outlines general principles of study design, study area selection strategy, principles for economic sustainability of the monitoring program, and the context of decision analysis and adaptive management in the monitoring program. We present a summary of key guide implementation issues and monitoring gaps, a discussion on how we might integrate and leverage existing monitoring programs, and a review of the pilot testing and initial implementation of the GEM program.

Ten areas of critical uncertainty are identified and clarified: Wildlife Community Structure, Wildlife Population Trends, Habitat Element Processes, Aquatic Ecosystem Processes, Moose Habitat Quality, Caribou Habitat Quality, Stick Nest Restrictions, Rutting Restrictions, Road Network Effects, and Harvest Area and Wildlife Habitat Supply Effects. However, because many outcomes from the application of the guides won’t be manifest for 40 to 60 years following their implementation, we also developed a strategic decision making framework to advise the selection and revision of future monitoring priorities and the identification of critical uncertainties over the long-term.

RÉSUMÉ

Le présent document expose les grandes lignes de l’orientation stratégique de la surveillance de l’efficacité des guides de la gestion forestière (Guide Effectiveness Monitoring (GEM), ou « surveillance de l’efficacité des guides »). Le GEM évalue les « résultats » et compte sur une surveillance axée sur les hypothèses pour vérifier à quel point les directives contenues dans les guides produisent les résultats recherchés. Cette approche se distingue de celle des programmes de surveillance des effets cumulatifs à grande échelle, conçus pour surveiller les changements se produisant dans l’ensemble de la province et résultant de nombreuses causes (y compris des activités de gestion forestière). Le terme « efficacité » implique la mise à l’essai d’une hypothèse donnée, tandis que le terme « effet » implique l’examen de conséquences encore inconnues.
Les origines légales du GEM se trouvent dans les conditions 30, 31 et 38f de l’ordonnance déclaratoire de la Loi de 2003 sur les évaluations environnementales. Ces conditions lient étroitement les projets GEM aux guides et exigent que tous les guides de gestion forestière fassent l’objet d’une surveillance de leur efficacité. De plus, ces conditions exigent que le Comité provincial des techniques forestières participe à toutes les étapes des projets GEM.

Les guides de gestion forestière doivent être compris dans le cadre de la Loi de 1994 sur la durabilité des forêts de la Couronne. Pour répondre à l’esprit de la Loi, l’objectif principal des guides consiste à maintenir les services écosystémiques en conservant l’intégrité écologique, objectif atteint en imitant les modèles et les processus de perturbation naturelle tout en en réduisant les effets négatifs. Par conséquent, la similitude de la structure communautaire, des tendances relatives aux populations et des processus écologiques entre les habitats créés par des perturbations naturelles et les habitats créés par l’application des principes contenus dans les guides de gestion forestière, dans diverses échelles spatiales et avec le temps, constitue une prédiction de première importance. Du point de vue de l’élaboration de l’étude, la comparaison entre les forêts créées par des processus de perturbation naturelle et celles ayant été créées par l’application des principes contenus dans les guides de planification forestière est celle qui permettra principalement d’évaluer l’efficacité. Il en résulte une restriction critique dans l’élaboration d’une étude statistiquement valable.

Le présent document présente les grandes lignes des principes généraux ayant présidé à l’élaboration de l’étude, de la stratégie de sélection de l’aire étudiée, des principes de durabilité économique du programme de surveillance et du contexte de l’analyse décisionnelle et de la gestion adaptative du programme de surveillance. Nous présentons un résumé des principales difficultés de mise en œuvre des guides et des principaux écarts de surveillance, une analyse sur la manière d’intégrer les programmes de surveillance existants et d’en tirer parti de même qu’une analyse de l’essai pilote et de la mise en œuvre initiale du programme GEM.

Dix champs d’incertitude critique sont définis et clarifiés : structure des communautés de la faune, tendances de la population faunique, processus d’éléments d’habitation, processus des écosystèmes aquatiques, qualité de l’habitat de l’original, qualité de l’habitat du caribou, restrictions relatives aux nids de branchage, restrictions relatives à l’oriénage, effets du réseau routier et effets des aires de récolte et des disponibilités d’habitat faunique. Cependant, puisque de nombreux résultats issus de l’application des principes contenus dans les guides ne se manifesteront que de 40 à 60 ans après la mise en œuvre, nous avons aussi élaboré un cadre de prise de décision stratégique relatif au choix et à la révision des futures priorités de surveillance et au repérage à long terme des incertitudes critiques.

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INTRODUCTION

The legal requirement for an effectiveness monitoring program derives from Conditions 31 of the Declaration Order regarding MNR's Class Environmental Assessment Approval for Forest Management on Crown Lands in Ontario (MNR-71) (MOE 2003) that states:

“MNR shall maintain a program of scientific studies to assess the effectiveness of guides”,

and Condition 38(f) that states:

“...each revised, amalgamated or new guide shall contain a description of an approach that shall be undertaken to monitor the effectiveness of the guide.”

Effectiveness monitoring is the evaluation phase of an adaptive management approach to resource management (Rempel et al. 2004). An adaptive approach to resource management speeds the process of learning by treating policies as hypotheses, and developing monitoring and research programs that directly test the effectiveness of policies and subsequent guideline direction. The Forest Resource Assessment Policy (FRAP v2) refers to adaptive management as a key approach required for ecosystem management. This interface between science and policy forms the foundation of forest management guide development and testing. In this context, effectiveness monitoring is hypothesis driven monitoring.

During the process of guide development various forest growth, harvest, disturbance, and habitat models were used to evaluate simulated forest conditions for the Landscape Guide (LG). Conceptual models based on critical assessment of predictions of effects and mitigation from the literature were used to evaluate options for the Stand and Site Guide (SSG). Through this modeling exercise alternative management options were initially assessed, and management options that failed to meet policy objectives were rejected. Specific guide direction has thus undergone an initial evaluation, but only through implementation on the ground and through measurement and comparison of expected results versus observed results can the effectiveness of policy options be rigorously evaluated.

The objective of the landscape guide is to direct forest management activities to maintain or enhance natural landscape structure, composition and patterns, and in so doing, to provide for the long term health of forest ecosystems in an efficient and effective manner. Ensuring long-term health of the forest ecosystem is mandated by the Crown Forest Sustainability Act (CFSA) (1994):

“The purpose of the Act is to ensure the long-term health of our forest ecosystems for the benefit of the local and global environments, while enabling present and future generations to meet their material and social needs” (CFSA 1994).

Ensuring long-term health of our forest ecosystems means, in part, that ecosystem patterns and processes reflect the structure, composition and function of comparable natural systems. Forest health is important because we don’t want forest management to negatively affect the provision of ecosystem services related to nutrient dynamics, primary and secondary production, habitat and predator-prey dynamics, hydrological cycles or pest and disease control. In healthy ecosystems forest management should not impede the ability of plant and wildlife communities to adapt to changing conditions. Genetic diversity and pathways of mobility are key elements for ensuring populations and communities can adapt to ever changing environmental conditions.

Ontario’s forest management guides are further based, in part, on the two CFSA principles that direct development of Ontario’s forest management planning manual (CFSA 1994).
The Forest Management Planning Manual shall provide for determinations of the sustainability of Crown forests in a manner consistent with the following principles:

1. Large, healthy, diverse and productive Crown forests and their associated ecological processes and biological diversity should be conserved.

2. The long term health and vigour of Crown forests should be provided for by using forest practices that, within the limits of silvicultural requirements, emulate natural disturbances and landscape patterns while minimizing adverse effects on plant life, animal life, water, soil, air and social and economic values, including recreational values and heritage values. 1994, c. 25, s. 2 (3).

The first principle mandates that the determination of forest sustainability should be based on whether or not ecological processes and patterns of biodiversity are conserved. The second principle directs that this conservation should be achieved through emulation of natural disturbances and landscape patterns, but while minimizing adverse effects on other values.

In the ecological literature, this direction would be interpreted as the conservation of ecological integrity.

**Ecological integrity refers to a condition in which biotic and abiotic components of ecosystems and the composition and abundance of native species and biological communities are characteristic of their natural regions and rates of change and ecosystem processes are unimpeded. PPCRA, 2006, c. 12, s. 5 (2).**

These principles of the Act provide the direction for both the development of the forest management guides, and the determination of effectiveness. The principal goal is to maintain ecosystem services by conserving ecological integrity. This should be achieved by emulating natural disturbance patterns and processes. We should measure effectiveness (success) by determining whether patterns of biodiversity and ecological processes are characteristic of comparable natural areas. Thus the principal comparison for evaluating effectiveness is between forests that have arisen from natural disturbance processes versus those that have arisen through application of the forest management guides.

**EMULATION OF NATURAL DISTURBANCES AND PATTERNS**

The emulation of natural disturbances and patterns, as directed by the Act, is both government policy and a well established scientific hypothesis stating that this is an effective approach to forest management in terms of achieving sustainable and healthy forest ecosystems, and maintaining ecological integrity. In essence, the testable hypothesis predicts that by emulating the pattern, structure, and composition of natural forest ecosystems through forest management, then natural patterns of biodiversity and ecological processes will be maintained in the managed areas (Fig 1).

Most elements of guide direction result in expected outcomes that arise from the “emulation of natural disturbance hypothesis.” Some of these expected outcomes are more uncertain than others, and a principal purpose of this document and the associated workplans is to translate key elements of guide direction into explicit hypotheses and predictions, and to identify those key predictions with the highest level of uncertainty that require effectiveness monitoring.

The CFSA (1994) requires determination of sustainability in terms of conservation of biodiversity and ecological processes. The response of the forest ecosystem to forest management and natural disturbance can be measured at the levels of population trends,
community organization and functional properties. These three classes of response are used to organize a strategy to monitor the effectiveness of forest management direction given in the guides in terms of conserving both biodiversity and ecological processes.

**Predictions Arising from the Emulation of Natural Disturbance Hypothesis:**

Across spatial scales and over time, the following will be similar between habitats that have arisen from natural disturbance versus habitats that have arisen through application of the forest management guides:

- **Community Structure:** The community composition and diversity of focal species (taxonomic and functional composition)
- **Population Trends:** Trends and abundance for selected focal species (at the stand and large landscape areas).
- **Ecological Processes:** The biotic and abiotic functional indicators of ecological processes (e.g., primary production, habitat creation, nutrient cycling, energy flow, predator-prey dynamics, gene-flow and hydrological cycles).

The evaluation of wildlife community structure and population trends should include assessment of habitat processes associated with wildlife responses. For landscape-level evaluations, quantitative predictions have been made using the prescriptive indicator models within the Ontario Landscape Tool (Elkie 2009), and these will be considered simultaneously with the wildlife response. For stand-level evaluation a monitoring project to assess the effectiveness of direction regarding wildlife trees and downed-woody material (DWM) could be developed.

At a broader (ecoregional) spatial scale, wildlife population trends and abundance respond to cumulative effects. This
component of the effectiveness monitoring plan could involve integration of data from existing MNR monitoring programs housed under the Provincial Wildlife Assessment Program (PWAP), and utilization of other non-MNR data sources arising from the Ontario Bird Atlas, Canadian Migratory Bird Monitoring Station, and Ontario Breeding Bird Survey.

The ecological processes component of the plan refers to a broad class of potential monitoring projects, and principally relates pattern to process through indicators. This component of the monitoring plan explicitly addresses the mandate to assess sustainability in terms of how well ecological processes are conserved. Processes include such examples as regeneration success, nutrient dynamics, hydrological processes, habitat selection dynamics, and predator-prey dynamics. Studies of ecological processes thus go beyond simple pattern description. For example, the caribou component would involve integration with much larger research plans and recovery strategies. These elements of the plan would require integration and expansion of existing long-term effectiveness monitoring programs housed at the Centre for Northern Forest Ecosystem Research (CNFER), and at other MNR research facilities.

MINIMIZE ADVERSE EFFECTS

The purpose of the policy to emulate natural disturbance at the landscape, stand and site scales is, in part, to reduce the need for and reliance on specific mitigation actions or management prescriptions to protect vulnerable or valued resources. These specific actions are sometimes called “fine filter” direction because direction provided through the “coarse filter”, i.e., emulating natural patterns and processes may not be sufficient to minimize adverse effects. In society there are many “filters” that guide decision making, and they range from being very coarse to very fine.

There are two situations when direction given in the Guides is not based on the natural disturbance paradigm: when no natural analog exists (e.g., soil rutting or specific mercury levels), and when employing the natural paradigm might result in an effect that society does not condone (e.g., violates Migratory Bird Convention Act or Fisheries Act) or does not meet its goals (e.g., conservation of species at risk or species of economic or recreational value).

From an effectiveness monitoring perspective, the predictions arising from actions taken to manage for specific values are qualitatively different than predictions arising solely from emulating natural patterns and processes. Also, the reference conditions against which comparisons are made differ from the natural disturbance paradigm. Just as with emulating natural disturbance and patterns, some Guide directions have a higher level of uncertainty than others, and might therefore require initial monitoring projects. These include the following:

a. Seasonal restrictions on forest management activities around occupied bird nests (SSG Section 4.2.2) will result in reproductive output comparable to nests in undisturbed situations.

b. Within the context provided by direction in the LG, the coarse filter direction in SSG Section 3.2.2, in concert with the fine filter direction in SSG Section 4.0 will retain sufficient residual forest within catchments to ensure that hydrological effects resulting from forest management activities do not exceed acceptable levels for specific parameters.

c. Restrictions on rutting and skid trail coverage in Section 5.2.1 will result in acceptable growth of residual trees (partial harvests) and regeneration success (all harvests).
In addition, implementation of the Guides may have an effect (positive or negative) on some aspects of the managed forest that are beyond their intended scope, including:

- Forest access road density and/or distribution
- Habitat for plant and animal species valued by First Nations and stakeholders relative to publicly accessible road network.
- Publicly accessible water body access points
- Available harvest area
- Habitat for plant and animals species valued by First Nations and stakeholders for which specific direction is not provided.

As a consequence, the Guide monitoring strategy may include monitoring the effects of the Guides on road networks (distribution, density, and access to resources) and monitoring effects of the Guides on wildlife habitat supply and available harvest area.

**SPECIES AT RISK**

Although the forest management program is not assigned direct responsibility for managing habitat for species at risk, forest management decisions often contribute to the successful implementation of habitat management and conservation strategies for these species. For example, restrictions on forest management activities at the stand scale may contribute to the protection and recovery of species at risk, such as the Blanding’s turtle, while restriction at the landscape scale may assist recovery of the woodland Caribou. Through partnership with First Nations, Stewardship Councils, Universities, federal government, non-government organizations, and others, the Guide effectiveness monitoring program could contribute to the assessment of habitat conservation plans developed for species of concern.

**GENERAL PRINCIPLES OF STUDY DESIGN**

The effectiveness monitoring program is founded on the principle of hypothesis-based monitoring. This and other concepts develop here have a history that began with an extensive workshop to evaluate effectiveness of forest management on species other than deer and moose (Background Document A: Proposal for Research on the Impacts of Timber Management on Other Wildlife). The underlying hypothesis is that new Guide direction is more effective than old (or no) Guide direction in terms of conserving biodiversity and ecological processes, relative to natural reference conditions.

The concept of reference condition is thus critical to the EM implementation plan. Reference areas will include landscapes that have arisen from natural disturbance events (e.g., old or newly burned areas with minimal human disturbance). Landscapes found within parks and protected areas, especially the large wilderness class parks within the AOU, may also serve as reference condition for certain hypotheses.

A key issue for effectiveness monitoring is determining if the treatment response (i.e., effects resulting from application of forest management direction) is biologically different from reference conditions. The reference condition may be stated a priori in the forest management guide (e.g., 25th-75th percentile analysis of natural disturbance simulation results), or may be defined in terms of natural reference conditions determined from field sampling (e.g., analysis of provincial parks and protected areas, game preserves, old burns, new burns, etc.). The expected treatment response may also be defined relative to the current condition. For example there may be an expectation that there will be no long-term decline in population levels of a species, relative to the current condition, or that species abundance will not drop below a critical
threshold. Emphasis will be on differences with an effect size (i.e., strength of the difference) that is biologically meaningful, and appropriate to the question.

Site, stand and landscape level replication will be possible within each study area. For example, multiple mensurative study sites resulting from burns or harvest can represent independent landscape-level replicates. Sites are nested within the overall study area, and are expected to range from about 5,000 – 50,000 ha. Stand-level samples could be nested within each mensurative study site, and within stands, site-level samples could be nested. Statistical analysis should be conducted in a manner that is appropriate to the sample design, and to minimize the effects of pseudo-replication and spatial autocorrelation.

Where possible, power analysis and effect-size should be defined before sampling begins. This will help reduce the chance that the sampling effort was insufficient to detect biologically meaningful effects if they occurred. Power analysis is based on determining a specified effect size (e.g., an increase of 25%), and the expected variance associated with the response variable.

General principles that should be considered while developing study designs include the following:

- Focus only on critical questions
- Define research hypotheses and alternative hypothesis a priori
- Establish appropriate reference conditions based on hypothesis
- Where possible, use power analysis a priori to establish sample sizes need to measure a given effect
- Where appropriate, use landscapes as the first level of replication
- Use prediction, a priori, to be clear about expectations
- Understand and model processes and mechanisms, not just correlations
- Use local knowledge, including knowledge of District Biologists and Foresters, First Nations, and others in study design, site selection, and consideration of complicating issues.
- Integrate evaluation across multiple scales so effects of strategic planning at the landscape level can be distinguished from effects of operational practices at the stand level
- Early on, substitute space for time using mensurative experiments
- Nest mensurative “treatment level” monitoring within long-term “ecoregional level” monitoring
- Predict cumulative effects by scaling projections across space and time using spatial harvest and succession models
- Where possible, use paired designs
- Search for good indicator systems, and then test them
- Evaluate habitat quality, not just quantity.

**STUDY AREA SELECTION STRATEGY**

The monitoring strategy includes both broad-scale, ecoregional-level monitoring that will occur over the long-term, and finer-scale monitoring that will focus on shorter-term monitoring projects. These shorter term projects may be based on a mensurative experimental design to compare results from forest management areas that resemble the new Guides (treatments) to appropriate natural reference sites and/or areas harvested with old guides and/or no guides. Because realization of the new Guide direction on the landscape will take years to occur, these studies essentially substitute space for time so evaluation of the Guides can take place sooner than later. These mensurative study sites will be nested within the broader-scale long-term study sites so that studies at either scale can inform the other. As a consequence, an important element of the study area selection strategy was to nest focused study areas within Landscape Guide ecoregions.
The forest landscape and ecological characteristics of the study areas must be appropriate to address the policy hypotheses, and to provide valid inferences for the area of undertaking. We considered the following factors:

- **Stratification by Landscape Guide Regions ecoregions**
- **Presence of large recent and old wildfires**
- **Presence of dispersed small cuts with high levels of edge (old guides) that are similar to landscape patterns that the new guides are moving away from (i.e., old guides)**
- **Presence of large, old aggregated or progressive clearcuts with little edge that are similar to landscape patterns that the new guides are moving towards**
- **Proximity to the northern limits of active forestry operation (Area of Undertaking)**
- **Proximity to ecozone transitions where climate change effects may first occur**
- **Presence of large parks and reserves, and preserves (Woodland Caribou, Wabakimi, Missinaibi, Chapleau Game Preserve, Algonquin Park).**

Research history and location of current activities were also considered because it is valuable to nest more detailed research into the context of effectiveness monitoring. Five broad study areas were selected based on these factors (Figure 2). The study areas were defined by first selecting the major forest management units (FMUs), and then adding large burns, parks, and preserves that intersect these. Parts of adjacent FMUs were also included to make the areas relatively contiguous.

**Figure 2.** Location of 5 study areas nested within Landscape Guide ecoregions (blue lines) and Hill’s Site Regions (brown lines). Each study area has a pairing of large park with FMUs, and the northern sites include large areas of natural disturbance.

**LONG-TERM SUSTAINABILITY OF AN EFFECTIVENESS MONITORING PROGRAM AND THE STRATEGIC ROLE OF MODELS**

Effectiveness monitoring is a long-term investment. It will take time for the new guides to be implemented, and following implementation it will be several years before enough landbase has been affected to provide sufficient sample sizes and replicates to fully address their effectiveness in terms of biodiversity patterns and ecological processes. After this, it will be years before sufficient variability and replicates in young to
old age classes become available. Over the long-term issues will arise, including changing management and environmental priorities, changing economic conditions, changes to organizational structure of Ministries, changes to staff and staffing levels, and future changes to forest management guidelines. Unlike a short term research project where the initiating staff can at least expect to author reports and publications, some of the more interesting field results of effectiveness monitoring will not be available until long after the current cohort of staff and scientific collaborators from other research institutes have retired. In addition, the application of “treatments” may have changed dramatically over time. Given all this, how does one ensure that an effectiveness monitoring program will be sustainable, and continue to have meaning and credibility over the long-term?

Administratively, the first step is to make effectiveness monitoring part of MNR’s core business, and this has been directed through DEC orders 30 and 31 (OMNR 2003). But from a science perspective, a strategy to maintain and develop long-term organizational and research memory could involve use of systems modeling. This will allow project teams to incorporate new knowledge, existing assumptions, and alternative hypotheses into a decision and analysis framework that treats forest ecosystems as complex systems (Kimmins et al. 2005), and focuses more on processes than past correlations (Kimmins et al. 2007). Some of the benefits of casting knowledge and assumptions as systems models include:

- Long-term memory of knowledge, assumptions, and uncertainties
- Mechanism to better understand and discover causal relationships, and to relate expected outcomes to expected changes in environmental conditions
- Ability to separate and explore the role of external versus internal factors on observed outcomes
- Ability to explore and understand cumulative effects
- Identification of key uncertainties and research priorities
- A link between what we think we know (predictions), and actual field observations (outcomes).

**DECISION ANALYSIS AND ADAPTIVE MANAGEMENT**

Adaptive management is not just a scientific/technical evaluation of policy effectiveness but also a social process to engage society and institutions in learning about management effectiveness relative to intended objectives of management actions. Thus, it is necessary to engage the public and stakeholders in the process. Concepts of decision analysis (Howard 1966) and adaptive management (e.g. Holling 1978, Walters 1986, Baker 2000) were used in the development of the landscape guide (see Crawford et al. 2005 for a comparison of these concepts). Jones and Nudds (2003) proposed combining decision analysis and adaptive management and outline a process for policy developers that are described below (see the LG for specific references to the applicable section of that guide). As we move ahead with effectiveness monitoring it will be necessary to refer to these steps to both remind us of the importance and necessity of involving public and stakeholders and as means of providing feedback.

1. **Involve as many parties as possible.**
2. **Specify management objectives and options.**
3. **Identify the critical uncertainties, as hypotheses.**
4. **Critical, rigorous examination of evidence for alternative hypotheses:**
5. **Develop models to forecast outcomes, given different hypotheses**
6. **Evaluate and rank competing**
hypotheses by likelihood in light of uncertainty:

7. Evaluate alternative management options.

8. Select options for inclusion in the guide.

9. Select the highest uncertainties in the landscape guide direction.

10. Design and implement a hypothesis-based monitoring program to evaluate effectiveness of policy options, according to sound principles of experimental design.

11. Monitor key responses.

12. Update ranking of competing hypotheses by likelihood given monitoring results. Section 7 of the landscape guide outlines the planned guide revision process.

Adaptive management often fails in that feedback loops are not identified and formalized. Fortunately, such a process exists through the implementation of two additional Declaration Order conditions (32(b) parts xiii and xiv; 33 (b) part iii), which require summaries of the monitoring projects described in this document to be included in the Provincial Annual Report on Forest Management and the State of the Forest Report, respectively. Results of these effectiveness monitoring studies will also be used during guide reviews to help assess the need for revisions (condition 38(d)).

Throughout the process, the Provincial Forest Technical Committee (PFTC) has been, and will continue to be involved as an advisory group. PFTC is a group that advises the Assistant Deputy Minister responsible for the forest program on how to ensure that forest management guides are kept current with respect to scientific knowledge and management practices by acting as a review board for these guides.

**MONITORING PRIORITIES AND GOVERNANCE**

Effectiveness Monitoring is a long-term strategic investment, and for the program to be sustainable the selection and funding of monitoring projects should be flexible to reflect changing conditions while still respecting the intent of the strategy, addressing critical uncertainties, and maintaining project relevance and quality. The Guide Effectiveness Monitoring (GEM) program is a strategic, well structured program that employs a top-down process to prioritize project selection and implementation based on critical evaluation of information needs and associated risks. This process will also be used to assess priorities as new monitoring issues arise. To do this, a project selection and governance structure is required.

The project selection and governance team might include representatives from Forest Management Branch (Policy section), Science and Information Branches (IMA, NESI, SSIS, NWSI), Applied Research & Development Branch (CNFER, WRDS, OFRI), Far North Branch, Fish and Wildlife Branch (Wildlife section) and Provincial Forest Technical Committee (PFTC). Criteria and a language ladder has been developed that can be used for assessing relative program investment and criteria for assessing project relevance and quality. This will serve as a decision framework for determining which new projects to fund.

Although directed new funding from MNR is required to fund the core effectiveness monitoring data collection activities, other funding will also be sought through various partnerships. Funding partners may include Ontario Hydro, Forest Industry, Mining Industry, CFS, CWS and NSERC. Management and administration of partner funding could be conducted through either the Forest Science Co-op or the Forest Research
Partnership. These arrangements could also be used to manage and administer funding for University-based monitoring projects.

Criteria for establishing priorities for effectiveness monitoring programs.

1. **Critical Uncertainties in Guide Direction:** The reliability of knowledge can vary among pieces of direction given in the Guide. Monitoring programs/projects should be focused on areas where there is most uncertainty about the reliability of knowledge used in the guides. What are the areas of highest uncertainty in the guides?

2. **Degree of risk for long-term predictions due to uncertainty.** In some cases knowledge presented in the Guide is used to make long-term predictions so planners can assess alternative management options in light of desired future forest conditions (e.g., the sustainability of viable wildlife populations). But if this knowledge is uncertain, then predictions based on the knowledge may also be wrong. Monitoring programs/projects should focus on uncertain knowledge where planning errors based on incorrect knowledge will significantly impact ecosystems and socio-economic benefits. What areas in the guides are most likely to have significantly incorrect long-term predictions if the knowledge used in developing direction is wrong?

3. **Degree of interest from First Nations and stakeholders.** When different pieces of direction are associated with similar levels of uncertainty or risk, those associated with a higher degree of First Nations or stakeholder interest will be given higher priority for EM research. First Nations may be interested in sustaining traditional ecosystem services such as food and herbal medicines, while the concern of non-government stakeholders may include concerns about effectiveness of direction in maintaining viable populations of SARs, effectiveness of direction in maintaining harvestable game populations, and socio-economic impacts. What is the degree of First Nations or stakeholder interest?

Criteria and language ladder for assessing relevance and quality of effectiveness monitoring projects.

1. **Linkage to the Strategic Plan:**
   a. The proposal is not clearly linked to a question arising from the strategic plan for effectiveness monitoring.
   b. The proposal is linked to a question arising from the strategic plan for effectiveness monitoring but there is not a well defined path leading from monitoring results to evaluation of guide effectiveness.
   c. The proposal is clearly linked to a question arising from the strategic plan for effectiveness monitoring and there is a well defined path leading from monitoring results to evaluation of guide effectiveness.
   d. The proposal is clearly linked to a question arising from the strategic plan for effectiveness monitoring, there is a well defined path leading from monitoring results to evaluation of guide effectiveness, and it is cast in an adaptive management context.

2. **Quality and clarity of research design/synthesis and work plan:** Monitoring activities should be funded only if the program/project is well conceived, the methods are sound, and clearly
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The proposed methodology is described.

a. The proposed methodology is poorly conceived, scientifically unsound and will not accomplish any of the stated objectives.

b. The proposed methodology is vague, scientifically questionable, and needs major revisions.

c. The proposed methodology is appropriate and scientifically sound and will accomplish the objectives with few modifications.

d. The proposed methodology is very well conceived, scientifically sound, and will accomplish the stated objectives.

3. Partner support and level of matching funds:

a. The proposal does not have any matching funds.

b. The proposal has less than 1:1 in matching funds from eligible sources (cash and in-kind).

c. The proposal has 1:1 matching funds (mostly in-kind, some cash).

d. The proposal has 1:1 matching funds (mostly cash or a balance of cash and in-kind).

4. Contribution from Collaborators and stakeholders:

a. There are no collaborators or stakeholders involved with the project.

b. There is limited collaboration with other researchers and/or stakeholders.

c. There is collaboration with other researchers and stakeholders. The other researchers have some knowledge and experience in this area of interest.

d. There is collaboration with other researchers and stakeholders. The other researchers have a proven track record and experience in this area of interest.

5. Project Budget and Work Plan (deliverables and schedule of work)

a. Proposed budget and work plan are unclear.

b. Proposes a clear budget and work plan but does not explain why the level of funding is requested.

c. Proposes a budget and work plan that are appropriate for the scope of the project and explains why the level of funding is requested.

d. Proposes a budget and work plan that are appropriate for the scope of the project, explains why the requested funding is necessary, and the deliverables demonstrate value for the funding requested.

6. Technology and Knowledge Transfer

a. Will be disseminated by traditional means such as publications seminars, workshops, and conferences.

b. Will be transferred by a combination of traditional means and some limited interaction with stakeholders and resource managers.

c. A plan for technology and/or knowledge transfer has been developed in consultation with stakeholders and resource managers.

d. A plan for technology and/or knowledge transfer has been developed with stakeholders and resource managers so there is a high probability that products of this project will be
used to improve policy and practices in the area of interest.

CRITICAL UNCERTAINTIES

Following the criteria for establishing priorities for effectiveness monitoring programs, 10 critical uncertainties were identified that should form the focus of the initial Effectiveness Monitoring program. Some of the initial wording was changed following the GEM workshop in December 2009 (Background Document B). The first 4 questions listed below are broad in scope, and for the most part address coarse-filter uncertainties related to how well the Guides conserve biodiversity and ecological integrity. The others are more specific, and relate more to fine-filter direction to address issues of specific social concern. Overtime workplans will be developed to address each of these uncertainties.

- **Wildlife Community Structure**: Will (a) emulation of natural disturbance patterns and processes result in species assemblage of forest songbirds similar to those found in forests arising from natural disturbances, and (b) will the harvest pattern direction in the LG conserve biodiversity better than the dispersed block-cut approach?

- **Wildlife Population Trends**: Will wildlife population trends in LG Regions be similar between areas arising from natural disturbance versus areas where LG and SSG have been implemented?

- **Habitat Element Processes**: Will the direction in the SSG ensure retention of a sufficient number of small residual patches, wildlife trees, and downed woody material to support wildlife communities and ecological processes (e.g., nutrient cycling) similar to those found in habitats arising from natural events?

- **Aquatic Ecosystem Processes**: Will the direction from the LG and SSG retain sufficient residual forest and minimize physical disturbance within catchments to ensure that hydrological, chemical, and biological effects resulting from forest management activities: i) do not exceed those observed in naturally disturbed catchments and ii) do not exceed acceptable levels for specific parameters (e.g., methyl mercury)?

- **Moose Habitat Quality**: Will the fine filter direction for moose in the SSG create habitat that sustains a higher density of moose (or a higher harvest of moose) than that produced by general coarse filter direction in the LG and SSG?

- **Caribou Habitat Quality**: Will the direction for caribou in the LG create habitat that contributes to sustaining viable populations of woodland caribou in the area of undertaking?

- **Stick Nest Restrictions**: Will seasonal restrictions on forest management activities around occupied bald eagle, osprey, and great blue heron nests result in nest site productivity comparable to nests in undisturbed situations?

- **Rutting Restrictions**: Will restrictions on rutting and skid trail coverage in the SSG result in acceptable growth of residual trees (partial harvests) and regeneration success (all harvests)?

- **Road Network Effects**: What is the effect of Guides on road networks (distribution, density, and access to resources)?

- **Harvest Area and Wildlife Habitat Supply Effects**: What is the effect of Guides on available harvest area and wildlife habitat supply?
KEY IMPLEMENTATION ISSUES, MONITORING GAPS, AND INTEGRATION OF EXISTING PROGRAMS

Implementing the GEM program does not necessarily mean starting and funding new monitoring programs. The GEM funding strategy is to first identify and evaluate what existing monitoring programs (within and outside of MNR) could contribute to meeting GEM objectives, and if such programs exist, evaluate how good the fit is with specific GEM analysis needs. This integration of research, science, and monitoring is taken from the perspective of the GEM program being a client to other initiatives. It is not suggested that other monitoring programs completely modify their design to satisfy GEM requirements, but where possible, design adjustments or supplementary sampling should be explored to evaluate whether needs can be meshed. New GEM programs are proposed only when this seems the most reasonable and/or cost-effective approach.

To address this issue, a one and a half day GEM workshop was held in Thunder Bay December 8 & 9, 2009 (Background Document B) where the main objectives were to (1) communicate the GEM strategic direction to a broad audience; (2) identify existing programs that could contribute to GEM needs; (3) identify issues, gaps and opportunities associated with existing or proposed monitoring; and (4) discuss the current status of the GEM program and its future direction. Thirty-five participants representing a broad range of MNR and non-MNR affiliations attended.

The first day of the workshop consisted of presentations from various experts in the field of GEM and of current monitoring research projects, followed by summary presentations of the various programs and projects that are occurring under the GEM direction and ones that could have potential linkages to it. The second day of the workshop began with morning breakout group discussions of the key GEM uncertainties. Summaries of these discussions are provided in the Background Document, which include comments provided by email after the meeting. The main objectives of the breakout groups were to: (i) create a summary of current ongoing monitoring and associated research that is contributing to GEM, (ii) identify how this monitoring contributes to the testing of the effectiveness of the LG and SSG, (iii) identify research and monitoring gaps, and (iv) suggest possible sources of funding. Good progress was made on all but the last item.

The 10 critical uncertainties were presented for discussion, and as a result most were accepted as is, but some were revised. The workshop ended with a wrap-up session of the discussion breakout groups. This revealed that some existing programs have design requirements that are not fully compatible with GEM requirements, and this reality must be considered as we identify monitoring gaps. For example, the issue of whether the MSIM/NFI sampling routine proposed by the Provincial Wildlife Assessment Program (PWAP) would meet the analysis needs of the GEM program, and if not, what additional sampling could GEM provide to meet any gaps, emerged as a critical question that needs addressing in the 2010 pilot field season.

From a strategic planning perspective, the “bottom-up” workshop approach represents a key step in the process of identifying and solving key issues, monitoring gaps, and integration of existing programs. With monitoring issues and gaps on the table, we can then begin thinking about approaches to resolving these gaps from the GEM perspective. From a “top-down” perspective, future funding decisions should consider the degree to which a proposed monitoring program also contributes to forest management guide effectiveness monitoring. The critical test is whether the proposed monitoring addresses the critical uncertainties
identified in the strategy, and whether the sample design separates forest management actions from other external influences on the measured response.

**PILOT TESTING AND INITIAL IMPLEMENTATION**

Initial pilot implementation of the GEM strategy was conducted in 2009 to evaluate how well the key concepts in the strategy could be translated to actual field sampling, to address sufficiency of sample designs, and to gain some idea of the expected annual cost. In 2009 work occurred on the *Wildlife Community Structure, Wildlife Population Trends, Aquatic Ecosystem Processes, and Caribou Habitat Quality* uncertainties. Progression through various stages of the pilot implementation will help reduce project uncertainties and provide a sound focus and structure for the GEM program (Fig 3).

*Wildlife Community Structure*: This uncertainty was addressed using a “biodiversity bioassay” based on 13 focal songbird species (Rempel 2007). Although the project focused on sampling songbirds, the results are actually relevant to a much broader range of species and biodiversity. In 2009 pilot testing of the monitoring protocol was conducted in the Lake Nipigon region (Ecoregion 3W) of Northwestern Ontario, where forest disturbance (harvest or fire) occurred more than 70 years ago. Initial results are reported in Background Document C, and final results are expected in 2011/2012. The monitoring protocol addresses the critical uncertainty of whether forest management results in forest conditions that conserve biodiversity values equally as well as forests arising from natural disturbances.

Key objectives of the pilot evaluation include assessing: (i) how precisely the sample protocol can estimate density of the 13 focal songbirds, (ii) the degree of statistical power to compare densities in reference areas versus managed areas, (iii) the ability to compare density and assess trends in 5-year time slices (using the first time period based on combined OBA, LLT, PWAP, and CNFER data collected in 2001-2005), (iv) the ability to characterize community assemblages, (v) logistical issues involved with sampling and (vi) expected

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<td>Tom Nudds</td>
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annual ODOE and staffing costs. From a strategic perspective, this project represents the GEM approach of carefully developing, testing, and costing-out a monitoring protocol before full implementation.

Wildlife Population Trends: Although not initially developed as a GEM program, the Wetlands and Waterbirds Project run by Tom Nudds and Luca Borger out of University of Guelph, and funded by FESC (Forest Ecosystem Science Co-operative), MNR and NSERC has relevance to the Wildlife Population Trends uncertainty. Like the GEM strategy, this project adopts the position of “no control, no conclusion”, and seeks to examine how existing waterfowl and waterbird data sets can test the hypothesis that “working landscapes should not differ significantly, in ecological aspects, from those landscapes that result from natural disturbances” (FESC 2009). This project will provide direction on how to utilize broad scale datasets for addressing hypothesis-based monitoring questions, as well as an initial evaluation of whether forest management is influencing waterfowl and waterbird population trends.

For 2010 it is proposed that the PWAP will implement a trial of the MSIM sample protocol using the NFI grid for plot placement. More detail on this is provided in Background Document B under the section “Wildlife Community Structure: Effectiveness of direction in Stand and Site Guides (SSG) and Landscape Guide (LG) to conserve natural assemblages of forest songbirds.”

Aquatic Ecosystem Processes: In 2009 work at CNFER focused on the evaluation of hydrologic linkages between terrestrial and aquatic systems and how disturbance of these linkages may influence stream ecosystem function. The studies will provide a series of biological, chemical and physical indicators of stream ecosystem condition as well as GIS based predictive models of hydrologically sensitive areas. In addition, the CFS/FESC program out of White River, the “BiolIndicators of Forest Stream Health” project, is examining catchment characteristics, stream characteristics, aquatic invertebrate communities and community function, with the goal of developing a biological indicator of aquatic ecosystem function and health (FESC 2009). This work demonstrates how a combination of MNR and non-MNR research and monitoring can be integrated to develop a solid GEM monitoring solution that addresses the critical Guide uncertainty. More detail is provided in Background Document B under the section: “Aquatic Ecosystem Processes: Effectiveness of Guide Direction in Maintaining Stream Ecosystem Integrity by Mitigating Catchment Scale Effects on Water Yield, Water Chemistry and Aquatic Biota.”

Caribou Habitat Quality: In 2009 work was completed on a spatially explicit Caribou PVA model to help evaluate the risk to caribou in the boreal zone, including forest harvest, road construction, and changes in the abundance of moose, deer, and wolves (FESC 2009). This collaborative scientific study, funded by NSERC, FESC and MNR is just the beginning of a much larger study on caribou habitat and populations. As part of the larger study, MNR will establish a standard Provincial Woodland Caribou monitoring program to provide baseline data on populations, range occupancy, southern edge of continuous distribution, and population health data (e.g., birth and death rates) for Woodland Caribou across the province. This will include the development of standards and protocols for caribou monitoring surveys. MNR is currently initiating a population range monitoring program at the local population range level to support a range management approach to Caribou recovery at a scale relevant to assessing variation in population dynamics and viability. This scale of assessment will be suitable to evaluate the cumulative effects of forest management planning and other anthropogenic disturbances as implemented at a Landscape Guide-Ecoregional scale. The broad-scale population range assessments will provide data on vital rates (e.g., recruitment),
distribution and movements of caribou as needed to refine preliminary delineated ranges and assess population status in relation to existing habitat conditions. Monitoring activities on each population range will include telemetry tracking of individual Caribou and population aerial surveys. A minimum of two population ranges will be surveyed per year starting in the winter of 2010. More detail is provided in Background Document B under the section “Caribou Habitat Quality: Effectiveness of Caribou Habitat Direction in the LG.”

Although not funded by the GEM program, this work represents the kind of monitoring and research initiative that through effective collaboration can address multiple objectives, including GEM uncertainties. In this case, GEM functions as a client of the various Caribou research programs and initiatives. In total, about $125.0 of targeted GEM funding was spent in 2009 that was in addition to other existing monitoring and research initiatives.

The Stand and Site Guide has just begun to be implemented in Ontario, the Landscape Guide will soon be implemented in the GLSL Region, but the Landscape Guide has not yet been completed for the Boreal Region. The GEM Strategy is putting the pieces in place to develop a financially sustainable long-term monitoring program for evaluating Guide effectiveness based on sound scientific principles. There will undoubtedly be many pieces that need to be added or changed in both the short-term and long-term, but a sound strategy is in place to steer this process.

Unlike uncertainties related to the featured species Moose Habitat Guides, the critical uncertainties here are not questions focused on young forest that can be addressed in a few years following implementation. The new Guides are more about ecosystem management and the conservation of biodiversity and ecological processes, and it will take many years for evaluation and testing to consider the full range of forest ages and conditions arising from application of the Guides. One of the early benefits of developing the strategy is learning what being a “science-based” organization means in terms of Guide evaluation. In this process we are learning how to translate policy and guidelines into testable hypotheses to ultimately guide and assist decision making. In an adaptive management context, the strategy will help provide a means for integrating scientific principles and learning throughout our institutional framework.

**Figure 3.** Progressive steps in pilot implantation. Objective is to reduce uncertainty in cost, scope, and project focus.
REFERENCES


