The Bowater-Mersey OGF Study

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1. Introduction

1.1 Importance of the OGF Concept

The extent of old-growth forest (OGF) in Eastern North America has declined since European colonization (Leverett, 1996; Mosseler et al., 2002). Management activities have simplified forest ecosystems and promoted even-aged forests (Loo and Ives, 2003). In the Acadian Forest Region for instance, human activities have increased the frequency of young, even-aged, early-successional species, and the abundance and age of late-successional species has declined (Loo and Ives, 2003).

While species richness is greatest early in forest succession (Franklin, 1993), OGF diversity is distinctive because it is comprised of highly specialized organisms that may not be found in any other forest stage. Due to their complex physical structure, OGFs provide a vital habitat component for many species, either seasonally or throughout the year (Freedman et al., 1994). There are no sharp ecological thresholds which can be used to define OGF (Arsenault, 2003), for what is considered OGF depends on species, site characteristics (Vora, 1994), the natural disturbance regime, and forest dynamics (Arsenault, 2003). OGF is usually associated with structural characteristics including canopy closure, stand structure, age and maturity by species (Gillis et al., 2003). Standing snags and fallen logs (coarse woody debris) are key structural habitat features of OGF (Freedman et al., 1994; Bonar et al., 2003) and may be absent or scarce in intensively managed plantations or second-growth forests (Gunn and Hagan, 2000).

There is currently an "overwhelming social demand for old growth forests" (Bonar et al., 2003). It is increasingly important that managers reconcile timber production with non-timber values (Work et al., 2003). "If the values of old-growth forests are to be sustained and enhanced, managers need to know how to integrate old-growth forests into managed landscapes in a manner that maintains ecological diversity at different spatial scales" (Vora, 1994) and over time. This requires an understanding of OGF ecological characteristics (Arsenault, 2003) and the natural variability of OGF on the landscape (Bonar et al., 2003). Forest managers need to know how OGF characteristics and values can be effectively maintained, and whether a zoned approach to forest management can ensure that all desired forest values are adequately sustained (Andison, 2003). A rigorous evaluation of the degree of compatibility between different forest values is essential (Work et al., 2003), as concerns abound regarding whether emphasis on certain objectives (e.g. ecological, economic or social) compromises others (Andison, 2003).

1.2 Background to the Strategy: The Bowater-Mersey OGF Study

With these thoughts in mind, forest managers with Bowater-Mersey Paper Company in southwest NS approached Dalhousie University's School for Resource and Environmental Studies in 2000 to inquire of the possibility of collaborating on a research project that might shed light on how the Company might best conserve OGF across its private lands in southwest NS. Given that the Company was a Partner in the Sustainable Forest Management (SFM) Network, and that PD was a founding researcher associated with the SFM Network, we jointly developed a research proposal for submission in the annual research-funds competition at the Network. Funding from the SFM Network was granted in 2004, with research having begun in 2003 using other sources of funds.

The study was overly ambitious in concept, having originally planned to examine 2-3 case-study forests with researchers at five universities. Eventually it became clear that one case-study forest could be examined in detail, given the resources of time, funding and personnel allocated to the project. Of the four forest values driving the project in the beginning, carbon had to be dropped, and the final analyses focussed on timber production, biodiversity, and public preferences.

The study's overarching goal was to develop a comprehensive strategy for conservation of OGF in the case-study forest. To do this, we felt we needed original ecological and social field work as well as a model-based analysis of future possibilities to satisfy the target values.

1.3 Project Methods and Approach to Strategy Development

To build evidence and a case for OGF conservation on Company lands, we determined that the following steps needed to be taken:

(a) Field trips to BMPC lands were needed for us to become familiar with the nature of OGF on Company lands.

(b) Targetted ecological field research was needed so that we could understand in detail the characteristics of old stands across the forest landscape. We implemented field studies on basic stand characterization, stand age, and abundance and distribution of coarse woody debris, ground flora, saproxylic beetles, and corticolous lichens.

(c) Targetted social field research was needed so that we could understand in detail how people of different walk of life value OGF. We undertook such research both at a local level (with research field tours of OGF stands) and a national level (with indepth interviews of forest-sector leaders).

(d) Simulation analysis was needed to check on the implications of alternative OGF management regimes for future forest structure and wood supply.

(e) Frequent meetings to discuss and debate a variety of issues related to OGF management.

As elaborated in Chapter 8, we determined that a conservation strategy should contain the following elements:

- a statement of scope
- a suite of corporate policy and commitment statements
- a set of OGF definitions
- a philosophy of OGF management

- objectives and treatment regimes for OGF
- a plan for inventory, monitoring and research
- a communications and public-awareness program
- a commitment to strategy renewal

Various elements of the strategy took inspiration from a combination of the following sources:

(a) literature review - study-team members have, in aggregate, combed through vast amounts of literature relevant to OGF, and some of it has generated strong insights into OGF conservation;

(b) original field work - eight students have engaged in field data collection and analysis - five on ecological themes, and three on social themes;

(c) spatially explicit simulation - to explore the potential ramifications of alternative OGF conservation strategies for timber and biodiversity, we prepared a set of 100-year simulations associated with the Bowater Mersey forests; and

(d) discussion among study-team members and colleagues - both structured and unstructured discussions have been used to develop and refine many of the ideas presented in this document.

1.4 Overview of the Report

Between this introduction and the strategy presented in Chapter 8, the reader will find the following materials:

Chapter 2. The Setting - here we describe the biophysical setting of the Bowater Mersey private lands in southwest NS, as well as the management and policy settings associated with OGF in NS;

Chapter 3. Conceptions and Definitions of OGF - the literature is reviewed here to canvass the range of published definitions of OGF;

Chapter 4. Ecological Characterization of Bowater Mersey OGF - the five studies that examined the ecological traits of OGF in southwest NS are summarized here;

Chapter 5. OGF Values - in this chapter, we present the study’s findings on how people, both local to NS and dispersed across Canada, value OGF;

Chapter 6. Stand-level Considerations for OGF Conservation: Silviculture;

Chapter 7. Strategy Assessments - this chapter summarizes results of our simulation work.

2. The Setting

2.1 The Forest

2.1.1 Bowater Holdings

Bowater Mersey Paper Company owns and manages approximately 246,000 ha of land located in western Nova Scotia. The company have deivied its land holding into three operational areas. St. Margaret's Bay is the most easterly area located to the west of Halifax between Highways 101 and 103. The South Shore – Rossignol area is located northwest of Liverpool and the Medway area located just south of the Annapolis Valley (Bowater Mersey 2005).

2.1.2 Composition

Bordered by boreal forests to the north and temperate forests to the south, Nova Scotia falls within the Acadian Forest Region, which covers the Maritime provinces of Canada and the northeastern New England States. With the exception of patches of boreal forest in Cape Breton and northwestern New Brunswick, the Acadian Forest is temperate, representing the confluence of the northern hardwoods and eastern hemlock-white pine forest types. It is characterized by long-lived, shade-tolerant tree species, of which red spruce (*Picea rubens*) is its defining feature; although red spruce is generally considered a montane or sub-montane species in the southern Acadian, in Nova Scotia it is found in all topographic locations. Other characteristic temperate deciduous species include sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and American beech (*Fagus grandifolia*); in addition to red spruce, the Acadian Forest's predominant temperate conifers are eastern hemlock (*Tsuga canadensis*) and eastern white pine (*Pinus strobus*).

Alongside these species, red maple (*Acer rubrum*) and relatively short-lived species associated with boreal conditions, namely balsam fir (*Abies balsamea*), aspen (*Populus* spp.), and white birch (*Betula papyrifera*), are found in localized, early successional environments, though natural disturbance processes favours the tolerant temperate species. White spruce (*Picea glauca*) is found on the coastal headlands of Nova Scotia and readily colonizes abandoned farm fields, but is rarely found in natural stands in inland areas. Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are common on wet, nutrient-poor sites, often in association with red maple. Red pine (*Pinus resinosa*) and northern red oak (*Quercus rubra*) are relatively common on dry, inland sites in southwestern Nova Scotia, growing on coarse-grained soils, often in association with white pine.

Species	Avg. max. Longevity	Shade tolerance	Species	Shade tolerance	Avg. max. longevity
Eastern hemlock	650		Northern red oak		300
Red spruce	450		Red pine		300
White pine	400		Black spruce		250
Sugar maple	350		White spruce		200
Yellow birch	350		Balsam fir		<200
American beech	350		Red maple		150

Several factors have significantly altered the compositional character of Nova Scotia's forests since European settlement. First, a long history of selective timber exploitation has reduced the prevalence of some species, such as white pine, particularly in old stands. Second, the introduction of beech bark canker disease to Nova Scotia in the 1890s led to the widespread infection and dramatic decline of American beech, which, prior to the canker epidemic, was likely the most prevalent temperate tolerant deciduous species in the region. Finally, industrial forestry practices that came to prevalence in the early-mid 20th century and continue today have vastly increased opening sizes and greatly reduced opening intervals, resulted in a shift away from long-lived tolerant species and towards those that favour early successional environments. Coupled with the establishment of even-aged monoculture plantations, the short-rotation stand-replacement paradigm prevents the re-establishment of old-growth on the landscape.

All of these factors confound attempts to define the "natural" state of Nova Scotia's forests; however, considering the best scientific knowledge available, it is clear that the current condition of forests in southwestern Nova Scotia is drastically different from what could be expected in the absence of harvest pressures and other transformative influences on the forested landscape. In the following description of the Acadian forest of southwestern Nova Scotia, we focus on a description of the forest landscape in which forest development processes and composition are governed largely by natural influences.

2.1.3 Ecological Land Classification

Bowater Mersey's woodlands are located within Nova Scotia's Western ecoregion and are found across nine ecodistricts, though four ecodistricts account for the vast majority of these lands. Virtually all of the Saint Margaret's Bay woodlands are contained within the Saint Margaret's Bay ecodistrict and virtually all of the Medway woodlands are located in the South Mountain ecodistrict. The South-Shore-Rossignol woodlands are divided between the Rossignol (running west-to-east from north and west of Lake Rossignol to east of the lower Mersey River) and Sable (south of Lake Rossignol and west of the Lower Mersey) ecodistricts, with the westernmost edge of South-Shore-Rossignol (abutting the Tobeatic Wilderness Area) falling within the South Mountain ecodistrict.

Saint Margaret's Bay woodlands

The Saint Margaret's Bay ecodistrict, which encompasses the bulk of the Saint Margaret's Bay woodlands, is noted for its moist climate, a consequence of its exposure to the Atlantic Shore. Underlain by the South Mountain granite batholith, soils are predominantly well-drained sandy loams that form a thin, discontinuous layer of till over an irregular distribution of low hills and ridges. As with most the western end of the province, soils are generally shallow and stony, though glacial landforms can provide sites of deeper till. Well-drained sites with coarse soils on hillslopes form approximately 40% of the ecodistrict's land area; well- and imperfectly-drained hummocks form another 40%. Ridges and level areas such as bogs form a minor portion of the land area. The moist climate of the ecodistrict favours the growth of red spruce, which is more common here than elsewhere in western Nova Scotia, and disfavours fire-adapted species such as white and red pine, and red oak, differentiating this district from the drier South Mountain ecodistrict to the west. Hemlock is locally abundant on moist, well-drained lower slopes; temperate hardwoods are found on occasional hilltops with deep, well-drained soils; and white pine and black spruce can be found where soils are shallow, coarse, and dry, often on ridgetops. Black spruce is also found in poorly-drained bogs, though these areas are generally less common in this district than elsewhere in western Nova Scotia due to the significant relief that defines the district's topography.

Medway woodlands

The contiguous portion of the Medway woodlands falls within the South Mountain ecodistrict. Inland from the moist climatic zones of the Fundy and Atlantic coasts, the district has notably dry summers and is characterized predominantly by coarse, shallow sandy loams that overlay the South Mountain granite batholith. Imperfectly-drained hillslopes form approximately 35% of the district's land area; well-drained hummocks and hillslopes form another 45%. The district is also marked by localized glacial landforms that are interspersed with imperfectly- and poorly-drained flat areas such as barrens and bogs. The dry inland climate of the South Mountain ecodistrict has increased the role of fire in forest development, and consequently, white pine, red pine, and red oak are relatively common on dry sites with coarse-grained soils. Particularly in the western portion of the ecodistrict (covering western Kejimkujik National Park and the Tobeatic Wilderness Area) repeated wildfires, which increased in frequency after European settlement, have created large treeless barrens. A small proportion of the ecodistrict is composed of well-drained drumlin landforms (the "hardwood hills" of north-central Medway woodlands), which are characterized by forest communities dominated by tolerant temperate hardwoods – sugar maple, yellow birch, and American beech. Well-drained slopes support red spruce and hemlock forests, with black spruce common in poorly-drained bogs which make up approximately 3% of the ecodistrict's land area.

South-Shore-Rossignol woodlands

The South-Shore-Rossignol woodlands fall within the Rossignol and Sable ecodistricts. The Rossignol ecodistrict covers an area spanning from the Tobeatic Wilderness Area and Kejimkujik National Park boundaries in the west and north, encompassing Lake Rossignol and its western fringe, and the land east of the Lower Mersey River valley, where it abuts the LaHave Drumlins ecodistrict east of the Lower Medway River. The Rossignol ecodistrict is represented by well-drained, medium-textured, stony soils of glacial origin (45% of the land area), overlying a gently undulating topography. Temperate tolerant hardwoods – predominantly yellow birch, but also sugar maple and American beech – are found on occasional well-drained upper slopes and hills; hemlock is common on well-drained lower slopes and flat areas, in mixture with red spruce and, to a lesser extent, white pine. Red oak is relatively common on coarser soils. Poorly-drained depressions and flat areas (approximately 6% of the ecodistrict) are dominated by black spruce and larch.

The Sable ecodistrict extends from the southern shore of Lake Rossignol and the edge of the South Mountain batholith in the north to the coastal fringe in the south, and from the western edge of the province near Pubnico to the Lower Mersey River valley in the east. It is distinguished by its flat topography, which supports extensive bogs and wetlands that are treeless or support a stunted black spruce forest and make up approximately one quarter of the land area. What little relief exists takes the form of localized glacial landforms interspersed with poorly-drained depressions. Within these depressions, small hummocks support white pine interspersed with black spruce. On elevated areas with good drainage and coarse soils, white pine and red pine are common; on elevated sites where soils are less coarse but still well-drained, occasional pockets of red spruce, white pine, and hemlock are found.

2.14 Forest Ecosystem Classification

A site-level Forest Ecosystem Classification (FEC) for southwestern Nova Scotia is in development but has not yet been completed. As a result, we rely on existing knowledge of forest types from previous work in the Acadian Forest, including the FEC for the Nova Forest Alliance landbase in central Nova Scotia, and local experience to define potential species associations that define site cover types for the region. Since boreal-associated species would not be expected to form old-growth in the presence of longer-lived, more shade-tolerant species, we focus on forest types dominated by temperate species which would dominate the later stages of forest development of southwestern Nova Scotia under natural conditions. The differentiation of site types by definition requires creating categories from gradients; these gradients may be developmental/ successional, edaphic, geographic, or topographic. As a result, some flexibility is required in the interpretation of this typology.

Eastern hemlock – red spruce – white pine

White pine and eastern hemlock are both long-lived species and are a common species assemblage in the temperate forests of eastern North America; red spruce forms an additional component in the Acadian Forest. White pine is less shade-tolerant that red spruce and eastern hemlock, and is generally an early-successional species within this forest type, with its representation in the canopy decreasing as stand age increases, though it can be sustained in the canopy in localized clusters through intermediate-scale (multi-tree gap) disturbance. Red spruce is a persistent component throughout development, and can form a dominant portion of the overstory in old-growth stands, though it often forms a secondary component to eastern hemlock in very old stands, where it is sustained by gap disturbance. This forest type grades into the eastern hemlock type (see below) as hemlock proportion increases. This forest type could be expected on moist, productive sites with medium-textured soils, particularly on mid-lower slopes. A deciduous component, primarily of yellow birch but also sugar and red maple, may be represented by scattered individuals.

Eastern hemlock

Eastern hemlock is found in nearly-pure stands (> 75% hemlock dominance by basal area) in southwestern Nova Scotia. These stands may have trended towards hemlock dominance through a combination of conditions that favour hemlock regeneration, natural succession, or the absence of disturbance that creates opportunities for red spruce or tolerant deciduous establishment or persistence. They may also be artifacts of historic removal of white pine and red spruce stems followed by crown expansion of residual hemlock stems. Because some of these stands are represented by an even-aged hemlock cohort, it is likely that hemlock formed a significant portion of the initiating cohort, suggesting that hemlock can become established, either dominantly or as a component of a mixed-conifer forest. Because hemlock forms dense canopies and is extremely shade-tolerant, it has been considered self-replacing. Thus, these stands may remain hemlock-dominated in the absence of intermediate disturbance.

Eastern hemlock – tolerant deciduous
Hemlock can form an association with tolerant hardwoods where soils are relatively deep and moist. Yellow birch is a particularly common associate, though sugar maple and American beech are also found. Red maple can also be found in association with eastern hemlock as an occasional canopy component.

Tolerant deciduous
On deep, well-drained, medium-textured soils, such as those found on drumlin ridges, sugar maple and American beech – the most shade-tolerant of the temperate deciduous species – frequently constitute the dominant canopy. Yellow birch is of intermediate shade tolerance and could be expected to form a portion of the canopy, though would likely become subdominant, represented by occasional old stems as the forest ages.

White pine – northern red oak – red maple
White pine is found in association with red oak and red maple on coarse-textured, moderately dry soils.

White pine
Although it will eventually be replaced by red spruce and hemlock on mixed-conifer sites where fires are infrequent, white pine can form stable nearly-pure stands in southwestern Nova Scotia where more shade-tolerant species are limited by site conditions, in particular, a fire-dominated disturbance regime and coarse-textured soils on dry sites. White pine can sometimes be found in association with black spruce, particularly in the Sable ecodistrict, and on poorer sites in the South Mountain ecodistrict.

White pine – red pine
White and red pine can form mixed stands on coarse-textured glacial outwash flats, particularly in the South Mountain ecodistrict. These stands are closely tied to fire distribution patterns. Black spruce is an occasional component, though fire favours the pine component.

Red pine
In the absence of fire, red pine can form nearly-pure stands that take on old-growth characteristics. These stands represent the end of a white- and red-pine mixture spectrum, and tend to occur on the driest of sites the two may share.

2.1.5 Disturbance

Although the occurrence of individual forest disturbances is temporally stochastic, or unpredictable in time, and broad-scale/long-term global changes affect the nature of disturbances in regional ecosystems, natural disturbances cluster within a characteristic *range* of spatial and temporal scales (the ***range of natural variability***) that defines the ***natural disturbance regime*** of particular forest regions. *Natural* is not used here to describe so-called *pristine* or *virgin* conditions that exist in the complete absence of human activity; indeed, modern ecology acknowledges that such terms are largely sentimental, and often indefinable. Humans have occupied eastern North America for at least 12,000 years, and evidence of human alteration of forest conditions extends several millennia into the past, making the differentiation of *natural* and *anthropogenic* (human-induced) disturbance difficult, and ultimately, arbitrary.

However, the severity and scale of change in the forests of eastern North America has increased greatly over the centuries since European settlement, and today human activity is the most significant determinant of forest conditions in the region. Therefore, what is considered the *natural* disturbance regime of a forest region is not what would exist in the complete absence of human influence, but what would be expected where human activity is a minor, rather than the dominant, influence upon of forest conditions. Forest scientists agree that conditions prior to European settlement offer the best surrogate for natural disturbance regimes.

2.1.6 Natural Disturbance Regimes of the Acadian Forest

A significant body of research has emerged from studies of the natural disturbance regimes of the forests of the northeastern United States. Northern New England has similar climatic conditions, forest type, and settlement history to that of Nova Scotia, giving some grounds for the inference of disturbance dynamics in Nova Scotia from those of the larger Acadian Forest Region.

The distribution of forest types in southwestern Nova Scotia is strongly influenced by topography and physiographic factors. As such, disturbance processes are superimposed upon an underlying patchwork of site conditions, which may influence the effect of disturbance on forest structure at the landscape scale. The existing literature on Acadian disturbance regimes does not account directly for such “baseline” spatial variability, though it does identify disturbance dynamics as they relate to particular forest types.

Types of Disturbance

A comprehensive literature survey integrating multiple lines of evidence of presettlement disturbance dynamics identified two characteristic types of natural disturbance that dominate the Acadian Forest: *severe fire* and *wind events*, and *canopy gaps*[1]. Disturbance does not occur with an exact and predictable periodicity, making a single estimate of a disturbance rate only a partially useful reference. Of more significance is the fact that disturbances do cluster around characteristic spatiotemporal scales (Fig. XXX[2]). The range of values within these clusters represents the range of natural variability for disturbance that underlies current definitions of ecological integrity (XXX), ecosystem-based management (XXX), and ecologically sustainable forest management (XXX).

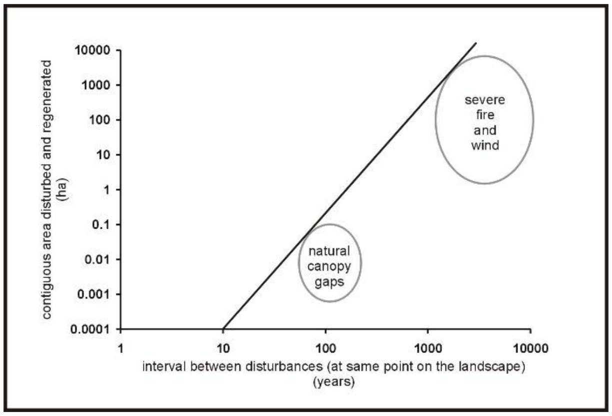


Fig. XXX. Boundaries of natural variation of natural forest disturbance in northeastern North American forests. The diagonal boundary line defines the upper limits of scales. Disturbances that fall to the right of the line can be considered to be within the range of natural variation.

Fire

Severe crown fire tends to kill the majority of the living forest structure, consuming part of this through combustion, and also consumes much of the litter layer, but fire leaves significant dead structural legacies in the form of snags and coarse woody debris. Severe fire in the temperate Acadian Forest is a rare occurrence (Table XXX[3]). Historically, the frequency of fires increased in the Acadian Forest during the settlement period (1700 – 1900) as a consequence of land clearing, and subsequently decreased due to fire suppression following the advent of widespread industrial forestry (1900 – present). Under natural conditions, the spatial scale of fire events is highly variable, ranging from less than five to tens of thousands of hectares.

Table XXX. Range of variation spatial and temporal scales of natural forest disturbance in red spruce, eastern hemlock, and temperate hardwood forests of the Acadian Forest Region, based on integration from multiple studies. *Boundary of range* of spatial scales indicates the range of *individual patch sizes* across the studies cited. *Range of mean* of spatial scales reflects the range of *average patch sizes* from individual studies.

	Spatial scale		**Temporal scale**
Disturbance	**Boundary of range**	**Range of mean**	**Range (years)**
Canopy gaps	4 – 1135 m^2	24 – 126 m^2	50-200

[1] Two seminal publications have integrated previous studies of forest disturbance in northeastern North America to describe the disturbance regime for the region: Seymour et al. (2002) and Lorimer and White (2003).
[2, 4] Reproduced from Seymour et al. 2002.

Severe wind	0.2 – 3728 ha	14 – 93 ha	855 – 14300
Severe fire	2 – >80000 ha	2 – 200 ha	806 – 9000

Fire differentially affects Acadian forest types. The return interval for fire on sites represented by a climax community dominated by red spruce, temperate hardwoods, and/or eastern hemlock is estimated to be between approximately 800 and over 14000 years. Red pine, white pine, and red oak forests are more susceptible to fire, because they favour drier sites and develop litter layers with high ignition potential. There has been little direct research on this forest type in the Acadian Forest, though research conducted on the disturbance dynamics of pine and forests in the Great Lakes region suggests that these sites have an average fire rotation period in the range of 170 to 350 years for pine-oak forests and 120 to 250 years of mixed red- and white-pine forests.[4] A reasonable estimate of the range of variability for similar forest types in southwestern Nova Scotia would likely be on the scale of 150 to 400 years.

Wind

Severe wind events affect forest structure in a patchy manner and tend to leave a highly heterogeneous fine-scale pattern of remnant living structure. They do not directly consume any biomass, instead converting some proportion of the standing structure to downed woody debris. Unlike fire, wind events do not have direct anthropogenic causes, and although there is some variability in storm frequency due to climatic shifts, the range of variation in storm frequency can be inferred from both presettlement and postsettlement sources. Evidence suggests windstorms likely represent the dominant disturbance process in the temperate Acadian Forest, though recurrence at a given site is infrequent, occurring within a range of frequencies from approximately 800 years to many millennia.

Severe wind disturbance does not generally create homogeneous regenerating patches at the scale commonly associated with the stand. The spatial extent of wind disturbances in Table XXX indicates the total area affected by the disturbance; individual patches (contiguous areas affected with the same degree of severity) vary with storm strength but tend to be small, ranging from single tree to ten hectares, with a distribution favouring the smaller end of this range[5]. Occasionally, larger patches (30-40 ha) are created, usually in old stands, but these tend to be rare. The complexity of severe wind effects on forest structure indicates that this disturbance type is best considered a partial rather than a large-patch-creating disturbance process, with more severe events (that may be considered stand-replacing) occurring with a frequency in the upper limits of the range of variability (over 1000 years).

Effects of severe wind differs across tree species, forest types, and development stages, as well as topography and soil conditions. In general, early-successional species – white and red pine, aspen, and white birch – are significantly more susceptible to windthrow and breakage than later-successional species[6]. Empirical evidence from New England

[4] Whitney 1986
[5] Foster and Boose 1992
[6] Foster 1988

suggests that susceptibility to windthrow increases with increasing proportion of conifers over hardwoods, as well as increasing tree height, suggesting old stands are more susceptible than young stands. Planted forests are more susceptible than naturally regenerated forests due to constrained seedling rootforms, as are forests that have been thinned or subjected to partial harvests that remove a sizable portion of the overstory (e.g. stripcuts and strip shelterwood cuts).

2.2 The Policy Environment for Sustainable Forest Management

BMPC forest lands in NS are held in fee-simple ownership by the Company. They are managed under the guidance of both provincial-government policy as well as Company policies. This section gives a brief overview of the current state of both set of policies, particularly as they relate to OGF conservation.

Sustainable forest management in NS is governed mainly by the Forests Act [1989] and its regulations. Two sets of regulations under the Act are of particular interest in this context. One is the Forest Sustainability Regulations, which has the aim to improve the sustainability of wood supply from private lands through increased silviculture. These regulations govern BMPC in respect of its purchases of wood from private woodlots. The other is the Wildlife Habitat and Watercourses Protection Regulations. Two provisions in these regulations apply to BMPC's private land: (a) the requirement to leave tree clumps in harvest blocks; and (b) the requirement to manage special management zones in riparian areas.

A Government of NS interim policy on old forests was implemented in 1999. It aims to set aside old forests (meaning to reserve them from timber harvests) on Crown lands across the province. Among coniferous species, the policy focusses attention on eastern hemlock, white pine, and red spruce.

Of greater significance to conservation of OGF on BMPC's lands are its own policies. As in interim measure (i.e., in advance of potential adoption of a detailed OGF conservation strategy), the Company decided some years ago to reserve from harvest any stand determined to be dominated by trees older than 120 yr. Tree ages were first identified in a preliminary way in inventory-making, and verified using tree cores in field visits. The policy has led to an area of OGF across the working forest (i.e., the parts of the forest considered eligible for timber harvest) of some seven thousand hectares.

In addition, the Company has a no-cut policy in effect for the first 30 m of forest from the water's edge in riparian zones, a policy that goes far beyond the provincial regulation in terms of reserved riparian forest. Using a definition for OGF based solely on stand age, such riparian buffers could accumulate large areas of OGF over time. This indeed was the case in our simulation analyses. Any current OGF in such riparian buffers has been accounted for in the seven thousand hectares mentioned above.

A final policy domain that could influence the abundance and distribution of OGF on BMPC lands is forest certification. BMPC has implemented certification under the Sustainable Forestry Initiative (SFI). In doing so, it has not been obligated to conserve its own OGF according to any requirements or specifications in the SFI certification standard. Rather, it is obliged to give "Support of and participation in plans or programs for the conservation of old-growth forests in the region of ownership" (SFI, 2004).

In sum, the broad concept of SFM is well established in NS, in both public- and private-sector policy domains. All major participants in industrial forest management in the province recognize the importance of OGF conservation. Both the Government of NS and BMPC started about a decade ago to take OGF conservation seriously and implemented interim policies. One could expect that OGF conservation on BMPC lands will in the future be based on its own initiatives such as the adoption of the kind of OGF conservation strategy as advocated herein, as well as any policies adopted by the Government of NS that may become requirements of private-land forest management.

3. CONCEPTIONS AND DEFINITIONS OF OLD-GROWTH

[NOTE: this section still requires additional text and referencing]

In most circumstances, old-growth definitions apply one or more of the following criteria:

- Forests that are, by some definition, dominated by or contain some notable proportion of trees that are considered to be old;
- Forests that are composed of a tree population with an age distribution considered to be "uneven";
- Forests that have undergone development that has been undisturbed, mostly undisturbed, or has persisted despite disturbance, for a relatively long period of time;
- Forests that have not been altered at all by human intervention, have not been altered significantly by human intervention, or have persisted despite human intervention;
- Forests that exhibit particular structural characteristics, such as relatively large trees, a relatively large quantity of large dead woody material, gaps in the overstory, a varied vertical and horizontal distribution of trees;
- Forests that contain tree, plant, or animal species considered to be specific to or associated with the ecological state associated with the previous criteria; and/or

Forests that elicit a particular emotional, spiritual, intellectual, or physical response among some people who observe them.

4. Ecological Characterizations of Bowater Mersey OGF

4.1 CHARACTERISTICS OF COARSE WOODY DEBRIS IN SOUTHWESTERN NOVA SCOTIA FORESTS

By Susan A. Thompson

Focusing on the characteristics of coarse woody debris (CWD) in southwestern Nova Scotia forests, the research is framed in the discussion of the importance of CWD in old-growth forests and the ultimate conservation of this valuable resource. The primary objective of the study was to: "evaluate the effects of stand age (using a chronosequence approach) and harvest treatment on the quantity and quality of CWD in coniferous stands on the private lands of Bowater Mersey Paper Company in southwestern Nova Scotia". A further objective was to determine the accuracy of the line-intersect method for estimating the volume of downed CWD, and to compare the difference in volume between using 7.0 and 9.0 cm as the minimum diameter to define CWD. Fieldwork was undertaken in eleven stands, being either harvested or unharvested, ranging from 55 to 190 years old. The stands, consisting of red spruce, white pine and eastern hemlock, were classified as young (40 to 80 yr), mature (80 to 120 yr), and old-growth (120+ yr) forest.

Results of the study showed that the volume of snags ranged from 13.3 to 50.2 m^3/ha in unharvested stands and 7.1 to 46.2 m^3/ha in harvested stands. Other findings show that the volume of downed CWD in unharvested stands ranged from 22.2 to 77.9 m^3/ha while harvested stands ranged from 57.0 to 154.0 m^3/ha. Averages by age class for these findings were also tabulated. Further, it was found that the volume of snags was concentrated in decay classes 1 and 2 (least decayed) with no major patterns by stand and age or harvest treatment. The volumes of downed CWD in decay classes 2 and 3 were higher in the harvested stands, while that in decay class 5 (most decayed) were higher in the unharvested stands. Regarding the use of the line-intersect approach, it was determined that this was indeed a useful method for estimating the volume of downed CWD in the sampled forest stands. The findings of this study have implications for forest resource managers as they suggest that harvest treatment may have an impact on the volume of snags contained in a stand; a higher volume of snags lends to greater biodiversity. Likewise, ecologically valuable stands of OGF were observed to contain twice as much volume in snags and downed CWD than younger age classes, thus demonstrating the importance of retaining and fostering the development of large living trees.

4.2 EFFECTS OF STAND AGE AND SILVICULTURE TREATMENT ON BEETLE (COLEOPTERA) BIODIVERISTY IN CONIFEROUS STANDS IN SOUTHWEST NOVA SCOTIA

By Philana Dollin

Dollin studied the relationship between saproxylic beetles and dead or decaying wood or fungi associated with deadwood as well as how this relationship can provide information on forest ecosystem health. Fieldwork was conducted on harvested and unharvested coniferous stands on the private lands of Bowater Mersey Paper Company in southwestern Nova Scotia. These stands were classed as young (40 to 80 yr) stands, mature (80 to 120 yr) stands, or old-growth (120+ yr) stands. The primary objective of the study was to "investigate relationships between forest stand age, silviculture treatment, dead wood and biodiversity, using saproxylic beetles as indicators". A further objective of the study was to define habitat for saproxylic species, using qualitative and quantitative examination of CWD as well as defining trophic relationships among the identified species as an indication of the complexity of ecological interactions.

Results of the study showed that stand age affected both species richness and species composition; as stand age increases, so does species richness. Old growth forests composed of diverse tree types and containing higher volumes of large-diameter CWD also showed higher levels of beetle species richness. Results from the study regarding the effects of harvest treatment on species richness and species composition differed from those reviewed in the literature; this study revealed that species diversity was higher in the partially harvested sites than in the unharvested sites. Although a positive correlation between mean volume of CWD and beetle species richness is often found in studies in the literature, this relationship was not found to be statistically significant in this study. Moreover, no significant differences in beetle species composition were found based on mean volumes of CWD for each stand. This study did, however, reveal the occurrence of 13 beetle species that had not been previously recorded in Nova Scotia. Management implications stemming from these findings reveal that the maintenance of a variety of habitats, including both young and old forest stands, is important for the conservation of saproxylic beetles. Beetles are active in nutrient cycling and decomposition in forest ecosystems, a function that is invaluable to the sustainability and health of Nova Scotia's forests.

4.3 COMPARISON OF UNDERSTORY VEGETATION IN A CHRONOSEQUENCE OF UNHARVESTED AND PARTIALLY HARVESTED CONIFEROUS FORESTS IN SOUTHERN NOVA SOCTIA

By Jessica N. Epstein

This research investigated the impacts of partial harvests on understory vegetation in a chronosequence of coniferous Acadian forests in southern Nova Scotia. Understory vegetation is important for the forest ecosystem as it is a source of habitat and food for wildlife, it acts as a nutrient cycler and regulator of the microclimate in a stand, and it forms a significant portion of the forest biomass. The study's objectives were to: 1) describe the differences in understory species richness, diversity and composition that occur in stands of different ages; 2) describe the differences in understory species richness, diversity and composition in partially harvested stands compared to unharvested stands; and 3) determine if the age of a stand at the time of partial harvesting differentially affects understory species richness, diversity and composition. Study sites for this research consisted of softwood-dominated stands in southern Nova Scotia with ages ranging from young (40 yr) to old growth (120+ yr).

Findings suggested that the understory species richness peaked during the understory reinitiation stage, but species diversity differed little between different-aged stands. Partial harvests were found to differentially affect the understory depending on the age of the stand at the time of harvest. While species richness and diversity were found especially affected in mid-aged stands, understory composition was more heavily affected the greater the age of the stand. Species attaining their greatest importance in old-growth stands were found to be most negatively affected by partial harvests. Ultimately, the results indicated that partial harvests in older stands pose a risk to species dependant on old-growth forests and especially species dependant on woody debris in the later stages of decay. Forest resource managers should be aware of the sensitivity of forest understory plants to subtle changes in ecological conditions and could apply the findings of this study to determine the proper distance of harvested stands from old-growth forests and the volume and state of woody debris in partially harvested stands.

4.4. RESTORATION OF ACADIAN OLD-GROWTH FOREST: ATTITIDUES AND BEHAVIOURS OF PRIVATE WOODLAND OWNERS IN CENTRAL NOVA SCOTIA.

By Andrea L. Dube

This research examined the adoption of woodland stewardship concepts as a means of maintaining forest biodiversity and conserving the threatened Acadian old-growth forest (OGF) in Nova Scotia. The purpose of the study was to examine the opinions and behaviours of private woodland owners in regards to woodland stewardship, which includes the restoration of compositional, structural, and process features of Acadian OGF. Particular objectives of the research were to "1) characterize Acadian OGF features and describe how these features can be restored through management; 2) understand woodland owner attitudes toward restoration of Acadian OGF features; 3) understand the compatibility of woodland owner self-reported behaviour with restoration of Acadian OGF features; 4) describe how stewardship initiatives can encourage and support the restoration of Acadian OGF features." A mixed-methods approach using quantitative and qualitative methods was employed for this research: a mail-in questionnaire as well as interviews with private woodlot owners was conducted.

Analysis of the questionnaire data aimed to reveal woodland owner attitudes and behaviours using descriptive statistics as well as the relationship between respondents' interest and participation in Acadian OGF restoration. The results showed that the demography of the woodland owners consisted mostly of middle-aged, well-educated men who were not dependent on their woodlands as a significant source of income. Most (90%) indicated that they were either very interested or interested in private woodland issues; however, a smaller majority (59%) indicated that they were very or somewhat informed about the issues.

In regard to actual participation in private woodland issues, over half (59%) of the respondents said that they were or have been a member of a forestry or wood-products organization, hunting-angling association, wilderness group or environmental organization. Several other issues such as the management of woodland, sustainable forest management on private woodland, restoration of OGF features on private woodland, as well as opportunities for and challenges to restoration were addressed in the questionnaire. Ultimately, respondents seemed to have a strong sense of stewardship and associated intrinsic values with their woodlands. Case summaries of the interviews conducted with four private woodland owners were also discussed in detail. The findings of the study as well as recommendations directed at the provincial government, the woodland-owner organizations, and the Nova Forest Alliance can ultimately help guide the implementation of stewardship programs that encourage the conservation and restoration of Acadian OG forest.

4.5 EPIPHYTIC LICHENS OF OLD-GROWTH FORESTS FROM SOUTHWESTERN NOVA SOCTIA: DIVERSITY, STATUS AND ECOLOGICAL RELATIONSHIPS

By Richard Troy McMullin

The research examined the ecological relationship between old-growth forests and the lichen communities that serve as an important nutrient cycler in forest ecosystems. Several objectives were established for the study: "1) determine the epiphytic lichen communities in forest stands, not subject to recent management, aged approximately 50 yr across a gradient up to the oldest forests that can be located; 2) identify lichen species that appear to be unique to old-growth forests; 3) apply pre-existing indices of ecological continuity to forest stands and lichen communities examined to determine whether they are appropriate for use in this region; 4) determine relationships between the lichen communities, structural complexity and ecological context of various forest stands; 5) determine relationships among the ecological needs of the epiphytic lichens encountered; and 6) determine regionally uncommon and sensitive field-identifiable lichen species." Fieldwork took place in 51 conifer-dominated forest stands in southwestern Nova Scotia with ages between 52 and 292 years.

In total, 135 lichen species in 60 genera were identified. Importantly, 26 lichen species were found to be new records for Nova Scotia, three could be species new to science, and one species appeared to represent a genus new to science. Data on the identified lichen species were used, with the help of two indices of ecological continuity, to calculate an age category value for each of the 51 assessed forest stands (a higher number relates to an older forest stand). Results of the study, using either index, did not identify any of the tree stands as 'old-growth', but when using a tree-coring method, some of the sampled stands were indeed considered 'old-growth'. Other findings suggested that the determination of lichen species richness is not related to tree age, the proximity of treed bogs, and to tree density but rather that higher species richness is most often found in areas with fluctuating light, a higher proportion of broadleaved trees, less amount of light overall, and more wetland area within 500 m. Moreover, it was found that lichens tended to have distinctly different ecological needs and did not necessarily mutually occur in a particular location. Ultimately, the results from this study showed that greater complexity in forest ecosystems yielded more microhabitats that are conducive to higher levels of lichen species richness despite the age of the forest. This has implications for forest managers in that it encourages them to preserve lichen species richness based on the evaluation of forest stands' structural complexity and ecological context and not solely based on age.

4.6 Structural Development in Conifer-Dominated Acadian Old-Growth Forests

By Anthony D. Pesklevits

Effective strategies for the management and conservation of old-growth forests are hindered by a lack of fundamental baseline information on old-growth characteristics and dynamics derived from extensive empirical research. This is especially true in regions where remnant old-growth is scarce, such as the Acadian Forest Region which constitutes much of Canada's Maritime provinces. This paper presents the results of an empirical study of forest age structure, compositional dynamics, and structural characteristics across a sequence of fifty-one sites dominated by a combination of eastern hemlock (*Tsuga canadensis*), red spruce (*Picea rubens*), and eastern white pine (*Pinus strobus*), in the managed forest of southwestern Nova Scotia, Canada. Sites ranged from 55 to almost 400 years old. Age structure, species composition, and structural attributes including the average of and variability of stem size, vertical stem distribution, density of large snags, and volume of dead wood were described and were related to site age to describe general patterns of structural and successional development. The results suggest that eastern hemlock with come to dominate oldgrowth sites, which can remain even-aged up to ages of 200-250 years old, while whitepine- and red-spruce-dominated sites develop an uneven-aged structure 50-100 years earlier in the development process. While several structural attributes showed clear relationships with site age, many exhibited significant variability even within narrow age ranges, suggesting that site age alone does not reflect a singular determinant of structural development trajectories in this forest type.

5. Values Associated with OGF

5.1 General

We have been unable to find a comprehensive accounting of OGF values in the literature, so we felt compelled to create one. We started with a well-referenced framework established by Bengston (1995) for general forest use, and expanded it to make sure it captured the full range of values we know to be associated with OGF, at least in Canada (Figure 5.1, taken from Moyer et al. 2008).

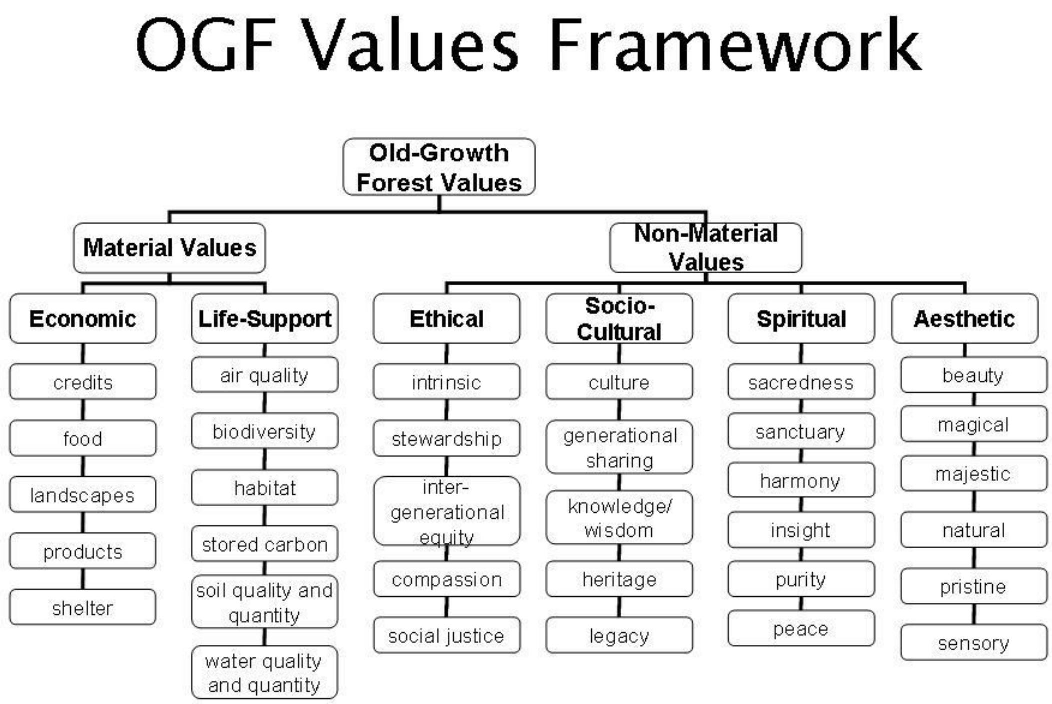


Figure 5.1 A framework for understanding values associated with OGF.

5.2 Local Values of OGF - The Owen Study

Rochelle Owen (Owen, 2006; Owen et al., 2008) studied the ways in which NS citizens associated with five constituencies (rural and urban residents, environmental-group members, forest professionals, and Aboriginal people) value OGF. Her findings are well summarized in two tables. In Table 5.2.1, three values traits are assessed: (a) the degree to which OGF values are specific to OGF, as opposed to being able to be satisfied by all forest development stages; (b) the relative degree to which the value is important to observers; and (c) the relative degree to which silvicultural interventions are likely to compromise satisfaction of the value. In Table 5.2.2, Owen (2006) groups the values into broad classes of high, medium and low value priorities. Owen's (2006) data make it clear that (a) in terms of the framework presented by Moyer et al. (2008), non-material OGF values dominate the minds of most citizens canvassed, (b) such values are specific to OGF, as opposed to other stages of forest development, and (c) silvicultural activities have relatively large negative effects of the satisfaction of such values.

Table 5.2.1. Values priority matrix of all participants (Owen, 2006).

Value	**OGF Value Specificity**	**Value Importance**	**Silvicultural Disturbance**	**Total Value Priority**
Habitat	medium	high	medium	med (high)
Natural Beauty	medium	high	high	high (med)
Biodiversity	medium	high	medium	med (high)
Sanctuary/Solitude (sacredness)	high	medium	medium	med (high)
Recreation/Camping/Hiking	low	medium	medium	medium (low)
Wildlife Appreciation	low	medium	medium	medium (low)
Education/Research	medium	medium	medium	medium
Water Quality/Quantity	low	medium	high	medium
Carbon Sequestration	low	medium	medium	medium (low)
Oxygen	low	medium	medium	medium (low)
Majestic Surroundings	medium	medium	medium	medium
Exploration/Adventure	low	medium	medium	medium (low)
Keystone Species	low	medium	medium	medium (low)
Soil Conservation	low	low	medium	low (medium)
Heritage	high	low	medium	medium
Fishing/Hunting	low	low	medium	low (medium)
Generational Sharing	high	low	medium	medium
Legacy	low	low	medium	low (medium)
Timber	low	low	low	low
Untouched	high	low	high	medium (high)
Medicine	low	low	medium	low (medium)
Pristine Area	high	low	high	medium (high)
Creative Inspiration	low	low	medium	low (medium)
Firewood	low	low	low	low
Eco-tourism	medium	medium	medium	medium
Peace	medium	high	high	high (med)
Protection	high	medium	medium	medium (high)
Personal renewal and reflection	medium	high	medium	medium (high)
Comfort	medium	low	medium	medium (low)

Table 5.2.2. Level of value priority by all participants (Owen, 2006).

Value	Total Value Priority	Level of Value Priority
Natural Beauty	high (med)	High
Peace	high (med)	
Habitat	med (high)	
Biodiversity	med (high)	
Sanctuary/Solitude (sacredness)	med (high)	
Protection	medium (high)	
Personal Renewal and Reflection	medium (high)	
Untouched	medium (high)	
Pristine Area	medium (high)	
Education/Research	medium	Medium
Water Quality/Quantity	medium	
Majestic Surroundings	medium	
Heritage	medium	
Generational Sharing	medium	
Eco-tourism	medium	
Comfort	medium (low)	
Recreation/Camping/Hiking	medium (low)	
Wildlife Appreciation	medium (low)	
Carbon Sequestration	medium (low)	
Oxygen	medium (low)	
Exploration/Adventure	medium (low)	
Keystone Species	medium (low)	
Creative Inspiration	low (medium)	Low
Medicine	low (medium)	
Legacy	low (medium)	
Soil Conservation	low (medium)	
Fishing/Hunting	low (medium)	
Timber	low	
Firewood	low	

5.3 Broader Values of OGF - The Moyer Study

Joanne Moyer (Moyer, 2006; Moyer et al., 2008) made an in-depth narrative-based look at how six Canadian forest-sector leaders understand and value OGF. In Moyer's (2006) words, "[the] research revealed that . . . three basic elements of OGF . . . were valued as unique and special aspects of OGF by the participants: natural ecological processes that serve as a reference point and provide environmental services; biotic components that are valued for economic, life-support and non-material reasons; and personal experiences that are valued aesthetically, spiritually, culturally and ethically". These findings suggest that, based admittedly on a small sample of "elite" citizens for whom sustainable forests are a top vocational priority, OGF is valued broadly, encompassing the full spectrum of values displayed in Figure 5.1 above.

5.4 Synthesis

Both Moyer (2006) and Owen (2006) concluded that successful OGF conservation depends on a much fuller and richer understanding of society's diverse OGF-related values than most forest managers currently hold. In the context of specific forests where OGF is a valued component of the overall ecosystem complex, what they state is needed is, first, a much more systematic elicitation of stakeholder OGF values, and, second, careful investigation into ways in which those values can be satisfied (or at least not compromised).

6. Stand-level Considerations for OGF Conservation: The Role of Silviculture

[NOTE: this section still requires additional text and referencing]

As we conceived the role of silviculture in OGF conservation, our thinking evolved toward a conception including three sub-roles, as outlined below.

6.1 OGF Management Using No Silvicultural Intervention

Based on the best available evidence assembled by forest ecological historians (e.g, refs), we surmise that the Acadian forests of Canada's Maritime provinces prior to European colonization were characterized by quantities and qualities of OGF that far surpass the situation today. At that time and previously, the resident Aboriginal people were significant forest users, and no doubt those uses had some influence on forest dynamics. However, the industrial culture and types of forest uses we know today did not exist, nor did the mechanized silviculture we also know today. Thus, we believe it is reasonable to assume that OGF of desirable quantities and qualities can exist today and into the future entirely independent of management interventions. Indeed, we believe this to be socially desirable at this time, given the general appeal among the citizens of Canada for increases in forested protected areas. Based on these notions, we hold that a comprehensive OGF conservation strategy ought to include a commitment to substantial OGF which would be reserved and thus off limits to silvicultural intervention. The dynamics of such OGF are thus clearly dominated by natural processes as well as human-mediated influences (e.g., invasive species, air pollution, climate change) from which we have no practical means to protect forests other than mitigation at source. Designation of reserved OGF would proceed at minimum under Company policy, and perhaps in a more formal way through legal means.

6.2 OGF Management Using Silvicultural Intervention

We take the view that OGF is not defined entirely by the absence of deliberate human influence in forest stands. We accept that some OGF should be defined as such, but that another significant category of OGF includes stands in which silvicultural intervention is acceptable, within bounds. Those bounds include: (a) stands where silvicultural intervention is taken primarily for timber production but is designed and implemented to conserve specific OGF characteristics; and (b) stands where silvicultural intervention is taken primarily to hasten the improvement of OGF traits, or to sustain OGF traits that might, with time under natural dynamics, wane.

6.2.1 Silvicultural Intervention Primarily for Commodity Production

- this section will speak mainly to partial harvests while maintaining some OGF traits; anticipated length is 200 words

6.2.2 Silvicultural Intervention Primarily for OGF Conservation

- this section will speak about accelerating the arrival of, and also sustaining, certain OGF traits (e.g., large trees; trees of appropriate species; creation of snags and DWD); anticipated length is 500 words

7. STRATEGY ASSESSMENTS

[Note: the following terms are used interchangeably in this report: (a) softwood = coniferous species = needleleaved species; and (b) hardwood = non-coniferous species = broadleaved species. This note will be moved to section 1 in due course.]

7.1 Strategic Options

To reach the project goal of developing a comprehensive, detailed, well-grounded, implementable OGF conservation strategy for Bowater Mersey, we needed to develop a number of forest-management scenarios based on alternative OGF strategies. Scenario-based work is most powerful when several alternatives are created and each provides significant contrast (Duinker and Greig 2007). It is also important that the scenarios be plausible and not impossible, especially from the forest management company's perspective (thus, for example, a scenario involving no timber harvesting over the entire area and time frame is just not plausible). We initially designed seven scenarios that implement different OGF strategies. After careful review and analysis of the seven, one scenario did not appear to be plausible so was removed from subsequent analysis.

7.2 Scenario Parameters

7.2.1 Data Sources and Software

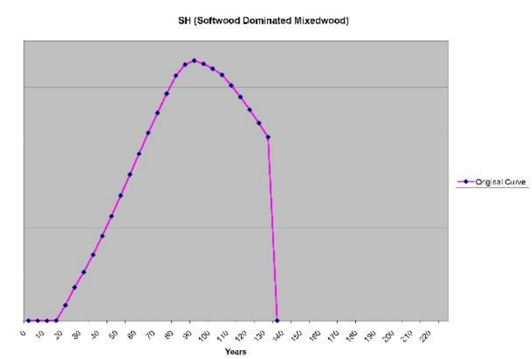
We used Remsoft's Woodstock forest modeling software. The software allowed us to create and modify the different scenarios, analyze the results in terms of multiple measures at various timeframes, and to export future spatial inventory (i.e. future forests) to ArcGIS software. Landscape biodiversity measures and habitat-supply values were quantified in ArcGIS.

The data source used for the scenario analysis was Bowater Mersey's 2007 planning inventory. The planning inventory is based of the company's forest resources inventory, which was created based on existing forest information and interpretation of air photos flown in the fall of 2006, and depletion records updated with satellite imagery in 2006. The planning inventory is a GIS-based polygon coverage with eight key attributes: area, age, cover-type, actions (harvesting or silviculture), site class, operation (buffer, operable, unique area), landscape management designation (aka TRIAD classes), and region (operations regions of Bowater Mersey, which are St. Margaret's Bay, Medway, and Rossignol). One key point about the existing inventory is that the age variable only delivers a maximum stand age of >120 yr.

We decided to simulate all scenarios for a 100-yr timeframe as compared to 80-yr timeframe conducted in previous forest management planning, as this gives a longer period to identify changes and may better reflect an actual rotation age of some forest types and practices. Scenario simulations for the entire Bowater Mersey forest lands were completed during 2007. No analysis was conducted on the surrounding lands outside of Bowater Mersey holdings.

7.2.2 Yield Curves

A yield curve is a projection of how a forest stand is expected to develop through its lifetime. It identifies the merchantable volume of a stand at any time during its development. Yield curves are critical in forest management planning because they identify how much wood is available. Bowater Mersey's original yield curves from the 2002 planning inventory were designed for the company's modeling parameters (80-yr timeframe and removed from harvest eligibility after 120 years of age). These needed to be adjusted to accommodate our longer modeling horizon and to allow some stands to be harvested beyond an age of 120 years. For most forests in Nova Scotia, stands start to lose volume (particularly sawlog volume) as they develop past a peak volume between ages 110 and 140 yr. However, the specific rate of decline for each cover type and site class has not been recorded for this region, and therefore volume curves beyond age 120 yr can not be modeled on real volume numbers. The original yield curves dropped to zero volume after their last recorded value (Figure xx). We elected to have a constant rate of decline following the latest record value for all sawlog volumes in the new yield curves. All yield curves were extended to age 225 yr.



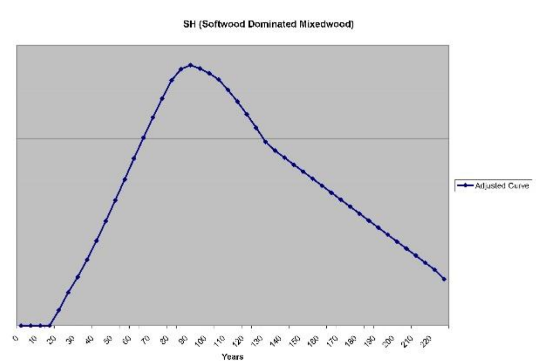


Figure xx. Example of an original yield curve (upper graph), as used in the company's timber-supply analysis, and an adjusted yield curve (lower graph), as used in this study.

7.2.3 Timber Harvest Options

The following harvesting types were used for modelling and planning: *Mosaic* - removal of standing trees with 3-5% left, *Pine Seed* – removal of all mechantable stems except 25-35 pine stems per ha, *Variable Retention* – removal of all but 10-70%, left in clumps or strips, *Shelterwood* – removal of 30-50% with an even dispersal of crop trees, *Selection* – removal of 40% every 20 years, *Commercial Thin* – removal of 30-50%.

7.2.4 Modelling Objectives and Constraints

All scenarios were set to run on the following objectives and constraints. All scenarios were set to maximize the harvest of the Spruce/Fir volume. All scenarios were run to have even flow of 'Spruce/fir' over the time of model. This presents fluctuations (spikes and troughs) in the volume of wood that the woodlands would supply to the company mill. All scenarios were also constrained by current silviculture levels (based on current costs per unit area). This constraint can limit the increased wood volume that could be gained from more-intensive forest-management scenarios. All scenarios exclude harvest from Bowater Mersey's designed Unique Areas and all buffers (30 m) around water bodies and wetlands. To keep a fairly stable forest composition over the 100-yr scenario timeframe, we set the maximum cover-type fluctuation at 20%. For example, this prevents excessive conversion of non-spruce/fir forest types to spruce/fir (at present the most desirable species for lumber and pulp/paper production). The final constraint requires that at least 30% of the area harvested be made according to modified-harvest techniques (Variable Retention, Shelterwood, Selection or Commercial Thin).

7.3 Assessment Indicators

All OGF scenarios were compared on four key elements: wood supply, OGF area, species-specific habitat supply, and landscape configuration. All key elements were measured for each scenario at 25-year time steps: 0 yr (i.e. 2006), 25 yr (i.e. 2031), 50 yr (i.e. 2056), 75 yr (i.e. 2081), and 100 yr (i.e. 2106).

7.3.1 Wood Supply

Wood-supply outcomes were compared in terms of average tonnes per year for *Total Harvest*, *Spruce-Fir Harvest*, *Other Softwood harvest*, and *Hardwood Harvest*. The forest age-class structure (total area in both 5-yr and 20-yr classes) was also examined.

7.3.2 OGF Area

To remove ambiguities about which kinds of OGF are being discussed below, we are using the following conventions. In all OGF classes below, stand age must equal or exceed 120 yr. Results are presented for the classes in bold.

OGF-Total is all forest meeting the age criterion.

OGF-Buffers is all OGF within riparian buffers.

OGF-WF (working forest) is OGF-Total minus OGF-Buffers. Also, OGF-WF is divided into **OGF-HSQ** (high quality, on site classes 1 and 2) and OGF-LSQ (low quality, on site classes 3 and 4).

OGF-HSQ is partitioned into OGF-HSQ(Cut) and **OGF-HSQ(Uncut)**. This is done because of the ecological importance and potential shortfall of high-quality uncut OGF in some scenarios.

7.3.3 Species-specific Habitat Supplies

In selecting species for habitat-supply analysis, it was understood that the species selected would be an imperfect representation of the large array of species that occur and utilize mature forest and OGFs. We considered this approach appropriate for purposes of assessing different OGF management policies based on the following premises:

- i) It is impossible to create a model for all species;
- ii) Coarse-filter approach can account for habitat requisites needed to maintain viable population sizes of most forest-dwelling species; and
- iii) Models created for a carefully selected list of species will adequately represent the habitat needs of many other species.

In the species-selection process, we first identified which vertebrate wildlife species use forest habitat in Nova Scotia and then rated each species on five criteria: degree of obligation to OGF, sensitivity to intensive forestry practices, species status (rare, vulnerable, threatened, or endangered), sensitivity to landscape configuration, and available information on habitat requirements. For manageability of the analysis, we determined prior to selection that we wanted no more than six species. Among them, we wanted at least one mammal species and one bird species, and at least one species that a preference for hardwood forest and one with a preference for softwood forest. With these provisos, one project-team member (Peter Bush) and one company representative (Jonathan Kierstead) conducted the species-selection process. The species selected were: American marten, pileated woodpecker, northern goshawk, barred owl, northern flying squirrel, golden-crowned kinglet.

The species-specific habitat supply models were all built with the same basic structure. Each consists of a matrix of habitats that were classified by stand-type and maturity class. Stand types used in the models were: hemlock, pine, spruce, softwood, softwood-dominated Mixedwood, Mixedwood, hardwood-dominated Mixedwood, and hardwood. Maturity classes represent five distinct age classes associated with identifiable differences in stand structure and composition. Maturity classes used in the model were regenerating, young, immature, mature, and overmature (see Appendix II for age limits on the maturity classes). The maturity classes were not part of the planning inventory so were created based on stand age and cover type (e.g. hemlock stands reach overmature class at a later age than mixedwoods). The suitability of the various habitats was evaluated based on empirical studies, literature review, and expert opinion. Suitability of individual development stages and habitat units were rated the following four-class rating system:

0 = unsuitable – species rarely occupy these habitats
1 = marginal – species occasionally occurs in these habitats but density is low, survival is low, or productivity is low relative to other habitats
2 = moderate – species commonly use these habitats but density is moderate, survival is moderate, or productivity is moderate relative to other habitats
3 = preferred – species commonly use these habitats and generally density is high, survival is high, and productivity is high relative to other habitats

Species models also incorporated recent timber-harvest information to adjust the suitability ranking (some species are less sensitive to selection harvest or shelterwood harvest than are other species). For example, an overmature pine stand that was recently subjected to shelterwood harvest would be adjusted from a 3 suitability score for a goshawk to a 2 suitability score, while the original marten suitability of 3 would be adjusted to a 1 (see Appendix II for all habitat-supply models).

7.3.4 Landscape Configuration

Landscape analysis evolved from the field of landscape ecology. Landscape ecology examines the spatial distribution of interacting ecosystems on a broad scale (Turner 1989). A landscape is defined as a heterogeneous land area composed of an interacting mosaic of patches (McGarigal and Marks 1994). Patches are unique to the investigation or phenomenon under study and can occur at multiple scales (McGarigal and Marks 1994). Since landscape analysis focuses on the study of patches, it is important to have a sound basis for the classification of patches (Turner et al. 2001). For this study, our patches were defined as patches of OGF, with the simplest definition of 'any stand greater than 120 yr). We examined four key measures of landscape configuration (i.e. landscape metrics) across all scenarios: *mean patch size, total edge length, mean-nearest neighbour,* and *core area*.

7.4. The Scenarios

After careful review and design, the project team presented seven scenarios to a stakeholders workshop in June 2007. Following the workshop, it was determined that 'Scenario 7 – High (60%) Modified Harvest' was not an operationally plausible scenario. Therefore, we present results here for the remaining six scenarios.

7.4.1 Scenario 1 - No OGF Strategy

Scenario 1 examined the situation if there was no particular strategy for OGF and just the other existing management strategies in place (e.g. unique areas protection, no cutting in buffers, protection from cover-type conversion, etc.). This scenario had no maximum age restriction on harvesting and no new spatial restrictions on the harvest-type location (see Table 7-4).

7.4.2 Scenario 2 - Retain All OGF

Scenario 2 examined the situation where all OGF was reserved from harvesting. This scenario applied the maximum age restriction on harvesting at 120 yr and had no new spatial restrictions on the harvest-type location.

7.4.3 Scenario 3 - Double OGF-HSQ

Scenario 3 examined the situation where at least double the amount of OGF-HSQ would be reserved from timber harvesting. To achieve the doubling at the end of the 100 yr timeframe, the model was set up to increase the are reserved by at least 25% of the starting area each 25-yr period. This scenario had no maximum age restriction on harvesting and no new spatial restrictions on the harvest-type location.

7.4.4 Scenario 4 - Spatial Reserves – High Connectivity

Scenario 4 examined the situation where the Landscape Ecological Management Zoning (LEMZ) approach was applied with high connectivity between reserved stands. The LEMZ approach includes zones of four different management intensities: old-growth-values zone (OGVZ), low-impact-management zone (LIMZ), regular-stand-prescription zone (RSPZ), and intensive-management zone (IMZ) (a full description of LEMZ is located in Appendix III). The assignment of stands to zones was originally conducted by Allan Smith. His design focused on a series of OGVZ reserves (5,259 ha) connected by a large network of LIMZ (24,750 ha). This scenario had no maximum age restriction on harvesting. The LEMZ zones set a spatial restriction as to where certain types of harvesting could occur.

7.4.5 Scenario 5 - Spatial Reserves – Large Amount

Scenario 5 examined the strategy of having a large amount of spatially assigned OGF reserves. The LEMZ approach was also applied in this scenario, but the amounts and locations of OGVZ and LIMZ were adjusted from scenario 4. We created nine reserves of approximately 1,000 ha (three in each region), with another 1,000 ha scattered through the area, for a total of 10,000 ha of OGVZ. The clusters of OGVZ reserves were selected by eye using spatial anchors of existing Unique Areas and larger polygons of OGF forest (> 15 ha). Clusters were designed to be a relative contiguous area and therefore included some forest that was not of OGF age and structure. However, if kept in these reserves, these areas will eventually grow into large contiguous clusters of OGF. We also designed the clusters to have significant surrounding buffers of LIMZ (10,000 ha) (i.e. all LIMZ stands were located in close spatial approximation of OGVZ stands). This scenario had no maximum age restriction on harvesting. The LEMZ zones set a spatial restriction as to where certain types of harvesting could occur.

7.4.6 Scenario 6 Spatial Reserves – Moderate Amount

Scenario 6 examined the strategy of having a moderate amount of spatially assigned OGF reserves. The LEMZ approach was also applied in this scenario, but the amounts and locations of OGVZ and LIMZ were adjusted from scenario 4 and 5. We created nine reserves of approximately 600 ha (three in each region), with another 1000 ha scattered through the area, for a total of 6,375 ha of OGVZ. The clusters of OGVZ reserves in Scenario 6 were in the same general locations as in Scenario 5. We also reduced the LIMZ to 6,375 ha in this scenario. This scenario had no maximum age restriction on harvesting. The LEMZ zones set a spatial restriction as to where certain types of harvesting could occur.

Table 7.4 Summary specifications for the six OGF scenario strategies.

Scenario Number	***Scenario Name***	***Harvest - Age***	***Harvest - Space***	***Other Constraints****
Scenario 1	No OGS	No upper age limit	No restriction	
Scenario 2	Retain All OGF	Upper age limit 120 yr (i.e. no harvest >= 121 yr)	No restriction	No harvest of stands great than 120 yr
Scenario 3	Double Quality OGF	No upper age limit	No restriction	Must be an increase of 25% of OGF in quality (sites 1 and 2) each 25 yr timeframe (i.e.100% increase at 100 yr)
Scenario 4	Spatial Reserves – High Connectivity	No upper age limit	Reserves of OGF and Light-touch	Only modified harvest in light–touch reserves (Light = 24,750 ha) No harvest in OGF reserves (OGF = 5,259 ha)
Scenario 5	Spatial Reserves – Large	No upper age limit	Reserves of OGF and Light-touch	Only modified harvest in light–touch reserves (Light = 10,000 ha) No harvest in OGF reserves (OGF = 10,000 ha)
Scenario 6	Spatial Reserves – Small	No upper age limit	Reserves of OGF and Light-touch (6375 ha)	Only modified harvest in light–touch reserves (Light = 6375 ha) No harvest in OGF reserves (OGF = 6375 ha)

* All scenarios had a cover-type conversion constraint. This ensured that the forest did not vary more than 20% based on the broad cover composition of softwood, mixedwood, and hardwood.

Note – **All scenarios try to maximize and even out the flow of spruce/fir harvest.**

7.5 Assessment of the Scenario Outcomes

7.5.1 Wood Supply

Total

When we compared the six scenarios, there were was some important differences in the *Total projected harvest.* Scenario 1, with the least restrictions, had the highest projected harvest at 500,792 tonnes/yr. Scenario 5 had the lowest harvest at 464,431 tonnes/yr. Scenario 5 reduced the amount of *Total projected harvest* by about 36,360 tonnes/yr, or a 7.3%, compared to the maximum harvest situation in Scenario 1. The total harvest in Scenario 5 was only 12,710 tonnes/yr (or 2.7%) lower than that of Scenario 2 (the interim strategy for the 2002 FMP). Also of importance to note is that Scenario 2 and Scenario 6 has almost identical total projected harvest (Figure 7.5.1).

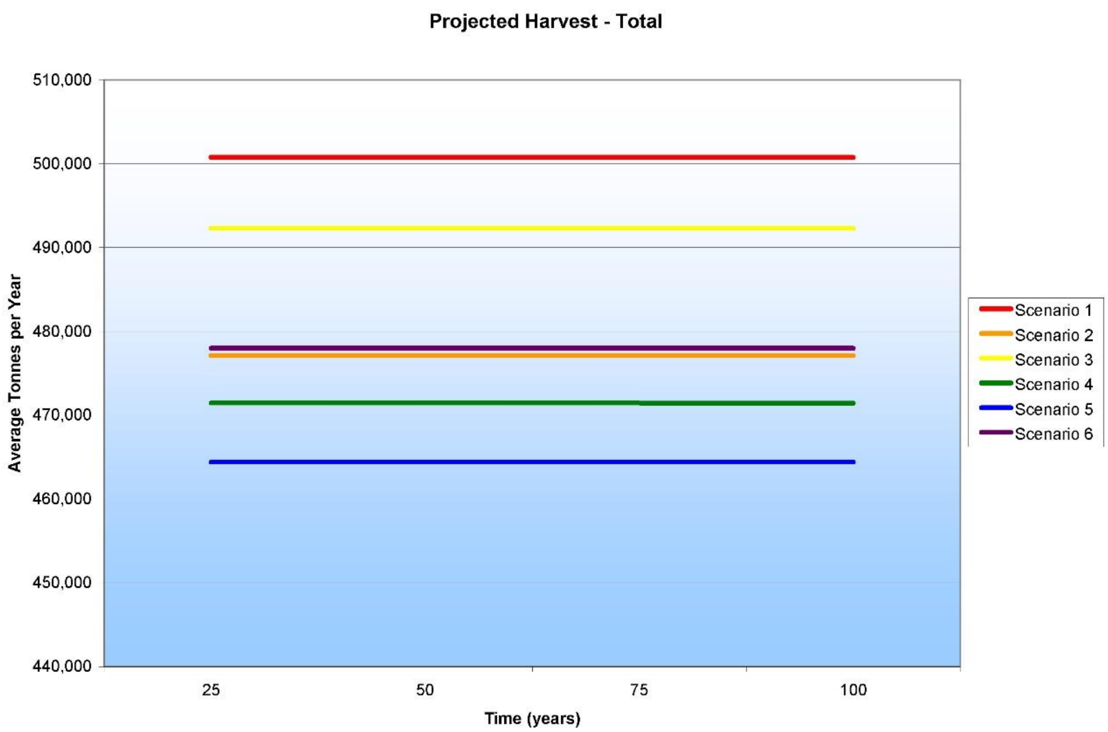
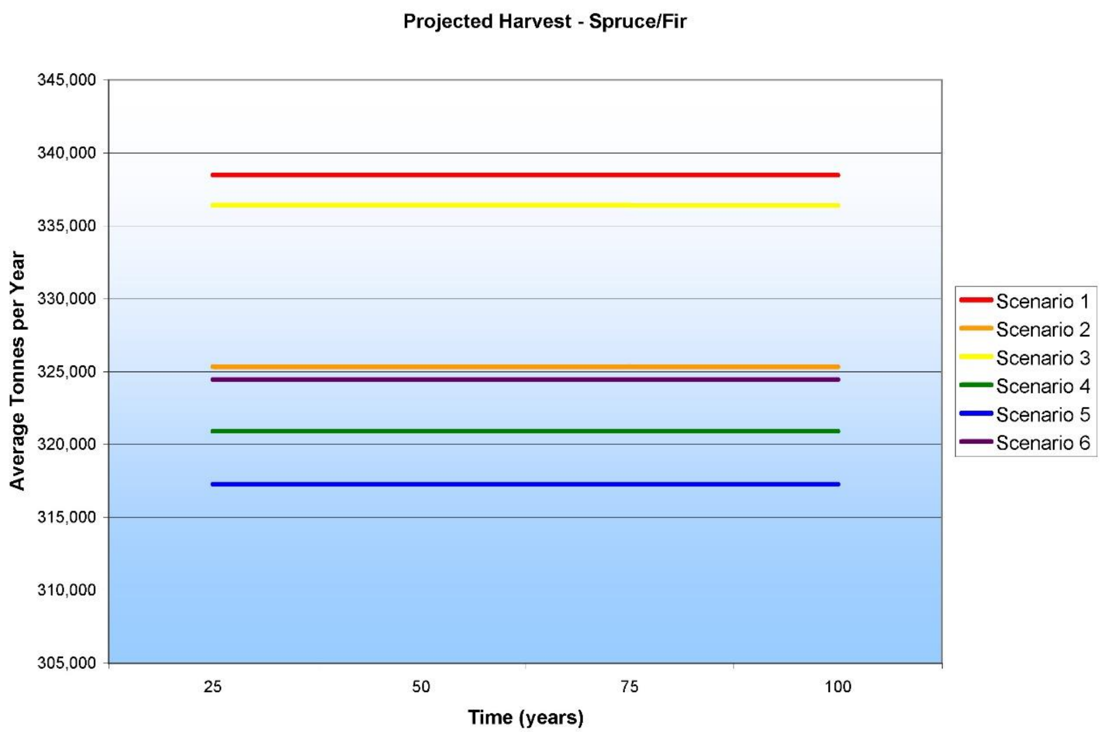


Figure 7.5.1 Total Projected Harvest

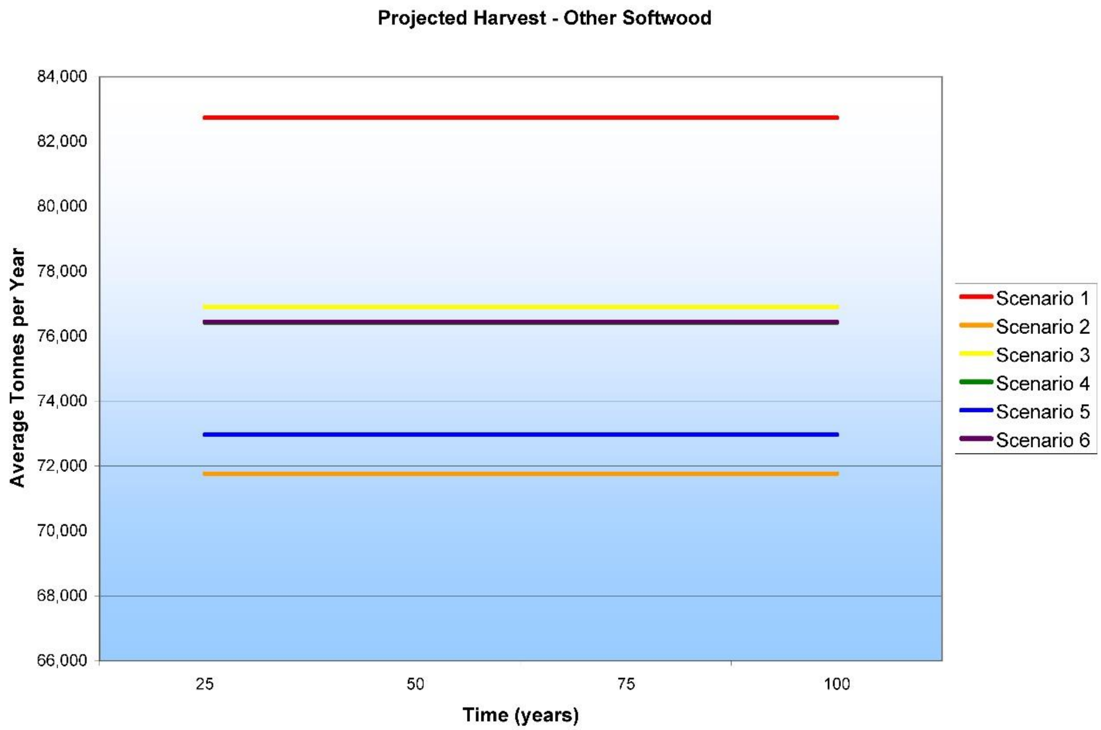
Spruce/Fir

The *Spruce/fir projected harvest* has a similar pattern across the six scenarios as the *Total projected harvest*. Again Scenario 1 has the highest projected harvest at 338,492 tonnes/yr, and Scenario 5 has the lowest *Spruce/fir projected harvest* at 317,291 tonnes/yr. Scenario 3 provides an interesting response in wood supply where, despite a strategy to double OGF-HSQ, there is only a small (2086 tonnes/yr or 0.6%) reduction in spruce/fir harvest compared to the highest Scenario 1 (no OGF conservation policy). Scenario 5 reduced the amount of *Spruce/fir projected harvest* by about 21,201 tonnes/yr, or a 6.3% reduction, compared to the maximum harvest situation in Scenario 1, and 8,049 tonnes/yr (or 2.5%) compared to Scenario 2.



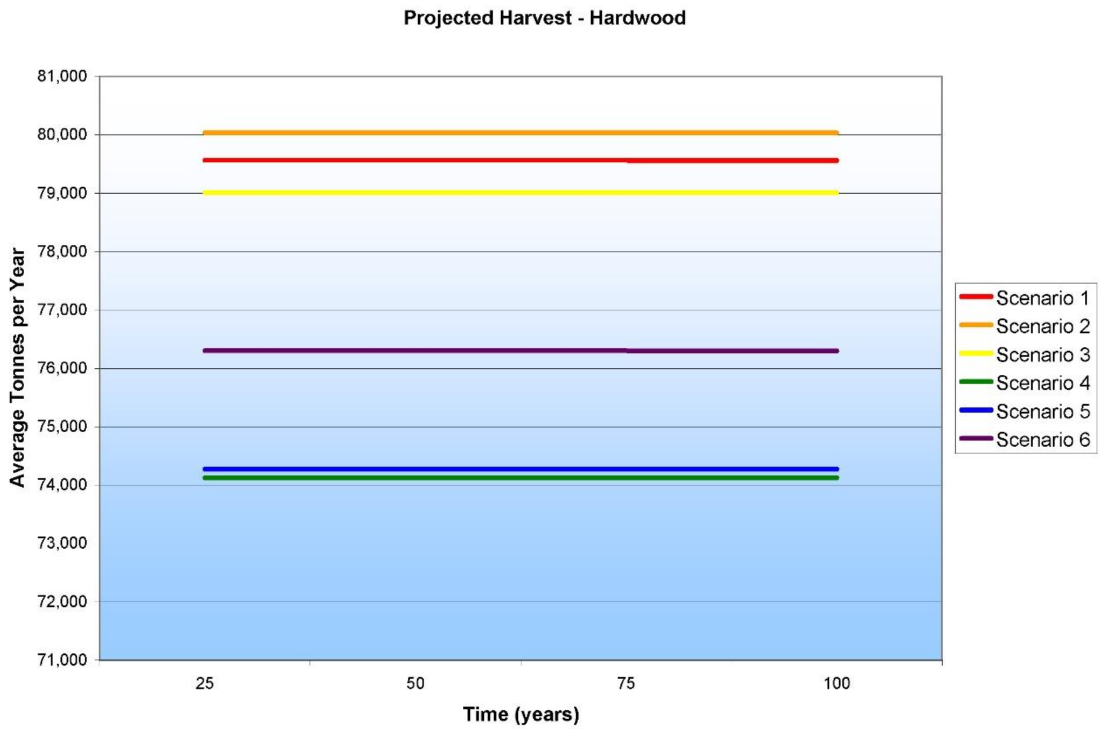
Other Softwood

Other softwood in this case refers mostly to white pine and hemlock. The *Other softwood projected harvest* is generally less significant than the Spruce/Fir harvest and accounts for ca. 16-17% of the total harvest. Scenario 2 has the lowest *Other softwood projected harvest* of 71,764 tonnes/yr. Mature pine and hemlock stands are being lost from the eligible list as they age and the model prioritizes the Spruce/fir stands for harvest.



Hardwood Harvest

The *Hardwood projected harvest* is generally less significant than Spruce/Fir harvest and account for approximately 15-17% of the total harvest. Scenario 2 has the highest *Hardwood projected harvest* of 80,037 tonnes/yr. Because of the loss of mature pine and hemlock stands from the eligible list, the model in this scenario is making up the harvest in hardwood stands.



7.5.2 Age Classes

An age class is a grouping of stands that have ages falling into a specified range. Age classes are used to enhance one's ability to comprehend the age structure of a forest. We examined the entire forests's age-class structure in terms of both 5-yr and 20-yr age classes. In the body of this report, we portray the age-class structure in terms of a series of stacked histograms, one for each 25-yr interval of the simulation period, portraying proportion of the entire forest in each 20-yr age class. An important thing to note is the relative change of area in mature classes (81-100 yr and 101-120 yr). Note the virtual disappearance of the 101-120-yr class in Scenarios 1, 2 and 3 by the end of the simulation period (100 yr). There appears to be good recruitment in the younger age classes for all scenarios. We have also included the 5-yr age-class structure in Appendix IV. Again one observes the virtual disappearance of the 101-120-yr class in Scenarios 1, 2 and 3 by the end of the simulation period.

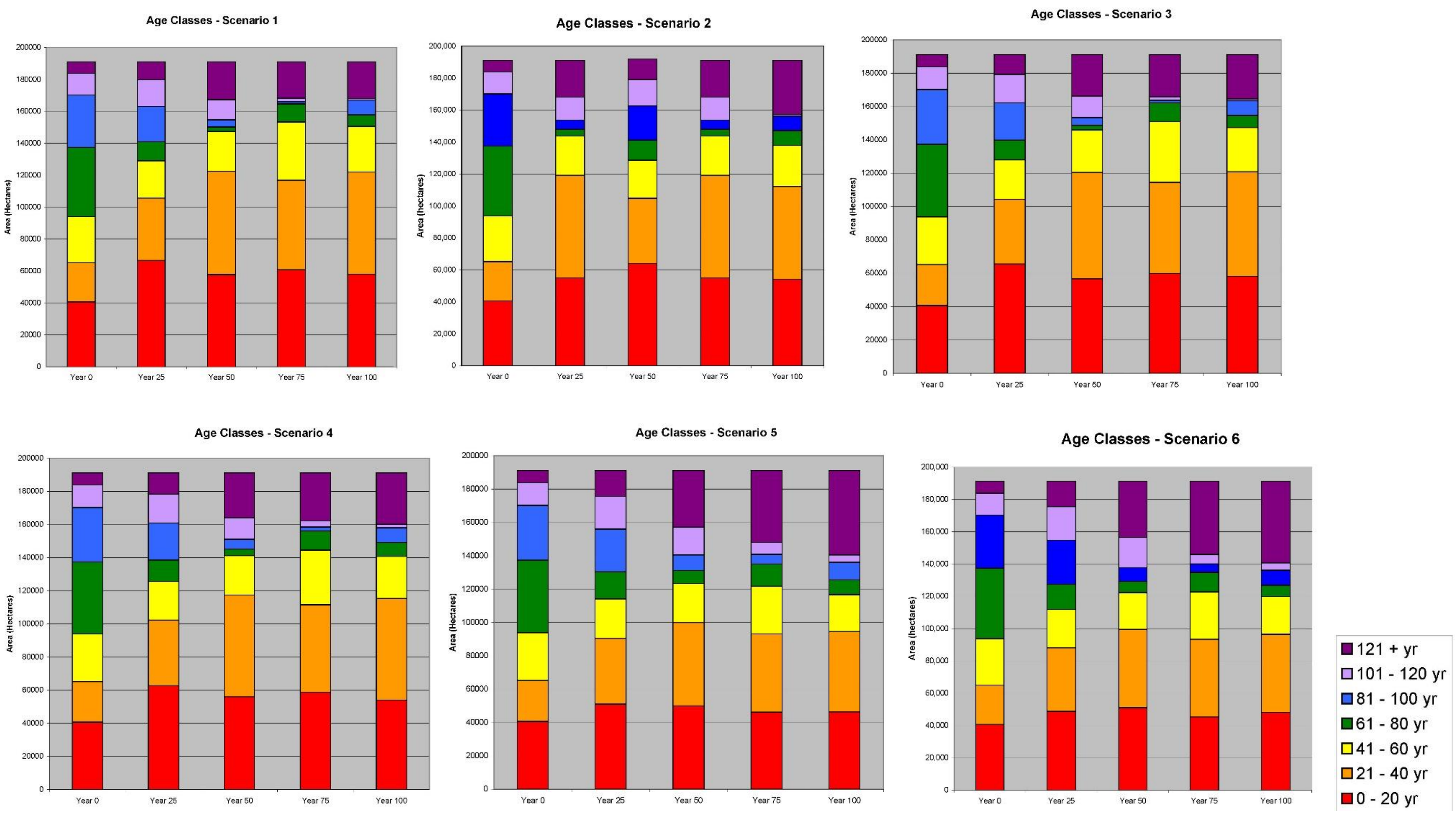
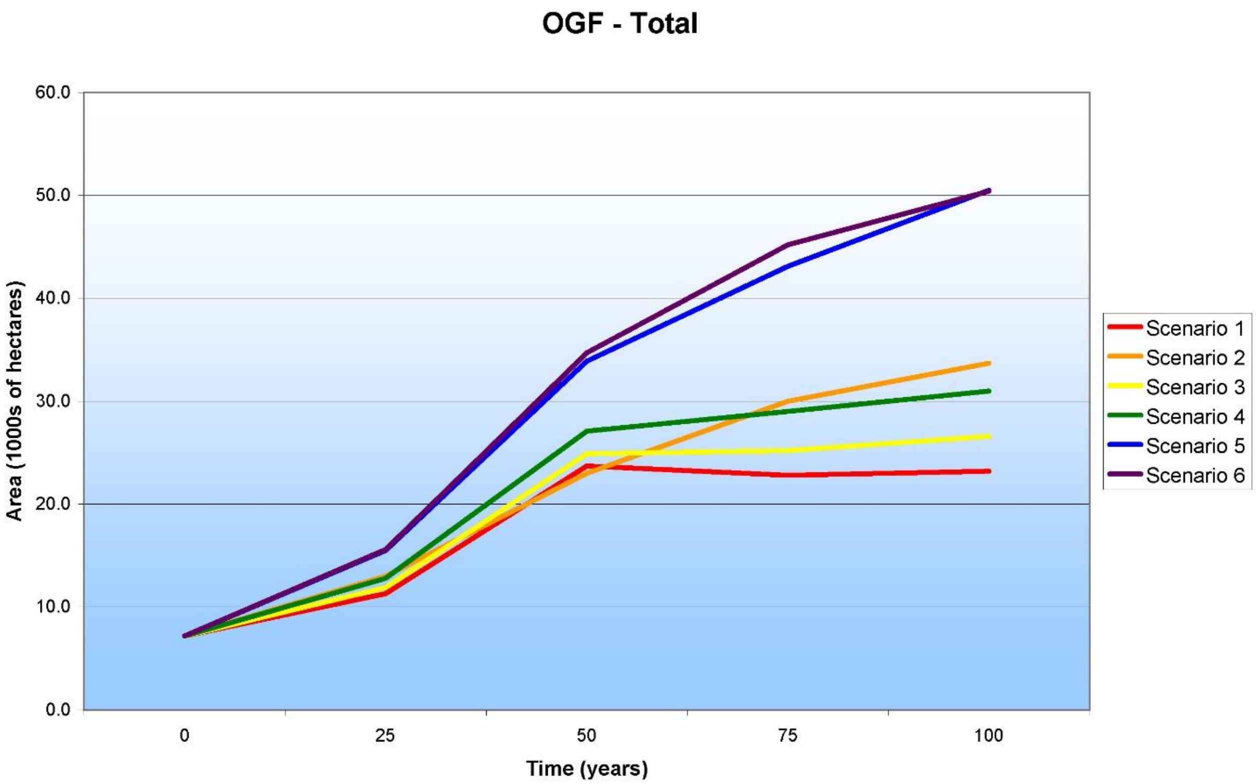


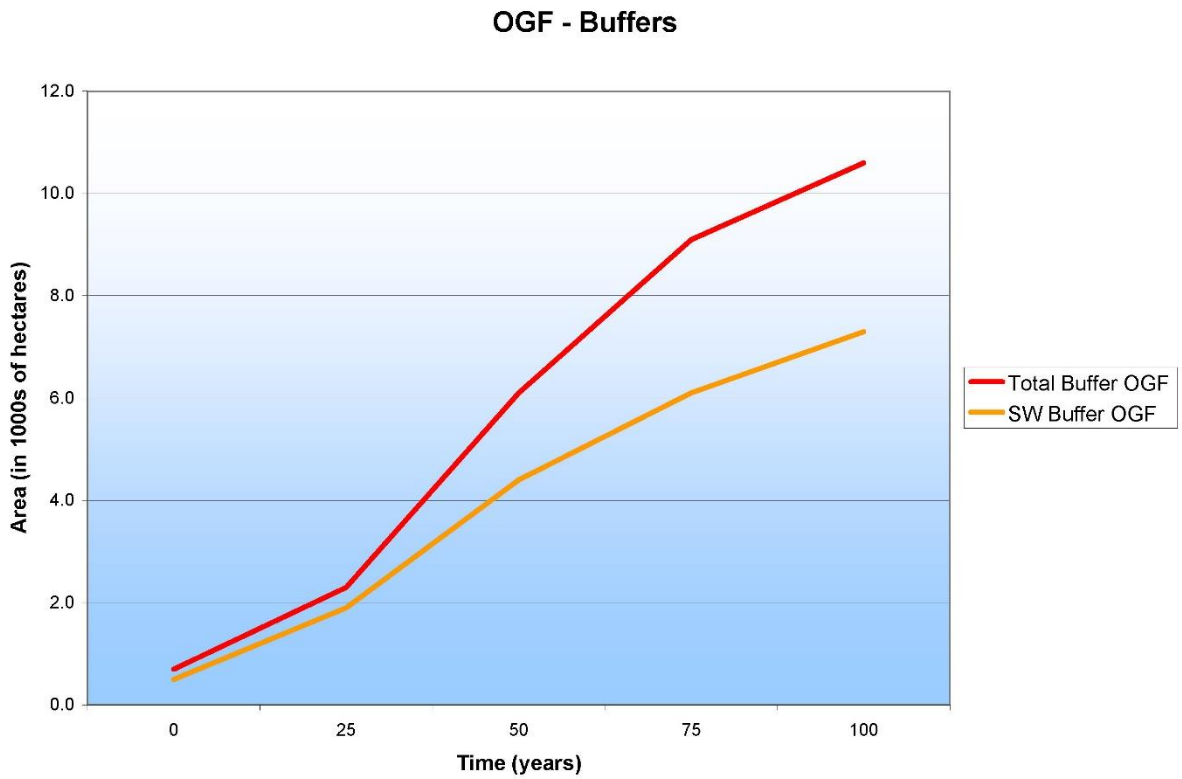
Figure 15: Age Class Structures by 20 yr periods

7.6 Old-Growth Forest

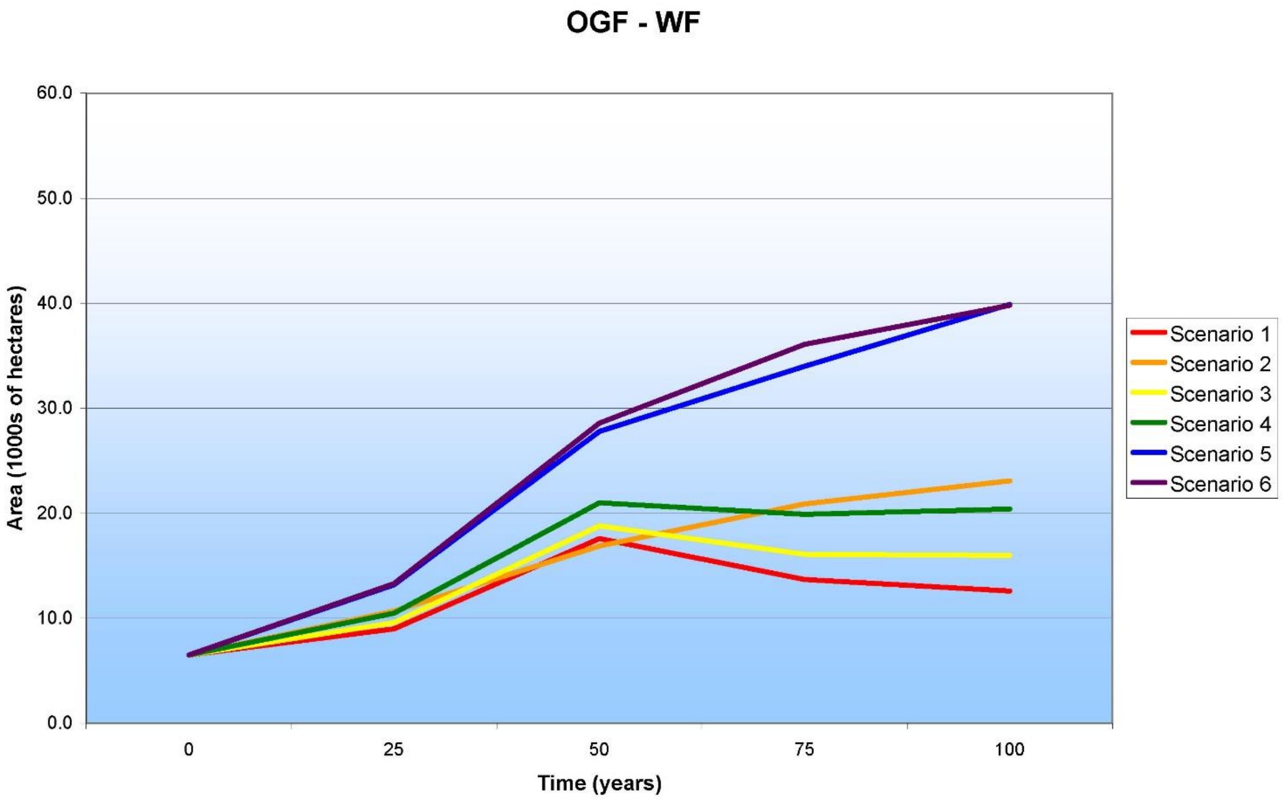
All scenarios show increases in OGF-Total over time. From a current amount of approximately 7,200 ha, some scenarios (5 and 6) show a possibility to have more than 50,00 ha of OGF-Total. Even Scenario 1 shows a projected increase in OGF-Total to 23,200 ha.



The riparian buffer strips provide an important consideration. Feedback from the stakeholder workshop suggested more detail and better understanding of what was happening to OGF-Buffers. Although the initial amount of OGF-Buffers starts out as relatively insignificant (700 ha), it increases dramatically to 10,600 ha (of which 7,300 ha are softwood OGF). This amount of OGF-Buffers is the same for all scenarios because we elected for all scenarios to prohibit harvesting in buffers.



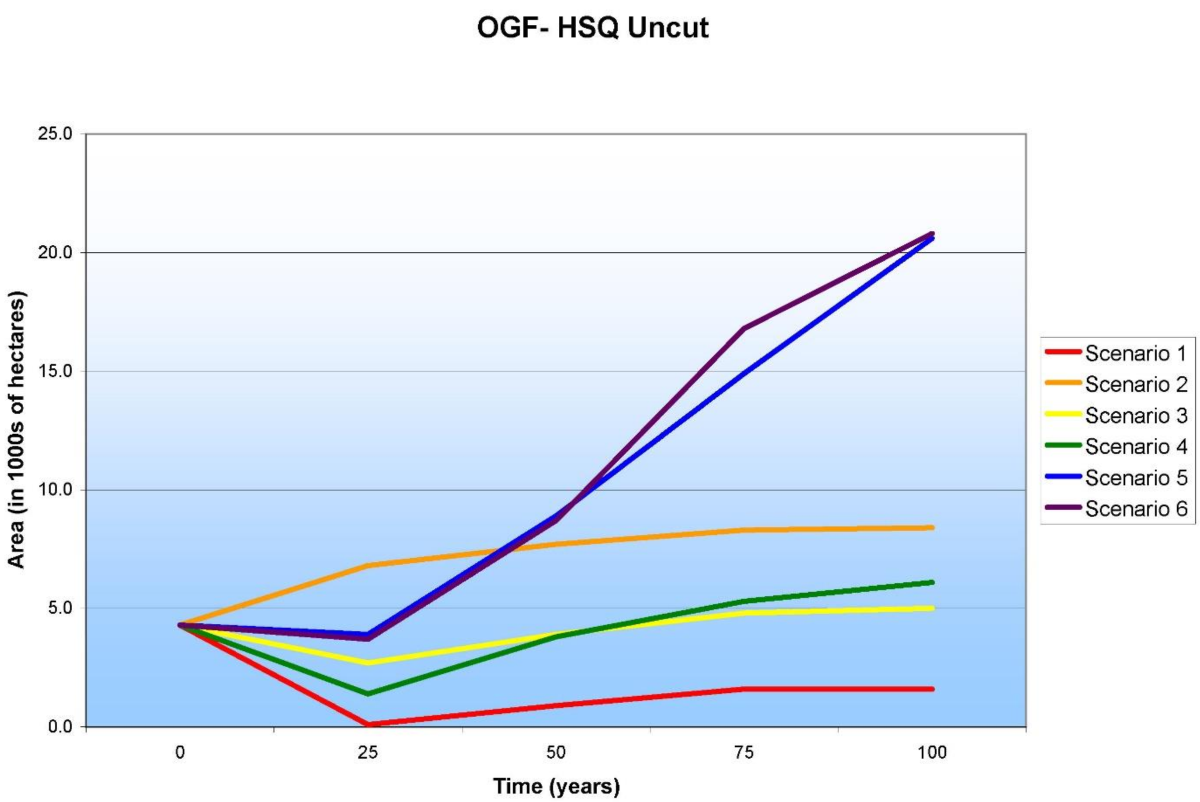
When one removes the influence of OGF-Buffers from OGF-Total, one sees a moderated increase in OGF in terms of OGF-WF. Scenarios 5 and 6 have the highest amount of OGF-WF with 39,900 ha, and Scenario 1 had the smallest increase from 6,500 ha to 12,600 ha.



However, not all of the OGF-WF is on high-quality sites. The modelling in each scenario automatically tried to harvest the most-productive stands (i.e. site class 1 and 2) first, and in some cases did not even consider site-class-4 lands if the projected wood volumes from them are too low. Overall, one wants to be careful that all of the OGF-WF is not just on low-quality sites (OGF-LSQ). When we examine just OGF-HSQ, Scenario 1 actually has a reduction of OGF-HSQ from 4,300 ha to 2,900 ha. All other scenarios have an increase over the 100-yr simulation period. Both Scenarios 5 and 6 are projected to have 22,800 ha of OGF-HSQ in yr 100 of the simulation. Note that, as expected, Scenario 3 (which was designed to double OGF-HSQ in a century) has just about exactly double the amount (4,300 to 8,700 ha).

OGF can also be partitioned further by considering previous timber harvests. Although it likely fair to say that all or most of this forest region has been harvested commercially at least once or twice (maybe even three times) in history, this past harvest history is not captured in the planning inventory. However, Bowater Mersey made efforts to include some recent harvesting (last 5-10 yr) in the inventory. The model will also keep a record of any stand harvests in the projections. This is generally not an issue when it comes to mosaic harvest as the age and cover-type are reset after harvest. This is more of an issue when partial timber harvest is considered. The age and cover-type are not reset until the second timber removal. Forest stands that have had a commercial thin, or selection or shelterwood cut, have a much different forest structure than a stand that has had no interventions.

If we examine only OGF-HSQ(Uncut), this likely gives us the best quality of OGF that we can protray given the nature of the planning inventory. We see that the scenarios really start to separate out considering OGF-HSQ(Uncut). Scenario 1 projects a significant reduction in OGF-HSQ(Uncut) from 4,300 ha to 1,600. It also projects an almost complete loss of this type of OGF (only 100 ha) at year 25. Scenarios 2, 3, and 4, project a modest increase in OGF-HSQ(Uncut). Scenarios 5 and 6 show the largest projected increase in OGF-HSQ(Uncut), from 4,300 ha to 20,600 ha (or a 480% increase).



In conclusion, in examining the amount of OGF area, it is important to consider what type of

OGF one is reporting. Scenarios 5 and 6 are projected to provided a significant increase in the total amount of OGF (OGF-Total) as well as more OGF-HSQ(Uncut). Over the planning period (100 yr), the forest buffers will also significantly contribute to the total amount of OGF across the landscape (OGF-Buffers). These narrow, linear strips around water bodies and wetlands may not have enough core habitat area for some species (e.g. northern goshawk or American marten). However, they can be of high value (a) for species of small-body vertebrates like the golden-crowned kinglet, (b) as reservoirs of lichen species, and (c) as foraging areas for species like the pileated woodpecker.

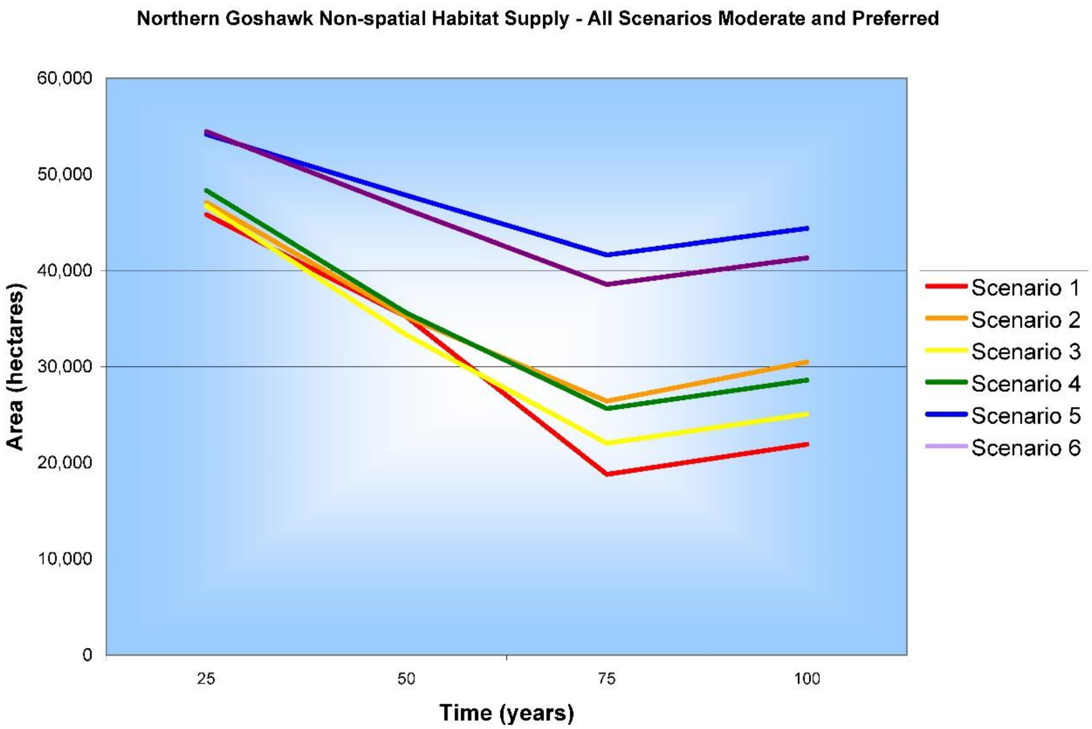
7.7 Species-specific Habitat Supply Analysis

In reviewing the species-specific habitat supply models, we decided to focus on the amount of moderate and preferred habitat.

7.7.1 The Northern Goshawk

The northern goshawk is a large forest-dwelling raptor that nests in mature and older forest. Northern goshawk habitat in all scenarios is projected to decline over the next 100 years. This may seem at odds with the OGF projections. However, this reflexes the northern goshawks preference for OGF (loosely overmature) as well as mature forest (for pine 85-130 yr, hardwood 70-100, see appendix V for other development stages). It is also reflective of the changes occurring in the preferred cover-type, with hemlock and Spruce being only marginal habitat (suitability = 1), where all others being either moderate or preferred in the mature and overmature stage. The loss of mature forest class age forest was identified in the projected ageclass structures.

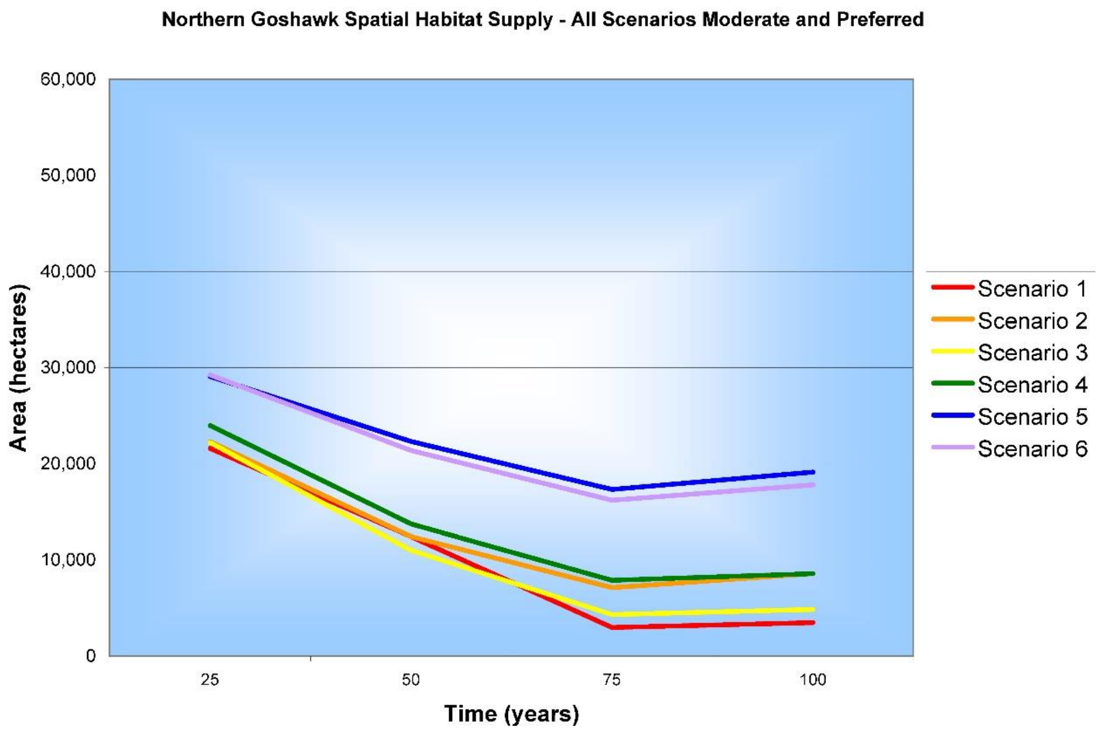
The spatial northern goshawk habitat supply analysis was added as a result of the stakeholder workshop. The spatial analysis identify there is overall less spatial suitable habitat for the northern goshawk and that Scenarios 5 and 6 (with their spatial clusters) are suffer a lower rate loss of habitat than the other scenarios.



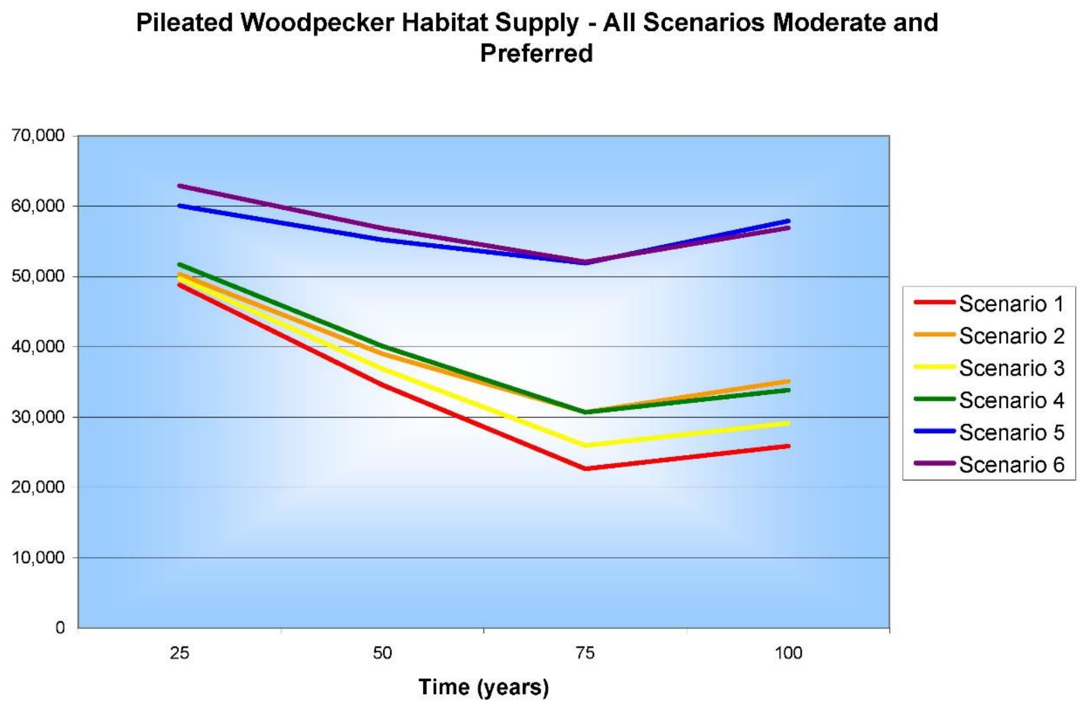
Spatial NOGO model
Generate a grid (1-ha cells) of NGhsi1
Convert reclassified grid to a shapefile (NGpatch1.shp).
Add field NGhsi2
For polygons with gridcode = 1 that are >= 24 ha set NGhsi2 = 1
Otherwise set NGhsi2 = 0
Create grid (1-ha cells) NGhsi2.

Rate suitability based on distance to roads, create a shapefile showing permanent all-weather roads (highways, primary roads, secondary roads). Conduct a distance analysis (distrds).
Reclassify distrds as follows:
If distrds >= 150 m then NGhsi3= 1
Otherwise NGhsi3 = 0

Calculate overall habitat suitability.
NGhsi4 = NGhsi1*NGhsi2*NGhsi3

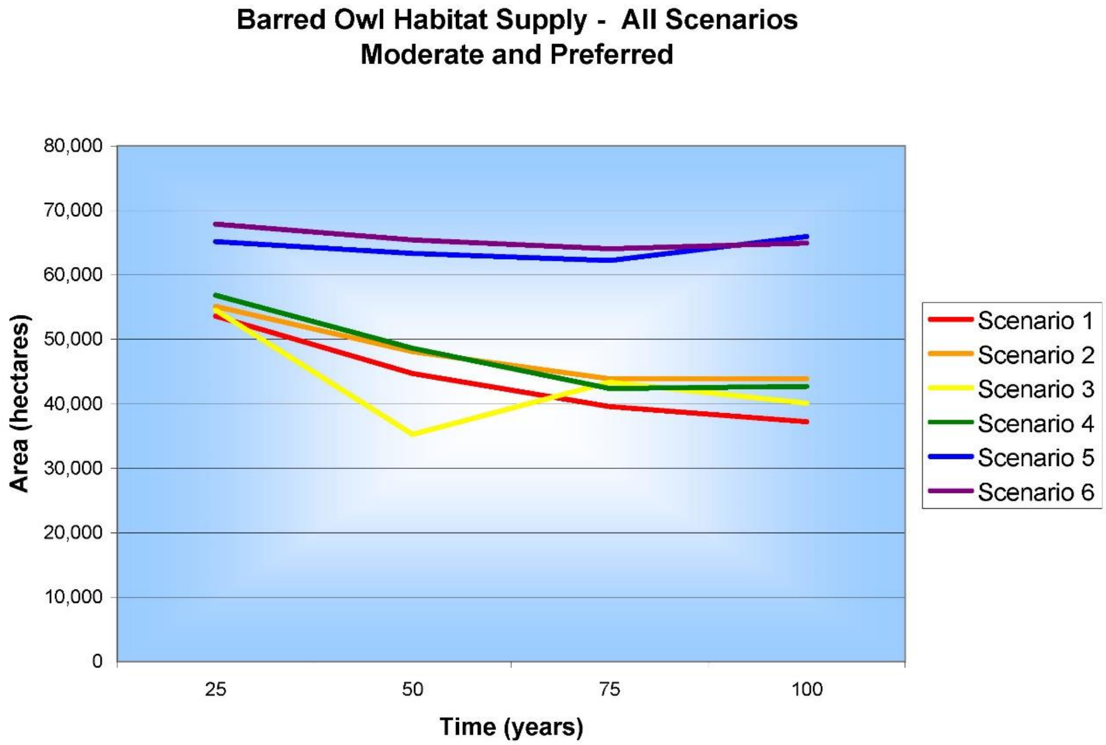


7.7.2 The Pileated Woodpecker


Pileated Woodpecker Habitat Supply - All Scenarios Moderate and Preferred
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
25
50
75
100
Time (years)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6

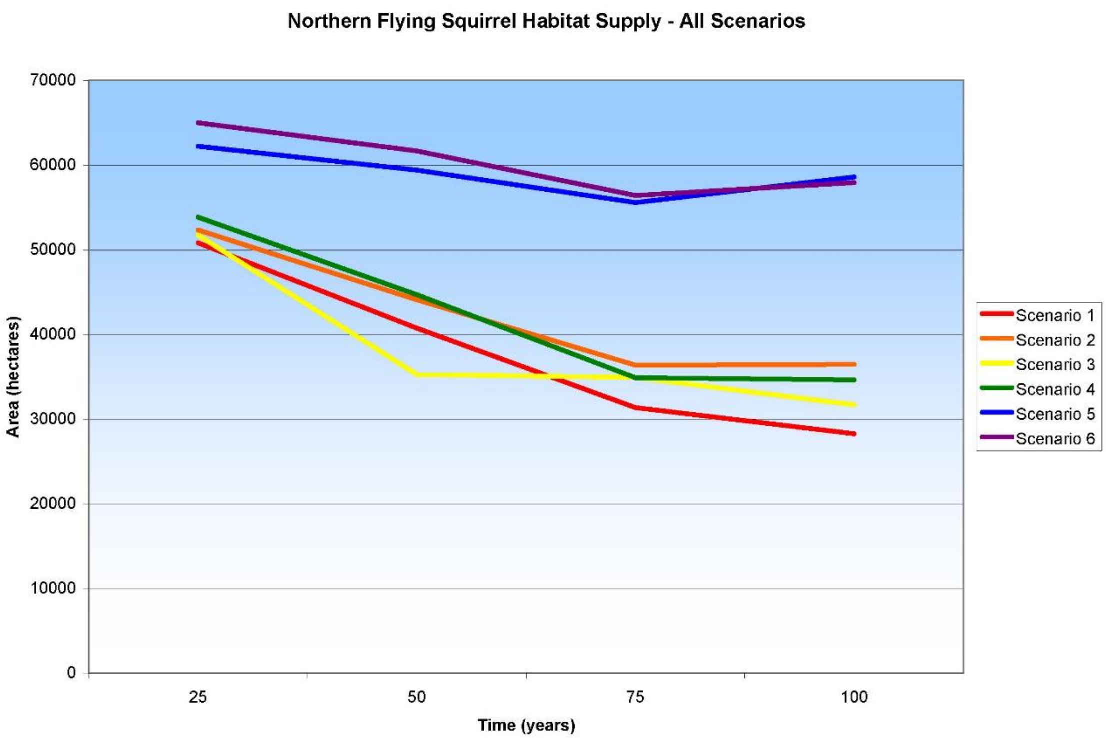
7.7.3 The Barred Owl

Nesting habitat preferences range from immature HW, HS, and SH to mature and overmature Spruce and all other Softwoods. Barred Owl is one of the more sensitive species to timber harvesting (the model reduces all habitats to a marginal rating with any harvesting).



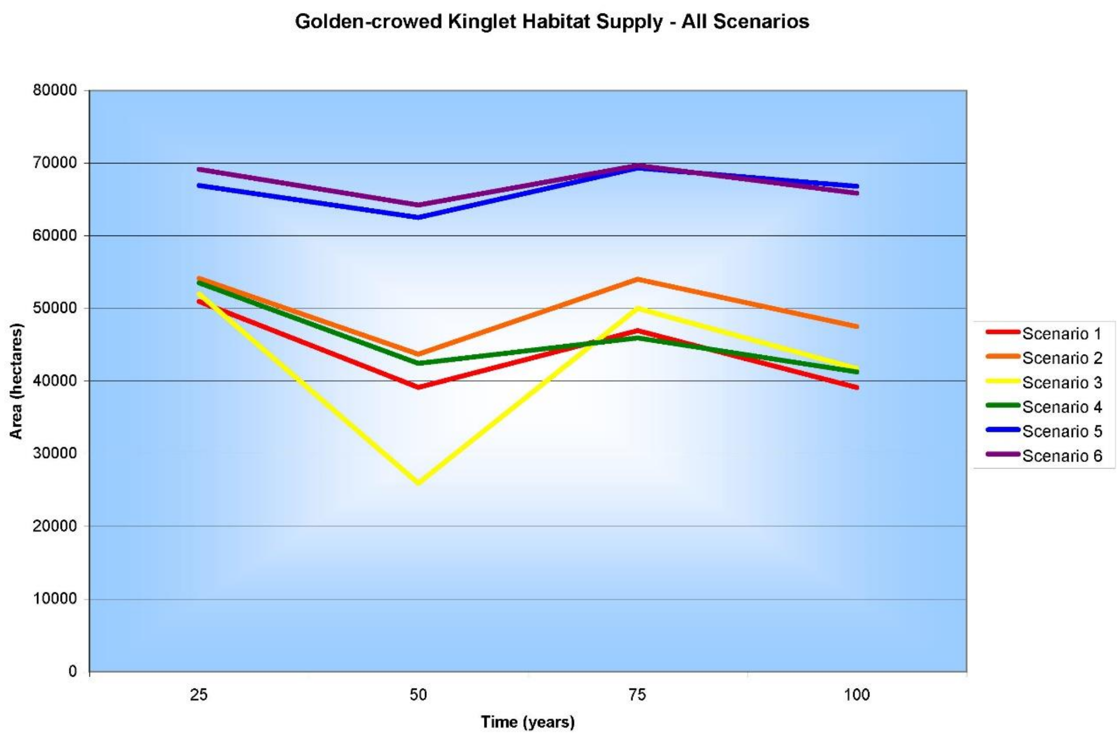
7.7.4 The Northern Flying Squirrel

The northern flying squirrel has a moderate and preferred rating for all mature and overmature habitats with the exception of LS. Additionally, immature SH and MW habitats rated as moderate. The northern flying squirrel was also a very sensitive species to timber harvesting (the model reduces all habitats to a marginal rating with any harvesting).



The Golden-crowned Kinglet

The Golden-crowned Kinglet generally prefers conifer habitats (immature to overmature) and is sensitive to harvesting other than selection harvest.



8. An OGF Conservation Strategy

8.1 Scope and Basis

The Old-Growth-Forest (OGF) Conservation Strategy of Bowater Mersey Paper Company (BMPC) is meant to apply to OGF, as defined below, within the company's freehold timber lands in southwest NS. The strategy is meant to be a key guiding document for BMPC's forest-management planning process. Actions to implement the strategy would be prescribed in the forest-management plan and other Company documents. At this time, the strategy proposals herein apply only to coniferous species. In the texts that follow, we have italicized the statements that we strongly encourage BMPC to adopt as integral parts of its overall conservation strategy for OGF.

A note is in order about the sources of and justifications for the positions we hold about OGF conservation, as summarized below. Our interest in OGF, particularly in connection with BMPC, began almost a decade ago. That means that we have been discussing OGF, visiting it, contemplating it, and researching it for many years. Consistent with the experiences of most policy- and strategy-development exercises for natural resources and the environment, one can not derive insight for promising management directions solely and directly from field investigations. The recommendations we make to the Company, as documented below, have their basis in a largely unknown combination of the following influences:

(a) discussions with a wide range of forest-sector people, including researchers, forest managers, professional foresters, forest advocates, forest recreationists and other lay people (and surely others), both in connection with BMPC forests and forests across Canada and Europe;

(b) field research conducted specifically as part of this project;

(c) a thorough canvassing of knowledge, ideas and propositions in the literature, including a wide range of OGF policy documents from a variety of jurisdictions;

(d) our simulation results, as reported in Chapter 8 of this report; and

(e) our extensive participation in numerous forest-policy developments for companies and governments in Canada and elsewhere.

Empirical ecological knowledge, as generated from field research, pertains to past and current ecological realities, and is necessary but insufficient to determine the future needs in forest management, as laid out below. Our recommendations pertain to what ought to be, and are informed by our aggregate and collective sense of promising and sensible directions for the pursuit of OGF sustainability.

8.2 Corporate Policy and Commitments

We recommend that BMPC adopt the following policy commitments as key leading elements of the strategy.

(a) OGF is a natural forest condition/state in the Acadian forests of Nova Scotia. Conservation of OGF is therefore an important objective in the sustainable management of the Company's freehold lands.

(b) People associate a wide range of values with Acadian OGF. The values span the gamut of economic, ecological and socio-cultural themes. Within the context of serving Company shareholder interests with profitable manufacturing of wood-based products, the Company is committed to satisfying as wide a range of OGF values as possible on Company-owned forest lands.

(c) OGF satisfies some forest values better than do other forest conditions/states (e.g., regeneration, immature, mature), sometimes much better. Thus, the Company considers it important to manage Company forests to conserve OGF in sufficient quantities and qualities to meet a wide range of OGF-related values.

(NOTE: our recommendations on what are, in aggregate terms, sufficient quantities and qualities of OGF on company lands are made below)

(d) Management of OGF on Company lands is guided by insights gained from ecological and social research, forest and wood-supply simulation, and public views on Acadian OGF. Of critical importance to the Company in relation to OGF management are: (a) quality, quantity and costs of timber; (b) conservation of biodiversity; and (c) public preferences.

(NOTE: our research project has provided some of those insights from its component studies on OGF ecological characterization and values elicitation, and from its simulation studies as reported in Chapter 8. We believe that the research reported herein provides sufficient basis for proceeding with an OGF conservation strategy.)

(e) OGF can develop entirely naturally (without human intervention or assistance), but certain OGF conditions can be accelerated, assisted or perpetuated using specific silvicultural treatments. Given that Company lands are held by the Company primarily for commercial timber production, this strategy will encompass both fully natural OGF as well as OGF subject to silvicultural treatment.

(f) The Company is firmly committed to implementing sustainable forest management in

accordance with the approach known as adaptive management. Therefore, the next forest-management plan will contain explicit provisions (i.e., values, objectives, indicators, targets and planned actions) for OGF, monitoring of OGF-related management actions and outcomes will be undertaken during plan implementation, and course corrections determined at the next planning exercise.

(NOTE: as a guide to implementing adaptive management on BMPC lands, we strongly suggest that the Company refer to the CSA Z809 Standard on Sustainable Forest Management. Z809-02 is available now, and the revised Standard Z809-08 will be available from the CSA at the end of March 2009.)

8.3 OGF Definitions

8.3.1 General

At the broadest level, OGF can be defined as a forest ecosystem dominated by old trees. For management and operational purposes, the Company needs a much more detailed definition that relates to measurable characteristics of trees and forest stands. Unfortunately, any detailed operational definition for OGF will contain arbitrary elements. The definition proposed here is provisional, with an expectation that the definition may need to be revised as deeper understanding is gained into concepts and values related to OGF as it exists, and can exist, on BMPC lands. The definition also reflects the facts that (a) OGF can exist in a variety of states, and (b) at any one location in the forest, OGF is a dynamic condition that can improve or degrade with successional processes, natural disturbance events, and silvicultural interventions. OGF is seen not so much as a forest condition that either is present or is not at a particular place and time, but rather as a set of characteristics that, taken together, display “oldgrowthness” on a scale ranging from zero (i.e., absolutely no old-growth character) up to some hard-to-define maximum state where all traits are as “oldgrowth-like” as they can be.

8.3.2 Considerations

For our purposes here, four tree/forest traits are deemed important in defining OGF on BMPC lands: (a) tree species and stand composition; (b) tree age; (c) stand size and shape; and (d) degree of silvicultural intervention.

(a) Tree Species and Stand Composition

Among the native coniferous tree species in Nova Scotia, only three are covered by this strategy: white pine, red spruce and eastern hemlock. This does not imply that other species are of no utility in the overall old-growth concept. Rather, it recognizes that old stands of other common coniferous species in the BMPC forest lands (e.g., black spruce, larch) are either common enough to be of little concern, less special in the sense of old-growth values, or not as valuable from a timber-supply point of view. A focus on these three species makes this strategy, in this dimension, consistent with current policy of the Government of Nova Scotia. These are the three conifer species that grow the largest and live the longest.

Most forest stands in the BMPC forest, as defined in the forest inventory used for management planning, contain more than one tree species, and many contain several species. Thus, an operational definition for OGF must incorporate consideration of stand composition, where the amount of the stand comprised of the three target old-growth species is taken into account. This can be done using crown coverage or basal area.

(b) Tree Age

OGF, by the very nature of the term, indicates an interest in the age of trees, where old ones, and the tree and stand conditions associated with them, are of primary importance. Unfortunately, there are several serious obstacles to making the age concept operational. For one, the actual age of trees is hard to measure accurately across a forest of a few hundred thousand hectares. Estimation techniques at the scale of forest stands can be significantly inaccurate. For another, the convention of dividing a forest into a collection of stands and assigning each an age (or time since last stand-replacing disturbance) may work well for even-aged stands where the stand-replacing disturbance (e.g., burn, windthrow, clearcut) is relatively recent, but breaks down where stands are all-aged and the last stand-replacing disturbance may have been centuries ago. Our field research indicates that this latter situation characterizes many of the older stands on BMPC forest land.

Finally, it is not clear exactly how to relate tree or stand age to the ecological and socio-economic characteristics for which OGF is chiefly valued. Not only are these relationships poorly known, but they are also as likely as not to display no obvious thresholds beyond which one could clearly observe characteristics associated with oldgrowthness. Despite these obstacles, it is nevertheless critical to find a way to incorporate tree or stand age into an operational definition of OGF.

(c) Stand Size and Shape

Generally speaking, OGF values are better satisfied the larger the area covered by old-growth characteristics. Stated in opposite terms, the smaller the stand with old-growth-compatible tree composition and age, the greater the likelihood that old-growth values are compromised. This is partly due to edge effects where OGF stands abut non-OGF stands or non-forest ecosystems. In these situations, conditions or processes which may negatively affect OGF values may be present. The phenomenon must also consider stand shape, since two stands of the same areal extent, one perfectly round and the other strongly elongated, may satisfy old-growth values to differing extents due to the edge effects. Thus, the amount of interior or core old-growth area of a stand is used to remove from consideration stands that are too linear in shape to satisfy the broad range of old-growth values.

(d) Degree of Silvicultural Intervention

A variety of signals have arisen from Canadian forest-policy initiatives - e.g., certification schemes, research findings, policy declarations - that a large forest should contain some reserved OGF. At the same time, though, it is broadly accepted that many old-growth values can be met in silviculturally treated OGF (e.g., partially harvested). With specific kinds of silvicultural treatment, reserved OGF may be transformed into treated OGF, and treated OGF, with sufficient time elapsing since the last silvicultural treatment, may eventually be transformed into reserved OGF. It is important, then, over long planning periods, to track the abundance and characteristics of both reserved and treated OGF.

8.3.3 OGF Definitions for BMPC Lands

We recommend that the Company adopt two definitions of OGF:

(a) *A definition appropriate for simulation analysis. The only criterion is stand age - any stand, of any size, type and location, is OGF if its age exceeds 120 years;*

(NOTE: we use 120 years because it is used in the current definition of OGF adopted by the Company.)

(b) *A definition to be adopted gradually over the life of the first iteration of the OGF conservation strategy. It applies the following criteria.*

A stand is considered reserved OGF if, having met all other criteria, it has not been subject to any silvicultural intervention for at least 50 yr. A stand is considered treated OGF if it has been subject to silvicultural treatment within 50 yr.

(NOTE: while 50 yr is an arbitrary limit, we consider it a reasonable one on the experiential grounds that many of the physical signs of silvicultural activity in a stand (e.g., stumps of cut trees, machine trails) will be difficult to discern once five decades have passed.)

A stand is considered coniferous OGF if:

- the basal area of white pine, red spruce, and eastern hemlock combined exceeds 20 m2/ha;

(NOTE: while 20 m2/ha is arbitrary, it is used as a limit to define appropriate basal area in riparian special management zones in provincial regulation, so it was adopted here.)

- stand age exceeds 120 years, where stand age is the average age of trees of the above species that are representative of the dominant canopy; age estimated from air photos is considered interim, to be replaced as soon as possible by age based on core data; where trees are cored to make the age determination, the age shall be the average of the three oldest trees cored once outliers have been removed;

- it has at least 5 ha of core area defined as area further than 50 m from a human-made feature such as a road, transmission line, or harvest block of any age or composition from which more than 50% basal area has been removed

(NOTE: a circular OGF stand of 10 ha that is surrounded by human-made features as above has ca. 5 ha of core area. The centre of a 5 ha circle is roughly 125 m from the circle's edge, which is about five tree heights of mature OGF-species trees. Both 5 ha and 50 m are arbitrary limits. Based on buffer applications used in forest-management planning elsewhere, 50 m is on the low side, but a low estimate is used here to capture as much potential OGF as possible. 50 m represents ca. two heights of mature OGF-species trees.)

The first definition of OGF above is used in this strategy only because it was used during the simulation analysis and therefore is relevant to the OGF targets presented below (Section 8.4.4). It should be replaced as soon as possible by the more restrictive definition so that calculations of the abundance and distribution of OGF can be grounded on a more sophisticated interpretation of OGF.

8.4 OGF Management

8.4.1 General

Two scales of management consideration are made: (a) the stand scale, where silvicultural interventions are implemented consistently across the entire stand; and (b) the landscape scale, where the spatial distribution of OGF is planned. Additionally, two types of OGF are to be planned for: reserved OGF and treated OGF, as defined above.

8.4.2 Silvicultural Intervention - The Stand Scale

Silvicultural interventions can be used to create or accelerate OGF conditions in stands that are not OGF by the definition above, or in current OGF stands that move to or maintain the assignment of treated OGF. Clearly, the definition above denies the possibility to accelerate the arrival of age characteristics of the dominant canopy. If the dominant trees in a stand are too young, they must age in the normal course of time before becoming OGF-eligible on the age criterion. The treatment opportunities include:

(a) treatments in non-OGF stands - treatments can be used to reduce the basal area of non-OGF species, which should have the effect of accelerating the arrival of a basal area of 20 m2/ha in OGF species; and

(b) treatments in OGF stands - any harvest treatments are allowed as long as the definition is not breached; if treatments take place in reserved OGF stands, they are re-assigned to the treated OGF category.

We urge BMPC to avail itself of a wide range of stand treatments to meet OGF objectives, consistent with timber-production goals and objectives.

8.4.3 Spatial Distribution - The Landscape Scale

Two main options can be pursued regarding spatial layout of OGF on the BMPC lands: (a) have no regard for the locations, sizes and juxtapositions of OGF stands across the landscape, and let OGF stands emerge where they will as a consequence of normal harvest planning and operations as well as prevailing forest conditions; or (b) deliberately design forest development for favourable locations, sizes and juxtapositions of OGF. Within the latter, there are again two variants: (b-i) strive for continuity of OGF conditions by linking OGF concentrations with corridors of mature forest and OGF; or (b-ii) focus on development of OGF aggregations at suitable locations throughout the working forest.

We are aware of no convincing evidence from the literature that OGF aggregations can not provide as significant improvements in biodiversity conservation as can an approach based on connectivity. In our view, connectivity corridors can function under a wide range of forest conditions, and do not need to be mature forest or OGF. Simulation analysis of wood supply, OGF abundance and distribution, and wildlife habitat suitability shows negligible (under 1%) changes in long-term even-flow maximum potential wood supply under a long-term program to create small (ca. 500-700 ha) units of reserved OGF surrounded by similar areas of treated OGF. The same simulation analysis reveals larger and significant reductions in wood supply associated with a connectivity-oriented approach. Therefore, the Company's approach to OGF conservation should focus on creating OGF aggregations in strategic locations where conservation benefits will arise soonest.

8.4.4 Forest-Management Objectives for OGF

BMPC's approach to OGF conservation has, until now, been characterized mainly by provisional withdrawal from the harvest schedule of any stand dominated by trees of 121 yr of age or older (as determined from interpretation of aerial photos and limited field verification). Our simulation analysis (Chapter 8) shows that such a policy reduces the long-term even-flow maximum potential wood supply, compared to a wood supply under a fully unrestricted search for eligible stands to harvest, by some 5% of total harvest, and some 7% of spruce-fir harvest. A program aimed at creating ca. 10,000 ha of reserved OGF in nine strategically placed aggregations, along with smaller area of treated OGF suitably co-located with the reserved aggregations, may be expected to result in a wood-supply reduction, compared to that under current policy, of some 3% of both total harvest and of spruce-fir harvest. Alternatively, a program to create ca. 6000 ha of reserved OGF in nine clusters, with a smaller amount of treated OGF associated with the clusters, is expected to result in a negligible wood-supply impact. The overall simulation results use the less-restrictive definition of OGF that includes all sizes and shapes of stands, of all species compositions, of inventory age exceeding 120 yr. However, identification of the OGF aggregation areas was guided by a search for hemlock, white pine and red spruce in older age classes in large stands.

If we were to propose quantities and qualities of OGF based on our simulation analysis, the following would be the specifications: use an aggregation approach to secure high-quality OGF across the BMPC lands; aim to manage the Company's forests in such a way that they result in the following areas of OGF, defined as all forest area with age exceeding 120 yr :

By 2060, achieve a total of 35,000 ha of OGF distributed as follows:

- 4,500 ha of reserved OGF in nine aggregations of ca. 500 ha each;
- 1,500 ha of treated OGF associated with the nine aggregations of reserved OGF;
- 23,000 ha of treatable OGF in stands scattered across the landscape;
- 6,000 ha of reserved OGF in riparian buffers;

By 2110, a total of 50,000 ha of OGF:

- 6,000 ha of reserved OGF in nine aggregations (of ca. 670 ha each);
- 2,500 ha of treated OGF associated with the nine aggregations of reserved OGF;
- 30,500 ha of treatable OGF in stands scattered across the landscape;
- 11,000 ha of reserved OGF in riparian buffers.

Reserve locations used by us to determine these quantities are presented in Figure xx.

The following explains the categories:

(a) Reserved OGF in nine aggregations - these areas have been hand-picked to represent the best opportunities to secure roughly 500-700 hectares of OGF as soon as possible, i.e., with as little time as possible for the stands all to become older than 120 years. While the reserved OGF stands should be identified and reserved in the next few years, not all the stands within them will be OGF by virtue of stand age, so it will take some time for the actual OGF area within them to reach the final target of 6,500 ha. The 50-yr target of 4,500 ha is a guesstimate at this time.

(b) Treated OGF associated with the aggregations - these stands represent the best opportunity to surround the reserved OGF with old stands in which some timber harvest may take place. They too should be identified early on, but will contribute to the total OGF count gradually, as stands develop the appropriate conditions.

(c) Treatable OGF - all stands except reserved and treated OGF (and other customary withdrawals from the harvestable landbase including riparian buffers) associated with aggregations are eligible for harvest in the simulation analysis. The constraint of modelling for even-flow wood supply over the 100-yr simulation period results in a situation where many such unreserved stands become older than 120 yr. Simulation results show that periodic harvests of such stands reduces OGF area at a lower rate than the rate of increase of OGF area due to recruitment of mature stands into the 120+-year age classes.

(d) The simulation analysis included the assumption that 30-m no-cut buffers are kept on all water bodies. With natural stand aging, the buffers represent increased reserved OGF over time.

Without question, application of the more-restrictive definition of OGF, to be adopted under this strategy, will significantly reduce the abundance of OGF on BMPC lands. Such reductions may be especially large for treatable OGF and buffer-zone OGF, mainly because these stands may be small or narrow, and be dominated by species not among the favoured species. On the other hand, the reductions would be relatively modest in the OGF associated with aggregations, specifically because these areas were chosen for appropriate stand composition and adjacency.

BMPC has the analytical capability to make refinements to the scenarios we have run. We urge the Company to undertake further scenario analysis to determine possible variants on our Scenarios 5 and 6 that might result in more desirable and balanced combinations of OGF abundance and distribution along with timber volumes and costs. As in all scenario-based exercises such as this, the array of scenario variants is infinite, and what is presented in this report is a first and highly approximate round of what should become an ongoing series of successively refined analyses of OGF conservation strategies on Company lands.

8.5 Inventory, Monitoring and Research

A great deal of uncertainty surrounds a confident pursuit of OGF conservation in any large industrial forest. We have identified the following important uncertainties that require the Company's attention during implementation of the strategy.

8.5.1 Inventory

A key component of forest-management knowledge is the quantitative characterization of forest composition and structure. Two main approaches are used to gather forest data for inventory preparation: (a) remote sensing, including both airborne and satellite sensors; and (b) on-the-ground measurement systems (e.g., permanent and temporary sample plots, pre-harvest cruises). The most uncertain element of current inventory work is characterization of stand age. BMPC should strengthen its inventory procedures in this regard by implementing special training of air-photo interpreters so they are better able to recognize multi-aged stands and to discern OGF conditions. It should also implement changes to the operational cruising procedure to include collection and mounting of cores from several dominant trees of all three coniferous OGF species (if present). The cores represent on-the-ground evidence of tree age, and mounting them gives opportunity for detailed measurement of historical growth patterns using dendrochronological methods. Finally, the Company should include an estimate of stand crown closure in forest-inventory development.

8.5.2 Monitoring

Monitoring refers simply to repeated measurement. Like forecasting that serves as the basis for forest-management planning, it focusses on key indicators the dynamics of which are important to quantify. On a time schedule consistent with indicator dynamics and the forest planning cycle, BMPC should monitor:

(a) indicators associated with OGF itself, including (by operating district) core area of reserved, treated and treatable OGF (probably every five years, consistent with plan renewal);

(b) ecological condition of each OGF stand, including overstorey composition, basal area by species, quantity of coarse woody debris (CWD), rate of tree mortality, status of regeneration, tree health (probably every ten years);

(c) occurrence and effects of natural disturbances, particularly storms and insect outbreaks, in/on OGF stands (as required);

(d) silvicultural treatments applied in treated OGF stands, including areal coverage, and stand ecological conditions before and after treatment (as required).

8.5.3 Research

8.5.3.1 Field Research

Notwithstanding considerable efforts to research the unique ecological character of OGF on BMPC lands in recent years, one must acknowledge the significant remaining gaps in ecological knowledge associated with OGF. The Company should accept responsibility to take a leadership role in addressing these gaps. It should work cooperatively with a range of research organizations to address the following highest-priority knowledge needs with respect to OGF on its lands:

(a) use of OGF and non-OGF stand types by important groups of animals such as songbirds and herptiles;

(b) nature and extent of windthrow following alternative harvest treatments in treated OGF;

(c) improved understanding of the relative importance of a range of OGF values held by various groups of citizens of Nova Scotia, in particular using in-woods focus groups.

8.5.3.2 Analysis to Support Planning

BMPC is commended for the fact that its forests have recently been subject to a suite of special investigations associated with OGF, probably to a greater extent than any other forest in eastern Canada. Still, despite this research attention, many OGF values and issues have yet to be addressed in the context of forest-management planning. The Company should therefore commit to improved OGF planning as follows:

(a) Spatial habitat supply analysis for key vertebrate species. Analysis supporting creation of this strategy included a non-spatial examination of habitat values for a small suite of vertebrate species. Considering that many vertebrate species with relatively large home ranges doubtless respond to the spatial configuration of various habitat patches, the Company should undertake to build and use spatial habitat models for an expanded suite of vertebrate species that make their home on Company lands.

(b) Dynamics of CWD in treated OGF. In reserved OGF, live trees are recruited to the pool of dead wood either by first becoming snags and then fallen logs, or by falling to the ground due to wind. In treated OGF, these processes also occur but are complemented by commercial timber harvests which reduce the pool of live trees that might become CWD. The likely outcome is that, over time, CWD abundance would be less in treated OGF than in reserved OGF. Given the importance of CWD, especially large pieces, in determining the quality and character of OGF, it is paramount to develop quantitative relationships between CWD and the passage of time in both reserved and treated OGF stands. These relationships are the foundation for CWD "yield curves" that would be used to track CWD abundance in forest-planning analysis. BMPC should commit to the creation of CWD yield curves for OGF in its lands.

(c) Carbon budgets associated with alternative strategies for managing OGF. At present, there is both ecological and economic interest in knowing whether forests in Canada are capturing more carbon from the atmosphere over time, or are releasing more. The ecological imperative relates to a desire to slow down the rate of climate change during the 21st century. The economic interest relates to the possibility to capture revenue through traded carbon credits if the forest can be confidently shown to be increasing its carbon pools. Either way, detailed calculations are needed to provide the required quantitative evidence. Such calculations can readily be made today for the Company's forests, given its current approach to forest simulation and the application of readily available models such as the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS), developed by the Canadian Forest Service. BMPC should use a carbon budget model to develop projections of the carbon budget of its forests, in particular exploring the roles of both reserved and treated OGF in that budget.

(d) Potential for climate change to invalidate the directions contained in this strategy. Despite all global efforts to reduce emissions of greenhouse gases to the atmosphere, there is scientific consensus (through the Intergovernmental Panel on Climate Change) that climate change will indeed occur to a significant degree in the 21st century. There are strong chances that it will occur to such an extent as to affect the normal development of Nova Scotia's forests. Rising temperatures are expected, along with changes in precipitation and wind patterns. Such climatic shifts may make it more difficult to conserve OGF on the BMPC lands. The Company should commit to undertaking a first-approximation analysis of the implications of climate change for managing its forests, in particular how climate change might alter the abundance and condition of OGF, both reserved and treated.

(e) Extension of the strategy to non-coniferous species. While the BMPC lands are dominated by conifers, and the Company's forest-products operations are based on coniferous wood, there are significant complements of non-coniferous tree species across the landscape. The OGF policy of the Government of Nova Scotia identifies three species - sugar maple, yellow birch, and American beech - as key non-coniferous OGF species. The Company should commit to inclusion, in the next iteration of this OGF conservation strategy, selected non-coniferous species. Given the widespread affliction of American beech with a bark disease (with no known treatment), and the wide distribution of red oak in the Company's forests, we recommend that BMPC focus its non-coniferous OGF strategy on sugar maple, yellow birch, and red oak.

8.6 Communications and Public Awareness

One of the rationales for BMPC to take a corporate interest in OGF is that there is growing public interest in OGF conservation. Such public interest is wide-ranging and extends at least to forest-products customers, conservationists, and the scientific community, not to mention also the general citizenry. If external eyes are focussed on BMPC lands and their OGF status, it behoves the Company to assist people's general and specific understanding of the OGF and how the Company is going about OGF conservation. Three avenues of activity could profitably be pursued:

(a) Communicating to Nova Scotians (local, provincial) and others about OGF on Company lands and how they are managed is considered vital. BMPC should develop both hardcopy and website materials related to OGF, and should seek opportunities to speak about its OGF conservation at local meetings as well as provincial, national and international conferences.

(b) Both research and experience have shown the power of field trips for people to be able to see first-hand what OGF on BMPC looks like, and how the Company is managing OGF. The Company should commit to further support of OGF-focussed field trips, both in response to demand and as part of routine Company field tours.

(c) Nova Scotia's economy will, in all likelihood, continue to favour tourism, and BMPC, as owner of significant forest lands, could well become a player in the tourism economy. Eco-tourism is a growing market segment. The Company should investigate the potential for using its OGF lands in a range of eco-tourism ventures. One promising example would be day-long OGF-centred learning experiences using a small bus and a trained guide.

8.7 Strategy Renewal

From the very date of strategy adoption, social, economic and ecological conditions will doubtless change, and over a few years may change so much as to make some parts of the strategy increasingly less applicable and relevant. BMPC should therefore commit to a review and renewal of the OGF conservation strategy within 5-10 years of the adoption date. The review and renewal exercise should focus on checking the ongoing relevance of all parts of the strategy, making course corrections, incorporating results of research and planning analyses, and incorporating non-coniferous OGF species.

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Appendix I: Species Habitat Supply Models

Suitability Rating for Northern Goshawk habitat

	Maturity Class				
	Regeneration	**Young**	**Immature**	**Mature**	**Overmature**
	0	0	0	1	1
	0	0	0	3	3
	0	0	0	1	1
	0	0	0	2	2
	0	0	0	3	3
	0	0	0	3	3
	0	0	0	3	3
mw	0	0	0	3	3
LS	0	0	0	1	1

	If above 1	If above >= 2
Selection Cut	1	2
Shelterwood	1	2
Other Modified	1	2
Variable Retention	0	0
Pine Seed	0	0
Ccut	0	0

Suitability of Rating for Pileated Woodpecker habitat

Stand Type	**Maturity Class**				
	Regeneration	**Young**	**Immature**	**Mature**	**Overmature**
Hemlock	0	0	1	2	2
Pine	0	0	1	3	3
Spruce	0	0	1	2	2
SW	0	0	1	2	2
SH	0	0	1	3	3
hw	0	0	1	3	3
hs	0	0	1	3	3
mw	0	0	1	3	3
LS	0	0	1	2	2

	If above 1	If above >= 2
Selection Cut	1	2
Shelterwood	1	2
Other Modified	1	2
Variable Retention	0	
Pine Seed	0	
Ccut	0	

Suitability Rating for Barred Owl habitat

Stand Type	Maturity Class				
	Regeneration	Young	Immature	Mature	Overmature
Hemlock	0	0	1	2	2
Pine	0	0	1	2	2
Spruce	0	0	1	3	3
SW	0	0	1	3	3
SH	0	0	2	3	3
hw	0	0	2	3	3
hs	0	0	2	3	3
mw	0	0	1	3	3
LS	0	0	0	1	1

	If above >= 1
Selection Cut	1
Shelterwood	1
Other Modified	1
Variable Retention	0
Pine Seed	0
Ccut	0

Suitability Rating for Northern Flying Squirrel habitat

Stand Type	Maturity Class				
	Regeneration	Young	Immature	Mature	Overmature
Hemlock	0	0	1	2	2
Pine	0	0	1	3	3
Spruce	0	0	1	3	3
SW	0	0	1	3	3
SH	0	0	2	3	3
hw	0	0	1	2	2
hs	0	0	1	2	2
mw	0	0	2	3	3
LS	0	0	1	1	1

	If above >= 1
Selection Cut	1
Shelterwood	1
Other Modified	1
Variable Retention	0
Pine Seed	0
Ccut	0

Suitability Rating for Golden-crowned Kinglet habitat

Stand Type	Maturity Class Regeneration	Young	Immature	Mature	Overmature
Hemlock	0	0	2	3	3
Pine	0	0	2	2	2
Spruce	0	0	2	3	3
SW	0	0	2	3	3
SH	0	0	2	2	2
Hw	0	0	1	1	1
Hs	0	0	1	1	1
Mw	0	0	1	2	2
LS	0	0	1	1	1

	If above 1	If above >= 2
Selection Cut	1	2
Shelterwood	1	1
Other Modified	1	1
Variable Retention	0	0
Pine Seed	0	0
Ccut	0	0

Suitability Rating for American Marten habitat

Stand Type	Maturity Class Regeneration	Young	Immature	Mature	Overmature
Hemlock	0	0	1	2	3
Pine	0	0	1	2	3
Spruce	0	0	1	2	3
SW	0	0	1	2	3
SH	0	0	1	2	3
hw	0	0	0	0	0
hs	0	0	0	0	0
mw	0	0	1	2	3
LS	0	0	0	1	1

	If above >= 1
Selection Cut	1
Shelterwood	1
Other Modified	1
Variable Retention	0
Pine Seed	0
Ccut	0

Notes:

Rating Scores:
0 = unsuitable – species rarely occupy these habitats
1 = Marginal – species occasionally occurs in these habitats but density is low, survival is low, or productivity is low relative to other habitats
2 = Moderate – species commonly use these habitats but density is moderate, survival is moderate, or productivity is moderate relative to other habitats
3 = Preferred – species commonly use these habitats and generally density is high, survival is high, and productivity is high relative to other habitats

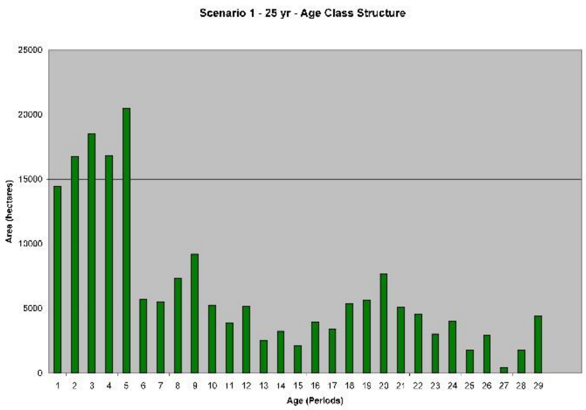
Age ranges associated with the five maturity classes for cover-types

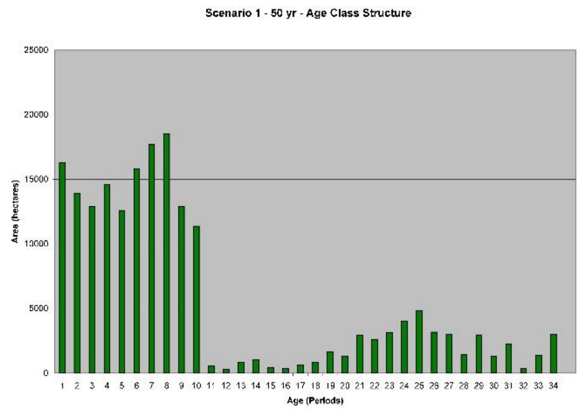
Cover-type	Presapling	Sapling	Immature	Mature	Overmature
Hemlock	0-15	20-45	50-85	90-155	160+
Spruce	0-10	15-40	45-80	85-115	120+
SW	0-15	20-40	45-80	85-105	110+
SH	0-10	15-30	35-65	70-95	100+
Pine	0-15	20-40	45-80	85-130	135+
MW	0-10	15-30	35-60	65-95	100+
HS	0-10	15-30	35-65	70-95	100+
HW	0-10	15-30	35-65	70-100	105+
LS	0-15	20-45	50-85	90-155	160

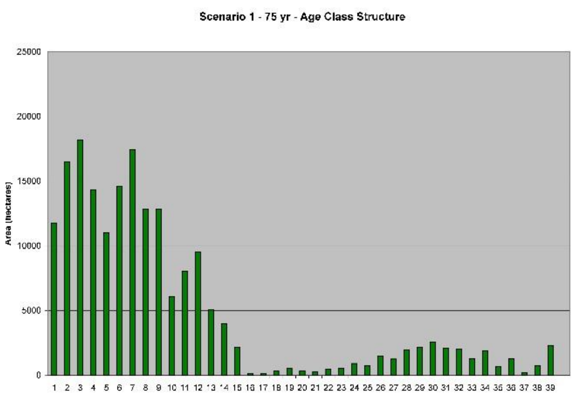
Maturity Classes	Definition
Presapling	Period of forest initiation following a stand replacing event—vegetation dominated by herbaceous plants, woody shrubs, and tree seedlings—stand attains maximum rate of height growth—trees < 3 m tall
Sapling	Period during which trees begin to dominate the site—sublethal competition occurs as canopy begins to close—stand height growth is rapid but declines relative to presapling
Immature	Period of dense canopy closure—lethal competition and self-thinning—little understorey development—stand height growth declines relative to sapling stage as competition intensifies
Mature	Period in which overstorey trees attain full development and sexual maturity—mortality of overstorey trees begins to create gaps and encourages understorey development—height growth slows dramatically
Overmature	Period with heavy mortality/turnover of overstorey trees results in mosaic of gaps and encourages development of multi-layered canopy—abundance of snags and DWD

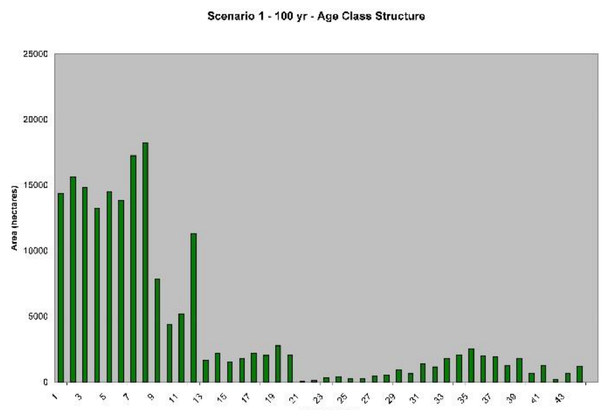
From: Holloway, G.L., B.J. Naylor, W.R. Watt. 2004. Habitat relationships of wildlife in Ontario. Southern Science and Information Section and Northeast Science and Information Joint Technical Report No.1 Queen's Printer for Ontario, Toronto, ON.

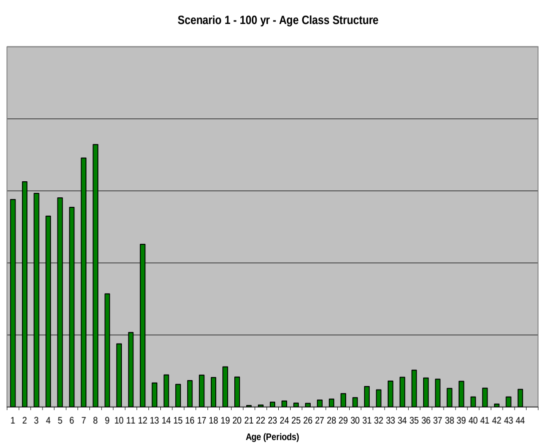
Appendix II : Five-Year Ageclass Structures

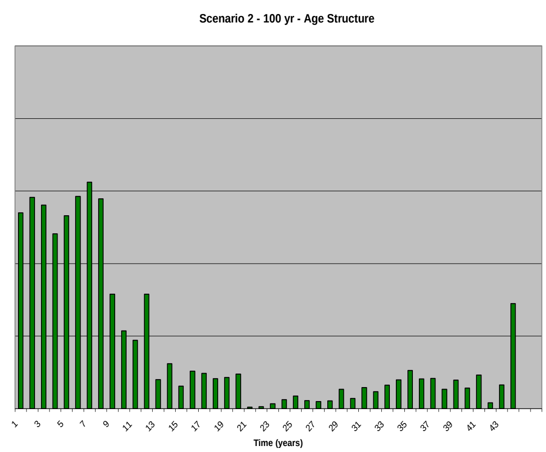


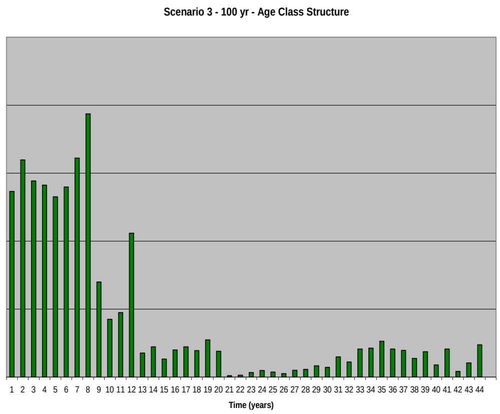











Scenario 3 - 100 yr - Age Class Structure
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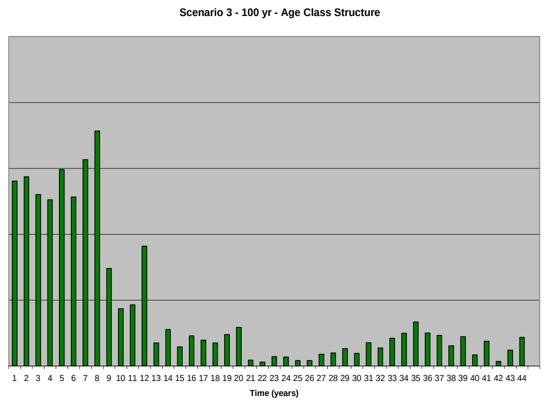
Time (years)


Scenario 3 - 100 yr - Age Class Structure
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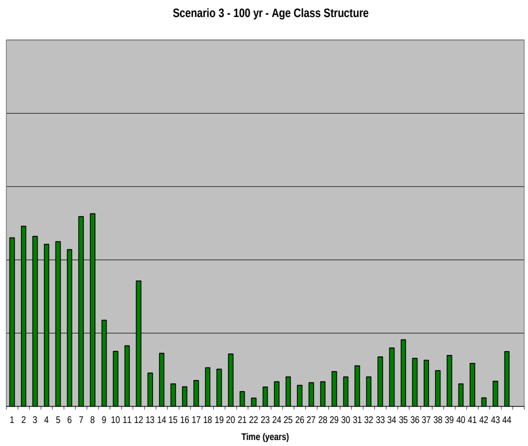
Time (years)


Scenario 3 - 100 yr - Age Class Structure
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Time (years)