Science-based Planning for Broad-scale Conservation of Boreal Systems

CANADIAN BEACONs PROJECT

UNIVERSITY OF ALBERTA

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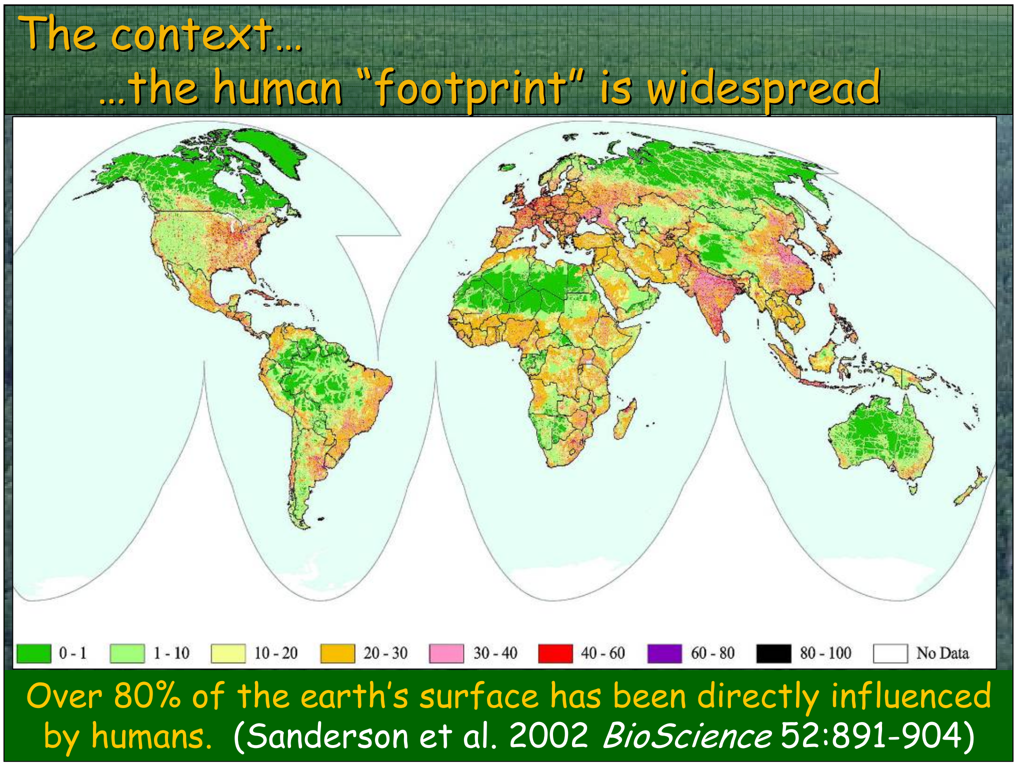
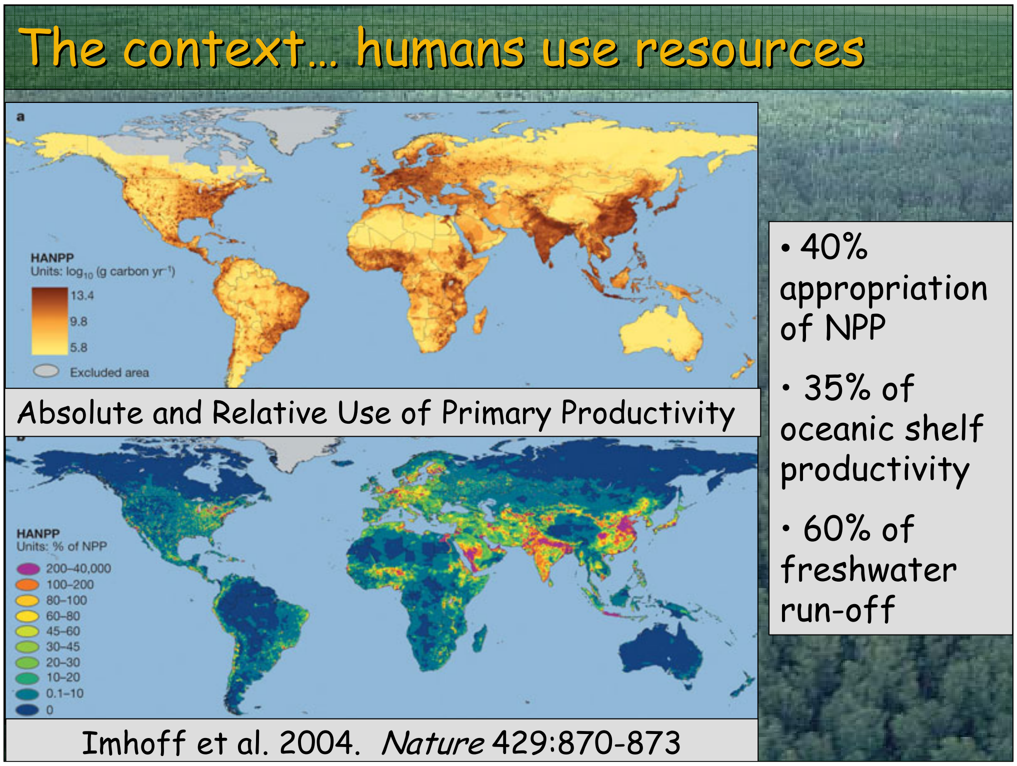
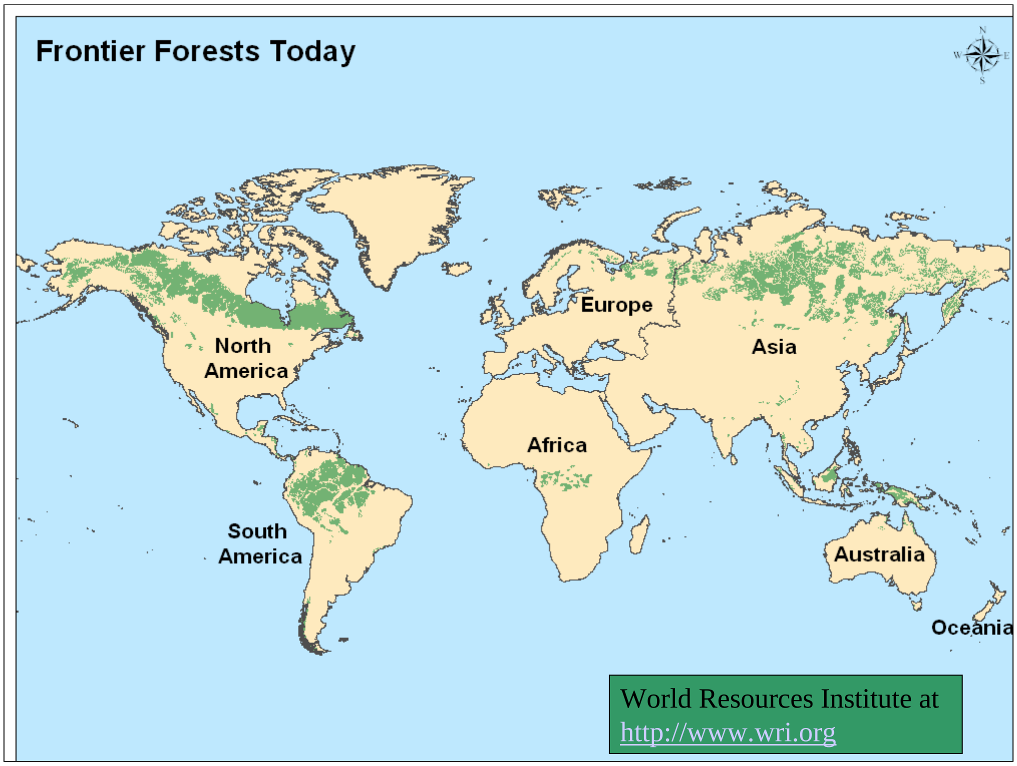
National Forest Congress, Ottawa, September 2006



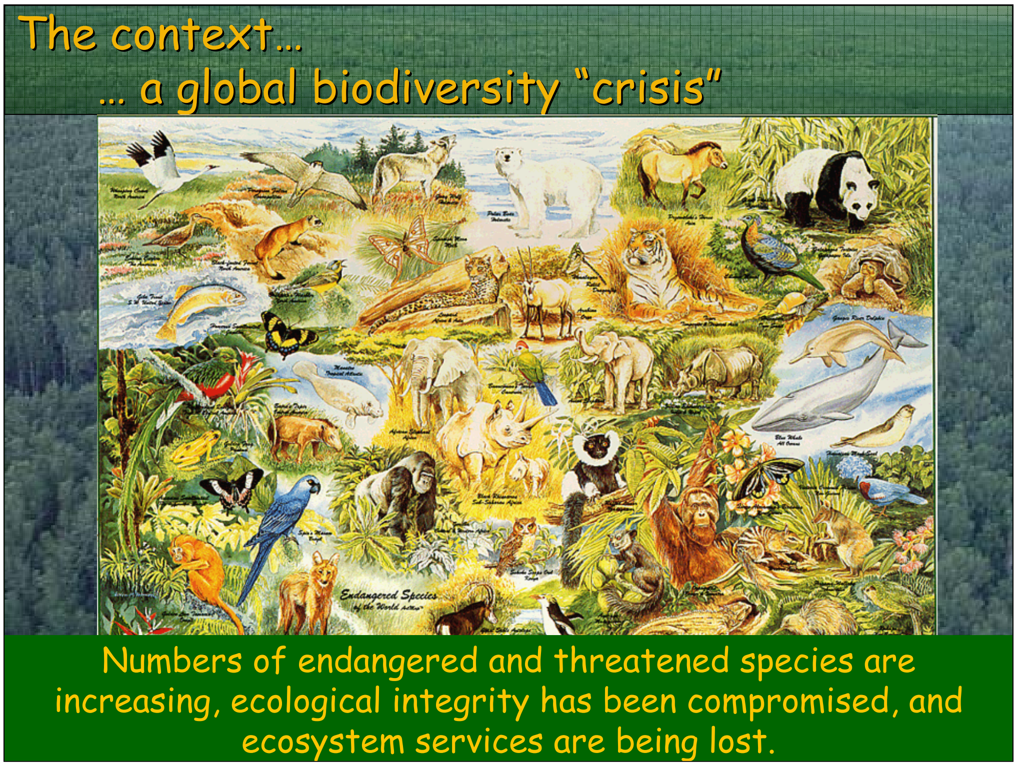
Human activities are widespread, and in many instances these activities have profoundly altered many natural systems throughout the world. Northern Canada contains some of the last remaining intact areas supporting healthy and abundant wildlife populations and naturally-functioning ecosystems. Scientists refer to such systems as having ecological integrity.



Human activities are also reflected in resource use. As a single species, we consume a staggering, and growing, proportion of the world's resources.

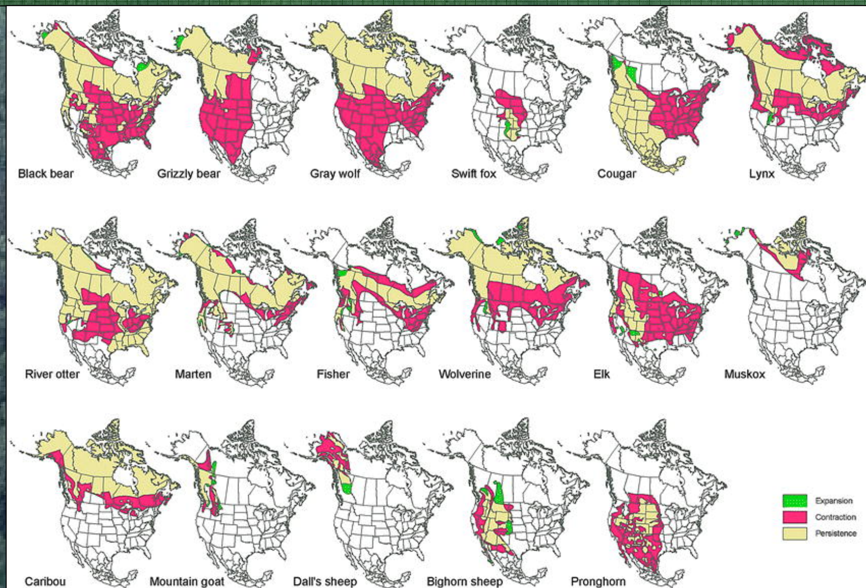


Resource consumption is evident in the pattern of forest loss globally, with a few key areas retaining the majority of the world's remaining, intact forest. Canada contains more intact forest than any other country, and most of this exists in boreal regions.



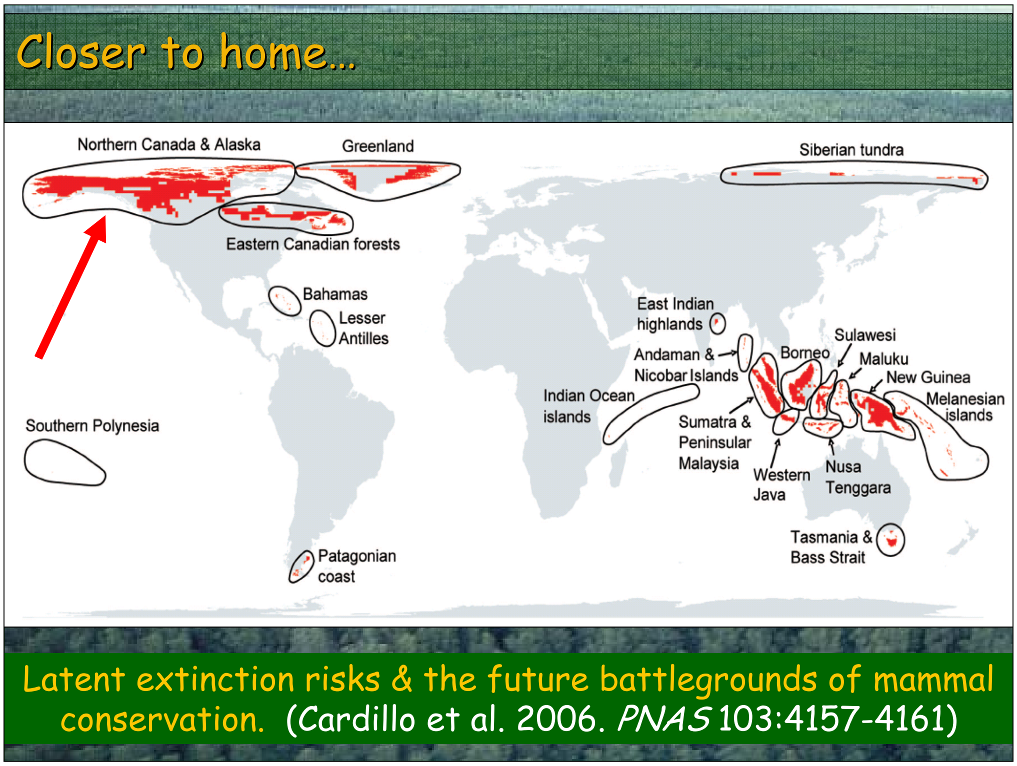
In systems that have been substantially altered, ecological integrity has often been compromised or lost, a pattern that is reflected in what is widely referred to as a global biodiversity crisis. This crisis is characterized by an increase in numbers of threatened and endangered wildlife species, and in many instances, a significant reduction in air and water quality, along with loss of other important ecosystem services.

Closer to home…



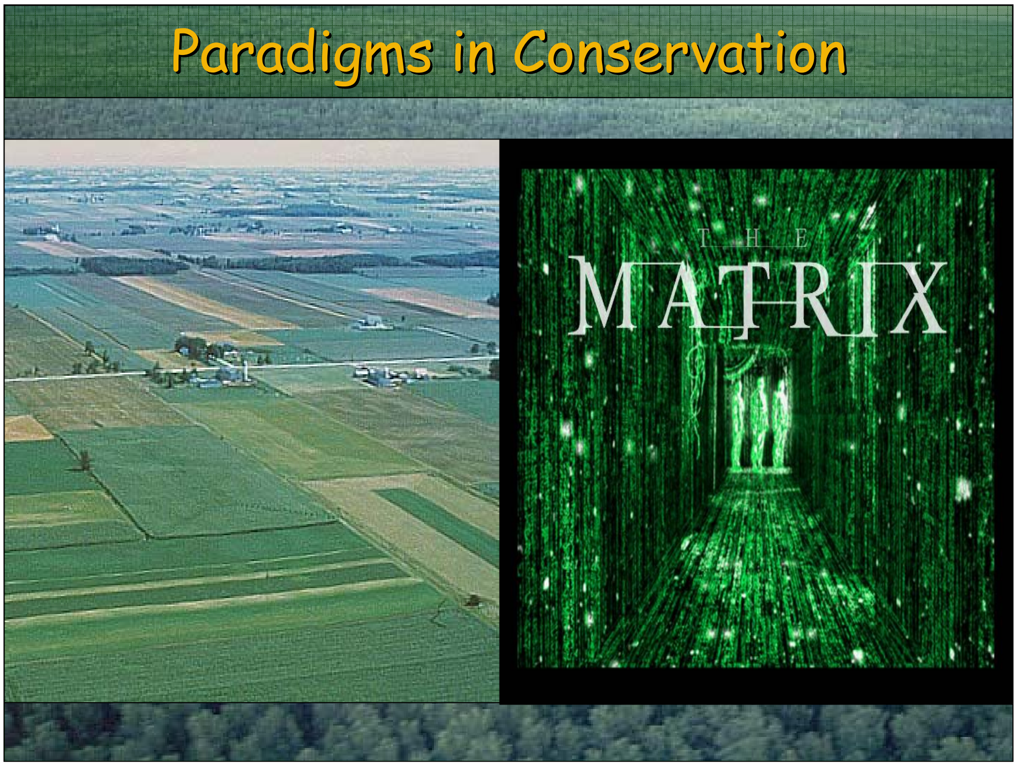
Range contractions of North American carnivores and ungulates. (Laliberte & Ripple 2004. *BioScience* 54:123-138)

In North America, investigations of changes in large mammal distributions clearly identify the northward contraction of ranges of most species, with boreal regions representing the remaining stronghold for many of these.

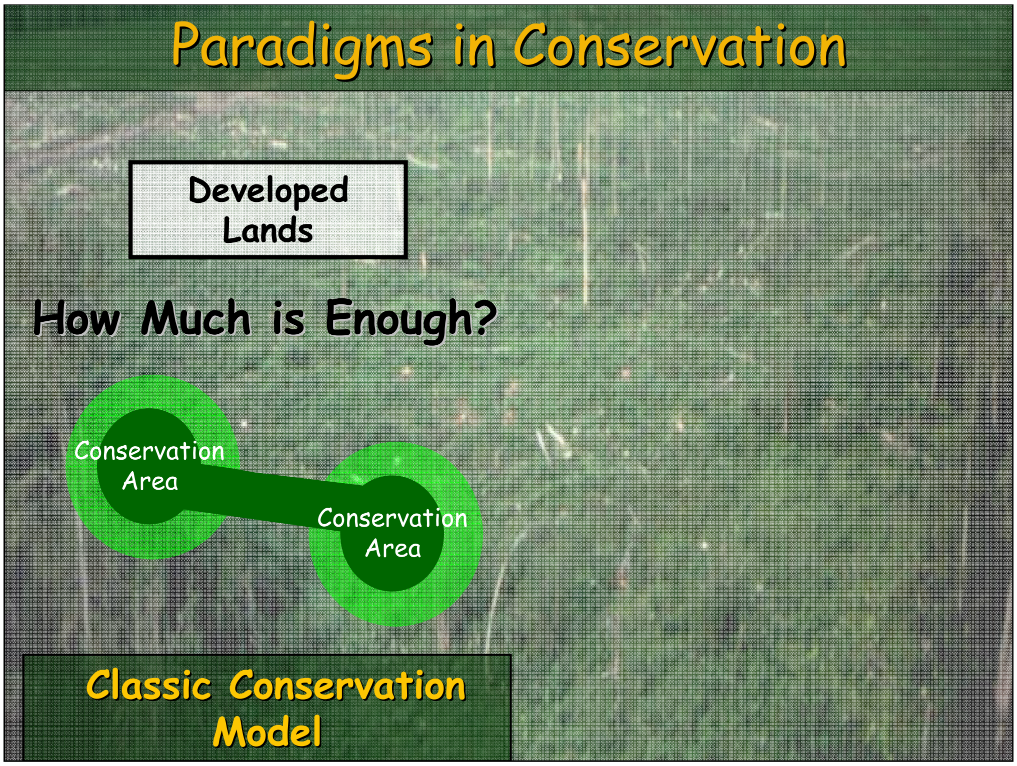


Nevertheless, a recent global analysis of latent extinction hotspots – sites that are likely to experience significant future species loss if land-use trajectories approximate those seen in other regions – has identified the northern boreal forests of Canada and Alaska as being at high risk for mammal species loss.

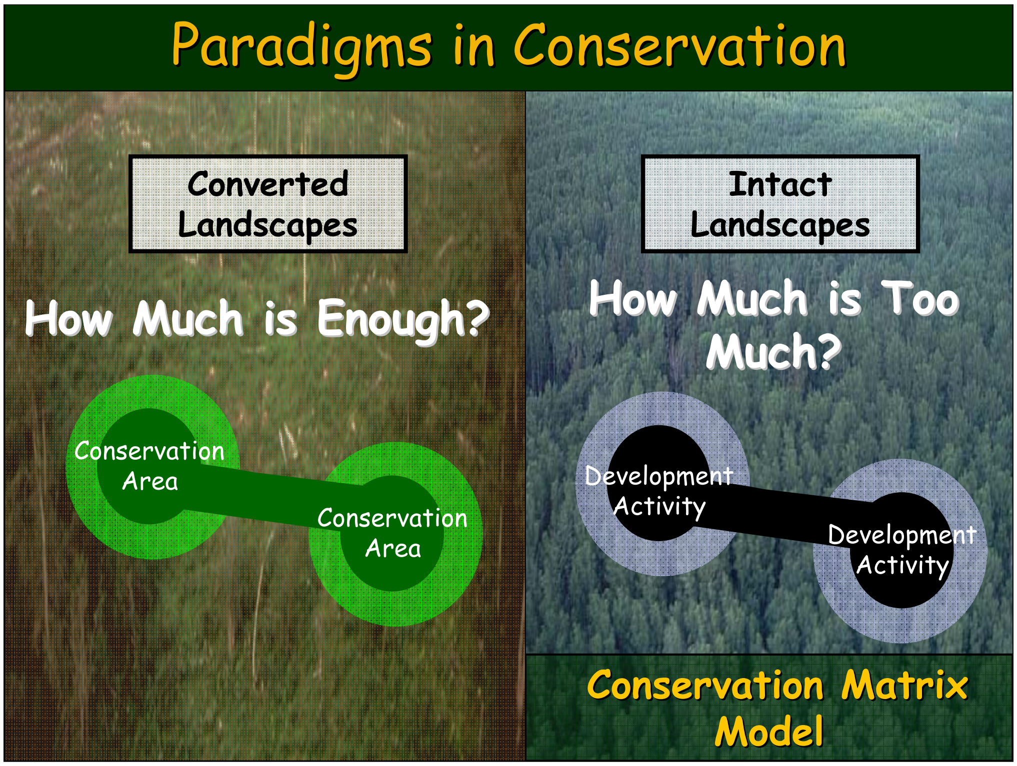
Similarly, concerns over dramatic declines of migratory bird populations throughout southern Canada and the United States have contributed to increased awareness of the effect of landscape alteration on the long-term viability of these species. Once again, the boreal is distinguished as critical to the persistence of species at continental scales. How then, in the face of increasing development pressures on boreal regions of Canada, can we conserve the ecological values that these areas currently support? Are there lessons that can be drawn from scientific experience elsewhere?



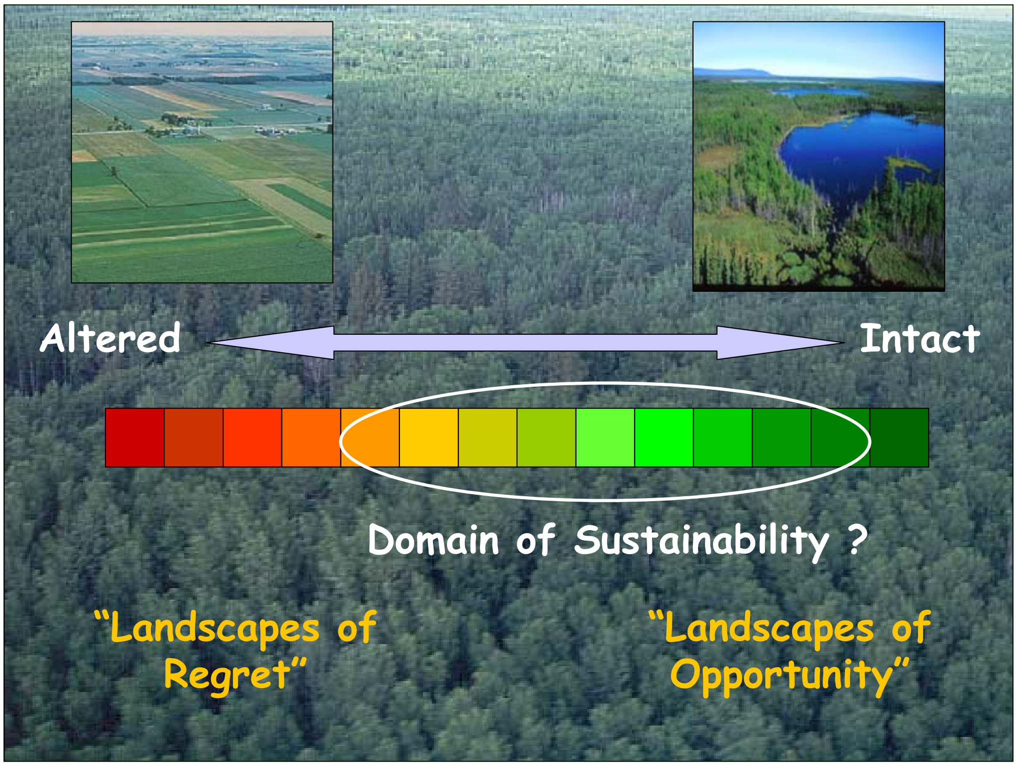
Conservation science emerged primarily as a crisis discipline in response to species loss and landscape degradation in human-altered systems. The focus has largely been on establishment of protected areas after significant conservation concerns have already arisen, and on the management of small, threatened populations. The classic model is one of patches of remnant vegetation embedded in a hostile landscape matrix. The majority of lands are not considered to contribute significantly to conservation, and in many instances, protected areas bear the full burden of achieving conservation goals. As a result, the development of pro-active approaches in conservation science has been limited.



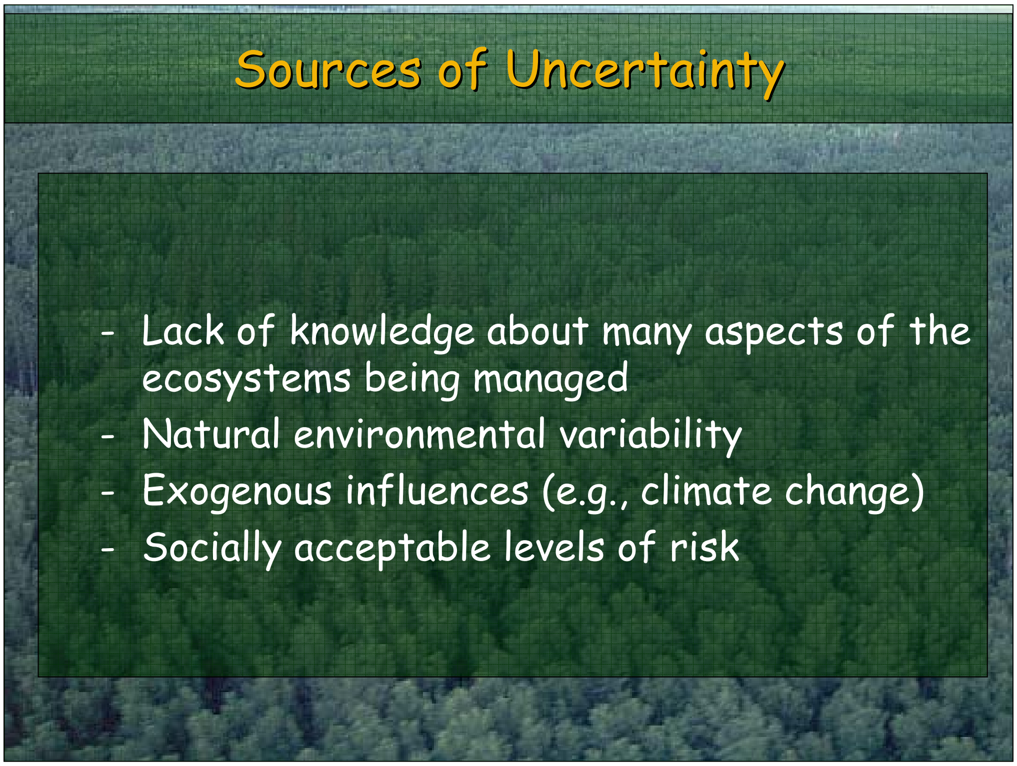
Given this context, the classic conservation model has resulted in many questions regarding "how much is enough", or what percentage of lands must be protected in order to achieve conservation goals? This is an important question, but in isolation, it does not address the full range of conservation potential that could be realized in carefully managed systems, particularly those that remain largely intact, and support a high level of ecological integrity. Nevertheless, the weight of scientific work points towards the need for large areas accounting for a significant portion of regions to be conserved to protect ecological values.



In largely intact systems, including boreal regions of Canada, where the vast majority of lands still maintain high conservation value, it is equally important to ask "how much is too much"? How much development can be supported such that the natural and cultural values and integrity of the region are not compromised by such activities? We refer to this as a "Conservation Matrix Model", where the matrix is the supportive environment that sustains these values, and within which a variety of land uses occur – ranging from strict protection to regulated resource development at appropriate scales. Unlike conventional approaches, the Conservation Matrix Model redirects efforts from re-active to pro-active conservation planning.

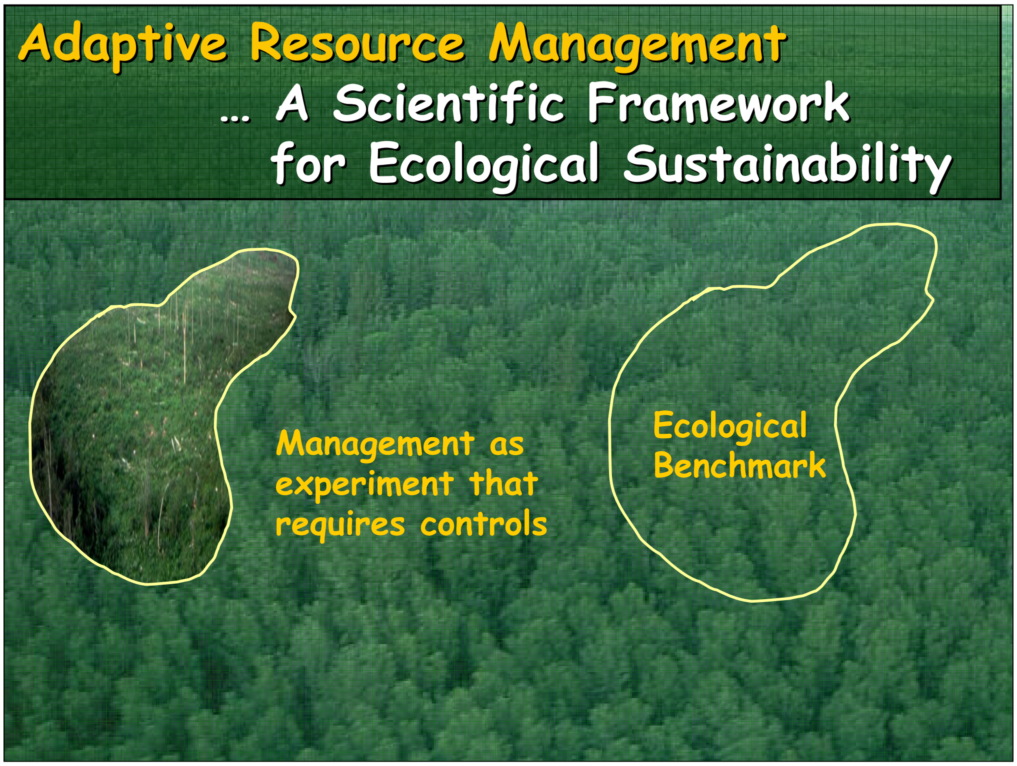


These factors contribute to the need to carefully consider the sustainability of potential development activities, in advance. Clearly, in highly altered landscapes, we have exceeded the capacity of natural systems to absorb the changes associated with certain activities, resulting in a loss of integrity and associated values. At the other end of the spectrum, we recognize that intact systems have high natural integrity. The challenge is to identify a framework for sustaining ecological and socio-economic systems, given inherent uncertainties, and to minimize the risk that "landscapes of opportunity" become "landscapes of regret".

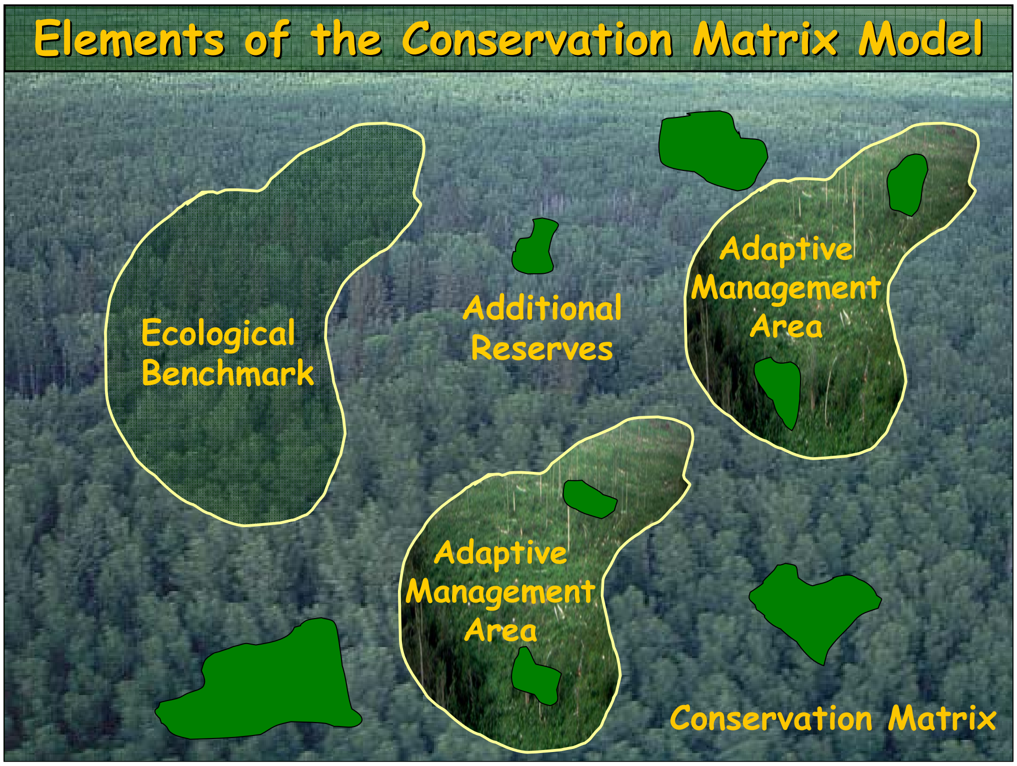


Uncertainties are related to a number of factors, many of which are particularly acute in boreal regions of Canada. For example, our state of understanding of basic system dynamics is very poor. This extends in some cases to even coarse distributional data on species of concern. We understand that northern systems experience substantial fluctuations due to natural variation in climatic conditions and resultant affects on plant and animal communities, but our ability to accurately predict the outcomes of such fluctuations on populations is very limited. Furthermore, the present and anticipated affects of more dramatic climate change in the north introduce additional uncertainties regarding the outcome of management activities. Finally, the social context in which management activities take place influences response to uncertainties, particularly regarding the level of risk that local communities are willing to assume in association with potential development activities.

The process of adaptive management, when properly implemented, is an important tool to address uncertainties and identify sustainable land management strategies. Adaptive management recognizes the need to support local economies and communities, but is precautionary in that it is a structured approach designed to reduce the risk of undesirable outcomes, particularly those that foreclose future opportunities. It explicitly recognizes the uncertainty inherent to resource management, and treats development activities as experiments that are carefully designed, incremental in nature, and rigorously monitored to evaluate whether objectives are being realized.

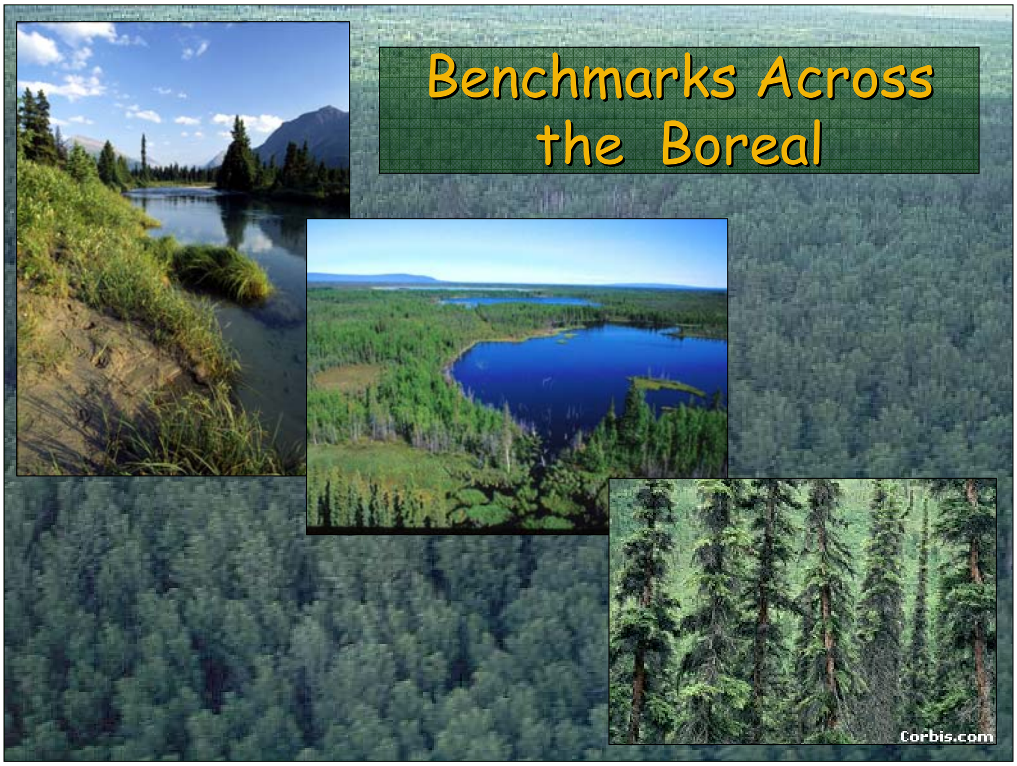


A fundamental tenet of experiments is that they require controls. In the context of resource development activities, scientific controls are critical for distinguishing the effects of intrinsic variation within a resource use area from the effects of changes induced by development activities. In the absence of such controls, we could fail to detect important changes in systems related to development activities; for example, if they are masked by natural fluctuations. Conversely, we could wrongly attribute such natural variations to development activities. Benchmark areas, as part of a comprehensive protected areas system, serve a critical role as controls for resource management experiments, in addition to contributing to other conservation objectives.

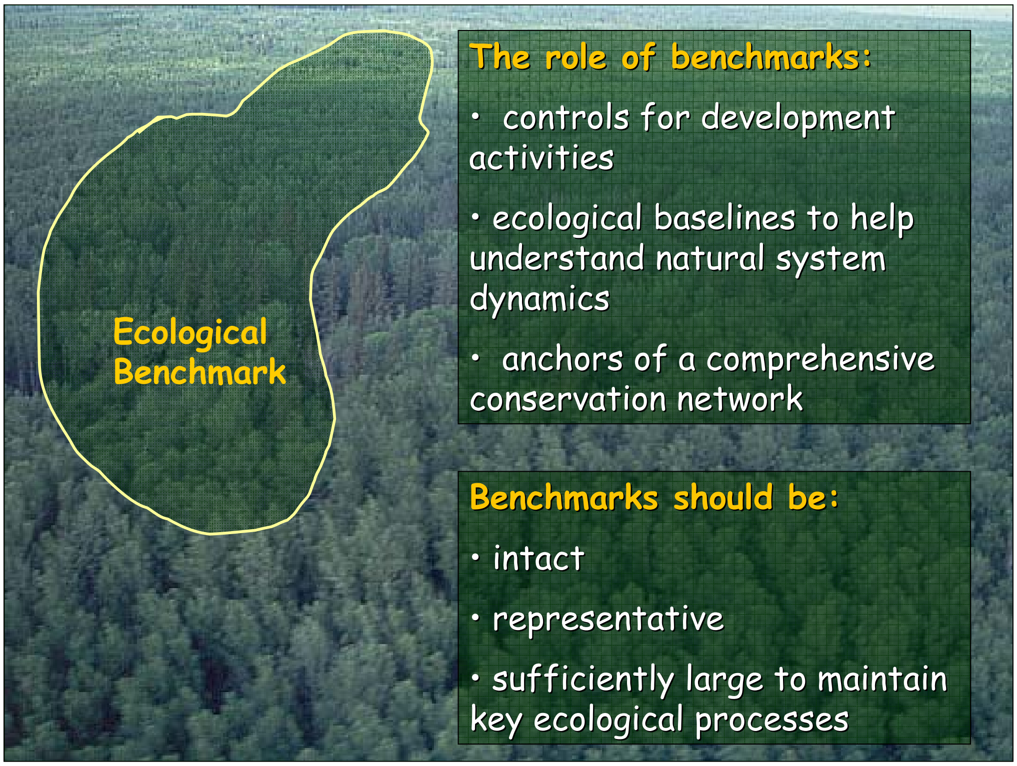


The Conservation Matrix Model (CMM) was developed to establish a scientific framework for conservation planning in boreal regions of Canada. The CMM is comprised of 4 principle components: ecological benchmark areas, additional reserves, active management areas, and the larger conservation matrix within which the former three elements are embedded, and to which they contribute. **Ecological benchmarks** are the anchors of a comprehensive reserve network and serve as reference sites or controls for understanding both the natural dynamics of ecosystems as well as their response to human activities. **Additional reserves** capture values that may not be well represented within benchmark areas, such as identified special elements (e.g., early-season open water for migrating waterbirds, areas of cultural significance, rare species occurrences), and may include existing and new protected areas (e.g., national parks, wildlife reserves) that do not fulfil benchmark criteria. **Active management areas** are sites of relatively intense human activity, such as forestry, mining, or oil and gas exploration. These areas are managed under the principles of Adaptive Resource Management, such that management activities are treated as experiments designed to identify truly sustainable practices. The **conservation matrix** is the supportive landscape within which less intense human activities are carefully managed so as not to erode other values.

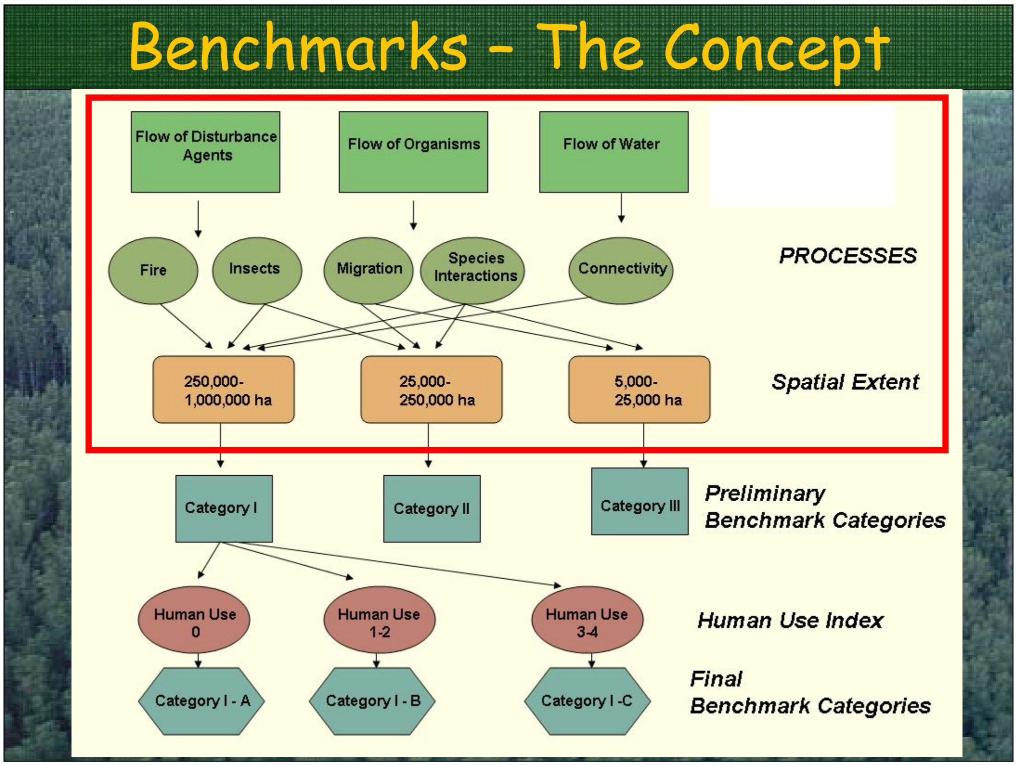
The CMM is pro-active, precautionary and comprehensive, recognizing the valuable contribution that all landscape elements can and must make to overall conservation objectives, and to achieving sustainable land management. The approach focuses on managing to maintain natural patterns of species distribution and abundance, and the processes that support them, rather than on minimum critical levels to avoid extinction.



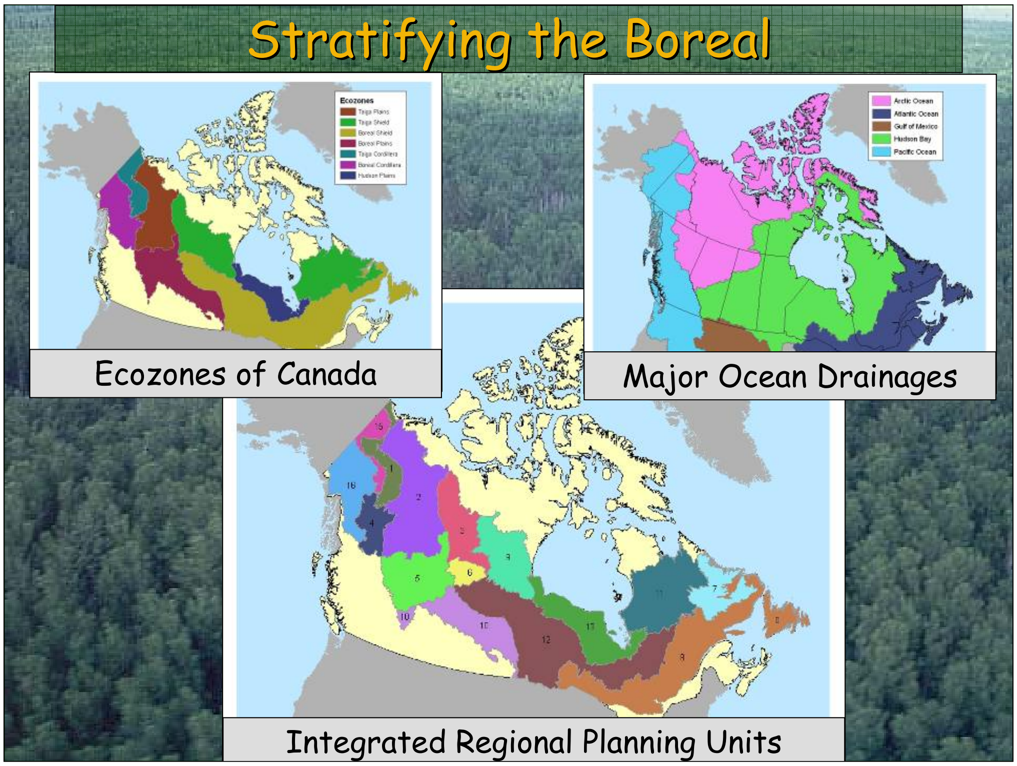
One goal of the BEACONs project (Boreal Ecosystems Analysis for Conservation Networks) has been to develop the conceptual framework and analytical tools to support identification of a system of ecological benchmarks across boreal regions of Canada. We have focused on this element of the CMM because this represents a time-limited opportunity for Canada to establish global leadership in this area, and because there was a paucity of scientific work on which to base such an assessment.



Ecological benchmarks should be intact, representative of environmental variation, and sufficiently large to maintain key ecological processes independent of external influences. In addition to serving as controls for development activities, they play an important role as ecological baselines to increase our knowledge concerning the natural dynamics of systems, and also act as anchors of a comprehensive protected areas system. As anchors, they represent areas with high natural integrity that provide a buffer against disturbance by maintaining internal sources for recolonization, and contribute to the resilience of the larger system to climate change.

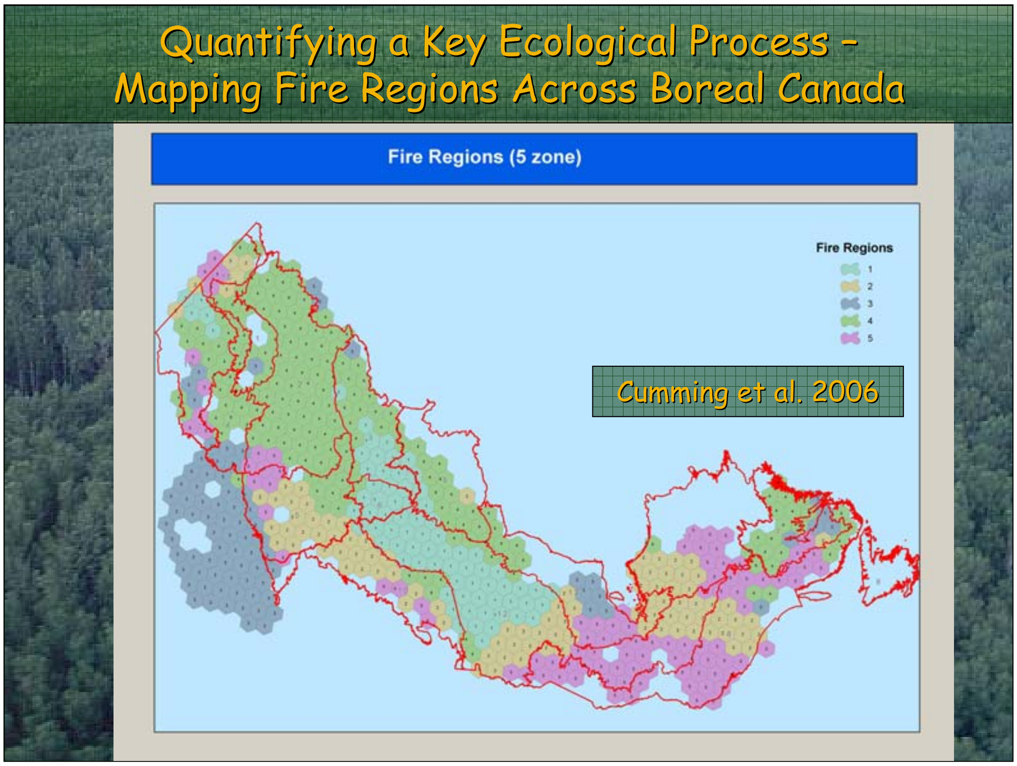


Our approach to conceptualizing the necessary attributes of benchmarks areas focuses on processes that shape ecological systems at broad spatial extents, and over relatively long time frames. These flows guide the size, condition and configuration of potential benchmark sites. The framework we have developed is flexible to landscapes with different human use histories, which translate into different opportunities and constraints. Here we highlight our analysis of system-level benchmarks – the most ambitious level that could be achieved.

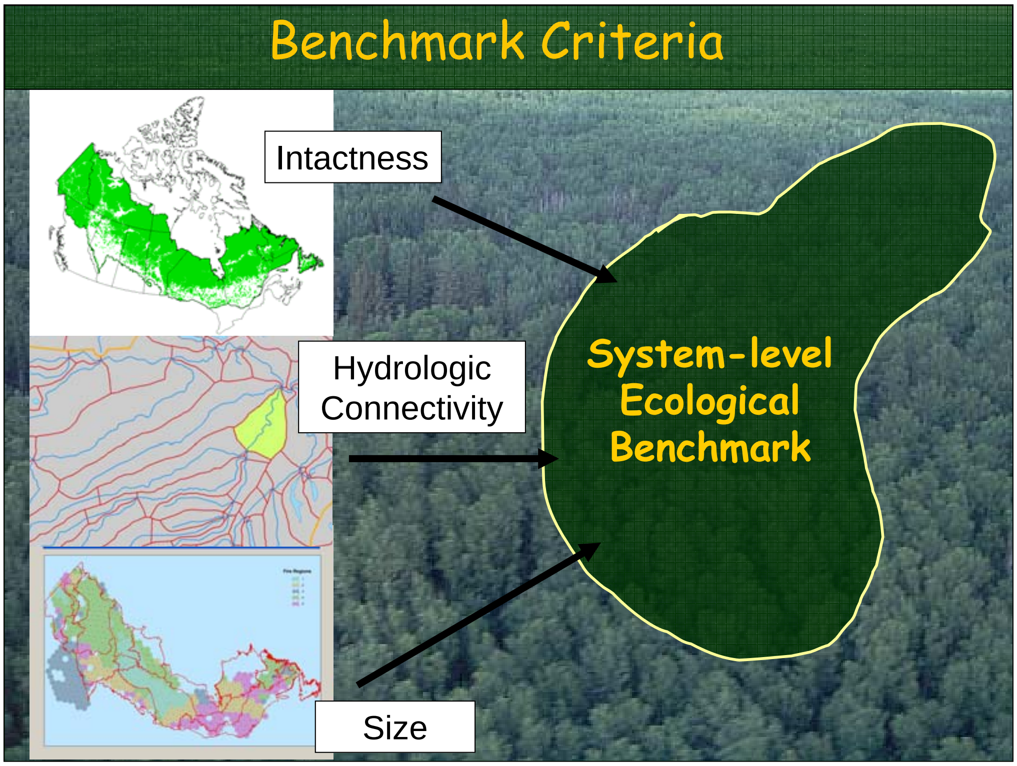


The large spatial extent of the boreal requires that the region be sub-divided into smaller planning units to enable finer spatial resolution of natural variability. To facilitate conservation planning in the boreal, we stratified the boreal into ecologically-based Regional Planning Units (RPUs). We considered ecological processes as the basis for the delineation of RPUs, and used existing classification systems of Major Ocean Drainages, Ecozones, and new research on Fire Regions to represent the largest abiotic and biotic processes operating on the landscape. As such, RPUs have with similar patterns of hydrological flow, terrestrial composition, and natural disturbance, at a spatial extent that is relevant for the planning of process-based ecological benchmarks.

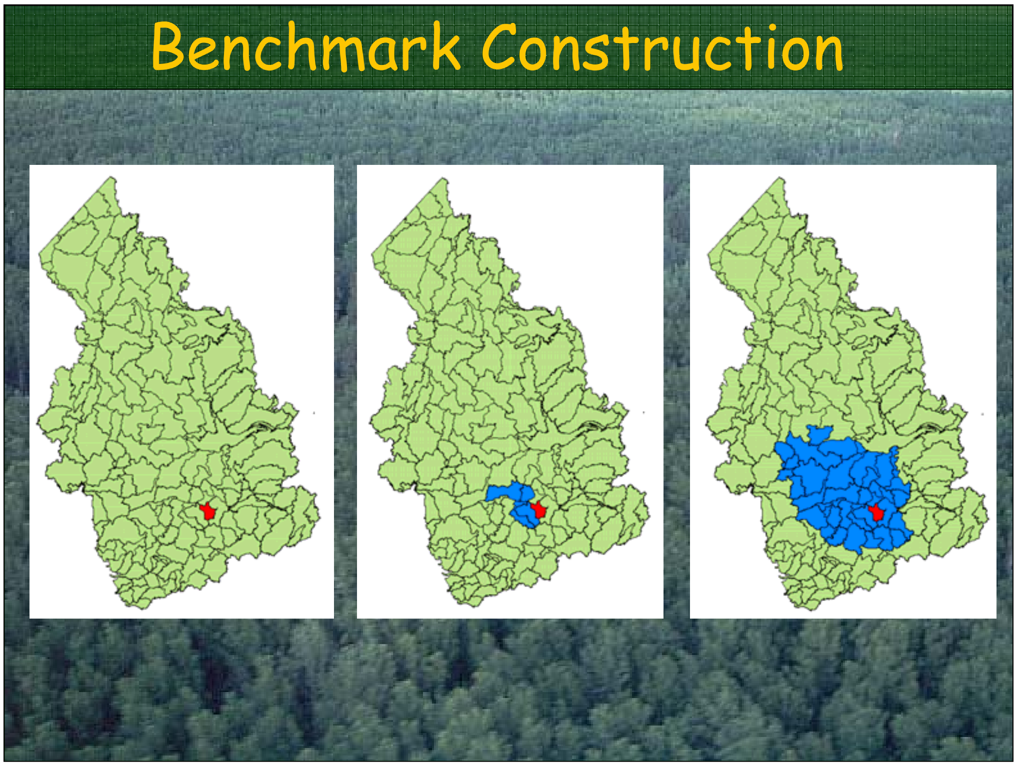
We recognize that boreal systems are inherently dynamic, due in large part to active natural disturbance regimes, and that natural disturbances fundamentally influence the distribution and abundance of many boreal species. Fire is the dominant disturbance agent in most boreal systems, and we used parameters describing fire regimes across boreal Canada in our benchmarks analysis.



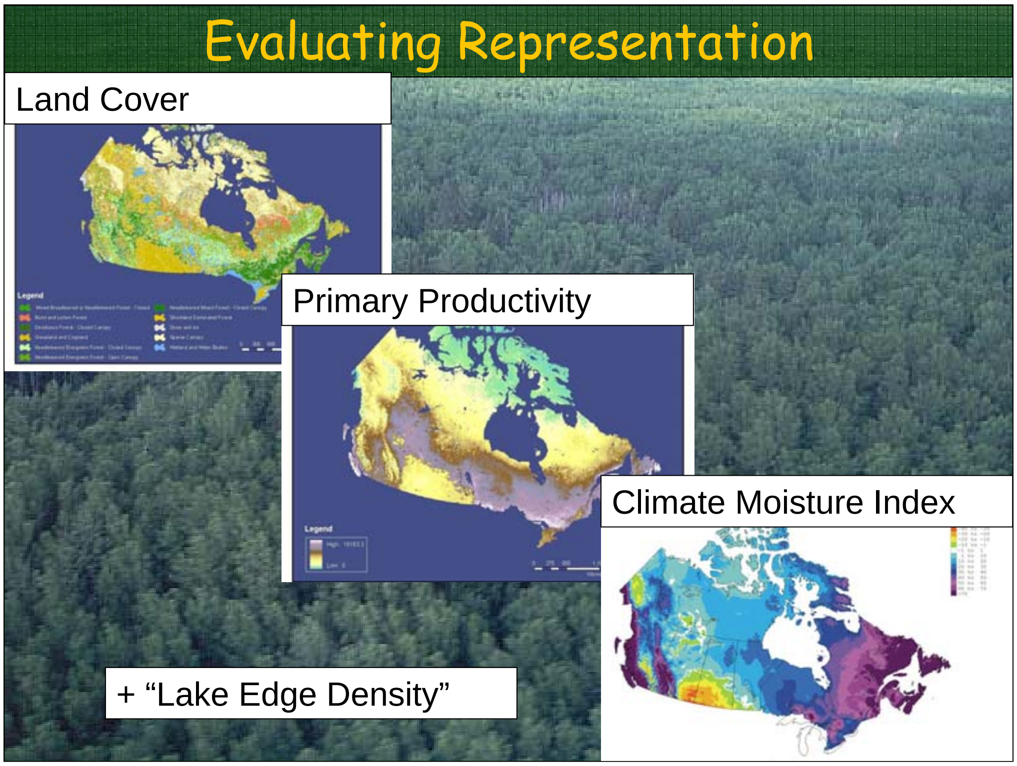
System benchmarks should be of sufficient size to experience the largest, anticipated natural disturbance (*e.g.*, fire), and still maintain internal recolonization sources for species whose habitat is rendered unsuitable by such disturbances. We completed an original, multivariate analysis of forest fire data across Canada to delineate regions with similar regimes, and used these regional attributes as a guide to determining benchmark size.



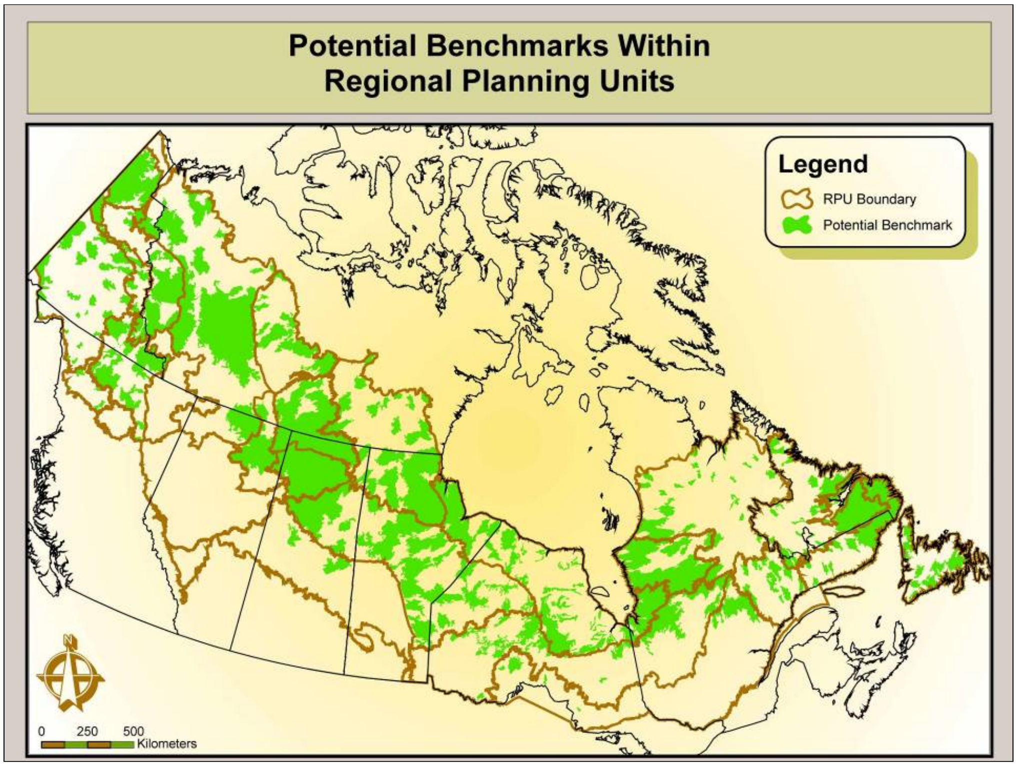
The primary criteria informing the benchmarks analysis were thus intactness, a measure of the absence of human industrial activity and a proxy for the intactness of biological and physical processes; hydrological connectivity of intact water catchments, as a measure of the integrity of aquatic systems; and size, as a measure of the resilience of the system to disturbance. We used an area-weighted intactness measure of IUCN category Ia and Ib protected areas in Boreal Canada as a guide to establishing an intactness threshold for the analysis, Global Forest Watch Canada data on landscape intactness, the National Hydrological Framework to delineate hydrological units, and our novel analysis of fire regions to inform area requirements.



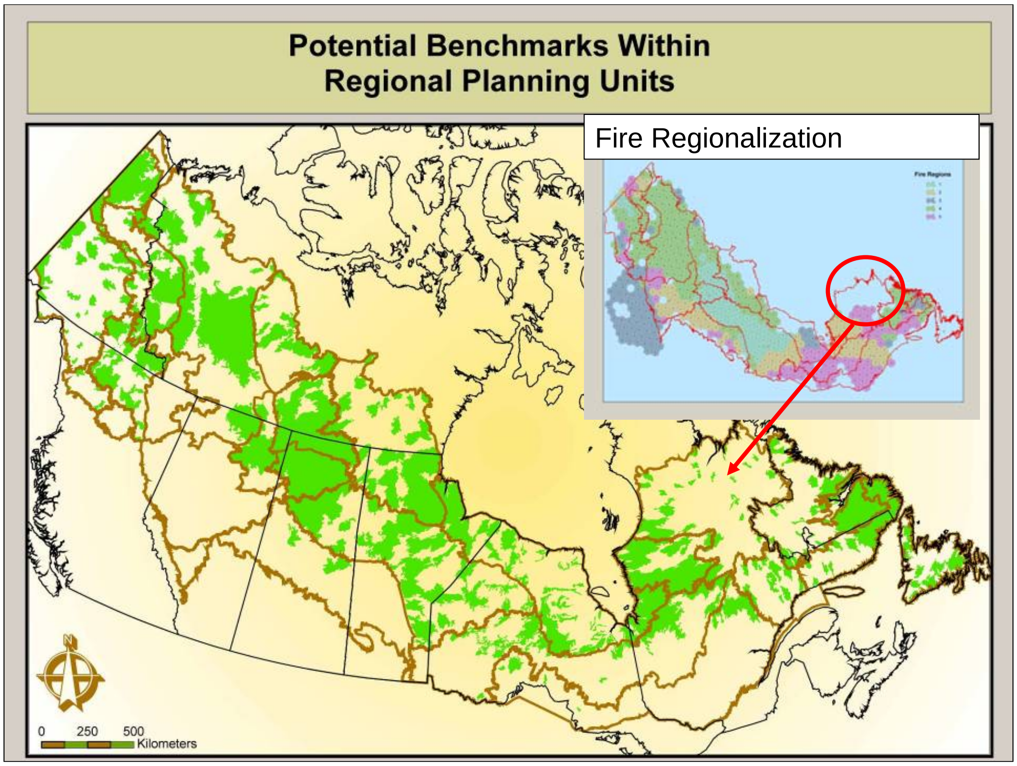
We used an automated algorithm, designed specifically for this work, to identify potential benchmark areas. We constructed intact hydrological and terrestrial units along networks to capture headwaters and downstream catchments, until a specified size was achieved. This was repeated for all possible sites, across all regions. The area illustrated here captures a portion of the NWT and northern Alberta.



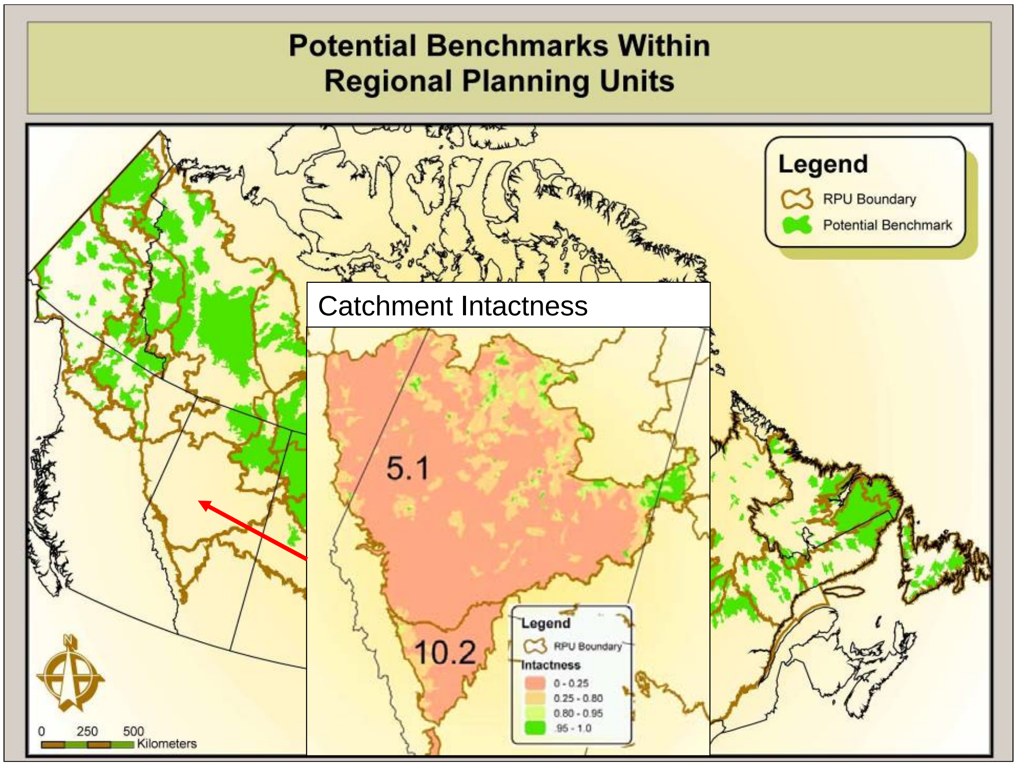
We evaluated and ranked the sites using four representation criteria: land cover, primary productivity, lake edge density and climate moisture index (CMI). CMI was included to facilitate assessment of climate change potential. More detailed information on these attributes and our reasons for selecting them is available. Clearly, other criteria could also be applied.



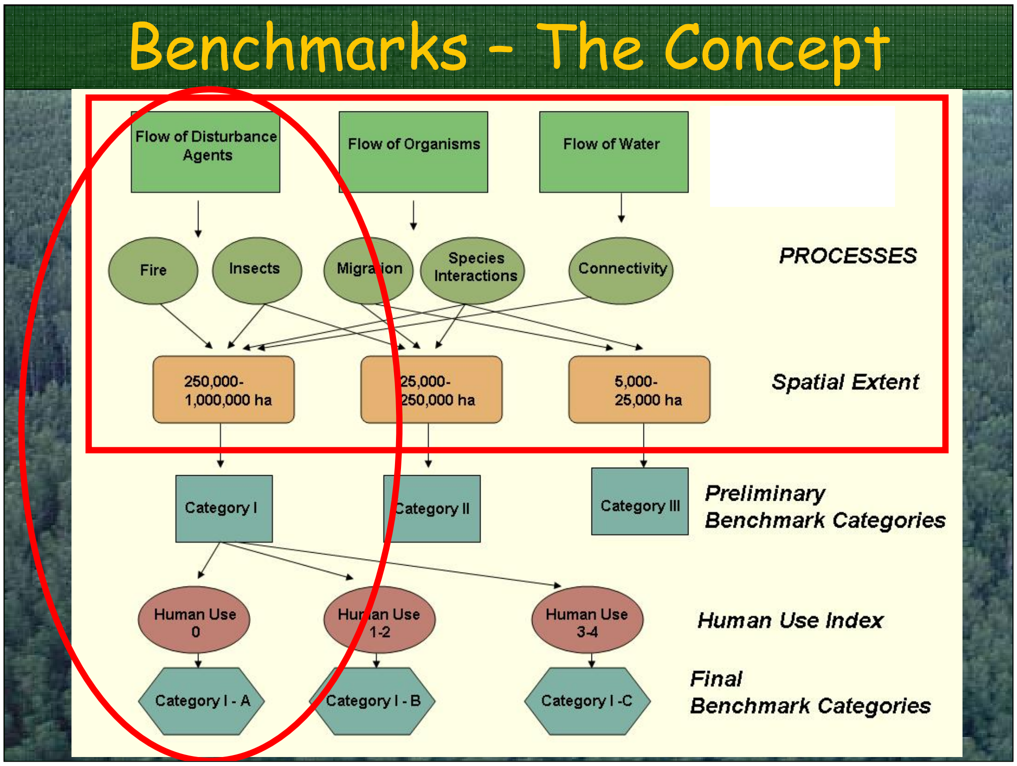
The outcome of these initial analyses is a set of potential benchmark sites across boreal regions of Canada. On this map, green represents the cumulative area of all potential benchmarks built within regions, given specific criteria and decision rules. The procedure is sensitive to changes in parameters, and a full sensitivity analysis is necessary to explore the implications of each attribute included. As a result, this and subsequent maps should be considered proof of concept, with respect to our ability to generate an objective-based network of benchmark areas across the boreal, but in no way a final product for implementation. Nevertheless, the work to date has revealed some important results. First, it is possible to apply an objective set of criteria to this problem and generate output that suggests there exist substantial opportunities to establish system-level benchmarks in boreal regions of Canada.



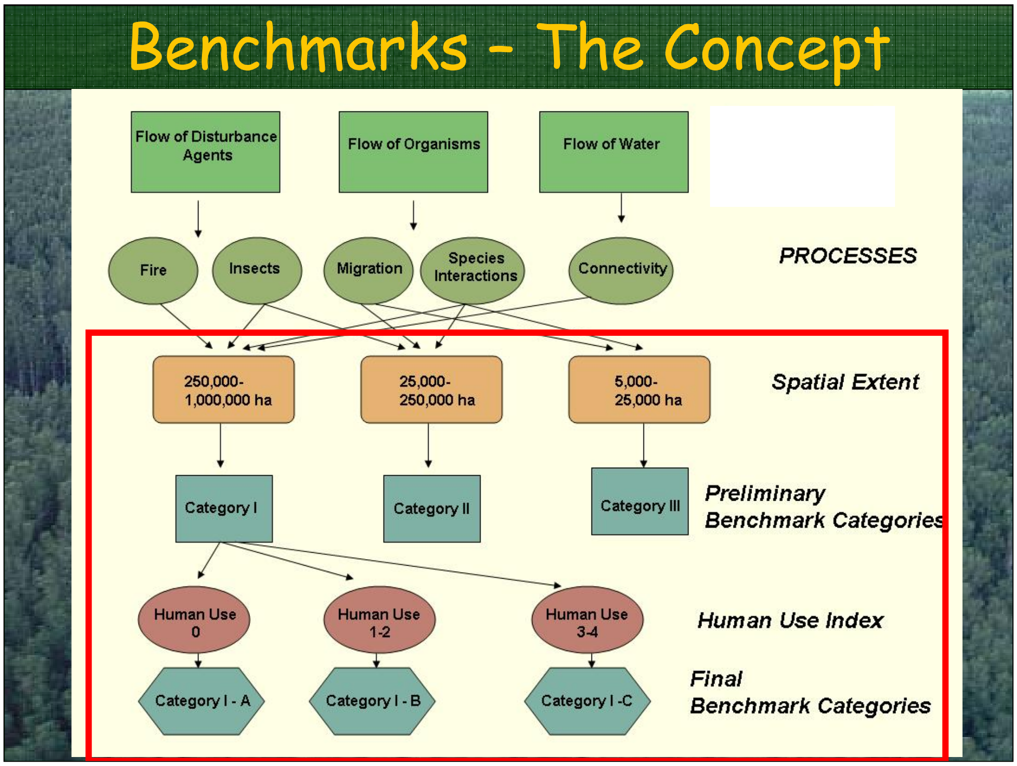
Nevertheless, it is clear in some regions, such as northern Quebec, that using the fire regime to establish the size threshold for benchmarks is inappropriate. This was not unexpected, as we anticipated that other natural disturbances, such as insect outbreaks and flooding regimes, would be important considerations in some areas. Quantifying these processes for inclusion in the benchmarks analysis is an important next step.



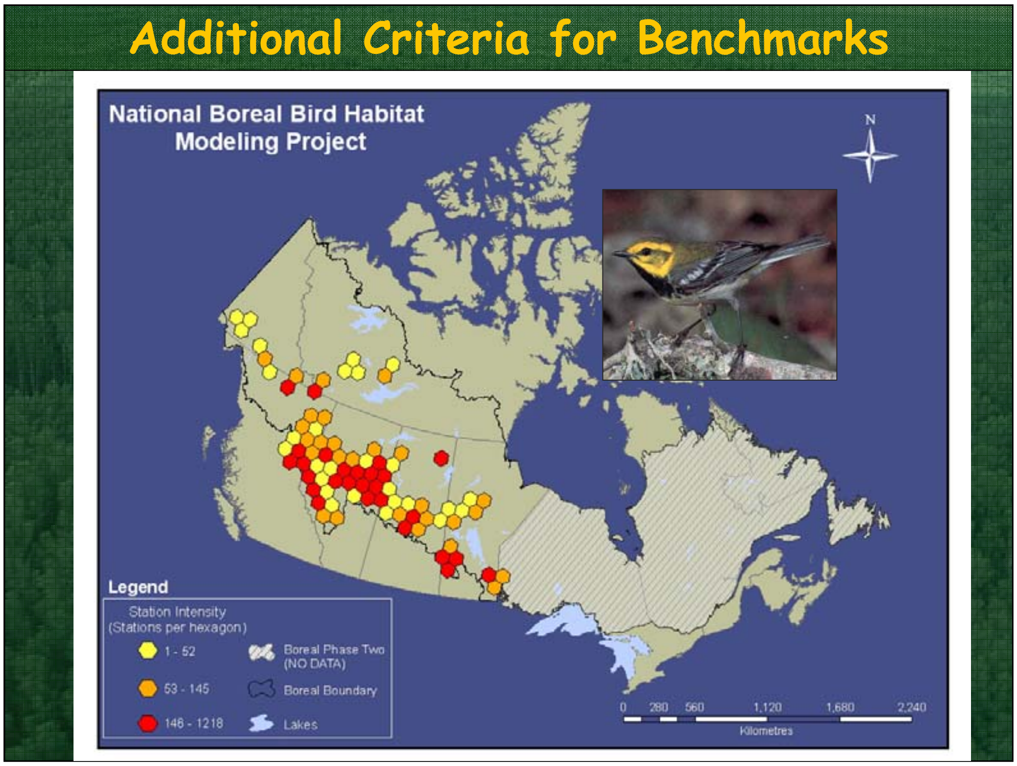
The analysis has also highlighted regions of the country where opportunities to establish system-level benchmarks have already been lost. This does not mean that the conceptual or practical value of benchmarks in general has been diminished, but that different criteria must be established to achieve the best possible outcome for benchmarking in areas with a more extensive and intense human footprint.



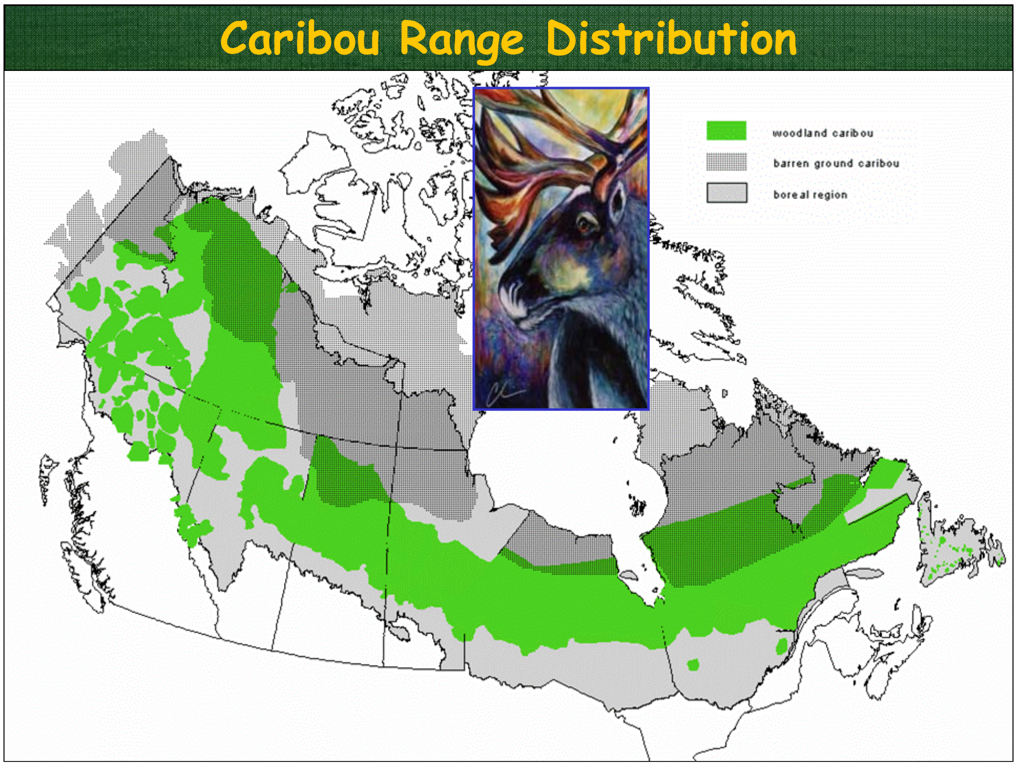
We have concentrated to date on delineating the highest, or system-level benchmarks – large areas with little human activity - as this represents a unique opportunity to establish such sites in advance of widespread development.



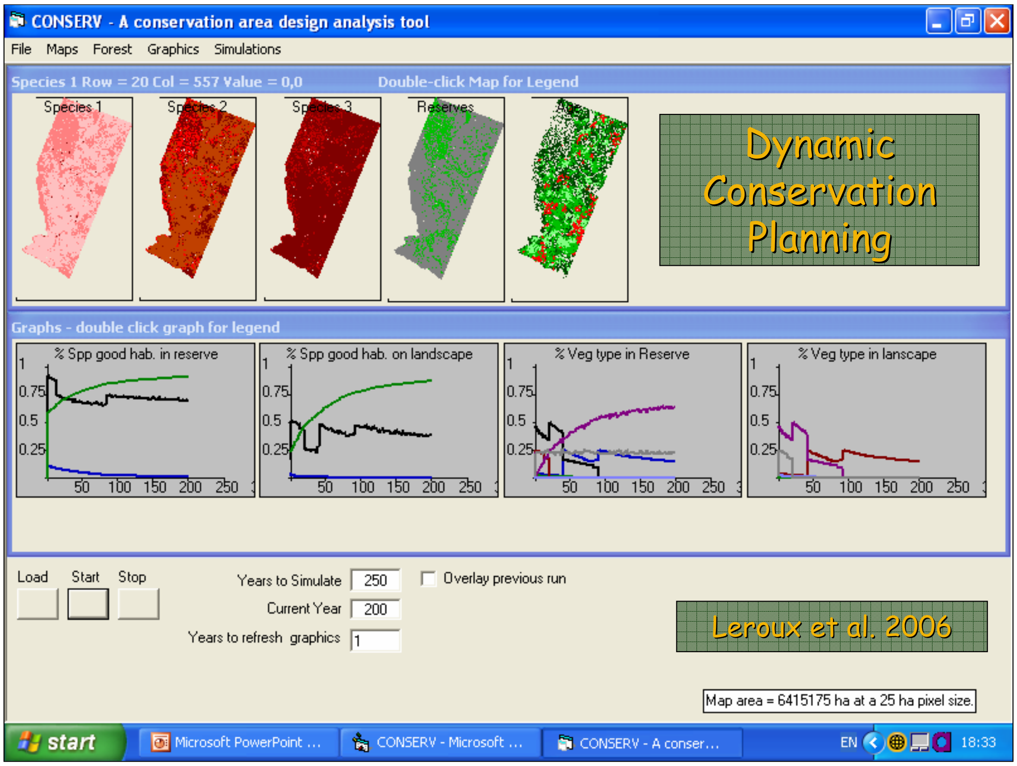
However, our framework is flexible, and future work will include revised criteria for identification of sites along a sliding-scale or continuum of benchmark potential, with the overall objective of achieving the best sites given existing landscape condition.



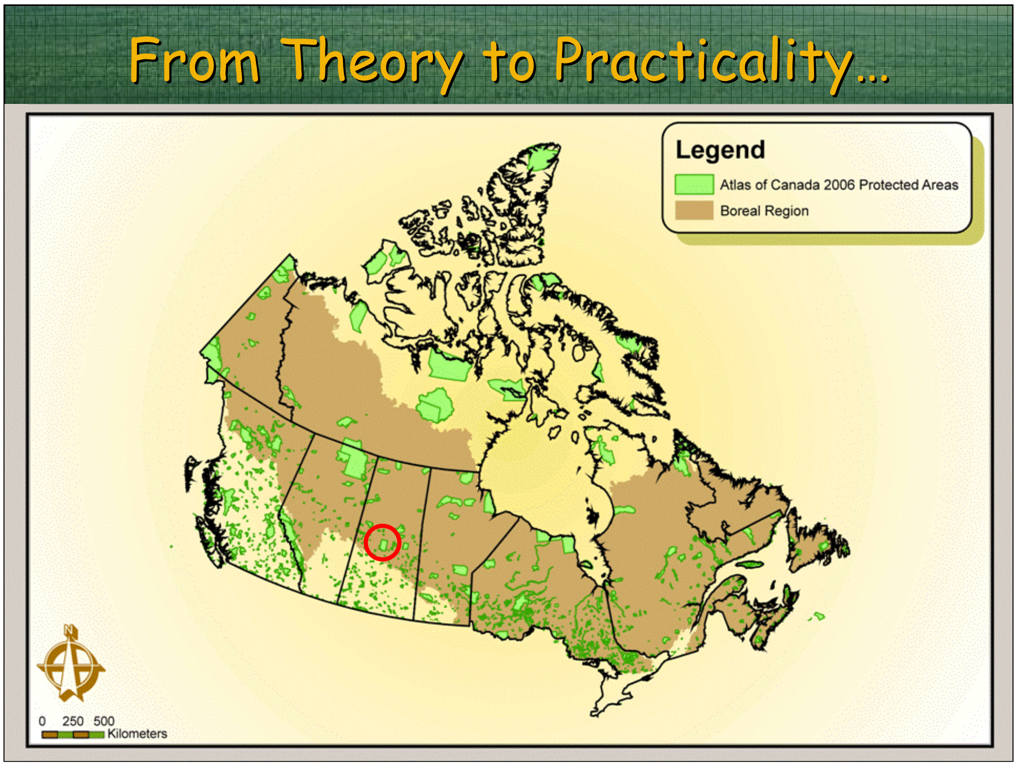
We are also pursuing inclusion of species-level data into our assessments. The National Boreal Bird Modeling Project, based at the University of Alberta and partnered with BEACONs, is assembling bird-habitat data from across Canada. It's primary objective is to develop the best possible predictive models for application in conservation and land-use planning. The first phase has focused on western boreal regions, but we are now expanding into eastern regions. This project has received tremendous response and support from a diverse group of academic, government, non-government and industry partners.



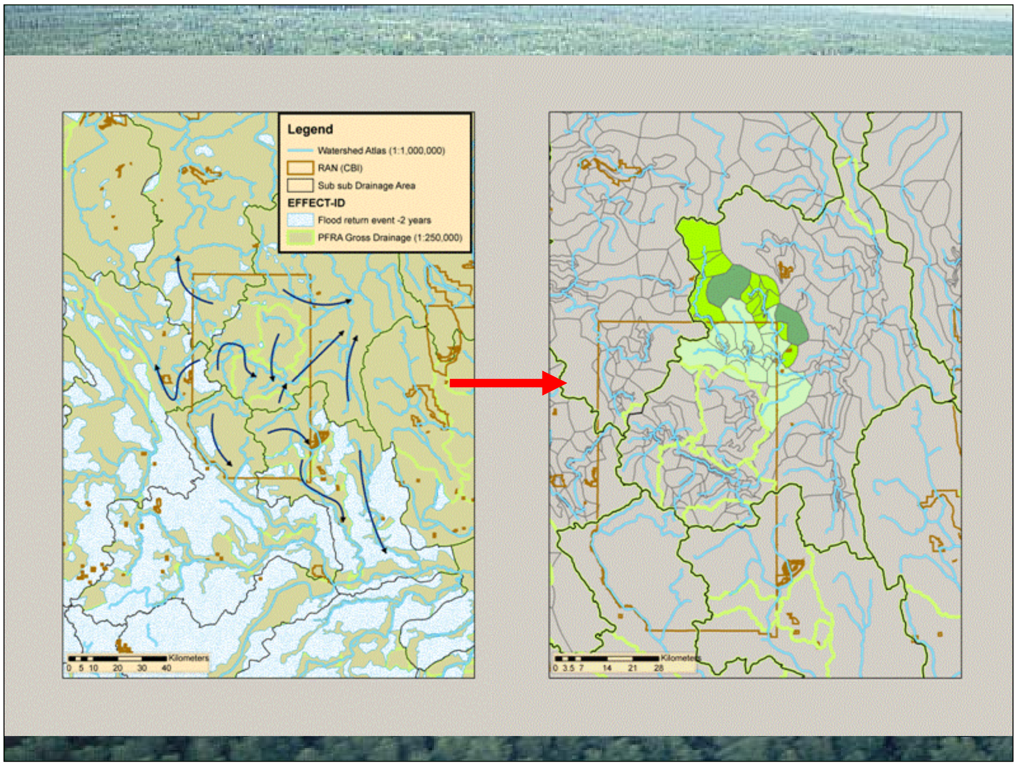
We are also assembling data on caribou distribution across boreal regions, and developing partnerships with regional experts to utilize more detailed, local information in our assessments. Regional expertise represents a critical component in advancing future work on many aspects of the Conservation Matrix Model, including benchmarking.



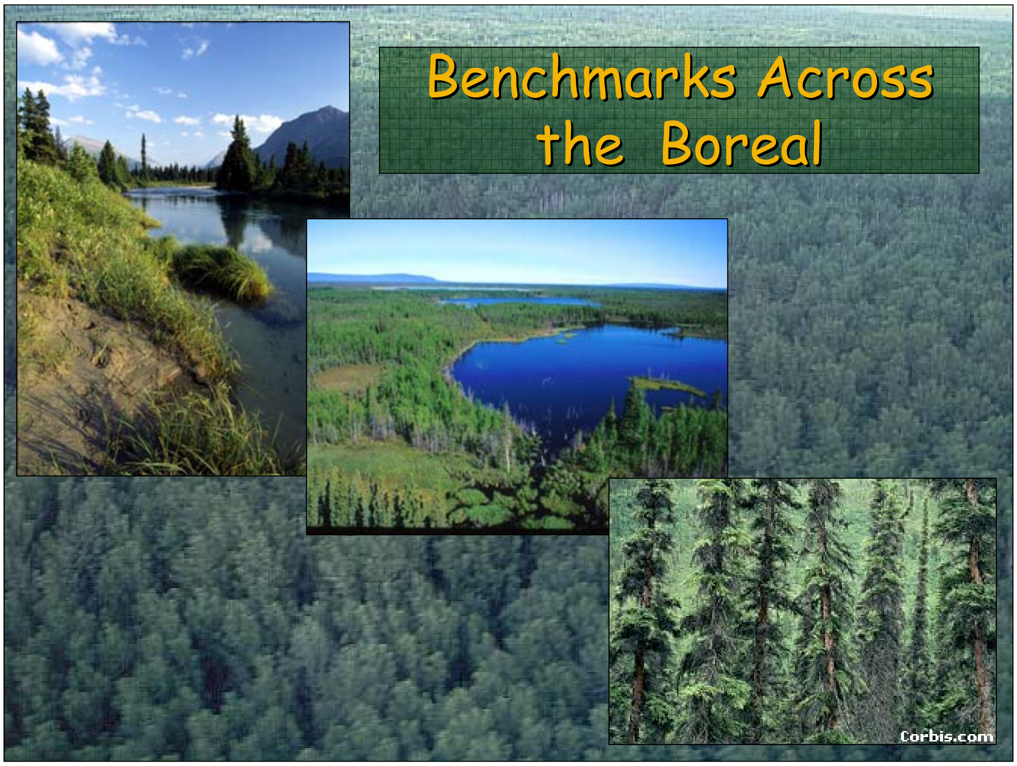
Finally, we have developed tools that allow us to track the projected change in conservation targets through time, give a variety of management scenarios, and also including the potential effects of climate change. This permits evaluation of the relative probability that a given strategy will achieve its objectives, given a specific set of conditions and assumptions. The projection depicted here was recently completed for the Gwich'in and Sahtu Settlement Areas in the NWT, and was designed to evaluate the potential efficacy of different reserve systems, and individual benchmark areas, to maintain their conservation targets through time, under an active natural disturbance regime. For this exercise, the reserve systems and benchmark areas were hypothetical, but caribou and fire models were calibrated with local data, and vegetation dynamics were driven by documented successional trajectories within the region. Such tools can support conservation and land-use planning efforts.



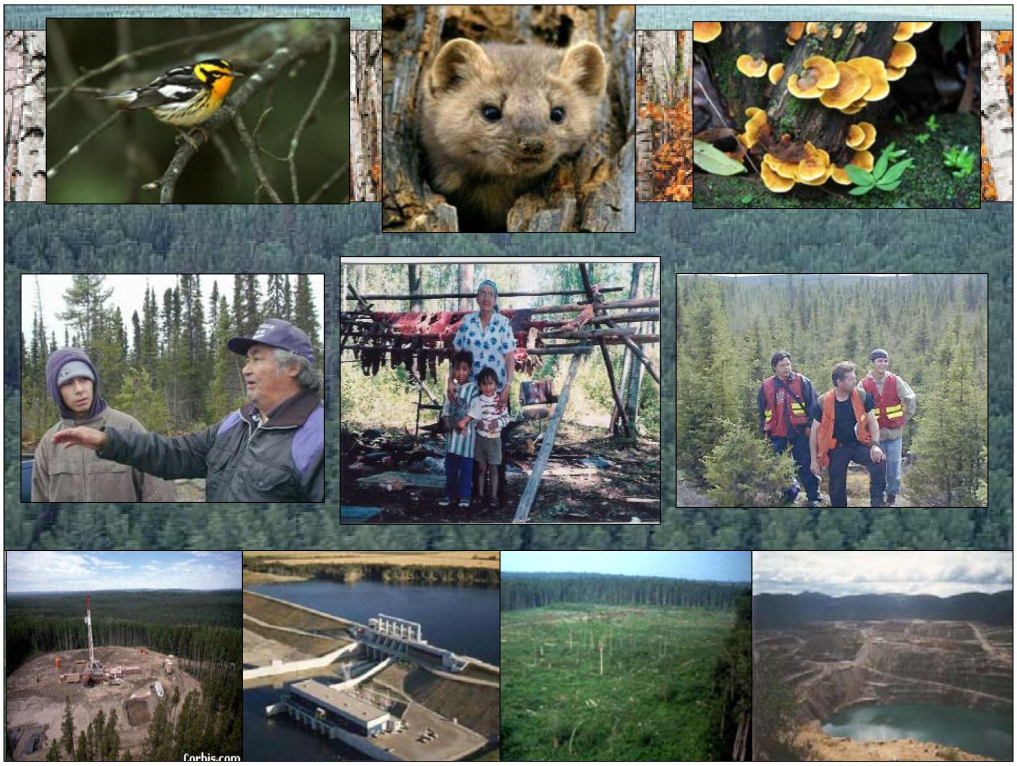
The work I have presented is largely theoretical, but there are many practical considerations in the establishment of real conservation networks. First, evaluation of the adequacy of existing protected areas must be undertaken to assess how this system might be augmented or enhanced to achieve broader objectives than that for which it was established. I use an example from Saskatchewan to illustrate this point.



The figure on the left illustrates the hydrological flows of the largest protected area in Saskatchewan – Prince Albert National Park. The existing park boundary clearly was not determined by ecological criteria, but it does capture most headwaters. It's size, however, is insufficient to capture system dynamics. Building on the hydrological network to include adjacent areas is one method to address this deficiency. Exploring opportunities for building on existing protected areas offers some efficiencies for implementing a more ambitious conservation strategy.



The CMM identifies benchmarks as a critical component of a comprehensive protected areas network, and protected areas are a key component of comprehensive conservation planning. However, decisions regarding levels of protection and delineation of reserve areas involve many considerations beyond those that science can support. The strength of the analyses we have completed is in their transparency, repeatability, flexibility and consistency across the boreal. They provide a foundation for science-based planning, and options for consideration in broader consultation processes.



There are many ambitions for boreal regions of Canada. Too often, we spend most of our intellectual energy examining what is probable, given past trajectories, rather that exploring what is possible, given vision and commitment. Uncertainty rests not with the projected outcome of conventional approaches to land-use planning, but in the efficacy of alternative approaches to achieving a broader set of objectives. This is where the opportunities for innovation lie.

Thank you.

The BEACONs project is partnered with Université Laval, through Dr. Steve Cumming, Chair of Boreal Ecosystems Modeling, Environment Canada's Western Boreal Conservation Initiative, through collaboration and support of the National Boreal Bird Modelling Project, and the Canadian Boreal Initiative, Natural Sciences and Engineering Research Council of Canada, and Canadian Foundation for Innovation, through financial support of our work.