MUSKOKA'S BIODIVERSITY

Understanding our Past to Protect our Future

MUSKOKA WATERSHED COUNCIL

2012

Muskoka
WATERSHED COUNCIL

This white paper was developed by a sub-committee of the Muskoka Watershed Council, including Anna Mallin, Ken Riley, Peter Sale, and Ian Turnbull, ably assisted by Judi Brouse, and with input from several other Muskoka Watershed Council members, including, in particular, Isobel Heathcote. It was formally adopted by Muskoka Watershed Council on September 21, 2012.

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Executive Summary

Biological diversity - or biodiversity - is a term used to describe the variety of life on Earth. It refers to the wide variety of ecosystems and living organisms: animals, plants, their habitats and their genes. It is an essential part of our environment, enabling our ecosystems to maintain productive soils, clean water, and fresh air. Biodiversity also confers ecosystem resilience which can help our environment recover from future shocks and changes. Hence, biodiversity is important to our well-being.

Muskoka is blessed with biologically diverse terrestrial and aquatic ecosystems. Their biodiversity has provided them with the resilience necessary to withstand environmental change and continue to function normally and provide the environmental goods and services on which we and other species depend. The explorations discussed in this report reveal that the Muskoka River watershed has always been undergoing change, initially in response to relatively gradual patterns of climatic change following the retreat of the last Pleistocene glaciation in this region about 10,000 BP. There were nonetheless profound changes in which the composition of the forest ecosystem was altered radically from an early boreal to a later mixed pine and hardwood forest seen today. With the arrival of aboriginal populations, and then Europeans, the nature and the pace of change quickened. Human activities altered terrestrial ecosystems profoundly and aquatic ones substantially.

It is unrealistic to expect that these ten thousand years of change have now come to an end, but neither is it realistic to suppose the future will be much like the past. Indeed, what is known about biodiversity and about climate change in this region suggest that the pace of change is likely to quicken substantially. This quickening pace increases risk because the various species that occupy the Muskoka River watershed are not all going to be capable of responding to more rapid change.

Many of the tree species, in particular, are unlikely to be able to move north as quickly as they will need to in order to remain within a climate to which they are well adapted. As a consequence the current pace of climate change has a real prospect of further depressing biodiversity, and ecosystems will lose the resilience their many species provide.

Whether we want to or not, humans are now entering a time when we will have to manage our ecosystems far more proactively than we have in the past, actively helping them cope with the new stresses they face, rather than focusing simply on

trying to avoid direct negative impacts by us on them. The old rule that said, "keep human influences away and Nature will take care of itself" will no longer apply.

So, how do we go about developing the conservation and management approaches that will be successful in coming years? And what roles do governments, business, and the community have in this process? While the details of the management actions, and the science behind them, are beyond the scope of this report, several important lessons have been suggested in the report that will help us all move forward. These lessons come from the science, and the history, and, yes, particularly from the knowledge and attitudes of our long-time residents.

The **first** lesson is that biodiversity, the biotic richness of our natural environment, is critically important in making natural ecosystems resilient to change. Corollary to this lesson is that we depend, to a surprising degree, on resilient natural ecosystems for essential goods and services that sustain us and fuel our economy.

The **second** lesson is that there is always change. Coupled to this is that the nature of ecosystem change is not always obvious at the start, and can have profound impacts on the provision of environmental goods and services. It is in our own self-interest to work to understand, and, where appropriate and possible, to manage future environmental change in Muskoka.

The **third** lesson is that we can no longer assume that Nature can always look after itself if we just get ourselves out of the way. This is a widespread belief with a dangerous corollary – that if we do something that damages the ecosystem, it will repair itself once we stop. That might have been correct once, but it is no longer so. The environmental impacts of climate change, biodiversity loss and other processes we have unleashed are going to be far too powerful for the Muskoka River watershed to remain as it is now into the future, even if we residents stop expanding the area of development, cease filling in any wetlands, halt all water pollution, even of salt from our roads, and recycle all our household garbage. We have got to actively manage to conserve biodiversity, and where possible to ease the process of environmental change, steering it wisely into good directions rather than hoping Nature can look after itself.

The **fourth** lesson is that, if we, as a community, are going to actively manage and conserve the environment and biodiversity to create a good future, we have a major challenge ahead of us. To become active managers, rather than leaving the ecosystem alone hoping for a past that cannot be attained again, is going to require three things. These are the best science, the most well-informed environmental policy, and very strong and enlightened support from the community.

This challenge, of course, can be an economic plus for our community. If we embrace it, we have the capacity to become the leaders who develop the approaches to environmental management that work for the future. Why not let Muskoka's environment really become our economy by driving us to build and apply the

knowledge about how to maintain vibrant natural ecosystems that all successful societies will require in the future? There are economic benefits here.

The **final** lesson, and perhaps the most important, is that we have to learn to become effective stewards of our land. We will not be able to become active managers unless we understand that actively caring for the Muskoka River watershed is economically wise, is appropriate for our own well-being, and is a responsibility we all share to sustain the ecosystems of which we are a part.

The conversations we shared with our groups of long-time residents demonstrated clearly that environmental stewardship is not a new idea but rather an idea that has been here throughout human occupation. But this attitude has been lost as more and more people in the economy of the 20th century lost their attachment to the land. Environmental stewardship does not preclude making a living off the land. It does not preclude further development and urbanization. But it does require recognition that we enjoy immensely richer lives if our environment is sustained, and that the only way to sustain our environment is to act responsibly to take care of it.

Introduction

The Muskoka region forms the southern boundary of the Canadian Shield in Ontario. Its environment is widely praised for its intrinsic beauty, its healthfulness, and the quality of life that it provides to its inhabitants. Environment is one of the first items mentioned when residents or visitors are asked what is special about Muskoka.

The statement "our environment is our economy" is widely recognized, frequently stated, and demonstrably true. There is a widespread desire to live within Muskoka's environment in a way that will preserve its value, and there is some concern that this may become difficult to do because of growing pressures on Muskoka – in particular from demand for more development and from climate change.

The goals of the Muskoka Watershed Council are to sustain and enhance the air, water and terrestrial ecosystems of the watersheds of Muskoka for the environmental, health, economic, spiritual and intrinsic values they provide. In 2010 – during the International Year of Biodiversity – a Biodiversity Sub-committee was set up under the Policy and Research Committee of MWC, with the broad focus to better understand Muskoka's diverse ecosystems in order to effectively champion our watershed health.

The varied backgrounds and expertise of Sub-committee members – including law, recreational enjoyment, marine ecology, local history, plant science, farming, environmental engineering, and local government and planning – insured that discussions were lively, informed and wide-ranging.

Key Issues

The group wrestled with three key issues. The **first**, and perhaps most challenging issue, was to find a way of applying biodiversity as a path to understand our environment, and to use this understanding effectively to champion watershed health. To do this, we needed a readily understandable explanation of biodiversity that would relate to Muskoka, and would describe what it is (its nature), how it is a key component of our overall environment, what benefits it confers (both economic and environmental), and what threats it faces.

Second, we recognized the need to understand the relationship of people to the watershed, and the changes that have occurred over time, both in that relationship

and in the environment itself. It is undeniable that the Muskoka environment has changed substantially over the years, and that people have both adapted to, and sometimes been the cause of these changes.

Third, we realized the importance of expanding, deepening and verifying our investigations by tapping into local knowledge and including in our discussions individuals from families who had lived, and worked here, sometimes for generations. Local participants had personal memories and family history that expanded and deepened the information we could gain from more traditional written sources.

Paper's Structure

The paper is structured into four sections:

1. A review of the history of environmental change in Muskoka,
2. Reports of a series of conversations with long term residents,
3. An assessment of the value of these discussions and of the participatory approach to research, and
4. A review of the scientific literature encompassing:
    a. the nature and role of biodiversity,
    b. the benefits of biodiversity, including maintaining resilience and providing ecosystem goods and services,
    c. global trends in biodiversity, and
    d. reflections on the value of managing our natural ecosystems to conserve biodiversity.

Muskoka Watershed Council sees this document as a first step in a longer-term program of education and awareness of biodiversity and ecosystem health. The need for effective conservation of biodiversity will grow in importance as stresses on our natural environment increase. New approaches and new partnerships will be necessary if we are to succeed.

Section 1

The History of Environmental Change in Muskoka

The most striking change in biodiversity in Muskoka arises from the intrusion of Euro-Canadians and Euro-Canadian trade starting in the mid-19th century. Information on the history of Muskoka is available in Murray (1963), Paterson (1968), and de la Fosse (2004).

Prior to European Contact

Prior to the 19th century, the balance of biodiversity in Muskoka's watersheds probably changed only slowly under the influence of natural processes, affected only modestly, if at all, by humans. Beaver harvesting by aboriginal groups may have been somewhat "managed" by limiting numbers caught in order to assure future supply. Forest underbrush may have been burned to enhance deer habitat and encourage berry growth. It is thought that, because fire stimulates the germination of their seeds, many of the white pine stands encountered by early settlers were the result of fires.

Before European contact and for some period thereafter, the Muskoka region hosted seasonal fishing and hunting camps of aboriginal peoples. Fish, deer and berries provided sustenance in the summer and were dried and stored for the winter. Ice fishing occurred when conditions were suitable. Deer, bear and small mammals provided food throughout the year. Fur bearing animal skins and deer hides were used for clothing. Birch bark was harvested and used for making canoes. The primary occupation of humans prior to European contact was the constant work of survival – following animals to be hunted, travelling to and from traditional hunting and fishing sites, making clothing and shelters. Tools to facilitate hunting, fishing, clothing and shelter making were fashioned of stone, bone and wood and, perhaps, some copper or other metals traded with neighbouring peoples (possibly from Upper Michigan). This round of activities was punctuated on occasion by wars between tribes.

The pattern of ecological change altered following European contact, starting in the early 19th century. European trade goods were introduced – including firearms, metal cooking pots and tools, and cloth, and trade itself generated demand for products.

The European trade goods meant that hunting could be carried out much more efficiently and clothing was no longer dependent upon hunting and trapping. In exchange for European trade goods, aboriginal people provided guiding services, furs, and sometimes, food. To the normal round of aboriginal "survival" activities was added trapping for trade.

By the early nineteenth century beaver were "trapped out" in southern Ontario and the fur trade moved, with ever increasing reach, towards the Northwest. Travel routes used by the fur traders from the northwest were located just to the south of the Muskoka Watersheds (Severn River) and to the north, along the French River. By the middle of the 19th century the peak of the fur trade had passed with the changes in European fashion no longer favoring beaver hats. However, trapping for fur bearing animals continues in Canada and in Muskoka to this day.

The Timber Industry

In addition to furs, Europeans (and later Americans) wanted timber. Starting in the early 1800's timber was harvested in the Muskoka area – starting along the Georgian Bay coast which provided water transportation. As the timber supply was exhausted in one location, logging moved inland along waterways that provided water transportation to move the logs to market.

In the early 1800's, logging for white pine was the main industry drawing Europeans to the area. The white pine stands were targeted first for the British shipbuilding market. Other tree species were targeted later for a variety of economic activities.

While British demand for square pine timber peaked in 1865, an 1871 report describes exhaustless growths of pine attracting large American lumbering firms to subdue the forests. Log drives were common with dams being built on lakes to raise the water levels for the spring log drive. Logging slash (tops) was littered across the logged areas and was often the cause of large fires. The relatively uniform age class structure of the vast majority of white pine stands today is a direct result of those fires and logging activities.

In those early days, loggers would fell the pine, choose the best logs, and float them down the watershed to Georgian Bay where they were boomed and towed across Lake Huron to the mills of Michigan. This exodus of timber led to local petitions to develop a railroad so that lumber could be milled in Muskoka and transported south. By the late 1800s, mills were established at several locations within Muskoka, and sawn lumber was shipped by rail to satisfy the demand for building materials in the growing cities of New York and Toronto.

With logging, there was increased European colonization. Land was acquired from native populations by treaty and to supplement meager farm income, settlers often

worked in the logging camps in the winter months. Aboriginal people increasingly took up farming where the land was suitable, either in permanent or in summer settlements. For example, the Beausoleil band was moved from an initial settlement near Coldwater to Beausoleil Island near Honey Harbour. The Band subsequently moved to Christian Island, which provided better farming conditions. Chief Bigwin and his group farmed on Bigwin Island in Lake of Bays in the summer while spending winters at Rama near Lake Couchiching.

Tree species beyond pine noted in the 1800s included basswood, ironwood, red oak, yellow birch, beech and maple. By 1882, the best of the hardwood had been harvested but the area was still yielding white oak, black and white ash, red pine, spruce, tamarack and hemlock.

Demand for the tannins found in hemlock bark led to the establishment of leather tanneries in Bracebridge in 1877 and Huntsville in 1890. Hemlock bark was purchased from the settlers and barged to riverside tanneries, and logging of hemlock for its bark expanded. The Bracebridge tannery closed in 1922. Huntsville's operated until 1960.

Forest fires that raged throughout the timbering era were said to consume more trees than the logger's axe. Pictures from the 1920s confirm that the landscape was stripped of old growth forests.

Yellow birch was targeted by loggers for its use as veneer in the 1930s and 1940s. The mosquito bomber used in World War II was built from this forest product. Logging in Muskoka reached its peak about 1900 (Census of Canada 1901).

High-grading (harvesting the best and leaving the rest) of hard maple began in earnest in the middle part of the 1900s and continued for quite some time. This has led to many hard maple stands that may appear healthy from a distance but have a higher amount of defective and diseased trees than would be naturally encountered. Since the 1970s, forest management has evolved from an exploitative phase to a forest improvement stage. Reverse high-grading began in the 1970's and has set the maple stands on a slow track to improvement and a healthier forest.

Logging has dramatically affected the mix of species in Muskoka's forests. Prior to European contact, forests had featured a large proportion of white pine. Initially, logging evolved into a more highly mechanized clear-cutting approach, and wave after wave of logging removed the white pine, then the yellow birch and the hemlock, and last the maple. The forest habitat and the species the area could support have been substantially changed. The forest is now regenerating with mixed hard and softwood species, including a high proportion of maples.

Transportation

Water Transportation

By the late 1860s, entrepreneurial instinct recognized that construction of dams and locks would facilitate steamboat transportation throughout large areas of Muskoka. Local petitions resulted in the government undertaking works necessary to connect Lakes Vernon, Fairy, Peninsula and Mary in north Muskoka, and Lakes Muskoka, Rosseau and Joseph in central Muskoka.

Key dates include:

- In 1875 the Huntsville locks and dam were constructed on the river connecting Fairy and Mary Lakes.
- In 1886 a canal was constructed joining Peninsula and Fairy Lakes.
- In 1871, construction of locks and a dam in Port Carling joined Lakes Rosseau and Muskoka for navigation.
- Also in 1871, a cut through a sand peninsula separating Lakes Rosseau and Joseph at Port Sandfield joined Lakes Rosseau and Joseph.
- Rapids on the Joseph River were blasted to make it navigable.

Before the combined works, Lake Joseph was 1.5 feet higher than Lake Rosseau and Lake Rosseau was 5 feet higher than Lake Muskoka according to early surveyors. On completion of the works, the upper lakes were the same level and about 2 feet higher than Lake Muskoka.

Before the first dam was built at Bala Falls on Lake Muskoka in 1829, the fall between Lake Muskoka and the Moon River ranged from 16 to 20 feet. The head on the Bala dam now is 4 metres (13 feet) (Acres International, Jan 2006).

Today, 42 dams within the watershed control and maintain water levels in the lakes and rivers. Examples of dam heights are:

- Huntsville 4.5 metres (14.8'),
- Baysville 3.5 metres (11.5'),
- Port Carling 3.5 metres, and
- Bala 4 metres (13').

Rail Transportation

The railroad arrived in Muskoka in 1875 and was slowly expanded northward. The Canadian National Line started in Gravenhurst and quickly expanded northward reaching Gravenhurst in 1875, Bracebridge in 1885 and Huntsville in 1886.

The Canadian Pacific Railroad was constructed through west Muskoka in 1906.

Navigation improvements and the coming of the railroad generally improved revenue opportunities for fleets of steamships operating in Muskoka. Tourists were able to leave Toronto and arrive later the same day at their Muskoka destination. By 1900, 10 passenger and freight steamships plied the Huntsville chain of lakes. On the Muskoka Lakes, a steamship fleet operated with about 15 ships in service at the peak of business. A unique narrow gauge railroad traversed the steep divide between Peninsula Lake and Lake of Bays, connecting the steamship service of both lake communities.

Settlement and Agriculture

Until the middle of the 19th century, the Muskoka River watershed was a large intact ecosystem occasionally traversed by itinerant humans engaged in hunting, trapping, lumbering and surveying. That changed when the area was opened for European settlement in the 1860s. Rough colonization roads were built, treaties for land acquisition were entered into with aboriginal peoples, land grants were made available, and the government began to promote immigration. The settler population grew from 190 in 1860 to 743 in 1862, and then rapidly to over 5,000 in 1871 and over 20,000 by 1901. These settlers were required to clear and plant a minimum of between 8 and 15 acres of land. Settlement on the thin soils of the Canadian Shield was encouraged by early descriptions of Muskoka agriculture that were extremely optimistic. Grant (1882) provides the following description of Muskoka:

> *"The proportion of good land is said to be sixty per cent of the whole; the soil for the most part being a sandy loam with clay subsoil; and in extensive tracts lying back of the lakes, generally free from stone. The root crops are unusually large; … Potatoes yield some three hundred bushels to the acre, and turnips from six to nine hundred bushels. Oats, rye, barley, and Indian corn are the chief cereals."*

A rapidly evolving economy fueled population growth. Would-be farmers struggled in the harsh conditions, many turning to logging in the winter months to make ends meet. In the 1870s, construction of dams, locks and dredged channels spurred navigation and commerce on the Muskoka Lakes and the Huntsville Lakes.

It can be estimated that by 1900, close to 40% of the land in Muskoka had been settled, with clearing underway. While small pockets of good farmland produced reasonable crops and animal production (Muskoka was known for the excellent quality of its lamb), the Great Depression in the 1930s forced many settlers to move on as they found it impossible to make a living on their limited agricultural sites. Evidence of these early efforts can be seen today, with often only a raised field stone square in the forest floor that indicates an old foundation. Many early settlers abandoned farming in favour of easier ways of making a living, including logging and later in support of the growing tourist industry. In the late 1880s and early 1900s, improved transportation by steam train and steamship and later by roads facilitated more settlement and the development of small towns and villages.

Early Tourism

Substantial environmental change occurred during the fifty years following settlement. Early on, settlers walked to their plots through heavily timbered forests following rough pathways. Corduroy roads were constructed with logs laid crosswise over frequent swamps. A description of a trip by stage from Washago to Gravenhurst in 1871 described burning forests bordering the "most dreadful" corduroy road. Settlers chopped down and burned large trees to prepare for crops, leaving the stumps to rot before pulling them out with oxen. Where the soil cover lay thin on cleared lands, the rains washed it from the bedrock. Cattle were left to fatten in the woods from spring to autumn, evidently finding the shoots of young basswood and maple quite succulent. However, the prevalence of leeks in the spring had a very bad effect on the milk.

Settlers noted abundant wildlife including loons, ruffed grouse, woodpeckers, bear, deer, wolf, weasel, mink, beaver, marten and muskrat. Lakes and streams were reported to be rich with fish including trout, bass, pickerel, perch, herring and muskellunge. Pioneers noted long winters that started in November and continued into late spring. Periods of cold were long with the trees cracking like pistol shots in severe temperatures. Then as now, summer arrived with every sort of venomous fly. Surveyor David Thompson in 1837 called them moskitoes (sic).

Economic objectives drove settlement, timbering and transportation. Human desire to experience nature amidst Muskoka's lakes, rivers, wetlands and forests has driven tourism from the early days of settlement to the present. Through the last two decades of the 19th century the hotel industry began to flourish. As the 20th century dawned, the natural beauty of the area spurred development of cottages throughout the district.

By the 1890s, development of steamship and railroad travel brought Muskoka's large lakes within a one-day travel radius for residents of urban centres as far south as Pittsburgh, Pennsylvania. That fact, the economic prosperity of the period, and the

allure of the district's environment resulted in rapid development of resorts and cottages. Incredibly, in the first quarter of the 20th century about 60 resorts operated on Lakes Muskoka, Rosseau and Joseph. The Huntsville Lakes and Lake of Bays together hosted some 40 resorts.

As well as the boating and other summer activities centered on the resorts, hunting and fishing became important parts of the tourism industry. Early records kept by hunters show that prior to 1800, elk were the predominant species in the dense old growth coniferous forests in the area around Dwight. These were gradually replaced by deer as logging altered the forest type. Moose are relatively recent in this region, first appearing around 1900. In the Dwight area, in the late 1800s the organized hunt was a key economic driver each September. Hunters would come from the US and Europe, and there were often up to 32 hunters present, brought there by train and steamship. The hunt would employ guides, cooks, resort operators, various suppliers, runners etc. The changes in the forest type and in the predominant game species are recorded in the hunt records kept by the operators.

By the 1950s ongoing improvements in road access and steady growth in cottage development had begun to erode the viability of the resort and steamship industry. The 1960s witnessed the end of many of the old resorts as well as the steamships that served them.

Summary

The relatively short history of European settlement in Muskoka marked a period of rapid environmental change. While there are relatively few data, the impacts of aboriginal populations on this region prior to European settlement appear to have been quite modest compared to those in other, more densely occupied portions of North America. These aboriginal impacts were chiefly the maintenance of a somewhat more open environment through the use of fire to favour deer habitat. With the arrival of Europeans there were successive waves of substantial environmental impact, beginning with the initial expansion of fur trapping into a commercial venture, and followed by successive waves of logging for preferred species. During the height of the logging industry, and clearing of land for agriculture, Muskoka's landscape was very different to today, with extensive areas denuded of forest and waterways almost choked with debris from logging and land clearing. The tanning industry resulted in significant local pollution with a range of substances arising from the treatment and processing of hides.

The development of the large resorts and a viable tourist industry gradually began to change the Muskoka environment, as logged and cleared landscapes began to re-grow. The classic resorts, and their clientele, gradually developed a new way for Europeans to view Muskoka – instead of it being a storehouse of products awaiting

extraction and sale; it became a destination, a place valued for itself. This dramatic turn-around has continued to the present day, as the phrase "our environment is our economy" testifies.

Section 2

Conversations with Long-term Residents

On six occasions, members of the Muskoka Watershed Council met with small groups of long-time residents who had experience in living and working on the land as loggers, farmers and trappers in Muskoka's natural environment (Table 1). Through these informal discussions, an understanding of the change in the landscape of Muskoka as seen by these residents unfolded. This section summarizes the reflection and recollections of these local residents, and can provide important insight into broader environmental issues and perceptions.

Each conversation began with a short introduction from one of the MWC members, outlining the objectives of the project. Participants were then invited to talk about places with which they were familiar. Particular interest was paid to the natural environment, and how this has changed during their own lifetimes, or from what they have heard from older relatives or neighbours. Participants were encouraged to comment on apparent reasons for the changes seen, to express their views concerning what is valuable in the present landscape, and to identify any threats they see on the horizon. So far as possible, MWC members listened, interrupting only occasionally to seek out additional information or a deeper discussion of views held. As a result, each conversation had a life of its own and dwelt on topics of most interest to the participants at that time. Despite this, there was a considerable commonality of topics and of views across the set of meetings. Here we summarize the discussions that took place and try to capture the views and perspective of these residents rather than filter with our own perspectives.

Table 1. **Meetings with Long-term Residents.**

Date	Location	Participants	MWC Members
Nov 30, 2010	Bracebridge	Jim Boyes Bill Dickinson Mel Golz Walter Holtz Anita Ruttan Allan Ruttan Bill Ruttan Paul Stephen	Judi Brouse Isobel Heathcote Anna Mallin Ken Riley Peter Sale Ian Turnbull
Feb 16, 2011	Dwight	Roy McKay Brian Tapley Nancy Tapley Rob Wilson Bob Atkins Ben Boivin Peter Cotterchio Walter Holtz Steve Lehman	Judi Brouse Anna Mallin Ken Riley Ian Turnbull
April 14, 2011	Severn Bridge	Gordon Adams Diane Kretschmar Terry Pilger Jim Robinson Don Schell	Judi Brouse Anna Mallin Peter Sale Ian Turnbull
May 30, 2011	Vankoughnet	Graydon Boyes Irene Boyes Myrna Conroy Deenie Golding Keith Johnston Maryann Tingey Vic Toll	Judi Brouse Anna Mallin Peter Sale Ian Turnbull
October 17, 2011	Glen Orchard	Inez Calvert Jan Jackson Norm Jackson Doreen Jennings Jack Jennings Linda Church	Judi Brouse Anna Mallin Peter Sale Ian Turnbull
October 19, 2011	Raymond	Betty Bogart Mabel Bogart Ted Hares Elmer Klingbeil Marette O'Brian Al Quinton Bill Shea	Judi Brouse Anna Mallin Peter Sale Ian Turnbull

Changes in Beaver Populations

Beavers play a keystone role in the ecology of Muskoka and have also played a key role in the social and economic fabric over many years. They frequently came up in conversation because of their impact on private property. By building dams and creating ponds they have a major effect on the landscape and ecological systems. The ponds they build often kill trees and become semi-permanent waterbodies that provide suitable habitat for a number of other aquatic species – mink, frogs and turtles were specifically mentioned as benefitting in this way. There was little discussion of wetlands themselves. The consensus was that wetlands needed protection. *(Separate conversations with local residents indicated that many feel that the area of wetlands has increased since the mid-20th century.)*

Beaver ponds have a natural cycle because once beaver have consumed the accessible food trees, mostly poplar and other fast-growing hardwoods, the pond becomes unsuitable and beaver move away. Abandoned ponds dry up as the dam gradually fails, and, with time, trees re-invade the space. Tularemia was discussed as an often fatal disease of beaver that is transmitted by fleas, and can eliminate all beaver in an infected lodge. *(This is actually a tick-borne bacterial infection caused by the bacterium Francisella tularensis.)*Participants reported that beaver will bring cedar branches into their lodges as an insecticide, but will often move to a different lodge if residing in an infected one. Infection often travels downstream from pond to pond.

Beaver have long been important as a component of the fur trade, and a limited trapping industry still exists in Muskoka. Skins of beaver and other species are sold at auctions held in North Bay. However, the world market for fur has declined significantly and trapping is not as profitable as it used to be.

The abundance of beaver in Muskoka was reported to have declined greatly early in the 20th century due to pressure from trapping. However, following the Depression, trappers organized to regulate the harvest, and this is now managed by the MNR in cooperation with the trappers. Some participants believed beaver are now more common than in the recent past, perhaps because of the general decrease in trapping activity or perhaps it is a perceived increase because there is more human development in rural areas. The question of whether trapping for sale of furs to the North West Company/Hudson Bay Company led to an early decline of beaver that then recovered, only to be reduced again by settler trappers did not evoke any firm opinions.

Other Wildlife

Our conversations revealed widespread agreement that the abundances of many animal species cycle between higher and lower numbers; that such cycling was a natural phenomenon; and that at least some species tended to cycle synchronously. Causal factors driving these cycles were not advanced, although the variation in number of hunting tags issued by the MNR was believed by some to modify the cycles of deer and bear. On top of these natural cycles, there was an overall sense that some species are now less common on average than in the past, while others are more common.

Mammals

There was consensus that there are now more moose in Muskoka than formerly, probably also more bears, but opinions were divided on the numbers of deer. *(None of our respondents mentioned elk, which disappeared in Muskoka around 1800.)*

Some reported more deer this year (perhaps a natural upturn in the cycle), others about the same, and some fewer. Most participants felt there were fewer wolves around (some argued there were more wolves, and some maintained wolves were migrating down from Algonquin Park), but all agreed there were more coyotes, and the issue of wolf-coyote hybridization was raised, in some cases with much passion.

Rabbits and porcupines were now less common while bobcat is effectively gone. On the other hand, weasels and squirrels were now more common, and marten were noted as more common around Vankoughnet. Reasons advanced for several of these changes included the effects of wolves, which have "pushed moose south from Algonquin Park, displacing deer", and the effects of coyotes (and coyote-wolf hybrids) in reducing populations of deer. Changes in the forest – less old growth, more regeneration of formerly cleared land – were believed to play a role in determining number of moose.

The decline in porcupines was attributed to the frequency with which they get killed on the roads. Fishers were reported to still be common, and their fondness for preying on cats was noted to cause irritation among seasonal residents. Coyotes were abundant enough to be causing significant losses of sheep in the Severn Bridge area, and bears were reported to damage grain crops by rolling about in the fields prior to harvest. Several participants at the Vankoughnet meeting expressed concern over the management of wolves by MNR – they felt that wolf populations were being encouraged to the detriment of other game and of livestock.

Birds

All agreed that there were now more wild turkeys, more raptors, owls and ravens, and, close to water, more geese and cormorants, and that there were fewer ruffed grouse, though perhaps not in Vankoughnet. Songbirds that had notably declined over the years included bluebirds, pine grosbeaks, bobolinks and whip-poor-wills. None were identified that had notably increased. Few reasons were offered for changes in bird numbers. The loss of formerly open land on abandoned farms was cited as a reason for decline of bobolinks and whip-poor-wills, and perhaps ruffed grouse. The decline of gray jays was also noted, with the cause likely related to the milder winters which would cause their food stores to deteriorate.

Reptiles, Amphibians and Fish

There were very few comments about reptiles, amphibians or fish, however there seemed to be a consensus in some groups that frogs were generally less abundant than formerly. Some participants believed that a number of turtle and snake species were now quite rare and certainly less common than before. Trout were noted as fewer by the group at Vankoughnet, and dams were mentioned as a possible negative impact on fish.

Summary

To summarize, most participants viewed cycles in abundances as normal for most animal species, but that, superimposed on these cycles, there were some long-term trends with some species now either rarer or more numerous than formerly. Reasons put forward to account for the long-term changes included effects of predation and competition and effects of habitat change, particularly those associated with the flushes of new growth following logging, and the loss of open pastureland following cessation of farming.

Fire

Fire was discussed only briefly. In one meeting, there was discussion of how settlers used to burn beaver marshes to improve them for the growth of cranberries, and how blueberries also do well on recently burned land.

Participants recognized that forest composition has changed substantially since the time of first European settlement. Historically, the landscape was dominated by white

pine while today forests are dominated by mixed hardwoods. The composition of the present-day forest is very different due to suppression of fire and other aspects of management of the land following initial logging. Whether these changes have led to an increased biodiversity or even a greater richness of species than was the case prior to settlement was not discussed.

Whether the amount of open space currently present is greater than, similar to, or even less than was the case prior to European settlement due to past clearing primarily for farming was another question raised that evoked no opinions as wildfire would have created open space from time to time in past centuries. However, many participants noted that there is considerably less open space today than there was in the 1950s and 60s when the land was recovering from the earlier logging and farming era.

Climate Change

At the Dwight meeting, discussion turned to climate change as witnessed at Bondi Village Resort, and more generally on Lake of Bays. Records kept at Bondi Village Resort show that ice out is now one day earlier than it was 100 years ago. Records from other lakes indicate that ice out dates may be up to two weeks earlier than in the past.

Warmer summer temperatures are also being experienced and the water at Bondi Village is warmer than in the past, with the consequence that there is more growth of algae. The resort's water intake has been moved to deeper water, but still needs to be cleaned every other day in summer to keep water flowing. Maple trees are being tapped about a month earlier than in the recent past (and many trees are looking "unhealthy"). In recent years there has been less snow and more long thaws during the winter season. The result is that the snowmobile season is now shorter as well as winter itself.

One participant expressed the fear that there will be increased natural disasters as a consequence of climate change – tornados, ice storms, and drought.

Calcium Decline

Participants at the Dwight meeting specifically mentioned Dr. Norm Yan's research on calcium decline in Muskoka lakes and the associated decline in numbers of crayfish. Calcium is being continuously leached out of the soils. This loss is exacerbated when trees are logged instead of rotting in place, because they cannot return their stores of calcium to the soil.

Associated with the discussion of calcium, three interesting comments were made:

- Several people state that land in Muskoka can support a limited number of crops of trees before becoming too infertile, and most lands here are already on their second crop of trees. What will happen in the future if logging continues?
- Most development in Muskoka is on the land most sensitive to the effects of development, namely the waterfront.
- Catfish seem to be no longer present in Lake of Bays, while crappie and pike have become common.

Agriculture

Most early settlers were required to clear a portion of their land in order to gain title, and farming provided a way of feeding one's family while generating some income. Except for a small area around Severn Bridge and Milford Bay, where there are some good class 3 soils, most settlers discovered that Muskoka was hardly ideal farmland, and many of the original farms have been abandoned.

Most of the original fields have reverted to forest. The forest regeneration followed a normal succession pattern, starting with alders and birch, which attract beaver and consequently the development of wetlands, while the forests change first to conifers (with hemlock the last of the softwood cycle to appear), and then to oak and maple. Beaver ponds become abandoned and drain and the land becomes dryer again. Red pine plantations were established as early as the 1930s and 40s. This planting continued up to the 1980s.

Even given the reduction in agricultural land, farming has clearly altered the Muskoka landscape, and with that, the types of species abundant here. The cessation of farming also brings alteration to the habitat as forests regenerate.

There was considerable discussion of the economics of farming in Muskoka. Diane Kretschmar, at the Severn Bridge meeting, is a relatively recent, full-time resident who was quite positive about the future of farming in Muskoka. She takes her sheep to market immediately prior to important Muslim holidays, and is investing in more vegetable growing because she expects the increases in gasoline prices are going to help foster a local food initiative and her vegetables will serve the Muskoka seasonal residents. The main problem for labour-intensive farming activities such as vegetable growing, however, is a reliable source of labor. Diane tries to hire only local residents, hoping that this will encourage people to stay on the land and enter farming themselves.

A second economic factor is the rising cost of land. Many participants recognized that farmers were being priced out of Muskoka by the growing cost of land – whether they

wanted to purchase land in order to farm it, or, in cases where they owned it, when it came time to pay land taxes. Participants seemed well aware of the various mechanisms available in Muskoka that might permit holding onto one's land despite inflating property values, and saw these as a partial solution. Some believed that local government would need to step in to save farming in Muskoka.

This led to a brief discussion of the conflict inherent among land owners between the view that the owner has the right to do anything with his/her land, and the idea that land owners have a responsibility to be good stewards of it. Some participants voiced the opinion that many farmers rely upon being able to sell at least some of their land for development in order to fund retirement. There was some receptivity to the idea that development (of farming land into residential or commercial land) should be restricted to sites adjacent to existing roads, and that creation of new roads should be discouraged, however the discussion did not delve very deeply into this issue.

When ecosystem services were raised by one MWC member present, the response was that ecosystem services do not provide any particular benefit to the land owner whose land provides those services. Many participants felt that, despite the difficulties of farming in Muskoka, a loss of a vibrant farming community would be a significant loss to the region and perhaps to the environment as well. The increase in the number of small hobby farms where seasonal or otherwise retired residents could keep a couple of horses and have a field mowed for hay was noted, and there was universal acceptance of the view that farmers in Muskoka are good stewards of their land.

Timber Industry

Participants agreed that there have been significant changes to forests due largely to the effects of the timber industry. Logging was the first major enterprise embarked upon by Europeans in this part of Ontario, although trapping happened at about the same time.

Logging remained a prime economic driver in Vankoughnet until 2000 when the last sawmill closed. In this community in the 1950s, the mills made the world go round, and July 1st was a big holiday during which the mills closed for the day and there was a dance. Since the closing of the mill it was felt that some of the community vitality has disappeared.

Logging was done to clear land for farming, but primarily it was done for the commercial timber harvest. Logging proceeded in "waves;" first there was logging of white pine, then of hemlock for the growing tanning industry, and finally for maple and other hardwoods for saw logs and increasingly for firewood. Selective cutting of

hardwoods is practiced today. One participant in Vankoughnet commented that the only market now is for white ash.

In the early days, logging generated a lot of debris that was generally poorly managed. Much was just left on the land to slowly rot, but other debris was dumped into lakes and rivers where it decayed slowly, releasing unwanted nutrients and consuming oxygen in the lakes. The major impact on land was the gradual shift from softwoods to hardwoods and from old growth to secondary growth forest.

The timber industry is currently very depressed due to market conditions. Participants noted that the second growth forest is not of as good quality as the first growth.

There was recognition that the practice of logging has changed over the years, with greater attention to post-cut management these days. On the other hand, there is now somewhat less pressure on land owners to manage their forests for wood production because most people no longer heat with wood, so there is not a need for a reliable harvest. One participant reported that another change in woodlot management was that where formerly deer were encouraged, now deer are actively discouraged because their browsing on saplings interferes with regeneration of the forest.

There was a suggestion that mature forests harbour less biodiversity than second growth, and some awareness that there may have been changes to forest composition due to some tree species moving north in response to changing climate, or due to the invasions of pest species such as the gypsy moth and the vector for Dutch elm disease. One participant at the Severn Bridge meeting remarked that following a large gypsy moth outbreak about 30 years ago, there was much talk of oak trees not recovering. However, he now sees a lot of very healthy-looking oak trees about. Another participant pointed out that the elms did not recover following Dutch elm disease, although it is still possible to find young elm in the forest and a few older elms that escaped the disease.

In a separate conversation with members of the MWC team, Brad Steinburg, Ecologist for Algonquin Park, reported to us that many parts of the watershed (particularly in Algonquin Park) are healthier today than they were in the early 1900s. The Algonquin Park that was immortalized by Tom Thomson looked like a war zone. Logging and fire had razed much of the park right to the shorelines.

Trapping

The trapping industry was a major topic for conversation at the Dwight meeting, and trapping cropped up again in Vankoughnet. Almost all of Lake of Bays Township is suitable for trapping, and the region south of Gravenhurst was also considered to be

good for trapping today. Registered trap lines cover Crown Land and there are many private trapping agreements over privately owned lands.

Trapping no longer provides a good living, but fur prices seem reasonably good at present, and the real underlying reason to trap is the sheer enjoyment of working on the land. Fur bearing animals that are trapped in Lake of Bays include beaver, fisher, martin and mink. Pelts are sold at the Fur Harvesters Auction in North Bay. In addition, one participant reported that MNR personnel live trap fisher and marten in Algonquin Park and relocate them further west to encourage an increase in fisher/marten populations. Consensus was that this effort was not particularly successful. *(A subsequent conversation with MNR personnel confirmed such relocations had been done in the past, but not since the early 1960s.)*

Participants agreed that, early on, a broad range of fur bearing species were trapped, most of which are not being trapped today. It was not clear whether this decline in harvest was due to the species no longer being present, or simply due to a collapse in the market for the fur. The steel traps brought into the region by settlers proved very efficient at capturing beaver, especially when baited with castor, and resulted in the beaver being trapped out. After the Depression, trappers organized to regulate the catch of beaver and other species. Now, management of the catch is under control of the MNR in cooperation with trappers and populations of fur-bearing species seem generally stable apart from the usual cycles in abundance.

While our participants considered possibilities that changes to forest type and extent might change abundances of fur-bearing species, or that beaver are more common now because the extent of trapping has declined, there were no clear opinions on these ideas.

Hunting

Hunting was not a frequent topic of discussion. The consensus was that hunting is less frequent an activity now than in past years. Reasons for this decline included the suggestion that people are less interested in eating game, that young residents who might formerly have hunted are away at university, and that fewer city dwellers hunt. No conclusions were drawn on the impact of reduced hunting. The discontinuation of the spring bear hunt was frequently noted as being associated with a perceived increase in the number of bear.

In order to determine if there has been an increase in the number of bear, we talked to Jan McDonnell, wildlife biologist for the MNR. She noted that bears are very difficult to count so a population estimate is difficult to establish. Anecdotally, and based on some of the population indices monitored by the MNR, there is little change in bear

populations in the 13 or so years since the spring bear hunt was cancelled. Prior to the cancellation of the spring bear hunt, relatively few bear were harvested in the fall. Most bears were harvested during the spring hunt. Interestingly, there are now nearly as many bears harvested in the fall as previously harvested in the spring hunt. It took a few years for the fall harvest to get to that point.

In another discussion, Brad Steinburg, Ecologist for Algonquin Park, noted that during the Second World War there was some commercial hunting of white-tailed deer (which were very abundant) to alleviate meat shortages. He was unsure precisely how many were harvested.

Tourism and Second Home Development

The development of the big hotels, and the tourism they supported, was another important early step in the development of the Muskoka economy. While tourism can be expected to have had a significant impact on our environment, this was not discussed in any detail. Participants agreed that the old hotels opened up the lakes to recreational use, without removing natural habitat along most of the shorelines. Their replacement by the growth of cottages/second homes has led to a much greater impact on shoreline environment. Participants generally agreed that this has impacted water quality in significant ways.

Discussion of development centered primarily on the development of waterfront land for seasonal homes. Participants agreed that the development of waterfront lots risks having negative impacts on water quality. They also tended to consider that the seasonal residents lacked a sense of stewardship for their land. Comments made included that wakes from boats destroy nests of loons, and that seasonal residents want a "theme park" atmosphere around them. There was general agreement that seasonal residents should be more careful not to kill the natural environment they have come here to enjoy. At the Vankoughnet meeting it was also generally agreed that if land is "harmed" it is harmed by outsiders. Examples were given of companies that come in to clear cut trees on a property, and then "steal" trees from neighboring properties. The problem is seen as "incomers" who don't respect the land. It was felt that people who have grown up in Muskoka are content with less money as they are used to having less. Being used to a simpler lifestyle, they are better stewards of their land. New landowners may not have the same sense of stewardship.

One participant noted the conflict between the need to protect the natural environment and the tendency to allow strip development along roads. As he noted, developed land brings in more tax revenue. Overall, there was a general awareness that development will likely continue, although at one meeting participants seemed to agree that now that all the waterfront property is developed there will have to be a

slowdown in development. One regret expressed at the Vankoughnet meeting was that with increasing numbers of seasonal residents and growing development, the sense of community is disappearing. Participants described how there are many more people now but less "community". The local school has closed and children are bused to Muskoka Falls. There used to be two post offices and a couple of stores, but these are all gone. Many cottages now exist around the small lakes, and permanent residents go elsewhere to work – such as to jobs in Bracebridge.

Overall, at all meetings, participants agreed with the notion that rural Muskoka land owners are generally good stewards of their land, and that we are now far better stewards than was the case 100 years ago. There was also considerable faith in the capacity of the environment to weather the stresses imposed by development, although the fact that some species have suffered while others have prospered was also accepted. The high impacts of the towns, the roads, the cars and road salt got mentioned but only in passing.

Transient Boating on Georgian Bay

One resident of Georgian Bay noted that invasive species introduced to Georgian Bay have had a profound effect on biodiversity. The aquatic ecosystem is going through massive disturbances, which are strongly apparent in the changes in aquatic species composition historically and currently.

Summary

At one meeting, Gord Adams commented that in Muskoka, we control almost all our watershed (except for the headwaters in Algonquin Park, and some parts of the Black/Severn watersheds). This gives us the unusual opportunity to demonstrate good stewardship without being too much affected from outside. Others expressed the fear that water will be diverted from the Great Lakes by the USA (in other words, Muskoka, like any other region in Canada, is not an island).

At all meetings, there was widespread agreement that biodiversity is constantly changing, that humans have had a big impact on these changes, and that we presently enjoy a pretty good level of ecosystem health and biodiversity. Participants also generally agreed that the growing pressure of development, climate change and other threats will make it even more important in the future for land owners and all other citizens and visitors to understand and implement good practices to conserve Muskoka's biodiversity.

Earlier residents, right back to the settlers and even First Nations, had to be good stewards if they were to retain the productivity and value of their lands. With less resource extraction and agriculture going on today, that imperative is much less critical to new residents. Stewardship now tends to focus on aesthetic values, ecological goods and services, and recreational potential. There is not the same impact on family and financial security as earlier residents faced if they failed to be good stewards of the land.

Section 3

Evaluation of Community Meetings – The Value of Local Knowledge and a Participatory Approach

Fascinating insights into a wide range of topics related to Muskoka's environment were gained from the series of informal participatory discussion sessions with local residents. Long-time residents of Muskoka have considerable knowledge of how the Muskoka environment has changed over the years. Many of these observations reflect local understanding of specific biodiversity-related processes.

The general understanding that nature is constantly changing reflects the dynamic nature of biodiversity. Comments regarding specific cycles of abundance of particular species, or the slow progression of ecosystem type in both wetlands and forest areas noted by residents reflect the scientific understanding on these issues. The observations concerning coyote/wolf hybrids reflect a substantial knowledge of evolution and genetic diversity.

Our participants also revealed the community awareness that traditional uses of Muskoka's biodiversity, including farming, trapping, and the timber industry, had diminished greatly in recent years; a fact verified from the literature. An over-riding concern in these discussions was the present and future impact of development, including the impact of the growth of cottaging and other recreational activities, along with population growth dependent on servicing these activities. This concern about our future clearly merits further study.

The individuals with whom we talked were mostly people who worked the land as farmers, loggers or trappers. In many cases, they had carried on the trades of their parents and grandparents. Loggers, farmers, trappers and hunters had a better understanding of ecological change and the reasons for it than people that lived in the small communities but were not intimately connected to the land. While comments during these informal conversations were seldom precise as to when, where, and how much change occurred, we suspect that in many cases, that detail would be available with further conversation. The memories of our long-term residents are a rich store of knowledge about the Muskoka environment.

All our participants seemed to be individuals who enjoyed the natural world and gained at least some of their recreation from it. Not surprisingly, their knowledge of natural history was often quite detailed, and they spoke with authority about many species. Thus their knowledge of changes in the Muskoka environment was frequently quite detailed.

Common Themes

In all these conversations, certain common themes reappeared. These were often stated as accepted fact, and were certainly broadly held beliefs. It was clear that considerable detailed knowledge was behind the comments made, and it is likely that in cases where contradictory observations were reported, an in-depth investigation would reveal that different things were indeed happening in different parts of Muskoka – individuals tended to focus comments on those locations with which they were most familiar.

1. *Nature is naturally changing in a cyclic way, and has a considerable capacity to recover following some deleterious change such as a wildfire or some human activity.*

   This faith in the resilience of nature probably accounts for a generally mild level of concern regarding future changes that we anticipate are coming, especially climate change. These people have seen evidence that the climate is currently changing, and did not dismiss the idea that climate change is human-induced and a coming problem, but, at the same time, they did not, for the most part, see climate change or any other changes likely to occur as probable to seriously disrupt the ecosystems on which they have relied throughout their lives.

2. *Humans have caused substantial changes to the Muskoka environment.*

   The changes have been profound, they have frequently been negative, but they have also become less severe with time. A strong belief was evident that we are now managing our impacts on the natural environment far more effectively than we did in past decades. Coupled with this was a concern that our capacity to steward the land may be eroded as more new seasonal and permanent residents dilute the close ties to the land which long-term residents maintain.

3. *When deleterious changes are caused in the present day, these changes are caused by less well-informed individuals, outsiders, and new seasonal and permanent residents.*

   At one meeting it was explicitly stated that 'long-time Muskoka land owners are good environmental stewards, with the clear implication that others in our community are less good stewards. While it is possible that this dichotomy is overstated, it is undeniable that everyone we spoke with valued the natural environment of Muskoka, and did their best to act as good stewards of their land.

   The importance of good environmental stewardship among long-time residents is relevant to current efforts to promote stewardship by MWC. It demonstrates that values and practices underlying good environmental stewardship have been present in the community from the early days. It is not something new. Rather, it should be recognized as something that MWC is trying to preserve.

Importance of Biodiversity

An increasing awareness about the relationship between biodiversity and watershed health is needed. A sustained effort to raise awareness of biodiversity issues, including issues such as the value of ecosystem services, is required across our community, and these conversations with long-time residents suggest they may be valuable allies in this effort.

Some further, targeted conversations with our long-term residents could be of considerable value. As well as yielding more detail on specific procedures or patterns of activity that have long been used to care for the land and more detailed information on patterns of change in specific parts of the Muskoka River watershed, these discussions should seek to integrate and advance both scientific and local knowledge. In this way, both local residents and MWC gain insight and familiarity with differing approaches in understanding our environment.

In the longer term, participatory approaches can help to increase awareness and consensus about our biodiversity and environment, and strengthen both development policy and environmental stewardship to insure a healthy environment best equipped to meet future changes.

Section 4

Building on What We Have Learned – Understanding Biodiversity Globally and in Muskoka

Biodiversity is a relatively new concept and scientific area of study. It was not until the Rio Conference in 1992 that Biodiversity was truly recognized as an important scientific concept and that the impact of the loss of biodiversity began to be studied in earnest. As with any new area of science our understanding of the processes is changing and evolving as new research is published. In some situations theories may appear to conflict or are in the early stages of development.

Also, as with any new science, scientists are still debating many of the broad concepts related to biodiversity and in some cases there is still disagreement on the amount of biodiversity loss, the impact of biodiversity loss, and even the rate at which people are impacting biodiversity as compared to natural species fluctuations.

In order to establish a basis for future action concerning biodiversity in Muskoka, the remaining sections of this report explore the evolving science around several issues related to biodiversity using examples from a Muskoka context where possible, and including information reported in the three earlier Sections. Parts of this last section may become technical and heavily scientific as we explore some of the current theories, discussions, and recommended actions.

What is Biodiversity?

Biological diversity - or biodiversity - is a term used to describe the variety of life on Earth. It refers to the wide variety of ecosystems and living organisms: animals, plants, their habitats and their genes. It is an essential part of our environment, enabling our ecosystems to maintain productive soils, clean water, and fresh air. Biodiversity also confers ecosystem resilience, which can help our environment recover from future shocks and changes. Hence, biodiversity is important to our well-being.

The Convention on Biological Diversity, as well as the Canadian and Ontario Biodiversity Strategies, recognize three levels of biodiversity – namely ecosystem, species and genetic levels. While we often think of biodiversity as the total number of species in an area, a healthy and resilient environment requires high diversity at all three levels.

Diversity of Ecosystems

The broadest level is the diversity of ecosystems. In Muskoka, there are various types of natural areas, or landscapes, such as forest, wetland, open spaces and aquatic areas. Within each, there are several different ecosystem types. For example, there are bogs, fens, shallow open waters, swamps and marshes. Each type of wetland differs in characteristics like water flow, nutrient availability, organic matter accumulation, and acidity. As a result, different habitats develop with different types of living organisms. In the same way, various types of ecosystems are found within the forests, open spaces, and waterways of Muskoka. The diversity among and within these ecosystems is needed to maintain both species and genetic biodiversity.

All ecosystems change, but the rate of change varies. Some wetlands can change rapidly, perhaps in response to beaver activity (see Section 2 above), or slowly, as in the case of acid bogs cut off from outside sources of nutrients. In these situations, species naturally evolve and change with the ecosystem shift. When people eliminate an ecosystem and it is not replaced, species that rely on that system become stressed and may become extinct.

Diversity of Species

Diversity of species forms the second level of biodiversity. Species diversity includes the sum of all species including the different plants, animals, and microorganisms in a given area. Going back to our wetland example, different combination of species are found in different habitats offered by the different wetland types.

In acidic, nutrient-poor bogs, sphagnum mosses, honey-dews and pitcher plants are found. In swamps, cattails and bulrushes are more likely to be found, with tree species such as tamarack, or even soft maples found on hummocks or around swamp edges, where aeration, growth and nutrient cycling is more rapid.

Different species of birds, mammals, reptiles, insects etc will find suitable habitat in the different types of wetland, and large differences in composition and abundances of soil microorganisms will be found depending on factors such as nutrient water flow and acidity level.

Species that move between different ecosystems, called link organisms, contribute to species diversity and can have profound effects on environmental health (Lundberg and Moberg, 2003). In Muskoka, migratory birds and herbivores including deer, beavers and insects are examples of link species.

Genetic Diversity

Genetic diversity includes the variation in genes found in individual organisms, populations, and species in a given area. These genetic differences, operating over millions of years, have resulted in the enormous diversity that we now experience on earth. Genetic diversity is fundamental in maintaining ecosystem resilience (Thompson et al., 2009).

There are many examples of genetic diversity operating in Muskoka. If we look at interbreeding groups (or population) of soft maple trees in the early spring, we will see large differences from tree to tree – in bark roughness, branching characteristics, or in bud size and shape (some buds are large and red; others are small and grey). Spring sap flow and sweetness also vary. As a species, soft maples in Muskoka are generally not thought to be worth tapping, as their sap volume is low and the sap is not sweet. Yet, individual soft maples can be found which are capable of producing as much maple syrup as a sugar maple tree.

Part of this observed tree-to-tree variation in syrup production is due to genetic differences, which can be passed on from one generation to the next. Other genetic differences that we don't readily see could provide disease or pest resistance, or suit the tree to different soil or changing climate conditions. Different species and populations possess very different levels of genetic variation.

Natural selection, abundance, and differences among individuals in reproductive strategies can all affect the amount of genetic diversity in a population. The totality of these genetic differences in an ecosystem constitutes its genetic diversity. Genetic variation is always in flux due to migration and gene flow among individuals, populations and species. The reference to coyote-wolf hybrids during our discussion meetings (section 2 above) is an example of local understanding about gene flow between species, and has only recently been confirmed in scientific reports.

These three types of diversity together form the *overall biodiversity* of a region. Globally, there are regions, particularly in the tropics, with much higher overall biodiversity, and other regions, such as the Arctic, that are less biodiverse. However, high diversity of one type does not require high diversity of the others, and the rules relating the three types of biodiversity to one another are complex. In general, high biodiversity confers two broad types of benefit, the provision of ecosystem goods and services, and the maintenance of ecosystem resilience.

Biodiversity Provides Ecosystem Goods and Services

A healthy ecosystem, with high levels of biodiversity provides a broad range of essential benefits both to human society and to the planet. These are known as ecosystem goods and services. A good analysis of biodiversity and ecosystem goods and services in Muskoka is found in Heathcote (2010), and a further explanation is found in Section 4 (Biodiversity's Role in Ecosystem Function) below. There are two types of benefits that arise from the provision of these ecosystem goods and services, based on how they are factored into our economy.

Ecosystem Goods

Ecosystem goods are those direct benefits from nature which are valued in our economy and form part of our Gross Domestic Product (GDP) such as food, fuel and lumber. These benefits accrue through direct use of natural products and can have a dollar value assigned to them.

Ecosystem Services

Ecosystem Services are those indirect benefits from nature which are not valued in our economy and do not form part of our Gross Domestic Product (GDP). These benefits accrue through indirect use of natural products and include such things as clean water, erosion-resistant and productive soils, clean air, and protection from the impacts of catastrophic events.

Muskoka Economy

Currently, in Muskoka our economy is heavily dependent on the indirect benefits of the environment. In particular, the economic value of recreation and tourism is largely dependent on a healthy natural environment, but the economic value to this industry of a healthy environment is seldom discussed and largely ignored in our economic accounting (University of Guelph, 2012).

In the past, the economy of Muskoka has been more dependent on the direct benefits of the environment through logging and agricultural. As seen in Sections 1 and 2 above, the logging industry and agriculture formed the backbone of the Muskoka economy from 1800 to about 1950, along with trapping, hunting and fishing. At the turn of the last century, half to three quarters of Muskoka's GDP was probably based on these activities (Census of Canada 1901). Since then, the economic importance of agriculture and the harvesting of forest products in Muskoka has greatly declined, and at present accounts for only 0.7% of Muskoka's GDP (Muskoka Economic Strategy, 2008).

It should be recognized that this reduction in direct use of ecosystem goods has both positive and negative aspects. On one hand, the reduction in Muskoka farming and logging has contributed to the large proportion of the Muskoka watershed presently under secondary forest cover. On the other hand, the reduced logging activity, and the reduction in open farm land due to regrowth following the decline of agriculture have created a shift in ecosystem diversity due to the loss of open land habitats. This shift has likely resulted in a significant reduction in overall ecosystem diversity and has affected many species. Particularly concerning to many Muskoka residents is the reduction in open grassland habitat needed for bobolinks and other songbirds.

The value of the tourism and recreation sector (including cottaging) is presently greater than that of any other economic sector in Muskoka. This sector has been the major driver for the growth of Muskoka's labour force by over 50% in the past 20 years. A further doubling of this sector is foreseen by 2031 (Muskoka Economic Strategy, 2008). The strategy of Muskoka's new regional tourism organization, Explorer's Edge, anticipates an even greater expansion, with a doubling of tourism receipts by 2020 (Explorer's Edge, 2011).

The tourism sector is dependent upon Muskoka's healthy forests, clean water, air, and aesthetic values which underpin the natural environment we all enjoy. The term, "the environment is our economy", confirms that this relationship is widely acknowledged. However, we need to ask whether the economic strategies presently being pursued fully consider the finite capacity of the ecosystem in Muskoka to support a significant increase in development. Many participants in our community discussions noted concern with increased development in their areas.

The natural environment in Muskoka is currently economically undervalued because so much of our economic base is dependent on indirect services. The *undervalued*, or "*free*," *ecosystem services* include the clean waters where we boat and swim, the healthy forests and the wildlife we enjoy watching and hunting, and the clean air that enables us to see the stars at night. There is concern among many in Muskoka (see Sections 1 and 2 above) that if we do not economically value our natural environment, future development could compromise it.

The failure of our present global economic system to adequately value the benefits from ecosystem goods and services is a growing concern. It is now recognized that such environmental benefits can only be maintained if biodiversity is effectively valued and sustained, both locally and globally.

Studies over the past two decades have revealed the enormous scope of this task as well as the costs entailed if we allow biodiversity to degrade. Recently, a global initiative, known as The Economics of Ecosystems and Biodiversity (TEEB), was set up to "initiate the process of analyzing the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation." Their report (TEEB, 2010) describes an approach to

recognize, demonstrate and capture the value of biodiversity and ecosystem services, and suggests how this model can be applied to ecosystems, human settlements and business.

Ecosystem Resilience and Biodiversity

As we start to think about how we live sustainably within the limits of our ecosystem we need to understand some basic ecological principles and how our actions may impact biodiversity.

The concept of ecosystem resilience was aptly summed up by one participant after our first discussion session (Section 2, above) who commented, "We sure beat up Mother Nature in the past – it's amazing how it has recovered."

> *Resilience*
>
> The capacity to recover ecosystem function following a disturbance, either natural or human caused, is known as *resilience*.
>
> *Resistance*
>
> The ability of an ecosystem, or ecosystem component, to withstand a disturbance without changing is known as *resistance*.

Understanding how biodiversity, ecosystem function and resilience interrelate is currently one of the central questions in ecology (Peterson et al, 1998). Here we review two mechanisms that help explain ecosystem resilience, all in the context of the resilience of the Muskoka environment. In the next section, we review recent evidence that the current global decline in biodiversity is having real impacts on the functioning of ecosystems.

Mechanisms

1. *Genetic diversity increases resilience.* Genetic diversity has traditionally been measured using observable traits that are passed on to offspring (for example, details of colour pattern, fin or scale measurements, or leaf shape in plants). These measurements are quite tedious but faster and more reliable methods are being developed. A high level of genetic diversity is considered by many scientists to be the most important factor in conferring resilience in ecosystems (Folke et al., 2004, Thompson et al., 2009, Sgro et al., 2010). Resilience is attained through natural selection, evolution and adaptation of individuals, populations and species. Resilience will be strong when genetic diversity is high.

a. *Slow Evolution* – Slow or natural evolution can be illustrated using lake trout in Muskoka as an example. With the expected gradual warming of lakes due to climate change, natural selection will occur. Individual lake trout which are genetically better able to tolerate the warmer waters will produce more offspring, shifting the mean of the lake trout population towards greater tolerance for warm water. Part of this change is passed on to future generations, resulting in adaptation. Assuming that the initial genetic diversity in Muskoka lake trout is high, that change in temperature is slow, and that there are plenty of lake trout in the population, no net loss of genetic diversity is expected, and the new population will retain its resilience and be able to adapt to repeated slow changes, through a process called recurrent selection. The future lake trout population has demonstrated that it is resilient to the change in temperature regime.

b. *Critical Event* - If an abrupt change to the lake environment were to occur – perhaps a spill of a persistent chemical – all lake trout could die, with the loss of that species from the lake – a major loss of resilience.

c. *Exceptional Individuals* - If a few individuals with exceptional tolerance to the chemical were to survive and pass this resistance on to their offspring, lake trout would continue to occur in the lake (adaptation would have occurred). This new population would have a very much reduced level of genetic diversity, and hence, reduced resilience to future critical events.

The reduced level of genetic diversity arises because the initial killing off of the great majority of individuals will result in a loss of genetic variation in the population. As the population rebuilds, it remains genetically less diverse than it was before the crash because many genes are simply no longer present.

Such an event, in which rapid and intense selection occurs, is called a genetic bottleneck. In such a case, many generations may be needed for genetic diversity to recover through such processes as mutation. Extensive research on both agricultural and forestry species has shown that populations which contain high genetic diversity are intrinsically more tolerant to diseases, pests and other environmental stresses because they include individuals with a broad range of capabilities including some that will be quite resistant to each of these stresses.

2. *Species diversity increases resilience.* The idea that increased diversity of species (also called species richness) imparts greater ecosystem resilience was first proposed by Darwin in 1857. Organisms in an ecosystem play particular roles in its functioning. Each organism can be thought of as occupying a particular *ecological niche* or belonging to a particular *functional group*, and a diverse ecosystem will often contain more than one species in each of its available niches or functional groups. Species that belong to the same functional group play similar, or overlapping, roles in the functioning of the ecosystem.

a. *Redundancy theory* assumes that a diverse ecosystem can continue to function even with some loss of species, because other species in the same functional group will compensate for the loss (Rosenthfield, 2002). This concept has also been called the insurance hypothesis. It assumes that some species will maintain ecosystem function, even if others fail (Yachi and Loreau, 1999). However, the loss of all species belonging to a particular functional group will result in loss of resilience and ecosystem function (Peterson et al., 1998). In applying redundancy theory to conservation, Walker (2003) argues that, "to best focus our efforts we need to establish how much (or how little) redundancy there is in the biological composition of ecosystems. Functional groups with little or no redundancy warrant priority conservation effort."

   While redundancy theory has received much study, environmental scientists are not yet fully agreed on the details of links between species diversity, ecosystem services and resilience. Ghilarov (2000), arguing from a perspective that maintains all species are, by definition, uniquely different ecologically, states that any redundancy of species will be impossible by definition. In his view, efforts to conserve species are always justified.

   By contrast, in talking about forest resilience, Thompson et al. (2009) state that:

   > *"While not all species play important functional roles in ecosystems, many do, and we may not know or understand the role of a given species. Further, under changed environmental conditions, species with previously minimal functional responsibilities may become highly functional…. in the biological realm, maintaining species and genetic diversity addresses the need to be prepared for whatever environmental changes might happen, and this is fundamental to the concept of resilience."*

   Finally, Sgro et al. (2010) de-emphasize the importance of species diversity, arguing that building evolutionary (i.e. genetic) resilience is the most effective approach for adapting to climate change. To achieve this, more attention to rapid measurements of genetic diversity, and more attention to the conservation of landscape diversity are needed.

   In summary, the details of the ways in which biodiversity confers ecosystem resilience are still being determined, but the understanding that there is a real, causal link between these is broadly agreed across the scientific community.

b. *Intermediate Disturbance* - the link between biodiversity and resilience is not expected to be linear. In 1978, Joseph Connell published an article in Science showing that there is an interesting relationship between the frequency or extent of disturbances to an ecosystem and the level of biodiversity within it. He called his idea the 'intermediate disturbance' hypothesis; it stated simply that local species diversity is maximized when ecological disturbance is neither too rare nor too frequent, and he illustrated this with information from both rain forests and coral reefs. The reason for this relationship is that when disturbances are very

rare, competitively dominant species become progressively more abundant and eliminate other species. Conversely, when disturbances are very frequent, only a minority of hardy opportunist species are able to survive. At intermediate levels of disturbance, a greater number of species can survive, and the disturbance regime prevents the competitive dominants from becoming too abundant.

This notion that increasing disturbance towards intermediate levels can increase biodiversity opposes the older idea that diversity is highest in undisturbed ecosystems. Evidence that highest species diversity occurs with intermediate disturbance, either in time or in space, has been found in a wide variety of ecosystems, including river ecosystems (Ward and Stanford, 1983), tropical rainforests (Molino and Sabatier, 2000), in subalpine forests (Buma and Wessman, 2011), and on coral reefs (Connell, 1978).

The important message from this hypothesis is that the effects on diversity of deleterious environmental impacts are not always linear. It follows, of course, that while the intermediate disturbance hypothesis refers specifically to species diversity, the relationship should carry through to genetic diversity.

We have clear evidence (Sections 1 and 2) that human activity in the past two centuries has created strong and frequent disturbance to forested lands in Muskoka, through cutting of forests for timber and for agriculture. These activities are now dramatically reduced.

If the intermediate disturbance hypothesis applies, Muskoka forests are likely more diverse now than at the height of the logging boom, and may even be more diverse than they were prior to European arrival, when mature forest was presumably more widespread.

While we do not know the details, forests in Muskoka likely have moved though a succession of stages to a point where high levels of species diversity have returned, but with changed species composition. Thus, the intermediate disturbance hypothesis can be a useful tool in understanding the resurgence in our natural environment in Muskoka over the past century.

3. *Biotic Resistance and Invasive Species.* High biodiversity likely also plays a direct role in protecting ecosystems from invasion by exotic species, including disease vectors. Charles Elton (1958) used the term 'biotic resistance' in first suggesting this possibility. In his view, ecosystems with rich biodiversity are able to use the available resources/nutrients more effectively than ecosystems with low species richness. This prevents the invasive species from gaining a foothold.

   A recent analysis of invasive species indicates that biotic resistance may operate by constraining the abundance of invasive species once they have successfully established (Levine et al., 2004). For example, in Muskoka, the restriction of purple

loosestrife largely to roadside ditches may be due, in part, to the operation of biotic resistance.

High genetic diversity, redundancy of species, intermediate disturbance and biotic resistance are all mechanisms for attaining resilience. They can maintain ecosystem functions in Muskoka, enabling adaptation to environmental change. Yet, it may be difficult to predict how effectively biodiversity can continue to confer its benefits in the face of the type, rate and extent of changes expected in the future. The following section explores this question further in a global context.

Global Trends in Biodiversity

Muskoka still enjoys high biodiversity, but as more stresses from both outside and inside the watershed are experienced, we can learn from other regions of the globe that have had to deal with significant biodiversity loss. There is evidence that biodiversity is in a state of profound decline globally and is degrading in Ontario, although the situation in Muskoka is less extreme than in many other places because pressures are somewhat less, and conservation practice is relatively strong. Given the value of high biodiversity, we must avoid complacency and work to insure our biodiversity is adequately conserved.

Increases in Species Extinction

Globally, many ecologists now feel that we are on the brink of the Holocene mass extinction, the sixth mass extinction the world has experienced since the evolution of complex, multicellular organisms in the Cambrian period, 570 million years ago. The Holocene epoch is the geologically brief interval of time encompassing the last 10,000 years since the last ice age.

The results of a recent study by Barnosky et al. (2011) confirm that current extinction rates are higher than would be expected from the fossil record, highlighting the need for effective conservation measures. We have already lost 1/5 to1/2 the mammals that existed in North America at the time of European settlement (Carrasco, 2009). This rate is approaching the rate considered by most scientists as being a mass extinction.

While rates of species loss are particularly high in highly stressed regions and ecosystems, losses of species are occurring in Ontario as well. Using global models, projections of global species loss to 2100 indicate that a very large fraction of species will become extinct due to human population increase, land use and climate change. These projected rates are, with one exception, two orders of magnitude higher than observed extinction rates in the second half of the 20th century (Leadley, 2010).

Homogenizing Populations and Ecosystems

Along with the extinction of species, and in many ways far more important, we are homogenizing populations and ecosystems, and by reducing sizes of populations we are reducing genetic variation. In short, we are engaged in a massive reduction of biodiversity across the world.

This loss of biodiversity, rather than the final extinction of particular species, is expected to have major consequences for the production of environmental goods and services, and hence will have significant economic consequences for us. It also reduces the resilience of ecosystems at a time when pressures on them are growing.

Despite global efforts to stem loss in biodiversity which began in earnest 25 years ago, the various methods used to measure it continue to show a reduction in biodiversity, and many show accelerating declines (Butchart et al., 2010). While early focus was on the effects of habitat alteration and loss on biodiversity, it is now recognized that climate change is going to have major effects in addition (Bellard et al., 2012). Some have criticized the results obtained from studies that focused on habitat loss since it is now evident that the true extent of decline in biodiversity due to human alteration of habitat has been underestimated (Mendenhall et al., 2012).

The loss of biodiversity is not restricted to those species that inhabit 'natural' ecosystems. It extends to the homogenization of agricultural species as agriculture evolves to an increasingly globalized industry focused on just a few types of a relatively small number of crop plants. As long ago as the mid-1960s, the Australian geneticist, Sir Otto Frankel, and others raised concerns about the imminent loss of genetic diversity in crop plant species. Projections were dire, and based on an assumed progression by all farmers away from traditional species of plants in favour of a few new high-yielding varieties.

There is some good news, however, because in the years since the 1960s, work by Guarino (2009) and others has revealed that even in areas that have adopted modern agriculture and new varieties, there is no evidence of genetic erosion in sorghum or rice diversity, for example, over the past four decades. Farmers in many areas around the world, particularly where cultural traditions remain intact, are maintaining and developing high levels of genetic diversity, which in some cases has actually increased over time. In these areas, conservation of agricultural biodiversity is now focused on community-based approaches, helping farmers to value and benefit from their local biodiversity and develop sustainable agricultural practices.

Ontario Biodiversity Loss

Ontario is not an island, and biodiversity is declining here as well. The recent call by Ontario's Environmental Commissioner (2012) for a Provincial government policy to stem the decline in biodiversity, points to the value to us of doing so. That report states:

> *"The loss of biodiversity directly affects Ontario. Similar to the rest of the world, the most significant threats to biodiversity in our province are habitat degradation, climate change, invasive species, overexploitation, and pollution."*

The State of Ontario's Biodiversity 2010 concluded that our provincial government's efforts to conserve biodiversity have increased over the last decade, but they have been insufficient to prevent its continued loss.

The message overall, here in Muskoka and elsewhere around the globe, must be that biodiversity is in serious decline, although the rate of decline varies regionally. As scientific and community understanding grows concerning the role of biodiversity in protecting ecosystem function, it is becoming clear that this deterioration is having an impact on the ability of ecosystems to function.

In June 2012, two important articles were published in the journal Nature. Bradley Cardinale of the University of Michigan led a team of authors (Cardinale et al., 2012) in a sweeping review of the past 20 years of research into the relationships between biodiversity, ecosystem functioning, and the provision of ecosystem goods and services. They presented six 'consensus statements' of which the first two are most important for our purposes:

1. There is now unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.
2. There is mounting evidence that biodiversity increases the stability of ecosystem functions through time.

They also made the chilling statement that "the impacts of diversity loss on ecological processes might be sufficiently large to rival the impacts of many other global drivers of environmental change."

The more technical paper by several of the same authors, led by David Hooper of Western Washington University (Hooper et al., 2012), conducted a series of global meta-analyses of published data across numerous ecosystems and geographic locations to explore the importance of biodiversity loss relative to other recognized causes of ecosystem decline such as climate change, pollution or over-harvesting. In their words, their "analyses clearly show that the ecosystem consequences of local species loss are as quantitatively significant as the direct effects of several global change stressors that

have mobilized major international concern and remediation efforts." In other words, there is now sufficient scientific evidence available to support the claim that biodiversity really matters, and that current rates of biodiversity loss are going to cause significant changes to the functioning of ecosystems.

Management Efforts

There are three important messages that can inform future management efforts in Muskoka:

1. The degree and nature of biodiversity decline may be very different in different areas; hence further location-based assessments of biodiversity are needed.
2. Engaging universities and other research scientists in local research projects will enhance our understanding of local biodiversity and add to our ability to develop strategic community-based biodiversity plans.
3. Recognizing local knowledge and empowering communities to take the lead in conserving and sustainably using biodiversity have been found to be very effective mechanisms to reverse or prevent biodiversity decline in some areas elsewhere around the world.

Our findings in conversations with local residents and the more traditional science-based research undertaken by Committee members point us toward expanding both approaches in Muskoka.

Biodiversity's Role in Ecosystem Function

Now, let us summarize biodiversity's role in the functioning of ecosystems, and let us explore how ecosystem function changes during the current general decline in biodiversity that is occurring globally, though at differing rates in different places.

If biodiversity is declining over time, we can anticipate that resilience within ecosystems must fall. What is currently not known with any certainty is how far biodiversity can fall before resilience reaches a critical level and the ecosystem can no longer provide its goods and services.

Some 'keystone' species may be so critical to the functioning of the system that their growing rarity or loss would be immediately reflected in a reduced ecosystem capacity. Other species, redundant ones with many similar species present and occupying the same functional group, may be able to be lost with no apparent effect on ecosystem functioning. Ultimately, of course, there must come a point at which ecosystem functions can simply not be maintained. Given the present limited

understanding, it seems prudent to take steps to minimize rates of species loss, preserving biodiversity and the continued production of environmental goods and services that it permits.

In Muskoka, while our biodiversity is not plunging rapidly, the range of pressures continues to grow, and further declines should be expected. These pressures include increasing development and growing human population, changing climate, and a broad array of subtle environmental changes due to various types of pollution, arrival of new pathogens and invasive species, and, to a lesser extent, continued exploitation of fish, game and timber. If we value our natural environment and recognize the important economic contributions it makes to our local economy, management to achieve conservation of biodiversity must become a priority goal. To do this effectively, we need to use:

- the best available science to pin down relationships between biodiversity, ecosystem function, and economic value,
- the broadest knowledge of the processes affecting our Muskoka environment, particularly including local knowledge and perspectives,
- knowledge of how and why it has changed in the past, and
- an effective broad-based collaboration among residents, seasonal residents and visitors, municipal and provincial governments, and the regulatory agencies to increase awareness and design and implement effective management policies and practices.

Logically, if regional biodiversity is progressively lost, there must come a time when ecosystems in that region will no longer be able to function appropriately (produce their goods and services) or respond resiliently to new environmental pressures.

Here in Muskoka, where environmental goods and services, whether explicitly valued or not, play a major role in driving our economy, and where our environment is currently of good quality (relatively high biodiversity, appropriately functioning ecosystems) but subject to growing human pressures, prudence would suggest that the protection of biodiversity is very much in our communal self-interest.

Patterns of Change and Managing for Resilience in Muskoka

Ignoring for the moment the evident impacts of humans on the Muskoka environment over the past several hundred years, there is considerable evidence of ecological change due to climatic changes in the past. A number of paleoecological studies have shown that forest types and landscape structure in this area have been changing due to the gradual warming trend throughout the Holocene.

The boundary between the mixed forest of white and red pine, beech, maple and oak typical of Muskoka today and the boreal forest of spruce, fir and jack pine that originally colonized as the ice retreated migrated steadily northward from 10,000 BP to 7,000 BP as climate warmed, reaching as far north as Timmins where it remained from 7,000 to 3,000 BP when temperature in this region was slightly warmer than today. It then moved south again as climate cooled, towards its present position south of Gogama (Liu et al., 1990).

These shifts in vegetation were neither uniform for all species nor entirely due to changes in temperature. Abundance and distribution of white pine varied markedly; this species is strongly influenced by the fire regime and dryer climates favour it. Abundance of white pine in the region has been declining over the past 2,000 years as climate became less dry and fire frequency presumably less.

When the effects of humans are factored in, particularly early logging that favoured specific tree species and our suppression of fire, the historical changes in the typical forest of Muskoka have been profound. White pine in particular is far less common now than it was at the time of European settlement. Hemlock has also become less abundant primarily due to logging activity, and these changes in abundance of dominant tree species have had significant impacts on the abundances of a range of other species. The complexity of the web of factors that determine forest composition is seen in Figure 1.

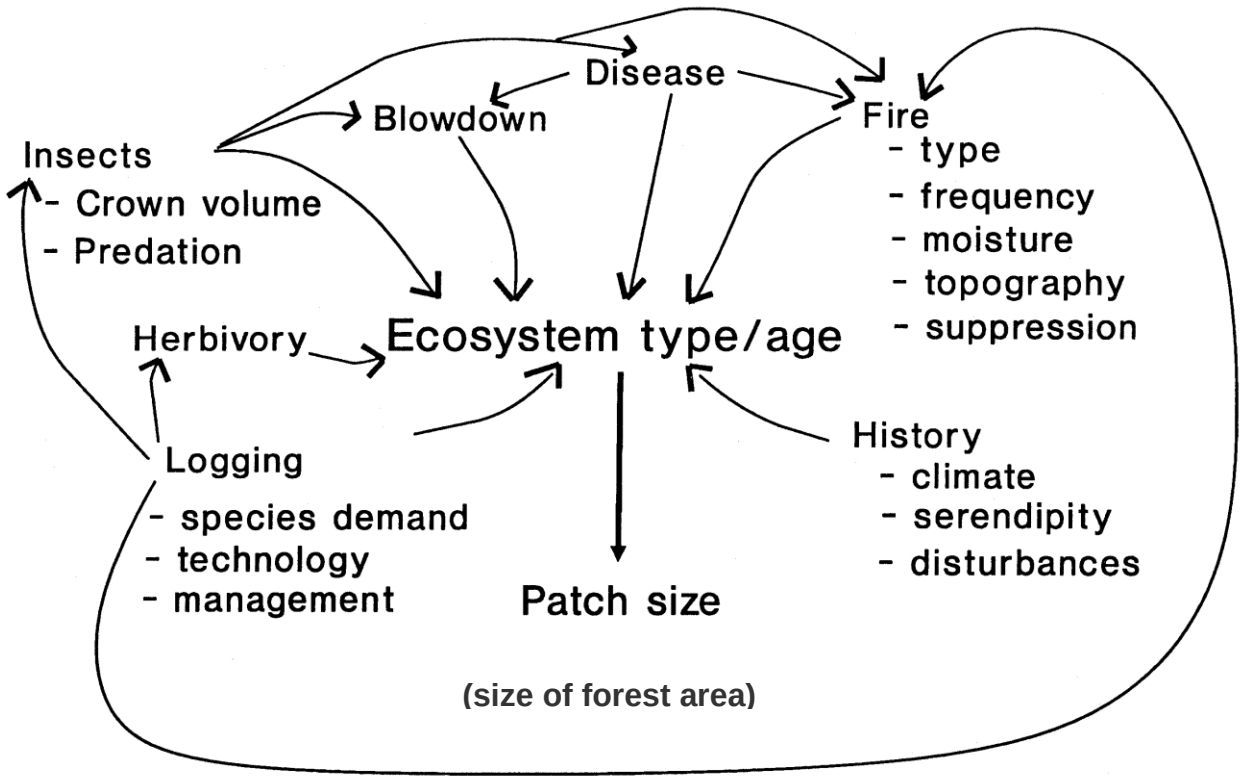

Figure 1. **A diagram showing the network of processes, some natural, some caused by humans, that together act to determine the structure of a forest ecosystem, including its type, its age, and the degree to which it is subdivided into patches separated by more open land (From Thompson et al., 1998).**

In Figure 1 above, 'ecosystem type/age' represents the state of the tree community, and it is influenced by a large number of factors. Most of these are 'natural' in the sense that they have been acting on forests long before humans became important in Muskoka. A few, such as 'logging', are uniquely human. Many are relatively simple, while others, such as 'fire', 'history' and 'logging', are more complex, so that, for example, in looking at logging it is necessary to consider which species, what methods of harvest, and what form of management of the process and of the land following harvest, is being employed. Only with information on these details can the effect of logging be gauged.

What is perhaps not obvious in Figure 1 is that human activities impact nearly all the factors shown. While we obviously control logging, we strongly influence fire regimes, we contribute to local history, and we have often had important impacts on the nature of insect attack, on diseases, and on patch size. In short, the nature of the Muskoka forest is determined by a multiplicity of factors, it has changed greatly in the past, and once humans are on the scene, the change of forest ecosystem type is a process influenced in many ways by us.

A similar story can be constructed using the ecological literature on our impacts on aquatic ecosystems in Muskoka. Suffice to say that our selective fishing, our stocking, intentionally or otherwise, with particular species, and our introductions, nearly always unintentionally, of noxious pest species have caused substantial change to aquatic ecosystems, both on our inland lakes and maybe even more pronounced on Georgian Bay.

Our building of dams, dredging of channels, and also our clearing of forested land have altered patterns of water flow, and with them the nature of aquatic ecosystems. And these patterns of human-induced change have been built upon on-going patterns of change as climate changed during the past 10,000 years.

Both on land and in the water, the Muskoka River watershed of 2012 is a stage in a journey as ecosystems shift and change, sometimes, but not always, because of human activity. It follows that, if maintenance of watershed health is to be our goal, we have to understand, anticipate, and (where possible) manage the changes that will surely come in the future, even if climate change and biodiversity loss were not upon us. We face a significant challenge, but the role of biodiversity in promoting ecosystem resilience offers us a clear path forward.

To put it simply, biodiversity confers resilience, and resilient ecosystems respond better to environmental changes, continuing to function well and continuing to provide the goods and services on which we depend. With change of many types happening, and knowing that we will not be able to control all change, the Muskoka community should adopt management approaches that conserve biodiversity throughout our region.

This "*management for conservation of biodiversity*" is simply good stewardship – acting in ways that favour long-term sustainability of ecosystem function. It is a task for land owners, other seasonal and permanent residents, visitors, MNR, MOE, and local and regional governments. All members of our community will benefit from such stewardship; the challenge is that with climate change and growing pressures of development, the task of conserving biodiversity becomes more difficult.

Thompson et al. (2009) provide a set of principles for preserving forest biodiversity through enhancing forest resilience. These are an excellent beginning to lead us forward, and are quoted here in full:

1. "Maintain genetic diversity in forests through practices that do not select only certain trees for harvesting based on site, growth rate, or form, or practices that depend only on certain genotypes (clones) for planting.
2. Maintain stand and landscape structural complexity using natural forests as models and benchmarks.
3. Maintain connectivity across forest landscapes by reducing fragmentation, recovering lost habitats (forest types), and expanding protected area networks (see #8 below).

4. Maintain functional diversity (and redundancy) and eliminate conversion of diverse natural forests to monotypic or reduced species plantations.
5. Reduce non-natural competition by controlling invasive species and reduce reliance on non-native tree crop species for plantation, afforestation, or reforestation projects.
6. Reduce the possibility of negative outcomes by apportioning some areas of assisted regeneration with trees from regional provenances and from climates of the same region that approximate expected conditions in the future.
7. Maintain biodiversity at all scales (stand, landscape, bioregional) and of all elements (genetic, species, community) and by taking specific actions including protecting isolated or disjunct populations of organisms, populations at margins of their distributions, source habitats and refugia networks (areas that are naturally buffered from extreme climate change). These populations are the most likely to represent pre-adapted gene pools for responding to climate change and could form core populations as conditions change.
8. Ensure that there are national and regional networks of scientifically designed, comprehensive, adequate, and representative protected areas. Build these networks into national and regional planning for large-scale landscape connectivity."

References

Barnosky, Anthony D.,Nicholas Matzke, Susumu Tomiya, Guinevere O. U. Wogan, Brian Swartz, Tiago B. Quental, Charles Marshall, Jenny L. McGuire, Emily L. Lindsey, Kaitlin C. Maguire, Ben Mersey & Elizabeth A. Ferrer. 2011. Has the Earth's sixth mass extinction already arrived? Nature 471, 51–57. Retrieved from http://www.nature.com/nature/journal/v471/n7336/full/nature09678.html

Bellard, C., C. Bertelsmeier, P. Leadley, W. Thuiller and F. Courchamp. 2012. Impacts of climate change on the future of biodiversity. Ecology Letters 15: 365-377

Buma, B., & C. A. Wessman. 2011. Disturbance interactions can impact resilience mechanisms of forests. Ecosphere 2: art64. Retrieved from http://dx.doi.org/10.1890/ES11-00038.1

Butchart, S.H.M., M. Walpole, B. Collen, A. van Strien, J.P.W. Scharlemann et al. 2010. Global biodiversity: Indicators of recent declines. Science 328: 1164-1168

Carrasco, M.A., A.D. Barnosky, A.D. Graham. 2009. Quantifying the Extent of North American Mammal Extinction Relative to the Pre-Anthropogenic Baseline. PLoS ONE 4(12): e8331. doi:10.1371/journal.pone.0008331

Chapin, F.S., E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S.E. Hobbie, M.C. Mack, & S. Díaz. 2000. Consequences of changing biodiversity. Nature 405: 234-242

Connell, J.H. 1978. Diversity in tropical rainforests and coral reefs. Science 199: 1302-1310

de la Fosse, Frederick. 2004. English Bloods. Natural Heritage Books, Toronto

Elton, C.S. 1958. The Ecology of Invasions by Animals and Plants. Methuen, London

Environmental Commissioner of Ontario. 2012. Biodiversity: A nation's commitment, an obligation for Ontario. Special Report to the Legislative Assembly of Ontario, January 2012: 28

Evans, L.T. 1999. Sir Otto Frankel, 1900-1998. Historical Records of Australian Science, 12 (4), http://www.science.org.au/fellows/memoirs/frankel.html

Folke, C., S.Carpenter, B.Walker, M. Scheffer, T. Elmqvist, L. Gunderson, & C.S. Holling. 2004. Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. Annual Review of Ecology and Systematics 35:557-581

Ford-Lloyd, B., Brar, D., Khush, G., Jackson, M., & Virk, P. (2008). Genetic erosion over time of rice landrace agrobiodiversity Plant Genetic Resources, 7 (02) DOI:10.1017/S1479262108137935. As cited in Agricultural Biodiversity Weblog The debunking of the genetic erosion meta-narrative continues by Luigi Guarino on July 7, 2009

Ghilarov, A.M. 2000. Ecosystem functioning and intrinsic value of biodiversity. Oikos 90: 408-412

He, Fangliang, & Hubbell, S.P. 2011. Species-area relationships always over-estimate extinction rates from habitat loss. Nature 473: 368-371

Heathcote, I. 2010. Biodiversity. In Climate Change and Adaptation in Muskoka. Muskoka Watershed Council: 12-16

Leadley, P., H.M. Pereira, R. Alkemade, J.F. Fernandez-Manjarrés, V. Proença, J.P.W. Scharlemann, M.J. Walpole. 2010. Biodiversity Scenarios: Projections of 21st century change in biodiversity and associated ecosystem services. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 50, 132 pages

Levine, J.M, P.B.Adler and S.G. Yelnik. A meta-analysis of biotic resistance to exotic plant invasions. 2004. Ecology Letters, 7: 975–989

Liu, Kam-Biu, 1990. Holocene paleoecology of the boreal forest and Great Lakes-St. Lawrence forest in northern Ontario. Ecological Monographs 60: 179-212

Lundberg,J. and F.Moberg. 2003. Mobile link organisms and ecosystem functions: implications for ecosystem management. Ecosystems 6: 87-98

Mendenhall, C.D., G.C. Daily & P.R. Ehrlich. 2012. Improving estimates of biodiversity loss. Biological Conservation in press doi:10.1016/j.biocon.2012.01.069

Molino, J.F. & D. Sabatier. 2001. Tree diversity in tropical rain forests: A validation of the intermediate disturbance hypothesis. Science 294: 1702-1704

Murray, F. ed. 1963. Muskoka and Haliburton 1615-1875. University of Toronto Press, Toronto

Muskoka Economic Strategy. 2008. Phase I: Background Report, Malone Given Parsons Ltd, unpublished

Paterson, D. 1969. Muskoka District Local Government Review. Final report and recommendations, unpublished

Peterson, G., C.R. Allen, & C.S. Holling. 1998. Ecological resistance, Biodiversity and Scale. Ecosystems 1: 6-18

Grant, G.M. ed.1882. Picturesque Canada – The Country As it is and Was. Belden Bros, Toronto

Rosenthfield, J.S. 2002. Functional redundancy in ecology and conservation. Oikos 98: 156-162

Sgro, C.M,A., J. Lowe, & A.A. Hoffmann. 2010. Building evolutionary resilience for conserving biodiversity under climate change. Evolutionary Applications 4: 326-337

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB. UNEP, Nairobi. ISBN 978-3-9813410-3-4

Thompson, I., B. Mackey, S. McNulty, A. Mosseler. (2009). Forest Resilience, Biodiversity, and Climate Change. A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43, 67 pages

Thompson, I.D., M.D. Flannigan, B.M. Wotton and R. Suffling. 1998. The effects of climate change on landscape diversity: an example in Ontario forests. Environmental Monitoring and Assessment 49: 213-233

Walker, B.H. 2003. Biodiversity and ecological redundancy. Conservation Biology 6: (1) 18-23

Ward, J.V. and J.A. Stanford. 1983. The intermediate disturbance hypothesis: an explanation for biotic diversity patterns in lotic ecosystems. Pages 347-356 in Fontaine, T.D. and S.M Bartell, editors. The dynamics of lotic ecysystems. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, U.S.A.

Wolosz, T. 2004 Class Notes. How many Species are there? Center for Earth and Environmental Sciences Platsburg State University , NY http://faculty.plattsburgh.edu/thomas.wolosz/howmanysp.htm

Yachi, S. and M. Loreau. 1999. Biodiversity and ecosystem productivity in a fluctuating environment. Proc. Nat. Acad. Sci. U.S. 96: 1463-1468