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February 13, 2001
Sarah Ingwersen

A CAUTION TO THE READER

This M.Sc.F. thesis has been through a semi-formal process of review and comment by at least two faculty members.

It is made available for loan by the faculty for the purpose of advancing the practice of professional and scientific forestry.

The reader should realize that opinions expressed in this document are the opinions and conclusions of the student and do not necessarily reflect the opinions of either the supervisor, the faculty or the University.

ABSTRACT

Biodiversity Conservation: Five Forest Management Plans Evaluated

Biodiversity is a complex concept that encompasses the structure, composition and function of the four levels of biological organization (genetic, species, ecosystem and landscape). A thorough understanding of these concepts and the implementation of the concepts in management are central to the conservation of biodiversity. Examining Ontario forest management plans to evaluate their approach to biodiversity is important to identify how well forest management is dealing with the concepts of biodiversity. Five Ontario forest management plans were examined using an evaluation form and associated criteria. The five plans were: the Trout Lake Forest Management Plan, the Nipissing Forest Management Plan, the French-Severn Forest Management Plan, the Kapuskasing Forest Management Plan, and the Whiskey Jack Forest Management Plan. The evaluation procedure was developed based on current literature that identified management techniques for the conservation of biodiversity. A score was assigned based on the comparison of the plan against the criteria. A chi-square test was conducted to determine if there were significant differences between the selected plans. There were no significant differences among the plans regarding their individual approaches to biodiversity. The Whiskey Jack Forest Management Plan was most thorough in its attempt to address important biodiversity concepts. Four of the five plans failed to identify the genetic level of biodiversity as a consideration in management. Addressing important biodiversity concepts in the context of forest management planning is essential to biodiversity conservation. By identifying areas where management plans could improve would initiate ground-level research into the biodiversity of northern regions and as a result would promote the conservation of biodiversity.

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INTRODUCTION

In little more than a decade, the idea of biodiversity has moved from arcane discussions in academia, to the forefront of the public mind. The literature on biodiversity and biodiversity conservation has exploded, and the concept is now a subject of discussion in many different forums. Virtually all land management plans written in North America, including forest management plans, must consider and plan for the conservation of biodiversity. For now and into the forseeable future, concern for biodiversity will have a major impact on forestry practices and the future of managed forests.

The concern for biodiversity developed in response to tropical deforestation (Wilson 1992). Loss of species diversity in the tropics sparked the realization that the earth was more than a function of the number of species (Wilson 1992). Genetic composition of populations, species associations and biogeochemical cycles all contribute to the complex web of life that is captured by the term biodiversity or biological diversity. The term has become a powerful symbol for the full richness of life on Earth. Biodiversity is also the new force behind reforming land management and the development of practices to establish a more harmonious relationship between humans and nature (Noss and Cooperrider 1994).

The primary purpose of this study is to evaluate five forest management plans from the period covering April 1, 1999 to March 31, 2005 to assess their overall approach to biodiversity conservation. Because biodiversity conservation is critical to successful forest management and because the public views forest management as a force that impacts biodiversity, it is important to identify sound management approaches to the conservation of biodiversity. Normally the forest management plan and the actions that follow are the vehicles by which people affect biodiversity in forests and therefore the plan is the best place to coordinate discussions on the topic.

Boyle (1991) pointed out the urgent need for a careful examination of existing and planned activities regarding biodiversity. Evaluating a forest management plan to determine if important biodiversity concepts are addressed helps to isolate where forest management succeeds and where it may be failing to conserve biodiversity. The concepts of biodiversity cannot be used in the development of sustainable forest management systems unless they are thoroughly understood (Kimmins 1997).

The Crown Forest Sustainability Act (CFSA) was introduced in Ontario in 1995 to replace the Crown Timber Act (OMNR 1996). The new legislation aimed to promote sustainable forest management practices with more emphasis on integrating other forest values and concerns. Various manuals guide management teams though the planning process including: the Forest Management Planning Manual; The Forest Information Manual; The Forest Operations and Silviculture Manual; and The Scaling Manual.

The Ontario Forest Management Planning Manual identifies biodiversity as an indicator of sustainability. Biodiversity is complex and conceptual understanding is central to effective forest management and conservation strategies. If managers follow a few general rules set out to conserve biodiversity, but do not understand the specifics, important elements may be overlooked. Acquiring a deep understanding of the concept of biodiversity will guide managers through thoughtful approaches to conservation and will promote greater appreciation for what is being managed. Ideally, the biodiversity strategy of forest management plans should be clearly stated in order to guide managers through effective management processes. In addition, all forest management plans are public documents and therefore should be written in a manner that is clear and concise.

While there is considerable knowledge about the ecology of northern forests, much remains to be learned about how forest management affects the biodiversity of these forests. The genetic constitution of populations, species associations, and the functional processes that keep the landscapes in a perpetual state of change are crucial components of biological diversity. Identifying forest management as the activity that impacts biodiversity is an important first step towards implementing an appropriate conservation strategy. Forest management can take steps now to incorporate sound biodiversity strategy including appropriate indicator selection and effective monitoring programs that will supply managers with the true picture of what is happening on the ground.

Examining how a plan is incorporating a biodiversity strategy will help to identify if management plans are addressing each conceptual component of biodiversity equally. If an important aspect of biodiversity is not identified in a forest management plan three assumptions can be made: 1) that management actions for one aspect of biodiversity will automatically take care of another aspect and therefore are not worthy of mention; 2) that managers do not fully understand the complexity of biodiversity; or 3) that managers are not aware of an aspect's importance to biodiversity.

Evaluating selected Ontario forest management plans will help to identify where forest management has been successful in addressing important biodiversity concepts and where planning has failed to address the key concepts. Assessing the plans will help to guide future biodiversity ground level research in northern regions. If management planning moves towards greater accountability for biodiversity, then more on the ground research can and will occur.

The clear communication of the biodiversity strategy in a plan is not to pay lip service to biodiversity but to communicate the biodiversity approach that will affect biodiversity on the ground. Clearly outlining the biodiversity strategy used in the forest management plan would aid forest managers in their task of managing biodiversity. In addition to aiding the managers, a clearly stated biodiversity strategy would enable the public to follow how the biodiversity of the forest is managed as forest management plans are public documents.

The silvicultural prescription, while in some cases may be extremely effective in conserving biodiversity on the ground, may not be thorough enough to address the entire issue of biodiversity. Some plans may communicate biodiversity approaches very poorly but may prove to be conserving biodiversity effectively, while other plans that communicate biodiversity very well in the plan may not be conserving it very well on the ground. This may indicate that effective biodiversity planning is misunderstood and that approaches have random success. Identifying where biodiversity planning could improve would help to guide researchers towards focused studies on the compositional, structural and functional aspects of biodiversity. This would facilitate greater understanding of Ontario's forests and would promote the use of effective management tools.

All of the selected forest management plans that were evaluated in this study were lacking important information regarding biodiversity. Most of the plans were lacking information in the same areas but some plans were lacking important information in areas where other plans did well; this indicates that there is not a unified and accepted approach to biodiversity in Ontario forest management. Identifying key conceptual areas in planning will aid in the effective implementation of management and monitoring tools to conserve biodiversity in the future.

LITERATURE REVIEW

BIODIVERSITY DEFINED

Many definitions of biodiversity have been proposed to the scientific community, and although the wording is slightly different, they all have a common theme. Boyle (1991), for example, defines biological diversity as the variety and variability among living organisms and the ecological complexes in which they occur. The word diversity, first used in a statistical or mathematical context, is defined as the number of different items and their relative frequencies. Thus, the term encompasses different ecosystems, species, genes and relative abundance (U.S. Congress, Office of Technology Assessment 1987). There are many levels of biological diversity, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity.

Noss and Cooperrider (1994) define biodiversity as the variety of life and its associated processes. They include in their definition: the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting.

The Forest Management Planning Manual for Ontario's Crown Forests (OMNR 1996 pp. GL7) defines biological diversity as: "the variability among living organisms from all sources including *inter alia* (among other things) terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

Most definitions of biodiversity include keywords and phrases such as: variety, complexity, abundance, evolution and associated ecological processes.

LEVELS OF BIODIVERSITY

Four specific levels of organization of biodiversity include: the genetic level, the species level, the community or ecosystem level and the landscape level. The levels are further divided into various components, and will be discussed later. The aim of this hierarchical approach to defining biodiversity is to organize the infinite complexity of nature (Noss and Cooperrider 1994) into workable concepts useful in a land management setting.

The Genetic Level

Genes are the raw material from which all other aspects of biological diversity are built and so genetic diversity is fundamental to the variety of life (DeWald and Mahalovich 1997). Genetic variation among and within species is a result of evolution; variation refers to the combination and frequency of gene sequences. Genetic traits can also be geographically dependent. Populations of the same species can exhibit unique combinations of genes, which enable local adaptation to environmental conditions. According to Noss and Cooperrider (1994) adaptations occur as a result of both random and deterministic forces. A random force refers to mutations that create new genes or sequences of genes or if genes are lost from a small population. Deterministic forces include natural and artificial selection in which specific traits are passed on to offspring. Genetic diversity is the foundation for all other levels of biodiversity.

The Species/Population Level

The species/population level is the most recognized level of biological organization. Some 1.4 million species of organisms have been discovered and named but the total number of species on earth has been estimated between 10 and 100 million species (Wilson 1992). Figure 1 illustrates the breakdown of known or classified species by major group. Monitoring the loss of species that have not been classified (the majority) is impossible and therefore protecting them and their role in the ecosystem is extremely difficult.

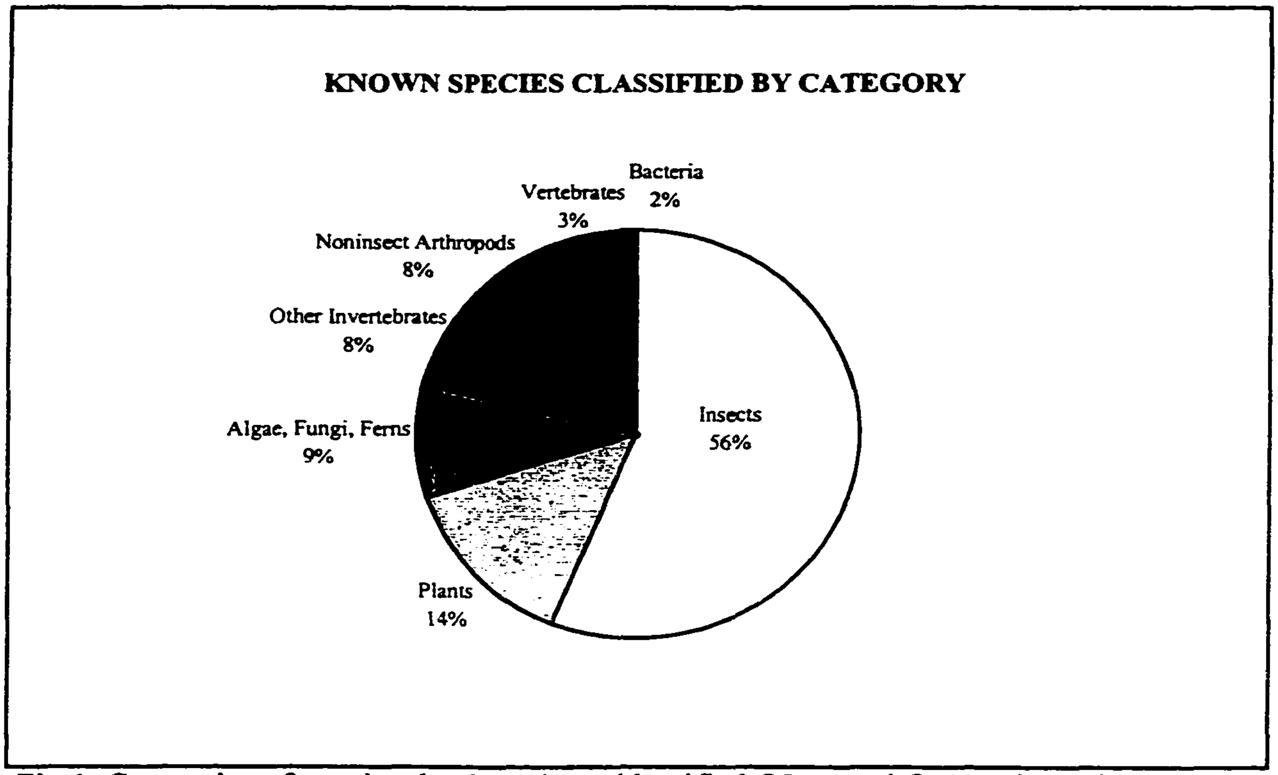

Fig.1. Categories of species that have been identified (Noss and Cooperrider 1994)

There are two commonly used measures at the species level of biodiversity: species richness and species evenness (Kimmins 1997). Species richness is the number of species in an area and species evenness refers to the relative abundance of species in an area. By these criteria, for a given number of species, a community will have greater diversity if all species have equal representation of individuals than if 90% of all individuals are from a single species and the other species comprise only 10% of the individuals (Kimmins 1997). However, diversity does not equal biodiversity. The concept of diversity refers to the number of species and their evenness within a community. Biodiversity is more than numbers, involving species identity and their roles on a variety of scales.

Protection of natural habitat is of prime concern to maintaining biodiversity at the species level. However, some species that are particularly sensitive to human activity may have to be singled out and managed and monitored in order to maintain their populations (Noss and Cooperrider 1994).

The Community/Ecosystem Level

The Canadian Biodiversity Strategy (Anonymous 1995) defines an ecosystem as a dynamic complex of plants, animals and microorganisms and their non-living environment interacting as a functional unit. Ecosystems can be defined at a variety of scales, for example, an ecosystem can be a group of interacting microorganisms in a gram of soil or it can be as large as the biosphere. The interaction of living species with the abiotic environment depends on various processes that keep natural systems functioning. Processes occur at all ecosystem scales and in all ecosystem types (or communities). The processes that are important to the maintenance of functioning ecosystems differ from ecosystem to ecosystem. Examples of terrestrial processes at work in terrestrial ecosystems include natural disturbances such as fire, nutrient cycling; plant-animal interactions, and predation (Noss and Cooperrider 1994). Examples of processes at work in aquatic ecosystems are evaporation, precipitation, infiltration/runoff and nutrient cycling. Disruption of these processes will affect biodiversity at all other levels of biological organization.

The Landscape/Regional Level

The landscape level of biodiversity is the next lével of biological organization. The genetic, species and ecosystem levels are all influenced by processes at the landscape level. A landscape may be comprised of a heterogeneous group of interacting ecosystems in a spatial pattern. A variety of tools have been designed to assist in forest management at the landscape level. Several mathematical indices have been developed to measure and manage landscape diversity (Burton *et al* 1992). Natural Resources Canada describes the structure of forested landscapes in terms of patch size, the amount of forest edge, the distance between habitat areas and the connectedness of habitat patches (Anonymous 1997). Human activities change natural landscape patterns which can, in turn, affect the lower levels of biological organization. Species composition and abundance, gene flow and ecosystem processes are examples of the elements that could be affected by human activity (Noss and Cooperrider 1994).

COMPONENTS OF BIODIVERSITY

In addition to the four levels of biological organization (genetic, species or population, community or ecosystem, and landscape) there are three components important to the conceptualization of biodiversity. The three components are composition, structure and function. Together, the four levels of biodiversity and the three components of biodiversity form a nested hierarchy. Each of the three components can be applied at each of the levels. Figure 2 represents this nested hierarchy (Noss 1990).

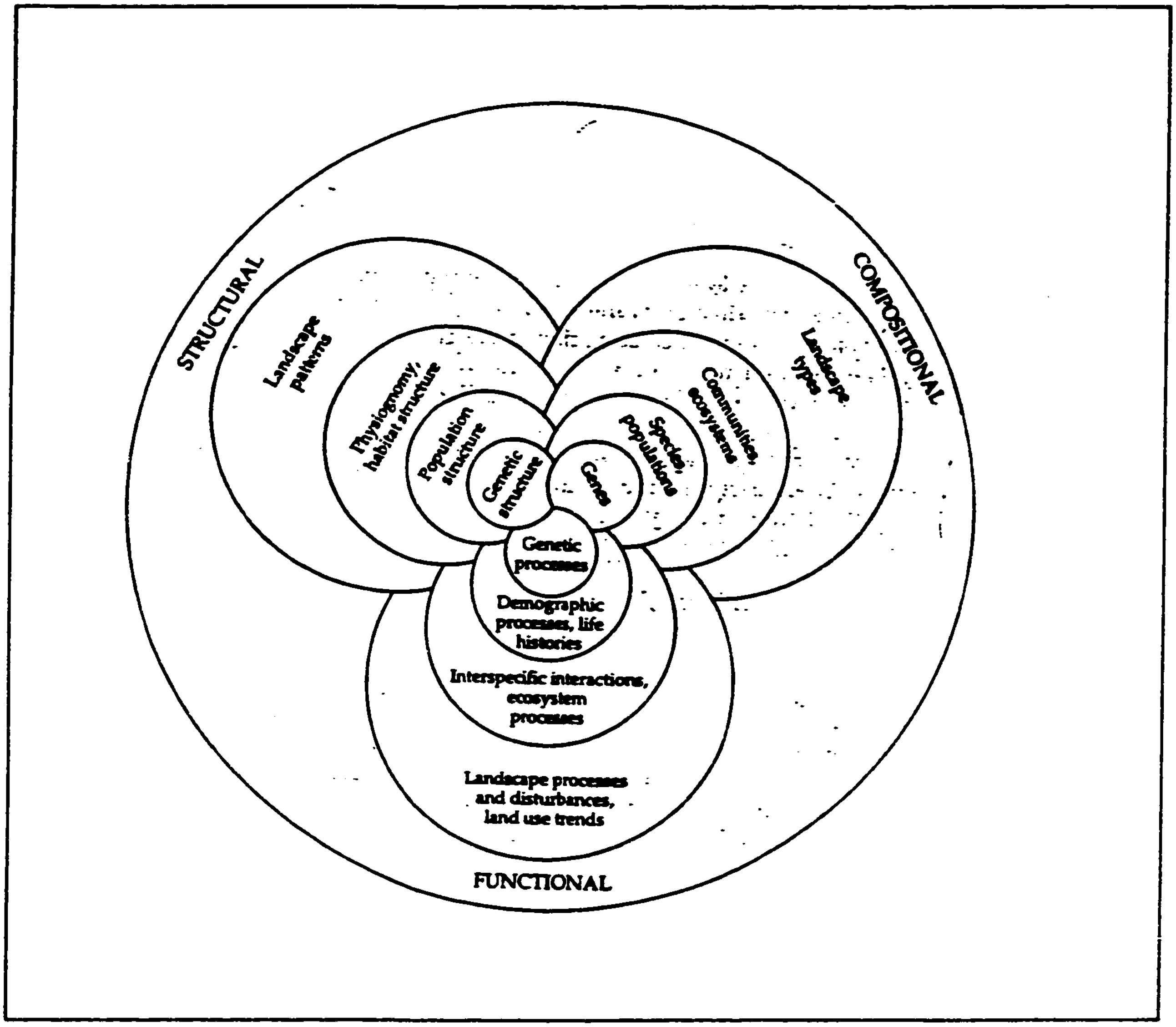

Fig.2. The nested hierarchy of biodiversity (Noss 1990)

Compositional Component

Composition refers to the variety of the elements in an area. For example the genetic constitution of populations, the identity and relative abundance of species in a natural community and the kinds of habitats and communities distributed across the landscape (Noss and Cooperrider 1994). Composition also refers to the presence/ absence and identity of various components at each level.

Structural Component

The structural component is the organization of interrelated elements. Landscape patterns, frequency distribution and habitat structure, distribution and dispersion of species across the region and the genetic differences within the species population are representations of the structural component (Noss and Cooperrider 1994). The structural component refers to how a community is configured, both vertically and horizontally. An example of the structural component of biodiversity in two different forest ecosystems is: one forest community may include a variety of tree canopy layers, one or more shrub layers, an herb layer and a moss layer with several standing dead trees (snags) interspersed; while another forest type may have only one tree canopy layer with a moss layer and no snags. (Kimmins 1997). Horizontal patchiness resulting from dying canopy trees, or small groups of trees creates gaps in the forest structure. This structure differs from a continuous canopy coverage of another stand and therefore the forest structure is different (Kimmins 1997). The structural biodiversity refers to the interrelated components at each level.

Functional Component

Function refers to the various processes and actions that maintain balanced systems. The functional component includes the climatic, geologic, hydrologic, ecological and evolutionary processes that generate biodiversity and that keep it in a perpetual state of change (Noss and Cooperrider 1994). The functional level of biodiversity can refer to the rate of various functional occurrences, for example, the rate of genetic drift, the growth rate of populations, nutrient cycling rates and energy flow rates.

BIODIVERSITY AND FOREST MANAGEMENT

According to the Canadian Biodiversity Strategy (1995), Canadians are stewards of approximately 20% of the planet's wilderness. Of that 20%, 24% are wetlands, 20% is freshwater, 10% is forest, and the remaining 26% is comprised of coastline and arctic ecosystems. There are an estimated 300 000 species of animals, plants, fungi and microorganisms in Canada (Mosquin and McAllister 1991). Of these, 76% of the terrestrial mammals and 60% of the bird species are forest-dwelling (Bunnell 1990). While species counts alone are not accurate indications of biodiversity, these numbers do suggest the importance of forests to a variety of Canada's flora and fauna (Boyle 1992). Forest practices can have a great impact on the components of biodiversity at all levels of biological organization. Because it is difficult to manage for the conservation of biodiversity, the use of a variety of measures and indicators of biodiversity has become accepted in Ontario forest management.

Indicators of Biodiversity

The selection of measures and indicators of biodiversity must first begin with a clear statement of goals and objectives. Goals and objectives should describe the desired outcome of the action. Goals are more general statements which may be achievable over the long term whereas objectives tend to be more specific and short term in nature. Objectives, ideally, would target the desired outcomes at each of the four levels of organization of the nested hierarchy of biodiversity. An indicator should be chosen for each stated objective. An indicator is defined as a selected measurable variable that relates to a specific forest sustainability criterion. Indicators are used in the assessment and determination of forest sustainability and to report on progress (OMNR, 1996). Indicators are chosen to monitor progress of the selected element of biodiversity. Indicators should be sensitive enough to detect problems in time to solve them. The relationship between the indicator and the element of biodiversity of interest should be well documented and defensible (Noss and Cooperrider 1994). Table 1 outlines an indicator selection framework for the nested hierarchy. Figure 3 illustrates the relationship between these concepts that I have used in this thesis and Figure 4 illustrates an example using this framework.

Measures of Biodiversity

Measures of biodiversity used in forest management planning in Ontario often involve two different concepts: richness and evenness. Richness refers to the number of elements present in the flora and fauna, or the landscape, of a designated area (Burton *et al* 1992). Evenness refers to the degree to which all elements share dominance in an area (Burton *et al* 1992). Richness and evenness are concepts associated with species diversity. Mathematical indices such as the Shannon Index and the Simpson Index use both concepts to calculate a diversity value. According to Burton *et al* (1992), these metrics are typically applied to limited categories of organisms, for example birds, or soil bacteria, or vascular plants, although sometimes they are also used at the landscape level. Research and development continues to introduce more comprehensive indices for describing multiple taxa.

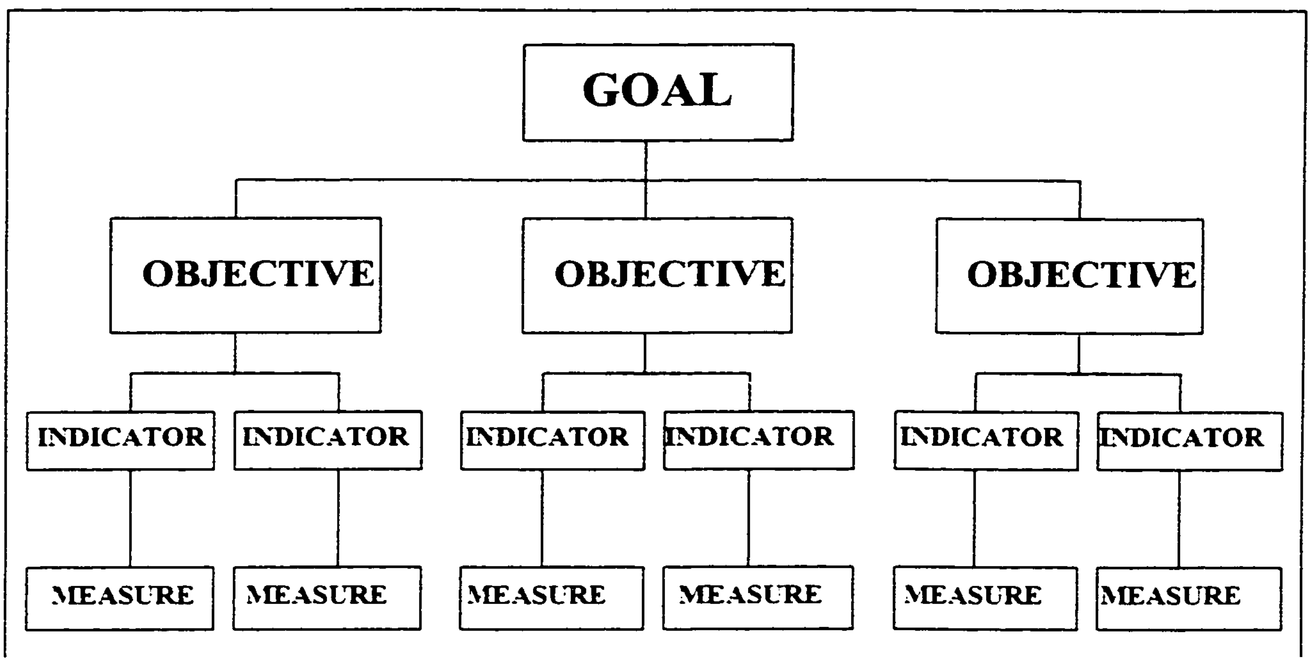

Fig.3. Schematic diagram of the relationship between goals, objectives, indicators and measures as used in this thesis

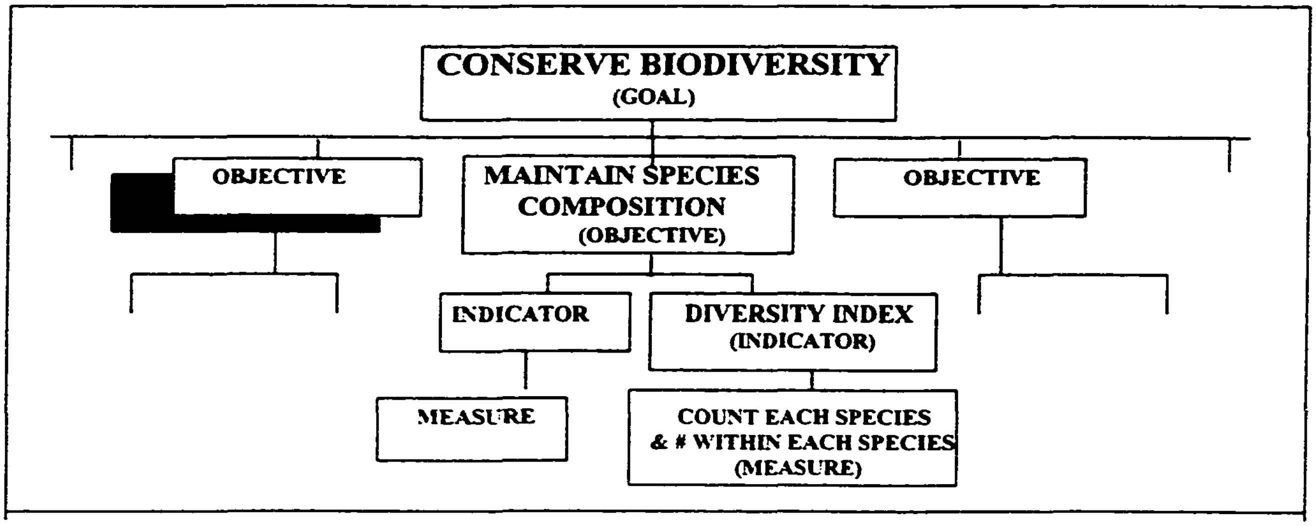

Fig.4. Examples of the relationship between GOALS, OBJECTIVES, INDICATORS and MEASURES

Table 1. Indicator Variables for Monitoring Biodiversity (Noss and Cooperrider 1994 pp.310-311)

	Indicators			
Level	**Composition**	**Structure**	**Function**	**Monitoring tools**
Genetic	Allelic diversity; presence of rare alleles, deleterious recessives, or karyotypic variants	Census and effective population size; heterozygosity; chromosomal or phenotypic polymorphism; generation overlap; heritability	Inbreeding dep-Ression; out-breeding rate; rate of genetic drift; gene flow; mutation rate; selection intensity	Electrophoresis; karyotypic analysis; DNA sequencing; off-spring–parent regression; sib analysis; morph-ological analysis
Population/ Species	Absolute or relative abundance; frequency; importance or cover value; biomass; density	Dispersion (micro-distribution); range (macrodistribution); population structure (sex ratio, age ratio); habitat variables (see community-ecosystem structure below); within- individual morphological variability	Demographic processes (fertility, recruitment rate, survivorship, mortality); metapopulation dynamics; population genetics (see above); pop- ulation fluctuations; physiology; life history; phenology; growth rate (of individuals); accli-mation; adaptation	Census (observations, counts, captures, signs, radiotracking); remote sensing; habitat suit-ability index (HSI); species-habitat modeling; population viability analysis
Community/ Ecosystem	Identity, relative abundance, frequency, richness, evenness, and diversity of species and guilds; proportions of endemic, exotic, threatened, and endangered species; dominance-diversity curves; life form proportions; similarity coefficients; C_4:C_3 plant species ratio	Substrate and soil variables; hydrologic variables; slope and aspect; stream gradients; vegetation biomass and physiognomy; foliage density and layering; horizontal patchiness; canopy openness and gap proportions; pool/ riffle/ run ratios; abundance, density, and distribution of key physical features (e.g., cliffs, outcrops, sinks) and structural elements (snags, down logs, woody material in water); water and resource (e.g. mast) availability; snow cover; water quality	Biomass and resource productivity; herbivory, parasitism, and predation rates; colonization and local extinction rates; patch dynamics (fine-scale disturbance processes); nutrient cycling rates; human intrusion rates and intensities	Aerial photographs and other remote sensing data; ground-level photo stations; time series analysis; physi-cal habitat measures and resource inventories; habitat suitability indices (HSI, multispecies); instream flow assessment; hydrologic measurements (streamflow, channel stability, sediment transport, etc.); observations, censuses and inventories, captures, and other sampling methodologies; mathematical indices (e.g. of diversity, heterogeneity, layering dispersion, biotic integrity
Regional/ Landscape	Identity, distribution, richness, and proportions of patch (habitat) types; collective patterns of species distributions (richness, endemism)	Heterogeneity; connectivity; spatial linkage; patchiness; porosity; contrast; grain size; fragmentation; configuration; juxtaposition; patch size frequency distribution; perimeter area ratio; pattern of habitat layer distribution	Disturbance processes(area extent, frequency or return interval, rotation period, predictability, intensity, severity, seasonality); nutrient cycling rates; energy flow rates; patch persistence and turnover rates; rates of erosion and geomorphic and hydrologic processes; human land-use trends	Aerial photographs (satellite and conven-tional aircraft) and other remote sensing data; Geographic Information System technology; time series analysis; spatial statistics; mathemati-cal indices (of pattern, heterogeneity, conn-ectivity, layering, diversity, edge, mor-phology, autocorr-elation, fractal dimension)

THE DIFFICULTY WITH MANAGING BIODIVERSITY

Biodiversity is a complex subject. Because biodiversity encompasses so many elements at both spatial and non-spatial scales, the production of a biodiversity management system is an enormous task. The difficulty with management of biodiversity is the infinite number of systems, organisms and gene sequences to be classified. While biological diversity is more comprehensive than species diversity, one must specify clearly the biological hierarchy and organizational level at issue in any discussion. In estimating biodiversity in a study area (e.g. pond or continent), a researcher might count all the taxonomic elements present, all the genetic elements present, or all the ecological elements present. Even in the unlikely event that all the elements present are known, no accepted calculus permits integration of counts of elements across levels within the hierarchy or across hierarchies. Arguably no such calculus should be sought (Angermeirer and Karr, 1994).

The complexity of biodiversity challenges the role it should play within the context of forest management. Dudley (1992) argues the usefulness of biodiversity per se as a criterion for government regulatory action. How can biodiversity be managed if it is beyond the scope of current knowledge. Because biological diversity provides important aesthetic, cultural, ecological, scientific, and utilitarian benefits to human society, the issue is everyone's concern (Ehrlich and Wilson, 1991). Acting on current knowledge of biodiversity management may benefit society and future societies.

METHODS

It was determined in the fall of 1997 that an examination of Ontario forest management and biodiversity would be the focus for this thesis. During this time the literature pertaining to this area of study was examined. During the fall of 1998 an evaluation with associated criteria was developed and forest management plans were chosen. The purpose of this study was to evaluate five 1999 forest management plans to assess their overall approach to biodiversity conservation. Thus, the purpose of this study was to examine the final product of a planning process. No models for examining forest management plans exist and therefore the first step of this study was to develop a model that would be consistently applied to the forest management plans. The evaluation format was developed based on my ability to understand the final product. This model has not been validated because of the constraint of time and resources. Future studies could be developed to validate this model in the assessment of biodiversity conservation.

SELECTION OF FOREST MANAGEMENT PLANS

From the 12 available 1998-1999 forest management plans, five were randomly selected. Forest management plans are prepared by the Ontario Ministry of Natural Resources (OMNR) and industry staff in accordance with the Crown Forest Sustainability Act. Two plans were from Northwestern Ontario, two plans from Central Ontario and one from Northeastern Ontario. The selected forest management plans included: the Trout Lake Forest plan, the Whiskey Jack Forest plan, the Nipissing Forest plan, the French-Severn plan and the Kapuskasing Forest plan. Figure 5 shows the location of the selected forest management plans in Ontario.

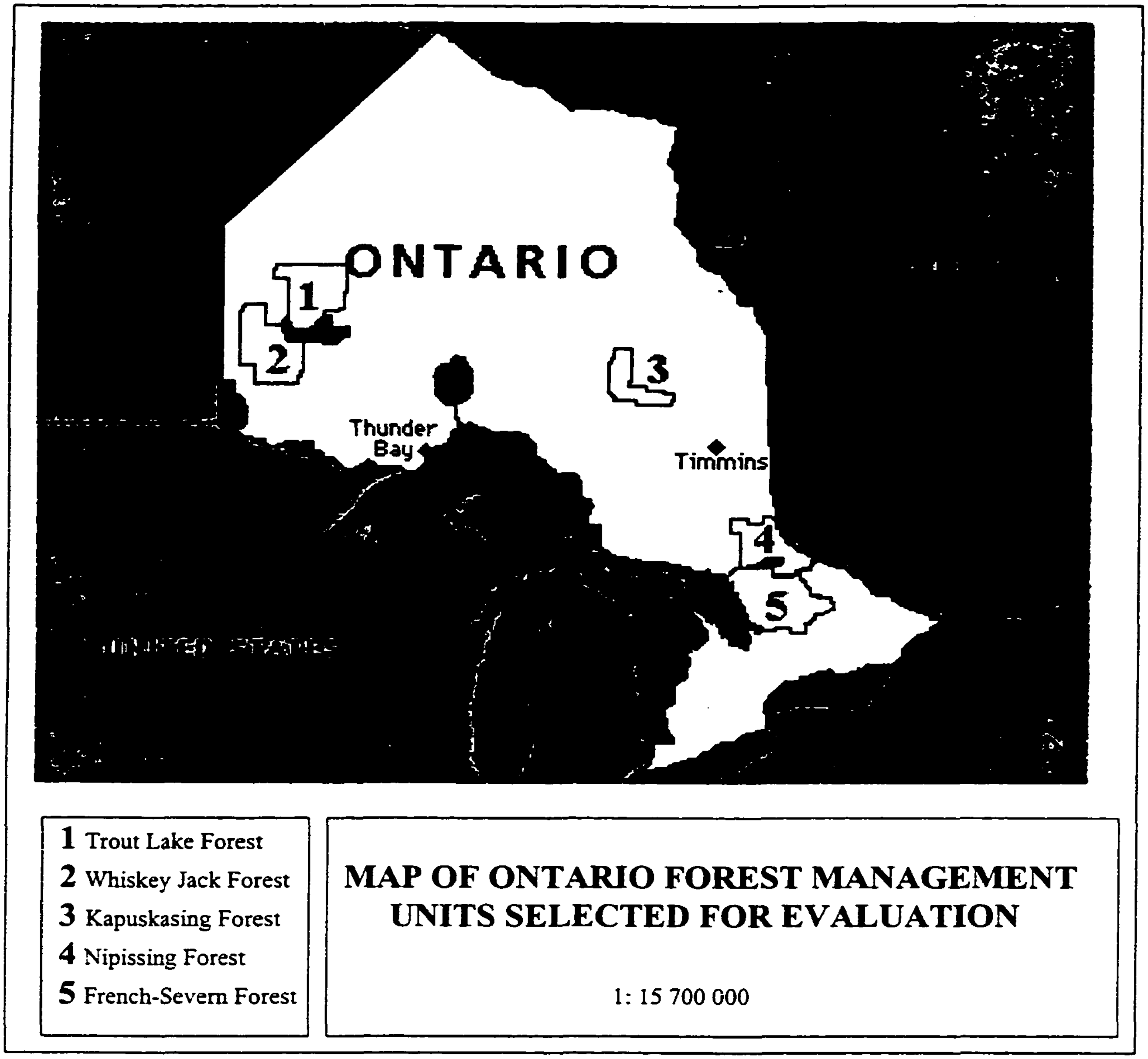

Fig.5. Map of selected forest management units

EVALUATION PROCESS AND EVALUATION CRITERIA

In order to evaluate the five forest management plans objectively, several evaluation questions were developed before the plans were examined. With each question I read through the management plan and assessed how the plan ranked according to the questions, I then compiled the answers and compared the results.

The questions addressed conceptual themes that are central to the understanding of biodiversity and were developed based on the literature that identified common areas of importance in the management of biodiversity. Table 2 shows the questions that were developed to evaluate the plans. The first question of the evaluation addresses the presence and quality of the definition of biodiversity. The next four questions consider the various levels of biodiversity (genetic, species, ecosystem and landscape levels) to determine whether they are accounted for in the forest management plan. The sixth question asks about the chosen indicators of biodiversity. Eleven questions deal with the presence/absence of indicators at the various levels of biological organization, and, in addition, address whether the indicator results were discussed in the forest management plan. Three more questions focused on goals and objectives stated in the forest management plan in relation to biodiversity. Four questions aimed to determine if the plan differentiated between the three components of biodiversity. The last question addressed whether the plan accounted for the existence of nature reserves in the management unit. Question formats included multiple choice questions, "yes/no" questions, range questions and list questions. The range questions were scaled from one to ten. Specific criteria for the range questions indicate the appropriate number to circle based on the information in the forest management plans, but generally "one" was very poor and "ten" represented excellent.

Each question in the evaluation had associated criteria that guided how the question was answered to reduce the subjectivity of the answers. The evaluation criteria were based on the literature on biodiversity. Like the evaluation questions, common themes in the conceptual framework of biodiversity were selected as the most appropriate answers to the evaluation questions. Table 2 also shows the associated criteria, in addition to the evaluation questions.

In questions 7, 9, 11, 13, 15, 17, 20, the clarity of an explanation was ranked according to four criteria. The four criteria included: 1) Clear explanation, that could be easily understood by the public; 2) Technical explanation directed towards professional understanding; 3) Brief, unclear explanation; 4) No explanation. If an explanation was given that defended and gave supporting information using language that the public could understand then the first criterion (clear explanation) was selected. If the second criterion was selected then that indicated that there was supporting information given but using highly technical language. The use of advanced language is not effective in the communication of intent in regards to forest management as technical language can be confusing to the public. If "brief and unclear explanation" was selected then that indicated that the explanation was not explicitly stated in association with the action. "No explanation" indicated that there was no reasoning or supporting information as to why the action was carried out.

Table 2- Evaluation questions and associated criteria

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
1	How well does the plan define BIODIVERSITY? a) Complete definition b) Partial definition c) Incomplete definition d) No definition	a) Complete definition: i) an explanation on the variety of life and associated processes ii) an identification of the various levels of biodiversity (GENETIC, SPECIES, COMMUNITY OR ECOSYSTEM and LANDSCAPE OR REGIONAL LEVELS) iii) a discussion of the complexity of biodiversity iv) identification of the concept of adaptation and evolution b)Partial definition -if any ONE of the above components is missing c)Incomplete definition -if any TWO of the above components are missing d)No definition
2	Does the management plan account for the genetic level of biodiversity? 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the genetic level of biodiversity ii) emphasis that species differ from one another iii) emphasis that individuals within species show variation iv) a discussion that unique combinations and frequency of genes is responsible for variation A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if it is only mentioned in the definition A score of "1" will be assigned if there is no mention of the genetic level

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
3	Does the management plan account for the species level of biodiversity? ________________ 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the species level of biodiversity ii) a discussion of population viability iii) an acknowledgment that the species level is the best known aspect of biodiversity iv) a discussion of the importance of the relationship between habitat and species diversity A score of between "3 to 9" will beassigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if it is only mentioned in the definition A score of "1" will be assigned if there is no mention of the species level of biodiversity
4	Does the management plan account for the community or ecosystem level of biodiversity? ________________ 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the Community/ecosystem level of biodiversity ii) emphasis that a community is a variety of species interacting in a given area iii) a brief discussion of ecosystems (that they are biotic communities with associated abiotic environments) iv) a discussion of some of the ecological processes that occur at this level (i.e. in terrestrial ecosystems: fire, nutrient cycling, plant-herbivore interactions, predation, mycorrihizal interactions and soil forming processes etc.) A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if it is only mentioned in the definition A score of "1" will be assigned if there is no mention of the community or ecosystem level of biodiversity

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
5	Does the management plan account for the landscape or regional level of biodiversity? ____________________ 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the landscape or regional level of biodiversity ii) a discussion that landscapes are a cluster of interacting ecosystems with emphasis on pattern and habitat mosaics iii) mention that regions (large landscapes) can be distinguished from other regions on the basis of climate, physiography, soils and biogeography iv) mention of processes that occur at this level (i.e. natural fire regimes, large mammal migration, landform evolution, and hydrological cycles) A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if it is only mentioned in the definition A score of "1" will be assigned if there is no mention of the regional or landscape level
6	Which indicators were chosen by the plan authors to represent biodiversity? ____________________ ____________________ ____________________	
7	Are there suitable explanations given by the plan authors for selecting the chosen indicators of biodiversity? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
8	Are indicators selected at all levels of biodiversity? YES ☐ NO ☐	

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
9	Are there suitable explanations given by the plan authors for selecting the chosen indicators? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
10	Are indicators chosen for the genetic level? YES ☐ NO ☐	
11	Are there suitable explanations given by the plan authors for selecting the chosen indicators? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
12	Are indicators chosen for the species level? YES ☐ NO ☐	
13	Are there suitable explanations given by the plan authors for selecting the chosen indicators? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
14	Are indicators chosen for the community or ecosystem level? YES ☐ NO ☐	

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
15	Are there suitable explanations given by the plan authors for selecting the chosen indicators? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
16	Are indicators chosen for the regional or landscape level? YES ☐ NO ☐	
17	Are there suitable explanations given by the plan authors for selecting the chosen indicators? a) Clear explanation, that could be easily understood by the public b) Technical explanation directed toward professional understanding c) Brief, unclear explanation d) No explanation	
18	Are general management goals such as "maintain biodiversity" clearly 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) identification of the general stated and discussed? Biodiversity management goals ii) a short discussion of why the management goals were chosen A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if the general management goals are only mentioned A score of "1" will be assigned if there is no mention of general biodiversity management goals

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
19	Are the objectives regarding biodiversity clearly stated? (i.e. maintain viable populations of all native species" or "protect representative natural communities") ____________________ 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) identification of the lower level objectives for the management of biodiversity ii) a short discussion of why the lower level objectives were chosen A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if the lower level objectives are only mentioned A score of "1" will be assigned if there is no mention of lower level objectives
20	Are biodiversity indicator results discussed by the plan authors? a) Clear discussion, that could be easily understood by the public b) Technical discussion directed toward professional understanding c) Brief, unclear discussion d) No discussion	
21	Does the management plan differentiate between the various biodiversity components? YES ☐ NO ☐	
22	Does the plan account for the compositional component of biodiversity? ____________________ 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) identification of the compositional component of biodiversity ii) a discussion of the genetic constitution of populations iii) a discussion of the identity and relative abundance of species in natural communities iv) a discussion of the types of habitats and communities distributed across the landscape A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if compositional component is only mentioned A score of "1" will be assigned if there is no mention of the compositional component

Table 2. (Continued)

QUESTION	EVALUATION QUESTION	EVALUATION CRITERIA
23	Does the plan account for the structural component of biodiversity? 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the structural component of biodiversity ii) a discussion of dispersion and vertical layering of species iii) a discussion of the horizontal pattern of species at varying spatial scales A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if the structural component is only mentioned A score of "1" will be assigned if there is no mention of the structural component
24	Does the plan account for the functional component of biodiversity? 1 2 3 4 5 6 7 8 9 10	A score of "10" would include: i) a clear discussion of the functional component of biodiversity ii) a discussion of processes that generate biodiversity (i.e. climatic, geological, hydrological, ecological and evolutionary processes) iii)a discussion of the dynamic nature of patterns over time A score of between "3 to 9" will be assigned depending on the clarity and content of the discussion based on the criteria listed to score "10" A score of "2" will be assigned if the functional component is only mentioned A score of "1" will be assigned if there is no mention of the functional component
25	In the management plan is there a discussion of reserve areas? (ie number, size, shape, location) YES ☐ NO ☐	

DATA COLLECTION

I evaluated each plan according to the question and criteria reported above. Each plan was read thoroughly and the evaluation was completed. The Northwestern Ontario plans were examined at the Ministry of Natural Resources in Thunder Bay and the plans for Central and Northeastern Ontario were examined at the Ministry of Natural Resources Information Centre in Toronto.

SCORING AND ANALYSIS

The results from all five forest management plans were compared graphically. Graphs were used to illustrate which plan was the most thorough in a given conceptual area of biodiversity. Plans were scored out of 145. The score for each question was weighted so that each question would be equally represented in the calculated percentage value. Table 3 outlines the assigned value for each question.

Table 3- Scoring Method used to evaluate the forest management plans

Question	Question Type	Total Possible Score	Value of answer
1	Definition	/6	a) = 6 b) = 4 c) = 2 d) = 0
2	Range	/10	1 to 10
3	Range	/10	1 to 10
4	Range	/10	1 to 10
5	Range	/10	1 to 10
7	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
8	YES/NO	/1	YES = 1 NO = 0
9	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
10	YES/NO	/1	YES = 1 NO = 0
11	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
12	YES/NO	/1	YES = 1 NO = 0

Table 3 (Continued)

Question	Question Type	Total Possible Score	Value of answer
13	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
14	YES/NO	/1	YES = 1 NO = 0
15	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
16	YES/NO	/1	YES = 1 NO = 0
17	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
18	Range	/10	1 to 10
19	Range	/10	1 to 10
20	Explanation	/6	a) = 6 b) = 4 c) = 2 d) = 0
21	YES/NO	/1	YES = 1 NO = 0
22	Range	/10	1 to 10
23	Range	/10	1 to 10
24	Range	/10	1 to 10
25	YES/NO	/1	YES = 1 NO = 0
	TOTAL	/145	

RESULTS

BIODIVERSITY DEFINITION

Biodiversity definitions in the five selected forest management plans varied. Two of the plans had no definition for biodiversity, two of the plans gave incomplete definitions and one plan had a partial definition (Table 1). The most comprehensive definition was found in the French-Severn Forest management plan; this plan restated the definition found in the Forest Management Planning Manual.

Table 4- Biodiversity definition

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Complete Definition					
Partial Definition					●
Incomplete Definition			●	●	
No Definition	●	●			

LEVELS OF BIODIVERSITY IN SELECTED FOREST MANAGEMENT PLANS

In three of the five selected forest management plans there was no mention of the genetic level of biodiversity (Fig.6). The remaining two plans, the French-Severn plan and the Kapuskasing plan, identified the genetic level of biodiversity as a consideration for sustainable forest management.

The Kapuskasing Plan scored a "5" because tree genetics were briefly outlined. In this plan there was a Tree Genetic Objective and a Tree Genetic Target. The Tree Genetic Objective was to ensure the preservation of local tree gene pool and that regenerated sites be planted with stock that is genetically adapted for that site (Kapuskasing Plan, 1999, pp. 143). The Tree Genetic Target was to collect a variety of seeds from a variety of sources on the Kapuskasing Forest Management Unit (Kapuskasing Plan, 1999, pp. 143). While it is important to address tree genetics nowhere in the plan did it address the importance of other gene pools, such as those of rare plant and animal species, to the maintenance of biodiversity in the Kapuskasing Forest Management Unit.

The French-Severn Forest Management Unit scored an "8" because, while only addressing tree genetics as with the Kapuskasing Forest Management Plan, it was more detailed in outlining the targets for the Objective. The Genetic Diversity Objective was to protect and conserve the genetic diversity of tree species (French-Severn Plan, 1999, pp. 113). The strategies (targets) were: 1) Use harvesting systems to promote natural regeneration. 2) Use tree marking in selection and shelterwood harvests as a tool to retain the most robust and healthy crop trees of each species. 3) Collecting and using seeds from local populations of each species to retain the diversity which currently exists. 4) Discouraging the use of exotic or introduced tree species in the landscape management unit. 5) Protecting and rehabilitating known populations of tree species which are the extremes of their range, for example Red Spruce, and species who's occurrence is rare or whose numbers have been drastically reduced, for example Eastern Hemlock and Red Spruce (French-Severn Plan, 1999, pp. 113). While this plan did not mention the importance of other gene pools it did identify important concepts at the genetic level of biodiversity.

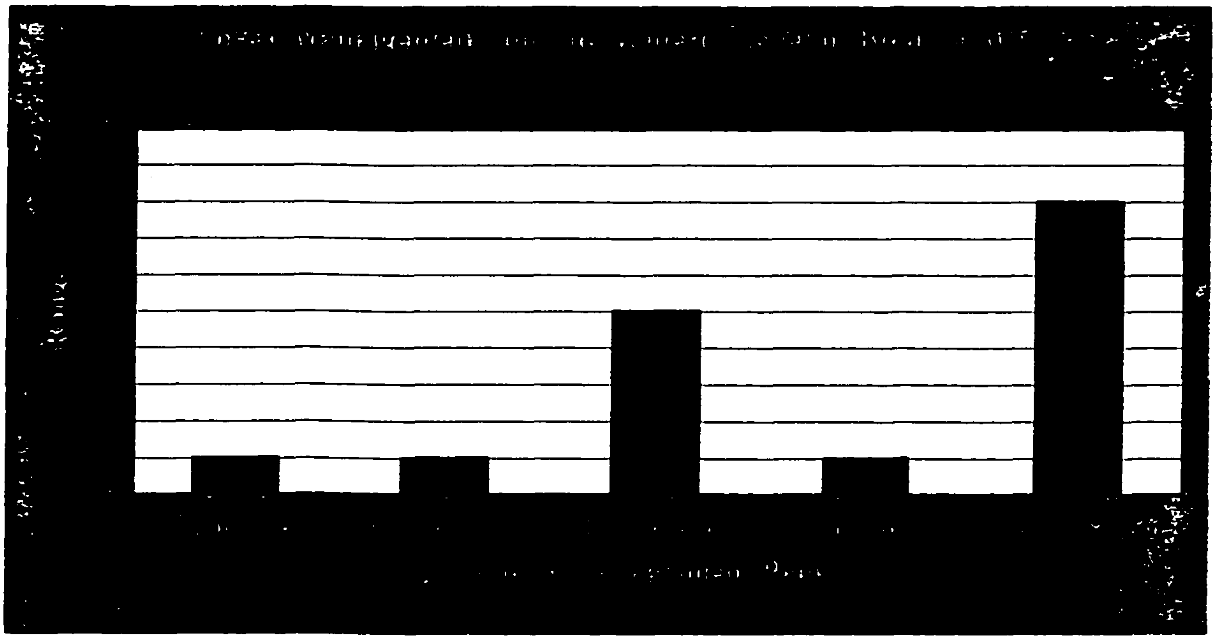

Fig.6. Forest Management and the Genetic Level of Biodiversity

Unlike the results for the genetic level of biodiversity, the species level was addressed in all five of selected forest management plans (Fig. 7). The French-Severn plan and the Whiskey-Jack plan gave the clearest and most thorough account of the species level of biodiversity in relation to forest management.

The Nipissing Forest Management Plan scored a "6" because the plan accounted for species within the Nipissing Forest Management Unit and briefly described the wildlife in the Unit. The plan did not give an explanation as to why these species were chosen nor did the plan put the chosen species into context as to why they were important. The list of species from the Nipissing Forest Management Plan (1999, pp.21) is as follows:

Eastern Redback Salamander	197,000 ha
Broad Winged Hawk	216,000 ha
Ruffed Grouse	22,000 ha
Barred Owl	904,000 ha
Least Flycatcher	110,900 ha
Ruby Crowned Kinglet	29,700 ha
Blackburnian Warbler	157,800 ha
White Throated Sparrow	14,2000 ha
Snowshoe Hare	15,200 ha
Northern Flying Squirrel	93,900 ha
Black Bear (Foraging)	27,300 ha
Black Bear (Fall/Winter)	10,300 ha

Marten	147,900 ha
Deer (Foraging)	8,700 ha
Deer (Winter)	76,700 ha
Moose (Foraging)	14,800 ha

While there were a variety of species that were implemented in the plan there was no mention of less noticeable species such as fungi, insects, or bacteria. The plan states that the selected species for the Nipissing Forest Management Unit are Moose and Pileated Woodpecker. White-tailed deer habitat will be managed through area of concern planning. In addition, modeling results for marten habitat will be shared with other forest managers in the surrounding areas and the region as a whole to ensure that marten habitat is not adversely affected at the eco-regional level (Nipissing Forest Plan, 1999, pp. 2-17). The plan outlines the habitats that will increase and the habitats that will decrease as a result of planned forest management activity.

The French-Severn Forest Management Plan scored an "8" because the plan listed species habitat requirements but also included statements to explain the approach to species management within the plan. The French-Severn Forest Management Plan (1999, pp.76) states that the French-Severn Forest Unit is home to a wide variety of birds, mammals, reptiles, amphibians, insects, plants and a host of other organisms too numerous to list. A principle of forest management is to sustain healthy forest ecosystems, which includes consideration of the habitat needs of all native wildlife species as well as biodiversity. Wildlife concerns in forest management were formerly dealt with through a featured species approach, which was based on the premise that managing for the habitat needs of a featured species (primarily deer and moose, both animals of early successional forests) satisfied the habitat requirements of most (wildlife) species. Now it is understood that a more appropriate goal of forest management is to create a diversity of habitat conditions at a variety of spatial and temporal scales by attempting to emulate, through forest management activities, the type of habitat diversity that would have occurred under a natural disturbance regime. This should provide for the majority of forest-dependent wildlife in the forest unit. However, special consideration is given to the needs of provincially or locally featured species that have complex habitat requirements, or that have special status. The following provincially or locally featured species are addressed in the forest management plan.

White-tailed Deer
Moose
Black Bear (the importance of berries, wasps, bees and ants were discussed in association with this species)
Eastern Massasauga Rattlesnake (threatened species COSEWIC, 1991)
Hawks, Osprey and Herons
Pileated Woodpecker
Marten

Other featured species included:
Atlantic Coastal Plain Flora

Habitat for Selected Wildlife Species (French-Severn Plan, 1999, pp. 41):
Barred Owl
Black Bear (Foraging)
Black Bear (Fall/Winter)
Blackburnian Warbler
Broad Winged Hawk
Least Flycatcher
Marten
Moose (Foraging)
Moose (Winter)
Northern Flying Squirrel
Pileated Woodpecker
Eastern Red-Backed Salamander
Ruby Crowned Kinglet
Ruffed Grouse
Snowshoe Hare
White-Tailed Deer (Foraging)
White-Tailed Deer (Winter)
White-Throated Sparrow

This plan did not score "10" because species biodiversity was not put in the context of the hierarchy of biodiversity. It gave a detailed account of how and what species were chosen for the purpose of the plan. The Whisky Jack Plan took a similar approach to the species level of biodiversity and therefore received the same score of "8".

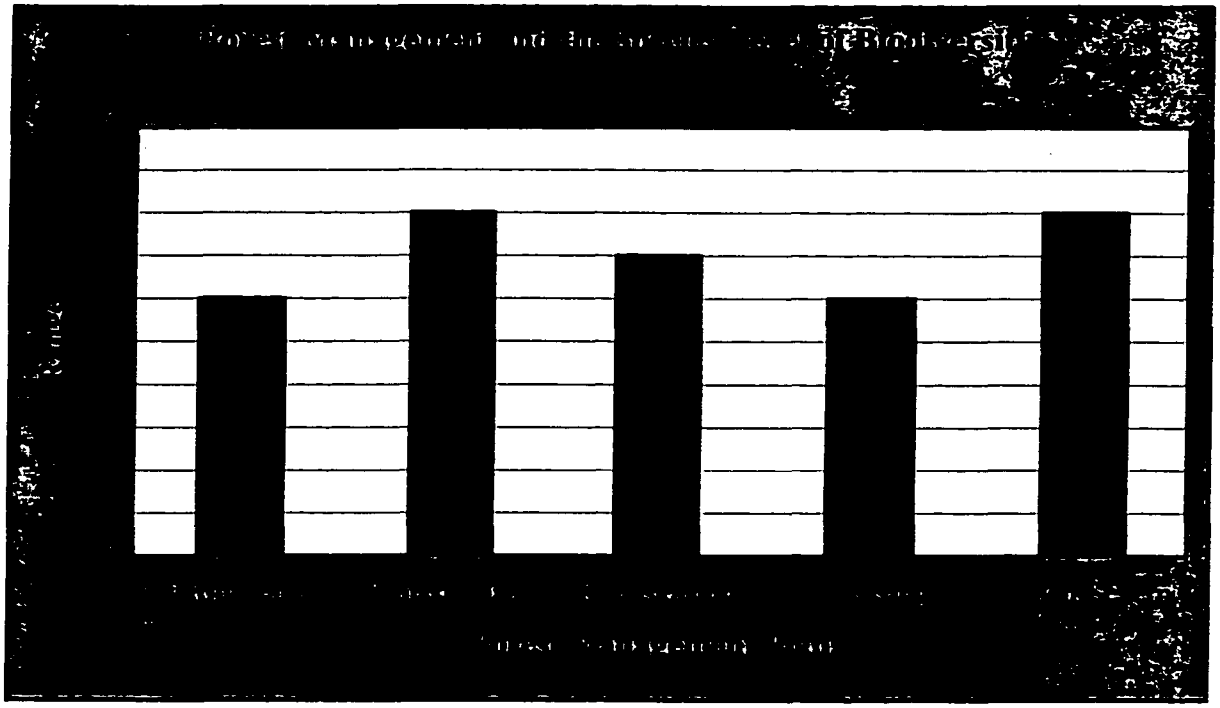

Fig.7. Forest Management and the Species Level of Biodiversity

The French-Severn plan and the Whiskey-Jack plan were the two best plans to account for the ecosystem level of biodiversity (Fig. 8). At the ecosystem level, as at the species level, all five of the selected forest management plans accounted for the ecosystem level of biodiversity.

The Nipissing Forest Management Plan scored a "4" because it did not put the ecosystem level in context and the plan did not list or describe ecosystems within the unit. The plan did mention the ecosystem approach to management but it was not specific as to how this would be carried out in the plan and in the management unit. It did describe forest types within the unit such as conifer, conifer/hardwood mix and mixed conifer. The Forest Diversity Objectives referred to the ecosystem level. Forest Diversity Objectives were 1) Maintain a range of age classes over time in all forest units to approach a more balanced age class distribution for each forest type. 2) Within 100 years, create a distribution of forest types more similar to that of pre-logging and pre-fire suppression. Historic records and recent forest management practices indicate that there was more White Pine and Red Pine in the past than there is now. 3) Over the term of this plan, have at least one old growth Red Pine and White Pine ecosystem protected in each site district for which the Nipissing Forest Management Unit is responsible (Nipissing Plan, 1999, pp. 3-38).

The French-Severn Forest Management Plan scored an "8" because it identified various ecosystems within the management unit including wetlands and old growth forest ecosystems. This plan identified several objectives for the ecosystem level of biodiversity. The landscape and forest stand forest diversity objectives refer to the ecosystem level and refer to it as it connects to other levels of biodiversity mainly the species and landscape level with references made to function, structure and composition. The plan did not score a "10" because it was not put in context within the framework of biodiversity as proposed by Noss (1990) and for the purpose of this study. The objectives are 1) To maintain a diverse forest landscape comprised of a network of ecological units including old growth (based on vegetation species occurrence and dominance in the overstory, understory and at ground level, as well as soil characteristics, and comprised of various size and balanced age classes). 2) To maintain a range of native tree species within and/or between forest stands in the management unit. 3) To increase, where practical and necessary, the proportion of under-represented tree species and forest types, which would naturally be more abundant if European settlement activity had never occurred (French-Severn Plan, 1999, pp. 113). The old growth diversity objectives are: 1) To sustain the representation of old growth white pine stands. 2) To contribute to the provincial and regional targets for the protection of old growth pine stands. 3) To expand the representation of old growth stands to the other forest types of the management unit, in accordance with evolving policy and guidance. The wetland objectives are: 1) To maintain the area and function of wetland ecosystems. This will be accomplished by continuing to inventory wetlands as part of the forest management planning process and by managing for beaver food supplies by applying area of concern prescriptions for forest operations along riparian areas and pond shorelines with the potential to provide beaver habitat (French-Severn Plan, 1999, pp.114).

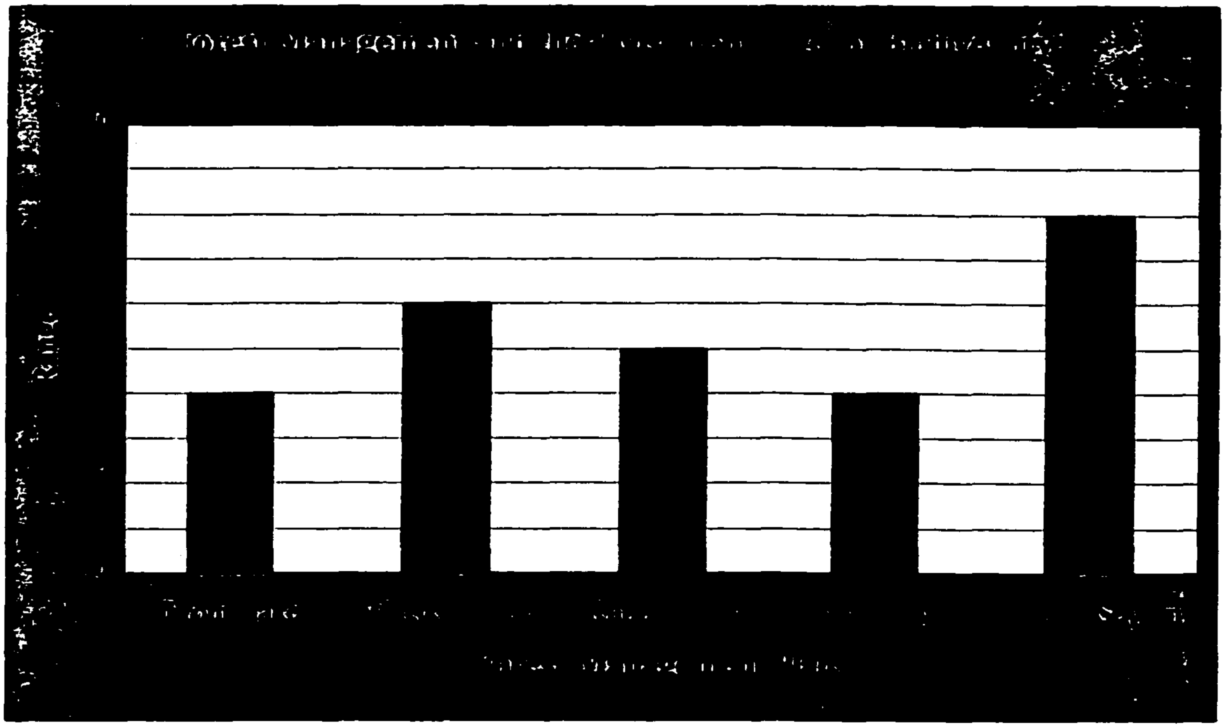

Fig.8. Forest Management and the Ecosystem Level of Biodiversity

All five of the selected forest management plans reviewed the landscape level of biodiversity (Fig. 9). The Trout Lake Forest and the Whiskey-Jack Forest plans were considered the two best plans to account for the landscape level of biodiversity in relation to forest management.

The Kapuskasing Forest Management Plan scored a "5" because it did not identify the landscape level within the framework of biodiversity. There was no discussion regarding how the plan managed at the landscape level. The plan did address processes at the landscape level and there was discussion within the plan of patch size in relation to the management unit.

The Whiskey-Jack plan scored a "10" because the plan contained a detailed description of landscape biodiversity and it was put in context compared to the other levels of biodiversity. Appendix 11 of the plan was very thorough. The Crown Forest Sustainability Act directs forest managers to maintain long term Crown forest health, i.e. forest sustainability, "...by using forest practices that, within the limits of silvicultural requirements, emulate natural disturbances and landscape patterns..." Biodiversity is a key criterion for assessing forest sustainability and it is measured, in part by evaluating landscape pattern or structure through spatial analysis. Landscape changes can directly impact ecological processes. Predator-prey interactions, the movement of organisms on the landscape, resource utilization, fire and the dispersal of seed, are all affected by the spatial configuration of landscape units Whiskey Jack Plan, 1999, pp. 1- Appendix 11). Ten landscape classifications were selected to examine changes in landscape biodiversity within the Whiskey Jack Forest. These landscape classifications were generated using Forest Resource Inventory data. Each landscape classification consisted of classes composed of patches (Whiskey Jack Plan, 1999, pp.1-Appendix 11). The landscape level was addressed in context of the biodiversity framework in Appendix 11. Appendix 11, titled Landscape Pattern Analysis for the Whiskey Jack Forest, was written as a report with sub-titles: Introduction, Indicators and Measures of Landscape Biodiversity, Landscape Classifications, Methods, Results and Discussion and Summary. This section was very clear and concise as to the landscape biodiversity in terms of description, measurement and outcomes.

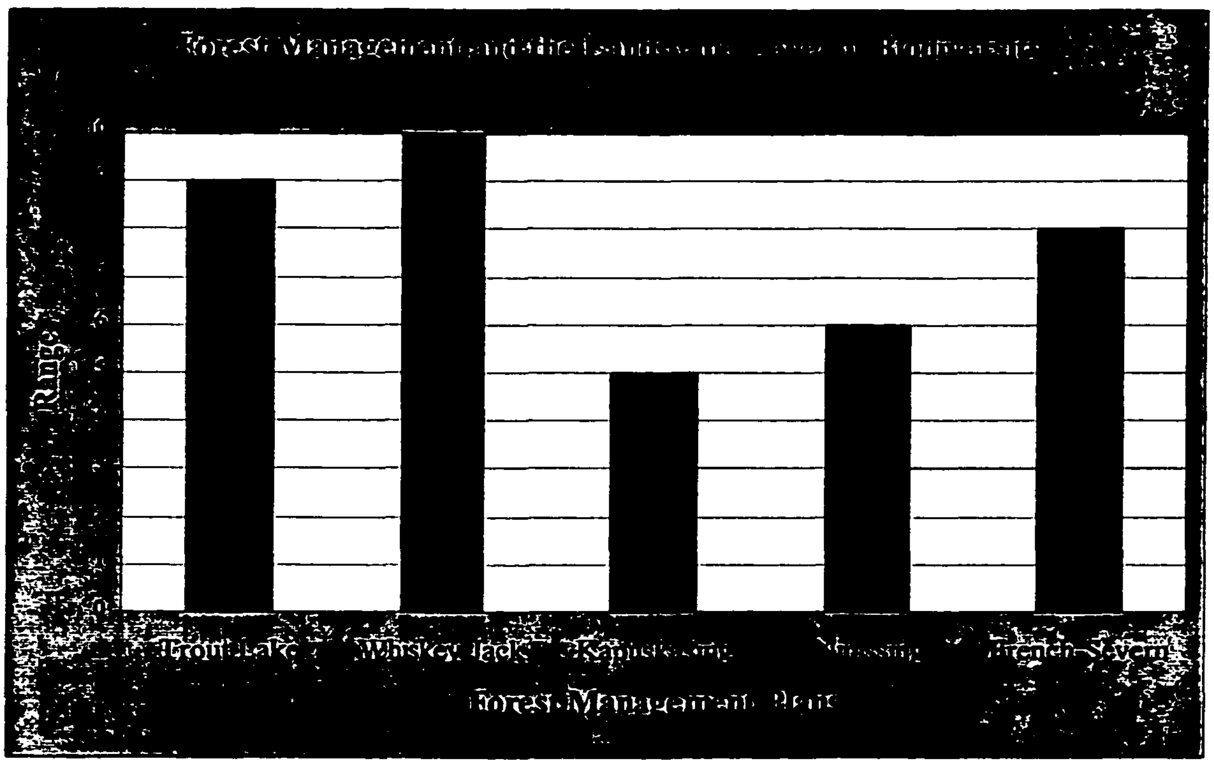

Fig.9. Forest Management and the Landscape Level of Biodiversity

INDICATORS OF BIODIVERSITY AND INDICATOR EXPLANATIONS

All five plans chose the same forest diversity indices to represent biodiversity: the Shannon-Weiner Heterogeneity index, Simpson Heterogeneity index and Shannon Evenness index.

The explanations for the chosen indicators varied in the five selected forest management plans. The most thorough plans for explaining why the various indicators were chosen were the Nipissing Forest management plan and the Whiskey-Jack Forest management plan. The remaining three plans had technical and brief and unclear explanations for the chosen indicators of biodiversity (Table 5). The French-Severn Plan had brief and unclear explanations for why the selected indicators were chosen. The plan was unclear in the identification of indicators and the explanations regarding indicators were very unclear. The plan lists the measurable indicator of biodiversity as Landscape Pattern or Forest Diversity. Landscape Pattern is Forest Edge (ED-Edge Density (m/ha)), Forest Interior (TCA-Total Core Area (ha)), (MCA-Mean Core Area (ha)), Forest Fragmentation (MPS-Mean Patch Size (ha)), Forest Isolation (MNN- Mean Nearest Neighbour (m)), Forest Spatial Pattern (IJI-Interspersion Index). Forest Diversity is Shannon-Weiner Index, Simpson Index, Shannon Evenness Index (French Severn Plan, 1999, Binder 12). This was the extent of the discussion of indicators and indicator explanation in the French Severn Forest Management Plan.

The Nipissing Plan identifies three measurable indicators of biodiversity and three measurable indicators for multiple benefits to society. The indicators for biodiversity are: 1) Landscape Pattern Indices: This is a spatial indicator used to assess landscape diversity. The model LEAP (Landscape Ecological Analysis Patterns) was used to assess landscape diversity for this plan. The results must be within the bounds of natural variation (as defined by an eco-regional range). 2) Forest Diversity Indices: this is a non-spatial indicator used to assess forest diversity. These indices are outputs from SFMM. These results must be within the bounds of natural variation. 3) Frequency Distribution of clearcut and wildfire sizes: this is a spatial indicator which assesses forest disturbance. Planned harvest should show movements towards emulation of natural disturbance frequency by size class. Research is available to compare planned harvest on the

Nipissing Forest to natural disturbance by size class. This indicator calls for large disturbance areas, which must be balanced against other planning requirements which call for small disturbance sizes (for example the moose guidelines) (Nipissing Plan, 1999, pp. 6-1).

Table 5- Explanations and Indicators of Biodiversity

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations		●		●	
Technical Explanations	●		●		
Brief, unclear explanations					●
No explanation					

INDICATOR SELECTION AND INDICATOR EXPLANATION

None of the five plans chose indicators for all of the four levels of biological organization.

The explanations for the chosen indicators varied in the five selected forest management plans. The best plans for explaining why the indicators for the species level were chosen were the French-Severn Forest management plan and the Whiskey-Jack Forest management plan. Two plans gave insignificant explanations for the chosen indicators of biodiversity and the Trout Lake Forest management plan gave no explanation for the selected indicators (Table 6).

Table 6- Explanations and Indicators for the Four Levels of Biodiversity

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations					
Technical Explanations		●			●
Brief. unclear explanations			●	●	
No Explanation	●				

GENETIC LEVEL INDICATORS AND INDICATOR EXPLANATION

None of the five plans chose indicators for the genetic level of biodiversity.

There were no explanations in any of the five plans to explain why genetic indicators were not chosen.

SPECIES LEVEL INDICATORS AND INDICATOR EXPLANATION

All five plans chose indicators for the species level of biodiversity (Table 7). The chosen indicators were explained very well in all five selected forest management plans. The Trout Lake Forest, the Nipissing Forest and the French-Severn Forest had the clearest explanations.

Table 7- Explanations and Indicators for the Species Level of Biodiversity

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations	●			●	●
Technical Explanations		●	●		
Brief, unclear explanations					
No explanation					

ECOSYSTEM LEVEL INDICATORS AND INDICATOR EXPLANATION

All five plans chose indicators for the ecosystem level of biodiversity (Table 8). The explanations for the chosen indicators were, generally brief and unclear in four of the five selected forest management plans. There was not sufficient information to explain why the indicators were chosen and what they were indicating. The Nipissing Forest had the clearest explanations.

Table 8- Explanations and Indicators for the Ecosystem Level of Biodiversity

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations				●	
Technical Explanations					
Brief, unclear explanations	●	●	●		●
No Explanation					

LANDSCAPE LEVEL INDICATORS AND INDICATOR EXPLANATION

All five plans chose indicators for the landscape level of biodiversity (Table 9). The explanations for the chosen indicators were, generally brief and unclear in three of the five selected forest management plans. There was insufficient information to clearly explain why the indicators were chosen. The Whiskey Jack Forest had the clearest explanations.

Table 9- Explanations and Indicators for the Landscape Level of Biodiversity

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations		●			
Technical Explanations				●	
Brief, unclear explanations	●		●		●
No Explanation					

MANAGEMENT GOALS AND BIODIVERSITY

All five plans were very clear in the statement of the desired goals for biodiversity (Fig. 10). Outlining goals guides forest management towards defining the desired future forest condition.

The biodiversity goal in the Trout Lake Forest Management Plan was: One overall broad goal for the Trout Lake Forest that was considered during the development of specific objectives was the maintenance of the biological forest diversity of the Trout Lake Forest within the bounds of natural variation, inherent to Site Region 4S and 3S. Forest biodiversity is a complex goal that is influenced by many factors of forest management. Therefore, forest diversity is being stated as a broad, overall management goal that will be influenced by the achievement of specific objectives and the implementation of strategies to achieve the various social, economic, and forest cover related to the estimated bounds of natural variation (Trout Lake Plan, 1999, pp.47). This plan scored a "10" because the plan stated a clear goal for biodiversity and stated how the goal would be achieved.

The biodiversity goal in the Whiskey-Jack Forest Management Plan was: The primary goal of this Forest Management Plan is to achieve a healthy, sustainable forest ecosystem vital to the well being of forest based as well as non-forest based communities (Whiskey Jack Plan, 1999, pp. 69). This plan scored an "8" because, while it addressed forest ecosystem sustainability, it did not address biodiversity specifically.

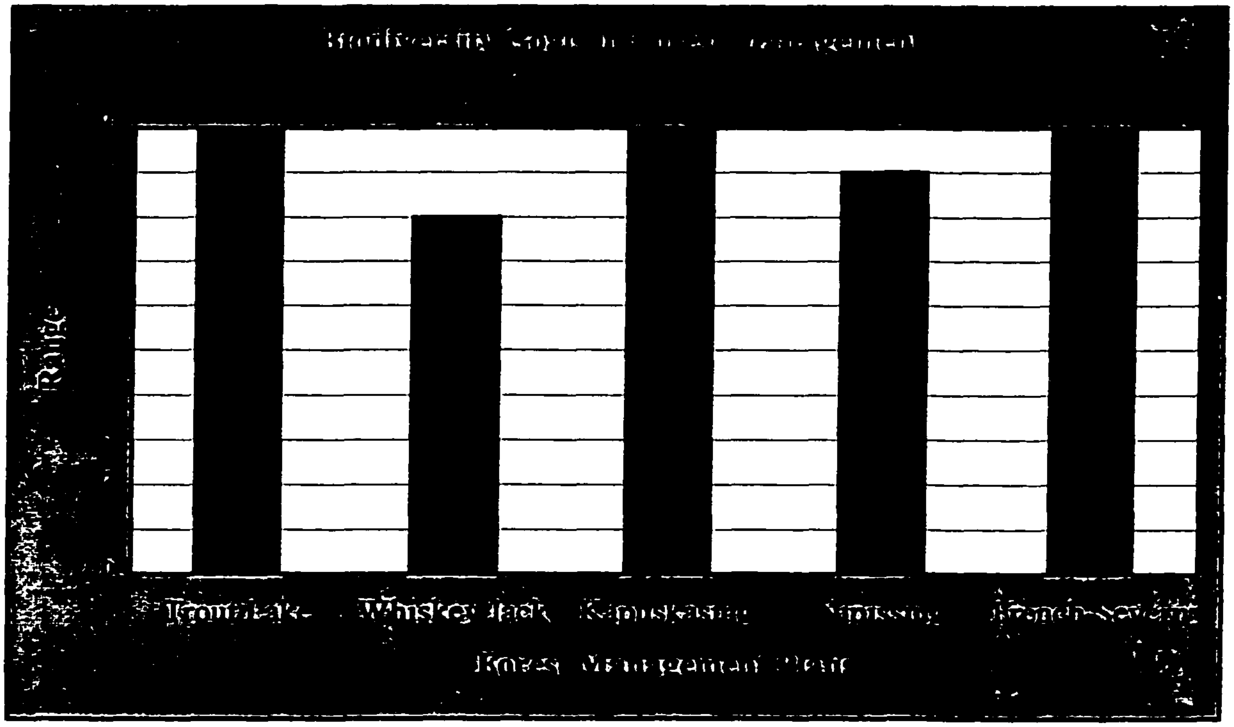

Fig.10. Biodiversity Goals in Forest Management

MANAGEMENT OBJECTIVES AND BIODIVERSITY

All five plans were very clear in the statement of the desired objectives for biodiversity (Fig. 11). The stated objectives in the five selected forest management plans further divided the goals into manageable statements regarding the desired future condition of the forest.

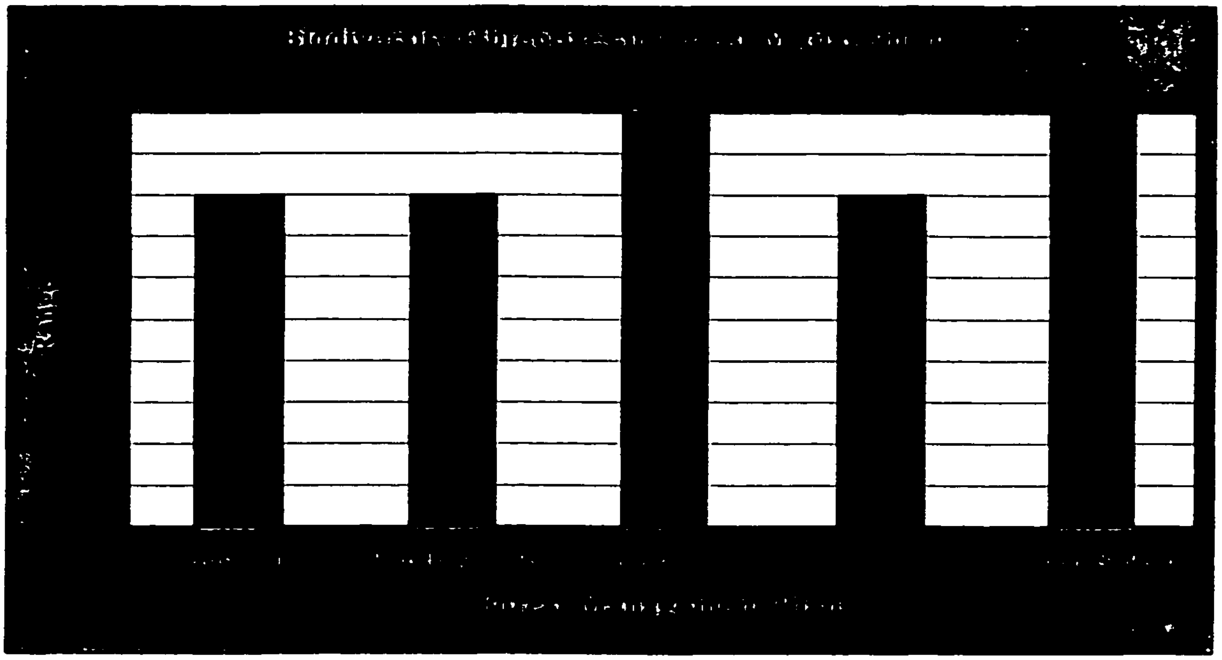

Fig.11. Biodiversity Objectives in Forest Management

BIODIVERSITY INDICATOR RESULTS

Three of the five forest management plans had technical explanations while two plans had clear explanations (Table 10). The technical explanations were directed towards professional understanding and excluded information that would make the explanations more accessible to the public.

The Nipissing Plan states that the resulting trends appear to be: more edge, smaller core areas, more patches, less forest interior and more evenness. Patch density, edge density, Shannon's heterogeneity index and evenness, and the interspersion/juxtaposition index increase by an average of 9%, while mean patch size, total core area, forest interior index and mean nearest neighbour decrease by an average of 5%. The average change is within the acceptable 10% change suggested by the MNR Northeastern Region. Each individual metric except for the interspersion/juxtaposition index is also within 10% change (Nipissing Plan, 1999, pp. 2-15). This plan did give result explanations but the plan does not explain clearly how biodiversity will be affected on the ground. The explanation was deemed to be directed towards professional understanding.

The Whiskey Jack plan gave a much clearer explanation for indicator results. Four pages are dedicated to the discussion of biodiversity results. The discussion is clear and there is direct reference to what will occur within the management unit. For example: and increase in patch density values for conifer, mixedwoods, and hardwoods 81+ years in the northern block indicates an increase in fragmentation amongst these classes. Given that 66% or 24,413 hectares of all allocations are 81+ years and located within the northern block, harvest allocations may account for some of this increased allocation…(Whiskey Jack Plan, 1999, pp. 7-Appendix 11). The explanations were very clear because the plan authors directly referenced how biodiversity will be affected within the unit.

Table 10- Biodiversity Indicator Result Explanations

	Trout Lake Forest	Whiskey-Jack Forest	Kapuskasing Forest	Nipissing Forest	French-Severn Forest
Clear Explanations		●	●		
Technical Explanations	●			●	●
Brief, unclear explanations					
No explanation					

BIODIVERSITY COMPONENTS

Three of the five plans differentiated between the three components of biodiversity while two of the plans did not. The Whiskey Jack Forest, French-Severn Forest and the Nipissing Forest management plans made relatively clear distinction between the components of biodiversity.

COMPOSITIONAL COMPONENT

All five of the selected forest management plans accounted for the compositional component of biodiversity (Fig.12). The Nipissing Forest management plan and the Whiskey Jack Forest management plan were the best at addressing the compositional component. All of the five plans identified the variety of elements in the forest management unit, however none of the plans addressed the genetic composition of the forest management unit. All of the plans addressed the identity and relative abundances of species in natural community and the types of habitats and communities that were distributed across the landscape.

The Kapuskasing Plan scored a "5" because while there was discussion regarding the identification of dominant tree species and mammals there was no indication of the composition of other important elements within the unit such as reptiles, insects (except those that damaged the forest), fungi and micro-organisms. There was also little discussion regarding the composition at the genetic (except for tree genetics), ecosystem and landscape levels. Forest unit composition will be monitored to ensure natural levels of biodiversity in the Kapuskasing Forest Management Unit (Kapuskasing Plan, 1999, pp. 143). If the compositional component is not addressed adequately within the plan itself, monitoring the compositional component will be extremely difficult. The compositional component was also not put into context of the biodiversity framework and therefore was given a score of "5".

The Nipissing Plan was given a score of "9" because it listed the dominant tree species, mammals, birds, amphibians and reptiles. It mentioned insects and fungi and other compositional components of the forest unit at the species level. The plan discussed compositional components at other levels too, but it did not put it into context of the framework of biodiversity.

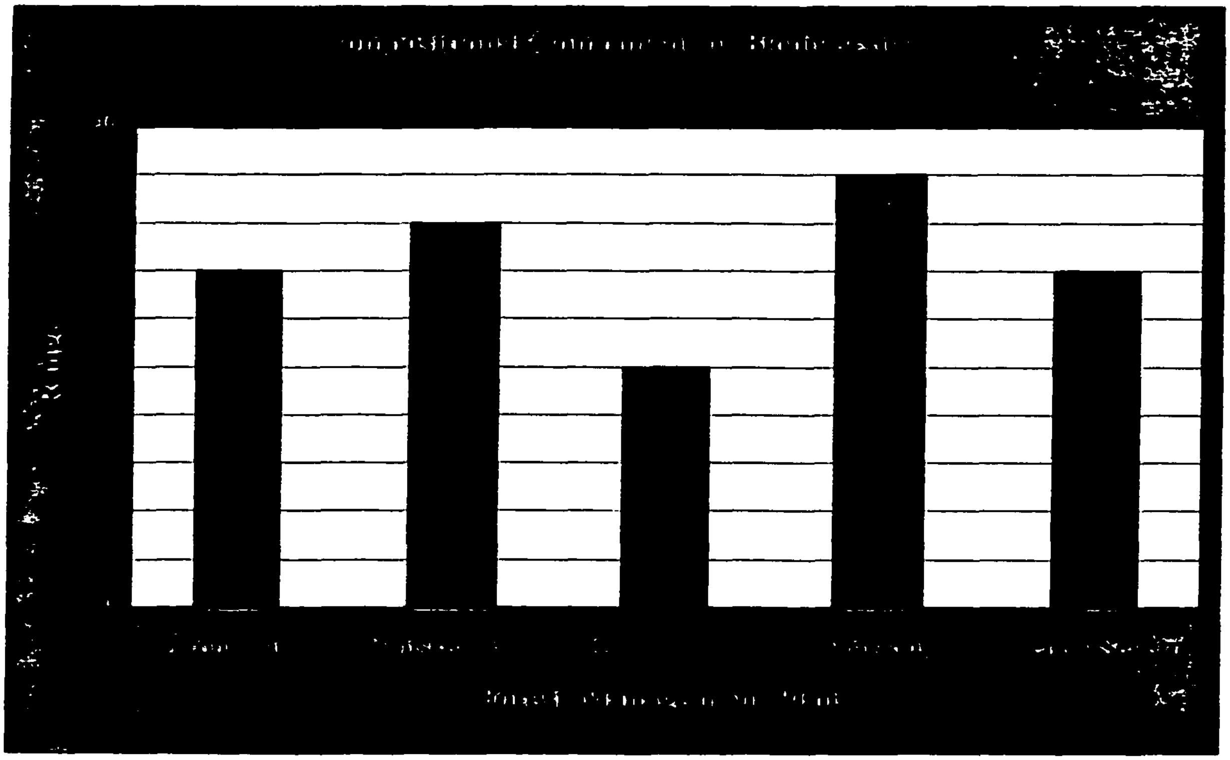

Fig.12. Compositional Component of Biodiversity

STRUCTURAL COMPONENT

All five of the selected forest management plans accounted for the structural component of biodiversity (Fig.13). The structural component was best described in the Nipissing Forest management plan and the Kapuskasing Forest management plan.

The Trout Lake plan did not specifically discuss forest structure in the plan text. One statement in the plan refers to age class structure: Stand composition and age class structure during 1980-1995 were most significantly influenced by forest fire (Trout Lake Plan, 1999, pp. 43). Elsewhere in the plan the moss and herb layers are briefly discussed but there is no context for these statements. The plan neglected to discuss the structure at the four levels of biodiversity and therefore the plan was given a score of "3".

The Nipissing Forest Management Plan scored a "9" because the plan outlines the specific age classes of horizontal layering and forest structure. Structural characteristics of the forest is represented by development stages of three broad age classes: 1) Pre-sapling 2) Sapling/Intermediate 3) Mature/Late Successional (Nipissing Plan, 1999). While the plan did not put the structural component in context of the biodiversity framework it was deemed the most thorough plan in regards to the structural component of biodiversity.

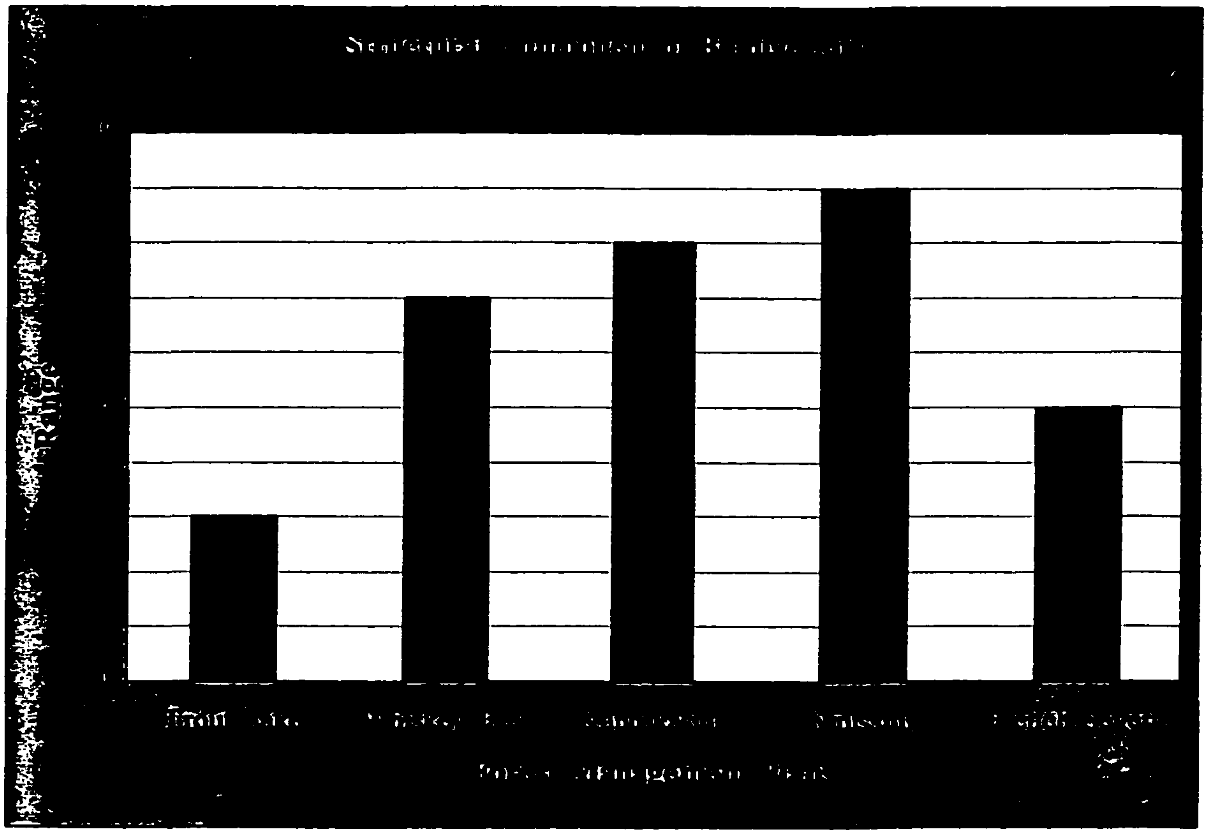

Fig.13. Structural Component of Biodiversity

FUNCTIONAL COMPONENT

All five of the selected forest management plans accounted for the functional component of biodiversity (Fig.14). The Nipissing Forest management plan and the Whiskey Jack Forest management plan were the most competent plans in terms of explaining the functional component of biodiversity.

The French Severn Forest Management Plan scored a "7" because they discussed a variety of processes at the landscape level such as evapotranspiration, run-off and forest fires (French-Severn Plan, 1999, pp. 76). It did not address functional processes at the other levels of biodiversity nor did it put the functional component into context of the biodiversity framework.

The Whiskey Jack Forest Management Plan scored a "9" because the plan discussed functional processes at three different levels. Some of the most important environmental changes occur at the spatial scale of landscapes. For example the boreal forest is regularly subjected to large fires, insect attacks and windthrow. The vegetation and animal populations found in these ecosystems have adapted to these natural disturbances. Other examples of landscape changes include clearcutting, urbanization, wetland loss and the conversion of forests to agricultural crops.

Landscape changes can directly impact ecological processes. Predator-prey interactions, the movement of organisms over the landscape, resource utilization, fire and the dispersal of seed, are all affected by the spatial configuration of the landscape units (Whiskey Jack Plan, 1999, pp. 1- Appendix 1). This plan did not put the functional component in the context of the biodiversity framework.

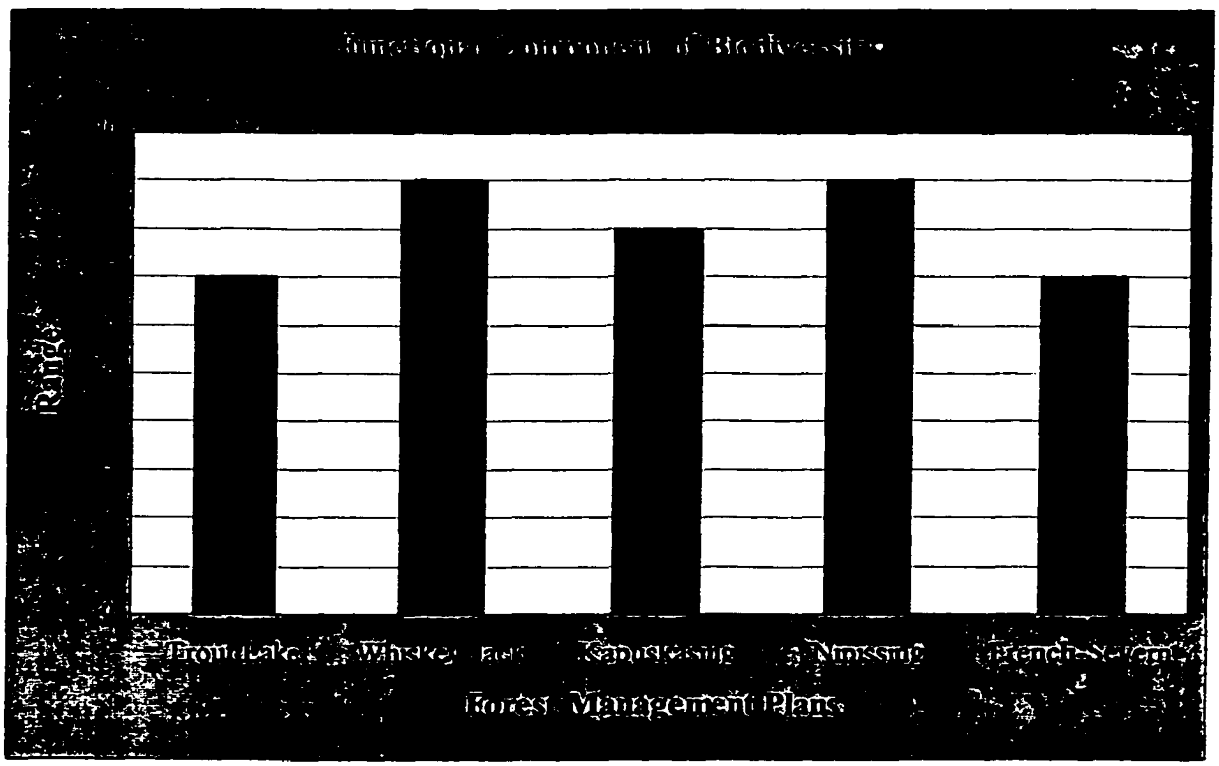

Fig.14. Functional component of Biodiversity

RESERVE AREAS

All five selected forest management plans included a discussion of reserve areas within the plan text.

OVERALL RATING

The Whiskey Jack Forest management plan, the French-Severn Forest management plan and the Nipissing Forest management plan were the most thorough plans to incorporate biodiversity concepts. The Whiskey Jack Forest management plan had a rating of 68.4%, the French-Severn and Nipissing Forest management plans had a tied rating of 67.1%, the Kapuskasing Forest Management Plan rated 58.2% and the Trout Lake Forest management plan rated 52.1%. Figure 15 is a graphical representation of the results of the weighted percentages found in Appendix One.

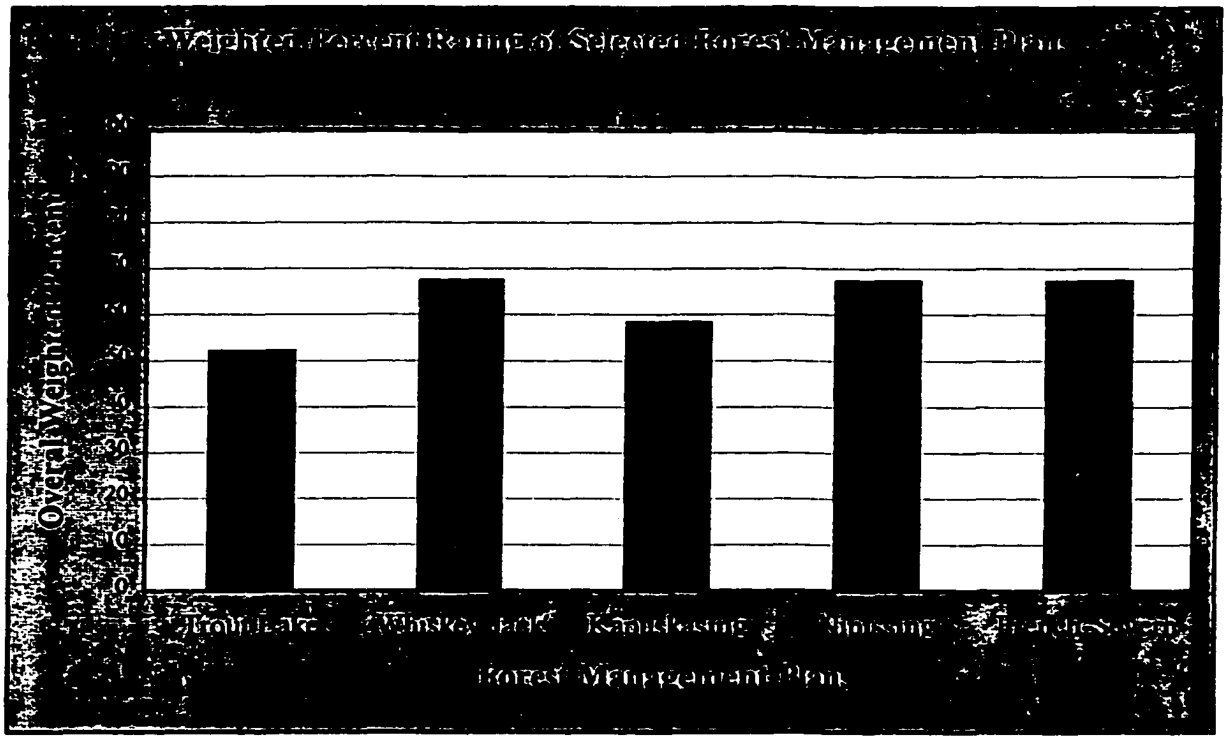

Fig.15. Weighted Percent Rating of Selected Forest Management Plans

DISCUSSION

If biodiversity strategies are to work, then foresters, planners, and other land managers must understand the basic concepts of biodiversity, why it is worth protecting and why it is a worthwhile goal in both managed and natural landscapes (Burton et al 1992). Conceptual understanding and clarity of communication are crucial to the maintenance of biodiversity through management. With the shift from traditional forest management practices towards an ecosystem approach to management, concepts can become confused creating conceptual gaps as well as significant conceptual overlap. The five forest management plans that were examined indicated this trend.

The model developed for the purpose of this study has not been validated. The validation process would require time and resources that were not available during the course of the study period. Validation of this model could be the basis for future biodiversity studies. The use of this model in the study was used to standardize how the plans were examined from one plan to the next.

The definition for biodiversity found in the Forest Management Planning Manual was adapted from the definition given in the Convention of Biological Diversity (CBD). The wording of the CBD definition is cautious: "the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems" (Kaennel 1998). This is a general definition on which the approach to biodiversity conservation in Ontario is based. The general nature of this definition encourages many interpretations of biodiversity conservation. A more specific definition such as that proposed by Noss and Cooperrider (outlined in the Literature Review section) would be a more helpful definition to include in Ontario forest management plans.

The French-Severn Forest Management plan had the most complete definition in comparison with the other plans, perhaps because the definition was written verbatim from the general definition given in the Forest Management Planning Manual. The

Nipissing Forest and Kapuskasing Forest plans gave incomplete definitions and the Trout Lake Forest and Whiskey-Jack Forests made no mention of any definition of biodiversity. The incomplete definitions left out the genetic level of biodiversity and they lacked discussion of the complexity of biodiversity. The selected forest management plans in Central and Northeastern Ontario regions had definitions while the plans from Northwestern Ontario did not. It is important to have a comprehensive definition of biodiversity to guide management activities. Starting with a comprehensive definition would help in the conceptual application of the levels and components that make up biodiversity. Then branching from the definition the components of biodiversity in a region, their distribution and their relationships can be identified, as well as what threatens them, how to measure and monitor them, and what can be done to conserve them (Noss and Cooperrider 1994 p. 4).

Ontario forest management plans have not adequately addressed genetic biodiversity. Three of the five selected forest management plans did not consider the genetic level of biodiversity while two plans made limited mention of this level. The difference between the plans could indicate that there is a lack of understanding of this level and a lack of understanding as to how to manage at this level. Because of the difficulty of measuring genetic diversity, it is rarely addressed in conservation planning (Hudson 1991 p. 86).

To assume that by managing to conserve or maintain higher levels of biodiversity (landscape and ecosystem levels) all lower levels of biodiversity will automatically be conserved is not a valid approach. The genetic level of biodiversity must be addressed in forest management through specific objectives, extensive inventories, indicators and measures. Maintaining natural variations both between and among species should be a primary management objective (Namkoong 1991). The schematic diagram in Figure 3, or something similar, should be followed for all levels of biological organization. By adhering to that framework management would follow a clear and concise order. The clarification of genetic biodiversity concepts is necessary if feasible and appropriate goals for biodiversity in forest management are to be implemented (Namkoong 1991).

As with genetic biodiversity, management objectives should be clear and concise for the species level of biodiversity and the approach to species level management should be clearly outlined. In addition, a clear and concise discussion should support why and how the approach was selected. All five of the selected forest management plans discussed the species level of biodiversity.

The single species approach to management is insufficient to maintain biodiversity. There is considerable bias in the selection of species and one thing is clear: traditional approaches to management have failed (Noss and Cooperrider 1994 p. 29). An example of the failure is the decline of red pine (*Pinus resinosa*) and white pine (*Pinus strobus*) in Ontario. In current forest management selected mammal and bird species are managed and monitored. There was almost no mention in any of the five selected management plans of: reptile species (except in the French-Severn forest management plan where the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) was mentioned); amphibian species (except for a listed reference to salamanders but without any indication as to how they are monitored); or insect species (except the species that may damage the forest); and none of the five plans addressed fungi in relation to forest management.

There is considerable conceptual overlap with terms used to describe species management and as a result within the forest management plans there was confusion in the use of these terms. Terms used in Ontario forest management to describe species management include: indicator species, selected species, featured species, keystone species, umbrella species and flagship species. An indicator species is defined as a species that is used as a gauge for the conditions of a particular habitat, community, or ecosystem (Meffe and Carroll 1997). A definition for selected species could not be found, however it was commonly used in the five forest management plans. Selected species usually appeared as a heading with a list of wildlife species underneath. Rarely were there any explanations about why those species were chosen, how they were chosen or what they represented.

The Ontario Ministry of Natural resources practices featured species management (Baker and Euler 1989). Featured species in Ontario include moose (*Alces alces*) or whitetail deer (*Odocoileus virginianus*), threatened or endangered species, or other species featured on a local basis (Baker and Euler 1989). Managing for featured species means managing the vegetation and habitat to suit the featured species. Managing featured species in this manner would provide habitat for other wildlife. According to the French-Severn Forest Management Plan, the creation of a diversity of habitat conditions at a variety of scales, in association with the featured species approach, is a more appropriate goal (French-Severn Forest Management Plan p.19).

A keystone species is defined as species that play a pivotal role in an ecosystem and upon which a large part of the community depends (Noss and Cooperrider 1994). The beaver (*Castor canadensis*) is an example of a keystone species because it affects habitat structure, hydrology and other ecosystem functions.

Noss and Cooperrider (1994) define flagship species as species that are popular and charismatic and which therefore attract popular support for their conservation. According to Noss and Cooperrider (1994) this is a flawed concept, as so little is known about species each species should be considered important. Although using this technique of identifying flagship species may be useful to gain support from the public, managing for these species may not present an accurate indication of what is happening on the ground. The selection of these species may have more to do with managing the public than managing the forest. The social aspect to forest management is, however, an important consideration.

Umbrella species are species that require large areas to maintain viable populations and by protecting their habitat, the habitat and populations of many other more restricted or less wide ranging species is protected (Noss and Cooperrider 1994). Species- level management approaches are similar and therefore, because there is conceptual overlap, they are often misused. This could affect forest management on the ground. These concepts should be used carefully in Ontario forest management planning and there should be a clear and concise discussion associated with each chosen species.

Single species management concepts and terms can cloud desired management outcomes. Within forest management, clear explanations should be given regarding what species concept is being used, why it is being used and how the species were selected and how they will be monitored. This would improve the approach to managing on the species level of biodiversity.

The shift towards ecosystem management in conjunction with species and habitat management has gained favour in land use management (Gerlach and Bengston 1994). The ecosystem level approach to management is a holistic approach that attempts to address the compositional, structural and functional components that keep ecosystems functioning. The challenge is to understand the relationships of ecosystem structure and function to management, whether responses meet the desired objectives, and what adjustments are required if responses are not as expected or desired (Kessler *et al* 1992).

Ecosystems are infinitely complex and dynamic. Management must be dynamic and flexible, and responsive to the dynamic nature of ecosystems (Meffe and Carroll 1997). All five of the selected forest management plans considered the ecosystem level of biodiversity. The French-Severn Forest and the Whiskey-Jack Forest plans were the most thorough plans that discussed the ecosystem level of biodiversity in relation to forest management, but all the plans were successful at discussing this level with varying degrees of clarity. While the account of this level of biodiversity was relatively well done in the five selected forest management plans, greater effort should be made to fit management of this level into the broader context of biodiversity. Discussion of how management would follow the dynamic nature of ecosystems would clarify how the ecosystems were being managed.

Approaching management from the landscape level, ensuring that unfragmented areas of interacting ecosystems are left undisturbed is more desirable than managing patch by patch. While managing at the landscape level is extremely important, it does not guarantee that the lower levels of biological organization will be completely protected. For example managing a large tract of land may cause a localized population to become extinct because there was not adequate attention paid to the specific requirements of the population. In this case individual protection programs are necessary to ensure that various localized or rare populations remain stabilized. Selecting areas (landscape gradients) for protection that are species-rich does not necessarily contribute to the maintenance of biodiversity because there may not be an equal representation of site-specific species. Ideally, a comprehensive conservation strategy, which includes landscape biodiversity management in association with other forms of management at lower levels of biological organization, would be the best approach to biodiversity conservation. None of the selected plans approached biodiversity in this manner.

Compositional component of biodiversity was addressed in each of the five selected plans. The Nipissing Forest Management Plan described the compositional characteristics that were represented by ten ecosite groups. According to the Forest Management Planning Manual for Ontario's Crown Forests (OMNR 1996 GL-11) the term ecosite refers to an ecological landscape unit (ranging from hundreds to thousands of hectares) comprised of relatively uniform geology, parent material, soils, topography, and hydrology, occupied by a consistent complex of successionally related vegetation. The Nipissing Plan addressed the relative abundance and the types of habitats and communities that were distributed across the management unit. It did not, however, address the genetic composition of populations within the Nipissing Management Unit and the plan failed to establish the relationship between the composition component and biodiversity. The identification and discussion of the compositional component of biodiversity is important to forest management. Both theoretical discussion and research-based discussion regarding the composition of the management unit is necessary.

As with the compositional component, the structural component was best addressed by the Nipissing Forest Management Plan. This plan stated that the structural characteristic of the forest is represented by the development stages (mainly three broad age classes) including pre-sapling, sapling/intermediate and mature/late succession. The Nipissing Plan referred to both the horizontal and vertical structure of the forest management unit, but it failed to discuss the genetic structure of the unit. The structural component was not identified in relation to biodiversity in this plan. None of the five plans addressed the structural component in the context of the biodiversity framework. Valuable information about the forest condition may be lost if management planning and research does not focus on monitoring the structure of landscape, ecosystems, species and genetics.

The functional component of biodiversity was the most thoroughly addressed component in the Nipissing Forest Management Plan and the Whiskey Jack Forest Management Plan. There was discussion in the Nipissing Plan of the processes that affect the management unit, with primary focus on natural disturbance processes such as fire. The processes were not identified as functional components of biodiversity. In the Whiskey Jack Forest Management Plan this statement indicates the awareness the processes that affect biodiversity: "Biodiversity levels could be fluctuating as older forests move into younger age classes due to disturbances. Levels would also be affected by an increase in the Jack Pine (*Pinus banksiana*) component of the forest. A younger forest dominated by Jack Pine regeneration will undoubtedly affect habitat requirements and food availability of many bird and small mammal species. We do know that caribou (*Rangifer tarandus*) were more abundant and widespread than they are today and white tailed deer were less abundant and widespread than they are today." (Whiskey Jack Forest Management Plan p.23).

All the plans that were examined failed to discuss functional processes at the genetic level. This component, however, was covered the most thoroughly at the species, ecosystem and landscape levels in each of the selected plans. Research into natural disturbances, especially fire and insect infestations have influenced how forests are managed. The French-Severn Management Plan states that more research is needed to examine how natural disturbances alter the landscape. "Managing for the maintenance of biodiversity is based on the premise that forest management should emulate natural disturbance. However, human induced disturbances to the forest have been occurring for over a century in this unit (French-Severn) without regard to concepts such as ecosystem management or biodiversity...In order to manage the forest to maintain biodiversity and improve species diversity, it is important to understand how the forest has been shaped by past forest harvesting practices." (French-Severn Forest Management Plan,1999, p. 10).

The Forest Management Planning Manual has very specific guidelines for planners concerning biodiversity in a forest management plan. The instructions to managers regarding landscape pattern or forest diversity indices include 1) forest diversity, 2) forest edge, 3) forest interior, 4) forest fragmentation, 5) forest isolation, and 6) forest spatial pattern (Forest Management Planning Manual, 1996, pp. A-28). While all the plans examined in this study followed the guidelines set out by the manual, some plans exceeded the parameters set out by the manual. The planning manual itself, through the evaluation of the products of the planning process, could incorporate the hierarchical approach to biodiversity in order to guide future planning processes. For example the genetic level of biodiversity is not outlined within the planning manual (except for tree genetics) and therefore the products of the manual (the plans) lack information for this level. The plans are excellent tools to examine the planning process itself and they provide insight into how biodiversity management guidelines can be improved in the provincial manual.

Overall, the selected forest management plans were similar in addressing the concepts of biodiversity. The plans have followed the guidelines set out in the Crown Forest Sustainability Act, however as shown through this study the biodiversity strategy could be improved. More explanation is needed as to why selected indictors were chosen and increased attention towards selecting indicators for all levels and components of biodiversity would improve forest (biodiversity) management in Ontario.

CONCLUSION AND RECOMMENDATIONS

Much of the uncertainty surrounding biodiversity derives from a lack of understanding of the subject, encapsulated in questions like: what is biodiversity, how is it measured, and what value should be applied to it? (Boyle 1991). Many biodiversity concepts in forest management have been misused and misinterpreted. In most areas all five plans were rated within a small range, indicating that plan authors have placed care in following the guidelines set for Ontario forest management. Using the hierarchical approach as proposed by Noss (1990) would improve forest management. It would help guide how biodiversity is addressed in forest management. Polishing the use of biodiversity concepts would aid plan authors in the implementation of sustainable forest management. The use of this approach would help the concerned public clarify how managers and scientists manage Ontario's forests.

Examining forest management to assess the biodiversity approach in forest management planning is the first step towards evaluating how biodiversity is being affected on the ground. By identifying conceptual gaps and conceptual overlap in regards to biodiversity, on the ground research can begin to construct a more thorough approach to biodiversity conservation.

Several recommendations have been formulated as a result of this thesis and they are as follows:

1. A more specific definition for biodiversity should be used in Ontario forest management and should include the four levels of biological organization, the three components and mention of the variety and adaptability of life.

2. The nested hierarchy approach to biodiversity should be implemented in forest management plans. The use of this approach would clarify how biodiversity is managed in Ontario.

3. Greater emphasis on research that focuses on the genetic level of biodiversity is necessary. Research should also focus on the effects of forest operations on genetic composition, structure and function. In response to more genetic research objectives, indicators and measures should be selected for this level of biological organization and incorporated into forest management strategies.

4. Clarification of the species/ecosystem approach is necessary in forest management. A general agreement should be reached to clarify concepts such as featured species, indicator species, keystone species, umbrella species and selected species.

5. A comprehensive strategy for the conservation of biodiversity in forest management should be written and used as a guide for forest management plan authors. Alternatively, the Canadian Biodiversity Strategy should be used in Ontario so that there is a national initiative towards the conservation of biodiversity.

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APPENDIX ONE:

Weighted Percent Rating of the Selected Forest Management Plans

Weighted Percent Rating of the Selected Forest Management Plans

Score	TL	Weighted (TL)	Nip	Weighted (Nip)	FS	Weighted (FS)	Kap	Weighted (Kap)	WJ	Weighted (WJ)
6	0	0	2	33.3	4	66.7	2	33.3	0	0
10	1	10	1	10	8	80	5	50	1	10
10	6	60	6	60	8	80	7	70	8	80
10	4	40	4	40	8	80	5	50	6	60
10	9	90	6	60	8	80	5	50	10	100
6	4	66.7	6	100	2	33.3	4	66.7	6	100
1	0	0	0	0	0	0	0	0	0	0
6	0	0	2	33.3	4	66.7	2	33.3	4	66.7
1	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
1	1	100	1	100	1	100	1	100	1	100
6	6	100	6	100	6	100	4	66.7	4	66.7
1	1	100	1	100	1	100	1	100	1	100
6	2	33.3	6	100	2	33.3	2	33.3	2	33.3
1	1	100	1	100	1	100	1	100	1	100
6	2	33.3	4	66.7	2	33.3	2	33.3	6	100
10	10	100	9	90	10	100	10	100	8	80
10	8	80	8	80	10	100	10	100	8	80
6	4	66.7	4	66.7	4	66.7	6	100	6	100
1	0	0	1	100	1	100	0	0	1	100
10	7	70	9	90	7	70	5	50	8	80
10	3	30	9	90	5	50	8	80	7	70
10	7	70	9	90	7	70	8	80	9	90
1	1	100	1	100	1	100	1	100	1	100
145	77	1250	96	1610	100	1610	89	1396.6	98	1616.7
2400		52.08%		67.08%		67.08%		58.17%		67.36%