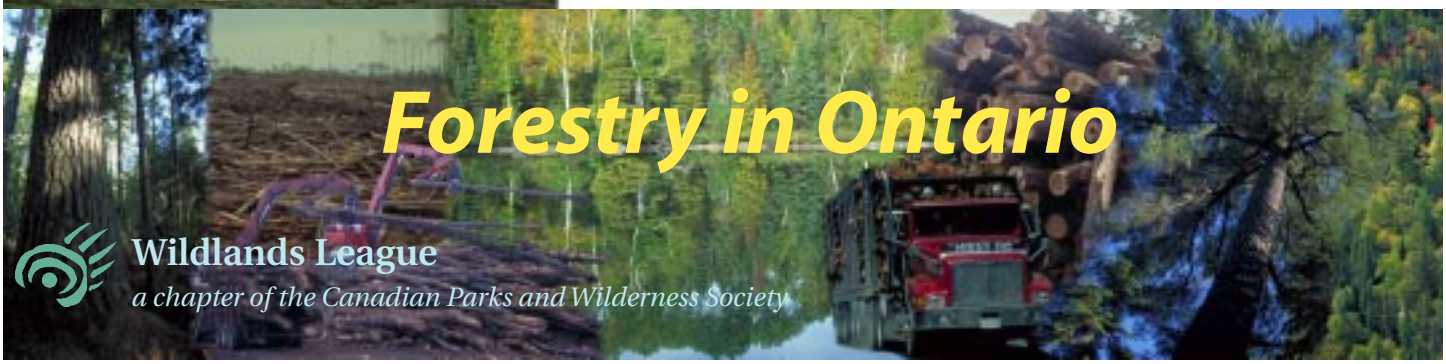


This series of fact sheets has been produced to increase public understanding of forestry in Ontario and to present innovative ideas on how these impacts can be mitigated. Forestry is the single largest use of public lands in Ontario and forestry activities can have a major impact on ecosystems. The Wildlands League is committed to improving forestry practices and reducing the ecological impact of logging by working directly with government and industry and by improving public awareness and involvement in forestry issues.

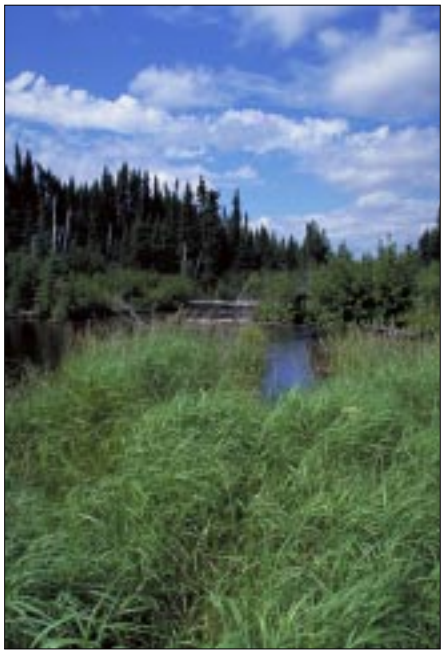
Good Boreal Forestry

Protecting the forest's critical characteristics

INTRODUCTION

We need to change the focus of forest management from generating wood supply for mills to a much broader focus on maintaining forest integrity. We also need to understand how protecting the functions, systems and structure of our forests also helps us secure economic benefits over the longer term. Simply put, if we want to reduce the impacts of logging on forests and protect the wildlife that depend on them, we must set clear objectives and put in place specific measures for protecting the characteristics, such as size, age and structure, that make natural forests work.

The first two sections of this fact sheet discuss the significant negative ecological impacts of current industrial forestry on our boreal forests, both locally and across the boreal landscape. The final sections outline a better approach to forestry in which the primary objective is the maintenance of critical forest characteristics. Under this system, decisions about the amount, extent, location and type of logging would all flow from a proactive approach to protecting critical forest elements. This proactive approach would allow forestry to continue to provide products, services and employment while also protecting the full range of natural, social, recreational, cultural and economic values and opportunities provided by forests.



Bruce Petersen

The boreal forest represents one of our best chances to apply better forestry practices.

ONTARIO'S BOREAL FOREST

The boreal forest covers 43 million hectares of land in Ontario[1], an area twice the size of Britain. It is an ever-changing ecosystem that is dominated by white and black spruce, jack pine, balsam fir, trembling aspen, balsam poplar and white birch. Natural disturbances, such as wildfires, insect outbreaks and windstorms and the ecological-succession processes that take place after these events, shape the boreal forest into a diverse mosaic of forest types and ages. The boreal forest is also an important source of livelihood, culture and spirituality for many Canadians, especially Aboriginal peoples, and provides a critical source of income for forest-dependent northern communities. The forest industry relies on the boreal region for over 90% of the wood cut in Ontario each year. [2]

The boreal forest is also one of the world's best remaining opportunities to protect intact wilderness and the species that depend on it. But this area is also under immense industrial pressure. Currently, 62% of Ontario's boreal forest is licensed to forestry companies for timber harvesting.[3]

Although Ontario's far north (north of roughly 51 degrees latitude) is currently free from industrial activity, industrial expansion and the development interests of First Nations will likely result in forestry operations reaching this area in the near future.

Logging has become one of the major forces of change in the boreal forest. Almost 200,000 hectares of forest are clearcut each year in Ontario[3]. This widespread clearcutting is having major ecological impacts on boreal forests:

1.0 IMPACTS OF INDUSTRIAL FORESTRY ON THE BOREAL LANDSCAPE

Old forests are disappearing

Old forests are a critical characteristic of the boreal forest. They have a unique composition and structure that can only develop with time (the age at which forests develop these unique characteristics depends on forest type – see Table 1). Without adequate areas of old forest, many species of plants and animals will decline or even disappear from the boreal forest.[4,5,6,7]

Table 1: Old Forests[57]

- 120 years for white and red pine, ash
- 110 years for cedar, tamarack
- 100 years for black spruce, white spruce
- 70 years for jack pine, balsam fir, poplar, aspen, white birch

Although frequent fires and other natural disturbances result in the boreal region having large areas of young forest, the random nature of fire means that a large proportion of the forest escapes burning and other impacts and reaches old age. Estimates of the amount of old forest – forest older than the average age – that existed in the boreal before the introduction of widespread logging range from 37 to over 50%.[8,9,10] Currently, about 44% of Ontario's inventoried boreal forest is over 80 years of age and about 28% is older than 100 years.[11] But current and projected levels of industrial logging will significantly reduce this proportion over the next 50 years to the point where the forests can no longer even sustain the supply of mature forest needed for timber production.[12]

In Finnish and other Scandinavian forests where hundreds of years of industrial forestry have nearly eliminated older forests, it is estimated that hundreds of forest species have already been lost.[6] Because traditional industrial logging plans are geared toward logging the entire managed forest every 70-100 years to maximize economic returns, the naturally large and important extent of old forests in the boreal will decline. These old forests will eventually disappear if we do not put in place explicit measures to protect them.

Woodland caribou need large old forests.

Tim Timmerman

Big forests are disappearing

The boreal is home to a number of species that require big, continuous areas of forest to survive, including the threatened woodland caribou, the American marten[13, 14] and several species of birds.[15] Decades of industrial cutting in the southern boreal forest have led to extensive fragmentation of the intact forest by clearcuts and roads.[16] Although some species like song birds that favour forest interiors have not clearly shown a negative impact as a result of this trend[17], another forest interior species, woodland caribou, has disappeared from most of this area.

Remote forests are disappearing

Remote forests accessible only by boat, foot or plane are rapidly becoming a thing of the past. Thirty-one percent of Canada's boreal forest region is already easily accessible by roads. In Ontario, there were 33,000 km of logging roads across the province in 1987, with an average of about 1,700 km of new roads being built every year.[18] As industrial forestry continues to expand throughout the boreal forest, less and less remote undisturbed forest remains.

Logging roads themselves have significant ecological impacts. They compact the soil[19], alter water flows[21] and lead to soil erosion[21,23,24] and sedimentation of water bodies.[24] Roads are also major entry routes for invasive exotic plant species. They alter wildlife movement and behaviour, in some cases blocking the daily or migratory movements of fish,[25] rodents,[26,27] snails[28] and amphibians[29] and disrupt the movements of larger wide-ranging animals like caribou and wolves.[30] For some species, high mortality due to road kills can have significant detrimental effects on populations.[31] Many species that are good indicators of forest health, such as wolves and caribou, avoid areas with high road densities.[30]

Roads also bring more people into the forest, including hunters and anglers. Motorized access to our forests has drastically increased hunting and angling pressure. In Ontario, moose hunter success rates have increased, partly as a result of extensive road networks.[32] Motorized access to lake trout lakes has also been shown to have dramatic negative impacts on lake trout populations due to increased fishing.[33] Meanwhile, wild, relatively inaccessible areas are becoming increasingly attractive to ecotourists as well as to hunters and

anglers who want a true wilderness experience and a chance to see wild creatures in a natural setting.

Simplified forest diversity

The boreal forest is made up of various forest types. Deciduous species like aspen and birch and conifers like jack pine, black spruce and white spruce grow either in pure single-species stands or together in mixed-species stands. The characteristics of particular sites and the history of natural disturbance (fire, insects) shape the composition of the forest.

Industrial logging methods and the difficulty of regenerating certain forest types after logging have led to the conversion of coniferous and mixed forests to deciduous forests.[34,35,36] Even where conifer forests are successfully regenerated, other species, such as poplar and birch, are often missing from the understorey. This represents a significant change in boreal habitat. The loss of mixed forest, in particular, has a direct impact on biodiversity, such as the composition of bird communities.[37]

The structure of the forest changes as it ages

Alberta Pacific Forest Industries Inc.

Water quality impacts

Water quality can be damaged by forestry operations. Logging close to shorelines can lead to changes in water temperature, light, sedimentation and can reduce the amount of food and structure found in aquatic habitats.[38] The proportion of forest logged around water bodies has a significant impact on water quality.

Cutting too much forest can result in changes in water flow, nutrient input and possibly even lead to increases in mercury, a neurotoxin that can work its way up the food chain.[39,40] Water quality impacts are, in part, determined by the characteristics of the water body and its environment,[39] but can be particularly significant when they occur in addition to natural impacts, such as those caused by fires.

2.0 LOCAL IMPACTS OF INDUSTRIAL FORESTRY

Clearcutting threatens habitat

Eighty-eight percent of the forest area harvested in Ontario each year is clearcut.[41] For the boreal forest, the proportion is even higher. This heavy reliance on clearcutting results in the simplification of the originally complex forest.[9]

Some foresters equate clearcutting to fire. However, unlike clearcutting, which removes almost all of the trees – and their nutrients – from a site, natural disturbances like fire leave many standing live and dead trees. These trees provide important wildlife habitat. Dead trees eventually fall down and provide habitat for different species like fungi, small mammals and insect species while helping to rebuild soils. The proportion of trees that may survive a fire depends on the fire's severity, but can be up to 50%.[9,42]

Under natural conditions many areas grow undisturbed for long periods of time, becoming increasingly complex in the process.[9] As younger trees establish in the understorey, the total number of species increases and

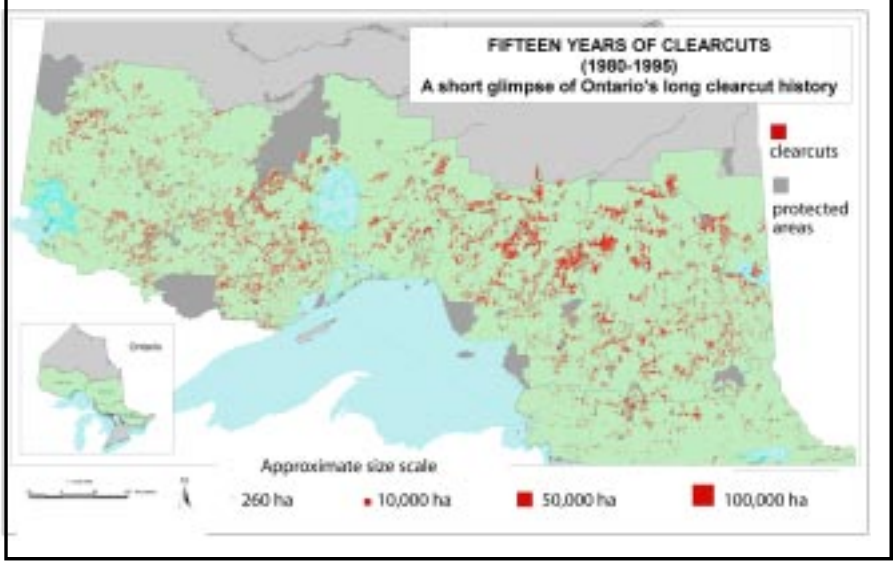
Emulation of Natural Disturbances/ Ecosystem Management

Ecosystem management is an increasingly popular approach to resource management. It focuses on protecting biodiversity by trying to preserve natural ecosystem patterns and processes.[52] In Ontario, this approach is emerging as "fire emulation."[53,54,55] The idea behind fire emulation is that if you make a logging disturbance more like a natural fire disturbance, then wildlife will benefit. This approach is also known as a "coarse filter" approach to protecting biodiversity because it is expected to benefit the majority of species in the forest.[52]

Unfortunately, a common flaw in this approach is to focus on emulating one or just a few of the characteristics of fire, even if it is a characteristic(s) that is unimportant for wildlife. For example, in Ontario, an approach commonly taken to fire emulation is to increase the size of clearcuts so they are in keeping with the natural size-range of fires, which can be very large.[55] The problem with this approach is that there is no evidence that large disturbances, per se, are important to wildlife.

A better way to approach fire emulation is to identify an ecologically critical characteristic of the natural forest that is at risk due to logging. Ecosystem management would then focus on providing for wildlife by emulating the natural extent and form of that characteristic. In the above Ontario example, it would make more sense to focus on the age-class distribution of the forest, and ensure that large areas of old forests remain available for sensitive species like caribou, marten and a host of other species that attain maximum abundances in older forests. A focus on emulating disturbance size would never guarantee that you would actually create a landscape with the natural proportion of old continuous forest that is the characteristic that is actually important for wildlife.

How Clearcutting Has Fragmented the Natural Forest. Clearcuts from 1980-1995



Partnership for Public Lands based on MNR data

the forest canopy becomes multi-levelled. Along with living trees, dead wood in the form of snags (dead standing trees) and fallen logs, branches and twigs are also critical characteristics of the natural habitat structure that keeps the forest lifecycle working.[43]

The removal of entire stands of trees through clearcutting threatens species that depend on the forest's natural complexity. In boreal Ontario, for example, clearcut logging results in decreases in the diversity of insect species that require logs for development.[45]

Replanting clearcuts with monocultures of crop trees further diminishes the forest's diversity. In Scandinavia, this approach to forest management has led to the loss of many wildlife species[6] and resulted in others being concentrated only in reserves that are protected from clearcutting.[46]

If we want to retain some of the boreal forest's complexity, we need to move away from clearcutting and adopt more partial-harvest techniques that harvest the forest in multiple stages spread over time, often leaving most of the trees standing after each cutting cycle.[45,48,9]

Special Values

Due to their uniqueness and biological importance, some areas of the forest have received extra protection from logging impacts. These areas include shoreline forests and breeding and feeding sites for species of special concern, such as the bald eagle and the great blue heron. Shoreline forests are particularly important because they protect water bodies, support a high diversity of plant and animal species, are used by up to 70% of all terrestrial animals,[49] and often contain larger, older trees that are of particular importance to wildlife.

In practice, the only protection required for shoreline forests during logging in Ontario is the establishment of no-cut reserves around some water bodies to prevent water-quality impacts on fish habitat.[50] This means that the other important values of shoreline forests may be lost when it is decided that logging presents little threat to fisheries values.

3.0 AN ECOLOGICALLY PROACTIVE APPROACH TO FORESTRY

Maintaining the critical characteristics of the boreal landscape

Landscape planning is key to maintaining the forest's critical characteristics. To be meaningful, landscape planning needs to be done spatially – on maps – with an understanding of where values and features are relative to each other. Currently most planning in Ontario is done without considering this actual on-the-ground relationship. This means, for example, that planners may set a target for a certain amount of a habitat type that must be retained after logging. However, simply setting a numeric target does not ensure that the habitat areas retained are the most useful to wildlife. A scattering of small areas may meet the quantity target set by planners, but lack the qualities that wildlife rely on.

The overall volume of timber that can be logged each year is also determined this way, without taking into account how operationally viable actual timber supplies are. Forest stands that are too costly to access or that are too small to make harvesting economic may, for example, be included in the calculation of available timber supply. Consequently, the current approach over-estimates how much forest can be sustainably logged.

A spatial, map-based planning system with the following goals should, therefore, be developed.

Maintain the natural (pre-industrial) proportion of old forests on the landscape.

❖ The natural proportion of old, uneven-aged forests should be retained through the use of reserves and longer rotation periods that allow stands to age before cutting. The natural proportion will vary regionally and may range higher than 50% of the area, but at least 30-40% of the area should be maintained in the form of older forests. If it can be demonstrated that areas harvested using selection harvest methods are capable of retaining the structures of these habitats that are critical for wildlife, selectively logged areas could contribute to retention requirements for old forests.

What's Wrong with the Way Things Are Done Now?

In many jurisdictions in Canada, the focus for resource planning is on identifying areas for harvest first and then trying to mitigate the impact on natural values second. To be more effective in maintaining a healthy, intact forest system, natural values that require protection must be identified first. After steps needed to maintain ecological integrity are taken, harvest areas can be identified.

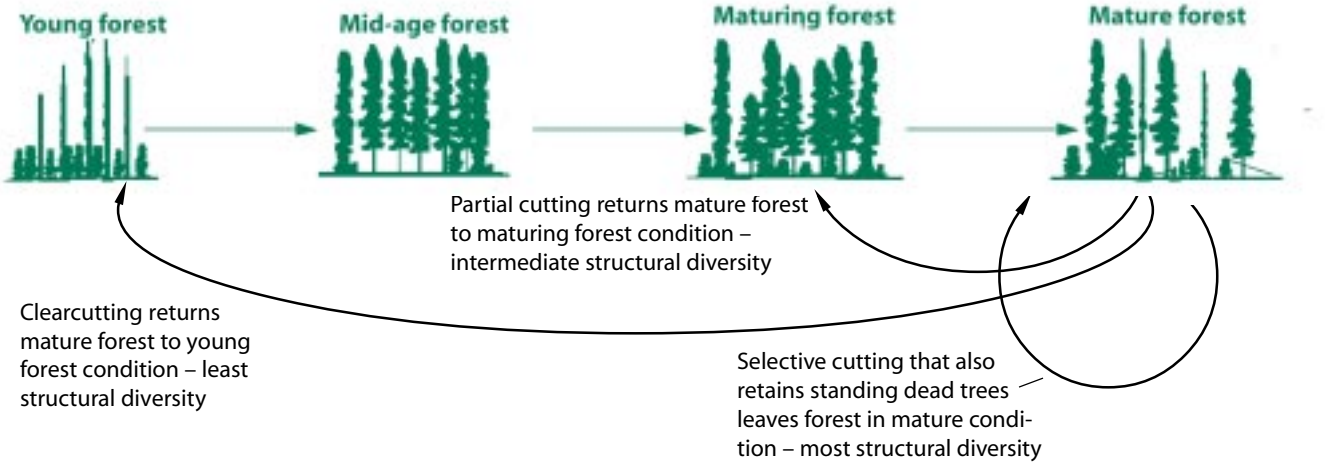
Typical system for deciding areas to be logged	Pro-active approach to deciding which areas of the forest need to be retained, and which can be logged
Determine tree species and age class mix of the total forest area	Determine variety of forest ecosystem types and age classes
Apply allocation/harvest criteria (average age at which forest is cut, timber growth and yield rates of the forest, mill demand for wood, etc.)	Determine location and size of key forest features to retain - Old forests for key species - Large intact forests for key species - Remote forests to protect from effects of roads and fragmentation - Areas of watershed needed to protect water quality
Map stands that are eligible for harvest (right age, mill demand for species, etc.)	Assess overall forest diversity and set targets for its maintenance or restoration
Apply constraints to logging (stream buffers, clearcut size restrictions, road locations, habitat features, etc.)	Map eligible stands for harvest
Final map of areas to be logged	Apply site-level restrictions (reserves, stand level retention, etc.)
Volume of wood to be produced	Final map of areas to be logged
	Volume of wood to be produced

There are some examples of management systems that have started to move in this direction. Ontario, for instance, requires the identification of large core areas of old forest that need to be set aside to protect marten before harvest areas can be identified.[51] Applying this approach to all of the critical characteristics of the forest would result in a forestry system that is proactive in maintaining the ecological integrity of the forest.

Maintain big forests in adequate amounts for area-sensitive species.

- ❖ Knowledge of species requirements and a precautionary approach should establish a minimum proportion of the forest to be retained in continuous old forests larger than some minimum threshold. For example, in Ontario, a current requirement is that 10-20% of the forest area to be cut should be retained in 3,000-5,000 hectare blocks of core old forest habitat suitable for marten.[51] Similar thresholds should be established for other indicator species that rely on continuous old forest.
- ❖ Ensure that large core areas of continuous habitat are connected by similar areas of old forest cover.
- ❖ Reduce habitat fragmentation by clustering cuts closely together within limited areas. Clustering will help meet the need to retain large contiguous forest areas today and also help ensure that areas are less

Natural Succession of a Black Spruce Forest and What Happens After Logging



Adapted from Bergeron, Leduc, Harvey & Gauthier, Forestry Chronicle

Where Should Forestry Take Place?

In Canada, industrial forestry, mining, and hydro-electric development has been expanding across the land, often before the public could make balanced decisions about where these activities should take place, which areas should be protected, and which areas will be safe-guarded for other non-industrial uses. Attempts to re-balance the distribution of uses and wealth, including the creation of protected areas, have often had to "claw back" land already allocated for industrial use or have had to target the small gaps left by existing uses like forestry.

Comprehensive land-use planning is a valuable tool to prevent this trend and ensure that forest uses are planned to the optimum benefit of nature, the economy, local communities and all forest users. To be successful, comprehensive land-use planning must be about more than just where to build a sawmill or where to locate a road. It must bring together all the different interests and find ways to accommodate these interests before any industrial licences are issued.

There are many opportunities in Canada, including in Ontario's far north, to apply such comprehensive planning to areas where industrial licences have not yet been issued. It is essential that comprehensive land-use planning occur in these areas before any industrial activity can begin. This comprehensive planning can, in turn, open the door to the implementation of the forestry practices describes in this fact sheet and the knowledge that we have made every effort to create well-managed forests.

fragmented by active roads in the future. These areas should have higher levels of residual standing live and dead trees to make up for the larger combined area being disturbed. A balance must also be struck between clustering cuts and ensuring that the overall area harvested is not so large that it impedes wildlife movement and affects the forest's ecological integrity.

Maintain remote forests to protect wildlife from the impacts of roads and fragmentation.

- Develop a comprehensive access plan that describes the existing and future road network. The plan should identify areas that will remain roadless and areas for which access will be controlled through effective road closures and physical abandonment of roads to protect remote values. As a guide, it would be reasonable to ensure at least half of the forest is off-limits to motorized vehicles at any time. The use of seasonal roads (e.g. winter roads) for harvest operations is an effective way of limiting motorized access to forests.
- A maximum density of active roads should be set based on a conservative estimate of the density tolerable to road-sensitive species like wolves and caribou.

Maintain or restore natural (pre-industrial) diversity of forest types.

- The composition of the pre-industrial forest should be set as a target towards which management should strive. Forest types that are significantly under-represented in the current landscape compared to the pre-industrial condition should be left unharvested and other areas should be targeted for restoration.
- Preference should be given to logging methods that are better able to maintain forest types that are difficult to re-grow.
- Tree genetic diversity should be maintained by ensuring that regional populations are not depleted and by relying on the original stand to provide the source of new seed and seedlings in the regenerating site.

Protect water quality.

- Limit the proportion of a watershed that is logged at any given time. In northwestern Quebec, it was determined that lakes that are large relative to their watersheds experienced significant water-quality impacts when more than 30% of the watershed was logged.
- Protect shoreline forests and prevent sedimentation impacts from roads by requiring a minimum setback for roads from water bodies, minimizing road crossings, and by using sound engineering techniques where crossings are required.

On-the-ground practices that protect habitat

To maintain the critical characteristics of the boreal on the ground, special values have to be protected from harvest and a move has to be made away from traditional clearcutting towards partial harvest systems.

Maintain habitat structure.

- Partial harvesting, including patch cuts, strip cuts, shelterwood (the removal of all or most existing trees in a number of cuts over time) and individual tree selection should be used to maintain the habitat and age structure that develops naturally in stands in the absence of a severe fire event. In mixed-wood forests composed of a distinct canopy and understorey, partial harvest systems should be used to remove the canopy, leaving the understorey intact to aid the future development of the stand.
- Clearcutting could continue to be practised in pure stands of shade-intolerant species to maintain the natural proportion of even-aged forest in the boreal.

Where clearcutting is used, a significant proportion of trees should remain in unharvested patches. This proportion should range from 10-50%, depending on the forest type.

- ❖ Individual living trees, standing dead trees, fallen trees and other dead wood should be left on site in amounts adequate to provide critical wildlife habitat. The amount should be based on an understanding of habitat needs. It is especially important to ensure that the post-harvest stand will continue to contribute deadwood material to the forest floor as it regenerates.
- ❖ Super-canopy trees that stand taller than all others, old trees and trees that offer cavities and fruits for wildlife should be retained.

Protecting special values.

- ❖ Specific trees and sites that are playing an important role for wildlife need to be protected with an adequate reserve to prevent disturbance. For example, in Ontario, guidelines have been developed to protect breeding sites and nests of raptors and important feeding and calving areas for moose and caribou. Protective measures should be based on the needs and sensitivities of the wildlife that use these forest structures.
- ❖ The values of shoreline forests need to be protected from harvesting impacts. Although some partial harvest of shoreline forests may be appropriate to meet habitat objectives, shoreline forests should generally be off-limits to logging.

The Role of Protected Areas

The cornerstone of any good system of resource management is a representative network of protected areas. Protected areas like national and provincial parks are areas that are off-limits to industrial activities like logging, mining, and hydro-electric development. These areas are important because no matter how good we think we might be at reducing or mitigating the effects of human activities, we might also be wrong (unfortunately, because ecosystems are so complex, we often are). Protected areas are places where natural processes can continue to operate without significant influences from industrial activities or human development. They are a safe home to wildlife that cannot withstand industrial activity and they provide us with a place to learn more about the way that nature operates. This information may one day be critical in recognizing and dealing with the impacts of industrial activities on our forests and for restoring aspects that have been lost or damaged.

As part of the overall landscape, protected areas also contribute to the goal of maintaining the critical characteristics of the forest landscape. For example, some old forest is found within protected areas. But it is also critical that protected areas not be largely used to satisfy all ecological targets for the landscape. The forest between protected areas must also be ecologically intact. Otherwise, protected areas will exist only as islands in an inhospitable sea that wildlife cannot move through or make their home in. Ecological integrity requires that large areas of forest be well-connected by areas that can support wildlife and their movement.[56]

MOVING FORWARD

Along with other environmental organizations, the Wildlands League has developed a proposal for making this vision of proactive forestry real in Ontario. It is available at www.wildlandsleague.org/goodforestry.html. This proposal needs to be rigorously tested for its effectiveness and its socio-economic impacts. It is our hope that the Ministry of Natural Resources and Ontario's forest industry agree to undertake such an analysis with us.

This template for proactive approach could also be applied in other parts of Canada. We encourage each jurisdiction to develop and test management regulations and guidelines for their own unique circumstances that follow this general approach.

Fact sheet written by Chris Henschel and Gillian McEachern, October 2001

REFERENCES

1. Ontario Ministry of Natural Resources. 1996. Forest Resources of Ontario. Forest Report Series. Queen's Printer for Ontario, Ontario, Canada.
2. Ontario Ministry of Natural Resources. 2000. Annual Report on Forest Management 1996/1997. Forest Information Series. Queen's Printer for Ontario, Ontario, Canada.
3. Ontario Ministry of Natural Resources. 2001. Annual Report on Forest Management 1998/1999. Forest Information Series. Queen's Printer for Ontario, Ontario, Canada.
4. Esseen, P., K. Renhorn and R. Peettersson. 1996. Epiphytic lichen biomass in managed and old-growth boreal forests: effect of branch quality. Ecological Applications 6:228-238.
5. Benkman, C. 1993. Logging, conifers, and the conservation of crossbills. Conservation Biology 7: 473-479.
6. Niemela, J. 1999. Management in relation to disturbance in the boreal forest. Forest Ecology and Management 115: 127-134.
7. Crites, S. and M. Dale. 1995. Relationships between nonvascular species and stand age and stand structure in aspen mixedwood forests in Alberta. Pages 91-114 in Stelfox, B., ed. Relationships Between Stand Age, Stand Structure, and Biodiversity in Aspen Mixedwood Forests in Alberta. Alberta Environmental Centre, Vegreville, AB. As cited in Schneider R. 2000. Old-Growth Forests in Alberta: Ecology and Management. Draft Report.
8. Van Wagner, C.E. 1978. Age-class distribution and the forest fire cycle. Can. J. For. Res. 8: 220-227.
9. Bergeron, Y, A. Leduc, B. Harvey and S. Gauthier. 2000. Natural Fire Regime: A Guide for Sustainable Management of the Boreal Forest. Sustainable Forest Management Network Working Paper. Report 2000-13.
10. Schneider R. 2000. Old-Growth Forests in Alberta: Ecology and Management. Draft Report.
11. Ontario Ministry of Natural Resources. 1996. Forest Resources of Ontario. Queens Printer for Ontario.
12. Ontario Ministry of Natural Resources. 1998. Wood Disposition Process and Regional Wood Supply and Demand Outlooks: Phase I. Queens Printer for Ontario, Ontario, Canada.
13. Potvin, F., Belanger, L. and K. Lowell. 2000. Marten Habitat Selection in a Clearcut Boreal Landscape. Conservation Biology 14(3): 844-857.
14. Ontario Ministry of Natural Resources. 1996. Forest Management Guidelines for the Provision of Marten Habitat. Ontario Ministry of Natural Resources. Toronto: Queen's Printer for Ontario.

15. Imbeau, L. Savard, J.P. and R. Gagnon. 1999. Comparing bird assemblages in successional black spruce stands originating from fire and logging. Can. J. Zool. 77: 1850-1860.
16. Global Forest Watch Canada. 2000. Canada's Forests at a Crossroads: An Assessment in the Year 2000. Beacon Hill Communications Group Inc., Victoria BC.
17. Schmiegelow F.K.A., C.S. Machtans, and S.J. Hannon. 1997. Are boreal birds resilient to forest fragmentation? An experimental study of short-term community responses. Ecology 78: 1914-1932
18. Environmental Assessment Board. 1994. Reasons for Decision and Decision. Class Environmental Assessment by the Ministry of Natural Resources for Timber Management on Crown Lands in Ontario. EA-87-02.
19. Vora, R.S. 1988. Potential soil compaction forty years after logging in northeastern California. Great Basin Naturalist 48: 117-120.
20. Megahan, W. F. 1972. Subsurface flow interception by a logging road in mountains of Central Idaho. pp. 350-356 in Watersheds in Transition. Proceedings of a symposium on "Watersheds in Transition." S. C. Csallany, T. G. McLaughlin and W. D. Striffler, eds. Fort Collings, Colorado. June 19-22, 1972. AWRA. Urbana, Illinois.
21. Wemple, B. C., J. A. Jones and G. E. Grant. 1996. Channel network extension by logging roads in two basins, western Cascades, Oregon. Water Resources Bulletin 32: 1195-1207.
22. Seyedbagheri, K.A. 1996. Idaho forestry best management practices: compilation of research on their effectiveness. General technical report INT-GTR-339. U.S. Forest Service, Intermountain Research Station, Ogden, Utah.
23. Furniss, M. J., T. D. Roelofs and C. S. Yee. 1991. Road construction and maintenance. In Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 297-323.
24. Oxley, D. J., M. B. Fenton and G. R. Carmody. 1974. The effects of roads on populations of small mammals. Journal of Applied Ecology 11: 51-59.
25. Merriam, G., M. Kozakicwicz, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. Landscape ecology 2:227-236.
26. Baur, A. and B. Baur. 1990. Are roads barriers to dispersal in the land snail *Arianta arbustorum*. Can. J. Zool. 68:613-617.
27. deMaynadier, P. G. and M. L. Hunter, Jr. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Reviews 3: 230-261.
28. Banfield, A.W.F. 1974. The relationship of caribou migration behaviour to pipeline construction. Pages 797-804 in V. Geist and F. Walther (eds). The behaviour of ungulates and its relation to management. International Union for the Conservation of Nature Press, Morges, Switzerland.
29. Bangs, E. E., T. N. Bailey and M. F. Portner. 1989. Survival rates of adult female moose on the Kenai Peninsula, Alaska. Journal of Wildlife Management 53: 557-563
30. Ontario Ministry of Natural Resources. 1999. 1999 Hunting Regulations Summary. Fall 1999-Spring 2000. Toronto: Queens Printer for Ontario.
31. Gunn, J.M. and R. Sein. 2000. Effects of forestry roads on reproductive habitat and exploitation of lake trout (*Salvelinus namycush*) in three experimental lakes. Can. J. Fish. Aquat. Sci. 57(Suppl. 2): 97-104.
32. Hearndon, K.W., S.V. Millson and W.C. Wilson. 1992. A report on the status of forest regeneration. Toronto: Queens' Printer for Ontario.
33. Carleton, T. and P. Maclellan. 1994. Woody vegetation responses to fire versus clearcutting logging: A comparative survey in the central can bore forest. Ecoscience 1(2): 141-152.
34. Jackson, S.M., F. Pinto, J.R. Malcolm and E.R. Wilson. 2000. A comparison of pre-European settlement (1857) and current (1981-1995) forest composition in central Ontario. Canadian Journal of Forest Research 30(4): 605-612.
35. Drapeau, P., Leduc, A., Giroux, J.F. et al. 2000. Landscape-scale disturbances and changes in bird communities of boreal mixedwood forests. Ecological Monographs. 70(3): 423-444.
36. France, R.L. 1997. Potential for soil erosion from decreased litterfall due to riparian clearcutting: Implications for boreal forestry and warm- and cool-water fisheries. Journal of Soil and Water Conservation 52(6): 452-455.
37. Carignan, R., D'Arcy, P. and S. Lamontagne. 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield lakes. Canadian Journal of Fisheries and Aquatic Sciences 57: 105-117.
38. Carignan, R. and R.J. Steedman. 2000. Impacts of major watershed perturbations on aquatic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 57: 1-4.
39. Ontario Ministry of Natural Resources. 2001. Annual Report on Forest Management 1998/1999. Forest Information Series. Toronto: Queen's Printer for Ontario.
40. Ontario Ministry of Natural Resources. 1997. Forest Management Guidelines for the Emulation of Fire Disturbance Patterns – Analysis Results
41. Lee, P.C., Crites, S., Nietfeld, M. et al. 1997. Characteristics and Origins of Deadwood Material in Aspen-Dominated Boreal Forests. Ecological Applications 7(2): 691-701.
43. Sugar, A., 2000. The long-term impacts of clear-cut logging on insect communities in the boreal mixedwood forests of northeastern Ontario. M.Sc.F Thesis, Faculty of Forestry, University of Toronto, Toronto.
44. Virkkala, R., A. Rajarsarkka, R.A. Vaisanen, M. Vickholm, and E. Virolainen. 1994. The significance of protected areas for the land birds of southern Finland. Conservation Biology 8: 532-544.
45. Burton, P.J., Kneeshaw, D.D. and K.D. Coates. 1999. Managing forest harvesting to maintain old growth in boreal and sub-boreal forests. Forestry Chronicle 75(4): 623-630.
46. Bergeron, Y. and B. Harvey. 1997. Basing silviculture on natural ecosystem dynamics: an approach applied to the southern boreal mixedwood forest of Quebec. Forest Ecology and Management 92: 235-242.
47. Naiman, R.J., Decamps, H. and M. Pollock. 1993. The Role of Riparian Corridors in Maintaining Regional Biodiversity. Ecological Applications 3(2): 209-212.
48. Ontario Ministry of Natural Resources. 1986. Timber Management Guidelines for the Protection of Fish Habitat. Toronto: Queens Printer for Ontario.
49. Ontario Ministry of Natural Resources. 1996. Forest Management Guidelines for the Provision of Marten Habitat. Queens Printer for Ontario.
50. Hunter, M.L., Jr. 1990. Wildlife, forests, and forestry. Prentice-Hall Inc., Englewood Cliffs, New Jersey, USA.
51. Ontario Legislative Assembly. 1994. Bill 171. An Act to revise the Crown Timber Act to provide for the sustainability of Crown Forests in Ontario. Legislative Assembly of Ontario, Ontario, Canada.
52. Ontario Ministry of Natural Resources. 1996. Forest Management Planning Manual for Ontario's Crown Forests. Toronto: Queens Printer for Ontario. 452 pp.
53. Ontario Ministry of Natural Resources. 2001. Forest Management Guidelines for Natural Disturbance Pattern Emulation. Draft 2.0.
54. Noss, Reed. 1995. Maintaining Ecological Integrity in Representative Reserve Networks. A World Wildlife Fund Canada/ World Wildlife Fund-United States Discussion Paper.
55. Ontario Ministry of Natural Resources. 1994. Conserving Ontario's Old Growth Forest Ecosystems: Highlights and recommendations of the Final Report of the Old Growth Forests Policy Advisory Committee

WILDLANDS LEAGUE

a chapter of the Canadian Parks and Wilderness Society

The Wildlands League was founded in 1968 to protect wilderness in Ontario and is a chapter of the Canadian Parks and Wilderness Society (CPAWS). We are solutions oriented and we get results. We are respected for our science-based campaigns to establish new protected areas, our efforts to ensure that nature comes first in the management of protected areas, and success at addressing issues of resource management and community development.

Wildlands League
Suite 380, 401 Richmond St. W.
Toronto, Ont. , M5V 3A8
phone (416) 971-9453
fax (416) 979-3155
info@wildlandsleague.org
www.wildlandsleague.org

Printed on paper containing 100% post-consumer recycled fibre.

Deborah Freeman

Montage photos, from left to right: Lori Labatt, WL files, Deborah Freeman, Bruce Litteljohn, WL files, Lori Labatt, Lori Labatt, Bruce Litteljohn