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Network News

Forest Health & Biodiversity

Canadian Forest Service

Eastern Old-growth Forests: Why Maintain Them?

The issue of old-growth forest conservation began in the western United States more than a century ago with the recognition that certain impressive forest ecosystems, such as redwoods, were being depleted. The preservation of representative examples of old-growth forests in parks has also occurred in Canada, most recently with the establishment of a national park in the Queen Charlotte Islands. In eastern Canada, conservation of old-growth forests has received considerably less attention than elsewhere on the continent. A 350-year history of logging has reduced the amount of old growth, and much of the old forests were gone before anyone began to consider conservation. However, in recent years, public concern has been raised in Ontario over the loss of old growth red pine- and white pine-dominated forests and, in the Christmas Mountains area of New Brunswick, over logging in some of the last remaining old-growth balsam fir/spruce forests.

What is old growth?

Many argue that it is impossible to provide a universal definition of old growth for all forest types. To complicate the issue, old growth can be defined from both ecological and forestry perspectives. Intuitively, an old-growth forest is simply an old forest, but the definition must be based on more than age

for several reasons:
first, the age of which trees? In many types of forest ecosystems, trees are normally uneven-aged and some species mature and die before others. In other words, some parts of the ecosystem change while others remain constant for a much longer period. Second, when do trees become old and count as old growth? One reason that old, temperate rainforests are so attractive is because of the high density of impressively large trees. However, trees can exist for a long period without adding significant biomass. For example, there are 150-year-old spruce stands along coastal Gaspé that have grown to only 1 m tall. Similar examples of small yet old trees can be found across the Canadian taiga at the tree line, and along the Niagara escarpment in Ontario. Typically, old trees in the balsam fir ecosystems of western Newfoundland do not grow much larger than 18 m before dying at around 90-100 years. Clearly, such trees are far from awe-inspiring, but they are nonetheless old growth under any definition.

"Old growth" must necessarily be an ecosystem-specific term that accounts for the variety and variability within and among forest ecosystems. However, certain characteristics are common to all old-growth forests (Franklin and Spies 1984, Hunter 1989) including: old trees exist in the stand, the stand has surpassed the natural disturbance interval, and the stand is multi-layered.

Two categories of old-growth forests can be defined: natural and secondary. Natural old-growth forests have arisen following natural disturbance and have never been directly altered by humans; secondary old-growth forests have been disturbed by humans. Natural, or primary, old-growth forests have scientific and pedagogical values that cannot be replaced, and likely can-

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not be duplicated except by nature. However, within such stands, natural processes such as fire should not be excluded if the ecosystems are to be maintained. Secondary old-growth forests may be close to natural in some instances, but they lack the value of virgin forests to test hypotheses about disturbance and for descriptive studies of old-forest processes.

Conservation

There are many reasons why we should conserve some old growth forests and allow younger, natural-origin stands to attain old age: natural, old- growth forests provide benchmarks for the scientific understanding of forest processes without direct human influence. Research in such forests, and comparisons to second-growth forests, provides insights into how systems may have changed as a result of timber harvesting, possibly fostering recommendations for improved harvesting techniques: Old forests have inherent value as places where humans have not modified the environment, thus maintaining certain unspoiled characteristics that are important to many people: They provide optimal habitats for certain wildlife species: woodland caribou, marten, red crossbills, and flying squirrels are some of the vertebrate species that prefer various old-forest habitats in eastern Canada. As well, carbon storage is greatest in large trees and their liquidation increases atmospheric carbon dioxide. Finally, old-growth forests provide a source of genetic diversity that may be lacking in secondary forests, particularly those where the best trees may have been selectively harvested.

The Canadian Forest Service, in cooperation with universities and the Ontario government, has been studying the fauna in natural old-growth forest ecosystems in Newfoundland and Ontario for the past 6 years. In Newfoundland, we posed the question: is there some aspect of biological diversity that would be lost if balsam fir forests were harvested before becoming “old”? In Ontario, studies have focused on white pine ecosystems and the questions: do all white pine mixedwood forests in Ontario maintain the same animal faunas? And, does the animal fauna associated with old-growth white pine forests differ from that in other old forests in the same area? In both provinces, we also attempted to determine if there are certain species that might be good “indicators” of old pine forests.

In Newfoundland, old-growth balsam fir, aged 90-100 years, differed from stands that had achieved similar height and stand volume at 60 years of age (and thus were considered ready to harvest), and could be statistically distinguished from the younger mature forest based on certain structural characteristics. There were different mammal, bird, and invertebrate communities inhabiting old balsam fir forests compared to the younger stands. It was clear that, even in structurally simple ecosystems, such as self-replacing balsam fir forests, biodiversity differs with age of the stand, and management that precludes old forests reduces biological diversity.

Most of the old-growth white pine throughout eastern Canada has been eliminated (Aird 1985) and regeneration is often difficult owing to an introduced disease, white pine blister rust. However, some original white pine forests still exist in Ontario. Fauna associated with old-growth white pine-dominated forests differed in various areas of the province. Further studies north of Espanola in central Ontario concluded that white pine-dominated mixedwoods, in general, and old-growth pine in particular, appear to maintain discrete animal communities. The data are as yet insufficient to establish clear functional links and long-term importance of old pine stands to these species. Nevertheless, under a conservative forest management objective to maintain biodiversity, it is clear that old-growth white pine must be maintained on the landscape. We are now in the process of estimating how much old pine forest is required and in what patch sizes to maintain animal communities.

Indicators

It is generally not often easy to choose valid indicator species for a given forest type and age class. However, such is not the case for the balsam fir ecosystems of western Newfoundland. In all cases, functional links between certain wildlife species and old forests were abundantly clear. However, in Ontario, although it appears that old pine forests do support distinct animal communities that preferred those habitats, all of the species, except some rare insects, were also found in other forest types.

Our work has barely scratched the surface with respect to the importance of old growth forests to animals. The work that we have conducted was designed to elicit answers over a short period to some fundamental questions, based on species that we could readily census. There are several more elusive and low density wildlife species that require study, and there are several other questions that need to be addressed with respect to the importance of old-growth forests, particularly those that deal with issues of sustainable forest use at the landscape level.

Our selection of only two of the many eastern old-growth forest types for these studies was based on concern over their decline. Of course, there are other eastern Canadian forest types that have also declined considerably (for example, red spruce forests) and in order to support conservation and restoration ecology programs to maintain biodiversity, much work remains to be done to understand the secrets kept by these old-growth forests. However, the maintenance of benchmarks so that we can understand natural forest processes is paramount in any land management strategy.

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Indicators for Monitoring Diversity Within a Species

One of the aims of forest biodiversity monitoring is to understand and manage the potential impacts of human activities, particularly forest management practices, on forest health and biodiversity. At the species level, the effects of forestry practices revolve largely around the reduction of breeding population sizes, population density, and distribution of breeding populations on a landscape scale (e.g., fragmentation and connectivity) to the point where ecological processes affecting population viability (Fig. 1) are disrupted or adversely affected.

Biodiversity monitoring involves making recurrent observations, and recording changes and trends based on established biological benchmarks for indicators at each level of the biodiversity hierarchy (landscape, community, species/genetic). Monitoring is aimed at determining the type, scope, impacts, and ultimately the causes of changes so that appropriate management activity can be directed at specific environmental, social, and economic objectives. This article presents some indicators for monitoring population viability in trees, with special emphasis on genetic diversity and reproductive success.

Useful indicators are usually quantitative and unambiguous. Practicality and simplicity are major considerations in choosing indicators that are cost-effective, technically feasible and scientifically valid. While working definitions for biodiversity conservation are being developed through the various criteria and indicator (C&I) initiatives under the auspices of the Convention on Biological Diversity (CBD), many aspects of the operational definition of biodiversity, particularly with respect to indicators for monitoring, need to be clarified before they can be used by land management agencies for reporting on the status of species at risk and those being adversely affected by human activities.

Trees have special significance as "keystone", "flagship" or focus species for biodiversity management because they normally define forested communities and represent a disproportionate amount of the biological resources on a forested site. By virtue of their size and dominance, trees form the habitat for many other associated organisms. Thus, trees are useful indicator species for biodiversity conservation and monitoring.

At an operational level, most forest land management agencies, including forest industries, may be concerned primarily with monitoring the impacts of human activities at the "coarse-filter" level of community diversity within managed landscapes and on species diversity within forested communities using resource inventory databases that are

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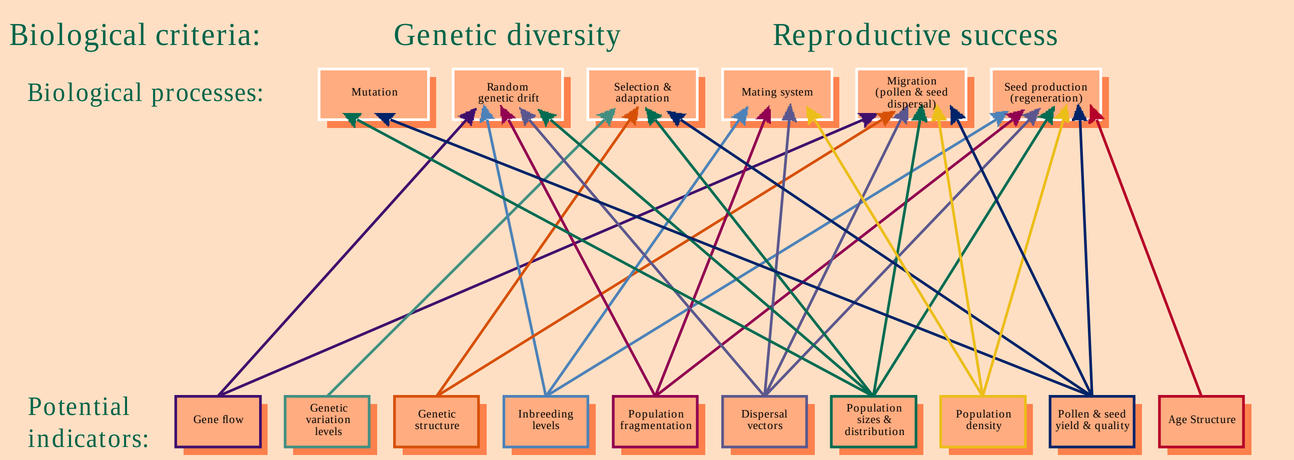
Fig. 1. Criteria and indicators for measuring and monitoring population viability



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normally available via remote sensing, GIS applications, and operationally-based ground surveys.

However, monitoring biological diversity using a "fine-filter" approach at the species level (e.g. genetic diversity and structure, reproductive behavior, inter alia) focuses on species life history traits and will be aimed primarily at rare, vulnerable, and threatened species or those of special interest and value. While there may be some controversy about the best approaches for conserving the genetic resources of a species, maintaining genetic variability at the species level forms the basis for the evolution of diversity at the community and landscape levels. As Vida (1994) puts it, "the future of species diversity is in the genetic diversities of the species."

Monitoring begins with the accumulation of benchmark data on selected indicators so that changes can be related to these benchmarks. Some of these potential indicators are presented in Fig. 1. Avoiding inbreeding and maintaining genetic variation are the main issues in the conservation of genetic resources. Although minimizing loss of genetic diversity within the species is a key policy concern in managing biodiversity, there are few, if any, comprehensive programs designed to monitor the status of forest-dependent species of concern. This weakens the ability of land management agencies to set conservation objectives at the species level.

The biological criteria that maintain population viability are affected by each of the biological processes listed in Fig. 1. Genetic diversity and reproductive success should be linked in the monitoring process because the former is mediated by the latter. While reproductive success can reflect either abiotic features of the environment or the demographic and genetic consequences of small population size associated with rare or declining species, ultimately, reproductive success will determine the genetic status of a species. Therefore, the suite of indicators presented in Fig. 1 recognizes reproductive success as a major component of population viability.

From the practical perspective of monitoring, the criterion of reproductive success includes several indicators for measuring and monitoring the biological processes that maintain genetic diversity. Moreover, many aspects of reproductive success present opportunities to develop some relatively simple, cost-effective indicators of population viability; whereas monitoring genetic indicators through direct measures that rely on sophisticated biochemical and/or molecular genetic marker techniques can be costly, time consuming, and require specialized expertise and facilities. However, several indirect or surrogate measures based on the distributional and demographic characteristics of a species (see Fig. 1) may provide some useful indicators for monitoring genetic status without the expensive laboratory analyses associated with direct genetic measurements.

The population/biological processes that maintain genetic diversity are relatively well understood in theory, but their relationship to distributional and demographic traits may vary with different species. Measures such as the dispersion of sub populations, connectivity, fragmentation, etc. affect the biological processes that maintain genetic diversity and reproductive capacity, but these relationships need to be better quantified at least for some of the major groups of species with common life history features. For instance, genetic and reproductive assessments related to minimum viable population size (e.g., parameters such as population size, density, fragmentation, dispersal corridors, etc.) or other threshold population levels provide a conceptual framework for the development of indicators.

Scientifically meaningful indicators for monitoring population viability are available. There are both direct and surrogate indicators for each of the important biological processes to be conserved. With some further development, more operationally feasible surrogate measures or indicators can be developed for more general use, and the more costly biochemical and molecular genetic marker approaches or the more time-consuming conventional quantitative genetic assessments based on common garden studies of adaptive or fitness traits may be reserved for species at risk or those of special value.

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The Tropospheric Ozone Threat to Canada's Forest Health

Just when you thought you understood the problem of ozone depletion and the accompanying threat of damaging UV-B , someone comes along and tells you that we have too much ozone!

Despite the growing problem of upper atmospheric (stratospheric) depletion of ozone, the lower atmosphere (troposphere) suffers from episodes of increased ozone due to the photochemical reactions of various emissions, from a variety of human sources, but mainly the automobile.

Ozone itself is a damaging agent exerting oxidative stress on plants which may vary in their tolerances. Ozone also predisposes plants to other injuries caused by frost, drought, and nutrient deficiency. Critical levels, established for the protection of crops and other plants, are now being exceeded over large forested areas, giving rise to the need for an extensive monitoring program to establish ambient levels and to detect damage symptoms in natural situations.

Currently, air quality monitoring is being carried out at "continuous" monitoring stations, however, these are limited to a few urban and rural areas. To address the need for forest-based monitoring, the Forest Health Network (FHN) has embarked on a program to develop new monitoring methods which can be implemented in remote forest stands to measure ozone exposure at various locations in the forest canopy where damage might occur. At the Atlantic Forestry Centre, a small passive monitoring device, and protocol for use has been developed to do the job (CanOxy Plate™). The device, developed by the Forest Health Network's Air Pollution Research Group, can be left unattended on site for retrieval at specified intervals or when an ozone event is thought to have occurred. The passive monitor is composed of a PVC shelter which houses a pair of ozone sensitive plates formulated with indigo dye. At the end of each sample period the plates are sealed and sent to the laboratory where the ozone reaction product is extracted and the relative ozone exposure is estimated by analysis.

The passive ozone monitors underwent initial trials in 1996 and operational trials during 1997, in a program lead by Roger Cox and coordinated by Bruce Pendrel and Forest Health Monitoring Unit Leaders. These trials involved the exposure of the CanOxy Plate sampler in the upper canopy, and at an adjacent forest opening at selected ARNEWS sites across the country. Local arrangements were made and the legwork done by the FHN staff at all five CFS establishments. For the two exposure periods of 2 to 3 weeks, CanOxy Plate and Ogawa passive ozone samplers were also co-located at the nearest continuous ozone air quality monitor. This allowed for the production of a field calibration for quality assurance assessment, and comparison of the two monitors under field conditions. Rigorous sampling for possible ozone symptoms was a key part of the 1997 operational trials. Ken Harrison lead sample assessment, in part a process of ruling out the overwhelming number of symptoms related only to foliar insects and diseases.

Ozone branch chamber fumigation system

Results from 1996 indicate similar performance of the two monitors, both yielding highly significant correlations with accumulated ambient ozone concentrations (r^2 of 0.97 for the Ogawa and 0.93 for the CanOxy Plate) suggesting a high degree of quality assurance for the more cost effective CanOxy Plate sampler under field conditions. Analysis of CanOxy Plates exposed at plots in forest openings indicated no exposure relationship with the amounts of ozone monitored at the nearest continuous air quality monitoring site, often several hundred kilometers away. This may indicate spatial heterogeneity in ozone exposure between the air quality monitors and the forest plots.

This information, together with our knowledge that strong gradients of ozone exposure are found within the canopy, underlines the importance of in situ monitoring of ozone exposure of Forest Health plots in areas of elevated ground level ozone. These results also encouraged the development of a passive ozone monitoring protocol.

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Complimentary to the above article is a story by Dr. Kevin Percy and Dr. Stewart Cameron of the Atlantic Forestry Centre on the potential threat stratospheric ozone depletion poses to forest health. This article can be located on Natural Resources Canada's world wide web site at http://www.NRCan.gc.ca/geos

Detecting Forest Pests

For some, the word 'exotic' triggers thoughts of tropical islands and clear blue waters. But for Canadian Forest Service (CFS) scientists Dr. Lee Humble and Dr. Eric Allen, 'exotic' coupled with the word 'species' may mean serious damage to native plants and trees, as well as to native insect species in Canada.

Pests or non-indigenous species from other countries have been 'hitching' rides on cargo or dunnage on ships since the beginning of trade on this planet. Although not many species outlast the journey, survival rates are rising as vessels coming from other continents now take less time to arrive at our ports. Greater numbers of containers being shipped across borders, more trade from temperate countries, as well as changes in the overall global movement of people all raise the potential for exotic species such as insects, fungi, nematodes, bacteria and plants to reach our shores. In collaboration with the Canadian Food Inspection Agency (CFIA), CFS researchers in the Forest Biodiversity and Forest Health Networks attempt to determine what native and non-native species are present within Canada's borders.

"It's a good detective story that's often impossible to solve," says Dr. Allen, who is head of the Forest Health unit at the Pacific Forestry Centre. "We often don't know about these pests until some time after they've reached our shores." To determine the pathways through which exotic pests enter the country, Dr. Allen focuses on quantifying high-risk commodities such as wood-based wire rope spools that have been found to contain some species of non-native insects. In cooperation with other scientists in the Forest Health Network, he is developing detection methodologies and creating risk scenarios to determine the likelihood of certain non-indigenous species establishing in Canada. Taking into consideration the life history of a particular species, Dr. Allen looks at the climate of the country to which the species is native and matches it to where the climate may be similar in Canada.

Asian long-horned beetle

"Three years ago we started looking at some urban parks and national wildlife areas in B.C.'s lower mainland to see if certain non-indigenous species that were a threat to forestry were established," says Dr. Humble, an entomologist who heads two insect trapping projects in the area. Two exotic species that the research team were trying to locate, the European spruce bark beetle and the European pine shoot beetle, were never found. However Dr. Humble and his staff did discover four well established exotic European or Asian ambrosia beetles.

From these forested areas on the lower mainland, 1500 trap collections were brought back to the insectary at the Pacific Forestry Centre for inspection this past summer. At this facility, containing more than 7500 different species of insects, staff examine and identify non-indigenous species in an attempt to detect newly introduced insects at an early stage. In this case, they found some six distinct species of exotic insects in one collection. Based on these studies, researchers were able to determine that more than 20 percent of the total bark beetle fauna at these sites was non-native.

"There is no way of knowing whether an introduced species is going to be harmful," says Dr. Humble. "They have not evolved with the plant species they're attacking on this continent. There tend to be no evolutionary checks or balances in place, so the plant may actually be more susceptible to the pest." Dutch elm disease, chestnut blight and white pine blister rust are three examples of major exotic tree diseases that have had a severe impact on native plant diversity in Canada.

At the Pacific Forestry Centre, staff are developing new tools that will greatly assist in tracking down non-indigenous species. With this information, scientists will eventually be able to assess the rate of introduction of these species, determining whether these rates are increasing or decreasing. "We have a unique set of circumstances here," says Dr. Humble. "In both the Forest Health and Forest Biodiversity Networks we're striving to develop methods to detect introduced pests."

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Fine Tuning the Picture

"Things are not always as they appear to be." This old adage has been reinforced by recent collaborative work done by Linda DeVerno of the Forest Biodiversity Network and Georgette Smith and Ken Harrison of the Forest Health Network at the Atlantic Forestry Centre. What began as an effort to reliably distinguish species of spruce budworm and jack pine budworm has flown off in a more dramatic direction.

Eastern spruce budworm and jack pine budworm are so closely related that the jack pine budworm was only described as a separate species in 1953. Throughout their natural range in eastern North America, the preferred hosts for spruce budworm (balsam fir and the spruces) and jack pine budworm (pines) occurred in separate areas, so routine identification was not considered a problem in the past. In parts of Atlantic Canada, however, there are areas of pines in close proximity to balsam fir and spruce stands. Since budworm adults disperse over wide areas the question of which budworm is present is important to foresters – if you are not positively certain of the insect you are working with, all your pest management strategy efforts could be futile.

Currently, identification of male moths is based on microscopic examination. There has never been a method for reliable species identification of female moths. Pheromone, malaise and light traps are widely used to capture budworms for population monitoring, but some of these moths are inevitably damaged by trapping and difficult or impossible to identify.

Using RAPD techniques (randomly amplified polymorphic DNA), DeVerno, Smith and Harrison collaborated to find a reliable means of separating these closely related budworm species whenever conventional diagnostic techniques couldn't be used (i.e. the specimens were damaged or were females). Species specific DNA fragments were identified in known specimens of eastern spruce budworm and jack pine budworm. These fragments were then found in DNA extracted from desiccated adults from the Atlantic Forestry Centre Insect Reference Collection in Fredericton, New Brunswick and the Nova Scotian Museum of Natural History in Halifax, Nova Scotia. Some of these specimens were over 50 years old. This techniques provides an exciting opportunity to validate earlier work with these species and identify previously undetermined material.

Readers are invited to examine the three adult insects in the photo. Are they jack pine budworm, spruce budworm or a hybrid?

RAPD techniques revealed that the identifications of budworm specimens which relied on host data, gross morphology, dissection and adult dispersal dates were often unreliable. RAPD showed that hybrids existed in the natural budworm populations of Atlantic Canada. These hybrids between eastern spruce budworm and jack pine budworm were known to occur in laboratory rearings, but were believed to be inhibited in natural populations. But what does this all mean?

Without RAPD testing of reliable reference material (referred to as voucher material) in reference collections from all past studies, it is impossible to know whether the intended budworm or a hybrid population was actually studied. The differences between the behavior of hybrid populations and pure populations haven't been studied.

There are wide ranging implications for all types of current research work on eastern spruce budworm and jack pine budworm. RAPD should be used as a tool for quality assurance and validation in monitoring programs, systematics studies, pheromone formulation, population dynamics and when developing pest management strategies for a specific budworm.

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Answers:

Top: Pure jack pine budworm (male)
Middle: Hybrid (male)
Bottom: Pure spruce budworm (female)

Canadian Council on Ecological Areas Conference, September 1997

The Canadian Council on Ecological Areas (CCEA) conference and annual general meeting held in Fredericton in mid-September was highly successful, attracting more than 200 participants and a variety of presentations that were both insightful and inspiring.

The two-day conference focused on the theme "Protected Areas and the Bottom Line". Speakers included Michael Soulé, the "father of conservation biology" currently based in Colorado, Dick Stanley, Chief of Economic Research with the Department of Canadian Heritage, and Gary Machlis, Chief Social Scientist with the US Parks Service. These experts all made it clear that there are biological, social and economic imperatives that are at least as important as the bottom line on wood supply.

Michael Soulé painted a less-than-encouraging picture for the survival of many species over the next 30 years. Michael said "the primary causes of the current debacle are population explosion, new technology and globalization of commerce", and he pointed out that protection of 12 percent of the globe in its natural condition would fall far short of the goal of maintaining viable populations of all species.

The plethora of approaches to valuing protected areas were described comprehensively by Dick Stanley. Gary Machlis told us that, "parks matter for lots of reasons and one of them is love." He went on to say that, "parks have a wide range of values and their future role locally, nationally and globally largely depends on protecting the full range of those values."

The conference was structured to present the big picture first, with a progressive narrowing of the focus over the two days. Concurrent workshops on specific issues, with carefully chosen resource people, ended the conference. These workshops were intended to provide people who are grappling with problems related to establishment and management of protected areas with opportunities for learning and interacting with others facing the same challenges.

Once Proceedings of this conference are published, Network News readers will be advised of their availability.

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