EASTERN ONTARIO MODEL FOREST
FORÊT MODÈLE DE L'EST DE L'ONTARIO

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BIODIVERSITY AND

YOUR EASTERN ONTARIO WOODLOT

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forests for seven generations

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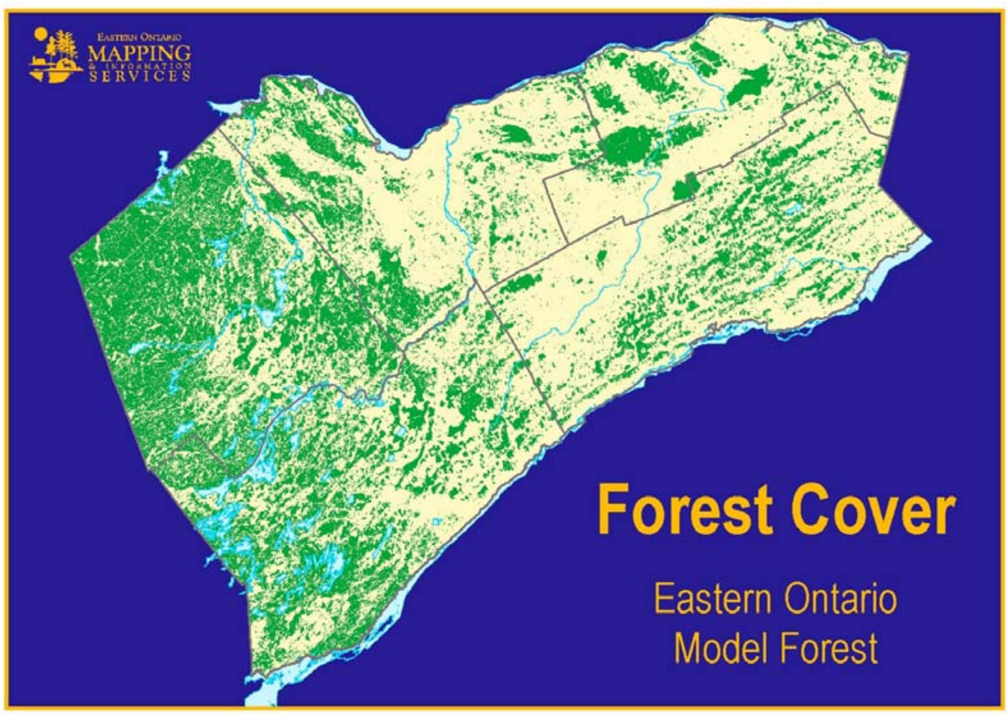
1. INTRODUCTION

Private landowners are stewards of more than three-quarters of the land in Eastern Ontario, of which 35 % is forest (Johnson 1999). Although most of the forest areas are small and fragmented they still support an incredible diversity of plants and animals.

The Eastern Ontario Model Forest (EOMF) is one of 11 large-scale working model forests in Canada, and represents the Great Lakes-St. Lawrence forest region. The EOMF works with government, landowners, industry, First Nations, and other stakeholders to conserve and enhance forest values such regional biodiversity and wildlife habitat.



Biodiversity and Your Eastern Ontario Woodlot is a series of Extension Notes discussing native biodiversity within the woodland communities in the EOMF region. The Extension Notes are designed to acquaint the landowner and other readers with some of the vegetation and wildlife found within woodlands, and to describe some of the relationships between them and other woodland components.. Each Extension Note:

- focuses on a major component (i.e., a species or guild) of a typical woodlot (e.g., trees, understory plants, mammals, birds, insects)
- provides an overview of the species group and an approximation of the number of species within the group found in eastern Ontario

- introduces some common and uncommon species within the group
- describes some of the factors responsible for species richness in the EOMF
- describes values, roles, and ecological interactions of selected woodland species
- discusses the conservation of biodiversity within the EOMF (e.g., the present situation, major concerns, what can be done)
- describes possible actions that can encourage biodiversity and the maintenance of healthy woodland communities
- includes a list of references and a glossary of technical terms used within the document.

The series is available from the EOMF (613-258-8241) and over the Internet (**www.eomf.on.ca**). This report provides more detailed information than presented in the extension notes.

Definition of biodiversity

Conservation biologists have proposed numerous definitions of biodiversity. For this document, biodiversity is the variety of life and its processes, including the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting (Noss and Cooperrider 1994).

Why is biodiversity important?

Biodiversity provides the basis for a functioning planet and the existence of living things. Natural cycles (such as the water cycle, the carbon and oxygen cycle) moderate our climate; provide us with food, clean water and breathable air. Natural ecosystems provide us with services such as the removal of air pollutants, pollination of crops, formation of soils, the recycling of materials through decomposition, protection from soil erosion by plants and trees, and the filtration and storage of water by streams and wetlands.

The natural environment provides us with the necessities of life and forms the basis for the world economy. Everything we buy and sell originates from the natural world. Nature provides us with food, medicines, and raw materials. It also supplies recreational and educational values. Tourism, hunting, fishing, nature observation and outdoor education, as well as much scientific research and biological monitoring, are best conducted in more natural and diverse areas.

For an increasing number of people, biodiversity also provides less tangible but nevertheless important intrinsic values. For them, the world is more interesting with a multitude of species. They find comfort, solace and aesthetic appeal in more pristine and natural areas. They recognize that other species have the right to exist, and that people may not have the right to deplete other species and degrade habitats beyond reasonable levels for their own ends. They believe that future generations have the right to experience the diversity of communities and ecosystems and to benefit from their services.

Ultimately, loss of biodiversity involves extinction of organisms. While extinction is a natural process, there is strong evidence indicating that humans are accelerating extinction rates. Although it is difficult to measure the consequences of declines in biodiversity, it is clear that continuing species losses will erode natural resource values, limit future options, and ultimately compromise ecosystem integrity and the sustainability of human activities (e.g., agriculture, forestry).

Introduction to biodiversity conservation

Learning about the biodiversity and how it can be conserved necessitates an ecological approach. Landowners managing their properties with conservation of biodiversity as an objective should be aware of the species diversity found on the property and of some of the important roles and interactions of those species. Because individual species constantly interact with other organisms and their environments, it is important to realize that management activities that introduce changes into natural communities such as woodlands not only directly affect certain species, but also affect the entire communities and landscape. Although this document focuses primarily on the woodland communities in the EOMF region, it should be remembered that all levels of the landscape are interconnected. For example, removing trees on a slope in a woodland, adjacent to a stream, could result in soil erosion. Large quantities of eroded soil could be transported into the nearest aquatic ecosystem, creating siltation problems and threatening the survival of many organisms. Similarly, the removal of vegetation between two adjacent forest stands could interfere with movements of animals between the stands, eventually leading to a loss of biodiversity within the region.

Levels of biodiversity

Biodiversity is more complex than just the number of species within a given location . It can be described at the genetic, species, community, and landscape level.

<u>Genetic diversity</u> refers to variation in heritable characteristics of a particular species. It exists at three levels: genetic variation within a single individual, genetic differences among individuals within a population, and genetic differences among populations.

<u>Species richness</u> refers to the number of different species contained within a given area. It is often referred to as species diversity. For example, within a woodlot there may be over a dozen tree species and hundreds of other plant and animal species. Loss of species can affect other species, *community structure*, *trophic dynamics*, and even landscape patterns.

<u>Community/ecosystem diversity</u> refers to the variety of *communities* or *ecosystems* across the landscape. Common communities within the EOMF include woodland, wetland, and grassland communities. Normally, communities and ecosystems follow natural boundaries.

<u>Landscape diversity</u> refers to variation in communities and ecosystems (i.e., habitat types) that are found across the greater region (often several thousand hectares in area), as well as the

relative sizes, shapes, and positions of these various components. Often, this diversity is strongly influenced by disturbances that create mosaics of habitat patches across landscapes.

Composition, structure, and function

Key to understanding the levels of biodiversity and how nature is assembled are the concepts of composition, structure and function. Composition refers to the physical make up of biodiversity, in a given area (e.g., species richness). Structure refers to how these components are distributed over space and time; their organization (e.g., species distributions over a region). Function is the role that each component plays within the system.

Concepts related to the species level

Conserving biodiversity at the species level really means maintaining populations. The following concepts concerning the species level are worth noting:

Populations

The main problem affecting species *populations of concern* is that they become too small and then disappear. When this occurs, the local adaptations represented in the populations are lost, and the ecosystem functions performed by those populations cease. When enough populations disappear, the species can become extinct.

Small populations are of special conservation concern because they typically have a higher probability of extinction over any given period than do larger populations. At least three factors can affect natural populations:

- random changes in genetic makeup of individuals of small populations
- rare and usually unpredictable *abiotic* or *biotic* events . For example, an ice storm could destroy a local plant population or an influx of predators may eliminate a population of rodents from a local woodland.
- other factors such as habitat loss or alteration, species collecting, hunting, and detrimental effects of non-native species introductions.

Small, localized populations are more susceptible to the impacts of these factors than larger, widespread populations.

Population viability analysis (PVA) uses observational, experimental, and modeling approaches to try to answer questions about the sizes of populations and habitats that must be maintained to avoid extinction in the future. Such studies consider the importance of factors that connect subpopulations within a *metapopulation,* recognizing that movements of dispersing individuals link local populations in the various patches, and that the fate of these populations is interconnected.

Recovery plans for endangered species often try to establish multiple populations to encourage the potential for dispersal among subpopulations and to reduce the risk of loss of the entire species to a single catastrophic event. They also try to increase each population size to a level where they are less threatened by genetic, demographic, and normal environmental uncertainties. This task is especially challenging where a species of concern currently exist in a single, small population, or is found in just one isolated habitat patch.

It is inherently difficult to establish quantitative guidelines for establishing viable population (and habitat) sizes. A suggested population size may be too small because it results in rapid loss of genetic variability or because it is too prone to extinction by a single event. Larger populations may appear to be safe for many years, but then may suddenly decline due to the presence of some limiting factor or a large-scale catastrophe. In addition, PVA must be conducted within the context of social goals and political and financial realities.

Metapopulations

Frequently, plant and animal populations do not exist as single, isolated entities, but as components of larger, interconnected population networks. These metapopulations, consist of two or more subpopulations, occupying suitable habitat in a landscape that permits movement of individuals (and hence gene flow) among the habitat patches.

The concept of metapopulations helps to explain how trends toward local extinctions in small subpopulations can be prevented or reversed by occasional colonization from other parts of the metapopulation. For this reason linkages or corridors among the different subpopulations is very important. Loss of these connections could greatly increase the chance of extinction for the entire metapopulation.

Source and Sink Dynamics

Individuals in many populations occupy habitat patches of differing quality. Those in highly productive and favourable habitats where reproductive success exceeds mortality are called *source habitats*. These habitats can produce abundant offspring, many of whom disperse to other areas to live and breed. Individuals in poor quality habitats often have lower reproductive success or survival. Habitats where local mortality exceeds reproductive success are called *sink habitats*. They are net importers of individuals, and without immigration from other areas, their populations head toward *extirpation*. Therefore, the fate of an entire metapopulation can depend on whether the reproductive success of individuals of a species in *source habitats* outweighs the lack of success by individuals in the *sink habitats*.

The concept of source and sink dynamics has implications for biodiversity conservation because it can help identify critical habitats. A source population may be small and occupy a relatively small proportion of total habitat, but it may be able to maintain a larger population in the sink. Protecting sink habitats instead of source habitats could waste valuable resources. It is important to not only concentrate on protecting habitat where a species is most common, but to also protect source habitats where it is most productive.

Concepts related to the community level

It is at the community level that species and populations interact with a myriad of other species in complex and largely unknown ways.

Succession

Ecological communities are dynamic, changing across the landscape and over time. *Succession* is defined as the replacement of one plant community by another over time. Much of this change results from natural disturbances, such as fire, insect and disease infestations, and storms. Fires selectively remove fire-intolerant species. Storms, in which trees are blown down or killed, alter the community structure by creating opening or gaps in which earlier successional species can colonize. Disease and parasites can affect community structure by altering species composition. Insect infestations often kill older, weakened trees and re-initiate the successional process. Colonization by new species can alter community structure by changing competitive or predatory relationships within the community.

The progress of a succession is not always predictable. Communities may proceed along different successional pathways depending on the severity and type of disturbance, the species available for colonization, and various other unpredictable factors. Often, disturbances return a community to an earlier stage of succession. A sever disturbance such as fire can revert a forest back into an open area.. Depending on events during the successional process, this open area could become a mature maple-beech forest, a conifer-dominated forest, a shrubland community, or a marsh.

A patchwork of habitats in different successional stages add habitat diversity to a region, providing a mosaic of different community types. A mosaic of different successional stages provides more overall habitat diversity than a broad expanse of a single habitat type of a single age. Large expanses of a single habitat cannot be discounted because they are critical to some species.

Community Structure

The types, relative abundances, and distributions of species present in an ecological community, as well as the ensuing interactions among them, all help to determine community structure. This structure is also influenced by local climatic and soil conditions, human activities, and past history. In most communities, some species dominate while others are naturally rare; some species are widespread, having more generalized habitat requirements, while others have more limited distributions and more specialized habitat requirements.

It is important to know that altering community structure may have drastic effects on the normal functioning of the community and the abilities of many species to maintain themselves. Great care must be taken with activities that can potentially alter community structure or the associated *abiotic* environment because the ramifications could be widespread.

Keystone Species

Keystone species play a disproportionately large role in community structure. They may be critical to the *trophic* structure by supplying an important food resource or by preying on other, more numerous species. They may provide a critical process in the system, or support other important interactions.

Some keystone species change the habitat in which they are found. In the EOMF region, beavers convert streams into ponds that are critical habitat for other animals, while pileated woodpeckers excavate cavities that can later be used by numerous other species.

Some of the most important keystone species are so inconspicuous that they are often overlooked. Their biological processes however, are critical to the functioning of larger species, communities, and ecosystems. For example, many bacteria, tiny invertebrates, and algae and fungi in soils decompose dead matter that would otherwise accumulate and remain unavailable to living species. M*ycorrhizal fungi,* associated with the roots of many tree species, enhance the ability of the roots to extract soil minerals. These fungi are critical to growth rates and productivity of the trees and may also protect the roots from infections by producing antibiotics.

Because of their important role in communities the removal, addition, or change to local populations of keystone species can have wide-ranging effects on other species; processes and interactions; and communities and ecosystems.

<u>Species Interactions</u>

Community members interact with each other in numerous ways. *Intraspecific interactions* involve activities such as courtship and reproduction; rearing young; territorial disputes; danger warnings; and competition for food, shelter, nest sites, or other resources. Interspecific interactions include predator-prey interactions, competition for limited resources, parasite-host interactions, and complex mutualistic relationships.

Mutualism refers to a relationship in which two or more species benefit from their interaction. One common example is pollinations of flowing plants. Bees, other insects or hummingbirds. receive pollen or nectar while the flowering plant benefit through fertilization and gene transfer. Another example is animals consuming fruiting and then helping to disperse seed through defecation.

A relationship in which only one species benefits is called a *commensal* relationship. For example, pileated woodpeckers create cavities that are used by other species; they also remove outer bark, allowing smaller birds such as hairy woodpeckers to find insects. Some warblers, kinglets and hummingbirds drink sap oozing from holes in trees drilled by yellow-bellied sapsuckers.

In part, it is these simultaneous interactions that result in a complex system. Any manipulation of parts of this system, such as fire suppression, weed control, or predator removal may have little effect or it could restructure the community and change species interactions in major and unpredictable ways. For example, the loss of a pollinator may lead to extirpation of a flowering annual, followed by the loss of other insects that may be associated with that plant. This could result in the loss of a food for small mammals, which would result in reduced prey available for larger predators.

Great care must be taken when making manipulations that can alter or restructure species interactions. Whenever possible, it is important to identify and maintain species interactions because of their importance to one or more species as well as to the larger community.

Introduction of Non-Native Species

The introduction of non-native species can seriously threaten native biodiversity by altering community structure, function, and ecological characteristics to the detriment of one or more species. Exotic species can be harmful because: they predate, feed, or parasitize native species; they compete with native species for limited resources; they can introduce diseases; or they can hybridize with native species. Because no natural controls are in place (predators, disease, parasites etc) some introduced species can expand quickly and out-compete some native species. Native species have not coevolved with the exotic, and therefore have no defences against them or their impacts.

With today's globalized trade there are an increasing number of insects, diseases, and plants that are brought into our landscape that can have a devastating effect on our natural communities. There are many examples form the past (Dutch Elm disease, gypsy moth) as well as present (butternut canker, emerald ash borer) to illustrate the possible harmful effects such introductions can have.

Not all non-native species introductions are destructive. However, it is usually difficult to predict the effects of introducing a species into a community or ecosystem. Consequently it is generally wise to avoid moving plants, animals, microbes, and fungi beyond their native ranges.

Concepts related to the landscape level

The natural landscape consists of patterns of habitat patches, such as streams, flood plains, ponds, old fields, slopes and ridges, patches of forest of different ages and sizes, as well as forest openings. Human landscape elements such as roads, homes and residential areas, airfields, agricultural croplands, plantations, and clearcut patches are superimposed on this natural landscape.

These habitat patches are connected in various ways. What occurs within a patch is not isolated and is affected by other patches. This concept of connectivity is important because major changes occurring in one habitat patch may have serious effects on another patch, even if they are not directly adjacent to each other.

The following concepts are important to biodiversity conservation, especially at the larger landscape level.

Fragmentation

One of the most serious threats to biodiversity and landscape integrity is *fragmentation* of once-continuous habitats such as woodlands. Fragmentation results in changes in the sizes, shapes, positions, and connections among the remaining patches. There is an overall reduction in the total amount of a habitat and the remaining habitat is found in smaller, more isolated patches surrounded by developed land. Fragmentation often leads to local population extinctions and altered ecosystem functions because this isolation results in smaller species populations and can stop the movement of individuals, materials, and energy among patches.

Edges

Under natural conditions (e.g., *riparian* areas, natural forest openings), edges form an important component of landscape diversity and help to maintain a greater diversity of species at a regional scale. However, as fragmentation increases, the size of habitat patches decrease, and the amount of edge increases.

Although some species such as white-tailed deer, ruffed grouse, squirrels, and raccoons thrive in edge habitat many other species do not. *Edge effects* on interior habitat conditions and species can threaten native biodiversity. Sunlight and wind on the edge of a forest stand significantly alter the microclimate at the edge and well into the forest. Edge areas are often sunnier and drier than forest interiors, encouraging plants tolerant of these conditions and discouraging those intolerant of these conditions. Other edge effects include increased rates of windthrow, greater canopy and subcanopy damage, and a proliferation of plants adapted to disturbance.

Forest songbird populations are impacted by increased fragmentation. With an increase in edge habitat, nest predatory species such as raccoon, skunk, fox, blue jay, crow are encouraged. Also, within 100 meters of the forest edge there is a significant threat to songbird reproductive success by high rates of nest parasitism by brown-headed cowbirds.

Size

Individual species, ecological functions, and all aspects of biodiversity are better maintained over the long term in larger areas than in smaller areas. Larger areas usually support a greater number of species because they generally consist of a greater diversity of habitats. Normally they can also maintain greater population and genetic diversity than smaller areas. Bigger areas better support larger vertebrates that require more space. In addition, they are more likely to accommodate and incorporate major disturbances such as fires and storms, without ill effects to living organisms or ecological functions.

Smaller areas have a greater edge to volume ratio, thereby increasing *edge effects* and decreasing the amount of true *interior habitat*. Smaller areas are more vulnerable to invasion by non-native and edge-adapted species.

Habitat Heterogeneity

A landscape is a mosaic of habitat patches of various sizes, shapes, successional stages, and ages. Over time, these patches and the spatial relationships among them change and new patches are created by *natural disturbance* (e.g., fires, storms, floods, droughts, tree falls, insect damage, beaver activity, herbivory, soil disruption by mammals) and human activities. Since biodiversity depends in part on the dynamics of these patches, recognition and accommodation of the natural variations of landscapes can better realize its conservation over space and time.

Heterogeneous landscapes are important and should be maintained because they generally accommodate disturbances better than do homogeneous ones, by offering species a diversity of habitat types at a given time. If succession, a disturbance, or other change destroys or alters a particular habitat patch making it unsuitable for a species, then other appropriate patches on the landscape may be available for colonization. Heterogeneous landscapes also better encourage the long-term persistence of species that exist as groups of populations in different habitat patches, by allowing movement of species among the patches.

The continuation of natural process across the landscape is important to maintaining habitat diversity and dynamics. This suggests that natural disturbance events should generally not be controlled or eliminated. In fact, lack of disturbance such as forest fires, may be a problem, and imposition of artificial disturbance regimes, such as *controlled burning*, may be required.

Context

The context or relative isolation of a natural area (e.g., landscape, community, habitat patch) from the rest of the world affects the maintenance of biodiversity and ecosystem functions, and can have positive and negative effects. The focus is often on the boundaries of natural areas because they are in contact with the surrounding landscape and are the areas through which plants, animals, materials, and energy move within and among the habitats.

In general, the smaller the natural area, the greater the effects from the surrounding landscapes will be. Where the area to perimeter ratio of a patch it is low (i.e., small or elongated patches with proportionately more perimeter length per unit of interior area), the average distance from a boundary to the interior is small. Species that require substantial amounts of undisturbed *interior* habitat fare poorly over the long term in such areas. Larger area-to-perimeter ratios are preferable for such species because interior habitat is farther removed from edge influences.

Buffers of native vegetation around natural areas such as woodlots can decrease exposure to adverse conditions from the surrounding landscape as well as increase available habitat. In the buffer areas of many nature reserves, exploitive activities such as timber harvesting and hunting are limited to ensure that the buffers ability to protect the reserve is not impeded.

Connectivity

One of the best ways to accommodate species and processes at the landscape level is to connect habitat patches with other, preferably protected, landscapes to allow the movement of species, materials, and energy among the patches. Conservation biologists promote *corridors* as important features in biodiversity conservation because they permit movement between habitats. Wildlife use corridors to move periodically among habitat types for breeding, birthing, feeding, or roosting. Corridors also permit permanent immigration and emigration of individuals among a network of habitat patches permitting gene flow and decolonization.

Connectivity exists on different levels. On a smaller, local scale, a fencerow or stream may connect close patches of habitat such as woodlots, allowing safe movement of small animals such as mice, chipmunks, and perching birds. Such a linkage consists of edge habitat and is not suitable for forest *interior species*.

At the landscape scale, larger corridors such as large forest strips connect major landscape features and allow for daily and seasonal and permanent movements. Due to their size they can also provide interior forest habitat.

Managing to conserve biodiversity

A detailed discussion of forest management and biodiversity concept issues in southern Ontario can be found in “A Silvicultural Guide to Managing Southern Ontario Forests” (OMNR 2000b). This guide provides simple guidelines to help landowners minimize impacts on biodiversity on their land.

Examples of good forest management practices can be seen throughout Eastern Ontario through the network of Demonstration Forest Sites developed by the Eastern Ontario Model Forest (www.eomf.on.ca). Landowners are encouraged to visit these sites to see on the ground examples of forest management

Landowners are encouraged to consider entering the Managed Forest Tax Incentive Program (MFTIP). This program offers a reduction in property taxes to landowners who are good stewards of their forested property. A landowner must prepare and follow a management plan to qualify for the program The Ontario Woodlot Association (1-888-791-1103 or www.ont-woodlot-assoc.org) and the Ontario Forestry Association (1-800-387-0790 or www.oforest.on.ca) administer this program.

Landowner’s Role

A woodlot can be managed to achieve the landowner’s objectives while also maintaining or increasing biodiversity.

Managing your property is a 4 step process

1. Management Planning

Before carrying out any activities in a woodlot, a management plan should be prepared. This can be a formal plan, as required for the Managed Forest Tax Incentive Program, or an informal plan. Each should contain:

- a general description of the overall property and how it fits into the local landscape;
- a statement of strategies and objectives;
- an inventory of the woodlot, including the trees, plants, and wildlife;
- a plan of activities including a list of financial or other resources needed over a period of time.

The inventory is arguably the most important component of the plan. In addition to giving a description of the trees, it should identify sensitive areas (wildlife habitats, riparian zones, old growth) needing protection, and elements of biodiversity (uncommon trees, rare and invasive species) needing attention. It is impossible to adequately maintain biodiversity or to measure progress towards objectives if a baseline of information is not established.

2. Plan Implementation

Plan implementation is the process of carrying out the activities proposed in the plan. A number of guidelines have been developed to guide this process. Applicable guidelines should be incorporated into the planning process, and followed in the field while projects are underway.

3. Monitoring
Monitoring is a regular process of checking various parameters, such as population size, growth of individuals, or breeding activity. On the property level it allows the landowner to measure his/her success in achieving objectives, and to assessing progress towards maintaining or improving biodiversity. Monitoring of various species of plants, mammals, birds, or herptiles can be done annually on a single property with results compiled by the landowner. Protocols are available from the LandOwner Resource Centre at 1-800-387-5304 (www.lrconline.com).

Another method of monitoring is to join a monitoring program. Data collected through such programs can be used to predict trends in populations over large areas. The Federation of Ontario Naturalists (1-800-440-2366 or www.ontarionature.org) can provide information on a number of such programs. The Eastern Ontario Biodiversity Museum (613-258-3415) maintains an e-mail network called the NatureList where sightings of rare species and oddities can be announced and identifications checked. Museum staff in Kemptville will also accept and identify specimens. The Natural Heritage Information Centre maintains and provides information on rare, threatened and endangered species and spaces in Ontario. Sightings of rare species can be reported through their web site http://nhic.mnr.gov.on.ca/nhic_.cfm.

Sightings and observations of any species that are rare to the EOMF area should also be reported to the biologist at the local Ministry of Natural Resources office in Kemptville (613-258-8204)

Using indicators

Monitoring all of the species in a woodlot regularly is a tedious task. A more practical approach is to focus on a few chosen species which can represent the remainder. These species are called *indicators.* The ovenbird is an example of an *indicator species*. Its presence in your woodlot confirms that you are adequately protecting interior habitat. A second group of indicators are called *habitat indicators*. These are measurements or estimates of the number or amount of habitat features or units that are present in a woodlot. The number of cavity trees is such an example of an habitat indicator.

The Eastern Ontario Model Forest and the Canadian Biodiversity Institute have produced a full list of species and habitat indicators and the criteria they represent. A document with guidelines is available. In addition, a participation program called the *Observer Network* has been implemented for landowners who are interested in working with others to compile and submit data. This program will help monitor conditions in woodlots across Eastern Ontario.

Management guidelines

The management activities that you are able to perform on your property depend on the characteristics of your property as well as your objectives. The following are general guidelines that, if followed, will help protect biodiversity on your property. Not all of them are appropriate for every property. Many of the general guidelines can be implemented on any property. Others, are only applicable to properties with specific forest conditions, age characteristics and size. Appendix 1 provides a listing of important habitats and suggested techniques to maintain them.

In general:

- When managing your woodlot, consider its context within the broader landscape.
- Work with neighbouring property owners to reconnect fragmented habitats, and to improve edge habitat between properties. To provide adequate habitat, contiguous woodlands should be at least 40 hectares in size.
- Species richness depends on habitat diversity. Protecting a variety of wildlife habitats will ensure that your woodland support a rich diversity of species. Appendix 1 provides a description of important habitats and how to maintain them.
- Work with contractors who understand the importance you attach to protecting wildlife.
- Consult professional foresters before managing your woodlot and use the best possible forest practices to help to ensure that critical habitats for wildlife are maintained.
- Avoid handling or touching wildlife, eggs, or nests.
- Protect all known animal movement corridors (e.g., areas linking upland forests to marshes, woodland ponds).

In the woodland:

- Do not begin harvesting before an inventory and site assessment have been conducted.
- Do not fragment your woodland property with large openings, roads, or more edge habitat. Protect at least 4 hectares of undisturbed interior habitat.
- Minimize trail width, the size of clearcuts, and the number of trails and openings. Trails and open areas may allow exotic species such as European buckthorn to become established.
- Remove or narrow trails and roadsides that fragment wildlife habitat by planting them to trees or shrubs. Roads should occupy no more than 2% of the stand.
- Maintain a canopy closure of at least 70%.
- Use no-cut buffers to protect sensitive habitats, such as deeryards, streams, and wetlands. Buffers along watercourses should be 10 metres wide on each side. The buffer around an active stick nest should be 150 metres.
- Keep livestock out of woodlands to reduce disturbance, retain understory vegetation and vertical complexity, protect wildlife habitat, and avoid soil compaction.
- Protect soil and vegetation by avoiding vehicle use during periods of wet weather and on slopes greater than 10%.

- Avoid ATV/snowmobile use in or close to significant wildlife habitat such as deeryards and conifer cover during winter, heronries and riparian areas during the breeding season.
- Minimize or eliminate stream crossings by vehicles. Use a culvert or bridge if a crossing is needed.
- Remove alien invasive plant species.
- Build brush piles, or when harvesting timber, leave brush piles to provide cover, basking, and hunting areas for wildlife.
- Retain shrubs and native vines (e.g., dogwoods, nannyberry, wild raspberry, wild grape, Virginia creeper) to provide wildlife food and to maintain understory habitat.
- Retain structural diversity in the stand to increase habitat diversity. For example, do not remove all shrubs or understory ironwood in a stand.
- Retain individuals of all tree species, particularly conifers (at least 10 per hectare), to maintain biodiversity.
- Retain rotting stumps, logs, downed trees and limbs to provide cover, escape, nesting, and feeding habitat for snakes, salamanders, toads, small mammals, and birds. The bigger the fallen logs left, the better. If possible, retain at least 5 large fallen logs per hectare.
- Retain nest and cavity trees and snags because of their wildlife value and future potential as woody debris. Identify and retain future nest and cavity trees.
- Leave at least 10% of each stand or at least 10 hectares to become old growth, especially those areas providing significant wildlife habitats or ecological services (e.g., groundwater recharge, slope stabilization). Old growth is defined as trees over age 120 or larger than 50 cm DBH (diameter at breast height).
- Retain mast trees for their ability to produce wildlife food.
- When harvesting, leave unmerchantable stems standing, or on the ground where they fall.
- Retain supercanopy trees (at least 1 per 4 hectares) for use by raptors and bears.
- Use proper harvest timing: harvest in fall when the ground is dry or in winter when the ground is frozen and snow covered; avoid harvesting in spring when the ground is soft, and the bark is easily torn from trees; avoid nesting and breeding periods.
- Retain any known snake hibernacula and corridors linking them to summer habitat for snakes. Maintain old foundations, rock walls, talus slopes and stone piles (especially those on well-drained slopes with a south-facing aspect) as potential snake hibernacula.
- Create herptile habitat by stacking wood or by placing boards in suitable areas (e.g., shaded, near water) and allowing them to rot.
- In stands that have been degraded in the past, (e.g. structural diversity reduced, or tree species diversity reduced) plant native species of trees and shrubs that are appropriate for site conditions.

Woodland edges:

- Improve abrupt edges by creating a wider, more gradual transition between cover types through naturalization or by planting shrubs important to wildlife (e.g., dogwoods, wild plum, nannyberry, serviceberries, highbush cranberry, hazelnut, elderberry, viburnums).
- Widen fencerows to approximately 10 meters to increase the amount of protective cover and plant diversity. Plant both sides of the fence with shrubs, trees, or vines such as virginia creeper, bittersweet, and wild grape.
- Connect fragmented areas by eliminating large openings with planted or naturalized shrubs and trees.

Near water bodies and watercourses:

- Provide basking habitat for turtles and snakes, in the form of logs, rocks, and other objects.
- Protect and encourage native vegetation as amphibian habitat for feeding, breeding, resting, cover, shade, calling, and escape from predators.
- Leave an uncut natural vegetation buffer of 10 metres around the edges.
- Maintain 300 metres of habitat for amphibians along the edges.
- Avoid spraying noxious chemicals near water or in areas where run-off could enter water bodies.
- Build turtle nesting habitat by spreading sand in an open, elevated area (to prevent flooding of the nest).
- Maintain natural drainage patterns and flow regimes. Ditches, drainage activities, dams, and constructed ponds can eliminate habitat and reduce natural biodiversity.

2. TREES

Introduction

Trees are what we typically associate with forests. They are also a critical biodiversity component. Components of forest biodiversity influenced by trees include:

- diversity of tree species,
- forest community type,
- structural diversity (layers in the canopy),
- habitat diversity (from down logs to cavity and nesting holes in trees), and
- litter layer and soil profile development.

Common tree species

An estimated 46 native species of trees are commonly found in the EOMF area (Table 1), not including the many varieties of Willow and Hawthorn. For more information see Farrar (1995).

Table 1: Tree species commonly found in the EOMF

Native species	
Eastern red cedar	Red oak
Eastern white cedar	White oak
Eastern white pine	Bur oak
Pitch pine	American beech
Red pine	Basswood
Jack pine	White birch
Tamarack	Grey birch
Balsam fir	Yellow birch
White spruce	Blue beech
Black spruce	Ironwood
Eastern hemlock	Willow
Sugar maple	Balsam poplar
Black maple	Eastern cottonwood
Red maple	Trembling aspen
Silver maple	Largetooth aspen
Manitoba maple	White elm
White ash	Rock elm
Red (green) ash	Slippery (red) elm
Black ash	Hackberry
Butternut[1]	Wild crab apple
Black walnut	Pin cherry
Shagbark hickory	Black cherry
Bitternut hickory	Hawthorn

Common exotic species
Norway spruce
Common apple
European larch
Scot's pine
Norway maple
Black locust
Austrian pine
Colorado spruce
Horsechestnut
Hybrid poplar

[1]Butternut is listed as endangered on the COSEWIC list

Forest Cover Types

These species do not occur randomly throughout the region. Along with associated shrubs, herbs, mosses and lichens, they form loose associations called forest cover types. Each cover type is adapted to specific soil conditions, and reacts in a somewhat predictable way to disturbance (natural and human), competition from other plant species, and natural succession. Twenty-five cover types have been identified in central Ontario. Five of these will be discussed in detail here, and are slightly modified from the originals presented in a "Field Guide to Forest Ecosystems in Central Ontario (OMNR 1997).

Impact of soil conditions on forest cover type

Almost all tree species in eastern Ontario grow best on fertile well-drained soils, however this is not where all tree species are commonly found. Generally, the trees that compete best for light and nutrients are found on fertile well-drained soils. Typical examples include sugar maple, beech, white ash, basswood and ironwood. Trees that do not compete as well on high quality sites are commonly found on very dry and/or very wet sites. Certain species are adapted to drier sites, including red oak and white pine; while other species including red and silver maple have adapted to wet soil conditions; eastern white cedar has adapted to both extremes.

Once trees also established they begin to modify the soil conditions on a site. Coniferous trees produce acidic needle litter which leaches some nutrients from the site. The acid-nutrient poor soils which develop are more favourable for future conifer establishment. Sugar maple stands produce rich leaf litter layers with high fertility, promoting competitive trees species on the site. the thick litter layers impede seed germination of many species. Sugar maple seeds are adapted to successfully germinate. The seeds are able to twist through the litter layers, and have a specially designed root to tunnel down into the mineral soil.

<u>Impact of disturbance and competition on forest cover type</u>

Light is commonly the most limiting factor for the establishment of specific tree species in a forest. Disturbance effects tree composition by altering the amount of light reaching the forest floor. Ice storms, blowdown, harvesting, fire and insect outbreaks all increase the amount of light reaching the forest floor. Disturbances generally promote *shade intolerant* species, i.e. species that cannot reproduce successfully in low light conditions typical of a closed canopy forest. No canopy disturbance promotes the most *shade tolerant* species: sugar maple, beech, hemlock and balsam fir. Small canopy disturbances such as a single-tree death or a blowdown promote intermediate shade tolerance species such as white ash and basswood, which typically grow faster than sugar maple. Large canopy disturbances such as a clearcut or forest fire, promote shade intolerant species such as poplar and aspen, which produce large quantities if wind-borne seed, and grow rapidly.

Tree species have also adapted to other aspects of disturbances. Red and white oak, and white pine have all adapted to thrive on dry ridges where forest fires are common. Mature trees of all three species have thick bark to withstand moderately intense fires, and oak seedlings have the ability to resprout after being top-killed by fire. Other species do not have these adaptations, and tend to die back after one or more fires on a site. Prescribed burns are currently being used by the MNR to promote oak regeneration in northern Lanark County.

<u>Impact of succession on forest cover type</u>

Succession is defined as the replacement of one plant community by another, and often leads to a stable climax community (Smith 1980). After major disturbances such as clearcutting, fire or agricultural field abandonment, forest succession is initiated. The first species to re-establish on these disturbed sites are species such as trembling aspen, green ash, and white elm. These *pioneer species* tend to produce large amounts of small wind-borne seed, grow quickly, and be shade intolerant to intermediate in tolerance. Once established, these species change the forest floor environment from a hot, dry area with abundant competing vegetation, to a cool shaded area with ample germination sites. Shade tolerant species such as sugar maple, beech, and hemlock will begin to establish on the site at this stage. Because the shade intolerant pioneer species cannot reproduce under their own canopy, they begin to die out and the shade tolerant species begin to fill the canopy. With no further disturbances this new canopy will be self-perpetuating - as canopy trees die they are replaced by their offspring. This new community is a *climax* community, and may persist indefinitely with no further disturbances. Poor quality sites may develop *sub-climax* forests such as white pine-red oak stands on dry ridges. These forests are not truly self-perpetuating without disturbance, but are as close to a climax forest as the site will allow.

Cover Type: Upland Oaks

General description: Occurs on dry ridges and shallow soils typical of the Canadian Shield. Examples include many stands in Charleston Lake and Murphy's Point provincial parks, and much of northern Lanark County.

Adaptations: Both white pine and red oak are adapted to survive wildfire. Mature trees of both species have thick bark to withstand moderate to heavy fires, and red oak seedlings can resprout after being topkilled by fire. Most of these stands are found on dry ridges and have been perpetuated through fire over the centuries. Both species are adapted to germinate and survive/grow in dry conditions. On very dry, shallow soil sites, white pine and red oak may form a subclimax community, which may persist without major disturbance. In the absence of fire, natural succession may take this cover type on another path. On sites with deeper soil, natural succession may promote shade tolerant species such as white spruce, sugar maple, and red maple to become established in the canopy and gradually replace the white pine and red oak.

Vegetation Description:

Canopy trees: white pine, red oak, largetooth aspen, white birch, red pine
Subcanopy trees: red oak, white pine, red maple, white birch
Regeneration: red maple, red oak, balsam fir, white pine, sugar maple, white spruce, white birch
Shrubs: bush honeysuckle, velvet-leaf blueberry, serviceberry, striped maple
Herbs, Ferns and Allies, and Grasses: wild lily-of-the-valley, bracken fern, wild sarsaparilla, large-leaved aster, rice grass, starflower, bunchberry
Mosses and Liverworts: *Dicranum flagellare, Ptilidium pulcherrimum*, *Pleurozium schreberi*
Lichens: *Cladonia coniocraea, Cladonia chlorophaea*

Cover Type: Early Successional Hardwoods

General description: Typically found on upland sites on shallow to drier soils. Typical examples include much of the abandoned farmland in Grenville County, and parts of the Marlborough Forest in Ottawa.

Adaptations: This cover type is dominated by early successional species, which are adapted to moving into disturbed non-treed areas and re-colonizing them. These species tend to be shade intolerant, fast growing, and short lived, and produce huge quantities of wind-born seed. This cover type is typically found on abandoned farmland, and may also develop after a large clearcut in forested areas. Unless a major disturbance happens again, the stand will slowly shift towards more shade-tolerant species such as Green Ash, Red and Sugar Maples.

Vegetation Description:

Canopy trees: largetooth aspen, white birch, trembling aspen

Subcanopy trees: green ash, red maple, white birch, largetooth aspen, sugar maple, black cherry
Regeneration: green ash, balsam fir, red maple, white spruce, white birch, sugar maple, trembling aspen
Shrubs: beaked hazel, mountain maple, fly honeysuckle, bush honeysuckle, low-sweet blueberry, velvet-leaf blueberry, northern wild raisin
Herbs, Ferns and Allies, and Grasses: wild sarsaparilla, blue-bead lily, bracken fern, wild lily-of-the-valley, starflower, large-leaved aster, ground pine, bunchberry, rose-twisted-stalk, rice grass, spinulose woodfern
Mosses and Liverworts: *Pleurozium schreberi, Brachythecium salebrosum, Callicladium haldanianum*
Lichens: *Cladonia coniocraea*

Cover Type: Upland Tolerant Hardwoods

General description: Typically found on *fresh* soils; many operating sugarbushes are found in this cover type. Typical examples include Sand Road Sugar Camp (Monkland), Wheeler's Pancake House (McDonald's Corners), Murphy's Point Provincial Park and many other sugar maple stands found on shallow to moderately deep soil over limestone bedrock.

Adaptations: Sugar maple is a very shade tolerant species that can move onto fertile deep soils and establish itself indefinitely in the canopy. Sugar maple is able to reproduce under its own shade, and can quickly dominate a site. Species such as basswood, white ash and black cherry are faster growers than sugar maple, and are able to survive in these stands by being able to rapidly exploit canopy gaps created by logging or natural causes. This cover type is a true climax community.

Vegetation Description:
Canopy trees: sugar maple, basswood, white ash, white birch, red oak
Subcanopy trees: sugar maple, basswood, ironwood, white cedar
Regeneration: sugar maple, white ash, basswood, black cherry, elm, ironwood, balsam fir
Shrubs: fly honeysuckle, leatherwood, chokecherry
Herbs, Ferns and Allies, and Grasses: red trillium, spinulose woodfern, helleborine, rice grass, wild sarsaparilla, large-flowered bellwort, fragrant bedstraw, wild lily-of-the-valley, blue cohosh, trout lily, marginal woodfern
Mosses and Liverworts: *Brachythecium salebrosum, Brachythecium reflexum, Ptilidium pulcherrimum*
Lichens: Parmelia sulcata

Cover type: Cedars and Cedar Swamps

General description: Found on moist mineral or organic soil. They have a high diversity of shrubs and herbs. Typical examples include the moist-wet areas of the Marlborough Forest and parts of Stony Swamp (Ottawa).

Adaptations: White cedar is a versatile species occupying almost all forest site types in eastern Ontario. White cedar stands in lowlands probably originated after hot fires burned through the swamps, leaving pockets of mature seed trees, and a favourable seedbed for germination. Once established, white cedar stands are quite stable, successfully regenerating through vegetative layering and seeding without major disturbances. Only balsam fir can successfully reproduce under a white cedar canopy (OMNR 2000b).

Vegetation Description:

Canopy trees: white cedar, trembling aspen, balsam poplar, black ash, yellow birch, white birch, red maple, white spruce
Subcanopy trees: white cedar, black ash, balsam fir, white birch, red maple, yellow birch
Regeneration: balsam fir, black ash, white cedar, red maple, sugar maple, white spruce
Shrubs: dwarf raspberry, mountain maple, fly honeysuckle, beaked hazel, swamp black currant, twinflower
Herbs, Ferns and Allies, and Grasses: spinulose woodfern, starflower, wild sarsaparilla, fragrant bedstraw, bunchberry, wild lily-of-the-valley, blue bead lily, goldthread, large-leaved aster, lady fern, naked mitrewort, rose-twisted-stalk, kidney-leaved violet, wood sorrel, sensitive fern
Mosses and Liverworts: Plagiothecium laetum, Pleurozium schreberi, Callicladium haldanianum
Lichens: Cladonia coniocraea

<u>Cover type: Lowland Hardwoods and Swamps</u>

General description: Typically found on moist soil typical of bottom slopes, floodplains and swamps. Typical examples include many areas in Larose Forest, and many low-lying stands in the Monkland-Maxville area.

Adaptations: Lowland hardwoods are species that have adapted to at least seasonal saturation of the soil. This community is another example of a sub-climax; it is not able to perpetuate itself without disturbance. Regeneration of lowland hardwood species is promoted by rapid canopy turnover rates; shallow rooting promotes windthrow and waterlogging kills many trees (OMNR 2000b). Windthrow on lowland sites also promotes pit and mound topography; the windthrown stumps and soil rot down into a mound leaving an empty pit beside it. The better drained mounds eventually support the majority of tree growth.

Vegetation Description:

Canopy trees: black ash, red maple, yellow birch, trembling aspen, sugar maple, balsam poplar, white spruce and basswood

Subcanopy trees: Black ash, red maple, sugar maple, white spruce, balsam fir
Regeneration: balsam fir, black ash, sugar maple, white elm, red maple, trembling aspen, white spruce
Shrubs: dwarf raspberry, beaked hazel, mountain maple, fly honeysuckle, chokecherry, wild red raspberry, red currant, alternate-leaved dogwood

Herbs, Ferns and Allies, and Grasses: spinulose woodfern, wild sarsaparilla, starflower, wild lily-of-the-valley, blue-bead lily, lady fern, fragrant bedstraw, large-leaved aster, rose-twisted-stalk, hairy solomon's-seal, oak fern, shinleaf, sensitive fern
Mosses and Liverworts: Brachythecium salebrosum, Callicladium haldanianum, Brachythecium reflexum
Lichens: Cladonia coniocraea

Plantations

In addition to the large area of natural forest in Eastern Ontario, there are also many plantations. Eastern Ontario has large areas of marginal farmland with soils that are too shallow, too stony, too wet, or too hilly to profitably farm. Since 1950, much of this marginal land has been abandoned. Some has returned to native forest cover, while some has been planted, with mainly coniferous trees. Between 1960 and 1985 the Ministry of Natural Resources (MNR) encouraged the planting of this land by entering into Woodlot Improvement Act Agreements (WIA's) with landowners and planting trees at subsidized rates. The MNR also managed marginal land for the counties. Trees were planted on abandoned lands, both as a future investment, and also to protect fragile sites such as the blowsands at Limerick and Larose Forests. The species most commonly planted were red and white pine, but white spruce, Norway spruce, Scot's pine, jack pine, tamarack, and European larch are not uncommon.

Plantations are often criticized as they start as monocultures (i.e. single species with little diversity), but given time, plantations can be converted into more natural forests, with considerable diversity. The first 5-10 years of a plantation's life are quite diverse because the trees are growing in old fields with many species of grasses, herbs, etc. Once *canopy closure* is reached however, most understory vegetation dies out as the trees allow little light to reach the forest floor. This period is short-lived however, and after the first thinning of the plantation, light once again reaches the forest floor and forest shrubs, herbs, mosses and lichens begin to grow. As the properties of the soil change and as more light reaches the forest floor following subsequent thinnings, hardwood species begin to establish on the site. Once the planted trees reach maturity, the understory of hardwoods can be released leaving a mixture of mature conifers and native hardwoods. An excellent example of the succession of a plantation can be seen at the Warwick Demonstration Forest near Berwick.

Rare species

Eastern Ontario is a unique area where many broad communities of vegetation meet. There is a U.S.-Carolinian influence from the south, bringing pitch pine, shagbark hickory, white oak and black walnut into eastern Ontario. There is a maritime influence bringing grey birch into the area; and there is a northern influence bringing red pine (native, not plantation) and black spruce into the area. All of these tree species are at, or near, the limit of their range in eastern Ontario.

This unique geography of overlapping vegetation zones has resulted in the only rare tree species in eastern Ontario, the pitch pine. Although common in the U.S., pitch pine is found in

Ontario only in the Thousand Islands area of Leeds County. An almost pure stand can be visited in St. Lawrence Islands National Park property on Hill Island.

Butternut, once plentiful in areas of the EOMF was placed on the Endangered species list in October 2003. Once plentiful, the species has all but disappeared in many parts of the U.S.A. and is under threat in Ontario, Quebec, and New Brunswick. The Forest Gene Conservation (FGCA) along with its partners, have been developing strategies for the conservation of butternut. Details can be found at www.fgca.net

Values

Individual trees have many values in a forest, both from a commercial and a wildlife standpoint. Trees produce many products for people, and they also provide food, nesting sites, shelter and temporary cover for wildlife.

Trees provide food directly for wildlife in the form of vegetation and mast. Deer, moose, and hare eat green vegetation and new twigs of young trees; ruffed grouse eat buds of poplar, ironwood and apple in winter; and squirrels, chipmunk and wild turkey eat *mast*. Decaying wood provides food for insects, which in turn provides food for woodpeckers and nuthatches.

Cavities provide nesting spots for many birds and mammals, including the wood duck. Holes excavated by woodpeckers and chickadees provide nesting sites for other birds and flying squirrels. The dense cover and thorns provided by hawthorn and buckthorn provides a protected nesting area for some birds.

Cavities in trees provide safe resting areas for raccoons to sleep; down logs provide moist shelter for amphibians; and loose bark on dead trees provides insulation for over-wintering arthropods. Conifer stands provide protection from wind, and also reduced snow depth as the needles catch snow as it falls, promoting *sublimation*. Deer often yard (congregate) in cedar or hemlock stands in the winter for shelter

Table 2: Number of species of amphibians, reptiles, birds and mammals using forest cover types in central Ontario and the habitat components they use.

Forest Cover Type	Total Number of species	Immature forest	Mature Forest	Cavity Users	Down log users	Mast Users	Conifer Users
Sugar Maple-Basswood	157	35	16	39	69	40	17
Lowland Hardwood	144	31	13	36	64	36	13

from OMNR (1998). For a complete listing see: Bouvier and Howes (1999)

Table 3: Common trees and their relative values to people and wildlife

Tree Species	Lumber Value[1]	Fuelwood Value[1]	Mast Value[1]	Cavity Value[1]	Snag Value[1]	Winter Cover Value[1]	Other Values
White cedar	M	L	L	M	M	H	posts, rails, oil
White pine	M	L	L	H	H	M	aesthetics
Balsam fir	M	L	L	M	M	M	
White spruce	M	L	L	M	M	M	
Hemlock	L	L	L	H	H	H	
Sugar maple	H	H	L	M	M	L	syrup
Red maple	M	M	L	M	M	L	
White ash	M	M	L	M	M	L	
Butternut	H	L	H	H	M	L	
Bitternut hickory	L	H	H	L	L	L	
Basswood	M	L	M	H	H	L	mouldings
Red oak	H	H	H	L	M	L	
White oak	L	H	H	L	M	L	
Beech	M	H	H	L	M	L	preferred nest tree
							of red shouldered hawk
Ironwood	none	H	M	L	L	L	
White birch	M	M	L	M	M	L	
Yellow birch	M	M	L	M	M	L	
Willow	L	L	L	L	L	L	
Trembling aspen	L	L	L	M	M	L	
Largetooth aspen	M	L	L	M	M	L	
White elm	L	M	L	L	L	L	
Black cherry	H	M	H	L	M	L	
Hawthorn	none	L	H	L	L	L	nesting cover

[1]H=high, M=moderate, L=low.

The location and size of stands of trees on the landscape is another aspect of biodiversity. Different wildlife species have different habitat needs; white-tailed deer and wild turkey flourish in areas with inter-mixed farmland, forest and wetland. This type of habitat is very common throughout eastern Ontario. The areas where different habitat types meet are called edge habitats, and they often support more species than the individual habitats combined.

Other wildlife species require forest interior habitat, large blocks of uninterrupted forest cover. Various definitions exist for forest interior ranging from forest area > 100m from any edge, to core forest blocks > 100ha. Edge habitat can be damaging to these forest interior species, as it may promote nest predation, parasitism, and increased predation.

Biodiversity conservation

Major conservation concerns affecting biodiversity

Exotic tree diseases such as Dutch elm disease, chestnut blight, and more recently butternut canker have impacted the type of forests we have today. White elm was once extremely common in moist stands throughout southern Ontario, but large trees are a rare sight today. Dutch elm disease, introduced from Europe, has all but eliminated mature elm trees, although many young trees can still be found. Butternut, a valuable timber and mast tree is currently being infected with butternut canker, an introduced disease which attacks and kills butternut trees of all ages and sizes and on all sites. The species has all but disappeared in many parts of the U.S.A. and is under threat in Ontario, Quebec, and New Brunswick. The species was classified as endangered under the Canadian Species at Risk Act in November 2003.

The Forest Gene Conservation Association (FGCA) and its partners are currently working on finding resistant elm trees to collect seed and grow resistant varieties. It has also very active in butternut recovery efforts, chairing the butternut recover team. The EOMF has established an butternut recovery fund to help fund conservation efforts. Additional information on how you can take part in these conservation efforts can be found at www.fgca.net.

Beech bark disease has recently moved north from the U.S. into stands near Cornwall, degrading many stems. A concern that has been raised in the Adirondacks is that the demise of beech will impact wildlife habitat. Beech trees are important for wild turkey and black bear during reproduction.. Beech bark disease has been shown to reduce mast production in beech trees

Other concerns include the introduced insect species Asian long-horned beetle and emerald ash borer, both species that are having a severe impact on the biodiversity of south-western Ontario forests. See section 5 for more information.

3. UNDERSTORY PLANTS

Introduction

There are approximately 84 species of small trees and shrubs and numerous herbaceous plants commonly found in the woodlands within the EOMF region.. Understory plants include small tree, *shrub*, and *herbaceous* plant species that comprise the vegetative growth under the canopy of a woodlot..

Some common understory species

Table 4 lists some of the common understory species in the Eastern Ontario Model Forest.

Table 4: Some common understory species in the EOMF

Species	Distinguishing features	Habitat	Interactions/Comments
Red baneberry (*actaea rubra*)	**Flowers** white, showy; in a fluffy cluster. **Fruits** showy, usually red on slender stalk	Prefers partial to full shade; moderately moist, nutrient-rich soils; in variety of forest types and ages	Berries eaten by deer and white-footed mouse, red squirrel, chipmunk, and red-backed vole, and many birds including yellow-bellied sapsucker, American robin, brown thrasher, gray catbird, and ruffed grouse. Pollinated by a variety of insects. Seed dispersal by birds and small mammals; chipmunk may bury the seed.
Wild sarsaparilla (*aralia nudicaulis*)	Large solitary compound leaf; flower-stem also comes from root, naked, about 30-40 cm high, terminating in 3 small many-flowered greenish umbels.	Open shade; widespread, dominant understory species throughout forests of the region	Preferred spring food of moose, white-tailed deer, ruffed grouse and thrushes. Black bear consume the fruits. Pollination by insects such as bumblebees, solitary bees, and syrphids. Establishment of seedlings rare and dependent on major disturbances. Seed dispersal by animals such as birds and black bear.
Large-leaved aster (*aster macrophyllus*)	Large (size of hand), thick, heart-shaped basal leaves; pale lavender to purple ray flowers; flowers late in season.	Dry or moist sites in many different forest types; prefers sandy, acid soil	Can form large dense colonies. Pollination by bumblebees. Seed dispersal by wind.
Canada mayflower (*maianthemum canadense*)	An evergreen herb, 4-20 cm with 1-3 leaves and small white flowers; a single clone can be 6 m in diameter and 30-60 years old.	Dominant understory species throughout forests of region	Pollination by solitary bees, bee flies, and syrphids. Some seed dispersal by birds.
Canada goldenrod (*solidago canadensis*)	Leaves 3-veined with 2 prominent veins parallel to midrib; yellow flowers in curved, one-sided clusters, together forming large terminal cluster	Tolerates wide range of soil types but typically found in fairly moist soils. Fairly shade intolerant although it occurs in sparsely wooded areas.	Has an allelopathic effect on sugar maple (*acer saccharum*) seedlings and reduces germination of herbaceous species, including itself. White-tailed deer selectively graze, particularly in late summer and autumn after flowering. An important source of nectar for honeybees. Flowers self-sterile and pollinated by insects. Seed dispersal by wind, with most falling within 2 m of the parent plant.
Blackberries (*rubus spp*.)	Prickly, erect or arching, thicket-forming shrub to 3 m in height; compound leaves; numerous white flowers; fruits red or black depending on	Shade intolerant. Open deciduous and mixed forests, on ridges, and in disturbed areas.	Among the most valuable wildlife food plants. Many birds, raccoons, chipmunks, squirrels, blanding's and wood turtle eat fruits. Deer and hare browse leaves and stems. Creates nearly impenetrable thickets where birds, hare, and

Species	Distinguishing features	Habitat	Interactions/Comments
	species.		other animals hide. Colonies of blackberry are common nesting sites for small birds. Seed dispersal by animal consumers.
Red elderberry (*sambucus canadensis*)	Leaves large, opposite, compound with five to nine leaflets; flowers white in pyramidal heads bright red fruits round, berrylike drupes	Prefers rich rocky soils with ample moisture. Shade tolerant or partially shade tolerant.	Berries food for hare, squirrels, fox, woodchuck, chipmunk, mice, and many species of birds including bluebird, woodpeckers, grosbeaks, veery, warbling vireo, red-eyed vireo, scarlet tanager, american crow, grouse. Hummingbirds visit flowers for nectar. Canes browsed by hare, deer. Hare locate their ground nests here. Valuable nesting and perching habitat. Seeds dispersed by consumers.
Bunchberry (*cornus canadensis*)	Low plant, usually less than 20 cm. Flowers are tiny white clusters surrounded by 4 large white bracts, appear like a single blossom red fruit.	Best growth in partial shade; prefers moist, well drained sites and cool, acidic soil	Food for moose. Veery, philadelphia and warbling vireo eat the fruit. dependent on bumblebees, solitary bees, beeflies, and syrphid flies for pollination. Nashville warbler sometimes nests beneath it. Seed dispersal by animal consumers.
Serviceberries (*amerlanchier spp.*)	A genus of tall, deciduous, *rhizomatous*, shrubs; flowers tiny and white, in clusters fruit dark reddish purple to black .	Occur over wide range of site conditions including forested slopes, open rocky woods, cliff edges; Less frequently on wet sites.	Small mammals, bears, and many species of birds eat the berries. Seed dispersal by birds and mammals.
Bush honeysuckle (*diervilla lonicera*)	A low, deciduous shrub 0.5-1.5m; leaves simple, opposite, toothed; branches close to the ground; flower pale yellow to orange or purple red.	Exposed, rocky sites and dry to mesic, well-drained soils. Relatively insensitive to variation in light intensity.	Winter browse for moose; winter and summer browse for white-tailed deer. Some songbirds feed on the fruits. Dependent on bumblebees, butterflies, moths for pollination. Successful seed set requires pollination by insects that have traveled from another clonal patch, usually some distance away.
Beaked hazel (*corylus cornuta*)	Bark smooth, light brown, often with a white striping; fruit a round, smooth nut with a very hard shell, enclosed in a leafy sac	Forest understory and edges. Tolerates fairly heavy shade but grows best in full	Nuts are rich in protein and fat; favourite of red squirrel, chipmunk, ruffed grouse, hairy woodpecker, and blue jay. snowshoe hare heavily browse young shoots during the winter.

Species	Distinguishing features	Habitat	Interactions/Comments
	which protrudes beyond the nut like a beak and is covered with stiff hairs.	sun. Prefers well-drained soil but can grow on the edges of wet sites.	Winter buds and spring catkins are a valuable protein source for ruffed grouse and American woodcock. Like many shrubs, hazelnut has important role in nutrient cycling within a forest; its leaves are rich in calcium and manganese and help fertilize nearby trees and other plants. Seed dispersal by small mammals and birds.
Wintergreen (*gaultheria procumbens*)	A small, broadleaf evergreen shrub, usually less than 20 cm with small thick toothed, glossy leaves. Flowers white, bell-like, often with a touch of pink, in 2 or 3 flower umbels. Fruit a berry, reddish violet, 6-9 mm long. Chewed leaves taste of wintergreen.	Open shade on a variety of sites such as dry to wet woods and clearings; sphagnum bogs, swamps. Sandy, acid soil.	Fruit eaten by a variety of mammals and birds including chipmunk, deer, grouse Leaves browsed by deer and moose. Pollination mainly by bumblebees and honeybees. Seed dispersal by animal consumers. Birds and rodents eat the berries in the winter.
Mountain maple (*acer spicatum*)	A deciduous tall shrub to 6 m; leaves usually three lobed, with small teeth; turn brilliant yellow and red in fall; flower small greenish, with narrow petals, in cluster forming an erect spike unusual in maples; fruit a two-winged reddish samara, in hanging clusters.	Prefers rich, moist soils on rocky slopes and flats, and along streams. Also grows well on drier or well-drained acid soils. Shade tolerant but can grow well in sun.	Tendency to layer rapidly gives a competitive advantage in the exploitation of light gaps. Often dominates the understory with beaked hazel. Unlike most maples, is insect pollinated.
Blueberry (*vaccinium angustifolium*)	A low-growing shrub, less than 0.5 m in height; generally forming dense, extensive colonies. Dangling, bell-like flowers. Fruit a globular berry averaging 6-12 mm in diameter.	Variety of forest types, along sandy riverbanks, and on exposed rocky outcrops of the Canadian Shield. Most commonly associated with light, well-drained acidic soils.	Black bear, cottontail, white-tailed deer feed on the foliage; red fox, black bear, raccoon, red squirrel, red-backed vole, mice, and chipmunk feed on berries. Black bear reproductive success may be correlated with annual blueberry crops. Flower buds eaten by ruffed grouse during the winter. American robin, crow, eastern bluebird, red-eyed vireo, brown thrasher, gray catbird, eastern towhee, black-capped chickadee, cardinal, scarlet tanager, Canada goose, and thrushes eat fruits. Nashville warbler commonly nests on ground beneath low blueberry shrubs. Pollination chiefly by bees.
Alternate-leaved dogwood (*cornus alternifolia*)	A large shrub or small tree that may reach 6-9 m high; leaves alternate, mainly at the end of	Moist woodlands, along forest margins, on stream and swamp borders.	Black bear eat the fruit. Leaves and stems are eaten by white-tailed deer, cottontail rabbit, and beaver.

Species	Distinguishing features	Habitat	Interactions/Comments
	the twigs; fruit a berrylike drupe.	Grows best on deep well-drained soils. Shade tolerant.	At least 11 species of birds including ruffed grouse eat fruits. Seed dispersal by gravity and animals.
Chokecherry (*prunus virginiana*)	Stems numerous and slender, either branching from the base or with main branches upright and spreading. Height ranging from 0.5-7 m or more. Fruit a drupe, each containing a small stone.	Wide range of soil textures, but many sites have silty or sandy soils with good depth, fertility, and drainage. Moderately shade tolerant, but prefers open, sunny sites.	Browsed year-round by deer, but used more intensely in spring and fall. Fruits eaten by cottontail rabbit, chipmunk, mice, fox, squirrels, black bear, raccoon; voles feed on bark in winter. Many birds eat berries including cedar waxwing, ruffed grouse, grosbeaks, woodpeckers, thrushes. Numerous insect foragers including eastern tent caterpillar, fall webworm. Seeds dispersed by gravity and animal consumers. Plants appear to decline in vigour and numbers as the forest canopy closes.
Wild black currant (*ribes americanum*)	A many branched, deciduous shrub, 0.5-2 m tall. Leaves 3-5 lobed, 3.5-10 cm wide, gland-dotted beneath. Branches erect, without spines. Fruit round, smooth black berry.	Variety of habitats including swamps, moist woods, along roadsides. Clay, sandy, and rocky soils. Somewhat shade tolerant, often growing in moist forests.	Fruit a valuable food source for chipmunk. Red squirrel, skunk, cottontail rabbit, white-tailed deer eat foliage and twigs. Many birds eat fruit. Many insects eat the stem, leaves, and fruit. Seeds dispersed by birds and mammals. Chief pollinators are bumblebees and honeybees.
Prickly ash (*zanthoxyllum americanum*)	Thicket-forming shrub; stems with stout prickles in pairs; prickly leaves gland-dotted, aromatic when bruised.	Open rocky sites; generally on drier sandy, shallower soils.	Can form dense colonies. Seed dispersal by birds (e.g., American robin, cedar waxwing, blue jay). Cover habitat for variety of birds.

Some rare/uncommon understory species

Plant populations are dynamic, changing over time and space. Species loss is often due to the loss or degradation of habitat and due to only slight changes in environmental conditions. Over-browsing by white-tailed deer is having negative impacts on some plants (e.g., American yew). Many species typically exist at low densities and were probably never common in the area. A species may be locally common but rare over its larger range; or, it may be locally rare, but relatively common over its larger range.

Table 5 lists just a few rare or uncommon species found in the EOMF region that can be readily identified. It is recommended that people who find them report their locations to ecologists at the Kemptville district office of the Ministry of Natural Resources.

Table 5: Some rare/uncommon understory species in the EOMF

Species and Distinguishing features	Habitat	Interactions/comments
Ginseng (*Panax quinquefolius*) Single erect stem with a whorl of 3 leaves consisting of 5 leaflets, each originating from same spot (palmate). Leaflet edges toothed; fruit bright red.	Grows best when it has about 75 to 80% shade. Often in rich woods with fertile soil and abundant organic material.	Usually not found in large colonies. Susceptible to collection by root diggers and plant collectors. Some decline probably caused by increasing size of canopy openings due to timber harvesting.
Wood sorrel (*Oxalis acetosella*) Leaves basal, with 3 clover/shamrock-like leaflets. Usually less than 10 cm tall. White flowers veined with pink.	Cool woods. Variety of soils. Often on organic mat over bedrock. Level to steep slopes and any aspect. Often a climax understory species.	Soil stabilizer due to extensive clonal growth, able to grow on steep ground and poor soils, and in deep shade. Consumed by chipmunk, white-tailed deer, dark-eyed junco.
American yew (*Taxus canadensis*) Evergreen, coniferous shrub, 0.3-1 m, occasionally taller. Branches dense, spreading up to 2 m long. Fruit a fleshy, red orange, cuplike aril surrounding a single seed.	Cool, rich, damp woods and wooded swamps; on banks; along bog margins; and ravines. Moist, loam soils; best on well-drained silt loams. Slow growing, shade tolerant species, growing best in the stable environmental conditions of climax forests. Usually not found in early or mid-successional communities. May have a competitive advantage over intolerant species only under a well-developed canopy.	Intolerant to moderate or heavy browsing by deer and moose . Disturbances tend to exclude yew and any removal of the overstory is likely to be detrimental. May indicate cool and moist, old-growth conditions. Highly preferred year round browse for deer and moose. Aril eaten by many birds, including ruffed grouse, cedar waxwing, robin. Birds disseminate seeds.
Witch hazel (*Hamamelis virginiana*) Large spreading shrub or small tree, 4.5-6 m tall, often in clumps of several stems (each clump is one plant). Yellow flowers in fall when leaves are falling. Leaves have uneven bases.	On *mesic* to dry, well-drained sandy sites. Open woods, edges, slopes. Moderately shade tolerant.	Pollinated by insects, especially gnats, parasitoid wasps. White-tailed deer browse twigs and foliage. Ruffed grouse eat seeds. Seed pods expel seeds

Factors contributing to species richness

In general, the vegetation of the EOMF region reflects the geography, geology, and climate of the region. In any given woodland, species richness and composition will be determined by:

- Soil and climatic conditions
- Substrate and soil pH
- Topography
- Aspect
- Presence of openings and water bodies
- Level of disturbance
- Nature of adjacent landscape
- History, including past management

Soil and climatic conditions change considerably throughout the EOMF region. In general, sites with higher yearly mean temperatures and abundant rainfall support greater species richness. Well ventilated and drained, moderately moist, loamy soils are also more likely to support more species than heavy, wet or shallow, droughty soils.

Woodlands with variations in soil pH can support higher species richness. Plant species richness can be quite high on parts of the Frontenac Axis east of Kingston, and in northwest Lanark County because there are pockets of more alkaline soils (i.e., higher pH) derived from marble bedrock. Being less erosion resistant than the acidic granite and gneiss bedrock types in these areas, this substrate encourages the development of more nutrient-rich, less acidic soils that support many plant species, including calciphiles (species that do best on calcareous soils).

Topography of the area also contributes to species richness. Woodlands found on sites with varying surface terrain provide habitats for a greater variety of plants than do woodlands on flat terrain with little or no variation in surface features. Landforms such as ridges, cliffs, talus slopes, depressions, seeps, and drainage areas all support species uniquely adapted for life in these areas. The aspect of some of the landforms also contributes to species diversity. Warmer, drier, south-facing slopes support several plants that are unlikely to be found growing on colder, moister, north-facing slopes. Woodlands with both north and south-facing landforms tend to have more species than those with only one or the other, including species with more southern and northern affinities. In addition, varying surface terrain interacts with local climatic conditions, creating microclimates favourable to some plants that are not found in other parts of the woodland.

Species richness also increases dramatically in woodlands with openings and water bodies such as creeks and ponds. Many plants thrive in these areas due to increased sunlight. In some woodlands, several uncommon species such as orchids may be found in swampy areas.

Disturbance affects species richness by creating conditions that favour establishment of some species while discouraging the establishment of others. When trees fall down or are removed, drier and brighter conditions at the forest floor encourage suitably adapted species such as goldenrods. Light intolerant species gradually disappear. The degree of disturbance can affect seed dispersal. When larger openings are created, air movement increases, resulting in greater establishment of species with wind-dispersed seeds. Birds, such as robins and cedar waxwings, that are more adapted to open areas are attracted to larger openings and can also disperse seed into the woodland. Disturbances such as roads and trails provide another mode of entry for seeds from outside the woodland (on peoples clothing and on vehicles).

The nature of the adjacent landscape influences species richness of a woodland. For example, large woodlands surrounded by predominantly agricultural land experience little infiltration by outside plant species. Smaller woodlands that border on residential areas and marginal farmland often have numerous species more commonly associated with these more open places. Normally, woodlands situated within a larger forested landscape tend to support fewer such species, as well as fewer non-native species.

The history of the woodland and surrounding landscape also determine current species richness and composition. For example, woodlands that have been fairly recently grazed by livestock tend to have fewer species than woodlands where grazing has never occurred. Woodlands that have been managed intensively for maple syrup production also tend to have fewer species because competing species have been selectively removed. Also, the closed canopy, allowing little light infiltration, inhibits establishment of all but the most light tolerant species. Recently logged woodlands may exhibit lower or higher species richness, depending on the original cover type, when the logging occurred, and how extensively and carefully it was conducted.

Values

Understory plant diversity in the EOMF region provides benefits for people residing or visiting the region. Most people intuitively prefer naturally diverse landscapes over those consisting of only a few species. Understory plants contribute to forest health, aid in soil stabilization, and prevent soil erosion. Collectively, these plants also help to support deer and waterfowl populations in the region, thereby indirectly aiding local communities that derive some revenue from hunters.

A diversity of understory woodland vegetation is important to many other species, communities, and ecosystems. They help to maintain the structure, stability, and health of natural communities through their roles in key processes (e.g., nutrient cycling, pollination), functions (e.g., provision of food, habitat), and many interactions.

Woodland community ecology

Species populations comprise the next level of biological organization: the *community*. Organisms found in a given community are typically adapted to the environmental conditions of that area. Many understory plants are members of several different communities (e.g., woodland, wetland, old field), while some, are normally only found in woodlands.

Community maintenance

Understory plants, like other community members, contribute to the maintenance of *community structure* and stability. A variety of understory plants creates both vertical and horizontal structure, providing important wildlife habitats. The plants themselves, especially their leaves, serve to maintain soil fertility and recycle nutrients. Many shrubs, such as beaked hazel (*Corylus cornuta*) have leaves rich in calcium and manganese which help to fertilize nearby trees and other plants. S*ymbiotic* associations between fungi and the roots of some plants enhance nutrient cycling.

The foliage of understory plants serves to moderate the microclimate on and near the ground by providing shade and slowing heat loss at night. Foliage also helps to protect soils from erosion and desiccation by absorbing the impact of raindrops and reducing sunlight infiltration respectively. The roots of these plants help to stabilize soils, especially on slopes and along open edges of woodlands, streams, and other water bodies.

In some woodlands, wild grape vines can be so abundant that they overgrow trees and shrubs, causing them or their branches to collapse under the weight. This may benefit the forest environment by creating patches in the canopy, allowing sunlight to penetrate to the ground, and enabling natural succession to continue.

<u>Provision of food</u>
Understory plants directly provide food for a variety of birds, mammals, and insects that consume leaves, bark, twigs, berries, and nuts. They also indirectly feed other animals that feed on insects and small mammals that are attracted to these plants. In addition, decomposers or *detrivores* break down the organic matter of the plants, thereby making organic nutrients available for uptake by other plants in the community. In general, a greater diversity of understory plants in a woodland supports and encourages a greater variety of other organisms.

For some species, plants are a very important food resource. In early winter, young fisher may not have developed sufficient skill to successfully hunt mammals such as rabbits. The berries of winterberry (*Ilex verticillata*), which persist in sufficient quantities at this time of year, help these animals stave off starvation. Black bear may rely on beech nuts to provide fat reserves necessary for hibernation.

Signs of animal feeding on understory plants are readily observed. Ragged ends on twigs indicate browsing by deer; smooth cuts at oblique angles indicate browsing by hare or rodents. Bare patches of *cambium* reveal areas where voles, mice, hare, and porcupine have chewed away the bark.

<u>Provision of habitat</u>
Many small trees, shrubs, and herbaceous plants provide food, shelter, and nest sites for a variety of wildlife. A variety of understory plant species results in several layers of vegetation ranging from the ground to several meters in height. This vertical complexity increases the amount of available habitat and consequently the species richness in a woodland. Different bird species can nest and feed at different heights, reducing direct competition for food and space.

Different species of birds nest at different levels within a woodlot. Woodland ground nesters include the ovenbird, white-throated sparrow and the hermit thrush. Chestnut-sided warbler, yellow warblers, black-throated blue warbler, and the common yellowthroat nest in shrubs and smaller trees in the understory.

Understory plants can influence the presence of other species in subtle ways as well. For example, several species of hawks become less numerous in woodlands with dense understories of leafy shrubs. The thick vegetation makes it difficult for them to sight and hunt their food. At the same time, their typical prey species such as chipmunk, mice and voles are likely to be more numerous because the predation by raptors is somewhat reduced. This in turn attracts other predators such as coyote, fisher, and marten.

Understory vegetation provides critical habitat for several species of amphibians found in the EOMF region. Shrubs such as speckled alder, dogwoods, viburnums, and willows. found near woodland ponds provide suitable shaded and moist conditions for tree frogs. Understory vegetation also provides escape cover and shelter from the sun for amphibians that spend most of their lives away from their breeding ponds (e.g., several salamander species, wood frog, American toad).

Species interactions

In the woodlands of the EOMF, understory plants are involved in at least five types of *interspecific* interactions.

Predation

Over time, woodland plants have evolved structures, adaptations, and strategies that help to ensure their success. For example, some trees and shrubs periodically “swamp” their seed predators (e.g., squirrels, mice, voles) with an overabundance of nuts and fruit (ultimately seeds) in a process called masting. This process attracts many potential seed dispersers. Due to the great quantity of seed available, it can not be all consumed, and some of it will find suitable sites and germinate. By alternating between occasional bumper crops and more common poor crops, plants can conserve energy enabling them to produce more seeds than all their predators could consume. During years of lower seed crops, populations of seed eaters may decrease and some birds such as finches will migrate to other areas in search of food.

Some understory plants have developed ways to discourage their consumption by herbivores such as deer, mice, and hare. Plants such as prickly ash have stems covered with thorns that discourage heavy browsing. Chemicals produced by sheep laurel), American yew, buttercups, milkweeds ,nightshade**,** and nettles discourage their predators.

Competition

Resources such as food, space, shelter, sunlight, and water are often in limited supply within a community. This can lead to competition between members of a population or between different species populations. Both have impacts on the community composition as well as on population growth rates and size.

Some plants ensure their success by out-competing their community associates. For example, vines such as riverbank grape and Virginia creeper, and shrubs such as blackberries clamber over other vegetation and absorb most of the incoming sunlight, to the detriment of other species. Others gain access to sunlight by growing and producing light-absorbing leaves faster than other species. The tendency of mountain maple to layer rapidly gives it a competitive advantage over other species in the exploitation of light gaps. The spreading roots of some species quickly absorb most of the rainwater, thereby depriving other plants. Some plants such as hedge bindweed , Canada goldenrod , and garlic mustard gain a competitive advantage by producing chemicals that are toxic to others growing in the vicinity.

Commensalism

Commensalism is probably rare because it is difficult to imagine one species not being affected by the close presence of another in at least some small way. One example may be birds that nest in dense thickets of blackberry shrubs. These birds benefit from the protection afforded by these prickly plants, and the plants are likely unaffected by their presence. Another example may be small, straggling shrubs such as glaucous honeysuckle and nightshade. They clamber over other plants and are therefore better able to receive sunlight and attract pollinators and seed dispersers. It is doubtful that they harm other plants.

Mutualism

Plants are involved in numerous mutualistic relationships. Two of the best examples are pollination and seed dispersal. Many understory plants depend on insect pollinators such as bumblebees, solitary bees, bee flies, and syrphid flies for cross pollination and successful reproduction. These insects, as well as hummingbirds, receive food in the form of pollen and nectar, while they transfer pollen from male to female reproductive plant organs, thereby enabling cross-fertilization of the plant.

Often plants and their pollinators have evolved together to increase the odds of successful pollination. For example, the red colour and long spurs of wild columbine indicate an evolved partnership between this plant and the ruby-throated hummingbird. The colour is attractive to hummingbirds and the bird's long bill enables it to reach the nectar deep in the spurs. Wild ginger, a common wildflower in the EOMF region, provides another example. It flowers in April, when the ground has barely warmed. Each flower provides abundant pollen and good shelter from cold winds for its pollinators, mainly small flies and gnats.

Many understory plants depend on a variety of birds (e.g., yellow-bellied sapsucker, American robin, blue jay, vireos, thrushes, woodpeckers, ruffed grouse) and mammals (e.g., white-tailed deer, raccoon, skunk) for seed dispersal. The latter receive a meal, while the seeds pass through their digestive system and are deposited elsewhere.

The leaves of some shrubs such as dogwoods, wild grapes, sumacs, Virginia creeper, and poison ivy, change to bright colours earlier than most other species. These shrubs produce fruits that is high in energy and rich in fats, but that rot quickly. The bright colours of the foliage might help bird consumers (often long distance migrants such as thrushes) find the berries before they rot, thus encouraging their wide dispersal.

Seed dispersal is not always obvious. For example, ants disperse the seed of many wildflowers such as spring beauties bloodroot, wild ginger, Dutchman's-breeches squirrel corn, bellwortsmost, violets and trout lily

Parasitism

Some understory species parasitize other plants in order to survive. Dodder is a rapidly growing plant that can spread from one plant to another, twining its stems over its host and becoming attached to it by many small haustoria (suckers). The plant absorbs all its food and water from the host plants through the haustoria. The Indian pipe indirectly absorbs its nutrients from trees, through its parasitic relationship with mycorrhizal fungi. Beech-drops grow over the roots of beech trees, its only known host plant.

Biodiversity conservation

Changes/loss of understory plant diversity

Increased urbanization and the loss and *fragmentation* of forest cover, wetlands, and grasslands have had impacts on biodiversity of the EOMF. Populations of some understory plants have declined due to disturbance and habitat destruction. Invasion of woodlands by exotic species such as garlic mustard, dog-strangling vine, and glossy buckthorn also may be responsible for losses of some native flora. Ginseng is listed as an endangered species, primarily due to over-collection for a lucrative market.

Major conservation concerns affecting biodiversity

Habitat fragmentation

When roads, residential development, drainage ditches, utility corridors, and logging cause habitat fragmentation, the remaining smaller patches are often unable to sustain certain members of the community over the long term. Roads, trails, and drainage ditches can also sufficiently change environmental conditions within a woodland to threaten the survival of populations of sensitive plant species.

Small patches of habitat threaten many species with local extinction. In this region, isolated forest patches may function as *sink habitats* for those species that are more dependent on larger, continuous blocks of forested land. Understory plant populations that are declining due to disturbance or other factors, may be lost simply because there is no nearby source of seed.

Edge effects

When habitats become fragmented, unnatural edges are created where none existed before. The shape of the fragments is important; detrimental *edge effects* are often more severe in long, narrow patches than in more square or circular fragments because the former have a larger edge to interior ratio.

Increased edge habitat can have negative impacts on community residents, including understory plants. Woodlands, especially isolated ones, with abundant edge habitat are highly susceptible to storm damage because of greater exposure of forest trees to wind. A drier interior environment can develop due to the effects of windthrown or removed trees and greater and continuous penetration of the woodland by wind and sunlight. Over time, changes in temperature, humidity, soil moisture, and infiltration by sunlight could lead to changes in species composition or declines in some plant populations.

Habitat heterogeneity

In general, understory plant diversity benefits from a variety of habitats located across the larger landscape. Woodlands, wetlands, grasslands, and other natural areas all provide different habitats for different species. In addition, a variety of woodlands at different successional stages and of different ages, with varied tree species composition and structure also helps to maintain understory plant species richness.

Context

The location of a woodland within the larger landscape can affect biodiversity. Development on adjacent lands can have negative impacts on woodland vegetation. For example, people often create roads and trails that encourage more disturbance within the woodland. Trampling, vandalism, and collecting plants all damage local woodland plant populations.

Invasive plant species

There are several non-native understory species found in the woodlands of the EOMF. Some of them, such as barberry, cultivated black currant (*Ribes nigrum* L.), mountain ash (*Sorbus aucuparia*), crab apple, and European guelder rose (*Viburnum opulus*) have little impact on most woodland communities. But other non-native plants including glossy and common buckthorn (*Rhamnus frangula, R. cathartica*), dog-strangling vine (*Cynanchum nigrum*), several introduced species of honeysuckles (*Lonicera spp*.), same's rocket (*Hesperis matrionalis*), purple loosestrife (*Lythrum salicaria*), and garlic mustard (*Alliaria petiolata*) are more harmful. These species become problems because they tend to be highly invasive. They become quickly established, often on recently disturbed sites, and then grow quickly. These species are more successful than associated native species at acquiring key resources such as water, nutrients, and sunlight. Also, since they are originally from other areas, they have few or no natural herbivores to keep their populations under control. Some, like common buckthorn, have become quite widespread because they can tolerate shade as well as sun and can adapt to most soils. Their fruits are not be preferred by birds but are consumed in sufficient quantities to permit seed dispersal to other areas. Table 6 lists the most common invasive species in the EOMF and recommended methods of control.

Table 6: Common woodland invasive non-native species and their control

Species	Recommended method of control
Dame's rocket	• Apply glyphosate at onset of flowering
Garlic mustard	• Control efforts aimed at preventing seed production • Small infestations or isolated populations cut at ground level • Glyphosate for heavy infestation, applied mid-spring; can also be applied in fall to rosettes, if temp. above 10 C
Common and glossy buckthorn	• Cut after peak flowering (May-July) then apply 30% glyphosate solution immediately to cut stumps or 6 weeks later to resprouts with a wick applicator (Strobl 1999)
Dog-strangling vine	• Light infestation - remove plant, including root system • Larger infestation - apply glyphosate at onset of flowering and 2-3 weeks later • Follow-up treatments required to eliminate surviving plants
Exotic honeysuckle species	• Open forests - repeated cutting to ground level can result in high mortality (at least annually) • Well-established stands - cut to ground level and treat foliage with 25% solution of glyphosate or tricloppyr to the cut stems

OMNR. 2000. *A Silvicultural Guide to Managing Southern Ontario Forests*
Louter et al.1993. *The autecology of competing non-crop vegetation on old field sites in southern Ontario.* OMNR.

4. REPTILES AND AMPHIBIANS

Introduction

Reptiles and amphibian are collectively known as *herptiles*. Approximately 18 amphibians and 16 reptiles are found in the EOMF region.

Some common reptiles and amphibians of the EOMF

Table 7 lists common species. Most amphibians and reptiles are not usually hard to observe, but a few of them can be somewhat hard to find. Many are found in or near water bodies. A few of the salamanders can be found in damp areas such as under logs and flat rocks. On warm and wet spring nights, spotted and blue-spotted salamanders move to their breeding ponds. Frogs are most easily found by their breeding songs and their movements. Most turtles are best observed as they bask in the sun on logs and rocks, or when the females are laying eggs. Snakes can be found by looking in their preferred habitat(s), often around rock and wood piles, large hollow trees, in old fields, and along shorelines. In spring, many snakes can be found in a single small area, as they emerge from their hibernacula.

Table 7: Common reptiles and amphibians found in the EOMF

Species	Habitat	Distinguishing characteristics
Blue-spotted salamander	Breeds in ponds; found in moist environments under debris such as logs, rocks	Bluish-black above with large bluish-white flecks
Spotted salamander	Breeds in ponds; found in moist environments under debris such as logs, rocks	Blue-black with round yellow or orange spots
Red-spotted newt	Ponds, swamps, ditches with aquatic vegetation; terrestrial form found in neighbouring damp woodlands	Aquatic form olive green with small black spots; terrestrial form orange-red
Northern redback salamander	Terrestrial, under logs, stones, other surface debris	2 color phases: red-backed has broad, red stripe on back; lead-backed is gray to almost black without stripe
American toad	Many different habitats	Some plain brown, others patterned; warts
Spring peeper	Wooded areas near ponds and swamps	Tan brown to grey with dark X on back
Gray treefrog	Usually trees and shrubs in vicinity of water	Greenish, brownish, or grey; ragged star-shaped pattern on back, white belly; undersurface of thighs bright orange
Western chorus frog	Shallow water bodies, ponds for breeding; otherwise wide variety of habitats, usually near water	3 dark stripes on back
Bull frog	Prefers large bodies of water, in aquatic vegetation	Large, plain green above, no dorsolateral ridges on trunk
Green frog	Ponds, swamps, marshes, shorelines with vegetation	Green to brown with dorsolateral ridges on trunk
Northern leopard frog	Commonly found in meadows, shorelines	Brown or green frog with irregularly placed dark spots
Wood frog	Moist woodlands, often found a considerable distance from water	Dark patch extending back from the eyes; usually brown to almost black
Snapping turtle	Slow-moving rivers, marshes, and mud-bottomed lakes	Large, with big head, powerful jaws; long tail with saw-toothed keels; algae on carapace
Midland painted turtle	Slow-moving rivers, marshes, and mud-bottomed lakes	Dark central blotch on reddish plastron, bright yellow spots on head
Common map turtle	Larger lakes, rivers	Yellowish spot behind the eye, map-like pattern on carapace
Common musk turtle	Shallow lakes with marl, sand, or gravel bottoms	Small (8-11.5 cm), 2 light stripes on head, barbels on chin and throat, foul-smelling
Milk snake	Open woods, clearings, fields, farmlands	Dorsal blotches saddle-shaped, reddish brown, tan, maroon, or olive-green; Y-shaped pattern on head
Northern water snake	In or near lakes, rivers, creeks, ponds, swamps, marshes	Stout-bodied; large head; brownish with mid-dorsal, large dark blotches
Brown snake	Open woods, clearings, fields, farms, roadsides	Greyish-brown with light stripe down center of back with small dark flecks on either side
Red-bellied snake	Open woods, clearings, fields, farms, roadsides	Reddish belly
Ribbon snake	Damp areas along streams, ponds, wet meadows, weedy shorelines	Slender; black to brown with 3 yellowish or beige stripes
Eastern garter snake	Variety of habitats, often near water	Black to brown with 3 yellowish, orange, or reddish stripes
Smooth green snake	Open woods, grassy clearings, fields	Bluish- to yellowish-green; small

Uncommon reptiles and amphibians in the EOMF

There are several uncommon species found in the region. While people are unlikely to see them, they should report any sightings to biologists at the Kemptville district office of the Ministry of Natural Resources. Like all animals populations, herptile populations are dynamic, changing over time and space. Table 8 lists some of the uncommon species, their respective rarity rankings, and where they are most likely to be seen. Some species may be locally common but rare over its larger range; or, it may be locally rare, but relatively common over its larger range.

Table 8: Uncommon reptiles and amphibians in the EOMF

Species	Habitat	Rarity ranking
Common mudpuppy	Usually lakes and rivers	Provincially common
Northern two-lined salamander	Rock-bottomed streams, seepages	Provincially common
Jefferson salamander	Breeds in ponds; under debris in moist areas	S2*
Four-toed salamander	Bogs, usually associated with sphagnum moss	Provincially common
Pickerel frog	Shorelines, wet meadows; prefers cool water	Provincially common
Mink frog	Cool waters with aquatic vegetation	Provincially common
Spotted turtle	Marshes, bogs, swamps, shallow water bodies	S3**
Blanding's turtle	Marshes, bogs, lake shorelines; sometimes wander away from water	Provincially common
Black rat snake	Open woodlands, rocky fields	S3**
Northern ring-necked snake	Woodlands, clearings, stony pastures near woods	Provincially common
Five-lined skink	Woodlands with rotting stumps and logs; rock piles; under rocks on rock outcrops	S3**

*S2- Provincial rank used by Natural Heritage Information Centre in Peterborough- very rare in Ontario; usually between 5-20 occurrences in the province
**S3- Provincial rank used by Natural Heritage Information Centre in Peterborough- very rare in Ontario; usually between 20-100 occurrences in the province

Factors contributing to species richness

The herptile fauna of the EOMF region reflects the climate of the region. In general, most amphibians prefer warm, moist conditions; reptiles like it hot and dry or moist, depending on the species. In addition to climate, several more specific factors contribute to the species richness of herptiles in a woodland, including:

- Presence of water
- Presence of structure
- Presence of nesting areas
- Presence of down woody debris
- Amount of predation (eggs, adults)
- Presence of corridors
- Context of the woodland

Amphibians and many reptiles require water for at least part of their life cycle. Some live their entire lives in or near water, while others just breed there. Woodlands with a creek, beaver pond, or the shoreline of a larger water body usually support a greater variety of herptiles than similar woodlands without water. Water bodies that have abundant aquatic vegetation, sticks, logs, and other debris that provide resting areas, escape cover, food, and substrates for egg deposition are the most attractive. *Riparian* vegetation promotes an abundant supply of insects and provides numerous perches for male frogs to call to females during the spring breeding season,

Herptiles require nesting areas. While ponds provide such sites for many species, others, such as turtles often deposit their eggs away from water. Most turtles bury their eggs, preferring locations with sandy or otherwise soft soils. Many snakes and some salamanders lay their eggs under rotting logs; a few do so under flat rocks.

Down woody debris is not only important as nesting sites, but also as refuge areas. Moist, decaying logs protect salamanders and provide habitat for their prey. Amphibians rest under them during dry periods in summer. Snakes hunt around ground debris such as logs and brush piles. Musk turtles sometimes lay eggs in the soft wood of decaying stumps.

Predation may have impacts on species richness. Breeding ponds with permanent populations of predatory fish are usually poor quality breeding sites for frogs because fish eat their eggs and tadpoles. Similarly, turtle populations benefit where nest predation is minimal. Abundant nesting habitat can make it harder for predators to impact local populations.

Corridors help herptiles move safely to and from their breeding ponds, nesting sites, summer ranges, and winter hibernacula. If these important habitats are severed from areas where the animals spend the rest of the year, species richness and population size can be seriously affected. Roads can have considerable impacts on many species. Vehicles kill many frogs, salamanders, and turtles as they move to or from their breeding/nesting areas. On cool spring nights, frogs may be attracted to warmer road surfaces; in fall, snakes like to bask in these areas.

The context of the woodland is important. Woodlands adjacent to natural areas (e.g., wetlands, beaver meadows) tend to support more herptile species than those bordered by croplands or residential developments. Problems for herptiles associated with landscapes dominated by humans include loss or degradation of habitat by tree cutting, alteration of moisture regime of the woodland, dredging and clearing of shoreline vegetation, increased algae blooms leading to deoxygenation, and greater predation by pets such as cats. These *anthropogenic habitats* also tend to attract more opportunistic mammals such as raccoons, coyotes, and fox that prey on herptiles.

Values

For many people amphibians and reptiles, like songbirds, provide a ready link to the natural world; their world would be somewhat diminished without spring choruses of breeding frogs or basking turtles. Herptiles are also among the few wild animals that can be easily and safely handled by people. Many children are introduced to nature appreciation by catching frogs, snakes, turtles, or salamanders, perhaps keeping them for a while, and then releasing them.

Herptiles have economic value as well. Bait dealers make money by selling leopard and green frogs to anglers. Frogs, toads, and some snakes destroy large quantities of harmful insects which can damage crops. Larger snakes help to control rat, mice, and other rodent populations. which can damage crops. Some turtles help to keep rivers, lakes, and ponds clean by scavenging dead fish and other animals.

Populations of reptiles and amphibians are sensitive to subtle environmental changes such as decreasing water quality or ozone depletion in the atmosphere. As a result, salamanders and frogs can function as indicators of environmental quality and can help us to monitor these and other changes.

In a woodlot, monitoring of indicator species can be used to evaluate the success of management activities. For example, the presence of salamanders indicates that your woodlot has sufficient woody debris on the forest floor.

Woodland community ecology

Organisms found in a given *community* are typically somewhat adapted to the environmental conditions of that area. Some herptiles are members of more than one type of community. For example, amphibians such as the American toad and wood frog, and reptiles such as the Blanding's turtle and garter snake are members of both woodland and wetland communities.

Briefly described below are some of the roles and species interactions of reptiles and amphibians that form an integral part of the ecology of woodland communities in the EOMF.

Community maintenance

Like birds and mammals, herptiles contribute to the maintenance of *community structure* and stability by providing a critical process in the system, or supporting other important interactions. For example, many species are part of the *trophic structure* of the woodland community. Snakes and frogs serve as important food resources for fish, mink, raccoon, and several species of hawks (e.g., northern harrier; red-shouldered, broad-winged, and red-tail hawks). Several species of herptiles prey on other, more numerous species within the woodland community. For example, American toads and smooth green snakes consume many different insects and grubs. Unlike foxes, hawks, owls, and other predators, snakes can get into small holes and underground burrows where they can catch mice and other rodents.

Burrowing by American toads improves soil aeration and helps to mix organic matter with the soil, thereby hastening the cycling of nutrients. Mole salamanders such as the blue-spotted and spotted salamander stay underground for most of their lives. Consequently, they also help to recycle nutrients found in the bodies of their food (e.g., earthworms and other invertebrates) and aerate the soil with their underground activities. Snapping turtles and northern water snakes also help to recycle nutrients by consuming carrion.

Species interactions

Predation

Both predator and prey species have evolved adaptations and strategies in order to survive. Some of the most interesting adaptations involve defences against predators. Several species use camouflage to avoid detection. The grey treefrog is not always grey, but is often green or light brown. Its scientific name, *Hyla versicolor*, refers to its ability to change colour in response to changing temperature, humidity, and light. This ability, and its pattern of colouration, allow these frogs to be well camouflaged on a background of lichen-covered tree trunks and branches.

Several amphibians protect themselves by secreting toxic substances. Although skunks, raccoons, and snakes can eat American toads, other mammals (including dogs and cats) learn quickly to avoid them because of their skin-gland secretions. These secretions are harmless to humans, but can irritate mucous membranes. Pickerel frogs and red efts secrete similar skin-gland secretions.

Competition

Like several other snakes in the region, black rat snakes consume rodents. But they are able to reduce competition by climbing into trees to exploit another food resource (birds and eggs) that is unavailable to other snakes. In a similar fashion, grey treefrogs, unlike other frogs in the area, forage high in trees for insects, mites, snails and spiders. These handsome frogs are often found beside electrical lights outside buildings where insects are attracted.

Interspecific competition occurs between bull frogs and green frogs in the EOMF because their breeding seasons overlap. As a result, the green frogs, are forced by the larger and more aggressive bull frogs to occupy territories closer to the shoreline.

Intraspecific competition results in several phenomena including emigration, territoriality, and dominance hierarchies. Territoriality is evident in adult male bull frogs and green frogs. During the breeding season, these frogs will aggressively defend their territories, consisting of several meters of shoreline, by swimming at and jumping on other trespassers of their species.

Biodiversity conservation

Loss of herptile diversity

In more developed parts of southern Ontario, including the EOMF region, populations of amphibians and reptiles are declining. Reasons for these declines are varied, complex, and not all well understood. In general however, habitat loss has been the main culprit. In some areas, exposure to environmental contaminants such as pesticides is also responsible for losses. Amphibians are especially sensitive to toxins in water (and air) because they breathe through their skin. These chemicals can also contaminate their food sources (e.g., insects) or eliminate them altogether. Direct persecution has hurt some populations of snakes. Bait fishing operations have undoubtedly put additional pressure on some frog populations, as has the harvesting of bull frogs on that species population.

Major conservation concerns affecting biodiversity

Connectivity

Perhaps the most important fact to remember when working to conserve herptile biodiversity is that most frogs, snakes, and turtles require different habitats at different times of the year. Local populations are more vulnerable when individuals have to travel considerable distances, especially if they must cross busy roads or large open areas. Each spring, road traffic kills large numbers of migrating breeders in many areas. Populations fare far better when all their habitat needs are in close proximity to each other, reducing the need to travel, therefore reducing mortality. Whenever possible, landowners should try to maintain important movement corridors for herptiles such as the areas between woodland ponds or shorelines and upland forest habitat or fields.

Habitat fragmentation

At its worst, habitat fragmentation could threaten many species with *extirpation*. For example, if a natural disturbance such as a fire or pond draw-down were to decimate a local population of salamanders within a severely isolated habitat patch (e.g., a habitat surrounded by roads and other open areas), immigration by salamanders from another *metapopulation* might not be possible if the animals could not successfully reach the habitat patch.

Edge effects

As with other woodland community residents, increased edge habitat can have negative impacts on herptiles members. Over time, changes in temperature, humidity, soil moisture, and infiltration by sunlight could lead to a decline in some herptiles, especially if edge effects lead to a change in the hydrological cycle within the woodland. Detrimental edge effects could be disastrous to local populations if they were to occur along woodland breeding ponds where large seasonal concentrations of herptiles occur.. An increase in edge habitat can also lead to more predation on herptiles (e.g., frogs, turtle eggs) by raccoon, skunk, and other animals that regularly forage in these areas.

Size of woodland

Although most reptiles and amphibians do not require large areas for survival, they are especially sensitive to disturbances that disrupt their environment because of their limited mobility and for many, their reliance on water for part or all of their lives. In general, larger woodlands afford their populations and habitats greater protection than smaller ones. A disturbance such as a severe drought could dry up a small pond, eliminating a local population of chorus frogs, simply because the animals have no other habitat in the immediate vicinity. In a larger woodland, the frogs may find another suitable area. Also, larger woodlands are often more biologically rich than smaller ones, due primarily to a greater diversity of habitats, and are less vulnerable to detrimental edge effects. They are also more capable of maintaining greater populations and genetic diversity of some species.

5. BIRDS

Some common birds of the EOMF

Table 9 lists common breeding birds of the region by families, based on similar anatomical characteristics. Most birds are easy to see if observers are patient and spend time in a variety of different habitats (e.g., wetlands, fields, forests, shorelines). Harder to see species are often small and stay at the tops of tall trees (e.g., wood warblers), are found at low densities (e.g., many *raptors*), or are highly secretive (e.g., rails).

Uncommon birds in the EOMF

There are several uncommon species found in the region. In general, you would not expect to observe these birds on every outing Table 10 lists some of these species, where they are most likely to be seen, and their rarity designation, if applicable. While people are unlikely to see some of them, they should report any sightings, especially of birds exhibiting breeding behaviour, to biologists at the Kemptville district office of the Ministry of Natural Resources. Bird populations are dynamic, changing over time and space, and once rare species can become more common (e.g., house finch, wild turkey) within a given area.. Please note that a bird may be locally common but rare over its larger range; or, it may be locally rare, but relatively common over its larger range.

Table 9: Common species of breeding birds found in the EOMF

Family	Common species in region	Distinguishing characteristics
Gaviidae (loons)	Common loon	Aquatic
Podicipedidae (grebes)	Pied-billed grebe	Aquatic
Ardeidae (herons, bitterns)	Great blue heron, green heron, American bittern	Primarily aquatic, colonial nesters
Anatidae (waterfowl)	Canada goose, mallard, American black duck, green-winged teal, blue-winged teal, wood duck, common merganser, hooded merganser	Primarily aquatic
Cathartidae (American vultures)	Turkey vulture	Carrion feeder; cavity nester; roost communally
Accipitridae (hawks)	Red-tailed hawk, northern harrier, osprey, American kestrel	Birds of prey (raptors); eat small mammals; osprey is fish eater
Tetraonidae (grouse)	Ruffed grouse	Gamebird
Meleagrididae (turkeys)	Wild turkey	Populations increasing; colonial rooster
Rallidae (rails)	Virginia rail, sora, common moorhen, American coot	Found in marshes; rails secretive;coot uncommon in some areas of EOMF
Charadriidae (plovers)	Killdeer	Birds of open habitats, ground nester
Scolopacidae (sandpipers)	Spotted sandpiper, upland sandpiper, Wilson's snipe, American woodcock,	Birds of open habitats, woodcock in wet woods, swamps
Laridae (gulls)	Ring-billed gull	Expanded populations around urban areas
Columbidae (pigeons, doves)	Rock dove, mourning dove	Birds of open areas, farmland; fast flyers
Strigidae (typical owls)	Great horned owl, barred owl	Birds of prey (raptors)
Apodidae (swifts)	Chimney swift	Mainly nest in chimneys
Trochilidae (hummingbirds)	Ruby-throated hummingbird	Only hummingbird in eastern North America; come to feeders, attracted by colour red
Alcedinidae (kingfishers)	Belted kingfisher	Nests in banks
Picidae (woodpeckers)	Northern flicker, pileated woodpecker, yellow-bellied sapsucker, hairy woodpecker, downy woodpecker	Cavity nesters, create cavities for other species
Tyrannidae (flycatchers)	Eastern kingbird, great crested flycatcher, eastern phoebe, eastern wood-pewee, alder flycatcher, willow flycatcher, least flycatcher	Eastern kingbird, alder and willow flycatchers birds of more open areas; the rest are found in forests
Hidundinidae (swallows)	Tree swallow, northern rough-winged swallow, barn swallow, purple martin	Consume many insects
Corvidae (jays, crows)	Blue jay, American crow	Intelligent birds
Paridae (titmice)	Black-capped chickadee	Hide many seeds in winter and find most of them
Sittidae (nuthatches)	White-breasted nuthatch, red-breasted nuthatch	Commonly associate with chickadees
Certhiidae (creepers)	Brown creeper	Forages on trunks of trees
Troglodytidae (wrens)	House wren	Vocal, close to ground, often near human habitations

Family	Common species in region	Distinguishing characteristics
Mimidae (mimic thrushes)	Grey catbird, brown thrasher	Birds of more open areas, thickets
Turdidae (thrushes)	American robin, wood thrush, hermit thrush, veery	Songbirds with melodious songs; except for robins, birds of woodlands
Bombycillidae (waxwings)	Cedar waxwing	Move in flocks, feed on berries
Sturnidae (starlings)	European starling *	Associated with urban areas, cavity nester, aggressive, fast flier
Vireonidae (Vireos)	Red-eyed vireo, warbling vireo	Associated with a variety of woodlands, edges
Parulidae (wood warblers)	Nashville warbler, yellow warbler, chestnut-sided warbler, black-throated blue warbler, black-throated green warbler, yellow-rumped warbler, pine warbler, black-and-white warbler, American redstart, ovenbird, northern waterthrush, mourning warbler, common yellowthroat	Songbirds, many with brilliant spring plumages
Ploceidae (weaver finces)	House sparrow *	Associated with urban areas
Icteridae (blackbirds)	Eastern meadowlark, red-winged blackbird, northern oriole, common grackle, brown-headed cowbird, bobolink	Associated with more open areas- fields, woodland edges, grasslands
Thraupidae (tanagers)	Scarlet tanager	Bird of forest interiors
Fringillidae (finches)	Rose-breasted grosbeak, indigo bunting, chipping sparrow, song sparrow, field sparrow, vesper sparrow, savanna sparrow, swamp sparrow, white-throated sparrow, purple finch, American goldfinch	Seed eaters, many colourful and vocal

* non-native species

Table 10: Some uncommon breeding birds found in the EOMF

Species	Comments
Northern goshawk	Prefers large stands; aggressive around nest, feeds on birds such as ruffed grouse, and on hare; sensitive to forest fragmentation
Cooper's hawk	Prefers large stands; feeds primarily on other birds; takes birds at feeders; VUL
Sharp-shinned hawk	Prefers large stands; feeds primarily on other birds; takes birds at feeders
Red-shouldered hawk	Prefers large stands; loud territorial call characteristic spring sound; feeds on high proportion of snakes; populations declining; VUL
Broad-winged hawk	Prefers large stands; often seen perch hunting on woodlands edges; takes rodents, also frogs
Bald eagle	Populations increasing in some areas; nests in large trees on wooded shorelines of lakes; sensitive to human disturbance
Black-billed cuckoo	Bird appears to be more numerous during forest insect outbreaks; not a nest parasite
Long-eared owl	Often roosts colonially with others of its species, often in conifers
Eastern screech-owl	Frequently mobbed by songbirds
Northern saw-whet owl	Migratory; characteristic call sounds like a repeated whistle, may be more common than supposed
Whip-poor-will	Nests on ground (no nest) near woodland edges; feeds at night, mainly by sight, especially on moths; well camouflaged
Red-headed woodpecker	Primarily deciduous woodlands; attracted to recent clearings; competes for nest cavities with small woodpeckers, kestrels, starlings
Olive-sided flycatcher	Primarily coniferous forests, bogs, especially with abundant dead trees; feeds on flying insects; defends nest vigorously
Yellow-bellied flycatcher	Coniferous forests and bogs; nests on or close to ground
Common raven	Highly intelligent; old nests often used by hawks and owls; cache food, often burying it; winter in communal roosts
Winter wren	Prefers areas in forest with heavy understory; nests in cavities (in stumps, trees) and in roots of upturned trees; secretive
Blue-gray gnatcatcher	Very active bird, habitat generalist; common cowbird host
Yellow-throated vireo	May prefer large stands; common cowbird host
Blue-headed vireo	Common cowbird host but often builds second nest over cowbird eggs, killing them
Philadelphia vireo	Prefers open woodlands, particularly with trembling aspen; in structurally simple forests, defends territories against red-eyed vireo
Magnolia warbler	Prefers mixed and coniferous forests, along edges and in natural openings
Blackburnian warbler	Nests high in dense branches of conifers; prefers mature forests; intolerant of disturbance affecting forest structure
Cerulean warbler	More often found in large forest tracts with mature deciduous trees; sensitive to fragmentation of forested breeding habitat; VUL; S3B
Canada warbler	Most often found in mixed forests, often in wet, low-lying areas with white cedar, alder; nests on or near the ground; VUL
Eastern towhee	Most often in open woodlands and forest edges; nests and forages primarily on the ground
Dark-eyed junco	More often found in early successional forests (e.g., poplar, birch), especially near openings, edges; usually nests on the ground; more often seen in winter
Evening grosbeak	Found in primarily mixed and coniferous woodlands; fond of maple sap; more common in winter months

Sources of information: M. Cadman et al. 1987. , P. Ehrlich et al. 1988.
VUL= vulnerable species COSEWIC designation; S3B- rare to uncommon breeding bird in Ontario; 20-100 occurrences in the province, Natural Heritage Information Centre in Peterborough designation

Factors contributing to species richness

Several specific factors help to determine the avian species richness found in a woodland, including:

- Diversity of vegetation
- Layers of vegetation
- Horizontal complexity
- Topography and aspect
- Presence of water
- Presence of corridors, linkages
- Size of woodland
- Context of the woodland
- Level of disturbance
- Changes in food abundance

A good diversity of vegetation provides food, shelter, and nesting sites for a variety of birds. Conifers (e.g., hemlock, balsam fir, pines) are especially important winter habitat for many birds because of the protection they provide from wind and snow.

Vertical complexity (i.e., layers of vegetation) encourages bird species richness within a woodland, because it allows different species to feed on the same or similar resource from different heights, thereby reducing direct competition. Multi-layers of vegetation also provide a greater diversity of nesting sites.

Horizontal complexity also encourages bird species richness. Woodlands with occasional gaps or openings in the canopy, as well as varied levels of canopy closure are attractive to many species. Species such as the red-shouldered hawk and cerulean warbler are dependent on a higher degree of canopy closure. Others such as the white-throated sparrow are associated with semi-open forests; while others such as the mourning warbler prefer forest clearings.

Woodlands with a variety of surface features such as ridges, cliffs, rock outcrops, talus slopes, and large downed woody debris such as brush piles and logs encourage the development of a diverse flora that attracts many birds. Cliffs attract turkey vultures and other large birds of prey because they provide ease of entry and exit as well as good views of the surrounding landscape. Slopes with southern exposures are warmer in winter and attract birds such as wild turkey that come to sun themselves.

Generally, a woodland with water, whether it is a stream, creek, or beaver pond, will support more species of birds than a similar woodlands without water. Some species are mainly aquatic (e.g., waterfowl, herons), while others are usually found in the vicinity of water (e.g., northern waterthrush). Water bodies also contribute greatly to vegetation diversity that in turn attracts different birds.

Woodlands that are linked to one another by natural vegetation or a waterway such as a creek are usually richer in bird species than isolated woodlands. Many birds avoid crossing open areas, and prefer to follow fencerows and wooded corridors when moving across the landscape.

Larger woodlands usually support greater species richness than smaller stands, but only if a variety of habitats are present. Stands with only a few tree species (e.g., plantations) normally are not attractive to many species. Birds such as cooper's hawk, red-shouldered hawk, barred owl, winter wren, blue-headed vireo, yellow-throated vireo, and cerulean warbler are more likely to be associated with stands at least 30 ha in size. Birds breeding in larger stands likely experience less nest predation than birds in smaller woodlands.

The context of the woodland is important. Woodlands surrounded by forested land tend to support more forest species than those bordered by disturbed areas such cropland and residential developments. These areas tend to attract more opportunistic mammals such as raccoon, coyote, and fox and birds species such as blue jay and crow that eat birds, their eggs and their young.

Many birds are adversely affected by disturbance such as noise, especially during critical times of the year (e.g., nesting,) Human or vehicular traffic and logging near nest sites will cause many birds to abandon their nests and even the stand. In addition, harvest damage and ill-placed roads and skid trails can destroy important wildlife habitat.

Changes in food abundance over time can also influence species richness as well as abundance. In many woodlands, natural irruptions of insects occur every few years. These attract many insectivorous birds. When irruptions occur during the breeding season, reproductive success and survival of fledglings of breeding birds may be improved, resulting in increased local populations.

Values

Avian diversity within the woodlands of the EOMF provides considerable economic and recreational benefits for residents and visitors to the region. The government receives income from the sale of licences to waterfowl hunters. Conservation organizations such as Wildlife Habitat Canada and Ducks Unlimited Canada also raise money for habitat improvement and other conservation projects from waterfowl hunters. There are also trickle down benefits to the communities where waterfowl hunters spend their money.

Bird watching is a fast growing past time. Many people enjoy watching the behaviour of a *guild* of birds (e.g., ducks, hawks) while others are more interested in seeing as many different species as they can. Birds also provide a good introduction to nature appreciation for many because they are interesting, colourful, active, and fairly easy to see and learn to identify. Once people have watched them for a while, many decide to learn more about other community members (e.g., plants, butterflies).

Woodland community ecology

Some bird species such as the scarlet tanager, winter wren and veery are normally only found in forested areas. Others, such as the wood duck and the hooded merganser are found in both wetland and woodland communities. The northern flicker, great horned owl and red-tailed hawk may be found in several different communities.

Community maintenance

Birds, like other organisms, serve to maintain *community structure* and stability by providing a critical process in the system, or supporting other important interactions. Many bird species are important to the *trophic* structure of the community. For example, the ruffed grouse is a critical food source for the goshawk and the fisher.

Many birds contribute to the health of forest communities and ecosystems by controlling the populations of other species, which when too numerous, can weaken ecosystem stability and health. Great horned owl, barred owl, red-shouldered hawk and other birds of prey help to control herbivores as such mice, voles, and hare. With the ability to breed at any time and with a gestation period of only 21 days, a single female meadow vole can produce several litters of from 1-9 young in a year. Their browsing would cause severe damage to vegetation if raptors did not keep their populations in check. As well, many different species of insects could jeopardize the health of the woodland community if it their populations were not kept under control by insect-eating birds.

Some species such as woodpeckers change the habitat in which they are found. The largest of this group, the pileated woodpecker, excavates many cavities of different sizes in both living and dead trees that are used by other birds, mammals, snakes, and insects.

Woodpeckers also help to recycle nutrients locked up in rotting stumps, dead trees, and fallen logs. The relentless scratching of the leaf litter by white-throated sparrow, eastern towhee, and other ground feeders mixes the soil and organic matter and further breaks down the leaf litter. American woodcock help to aerate the soil when they probe for earthworms with their long bills.

<u>Seed dispersal</u>
Birds are well known for their role as seed dispersers because so many of them feed on fruits and seeds. Some species such as blue jay, raven, and chickadee cache seeds and nuts for later consumption. The un-retrieved seeds found on suitable growing sites often germinate.

<u>Species interactions</u>
Species interactions are critical to community ecology. For example, in years when trees produce abundant mast, chipmunk and red squirrel populations can increase due to more available food supply. In turn, some breeding bird populations may suffer declines due to greater nest predation by these animals.

<u>Predation</u>
Both predator and prey species have evolved adaptations and strategies in order to survive. Woodland raptors such as red-shouldered and broad-winged hawk hunt by dropping on their prey from a perch located in or close to suitable habitat. Sometimes these birds are seen beside roadsides, sitting quietly on the edge of forests or wetlands. Goshawk, Cooper’s, and sharp-shinned hawks actively pursue birds inside the forest, often using terrain features to get as close to their prey as they can, before accelerating. Their long tails help them manoeuvre through dense brush and trees. Great blue herons live in colonies. During the day, when birds disperse to feed, less experienced birds may benefit by following older birds to better foraging areas.

Prey species have evolved their own defences against predators. Many smaller birds hide, using their speed and agility to dive into bushes at the first sign of danger. Others, such as whip-poor-will and ruffed grouse, rely on camouflage, remaining motionless to avoid detection. A few such as ruffed grouse, woodcock, and eastern towhee use distraction displays, faking injury to lead away nest predators. Numerous species are careful to hide their nests and behave quietly whenever they are around them. Many of them even take broken eggshells from within the nest and drop them some distance away, to divert nest predators from their nests.

Several species (e.g., wild turkey) use the strategy of flocking together to protect themselves. There are several advantages to this behaviour. First, it reduces predator success because more eyes are better able to detect predators and sound an alarm at the presence of danger. The sudden flight of a flock might also serve to bewilder a predator, giving all members a chance to escape. In addition, flocking decreases the time each individual bird must spend watching for predators, thereby increasing the time available for feeding and other activities. Many species such as crow, red-winged blackbird, swallows, and several songbirds will mob predators, flying at them and alarm calling, in attempts to drive them away. Finding mobbing birds is a good way to find to birds of prey, especially owls, which tend to be harder to see during the day.

Competition

Interspecific territoriality is more common in relatively simple habitats that limit the variety of resources such as food, and when the birds involved have specialized requirements. Philadelphia vireos are interspecifically territorial with red-eyed vireos in forest with a simplified physical structure. In more complex forests however, their territories can overlap and their aggression will vary with food abundance and stage of nesting (Ehrlich et al. 1988).

Another phenomenon, called *resource partitioning,* provides an example of a collective behaviour that can reduce *interspecific* competition. Closely related birds (e.g., wood warblers) divide up resources such as food. For example, several species may all feed on caterpillars, but will forage in slightly different ways; from different perches, on different parts of a tree or vegetation levels; and sometimes even at different times. This approach allows different species to use or share the same resource, without occupying the same physical location at the same time. It can also result in greater species richness in a woodland.

Owls represent a group of raptors that have evolved specific adaptations (e.g., soft feathers, excellent hearing and sight) that have allowed them to hunt at night, thereby reducing direct competition with other raptors such as hawks and falcons.

Intraspecific competition results in several phenomena including emigration, territoriality, and dominance hierarchies. Territoriality is evident in breeding birds. In some species, obtaining and defending a *territory* may be a prerequisite for reproduction. In spring, numerous male songbirds perch on treetops and branches, singing to advertise themselves and their territories to others of the same species. These birds will also actively defend these territories by chasing away other *conspecifics*.

There is only a limited number of breeding territories within a habitat such as a woodland. As population size increases, fewer territories are available and more individuals fail to reproduce because they do not have a territory, or at least a desirable territory. Apparently in some species, females select their mates on the basis of the quality of their territory. Hence, males without territories do not breed.

During winter, dark-eyed juncos show *intraspecific* territoriality. Flocks of from 10-30 birds exhibit definite social ranking and mutually exclusive foraging territories (Ehrlich *et al.* 1988). Some birds forage together with other species. By associating with species with different food preferences and foraging techniques, each individual faces less competition than it would in a similar flock of *conspecifics.*

Commensalism

Woodpeckers are involved in several commensal feeding interactions. The pileated woodpecker is able to remove the outer bark from tree trunks, allowing the hairy woodpecker, which cannot remove bark, to catch exposed insects. These large woodpeckers also create cavities that are later used by other birds and mammals for shelter, denning, nesting, and foraging habitat. Given the value of this one species of bird to the woodland community, protection of suitable habitat for it (e.g., existing and potential cavity trees) has become a priority in many biodiversity conservation programs.

Mutualism

Ruby-throated hummingbirds receive nectar from flowers of several plant species (e.g., columbine, red elderberry); the plants are cross-fertilized. Many birds help plants to disperse their seeds, receiving a nutritious meal in return. Holes drilled by the yellow-bellied sapsucker ooze sap that is also drunk by some warblers, kinglets, and hummingbirds.

In the EOMF, several species of birds including black-capped chickadee, white-breasted and red-breasted nuthatches, and downy and hairy woodpeckers commonly forage together, especially in winter. Such mixed-species flocking provides members with predator defence, as well as improved feeding efficiency. Having more individuals searching for food also increases the likelihood of finding a good feeding area. By moving together, species with similar diets can avoid areas that have already been searched for food.

Biodiversity conservation

Changes in avian diversity

During the last fifty years, the variety of bird species in much of the EOMF region has changed. This is largely due to an increase in urbanization and the loss and fragmentation of forest cover, wetlands, and grasslands. Birds such as cardinal, blue jay, common grackle, American robin, and gray catbird are now widespread because they tolerate edge habitats, and can survive near urban areas. Species that depend on forest interior habitat, including raptors such as barred owl and goshawk, and songbirds such as thrushes, yellow-throated vireo, black-throated green warbler, and scarlet tanager, are vulnerable to forest *fragmentation*. Ornithologists are concerned about some of these species because their populations appear to be declining. Table 10 lists some uncommon species in the EOMF.

Major conservation concerns affecting biodiversity

Habitat fragmentation

Bird species that are area-sensitive or considered forest *interior species* are particularly vulnerable to forest fragmentation. They require large continuous blocks of forest (usually at least 10 ha in size) for shelter, nesting, and food. This is a large guild of species that includes numerous migratory songbirds and raptors, and their habitat requirements are not all fully understood. Some will nest only in the interior of woodlands and avoid stands that are too small. Others may nest only on the edge of large tracts, making them more susceptible to forest fragmentation.

Edge effects

Increased edge habitat can have negative impacts on the bird species in the woodland community. Woodlands, especially isolated ones, with abundant edge habitat, are highly susceptible to storm damage because of greater exposure of forest trees to wind. This can lead to a loss of nests and nest trees. Changes such as increases in infiltration by sunlight, along with the associated increase in temperature and decrease in humidity could lead to changes in species composition or declines in some species such as ground nesting birds that require lush, shaded habitats. In addition, edge habitats frequently support nest predators such as skunk, crow, blue jay, and feral housecats that cause declines in some forest bird populations.

The brown-headed cowbird is a serious problem in edge habitats. This species is a nest parasite that thrives along the edges of woodlands. It does not build its own nest, but instead lays its brown-speckled eggs in the nests of other birds, leaving them for the host bird to hatch and raise. Cowbird chicks hatch earlier than most host species and out-compete the other nestlings for food and space.

Size of woodland

Area-sensitive species such as goshawk, barred owl, and red-shouldered hawk require large woodland habitat to sustain long term populations. Some species such as pileated woodpecker may be able to nest in smaller woodlands, but still require a predominantly forested landscape. Certain species, mostly *passerines*, may use small areas of suitable habitat within a larger tract. For example, it is generally believed that pine warblers require about 30 ha of mature pines. However, they will nest in predominantly deciduous woodlands with some pines, provided the stand is large enough.

Habitat heterogeneity

In general avian diversity benefits from a variety of habitats located across the larger landscape. Woodlands, wetlands, grasslands, and other natural areas all provide different habitats for different species. However there are less obvious impacts of habitat heterogeneity on diversity. For example, bird species composition and populations change with forest structure and composition, associated with successional processes. Some species are more commonly found in early to mid-successional forests, but become less abundant in older, more mature stands. Furthermore, changes in forest structure such as the creation of canopy openings, or an increase or decrease in understory shrubs alter the suitability of woodland communities for particular bird species. It is, therefore, important to maintain a variety of woodlands across the EOMF region.

Context

Development on adjacent lands can have negative impacts on woodland birds. The activities of humans and their pets can reduce breeding success of some species and eventually lead to a decline in bird species richness. For example, people often create roads and trails that encourage entry into the area by more nest predators. Increased human use often disturbs birds, particularly at critical times of the year such as the nesting season, or results in loss of forest structure. Different levels of vegetation attract different bird species, so as structure is simplified, species richness declines. In addition, some woodland birds require adjacent open habitats. If these areas are developed, they may be adversely affected.

These impacts from the surrounding landscape have another more insidious impact on the birds of the woodland community. They could create *sink habitats.* Local mortality of nesting birds and their offspring would begin to exceed reproductive success due to increased predation. Unfortunately, birds would continue to nest in the stand, possibly leading to an overall decline in the local population.

Connectivity

Connectivity can also help to offset losses due to the effects of *sink habitats* by allowing immigration by individuals from *source* habitats. While many birds will fly across open areas, numerous forest birds prefer to move through woodlands. Linkages among patches of woodland also encourage movement by the prey species of some woodland birds such as raptors.

Invasive non-native species

An increased occurrence of non-native shrubs in forest understories may also be linked to the decline of songbirds. Whelan and Schmidt (1999) discovered that predation of both robin and thrush nests was higher in the non-native shrubs than in the native shrubs and trees in a 200 hectare deciduous woodland. Birds that nested in non-native shrubs lost more eggs to raccoon and other predators. The researchers speculated that the increased predation was partly due to differences in the physical structure of non-native and native shrubs. At the study site, the native hawthorn shrub with its sharp thorns had largely been replaced by non-native buckthorn whose thorns do not deter mammalian predators. Also arrowwood had been supplanted by the non-native honeysuckle, with its sturdier branches that could both help predators climb higher and support nests closer to the ground where they are more accessible to predators.

In woodlands with few other shrubs, however, invasive species may provide locally important nesting and cover habitat for some birds, as well as food source for a variety of animals, especially in winter when other berries have been consumed. In these situations, it might be more prudent to gradually remove these species, while replacing them with valuable, native shrub species.

6. INSECTS AND OTHER ARTHROPODS

Introduction

Insects belong to a larger group of organisms called Arthropods. They are the largest group of organisms in the world representing an estimated 90 % of the world's species (Pimental et al. 1992). Approximately 879 000 species of arthropods have been described worldwide; 86 % of these species are insects (Britannica 1995).

The Arthropod Phylum is composed of 3 groups. These are:

- Tracheata (insects, centipedes, millipedes, symphala and pauropods)
- Crustacea: these are primarily marine organisms (such as lobsters, crabs) but there are some terrestrial species such as sowbugs and freshwater species such as crayfish
- Chelicerata (spiders, scorpions, ticks, mites, and others)

Table 11 shows the further breakdown of these groups and gives a worldwide and Canadian species estimate for each group, along with an estimate of the percentage of each group that has been described and or recorded. It is estimated that only 51 % of the Canadian arthropod fauna has been discovered and named (Danks 1993).

Arthropods are distinguished from other organisms by a few distinctive features:

- a segmented body
- a hardened exoskeleton which is secreted by their underlying skin cells. This exoskeleton is periodically shed to allow for growth, a new one is formed and stretches and hardens over the enlarged body.
- paired, jointed appendages on the segments ; appendages are modified depending on use for swimming, walking, running, jumping, burrowing, crushing)

Other features have evolved as adaptations to the habitats they occupy. Arthropods living in streams and wetlands have gills. Many insects have wings. Some predatory beetles have razor-sharp cutting mouth-parts while butterflies have a long proboscis for slurping up nectar. Dragonflies have a keen sense of vision to locate their prey while bark beetles rely on pheromones (chemical signals) to locate their host plants.

Arthropods occur everywhere in almost every type of habitat. Their diversity of body form, feeding habits, mating rituals and other survival strategies stems from their ability to adapt to differences in their environments.

Most arthropods (other than insects) exhibit little or no changes in their appearance over their life cycle, with their young resembling the adult in most ways. Eggs of crustaceans, and arachnids (spiders, mites etc.) tend to hatch into larvae that, except for in size, look very similar to the adult. Some insects (such as grasshoppers, crickets, true bugs) also resemble the adult form, hatching as nymphs that acquire adult features (such as wings) during various stages of growth.

Insects such as beetles, butterflies, moths, flies and wasps hatch as larvae which are very different from the adult. The larvae tend to occupy different habitats than the adults, eat different foods and eventually form a pupal stage (with metamorphosis) to become an adult. This strategy of development has been very successful. These groups (the Coleoptera (beetles), Lepidoptera (butterflies/ moths), Diptera (flies), and Hymenoptera (wasps, bees, ants)) are the most abundant of insect species, making up about 87 % of all insect species.

Table 11: Estimated Number of Described Species of Arthropods

Order	Common Examples	# described worldwide	# known in Canada	% described/
TRACHEATA				
Class Insecta				
Thysanura	silverfish and bristletails	580	2	17 %
Diplura	Diplurans	660	2	40 %
Protura	Proturans	325	3	38 %
Collembola	springtails	6 000	295	57 %
Ephemeroptera	mayflies	2 000	301	73 %
Odonata	dragonflies/ damselflies	4 950	194	98 %
Plecoptera	stoneflies	1 550	250	81 %
Orthoptera	grasshoppers, crickets, etc	20 020	212	90 %
Dermaptera	earwigs	2 000	5	100 %
Psocoptera	booklice and barklice	1 100	72	70 %
Hemipera	true bugs	23 000	3 079	73 %
Homoptera	leaf hoppers, aphids etc.	32 000	6 500 (NA)*	
Thysanoptera	thrips	4 000	102	41 %
Neuroptera	snakeflies, lacewings	4 600	75	84 %
Mecoptera	scorpionflies	350	22	69 %
Lepidoptera	butterflies/ moths	146 300	4 692	70 %
Trichoptera	caddisflies	4 500	546	73 %
Diptera	two winged flies	85 000	7 058	49 %
Siphonaptera	fleas	1 370	180	95 %
Hymenoptera	bees, wasps, ants	103 000	6 028	36 %
Coleoptera	beetles	290 000	6 748	74 %
Other Insects			74	
Total				55 %
Class Chilopoda	centipedes	2 500	70	67 %
Class Diplopoda	millipedes	10 000	64	65 %
Class Symphyla		160	2	17 %
Class Pauropoda		500	23	70 %
CHELICERATA				
Class Arachnida		70 750	3225	29 %
Araneae	spiders		1 256	90 %
Acari	mites	30 000	1 915	20 %
Other Arachnids	(ticks, harvestmen, scorpions)		54	
Other Chelicerate	arthropods		50	
CRUSTACEA	Terrestrial Isopods and Decapods**		45	92 %
ALL TERRESTRIAL ARTHROPODS				51 %

[1] % of Canadian species
Danks 1993; Heliovaara and Vaisanen 1993; Biological Survey of Canada 1988
*number of Homoptera species is an estimate for North America from Borror and White 1970.
**includes estimate for terrestrial crustaceans only

The Eastern Ontario Model Forest area has been settled for a relatively long time and its arthropod fauna is relatively well known. Species occupying the area are a mix of northern (boreal forest) and southern (deciduous forest) species; many are at the northern or southern limit of their distribution (Danks 1993). A mix of agricultural lands with natural and managed forest ecosystems in the region provides diverse habitats for arthropods. Estimates of 260-1000 species of arthropods per hectare have been made for rich agro-ecosystems in temperate zones (Pimental et al. 1992). Although the best-known species in our area tend to be pests of humans (e.g. mosquitoes and blackflies) and crops (e.g. European corn borer), pest species make up less than 1 % of all of the insects and other arthropod species in the region.

Common Arthropods of Eastern Ontario forests

Springtails – In late winter, springtails make their way from the ground to the snow surface, where they appear as jumping black dots. Because of this they are sometimes called "snowfleas". They are very abundant in forest soils and can be used as a sign of soil chemical properties.

Mayflies and stoneflies – These insects spend their larval stages in water, where they are an important food of fish. They emerge as flying adults, often in large swarms near water.

Dragonflies and damselflies – The larvae of these insects are aquatic predators. The flying adults patrol the forest, catching insects on the wing.

Bugs – True bugs belong to the order Hemiptera. They are characterized by a thickened part of the front wing which leaves the rear part of the wing exposed. Common bugs include water boatmen, backswimmers, and water striders in ponds, leaf bugs, ambush bugs, and stink bugs.

Cicadas, aphids, scale insects – Cicadas live in trees where the male sings a loud buzz on hot summer days. Aphids and scale insects feed on plants in the forest.

Butterflies and moths – The forest has relatively few butterflies compared to other habitats. Two common forest butterflies, the northern pearly-eye and the little wood-satyr, are small and not brightly coloured. Several forest moths feed on trees: budworms, tent caterpillars, borers, webworms, cutworms, loopers, leafminers, and the gypsy moth.

Bees, wasps, ants – These insects are closely related, belonging to the order Hymenoptera. They are very common and abundant in the forest. Members of this group include sawflies, ichneumons, and gall wasps.

Beetles – This is the most diverse group of insects. They are characterized by a hard shell which covers the entire wing surface when not flying. Common forest examples are ladybird beetles, lightning or firefly beetles, the whirligig beetle (found in ponds), wood-boring beetles, bark beetles, leaf beetles, long-horned beetles, click beetles (whose larvae are called wireworms), June beetles, and weevils.

Flies – True flies have only one pair of wings and most have sucking mouth parts. Common forest flies include crane flies, midges, mosquitoes, black flies, horse flies, and deer flies.

Centipedes and Millipedes – These many-legged arthropods are abundant in forest soils where they feed on organic matter.

Spiders, Mites, and Ticks – These arthropods belong to the Class Arachnida and are characterized by having eight legs.

Isopods – Isopods, or sowbugs, are crustaceans which live in forest soils.

Value

Insects and other arthropods aid in decomposition

Soil organisms play a huge role in breaking down plant debris such as fallen leaves, branches and dead trees. In the litter and organic layers of the soil, mites and collembolans usually account for 95 % of the micro-arthropods present. Their densities can be as high as 300 000 per square metre in areas with extensive amounts of aerobic organic matter (Seastedt 1984).

Organisms such as millipedes, sowbugs and oribatid mites feed directly on the plant litter, reducing it into smaller pieces and increasing the surface area for microbial breakdown. These species also contribute to improving soil structure as their feces mix into the organic layer. Other mites, beetles and collembolans feed on the microbes (fungi and bacteria) which are decomposing the litter. Their feeding stimulates microbial growth and they facilitate microbe transport (in their guts) to new areas. Animal matter (dung and carrion) is also decomposed with help from insects and other arthropods.

Dead wood is a critical habitat in the lifecycle of many arthropod species. Species such as bark beetles readily colonize recently dead or dying wood. Other species depend on the later stages of decay. For these species, factors such as low temperature and high moisture content in the logs are critical for survival. Some long-horned beetles spend 2 to 3 years in the larval stage feeding within one log before developing into an adult beetle. Under dry conditions it can take 6 to 7 years for the larva to develop (Warren and Key 1989). Many species associated with large decaying logs are impacted by forestry practices and loss of mature forest habitat. Temperature and moisture changes associated with tree removal can be extreme and often lethal to these species. In Canada, much less is known about these sensitive species and their associated food webs than in other countries. In some European countries, with more intensive forestry practices (e.g. Finland, Norway, Great Britain), many of these species have been placed on the endangered list (Warren and Key 1989).

Insects and other arthropods as herbivores

Many insects and some other arthropods have evolved to feed on a specific variety of plants and plant parts. The nutritional value of various plants and plant parts is highly variable. Many plants contain toxins, and others are difficult to digest (Howe and Westley 1988).

Woody plants contain high concentrations of lignins and tannins, which are extremely difficult for most organisms to digest. All plants are made up of cellulose and hemicellulose (80-90 % of total weight) which are indigestible by predators and *omnivores,* and only partly digestible by herbivores.

Plant toxins have also evolved as a defence against herbivores. Some may also have a natural function in the plant (e.g. growth hormone). Milkweed, the favourite food of the monarch butterfly caterpillar, contains cardiac glycosides, a toxin to most species. The monarch caterpillar has the ability to feed on milkweed without suffering any toxic effects. Monarchs also have the ability to sequester the toxin as protection against predators. Not all plants are as toxic to insects and herbivores as milkweed is. In North America there are only a few insects (11) from four insect orders that feed on milkweed exclusively. Other plants have hundreds of species of insects associated with them, specialized to particular parts (e.g. roots, cones, leaves, flowers). Some herbivores are generalists as well, feeding on a variety of foods.

Table 12 gives some examples of forest insect herbivores from this region.

Table 12. Common insect herbivores of trees in the EOMF

Area of feeding	Damage caused	Examples
Shoot and Tip Miners	damage current year shoot growth and leader, leads to forking, bushy trees	white pine weevil (Coleoptera) eastern pine shoot borer (Lepidoptera) European pine shoot moth (Lepidoptera)
Sap Suckers	can cause gall formation, foliage loss, dieback	spider mites (Acari) wooly and gall-making aphids (Homoptera) scale insects (Homoptera)
Defoliators	leaves skeletonized, mined, rolled	elm leaf beetle (Coleoptera) red-headed pine sawfly (Hymenoptera) larch sawfly (Hymenoptera) spruce budworm (Lepidoptera) tent caterpillars (Lepidoptera) hemlock looper (Lepidoptera) gypsy moth (Lepidoptera)
Phloem Feeders	trees girdled or killed by associated fungi	pine engraver bark beetle (Coleoptera) red terpentine beetle (Coleoptera) sugar maple borer (Coleoptera)
Root and Root Collar Feeders	girdling at root collar causes wilting, sometimes death	weevils in genus Hylobius (Coleoptera) cutworms (Lepidoptera) white grubs and wireworms
Cone and Seed Insects	cones small, drop early, seeds empty	cone beetles (Coleoptera) seed bugs (Hemiptera)

Silvicultural practices often effect the growth and development of forest pests. For example, the best practice to reduce damage from the white pine weevil is to manage white pine under an existing overstory (Katovich and Mielke 1993). White pine weevils tend to attack large, terminal branches, avoiding the smaller ones grown in shade. Sugar maple stands are more susceptible to extensive maple borer damage following heavy thinning or long term grazing (Coons 1987). The maple borer beetle creates galleries in the outer sapwood causing bark loss in the area of attack. Trees then become susceptible to breakage and rot.

The degree of damage to woodlands and individual trees caused an explosion in the population of wood-boring insects in the EOMF area after the ice storm in 1998. Bark beetles and many other wood-boring insects are known for their ability to locate and exploit severely stressed or injured trees (Schowalter 1988). Many bark beetles facilitate the dispersal of fungal spores into dead and dying wood, and salvage operations had to work quickly to avoid the spread of blue-stain and other fungi that would damage wood quality.

Insects and Other Arthropods as Predators and Parasites

Like the herbivores, arthropod predators and parasites have evolved to occupy all habitats. They prey on many different food items from insects and other arthropods, to molluscs and even vertebrates.

Probably the most well known of the predatory arthropods are the spider. Although they are commonly known for their web-spinning abilities, only 60 % of spiders actually construct webs or aerial traps for their prey. The others use hunting strategies such as ambushing their victims (e.g. crab spiders) or running down their prey (e.g. wolf spiders and jumping spiders). Lady beetles are another well known predator. They feed on aphids and other agricultural pests during both their adult and larval stages. Dragonflies catch their prey while flying, feeding on mosquitoes and midges. The nymph stage lives in water where it is a fierce predator on aquatic invertebrates. Giant water bugs (and predaceous diving beetles also feed on aquatic invertebrates and even tadpoles and small fish. Carabid (ground) beetles are active predators that feed on insects such as cutworms, caterpillars, beetle larvae and maggots and can be beneficial in controlling pests.

While many predators are generalists, some are specialized to hunt for specific types of prey. *Scaphinotus* ground beetles have a long, narrow head allowing the beetles to feed on snails through the opening in their shell. Hister beetles have flattened bodies, living beneath the bark of recently killed hardwoods, and preying on insects associated with dead wood.

Almost every species of arthropod is parasitized or eaten by at least one other species. Parasites tend to be smaller than predators and are usually smaller than their host in order to live off a small portion of the nutrients from the host per day (Price 1984). Parasites also tend to be more specialized than predators because of the need for special adaptations to live so closely with the host (Price 1984). Some examples of parasites are lice, fleas, ticks, bed bugs, parasitic mites, and bot flies. The most diverse group of insect parasites are wasps from the Ichneumonoid and Chalcidoid super-families (Price 1984). These wasps lay their eggs in the larvae of other insects, and when the parasitic larvae hatch they eat the host larvae from the inside out. Many of these parasitic species have hyperparasites that lay their eggs in the larvae of the parasites.

Biting flies are not really parasites because they just graze on animals, and never live on or in their bodies (Price 1984). Although species such as mosquitoes, black flies, deer flies, horse flies, no see-ums and stable flies are a nuisance to humans, they serve a critical role in the food chain. They provide food to many other insects and spiders, migrating songbirds and carnivorous plants such as sundews and pitcher plants (Schneider 1995). The larvae of blackflies and mosquitoes are aquatic and are an important component of the freshwater food chain, providing food for aquatic arthropods, frogs and many fish.

Predators and parasites play a huge role in controlling the populations of pest species. An estimated $20 billion US dollars is spent annually worldwide on pesticides for agriculture and forestry (Pimental et al. 1992). Predators and parasites living in these ecosystems are estimated to provide 5 to 10 times that value in pest control (Pimental et al. 1992).

Insects as Pollinators

Insect pollination facilitates the transfer of genetic material between individual plants of the same species. The relationship benefits both plant and insect as the insects are rewarded with nectar and pollen. Nectar from flowering plants contains a variety of sugars for energy, and pollen is rich in protein-making amino acids.

Flowering plants have evolved a range of characteristics to attract specific groups of pollinators. Variations include: colour, flower shape, smell, variety of nectar sugars and their concentration, and flowering period. For example, flowers pollinated by butterflies tend to be tubular, sweet smelling, pink or purple in colour, with ample sucrose-rich nectar (Howe and Westley 1988). Butterflies are able to access the nectar with their long proboscis. Flowers pollinated by hawk moths (a nocturnal species) are similar in shape to those used by butterflies, but are usually white or green and open up at night instead of during the day (Howe and Westley 1988). Flowers pollinated by beetles tend to be flat or bowl shaped and without nectar, with the beetles consuming large quantities of pollen as their reward.

Insect pollinators are responsible for pollinating orchards, many vegetable and field crops, and most native plant species. Over 40 crops in the U.S. (valued at approximately 30 billion annually) depend on insect pollination for production (Pimental et al 1992). Bees also provide products of commercial value such as honey and beeswax as a direct result of their role in pollination.

Biodiversity conservation

Species at risk

Conservation of arthropods is a relatively new area of science. Most of our efforts are being focused on pest management, battling the many introduced species, and working on our knowledge of the Canadian fauna (see Table 11). A few butterfly species are recognized as being "at risk" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and there are two species of concern in the Eastern Ontario Model Forest region. The West Virginia white butterfly is listed as vulnerable provincially. The species is at the northern distribution of its range in Ontario, but still quite common in parts of the United States (Royal Ontario Museum 2001). The Monarch is also designated as vulnerable by COSEWIC, but its status remains under review by the Ontario Ministry of Natural Resources (Federation of Ontario Naturalists 1998).

Introduced species
Over 1 500 species of insects have been introduced into the United States and Canada. Seventeen percent of these have become serious enough pests to require the use of pesticides (Pimental 1992). Some examples of major pests introduced into Canada are: gypsy moth, European corn borer, codling moth, European pine sawfly, larch casebearer, and the winter moth.

The Asian long-horned beetle and the emerald ash borer are two of the most recent and most serious introductions. The Asian long-horned beetle is native to Northeast Asia and attacks and kills healthy hardwoods such as maples, elms, poplars and willows (Natural Resources Canada 1998). It was introduced to North America via wooden shipping crates, the first outbreaks occurring in New York City and Chicago. In September 2003 an infestation was discovered between the Cities of Vaughan and Toronto. The emerald ash borer, also native to eastern Asia, attacks and kills all species of ash trees. It was first discovered in Canada in 2002 in the Windsor, Ontario Detroit Michigan area. Both of these insects are a serious threat to forests in Ontario. Because there are no natural controls to prevent their spread in North America, the Canadian Food and Inspection Agency is implementing aggressive campaigns to control the spread, and to eradicate, these pests. See http://www.inspection.gc.ca/english/plaveg/pestrava/pestravae.shtml for more details.

7. FUNGI

Introduction

Although fungi were traditionally included in the plant kingdom, they lack chlorophyll and are structurally very different from plants. Fungi are now recognized as a distinct kingdom, with approximately 100,000 described species and an estimated 200,000 more that have not been discovered or recorded (Lincoff 1981).

Fungi exist mainly in the form of slender filaments, called hyphae, which are barely visible with the naked eye. A mass of hyphae is called a mycelium and may be very extensive in size. All parts of a fungus are filamentous. Fungi lack chlorophyll and obtain their food by secreting enzymes into their substrate and absorbing the released organic material once the material is partially digested. They feed on both dead organic and living matter.

Species feeding on dead organic matter such as dead wood, leaf litter, carrion and dung are called saprophytes. Fungi species that feed on living organisms are referred to as parasitic fungi. Some examples of parasitic fungi are diseases of plants such as rusts and smuts, and fungal infections on humans such as athlete's foot. Fungi can also exist in mutualistic associations with other organisms. Lichens are a symbiotic association between fungi and algae and mycorrhizae are a symbiotic association between plant roots and fungi. A few species of fungi are predaceous, attacking and consuming small organisms. The oyster mushroom is able to prey on nematodes (small round worms) by anesthetizing the worms before enveloping them in hyphae and excreting digestive enzymes (Raven et al. 1986).

Most fungi produce spores of some kind which are spread by wind, water, animals, the movement of soil, or by infested plant material. Fungal spores are present everywhere, and along with bacteria, are the first to access a new resource. When a spore lands in a suitable environment it germinates and produces a germ tube, which then develops into a hyphal strand. The strand is able to branch, grow and spread. Hyphal strands grow at an extremely fast rate. It is estimated that within 24 hours, an individual fungus can produce greater than 1 kilometre of new mycelium (Raven and Johnson 1989).

There are three divisions of fungi, distinguished primarily by their sexual reproductive structures.

Zygomycetes:

- 600 species worldwide
- most live on decaying plant and animal matter in the soil
- some are parasitic on plants and animals
- a common species is black bread mould found on breads and fruit
- one of the most important groups is the genus *Glomus* (and related genera) which grow in association with plant roots forming mycorrhizae

Ascomycetes:

- 30,000 described species
- includes 350 species of yeasts, that are a critical element in bread, beer and wine production because of their ability to ferment carbohydrates and breakdown glucose into ethanol and carbon dioxide
- includes morels, common food moulds, truffles
- also includes several serious plant pathogens such as powdery mildew, chestnut blight, and Dutch elm disease
- lichens are generally a symbiotic partnership between ascomycetes and algae (a few are basidiomycetes)

Basidiomycetes:

- 25,000 described species
- includes the mushrooms, toadstools, puffballs, jelly fungi and rusts and smuts
- the basidiocarps or mushrooms that contain the reproductive spores in this group are the most visible and well known part of the Kingdom Fungi
- mushrooms are commonly considered the edible form and toadstools the poisonous form -but scientists do not use this distinction
- Mushrooms usually consist of a cap that sits atop a stalk; under the cap are rows of gills containing the spores

Fungi Imperfecti

There are another 25 000 fungi called Fungi Imperfecti that appear to have lost their ability to reproduce sexually. They are simply classified together because their reproductive strategies have not been observed. Most of the species are ascomycetes, a few are basidiomycetes. Among the more important genera are Penicillium (providing the well known antibiotic Penicillin) and Aspergillis (providing fermenting services). Most of the fungi that cause skin diseases in humans, including athlete’s foot and ringworm are Fungi Imperfecti.

Common fungi of Eastern Ontario forests

Slime Moulds
Most of their lives, slime moulds are hidden within rotting wood. When it is time to reproduce, they migrate (up to a metre or two) and climb objects from which they can disperse their spores. They then become visible on logs, stumps, or tree trunks as frothy yellow, white, or pink slime.

Sac Fungi
Members of this group produce their spores in a sac-like mother cell. Included in this group are:

- blue-stain fungus – which causes staining of logs
- cup fungi
- earth tongues
- morels – on the ground in woods
- false morel - poisonous

Puffballs
These mushrooms produce spores inside their bodies. Members include:

- puffballs – both giant and small
- earthstars
- bird's nest fungus – which looks like a tiny nest with eggs
- stinkhorn – with a strong odour to attract flies which distribute the spores

Jelly Fungi
The bodies of these appear to be made of jelly.

Coral Fungi
The coral fungi look like corals and produce spores on the outside of their bodies.

Tooth Fungi
Species in this group can take a number of forms. They produce spores on the outside of tooth-like spines.

Bracket Fungi
In bracket fungi the spores are produced in tubes which line the underside of the body. Examples include:

- polypores
- artist's conk – on living trees or recently cut hardwood stumps and logs
- turkey tail – on hardwood stumps and logs
- chicken-of-the-woods – on both coniferous and hardwood trees and stumps

Boletes
The boletes, or sponge mushrooms, have tubes like bracket fungi, but are soft and spongy.

Gill Fungi
Most common mushrooms belong to this group and bear their spores on gills under the cap. The colour of the spores can help in identification.

- shaggy mane – grows in grass in disturbed areas

- inky cap – on well-rotted wood
- amanita (death cap, fly agaric, destroying angel) – the best known of these are poisonous
- chanterelles – on the ground in woods
- fairy ring fungus – in grass
- oyster mushroom – on dead logs, stumps, or standing trees
- lactarius – bleed a milk-like fluid when cut
- russula – characteristically brittle, often red

Values

Together with bacteria, fungi are the major decomposers of the biosphere, breaking down organic material, releasing carbon dioxide to the atmosphere, and releasing nitrogen for recycling by plants. It is estimated that, on average, the top 20 centimetres of fertile soil contains nearly 5 metric tons of fungi and bacteria per hectare. One of the most significant activities of saprophytic fungi is the ability of many species to breakdown cellulose, hemicellulose, and lignin, structural components of plant tissues that most organisms are unable to utilize. Many fungi species are able to attack cellulose and hemicellulose components of all plants. However, far fewer species are able to decompose the lignin in woody tissues (Jennings and Lysech 1996).

Some fungi are extremely useful in the production of food products. Yeasts are essential in making bread, beer and wine. Other species are used in the aging of cheese and production of soy sauce and tofu. Fungi have also proved invaluable in the production of antibiotics and as a tool in cleaning up toxic substances in the environment.

Many species of fungi form mutualistic relationships with other species. Lichens are symbiotic associations of fungi and algae, which together have been able to colonize some of the harshest environments in the world. Ambrosia beetles and the ambrosia fungus also mutually benefit from their relationship. The beetles disperse the fungal spores to susceptible trees during their life cycle. The adult beetle bores deep into dead or dying wood to lay its eggs, inoculating the wood with the ambrosia fungus as it tunnels. The fungus then begins to grow, and as the beetle larvae hatch they feed on the fungus until they pupate and metamorphose to the adult stage. The adult beetle eventually exits the tree and moves on to find another suitable host tree.

Approximately four fifths of all vascular plants form associations, called mycorrhizae between their roots and fungi, a critical relationship for plant nutrition. Of the two major types of mycorrhizae, endomycorrhizae are by far the most common, occurring in about 80 % of all vascular plants. There are fewer than 100 species of endomycorrhizae which form relationships with a wide variety of vascular plants. In endomycorrhizae, the fungus penetrates the cortical cells of the plant root, where they form coils, swellings, or minute branches. The fungal hyphae also extend several centimetres into the surrounding soil. There are approximately 5000 species of ectomycorrhizae, associated primarily with trees and shrubs in the beech, willow, and pine families. The fungus forms a sheath around the root of the tree, but does not penetrate the root cells. The mycelium extends into the soil and transports nutrients to the plant. Ectomycorrhizal associations are generally very specific, with each fungal species being associated with a single plant species.

Fungi and plant disease

Many fungi attack living organisms. Well over 5,000 fungi species attack economically valuable crops, garden plants and trees as well as cause serious diseases in humans and domestic animals. Fungi cause most tree diseases. This accounts for more volume loss per year than both insects and fire (Myren 1994). Insects, however, are the leading cause of tree mortality (Myren 1994).

Table 13 lists some common diseases of trees in the Eastern Ontario Model Forest region along with recommended management techniques for dealing with outbreaks. Because of the rapid colonization ability of fungal spores, it is important to limit the damage from felling and skidding in your woodlot during any harvest operations.

Table 13. Some fungal infections of trees in the EOMF

Disease	Symptoms	Management
White pine blister rust	On eastern white pine with *Ribes* (currants) as alternate hosts. Fungus kills inner bark and recently formed wood, girdling and killing branches	Prune and burn diseased branches / trees.. Remove *Ribes* within 300m radius of pine. Manage young white pine under an existing overstory to reduce moisture and rust.
Armillaria root rot	Common on pine, spruce, poplar, maple, oak, balsam fir. Girdles trees at root collar, kills roots.	Control is very expensive but removal of old stumps can reduce spreading .
Fomes root rot	On white, red, Scots and jack pine root rot and death to seedlings and larger trees, infected trees prone to windthrow.	90 % of infections are started in freshly cut stump tops. Borax application immediately after cutting will reduce spread of the fungus.
Dutch elm disease[1]	Fungal spores carried from tree to tree by bark beetles initially causing vascular damage and wilt, and eventually death	Promptly remove dead and dying trees. Kill beetles in baited traps. Chemical treatment can be injected through root system.
Black knot	On black cherry and ornamental cherries and plums Black cankers on trunk and branches	cut and remove all diseased branches approximately 15 cm back from the knot in late fall
Leaf spot (variety of fungal species)	Variety of hardwood species Discolouration, spotting on leaves	More of an aesthetic problem. Raking and destroying infected leaves in fall.
Powdery mildew	On poplars and willows white, velvety growth on both leaf surfaces, black fruiting bodies in fall	fungicides pruning to increase air circulation in and around plants
Beech bark disease[1]	On American beech A scale insect infestation followed by a fungus causing cankers / deformation	Disease can be slowed by vigorous selective cutting and removal of infected stems during early stages of outbreaks

Disease	Symptoms	Management
Nectria canker -	On poplar, basswood, beech, birch , maple Canker with ridges of callus which are often concentric or target-shaped	Remove affected trees if widespread in stand (>20 % of crop trees), regeneration of more resistant species should be encouraged to
Eutypella canker	On maple (primarily sugar and red) - Canker on the trunk, with well-defined area of dead bark, surrounded by callus entry point for decay fungi, breakage	Remove infected trees during thinning Remove larger trees when fruiting bodies appear on canker to reduce infection of others in the stand
Ambrosia fungus	Spread by ambrosia beetles which tunnel deep into the wood and feed on the fungus at both larval and adult stages Wood is deeply stained by the ambrosia fungus	Beetles generally attack dead or damaged trees, and can degrade material recently felled for lumber by introducing staining fungi; Cutting / drying wood shortly after felling is essential to deter infestation
Butternut canker[1]	Affects healthy as well as stressed Fungus kills inner bark, forming cankers eventually girdling and killing branches Kills most trees that become infected	No effective control Monitor for resistance in remaining trees
[1] **Introduced species**		

8. MAMMALS

Introduction

The relatively extensive forest cover within the Eastern Ontario Model Forest (EOMF) region provides excellent habitat and viewing opportunities for many mammals. Some of these larger animals travel over several kilometres in a couple of days while others live their entire lives within a single woodlot. Approximately 47 native mammal species are found here, with an additional 2-3 species of introduced mammals.

Some common mammals of the EOMF

Table 14 lists the common mammals of the EOMF by recognized families, based on similar anatomical characteristics. With the exception of the smaller species such as ., mice, voles, and bats, most mammals of the region are fairly easy to identify when seen.

Animals that are easy to see such as squirrels, chipmunk, groundhog, white-tailed deer, raccoon, porcupine, beaver, muskrat, and cottontail rabbit tend to be numerous, active during some daylight hours, and found in relatively close proximity to humans. The remainder, the smaller species such as mice, voles, shrews, moles, and bats, and the more elusive carnivores (e.g., red fox, coyote, fisher, marten, ermine) are only observed incidentally. These species are primarily nocturnal, often wary, and are usually found in low densities. However, with a little patience, and some knowledge about the mammals of interest, they can be successfully observed. The best way to see them is to look for them in areas where you find animals signs such as tracks, *scat,* hair or browsed vegetation and to concentrate you efforts on the hours of dusk and dawn. During winter months, when food is scarce, predators can sometimes be seen during daylight hours.

Table 14: Families and species of mammals found in the EOMF

Family	Species	Distinguishing characteristics
Soricidae (shrews)	Masked shrew, smoky shrew, water shrew, pygmy shrew, and short-tailed shrew	Insectivores; small size, very active, eat insects, teeth usually have reddish color
Talpidae (moles)	Star-nosed mole, hairy-tailed mole	Insectivores; most of life spent below ground; tunnelling creates mounds and ridges on surface
Vespertilionidae (plainnose bats)	Little brown bat, big brown bat, silver-haired bat, long-eared bat, red bat, hoary bat	Insectivores; nocturnal, roost by day singly or in colonies; some migrate, some hibernate in region
Sciuridae (squirrels)	Red squirrel, grey squirrel, northern flying squirrel, southern flying squirrel; groundhog, eastern chipmunk	Rodents; groundhog and eastern chipmunk are only ground squirrels found in region, but can also climb trees
Castoridae (beavers)	Beaver	Large flat tail, world's second largest rodent; important furbearer
Cricetidae (mice, rates, lemmings, voles)	White-footed mouse, deer mouse, southern bog lemming, red-backed vole, meadow vole, muskrat	Smallest rodents in region; staple of carnivore diets; muskrat has value as furbearer
Muridae (Old World rats and mice)	Norway rat, house mouse	Introduced rodents; found around human dwellings
Zapotidae (jumping mice	Meadow jumping mouse, woodland jumping mouse	Rodents; hibernate during winter; move quickly by jumping
Erithizontidae (porcupines)	Porcupine	Rodent; many road-killed, vocal in fall rutting season
Leporidae (hares and rabbits)	Eastern cottontail rabbit, snowshoe (varying) hare, European hare	Rodents; staple in many carnivore diets
Cervidae (deer)	White-tailed deer, moose	Lower incisor teeth are absent; most important game animal in region
Mustelidae (weasels, skunks, otters)	Striped skunk, marten, fisher, ermine, long-tailed weasel, mink, otter	Highly efficient predators; mink, marten, fisher, otter have economic value as furbearers
Ursidae (bears)	Black bear	Omnivore; hibernates; poor vision but exceptional sense of smell; very fast over short distance
Procyonidae (raccoons, coatis)	Raccoon	Omnivore; dens during cold spells but not a hibernator; some furbearer value
Canidae (dogs, wolves, foxes)	Red fox, coyote	Food predominantly small rodents and rabbits/hares, but also eat variety of other foods; excellent senses of smell, hearing, and sight; furbearer value
Felidae (cats)	Bobcat, lynx, feral cat	Purely carnivorous; highly secretive and elusive; bobcat may be slowly increasing in region

Some rare / uncommon mammals in the EOMF

There are several uncommon species found in the region. Table 15 lists some of these species, their respective rarity rankings, and where they are most likely to be seen. The status of some of these species is extrapolated from historical and trapping records and from observations and studies by experts and species specialists.

Table 15: Some uncommon woodland mammals in the EOMF

Species	Habitat	Rarity ranking
Black bear	Forests, forest/field edge	Provincially common but uncommon in EOMF
Southern flying squirrel	Hardwood forests	COSEWIC- vulnerable; S3
Fisher	Large forests; forest/field edge; forest/wetland edge	Provincially common but uncommon in EOMF; appears to be currently increasing in some parts of region
Marten	Large forested areas; forest/field edge	Provincially common, but very uncommon in EOMF; may be increasing in some part of region
Bobcat	Forests, swamps, fields	Provincially common but very uncommon in the EOMF; may be increasing in numbers here
Lynx	Forests, swamps	Provincially common but uncommon in the EOMF
Moose	Forests, swamps, lake shorelines	Provincially common; Uncommon in EOMF but populations in Larose forest, Alfred Bog- some individuals periodically wander
Eastern pipistrelle	Wooded areas near water	Provincially uncommon; S3

Explanation Of Status Designations
COSEWIC- Committee On The Status Of Endangered Wildlife In Canada
Natural Heritage Information Center Designations: S3- Rare To Uncommon In Ontario; 20-100 Occurrences In The Province

Factors contributing to species richness

Several specific factors help to determine the species richness of mammals, including:

- Diversity of vegetation
- Soil depth, texture, and drainage
- Topography, surface terrain, aspect
- Presence of water
- Animal corridors
- Size and context of woodland
- Landscape
- Level of disturbance

A good diversity of vegetation attracts many small herbivores, virtually assuring the presence of some of their predators. Presence of conifers encourages small mammals because of the winter thermal protection these stands provide. In winter, when snow makes moving around difficult , predators also hunt in areas with cedar, hemlock, fir, spruce, and pine.

Soil depth, texture, and drainage influence where *fossorial* animals are found. Burrowers such as moles and groundhogs usually avoid woodlands with shallow, stony soils over solid bedrock. They prefer deeper, lighter, moderately fresh, loams because shallow, heavy, coarser, or water-saturated soils discourage their digging.

Woodlands with a variety of surface features such as ridges, cliffs, rock outcrops, talus slopes, and large downed woody debris attract many mammals. These features encourage the development of different species of vegetation such as blueberries that attract foraging deer, fox, coyote, raccoon, bear, and other animals. Larger animals such as bear, deer, and coyote prefer to travel along ridges. In winter they like to sun themselves on ridges and cliffs, or rest in these areas because they provide good views in several directions. Large brush piles and logs attract mammals looking for denning sites. Although caves are uncommon in the EOMF region, some may be extremely important to regional populations of hibernating bats.

Woodlands with water such will usually support more species of mammals than similar woodlands without the presence of water. Some species are mainly aquatic (e.g., muskrat, beaver, otter, mink), while other regularly visit *riparian* areas, looking for food (e.g., fisher, bobcat, coyote, raccoon). Water bodies also contribute greatly to vegetation diversity, which in turn provides a variety of habitat for mammals.

The presence of animal movement corridors adds to the species richness of a woodland. These pathways allow animals to move safely across the landscape. Often they are small and narrow corridors such as fencerows, little-used paths, unopened road allowances, railway tracks, creeks, or vegetated shorelines.

Larger woodlands may support greater species richness, but only if a variety of habitats are present. Large areas covered by few tree species (e.g., plantations) normally are not attractive to many wildlife species.

Woodlands surrounded by forested land tend to support more forest species than those bordered by disturbed landscapes. The latter also tend to attract more opportunistic mammals such as raccoon, coyote, and fox that can prey on many mammals found in woodlands.

Normally reclusive mammals such as coyote, fox, bear, and weasel are less evident in woodlands where human activities are common. This is especially true if such activities occur during critical times of the year (e.g., rearing time, winter). Human or vehicular traffic near den sites will cause animals to move their young or leave the area completely. Regular snowmobile travel near or through areas that shelter wildlife in winter can stress animals and cause them to leave. If logging is heavy, the resulting stand may be sufficiently changed to discourage animals dispersing from other areas to take up residence. In addition, harvest damage and ill-placed roads and skid trails can destroy important wildlife habitat.

Values

The economic and recreational value of several mammals is readily apparent. Some mammals such as beaver, otter, mink, muskrat, and fisher are fur-bearers providing trappers with a financial return for their efforts. For example, in 1997, the value of pelts from Ontario trappers was about $3,908,500. In the Kemptville district alone, some 455 trappers purchased $17,000 in licenses, trapped 6,498 beaver which brought $11,046.60 in royalty fees for the fur bearers sold on the open market. (J. McKenzie, pers.com.)

Hunting also provides substantial economic benefits. In 1997, deer hunters alone accounted for $4,160,000 in licence sales. New hunters, about 10,000 per year, spend about $50,000 to participate in Hunting Education courses (J. McKenzie, pers.com.) These hunters also spend a considerable amount of money purchasing ammunition, hunting gear, meals and refreshments, and gas for their vehicles.

Mammals can provide recreational opportunities as well. More and more people are enjoying wildlife viewing. Beavers create ponds that provide places to canoe, fish, hike, and picnic.

Woodland community ecology

Mammals found in woodland communities are typically adapted to the environmental conditions found there. Some animals are members of more than one type of community. For example, water shrew, beaver, and mink are members of both woodland and wetland communities.

Community maintenance

Mammals, like other organisms, serve to maintain *community structure* and stability by providing a critical process in the system, or supporting other important interactions. The snowshoe hare and the fox are keystone species in woodlands because of their important contribution to the *trophic* structure. The hare is a food resource for the fisher; the fox preys on the more numerous voles.

Females of many small mammals (e.g., rabbit, voles, mice) produce multiple litters, thereby supplying an abundant supply of food for a variety of predators. When feeding in the canopy, squirrels nip off branches and acorns. Some of these fall to the forest floor where they are consumed by other animals (e.g., white-tailed deer, fox, wild turkey).

Many mammals contribute to the health of forest communities and ecosystems by controlling the populations of other species, which when too numerous, can weaken ecosystem stability and health. For example insectivores such as moles, shrews, and bats, control insect numbers by consuming them at all stages of their life cycle. Many predators help to control herbivores such as mice, voles, and rabbits. Their browsing damage on small shrubs and trees would be considerable if it were not for predators such as fox, coyote, and weasels. An absence of the grey wolf, has aided the expansion and proliferation of white-tailed deer throughout the region. Perhaps eastern coyotes can fill the *niche* vacated by the wolf.

Numerous small mammals help to cycle nutrients and aerate the soil. Mice, voles, and especially shrews and moles dig holes and tunnel just under the soil surface, thereby helping incorporate oxygen, water, and organic material from above the ground into subsurface layers. Black bears tear apart stumps and rotten logs hastening their decomposition and the subsequent return of nutrients to the soil.

Habitat creation

Some keystone species change the habitat in which they are found. When beavers convert streams into ponds they change the flow rate of the water, level of water tables, and many other habitat characteristics including nutrient dynamics, sedimentation rates, channel geomorphology, and biogeochemical cycles. This changes habitat availability for terrestrial and amphibious species.

Burrows dug by groundhogs and foxes may be used by other animals such as chipmunks, snakes, and American toads.

Seed dispersal

Smaller mammals such as mice, voles, chipmunk, and squirrels help to disperse the seeds of numerous plants. Squirrels and chipmunks bury nuts from mast-producing trees such as oaks and hickories for later consumption. Many of these will germinate and grow into trees. Mice and voles often take a berry to a safe location to eat the pulp and leave the seed behind.

Species interactions

Predation

Both predator and prey species have evolved adaptations and strategies in order to survive. Some predators such as raccoon, skunk, and fox feed opportunistically on whatever local food / prey supplies is available throughout the year. This approach minimizes their vulnerability to fluctuations in food supply (e.g., vole population crash). Others such as coyote, fisher, and marten make use of patches of habitat where prey is abundant, especially during winter months. By finding and then spending most of their time near these habitat patches (e.g., clumps of conifers, rodent snow tunnels), they save energy at a time when colder weather and snow cover increase their energy expenditures.

Shrews are among the most interesting predators in this region. Their high metabolic rate obliges them to be almost constantly hunting for food. Without a constant supply of food, they can die quickly. The short-tailed shrew is found in a variety of habitats and eats insects, worms, snails, and other invertebrates. A predatory adaptation, poisonous saliva, helps this animal survive. As the shrew bites its prey it injects venom that paralyzes it. Because the prey is only paralyzed, not killed, its metabolism is still functioning and it can be stored for future use without fear of spoiling.

Prey species have evolved their own defences against predators. Many smaller mammals such as mice, voles, and chipmunk stay close to protective cover, scurrying into hiding at the least hint of danger. By staying in tunnels, voles can forage more freely during winter, while remaining unexposed to predators. Camouflage is a common defence used by prey species. When snowshoe hares moult to their characteristic white winter color it provides a dual function. It provides effective camouflage against the snow and allows more heat absorption through the skin. Darker hair would result in most of the light being absorbed at the surface of the coat, away from the body, where it could be quickly lost to the environment.

In winter, white-tailed deer *yard* together, spending more time in areas with coniferous cover. This concentration not only increases their chances of surviving the effects of cold temperatures and deep snow, but also reduces predation. In yarding areas adjacent to foraging areas, individuals can spend more timing feeding and less time watching for predators.

Competition

Intraspecific competition results in several phenomena, including dominance hierarchies, territoriality, and emigration. For example, periodic competition for a limited supply of food or cavities causes squirrels to leave woodlands in search of unutilized resources.

Dispersion of the young is common to most wildlife species. It helps to ensure genetic mixing and occupation of all suitable habitats. However, in their search for areas not occupied by their own species, many relatively inexperienced raccoon, beaver, and other animals must travel through territories already occupied by others that may attack and even kill them. The successful animals will seek to avoid *conspecifics* and establish their own territories.

Mammals avoid direct *interspecific* competition by eating different foods, occupying different habitats, being active at different times, or generally avoiding each other. In the EOMF, most predators have home ranges that overlap. Mid-sized carnivores such as fox, coyote, fisher, and bobcat may compete for the same food resource (e.g., local rodent population), particularly when food is scarce. These animals avoid each other whenever possible by leaving scent and signs along their travel routes, or by moving around their *home ranges* at different times. In winter, it is fairly common to see tracks of one of these species approach, and then turn directly away from the tracks of another species.

Commensalism

Mammals are involved in several commensal relationships. Mammals such as fox and coyote dig dens that are later used by other species for shelter or dens. Others such as raccoon and fisher use abandoned bird nests in which to rest. Predators such as coyote use the flocking behaviour of crows and ravens to locate animal carcasses.

Mutualism

There are numerous mammal species that have a mutualistic relationship with plants. The animals obtain a meal of fruit, the seeds in the fruit pass through their digestive system and are deposited elsewhere, therefore benefiting the plant by dispersing its seeds.

One of the most interesting and important relationships involves the woodland jumping mouse. This small rodent eats fungi that grow underground, some of which are *mycorrhizal fungi*. The mycorrhizae are critical to the growth of some trees and can therefore have an impact on overall forest health. The mouse distributes the spores of the fungus, enabling other trees of the same species to associate with the mycorrhizal fungus.

Biodiversity conservation

Changes in mammalian diversity

Increased urbanization, and the loss and *fragmentation* of forest cover, wetlands, and grasslands have had impacts on mammalian diversity of the EOMF. Populations of some mammals appear to be somewhat cyclical; highly visible species such as snowshoe hare, fox, and coyote vary in number over time and space. White-tailed deer populations continue to grow in this region, due in part to an absence of predators, a series of mild winters, and abundant food. Coyote populations are currently increasing and they may prey on deer, especially during the winter months.

A few animals are making a comeback in the region. Residents in the EOMF region regularly observe fisher and black bear, marten are occasionally seen. Little is known about many populations of rodents and insectivores, largely due to their small size and secretive nature. Table 2 lists some uncommon species in the EOMF.

Major conservation concerns affecting biodiversity

Habitat fragmentation

The smaller patches of habitat that are a result of fragmentation are often unable to sustain certain members of the community over the long term. Mammals such as black bear, that require extensive ranges of forested land, will likely not survive over the long term in a landscape consisting of a mosaic of small woodlands.

Isolated forest patches may function as *sink habitats*, threatening some populations with *extirpation*. For example, snowshoe hares dispersing into suboptimal habitats because of *intraspecific* competition may not find enough food or cover, or may fall easy prey to predators. Over time, such sink habitats could cause declines in the local population as more hares move into these areas.

Edge effects

Increased edge habitat can have negative impacts on community residents, including some mammals. Over time, the changes in temperature, humidity, soil moisture, and infiltration by sunlight common in edge habitats could lead to changes in species composition. Some species such as woodland jumping mice, masked shrew, and red-backed vole may slowly disappear because of loss of canopy cover. Others may be more vulnerable to predation by raccoons, skunks, foxes, feral cats, and other animals that hunt in and close to edge habitats.

Size of woodland

Area-sensitive species such as black bear, lynx, and fisher usually require at least 25 ha of woodland habitat to sustain long term populations. These animals often travel many kilometres in search of food and suitable resting areas. Also, some small mammals such as red-backed voles are somewhat area-sensitive, preferring larger stands with dense forest canopy and coarse down woody debris. Reduction of the area of woodlands across the EOMF will have negative impacts on these species and will encourage species that are more tolerant of fragmented forests and edge habitats such as white-tailed deer, raccoons, and skunks.

Habitat heterogeneity
Across the EOMF, woodlands of different ages, successional stages, and species composition and structure all contribute to native biodiversity. Some mammals such as the marten appear to require older stands with a significant conifer component. Others such as white-tailed deer do better in early to mid-successional stands with abundant herbaceous and understory vegetation. Flying squirrels prefer mature woodlands with numerous large, deciduous trees. Numerous mammals such as the fisher, coyote and deer use several different woodland types. For some predators, the physical structure of the woodland may be most important since the availability of their prey is largely dependent on it.

Context
As mentioned in earlier sections, the location of a woodland within the larger landscape can affect biodiversity. Human activities in adjacent disturbed habitats directly affect the diversity of mammals in the woodland**.** Creation of trails and roads increases populations of opportunistic predators. Domestic cats can prey on small mammals, and dogs may harass squirrels, deer, and other animals. As a result, there may be gradual decline in species richness. In general, interconnected woodlands with gradual transitions to different habitats are more valuable to mammals and other wildlife than insular woodlands with abrupt edges bordering on croplands or roads.

Connectivity
Animals populations need to be able to safely disperse to find mates and food, reproduce, and escape threats to survive. Woodland mammals such as the fisher and marten avoid crossing large, open areas. A study in eastern Ontario discovered that small mammals such as chipmunk and white-footed mouse were reluctant to cross open fields between forest patches, probably because of the threat of predation by birds of prey, foxes, coyotes, and other predators (Wegner and Merriam 1979). In the fragmented forest landscapes of the EOMF region, maintaining and enhancing natural corridors important to various mammals (and other wildlife) can help to conserve both local and regional biodiversity.

9. FERNS

Introduction
Ferns are a diverse group of plants that retain many of the characteristics present when plants first moved from the sea onto land over 400 million years ago. They have a unique life cycle, without flowers and seeds. Approximately 45-50 species are found in the EOMF area.

Life cycle of ferns
The life cycle of ferns is one of the most interesting in nature because it involves 2 generations- *sporophyte* and *gametophyte.* It is the *diploid*, sporophyte generation that most people recognize. Briefly, ferns produce spores that develop into gametophytes. The gametophytes produce the new fern plants.

The sporophyte generation
In summer, tiny greenish specks appear on the undersides of the fertile fronds. They mature rapidly, turning into dark brown spots called *sori*. Sori are tiny masses of spore cases, or sporangia, which contain the *haploid* spores. When the spores are ripe and conditions are

dry, the spore case opens and expels the spores. A dry wind helps the spores to disperse, giving them an opportunity to land on suitable sites. The spores of the common marginal shield fern develop into gametophytes in about 2 weeks. These gametophytes develop into new young ferns after about 3 ½ months.

The gametophyte generation

If a spore is blown to a suitable location, it grows into a group of cells called the *prothallus*. The *prothallus* has *rhizoids* that absorb water and minerals from the soil, archegonia (or female sex organs) that produce a single egg, and antheridia (or male sex organs) that form swimming sperm.

If moisture is plentiful, the corkscrew-shaped sperm use their cilia to swim to the archegonia. The sperm usually travel to an archegonia that is located on another prothallus because the two kinds of sex organs on the same prothallus rarely mature at the same time. The archegonia exude a chemical that attracts the sperm. Fertilization results in a new diploid sporophyte generation. The embryo sporophyte grows a foot that penetrates the prothallus to obtain nourishment until it becomes self-sufficient. Afterwards, it grows a root down into the soil, and a stem upward that produces the first small leaf. Eventually multiple leaves, stems, and roots develop, and the fern is ready for the next cycle.

Some common ferns of the EOMF

While many of the most common ferns grow in several different habitats, others are more restricted. Table 16 lists common species found in the region and the habitats with which they are often associated. As compared to other vascular plants, there are relatively few species of ferns, making it much easier to find and learn most of them.

Table 16: Some common ferns in the EOMF

Habitat	Species	Distinguishing characteristics
Rich woods – usually moist, shaded conditions with deeper, fertile soils	Maidenhair fern (*adiantum pedatum*)	Often a large fern; delicate, lacy, layered appearance; whorled growth form, almost parallel to the ground
	Christmas fern (*Polystichum acrostichoides*)	Usually large evergreen fern, lustrous rich green tapering leaves growing in bouquet-like clusters; leaflets holly-like, shaped like Xmas stockings; conspicuously green in winter; also found in more open woods
	Silvery spleenwort (*athyrium thelypterioides*)	Tall, dull green fern, with short, stubby, hairy stalks; underside of fronds have a silvery appearance
Moist to wet areas (e.g., seeps, woodland depressions, pond edges)	Marsh fern (*thelypteris palustris*)	Medium-sized fern arising periodically from an elongate *rhizome*
	Sensitive fern (*onoclea sensibilis*)	Medium-sized fern with broad, leathery triangular leaves (not delicate or lacy); wand-like

Habitat	Species	Distinguishing characteristics
		spore stalks conspicuous in winter
	Cinnamon fern (*osmunda cinnamomea*)	Tall arching fern with vase-like growth habit and circular growth clusters Has one of the largest rhizomes of any Canadian fern.
Open woods- e.g., forest openings, glades, roadsides; more sunlight, drier, with more grasses, sedges	New York fern (*Thelypteris noveboracensis*)	Yellow-green, usually growing in small colonies of 3 or more leaves to a clump and scattering through areas where found; double taper to the blades of the frond
	Bracken fern (*pteridium aquilinum*)	Easily recognized; large, triangular blade; forms colonies
Rocky habitat (e.g., rock walls, talus, granitic outcrops, rock fissures; often little or no soil)	Rock or common polypody (*Polypodium virginianum*)	Small, robust, evergreen; commonly seen growing in large colonies on rocky talus and slopes, boulders, and ledges.
	Rusty woodsia (*woodsia ilvensis*)	Small, easily over-looked; grows in tufts in dense mats; light green with silvery white undersides turning rusty brown in fall and during dry seasons
	Fragile fern (*cystopteris fragilis*)	Small, bright green fern; fragile, delicate appearance; often found on moist, shaded cliffs
Ferns of a variety of habitats (most common ferns in EOMF)	Lady fern (*athyrium filix-femina*)	Usually large lacy-cut fern growing in circular clusters; unlike wood ferns, stalks are usually smooth or with just a few pale scales
	Marginal shield fern (*dropteris marginalis*)	Medium-sized fern; leathery, evergreen, dark green growing in scattered individual clumps; conspicuously green in winter; sori located on the margins of the leaves
	Spinulose wood fern (*Dryopteris carthusiana*)	Medium-sized to large, usually evergreen fern; lacy-cut leaves arise in circular clusters; very scaly stout stalks; similar to lady fern but appears more robust

Some rare / uncommon ferns in the EOMF

Several species of ferns such as goldie's fern typically exist only at low densities in the woodlands of the EOMF. Table 17 lists a few rare or uncommon species found in the EOMF region that can be readily identified.

Table 17: Uncommon ferns in the EOMF

Habitat	Species	Distinguishing characteristics
Rich woods – usually moist, shaded conditions with deeper, fertile soils	Narrow-leaved spleenwort (*Athyrium pycnocarpon*)	Tall, slender, pale green fern; narrow-leaved, growing in circular clusters of 5-6 leaves from each rootstock.
	Goldie's fern (*dryopteris goldiana*)	Largest fern (fronds up to 1 m long); golden-green, coarse, backward-tilting leaves
Moist to wet areas (e.g., seeps, woodland depressions, pond edges, moist cliffs)	Bulblet fern (*cystopteris bulbifera*)	Long, narrow streamer-like leaves with fine dissections, small round bulblets on lower leaf sides; also found on moist cliffs
	Long beech fern (*phegopteris connectilis*)	Distinctive triangular blades, lowest pair of leaflets drooping downward and outward
Open woods (e.g., forest openings, glades, roadsides); more sunlight, drier, with more grasses, sedges	Leathery grape fern (*Botrychium multifidum*)	Small, easily over-looked, grows close to ground, rubbery feel to frond
	Hay-scented fern (*dennstaedtia punctilobula*)	Usually found in large colonies with little other vegetation growing among it; distinctive odour; brittle, yellowish-green fronds, erect or somewhat arching
Rocky habitat (e.g., rock walls, talus, granitic outcrops, rock fissures; often little or no soil)	Ebony spleenwort (*asplenium platyneuron*)	Easily recognized- small, narrow fern with stiff, upright fronds and shining dark stems and axis; usually seen as 1-3 plants, sometimes as small colony
	Walking fern (*camptosorus rhizophyllus*)	Easily recognized- small evergreen fern with long, narrow, tapering and arching leaves

Factors contributing to species richness

Several factors help to determine the species richness and composition of ferns one encounters in a woodland including:

- Soil moisture and pH
- Topography and aspect
- Level of canopy closure
- Level of disturbance
- Nature of adjacent landscape
- History, including past management

Some ferns grow on moist, almost water-saturated soils (e.g., sensitive fern, royal fern, interrupted fern, ostrich fern); others prefer slightly damp soils (e.g., fragile fern); and still others seem to prefer drier, almost droughty soils (e.g., bracken fern, rusty woodsia). Woodlands that have a variety of soil moisture conditions provided by such habitats as seeps, swamps, dry openings, and rocky outcrops, tend to support a higher species richness of ferns.

Many species of ferns such as walking fern and smooth cliff-brake are more commonly encountered on more basic soils. For this reason plant species richness can be quite high on parts of the Frontenac Axis east of Kingston, and in northwest Lanark County where there are pockets of more alkaline soils (i.e., higher pH).

Variety and aspect of the terrain features in an area also contribute to species richness. Usually woodlands found on sites with varying surface terrain provide more habitat for a greater variety of plants than do woodlands on flat terrain. Many ferns grow on cliffs and rock outcrops, as well as in cool depressions, seepage and drainage areas. Some ferns prefer cooler, moist northern exposures while others prefer warmer, drier south-facing slopes. Woodlands with both north- and south-facing landforms tend to have more species than those with only one or the other. In addition, varying surface terrain interacts with local climatic conditions, creating microclimates favourable to some plants that are not found in other parts of the woodland.

The level of canopy closure also affects fern species richness and composition. Many species, including fragile fern and maidenhair fern are not usually found in, or do poorly in sunny, open conditions. Others such as sensitive fern and bracken fern appear to thrive in these areas. Species richness also increases dramatically in woodlands with openings and water bodies such as creeks and ponds. Many plants thrive in these areas due to increased sunlight.

Disturbance affects species richness by creating conditions that favour some species and discourage others. When trees fall down or are removed, drier and brighter conditions are created at the forest floor causing many ferns that require more shaded, moist conditions to disappear. The same can occur when patterns of drainage are disrupted creating drier conditions within woodlands.

The nature of the adjacent landscape influences species richness of a woodland. For example, large woodlands surrounded by predominantly agricultural land experience little infiltration by outside plant species. However, small woodlands that border on residential areas and marginal farmland often have numerous species more commonly associated with these more open places. Normally, woodlands situated within a larger forested landscape tend to support fewer such species, as well as fewer non-native species.

The history of the woodland and surrounding landscape also determine current species richness and composition. For example, woodlands that have been fairly recently grazed by livestock tend to have fewer species than woodlands where grazing has never occurred. Recently logged woodlands may exhibit lower or higher species richness, depending on when the logging occurred, and how extensively and carefully it was conducted.

Values

Many ferns have wide-spreading roots and rhizomes, and horizontal leaves that aid in soil and slope stabilization, add moisture to the soil, and help to prevent soil erosion. They may also build soils where none exist by their decomposition, by their *stoloniferous* growth, by the capture in their fronds of other organic material such as leaves, and by the ability of some of them to do well in marginal areas.

Some people eat the young leaves of some species such as cinnamon fern. The wiry roots and *rhizomes* of cinnamon fern are often used in greenhouse orchid culture as a germination medium called osmundine (Eastman 1995). Ferns are also used for decorations, ornaments, fertilizer, and medicines. In the U.S., crested wood fern and purple cliff-brake are used to expel parasitic worms from the stomach and intestinal tract (R. Allen 1999).

Woodland community ecology

Many ferns of the EOMF are restricted to wooded areas; others are members of several different communities (e.g., woodland, wetland, old field).

Community maintenance

Understory plants, including many ferns, contribute to the maintenance of *community structure* and stability. A variety of ferns creates both vertical and horizontal structure, providing important wildlife habitats. Their foliage serves to moderate the microclimate on and near the ground by providing shade and by slowing heat loss at night. Foliage also helps to protect soils from erosion by absorbing the impact of raindrops and from dehydration by reducing sunlight infiltration. The roots of ferns help to stabilize soils, especially on slopes and along open edges of woodlands, streams, and other water bodies. Ferns with networks of large rhizomes also create soil structure, increase soil aeration, and retain moisture

Provision of food

Although ferns are probably not major wildlife food, the evergreen fronds of some of the wood ferns provide an important winter food for ruffed grouse and white-tailed deer. Some small mammals eat the fiddleheads (emerging fern leaf or frond) of cinnamon and royal ferns . White-tailed deer consume rattlesnake fern. Numerous insects also make use of ferns. For example, in late summer and fall, the osmunda borer moth caterpillar and the sensitive fern borer moth feed in the stems and rhizomes of royal and cinnamon ferns. Later in the season they emerge as stout-bodied, orange-winged noctuid moths (Eastman 1995).Ferns provide food indirectly to other animals by providing habitat for their prey. In addition, decomposers or *detrivores* break down the organic matter of the ferns, thereby making organic nutrients available for uptake by other plants in the community.

Provision of habitat

Some of the larger ferns such as cinnamon, interrupted and ostrich ferns often form large thickets that provide excellent cover habitat for small mammals and birds. Several species of birds including veery and brown thrasher sometimes nest in or near the center of fern clumps. Yellow warblers use the downy wool from cinnamon fern to line their nests. In some woodlands, ferns also form an important layer of vegetation just above the ground, adding vertical complexity and habitats that contribute to species richness. Ferns also help to maintain the shaded, moist conditions and microclimates of woodlands that are important to many salamanders and interior forest habitat birds.

Species interactions

Predation

Over time, plants, including ferns, have evolved structures, adaptations, and strategies that help to ensure their success. The fronds and the rhizomes of ferns are usually coated with hairs or scales that serve as defence against fern predators, including ants, crickets, beetles, slugs, nematodes, and fungi. Many ferns produce tannins that inhibit digestion, are relatively resistant to pathogens, and decompose slowly.

Bracken fern, a common plant in the EOMF region, is a very successful fern, found worldwide. It can become so dominant that it excludes herbaceous plants. In Southern California, Gliessman and Muller (1978) discovered that *phytotoxins* leached by rainfall from dead, standing bracken fronds, were largely responsible for this herb suppression. Some bracken fern produces toxins that discourage grazing by some herbivores.

Competition

Many ferns compete successfully by growing in marginal habitats where other plants do poorly or cannot survive. They have evolved adaptations for holding and forming soils for their own benefit and, incidentally, for the benefit of the communities in which they are found. Ferns such as rusty woodsia and smooth cliff-brake may reduce or avoid *interspecific* competition by growing in small rock crevices (and on rocks) where few other plants can survive. The crevices also shelter the plants, minimizing significant fluctuations of climatic and microclimatic factors, and help to collect organic material.

Other ferns, including royal, cinnamon, and ostrich ferns, can grow in dense stands that provide a competitive advantage to them. Other plants have a harder time becoming established, particularly after the fern fronds have flattened out across the ground, forming a dense mat. Their stiff, upward growing fronds and thick rhizomes effectively capture rainwater and organic matter, further enhancing their advantage over competitors.

Commensalism

One of the most evident *commensal* interactions in the woodlands of the EOMF involves ferns that provide cover for ground nesting birds such as winter wren, dark-eyed junco, veery, hermit thrush, and white-throated sparrow. Another fern, common polypody, occasionally grows in crotches of trees where moisture and organic matter collect.

Mutualism

The *mycorrhizae* of certain fungi are associated with the roots of rattlesnake fern and adder's tongue. The fungi benefit by taking nourishment from the roots of the fern, while the ferns use nutrients absorbed by the fungi.

Biodiversity conservation

Changes/loss of understory plant diversity

Invasion of woodlands by exotic species such as garlic mustard, dog-strangling vine, and glossy buckthorn also may be responsible for losses of some native flora, including ferns.

Major conservation concerns affecting biodiversity

Habitat fragmentation

Roads, trails, and drainage ditches can sufficiently change environmental conditions within woodlands to threaten the survival of populations of sensitive plant species. For example, if a road diverts a small creek, ferns growing in that area may be lost.

Small patches of habitat that are a result of fragmentation may function as sink habitats for some fern populations.

Edge effects

Many ferns require cool, moist conditions. Others, such as the rattlesnake fern require a certain amount of shade. If logging or other activities create new edge habitat, environmental conditions (e.g., temperature, humidity, soil moisture, sunlight) may change sufficiently to cause a decline or loss of some local fern species.

Habitat heterogeneity

A variety of woodlands at different successional stages and of different ages, with varied tree species composition and structure, helps to maintain fern species richness.

Context

Development on adjacent lands can have negative impacts on woodland vegetation. Trampling, vandalism, and plant collection damage local woodland plant populations including ferns.

Invasive species

As with other native understory species, invasive introduced species such as glossy and common buckthorn , dog strangling vine Dames' rocket, and purple loosestrife can out compete and displace native fern species found in the same habitats.

10. MOSSES AND LICHENS

Mosses

Mosses are one of three classes of bryophytes, with the other two being liverworts and hornworts. The common characteristic of bryophytes is the slender, usually colourless projections called rhizoids which anchor these simple plants to their substrate.

Many groups of plants contain members that are commonly called "mosses". Reindeer moss is lichen, club mosses and Spanish mosses are vascular plants, and sea moss and Irish moss are algae. Unlike vascular plants, mosses generally lack specialized vascular tissue including true leaves, stems, and roots. Mosses do have leaf and stem-like structures, called gametophytes. Gametophytes of mosses are almost always leafy, with small, simple leaves which may be tufted or creeping. Moss leaves are found in three rows, spirally arranged around the stem, with the leafy branches appearing flattened in the creeping species. Sporophytes, the spore-producing structures, grow as branches off the gametophytes.

There are three subclasses of mosses:

True Mosses

- there are 10,000 different species of the family Bryidae
- these mosses have leafy gametophytes with small, simple leaves that are either erect with few branches or are feathery in form
- common species found in eastern Ontario include:
  - Ciliate ledwgian moss: also known as witches hair
  - Common hair cupmoss: at one time used for bedding
  - Nodding pohlia moss: with shiny, orange-red stalks and nodding capsules, found on rotten logs
  - Common four-tooth moss: with a stem that often ends in a bowl like cluster of leaves and erect capsule with four teeth at the mouth
  - Ringed dog moss: may appear green or brown but it always has a yellowish tinge
  - Lawn moss: forms dense, woolly mats that look like green lawns on tree bases
  - Common fern moss
  - Schreber's moss: with big red stems

Peat Mosses

- there are 350 species in the genus *Sphagnum*
- the stems of their gametophytes bear clusters of branches, often five in a node, which are densely tufted near the apex of the stem forming a "mop" like head
- the leaves lack midribs and mature plants lack rhizoids
- tend to grow in boggy places, where they always grow turgid, erect, and packed together
- their water holding capacity is up to 20 times their dry weight
- a conservative estimate of the extent of peat bogs is 1 % of the world's surface
- common species found in eastern Ontario include:
  - Wulf's peat moss: with its large, distinctive clover-like heads
  - Common brown peat moss: normally found at the top of old, dry hummocks

Common green peat moss: the most common peat moss which can be recognized by its flat, spreading branches

Granite Moss

- only 100 species in the genus *Andraceae*
- small, blackish-green or dark reddish-brown tufted rock moss
- primarily found in the arctic and mountainous regions

Of the estimated 550 species of mosses found in eastern Canada, 430 are found in Ontario (Ireland and Cain 1975).

Because mosses do not have roots they have evolved unique strategies for survival. Some mosses are aquatic, and other are confined to moist areas. Others have the ability to dehydrate during dry periods and then resume normal metabolic activity once moisture is returned. Still others have evolved to be able to colonize rock and bark which are impenetrable to roots of higher plants (Richardson 1981).

Mosses play a key role in early plant succession, forming the substrate for other species. Species such as sugar maple use moss as a prime moist seed-bed for regeneration. Mosses can also limit the regeneration of many species such as yellow birch and hemlock.

Modifying water regimes will have serious impacts on mosses present in a woodland. Logging may expose moist areas directly to the sun's rays, affecting future moisture availability. Drought tolerant species will be favoured under these conditions over species requiring humid, moist conditions. Reforestation efforts can also affect moss species by changing tree species composition. Planting conifers such as white and red pine in areas formerly occupied by mixed woods can alter soil pH, impacting a variety of moss species.

Peatlands have evolved since the last glaciation period. They develop in places that are water-soaked throughout the growing season. Bogs and fens are the only types of wetlands that can develop as peatlands, as they are water soaked throughout the growing season and plant growth generally exceeds decomposition (Crum 1988). Other wetlands such as marshes, sedge meadows and swamps tend to have aerated soils, are subject to fluctuating water levels, and have more rapid decomposition rates (Crum 1988). Sphagnum is the key plant for deep, rapidly accumulated peat formation. Sphagnum flourishes in habitats with uncommonly low inorganic ions. It maintains a low pH by releasing hydrogen ions that encourage acid conditions which not only inhibit competition from other plants, but also inhibit microbial decomposition. Peat moss deposits tend to be restricted to bogs, where sphagnum dominates under a shrub or tree layer typically composed of black spruce or tamarack. Peat deposits in more mineral-rich fens, fed by nutrient-rich ground or surface water, are characterized by the accumulation of grasses and sedges under a shrub or tree layer (Crum 1988).

The 5000 hectare Mer Bleue Bog and the Alfred Bog are examples of the extensive peatlands found in eastern Ontario

Importance of mosses

Peat is famous for its ability to hold water. It is a useful product for gardeners, and an industry has developed to harvest and produce peat moss. It can also be dried and burned as a fuel, or used for decoration.

Peat bogs are reservoirs of water which can be returned to the atmosphere during dry conditions. Bogs create unique conditions for wildlife, creating a haven for rare species of all types. Orchids in particular, such as the southern twayblade, are bog specialists. Alfred Bog harbours a large moose population, while Mer Bleue has gray jay, sandhill Crane, and spotted turtle. The Richmond Fen has its own rare bird, the yellow rail.

Lichens

There are 20,000 species of lichens, found widespread throughout the world. Three hundred and seventy species have been identified within a 30 mile radius of Ottawa. (Brodo 1981).

Lichens are symbiotic associations between fungi and either green algae or *cyanobacteria*. The most visible portion is the fungus, which cannot grow normally without its photosynthetic partner, the algae. The algae provides the nutrients, while the fungi provide protection from the extremes in the environment. This successful partnership allows lichens to live in some of the harshest habitats in the world. They are found growing on bare soil, tree trunks, and sun-baked rocks.

Lichens are often strikingly coloured, occurring in colours such as white, black, red, orange, brown, yellow, and green. The pigments in lichens probably play a role in protecting the photosynthetic partner (algae) from the destructive action of the sun's rays. At one time, these pigments were used as natural dyes (e.g. in manufacturing Harris tweed).

Lichens are able to survive in inhospitable habitats partly because they are able to dry or freeze to a condition that we might call suspended animation. Once the drought or cold has passed, the lichens recover quickly. In harsh environments, with growing periods of only a few weeks, their growth may be extremely slow. Many relatively small lichens appear to be thousands of years old and are among the oldest living things on earth.

There are three subgroups of lichens based on differences in growth form.

- Crustose lichens: These lichens are crust-like in form and often have hyphae that grow into the stone or bark they are attached to.
- Foliose lichens: These lichens form like leaves, with a clear difference between the upper and underside.
- Fruticose lichens: This group includes stalked, shrubby and hair-like forms.

Importance of lichens

The importance of lichens can not be overstated. As pioneers, they form the first soil on rock surfaces. Lichens, in which the photosynthetic partner is *cyanobacteria*, are especially important because they fix nitrogen from the air for use by the lichen. Some of the nitrogen is leached into the environment and is used by other pioneering species. Lichens also facilitate the breakdown of rocks by secreting chemicals that erode rock directly. Soil eventually accumulates around the base of the lichen, and the improved nutrient-rich environment eventually gives way to mosses, and vascular plants (Raven and Johnson 1989). Lichens are also important as valuable food sources for a great variety of small and large animals (from snails and beetles to caribou).

Lichens are a valuable food source for a great variety of small and large animals (from snails, beetles, flying squirrels, and the red-backed vole, to deer, elk, moose, mountain goat, and caribou). Many terrestrial arthropods also eat lichens.

Over 50 species of birds are known to use lichens for nesting material. The northern parula warbler in particular is closely associated with lichens. The northern flying squirrel builds its nests largely with *Bryoria*, the horsehair lichen. Some insects cover their backs with lichens for camouflage.

Lichens are extremely sensitive to pollutants in the atmosphere because of their ability to absorb substances dissolved in rain, in dew, and directly from the air. For this reason they can be used as bio-indicators of air quality. Because they have no way to excrete substances once they have been absorbed, toxic compounds tend to concentrate in their tissue (Raven and Johnson 1989). The toxins are particularly harmful to the photosynthetic partners, damaging chlorophyll and other metabolic compounds. Sulphur dioxide is particularly harmful, quickly destroying limited supplies of chlorophyll in the lichens (Raven and Johnson 1989). Lichens are generally absent in cities and their surrounding areas because of the high sulphur dioxide levels released from automobile traffic and industrial activity. Arctic lichen absorption of radioactive dust from the Chernobyl nuclear disaster in 1985 rendered the meat of reindeer feeding on those lichens unsuitable for human consumption for some time.

An abundance of lichen growth can be used as an indicator of undisturbed old-growth forest conditions. Monitoring programs using lichens provide an assessment of forest management and of air quality.

Lichens can change the reflectivity of soil surfaces from a heat-absorbing, drought-inducing dark brown, to a reflective gray. They have been introduced in some areas to improve soils for tree planting operations.

People have used lichens for food, decoration, dyes, medicines, poisons, and fibers. More recently they have been used to make perfumes and antibiotics. Because lichens grow slowly at known rates, they can be used to date artefacts and exposed rock surfaces.

Lichens can have negative impacts on human activities. Hair lichen provides egg-laying habitat for the destructive hemlock looper moth. Some lichens can inhibit beneficial soil fungi and lower the germination rate of certain seeds. Lichen growth can damage statues and gravestones.

11. THE FOOD DECOMPOSITION WEB

Introduction

Soil is a very diverse biological community, considered by some as an ecosystem on its own. The primary input is dead plant material, ranging from leaves and fine roots, to large logs. Bacteria, fungi and invertebrates break this material down into soil organic matter and decomposition by-products (e.g. plant nutrients, carbon dioxide, and water). The following describes the variety of organisms and the roles they play in this breakdown process.

Variety and values

Canadian soil contains representatives from all five kingdoms, nine animal phyla, and all known types of microorganisms:

Kingdom Monera- blue green algae and bacteria

Kingdom Protista- protozoa (*e.g.* amoeba)

Kingdom Fungi- true fungi and slime moulds

Kingdom Planta- algae, bryophytes, and vascular plants

Kingdom Animalia
- Phylum Platyhelminthes- flatworms
- Phylum Nematoda- nematodes
- Phylum Acanthocephala- parasitic worms
- Phylum Nematophora- parasitic worms
- Phylum Rotifera- wheel animals
- Phylum Mollusca- slugs and land snails
- Phylum Annelida- earthworms
- Phylum Arthropoda- spiders, mites, sowbugs, centipedes, millipedes, insects
- Phylum Chordata- amphibians, reptiles, mammals

Bacteria and fungi: the Soil Microbial Biomass

Soil microbial biomass (SMB) averages about 5 tonnes/ha (2 tons/acre). It is made up of bacteria, blue green algae, true fungi, and slime moulds. The primary food source of the SMB is decaying vegetation. The rate that decaying vegetation is converted into microbial biomass is largely dependent on the vegetation being shredded and mixed with soil by larger organisms such as mammals. Assuming this shredding and mixing is done, decomposition occurs in two stages. First, shredded leaves and soil fauna feces are rapidly mineralized and absorbed into the microbial biomass itself. Bacteria rapidly reproduce and grow, absorbing plant sub-components. Fungi extend hyphae into the decaying vegetation, absorbing nutrients and materials into its system. Very few nutrients are actually available to plants at this time; most are tied up in the microbial biomass itself. The second stage of decomposition is the slower *mineralization* of the microbial biomass and the more resistant plant residues such as wood and bark. As the microbial biomass dies back after its initial feeding frenzy, or as it is eaten by other soil animals, nutrients become available for plants. The SMB is a nutrient storage mechanism in soil, preventing saturation of the soil with nutrients in the fall when plants are dormant, and reducing loss of nutrients through *leaching*. Table 18; shows the distribution of nitrogen in the Boreal forest. The organic soil strata contains humus and SMB.

Table 18: Boreal forest nitrogen breakdown
(from Larsen 1980)

Estimated maximum amounts of N in kg/ha

Location	Amount (kg/ha)
Canopy	200-300
Boles	150
Branches	150
Roots	150
Ground Flora	25
Organic soil strata	700-4000
Mineral soil strata	0-2500

Turnover of nutrients in SMB takes an average 1.5 years, as opposed to the 1000's of years it takes to turnover soil *organic matter* (Voroney et al. 1989; Hendrix et al. 1990; Brookes et al. 1990; Jenkinson and Ladd 1981).

Nematodes

Nematodes are small white worms that are very abundant in soil; population estimates range from 8,100/m^2 to 30,000,000/m^2. Soil nematodes have a wide variety of feeding habits, feeding on decaying organic matter, bacteria, fungi, protozoa, and other nematodes. Some nematodes are parasites of plants. Nematodes are important in releasing plant nutrients from the SMB. Studies have shown that soil with nematodes have higher bacterial densities than soil without nematodes. Plants grown in soil with bacteria and bacterial feeding nematodes were found to grow faster than plants in soil with only bacteria (Yeates 1979; Ingham et al. 1985). This benefit of nematodes may be due, in part, to a grazing effect that will be covered in subsequent sections.

Earthworms

Earthworms are among the largest soil fauna, and have a variety of influences on soil fertility, structure and hydrology. Earthworms are instrumental in the breakdown of decaying plant residues. Decomposition is promoted by:

- fragmentation and mixing of plant residues into the soil
- digestion of bacteria and fungi releasing nutrients
- stimulation of fungal spore germination during digestion
- transportation of micro organisms in feces.

Plant residues have been found to breakdown 25-35% faster when earthworms are present, as compared to when no earthworms are present. Earthworms have been found to increase mass and depth of plant roots, plant height, mass of foliage, and yield of barley plants (Edwards and Lofty 1980; Shaw and Pawluk 1986a; Zachmann and Linden 1989; MacKay and Kladivo 1985; Ghilarov 1963; Shaw and Pawluk 1986b; Vimmerstedt and Finney 1973; MacFayden 1968).

Earthworms also influence soil physical and structural properties. Earthworm burrowing increases the rate of water infiltration into soils. The burrows act as stable and continuous *macropores* conducting large volumes of water away from the soil surface (Ehlers 1975; Baeumer and Bakermans 1973; Lal 1988). Soil structure is enhanced by earthworm feces, which contain clay-bound neutral sugars that attract and bind soil particles together (Shaw and Pawluk 1986a).

Soil arthropods

Soil arthropods are primarily mites and springtails. Mites have a variety of feeding habits including microbivory (eating the SMB), saprobivory (eating rotting plant material), omnivory (eating bacteria, fungi and algae), and carnivory (eating springtails and nematodes). The SMB, springtails, and mites are analogous to a grazing food chain above ground. Moderate levels of herbivore grazing by animals such as buffalo or zebra on grasslands typically stimulates grass growth. In a similar fashion, springtail and mite grazing on the SMB stimulates SMB growth. Lions and other predators keep herbivore populations in check on the plains of Africa, a necessary role as excessive grazing reduces grass production and could result in a herbivore population crash. Carnivorous mites perform a similar role to the lions, decreasing springtail and bacterial and fungal grazing nematode populations (Santos et al. 1981; Elkins and Whitford 1982). Fungal grazing mites may also increase decomposition rates by browsing on *senescent* hyphae, stimulating fungal growth. Selective grazing may also alter the structure of microbial communities (Santos et al. 1981; Mitchell and Parkinson 1976). Springtails often preferentially feed on fungi, increasing bacterial proportions in the SMB (Hanlon and Anderson 1979).

Cryptozoic arthropods

Cryptozoic arthropods are those that live on the soil surface, and include sowbugs, centipedes, millipedes, insects, spiders, and slugs (not an arthropod). These animals have a wide variety of feeding habits.

Sowbugs feed primarily on living and decaying plant tissue, and fungi. Fungal feeding by sowbugs on *senescent* hyphae is believed to stimulate fungal production (Peterson and Luxton 1982; Richardson and Morton 1986).

Slugs also feed on both living and decaying plant tissue, and fungi. In one study, slugs were found to consume 8% of annual leaf litter input. The resulting feces are high in moisture and nitrogen and stimulate microbial growth (Peterson and Luxton 1982; Jennings and Barkham 1979).

Spiders, carabid and staphylinid beetles, and harvestmen are common predators on the soil surface eating a variety of smaller animals.

Millipedes feed on fungal hyphae in dead plant material, and on partially decomposed plant material, fragmenting large pieces of litter in the process, making them more accessible to microbes and other small decomposers (Birch and Clark 1953).

Abundance in the ecosystem

Relative abundance for the broad organism groups just discussed is provided in Table 19. Although abundant, ranging from 20-72 pounds/acre, soil fauna do not even approach the abundance of the soil microbial biomass (2 tons/acre). This is typical of every ecosystem; grazers and predators are always far less abundant than primary producers.

Table 19: Biomass estimates for soil microflora and fauna groups in different biomes

Group	Common name or example	BIOME							
		Temperate grassland		Temperate coniferous forest		Temperate deciduous forest mor		Temperate deciduous forest mull	
		mg/m^2	lbs./acre	mg/m^2	lbs./acre	mg/m^2	lbs./acre	mg/m^2	lbs./ac.
Protozoa	amoebas	200	1.8	200	1.8	200	1.8	200	1.8
Nematoda	nematodes	440	3.9	120	1.1	330	2.9	330	2.9
Enchytraeidae		330	2.9	480	4.3	430	3.8	430	3.8
Collembola	springtails	90	0.8	80	0.7	130	1.2	110	1.0
Cryptostigmata	mites	110	1.0	450	4.0	700	6.2	180	1.6
Mesostigmata	mites	60	0.5	80	0.7	40	0.4	40	0.4
Protostigmata	mites	40	0.4	30	0.3	10	0.1	10	0.1
Total Acari	mites	120	1.1	500	4.5	900	8.0	300	2.7
Large Oligochaeta	earthworms	3100	27.6	450	4.0	200	1.8	5300	47.2
Diplopoda	millipedes	1000	8.9	50	0.4	420	3.7	420	3.7
Diptera larvae	fly larvae	60	0.5	260	2.3	330	2.9	330	2.9
Isoptera	sowbugs	1	0.0	1	0.0	1	0.0	1	0.0
Chilopoda	centipedes	140	1.2	70	0.6	130	1.2	130	1.2
Carab.+Staph.	beetles	80	0.7	120	1.1	90	0.8	90	0.8
Araneae	spiders	30	0.3	50	0.4	40	0.4	40	0.4
Gastropoda	slugs	100	0.9	20	0.2	270	2.4	270	2.4
Formicoidea	ants	100	0.9	10	0.1	10	0.1	10	0.1
Total		5800	51.7	2400	21.4	3500	31.2	8000	71.3

Modified from Peterson and Luxton 1982

Decomposition of the leaf litter

Decomposition of plant residue results from a synergistic relationship between invertebrates and microflora. Excluding invertebrates from residue reduces the rates of breakdown and nutrient release. This is a result of the Soil Microbial Biomass (SMB) no longer being stimulated. The SMB can also immobilize nutrients; grazing by invertebrates releases them. Fragmentation of litter increases the surface area of fresh substrate for SMB growth. Soil fauna accumulate potassium and sodium, and immobilize nitrogen and phosphorus. These nutrients are subsequently released for plant growth when the animals die (Peterson and Luxton 1982).

Mull and Moder are terms that describe the decomposition pattern of leaf litter in forest ecosystems in Canada and the northern U.S.

Mull

The Mull profile is very simple, a leaf litter layer above a layer of topsoil. Mulls typically develop on fertile soils in warm areas under deciduous forests. They become increasingly more common as you move towards southwestern Ontario. In the fall, deciduous trees drop their leaves forming a fresh leaf litter layer on the surface of the soil. This layer is immediately colonized by the SMB, but it can't do much with the leaves in this form. Fall is a peak period of earthworm activity, and large earthworms begin to shred the leaves, dragging small pieces back into their burrows to eat. Once in the earthworm's gut, and subsequently in the feces, the SMB really start to grow as the leaves are partially digested and moistened. Once the SMB takes off, the grazers and predators also rapidly increase. Earthworm activity ceases over the winter but picks up again in the spring. By mid-summer the majority of the leaf litter is gone from the surface of the soil leaving only mineral soil horizons. Soil fauna that feed on the SMB will release nutrients to plants over the spring and summer. By the fall the cycle is ready to begin again.

Moder

Moder profiles are the most common soil profile in eastern Ontario. They are typically found on moderate to low quality sites (soils of low-moderate fertility, poor or rapid drainage) under mixed forests. Moder profiles are also found under coniferous trees on average to above average quality sites. Earthworms also play an important role in Moder profiles, but they do not remove the majority of the leaf litter from the soil surface. Instead, the leaf litter accumulates over time in three distinct layers: an undecomposed litter layer, a partially decomposed litter layer, and an earthworm feces layer. When leaf litter falls to the ground, it is colonized by the SMB, which slowly starts to break the leaves down. This process generally takes more than one year, resulting in the distinct undecomposed leaves above partially decomposed leaves. Once the leaves are partially broken down, earthworms, different from those found in mull systems, eat both the partially decomposed leaves and soil along the mineral soil/leaf litter boundary. The result is a layer of earthworm feces which are very rich in nutrients and high in moisture. This layer is easily seen in the field, as it contains polished white sand grains, which are cleaned as they pass through the earthworms' gut. Feeding by the earthworms, and subsequently by grazers and predators, releases nutrients for plant growth.

Humus formation

Plant residues are made up of a variety of compounds; some of which are easily degraded, others that are not. Carbohydrates, proteins, hemicellulose and cellulose are relatively easily broken down by the SMB and soil fauna activities.   Lignins, fats, turpines, and waxes are very slow to break down. During the breakdown process, the SMB synthesizes complex chemicals that are resistant to breakdown following the death of the organism. These resistant plant components combined with the resistant SMB constituents are the building blocks of humus. Less than 1% of organic material added to the soil is left as humus (Brady 1984).

Humus in soil is made up of humic and fulvic acids which are very resistant to breakdown. Under natural conditions, individual humus particles may be stable for thousands of years. Human activities such as plowing and site preparation for tree planting may speed up the rate of humus breakdown through mixing and oxidation.

Landowner impacts

The soil decomposition food web is a resilient stable system, which is generally only significantly affected by large-scale disturbances such as prescribed burns and site preparation following clearcuts. Although private landowners generally do not undertake such ambitious projects in eastern Ontario, there are other more common activities that can affect the long term fertility of soils.

Topsoil removal

The majority of nutrients in the soil are in the organic and A horizons (the leaf litter and black soil layer). When these layers are removed for quarries or aggregate removal, building construction, or for sale, the ability of the soil to retain nutrients and process new organic matter is greatly reduced. The addition of soil amendments such as biosolids can help to offset these losses.

Whole tree harvesting

Whole tree harvesting removes considerably more nutrients from a site than removing only merchantable stems does (Table 19). Forest soils do not have the capacity to fix large amounts of nitrogen as some leguminous agricultural crops do, nor are forested soils fertilized as cropland is. Removing excessive nutrients from a forested site will degrade the site over time. In Europe, aesthetics and a fuelwood shortages encouraged the removal of wood down to 1" twigs. This practice has been going on for centuries, and records are now showing a significant decline in tree growth over 4-5 rotations (cutting cycles). Careful thought should be put into any management plan that encourages whole tree harvesting. The more vegetative material that can be left on the site, the better the long-term fertility and tree growth should be.

Planting trees to protect and revitalize fragile sites

In the late 1800's and early 1900's, much of the forested land of eastern Ontario was cleared for agriculture. Areas with fine silt and sandy soils were not suited to row crops because they were very vulnerable to wind erosion. Limerick and Larose Forests were two such areas. Wind removed the majority of topsoil and along with it, the nutrients. No longer fit to farm, many of these farms were soon abandoned or forfeited for taxes. The Ministry of Natural Resources planted red and white pine on many of these blowsand sites under the Agreement Forests Program in the 1930's and 40's. . Red and white grew well on these low fertility sites, and eventually stabilized the soil. Over time, their needle litter built up a Moder profile on the surface of the soil. This organic material is slowly adding humus to the soil and the sites are gradually returning to their natural state. The Moder profile is well developed, but the A horizon is only weakly developed with low amounts of humus and low natural fertility. It will take hundreds of years to rebuild humus to its previous levels.

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13. GLOSSARY

Abiotic: The non-living components of the environment such as air, water, rocks, soil, and plant litter.
Alien: Referring to a species which is non-native or which does not originally live in an area; synonymous with exotic.
*Anthropogenic habitats***:** Refers to habitats that are highly altered or created by the activities of humans.
Area sensitive: Refers to species that require relatively large habitats and that, over the long term, do not do well in smaller habitats.
Biotic: Pertaining to any aspect of life, especially to characteristics of populations and communities.
Buffers: Areas of native vegetation (either naturally occurring or planted) that help to protect natural areas from disturbance, primarily of human origin.
Calciphile: A plant that prefers soil or water high in calcium or lime.
Cambium: A layer of growing tissue between the xylem and phloem or the inner bark and the wood of a tree.
Canopy closure: The degree that tree canopies overlap limiting light onto the forest floor. 90% canopy closure is equal to 10% of the canopy being open and allowing light into the stand.
Canopy trees: Trees receiving direct sunlight from above on two sides of the crown or more. These trees are the tallest in the stand.
Climax community: Stable end community of succession that is capable of self-perpetuation under prevailing environmental conditions.
Commensalism: A form of symbiosis between two partner species in which one species benefits and neither is harmed.
Community: A collection of all populations of species interacting with one another in the same environment; all organisms living in a particular habitat and affecting one another as part of the food web or through their various influences on the physical environment.
Community structure: The various horizontal and vertical physical elements of a community as determined by the type of species present and their relative abundance in the community.
Conspecifics: Individuals of the same species.
Controlled burning: The planned application of fire with the intent to confine it to a specified area and produce certain planned and desired benefits; synonymous with prescribed burning.
Corridors: Strips of habitat connecting isolated habitat patches or landscapes
Cyanobacteria - A photosynthetic bacteria, generally blue-green in color and in some species capable of nitrogen fixation. Cyanobacteria were once thought to be algae. Also called blue-green alga
DBH: Diameter at breast height; a tree measurement which is the diameter outside of the bark at 1.3 metres from the ground.
Detritivore: Any organism that obtains most of its nutrients from the detritus in an ecosystem.
Diploid: Having two of each kind of chromosome (except for the sex chromosomes).
Ecosystem: The collection of all living things, plus the nonliving environment, within a prescribed place at a particular time.
Edge effects: Ecological changes that occur at the boundaries of habitats, communities, or ecosystems.

Ephemeral: Lasting a short time. The spring ephemerals are a group of woodland wildflowers which bloom before tree leaves block sunlight from the forest floor.
Evapotranspiration: The process in which moisture evaporates from the surfaces of plant leaves and water is drawn up the stem from the soil to replace it.
Exotic: Referring to a species which is non-native or which does not originally live in an area; synonymous with alien.
Extirpation: Elimination of a species from a particular area; local extinction; a species or sub-species disappearing from an area without becoming extinct throughout its range.
Fossorial: Refers to digging or burrowing.
Fragmentation: The process by which areas (e.g., woodlands, habitats) are increasingly subdivided into smaller units, resulting in greater insularity and loss of area of each individual fragment.
Fresh: Soil moisture conditions under which tree growth is ideal. Part of a moisture regime scale going from driest to wettest: DRY-FRESH-MOIST-WET
Fronds: Leaves of ferns.
Gametophyte: The gamete-producing, usually haploid generation in the life cycle of a plant.
Guilds: Groups of species within a community that exploit the same set of resources in a similar manner, but are not necessarily closely related taxonomically.
Haploid: Having only a single set of chromosomes (n) as is present in gametes (haploid reproductive cells).
Herbaceous: Refers to non-woody plants that die to the ground at the end of the growing season.
Herbivory: The consumption of plant material (usually living) by an organism.
Herptiles: Collectively, reptiles and amphibians.
Hibernacula: Plural of hibernaculum – the place of hibernation, usually referring to reptiles.
Home ranges: The home region of an animal, having a flexible, undefended boundary.
Hyphae: Long, threadlike branching bodies that constitute the mycelium of a fungus.
Indicator: A species or habitat measurement used to predict site quality and characteristics.
Interior habitat: Habitat for interior species.
Interior species: Refers to species requiring habitat which is found primarily or only distant from the borders of a specific habitat (e.g., forest).
Interspecific: Among different species.
Intraspecific: Among individuals or populations of the same species.
Invasive: Referring to a species which spreads rapidly into a new area; may be native or non-native.
Irruption: A rapid increase in the number of individuals of a species due to migration or reproduction.
Keystone species: A species that plays a critical role in an ecosystem and upon which a large part of the community depends; its effect is disproportionately large relative to its abundance.
Layer: The process in which an undetached branch of a plant, lying on or partially buried in the soil, sprouts roots and is capable of independent growth as a new plant.
Leaching: The removal of materials in solution from the soil by percolating waters.
Macropores
Mast: Fruit or nuts produced by trees and of some value to wildlife as food.
Masting: The production by trees of large amounts of seed in order that all cannot be consumed by seed-eaters.

Mesic: Refers to a habitat, soil, or site that is moderately moist, and that is not excessively dry or wet.
Metapopulation: A population of populations, all of the same species; each individual population within a metapopulation is referred to as a local population.
Mineralization: The conversion of an element from an organic form to an inorganic state as a result of microbial decomposition.
Mutualism: A form of symbiosis between two partner species in which both of them benefit.
Mycelia: Plural of mycelium - threadlike mass of a fungus from which arise reproductive fruiting bodies.
Mycorrhizae: Plural of mycorrhiza - a mass of fungus hyphae often found in symbiotic association with vascular plant roots; can refer to the symbiosis itself.
Mycorrhizal fungi: Fungi found in symbiotic association with vascular plant roots.
Omnivores: eat both plant and animal matter
*Natural disturbance: F*ires, storms, floods, droughts, tree falls, insect damage, beaver activity, herbivory, soil disruption by mammals
Naturalization: The process of allowing natural regrowth of plants.
Niche: The place or role of a species within its ecosystem.
Parasites- organisms that live on or in another organism of a different species, and take nutrients from it
Parasitism: A form of symbiosis between two species in which one benefits (the parasite) and the other is usually harmed.
Passerines: A taxonomical term referring to the perching birds.
Phytotoxins: Toxins produced by plants.
Pioneer species: Species that first colonize a site after a large disturbance. These species are usually fast growing and produce large quantities of highly mobile seed.
Populations of concern:
Predator: organisms that kill and consume more than one animal in their lifespan
Prescribed burn: The planned application of fire with the intent to confine it to a specified area and produce certain planned and desired benefits; synonymous with controlled burn.
Prothallus: Free-living gametophyte of ferns.
Raptors: Refers to birds of prey (e.g., owls, hawks, falcons, eagles).
Regeneration: The growth of young trees generally less than 10 cm in diameter, and less than 10 m tall, or the young trees themselves.
Resource partitioning: The differential use by organisms of resources such as food and space.
Rhizoids: Thread-like outgrowth from a gametophyte of ferns, mosses, liverworts, usually serving to anchor the plant and absorb nutrients and water.
Rhizome: An underground, usually horizontal rootlike stem producing stems and roots; a rootstock.
Riparian: Pertaining to the edges of water bodies and courses; usually refers to vegetation or habitat in these areas.
Saprophyte: An organism which feeds on dead organic matter.
Senescent: Fungal hyphae in decline or resting until the next food source becomes available.
Shade intolerant: Describes trees which cannot survive in shaded conditions typically found in a forest understory.
Shade tolerant: Describes trees which can survive under low-light conditions typical of a forest understory.

Sink habitats: Areas where local reproductive success of a species population is less than its local mortality; without immigration from other areas, populations in sink habitats usually become extirpated.
Scat: Animal feces, dung, or droppings.
Shrub: A woody plant branching at or near the base and without a distinct single trunk.
Soil organic matter: The organic fraction of soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population.
Sori (plural of Sorus): Clusters of sporangia bearing the spores.
Sporophyte: An individual of the diploid generation in the life cycle of a plant.
Stick nest: A platform of sticks constructed by some bird species (particularly raptors) for nesting.
Stoloniferous: Producing stolons- elongate stems that creep over the surface of the ground.
Subcanopy trees: Trees which receive direct sunlight from above from one side of the crown or less; growing under the main canopy.
Sub-climax: A climax community which cannot quite perpetuate itself without disturbance, but site conditions will not allow it to proceed further through succession.
Sublimation: Changing state directly from solid to gas. Snow sublimates directly from tree branches into water vapour.
Succession: Progressive changes in species composition, organic structure, and energy flow of a natural community over time.
Supercanopy: Referring to a tree which extends well above the main forest canopy.
Symbiotic: Relating to symbiosis - the intimate coexistence between dissimilar organisms, literally, “living together”; includes mutualism, commensalism, and parasitism.
Trophic: Pertaining to nutrition and its processes.
Trophic structure or dynamics: Describes pathways by which nutrients and food energy move through community members (e.g., plants, herbivores, carnivores, detritivores); often represented by food chains and food webs with links among the various levels.
Turnover: The movement of nutrients from one state to another, for example, from the soil microbial biomass to solution in mineral soil.
Vascular plants: Plants characterized by their internal vascular tissue that enables them to attain stature and strength, as well as conduct water and nutrients from the soil to the topmost leaves.
Yard

APPENDIX 1: IMPORTANT HABITATS AND HOW TO MAINTAIN THEM

Habitat and description	Values	Guidelines
Forest interior habitat Refers to the sheltered, secluded environment away from the influence of forest edges and open habitats; generally at least 100 m in from the edge of the forest; therefore, larger areas of forest interior are found in larger forest stands	• provides shelter, nesting habitat, food, resting areas, refuge from predators for many birds, most importantly, birds vulnerable to forest fragmentation (i.e., habitat for forest interior or area sensitive species) • helps to maintain local populations of birds dependent on these habitats that are in short supply in the fragmented forests of southern Ontario • serves to maintain the biodiversity of the area or region • helps to maintain forest health by supporting birds that provide important ecological services (e.g., pest control, seed dispersal, pruning, fertilization)	• identify important stands (e.g., often the largest, contiguous forest stands in the area; larger stands with few internal openings and few irregular edges) • try to maintain forest blocks of at least 30 ha, and preferably with 50 ha or more in closed canopy condition (e.g., at least 70% canopy closure) through single-tree selection • ensure that forestry activities do not reduce the overall area of the forest, or increase fragmentation or edge habitat • avoid forestry activities during the breeding season (Mar. 20 to Aug. 31[1]) • consider reducing the harvesting of trees within the forest interior; protection of forest interior for wildlife habitat (e.g., as an AOC or core protected area) is a management objective • minimize removal of larger trees and snags • leave some clumps of larger diameter trees • carefully weigh potentially conflicting objectives for creating gaps (e.g., silvicultural objective of regenerating less tolerant species) vs wildife objective of maintaining forest interior bird habitat • maintain dense stands of trees at edges of woodlots and minimize the number of exit laneways particularly on vulnerable edges (e.g., southwest-facing)

[1] The Aug. 31st date is recommended since some species produce two broods/breeding season. Extending the normally recommended period of March 20 to July 31st will improve survival of fledglings.

Habitat and description	Values	Guidelines
Clumps of large-diameter trees Either medium sawlog (38-48 cm dbh) or large sawlog (50 – 60 cm), and extra-large sawlog (>62 cm) size	• some forest interior species prefer nesting in the vicinity of large-diameter trees (e.g., veery, scarlet tanager, cerulean warbler)	• where possible, retain clumps of larger diameter trees, especially if the stand is within a core forest area that provides more than 40 ha of forest interior • where possible, use tree marking and single-tree selection cutting to encourage the development of some clumps of larger trees especially within the forest interior • avoid forestry activities during the breeding season (Mar. 20 to Aug. 31)
Mast trees Trees and shrubs producing edible fruits (e.g., acorns, beech nuts, and berries, from beech, oaks, hickories, basswood, black cherry, ironwood, butternut, dogwoods, viburnums, choke cherry)	• at least 75 species of wildlife eat the fruits, berries, nuts (known as mast) produced by a variety of trees and shrubs • availability of mast can influence weight gain, reproductive rate, and even survival of some animals • serviceberries, pin cherry and alternate-leaved dogwood produce berries in midsummer that are eaten by adult breeding birds at a time when they require extra energy; winterberry provides important food source during late fall, winter • mast-producing species increase the wildlife diversity within the stand and surrounding area	• retain healthy, mature trees with large, rounded, vigorous crowns because these trees generally produce more mast • retain numerous oak trees with 40-65 cm DBH because such trees produce the heaviest acorn crops • on appropriate sites, encourage the growth and regeneration of mast producers through tree marking and silvicultural activities

Habitat and description	Values	Guidelines
Old-growth or mature forest Refers to stands in the region that are considerably older than most other stands (hence age in years is relative, but at least 80-100 years old), often with numerous big trees and canopy gaps, large amount of downed woody debris	• provides benchmarks for research and education • supports associated species that are now uncommon or rare due to limited old-growth forest habitat • contributes to habitat and community diversity at a regional scale • provides habitat for some species with specialized habitat requirements (cerulean warbler, pileated woodpecker, southern flying squirrel, redback salamander, yellow-spotted salamander) • meets specialized timber requirements (e.g., high-value veneer or specialty wood products) • meets spiritual and aesthetic needs of some people	• identify prospective sites (e.g., old-growth potential exists; minimal or no human disturbance; potential to manage stands for old-growth characteristics is possible and desirable) to encourage or maintain • preserve some exemplary stands (i.e., no management, no cutting) • initiate old-growth stands by extending rotation periods • refrain from removing dead wood from potential old-growth stands • treat stands adjacent to potential sites with an old-growth prescription that leaves higher basal area in larger diameter trees to manage these stands for old-growth characteristics
Stick nests Platforms made predominantly of twigs, sticks, and/or small branches usually located in or just below the crown of a tree, in primary or secondary forks or on a sturdy lateral limb	• stick nests are primarily built by raptors (hawks, eagles, owls, falcons) for nesting • their maintenance can help to offset declines of some raptor species • these nests can increase the wildlife diversity of an area because they may be used by a variety of animals including barred owl, great horned owl, long-eared owl, merlin, raven, crow, and squirrels • different species will use each other's nests • important resting areas for some mammals (e.g., fisher)	• retain all trees with stick nests, whether nests are active or inactive • if stick nest is active, retain surrounding trees within a radius of 150 m • for active red-shouldered or cooper's hawk nests, maintain an additional 20 ha of suitable nesting habitat located to encompass adjacent suitable habitat and satellite nests • do not schedule harvesting during Mar. 1 - July 31st breeding season • only selection harvesting, designed to retain at least 70 % canopy closure, should be used • avoid locating roads or landings within 200 m of stick nests

Habitat and description	Values	Guidelines
Supercanopy trees Living trees that stick up above the main canopy of a stand	• used by large raptors such as bald eagle for roosting & nesting, and wild turkey for roosting • used by black bear as refuge trees and bedding sites • may be important as a potential seed source for surrounding stand • may provide guidance for migrating birds	• retain some supercanopy trees in all cuts • retention of at least 1 supercanopy pine or hemlock of at least 50 cm dbh (or preferably a cluster of at least 3 trees) per 4 ha of cut can enhance habitat suitability for bears • try to retain at least 1 supercanopy tree per 16 ha around eagle nests • give special protection to pines, hemlock, or spruces near wetlands--try to retain at least 1 supercanopy tree (or preferably a cluster of at least 3 trees) per 500 m of shoreline
Open water shoreline Shallow water and riparian vegetation found along edges of water bodies	• bald eagle and osprey prefer nesting in this area • provides bald eagle winter roost if adjacent water has fish and remains open • feeding/denning sites for mink, otter • aquatic feeding area for moose • nesting habitat for loon, other waterbirds • foraging habitat for many species • important habitat for many birds amphibians, reptiles, mammals • movement corridors for many mammals • may be part of deeryard in areas where shoreline is predominantly conifers	• maintain riparian vegetation and down woody debris • minimize human disturbance • retain natural cover.

Habitat and description	values	Guidelines
Woodland ponds Areas of standing water, permanent or temporary	• most amphibians (such as frogs, salamanders) require a source of water to reproduce • these areas are often very important to local populations because they tend to support concentrations of amphibians • provide habitat and increase species richness • important foraging habitat for many mammals	• identify potential ponds (e.g., shallow, unpolluted water, either temporary or permanent, with appropriate habitat) • ensure that activities in the vicinity of the breeding pond do not change the moisture regime of the pond or the adjacent woodland (e.g., no major decrease in shade in surrounding forest or loss of water • activities should not fragment existing forests in a way that reduces the habitat for adults of certain species after they leave the breeding pond • activities should not sever the travel corridors from breeding ponds to summer habitat • logging roads should be at least 20 m from potential amphibian breeding ponds
Turtle-nesting areas (shoreline areas) Areas adjacent to waterbodies and wetlands supporting seasonal concentrations of nesting turtles	• better sites permit egg-laying females to dig out nest, provide good exposure to sun, and allow faster development of eggs • these sites may be very important to local populations in some areas where sand or gravel is in limited supply	• forestry activities should not disrupt turtle-nesting areas such as shorelines of wetlands, lakes, and rivers • do not build logging roads that separate water from backshore areas as they may increase the incidence of road-killed turtles
Bat winter hibernacula Caves and mines where these animals can safely hibernate during the winter months	• hibernacula may be critical to long-term survival of local or even regional populations • some hibernacula may be used by several species of bats and other animals such as snakes • in some areas hibernacula may be scarce and therefore very important to their users • some hibernacula may support large numbers of bats due to their scarcity	• no disturbance during hibernation (e.g., no forestry operations within 200 m of entrance to a bat hibernaculum) • in order to maintain movement corridors for snakes, only single-tree selection is recommended for use in forests with known hibernacula • operations should not disrupt surface microhabitats such as vegetation, downed woody debris, rocks and talus, or movement to summer range • overstory canopy closure should not be opened up too much

Habitat and description	values	Guidelines
Seeps, springs, streams (including intermittent) Areas where water is found at or very near the surface of the ground throughout all or much of the year	• these areas provide important habitat for many aquatic and terrestrial species • rare or uncommon species are often found in these areas (e.g., ginseng and numerous other plants; two-lined salamander) • they can serve to maintain or influence the hydrological regime of adjacent areas such as wetlands • seepage areas are often important overwintering habitat for frogs	• retain high canopy-closure (e.g., at least 75 %) in the vicinity of these areas • avoid marking trees that will likely be felled across these areas • avoid locating roads or landings in these areas • avoid crossing these areas with heavy equipment
Snags Standing dead trees	• barred owl, pileated woodpecker, hairy woodpecker, silver-haired bat, raccoon, some snakes and amphibians, many insects, fungi and other life forms rely on snags for food and shelter • when snags fall over, they add to the level of decomposing wood on the ground • some raptors use snags during hunting to observe the surrounding area • during sunny weather, some birds perch on snags to dry plumage, warm themselves	• leave as many snags as possible, preferably exhibiting a variety of different stages of decay • retain at least 4 smaller (< 50 cm dbh) and 1 larger (> 50 cm dbh) for a total of 5 snags/ha
Marten and Fisher habitat (e.g., denning and home range habitat)	• in general, provision of habitat for fisher supplies at least some of the habitat required by various other species that are also associated with larger, mature and old-growth forests, cavity trees, and downed woody debris • provide some income for trappers	• follow OMNR guidelines for marten wildlife habitat • this should also benefit fisher

Habitat and description	values	Guidelines
Conifer patches within a predominantly hardwood/mixed stand Better areas have little human disturbance and are adjacent to suitable hunting/foraging area Better ones adjacent to water bodies, suitable hunting areas for raptors	• provides important thermal protection, roosting, and shelter during winter for deer, moose, numerous small mammals, birds, wild turkey, raptors, and birds; hunting habitat for predators such as coyote, fisher • adds to the wildlife diversity of an area/stand by providing habitat for some species commonly associated with conifer forests • serves as natural seed source for regeneration of conifers species such as white pine or hemlock that historically were more widespread	• retain long-lived conifers such as Hemlock, White Pine, White Spruce, and White Cedar and only remove when they compete with very high quality hardwoods • retain trees with high vigour and low risk unless retained to meet cavity tree objectives • retain trees in clumps of 3 or more because they are especially valuable to wildlife • on appropriate sites, mark and use silvicultural activities to encourage the regeneration of conifers • minimize disturbance to these areas, especially in winter
Hollows, cavities in dead or living trees Usually develop following injury to the trees or excavation by woodpeckers, allowing wildlife access to their interior	• at least 50 species require cavities for nesting, denning, roosting and/or feeding • increase the wildlife diversity of the area • provide protection from exposure that can be critical to winter survival of some species (e.g., gray and flying squirrel) • cavities made by primary excavators (e.g., woodpeckers) are used by other species (e.g., owls, squirrels), thus increasing the wildlife diversity of the area • the southern flying squirrel, a vulnerable species, is dependent on cavities	• try to retain cavity trees that will last at least 20 years (e.g., cavities in living tolerant hardwoods are likely to last longer than cavities in intolerant species such as Poplar or White Birch) • retain large-diameter cavity trees (usually at least 45 cm dbh) because they provide potential cavities for both large and small animals • retain cavity trees providing multiple wildlife benefits (e.g., oaks, hickories, beech, black cherry, basswood, ironwood provide mast for a wide variety of wildlife; conifer cavity trees provide protection from cold, snow, predators and will eventually form long-lasting standing dead trees) • give preference to trees with cavities in the upper portion of the bole

Habitat and description	values	Guidelines
Down woody debris (DWD) DWD refers to fallen trees, limbs and branches, and their remains found on the forest floor; best DWD is adjacent to waterbodies, animal movement corridors	• provides important cover, denning, hiding, breeding foraging habitat for a variety of wildlife (e.g., invertebrates, salamanders, ruffed grouse, small mammals, mink, fisher, wildflowers, mosses, ferns, fungi, bacteria) • increases wildlife diversity of the stand • provides insulation from heat and cold • absorbs and retains moisture (even during drought) • their decomposition adds organic matter and nutrients to the soil, improving tree growth • provides required seedbed for regeneration of some species (e.g., yellow birch, hemlock and white cedar)	• identify areas for retention with high DWD • ensure skid trails are efficiently laid out to minimize skidding disturbance • use narrow trails instead of roads • remove branches and tree tops from harvested trees at the felling site rather than at a landing • do not remove down organic debris • do not disturb large rotting logs, hollow logs

Source: OMNR, 200b