Mapping Nova Scotia's Natural Disturbance Regimes

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Authors:

Peter Neily, RPF
Eugene Quigley, TFR
Bruce Stewart, RPF

Cover Photo:

Regrowth of a spruce budworm killed balsam fir forest
Cape Breton Highlands, Nova Scotia

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Contacts:

Nova Scotia Department of Natural Resources
PO Box 68
Truro, NS
B2N 5B8

Peter Neily	Eugene Quigley	Bruce Stewart
902 893-5692	902 893-5677	902 893-5684
pdneily@gov.ns.ca	ejquigle@gov.ns.ca	bjstewar@gov.ns

Abstract

Natural disturbance regimes which have influenced forest structure and composition in Nova Scotia were determined and mapped on the provincial Ecological Land Classification. Fifty-one percent of the forested area evolved from infrequent and/or gap natural disturbance regimes and developed uneven-aged softwood forests of red spruce, eastern hemlock, and white pine or uneven-aged hardwood forests of sugar maple, yellow birch, and beech. Forty-three percent of the forested area developed from frequent natural disturbance regimes giving rise to predominantly even-aged forests of balsam fir, jack pine, red pine, black spruce, and red maple. The remaining six percent of the land area has site and climatic conditions that produce treeless barrens, wetlands, and rocklands, and krummholz. Mapping the distribution of natural disturbance regimes assists strategic planning at the landscape level as well as the prescription of operational treatments at the stand level. Research continues to advance the understanding of the natural processes that produced the Acadian Forest and will be reflected in future revisions of this mapped description of forests and their natural disturbance history.

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Introduction

Since the last glaciation more than 10,000 years ago, natural disturbance regimes have helped shape the forests of Nova Scotia. Following European arrival in the 17th century human caused disturbances have increasingly created conditions in much of the forest that no longer reflect the processes and structures initially produced by natural disturbances. In order to provide guidance for more natural-based forest management a quantitative and spatial description of the natural disturbances and potential climax forest is required. Parminter (1998) states that "where lands are managed to produce various resource-based goods and services, an assumption underlying ecosystem management is that the greater the similarities between the effects of a natural disturbance and the effects of management activities, the greater the probability that natural ecological processes will continue with minimal adverse impact." The intent of this report is to describe the methodology used to determine the distribution of natural disturbance regimes that characterize the pre-European forests in Nova Scotia and to provide a mapped representation of these disturbances using the provincial Ecological Land Classification (ELC)[1] (NSDNR, 2006). Ecoregions (Appendix I), ecodistricts (Appendix II), and ecosections from the ELC are used to describe the distribution of the disturbance regimes.

The biodiversity of the province has evolved and adapted to reflect natural disturbance processes in the forest. By changing existing forest conditions and initiating secondary succession, natural disturbances create new ecological communities. This may involve the complete removal of vegetation as would occur with an intense fire, or the partial removal of a particular species or individual following less intense disturbances as may occur with insect infestation, windthrow, or senescence. Over time the proportion of habitats in various stages of development may not vary much at the landscape level, although the actual location of these stages will change as new disturbances occur and previously disturbed areas evolve. In this disturbance mosaic, habitats for a range of native species that depend on different stages are maintained.

In Nova Scotia natural disturbances and tree species distribution have been influenced by a progressively cooler and wetter climate since 4000 yr. B.P. which at first favoured climax species such as yellow birch, sugar maple, and hemlock but which eventually led to a resurgence of boreal species such as spruce, larch, and fir (Green, 1981). The start of European settlement in 1604 signalled the beginning of significant landscape changes such that by 1900 over 20% of the province (890,000 hectares) had been cleared for agriculture (Fernow 1912). Extensive forest harvesting, with much of the timber shipped to France and England (Johnson, 1986), left Fernow (1912) to estimate that only 6.5 %[2] (275,000 hectares) of the current provincial forest land base was still in a virgin (primal) state and most of that was comprised of the extensive balsam fir forests on the Cape Breton Highlands.

The adoption of a policy of ecosystem-based management enhances the ability to maintain

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[1] Available online: http://www.gov.ns.ca/natr/forestry/ecosystem/elcpg1.htm

[2] Current forest land base is 4,256,846 hectares (Townsend, 2004).

natural successional and climax forests reflective of the Acadian Forest region[3]. Forest management planning and silviculture can be designed to simulate the frequency, intensity and scale of natural disturbance regimes, thus creating natural looking landscapes while conserving the structures and functions that native biodiversity has developed upon.

During the next 100 years significant climatic change is anticipated and natural disturbances and biological communities will change in response to climatic pressures. Nova Scotia's Code of Forest Practices (NSDNR, 2004) outlines the principles of ecosystem-based management required to ensure a sustainable forest for the future and for the maintenance of biodiversity in forests under management. The focus is on managing forest ecosystems to sustain their natural attributes by incorporating disturbance ecology into forest management planning. Implementation of a strategy to maintain the adaptive capacity of ecosystems will be the best opportunity to provide an array of wildlife habitat, maintain diverse gene pools, and sustain the processes that support healthy ecosystems. However, Kimmins (1993) cautions that emulating natural disturbances should be only one tool in the toolbox of sustainable forest management.

Natural Disturbance Regimes

Natural disturbances in the temperate forests can be divided into two types based on the amount of overstory removed. Those which kill most of the existing trees above the forest floor vegetation are referred to as major disturbances or stand-replacing disturbances. Those which leave a significant portion of the pre-disturbance trees alive are referred to as minor disturbances (Oliver and Larson, 1996). Since disturbances exert a strong control over the species composition and structure of forests; Frelich (2002) states, as a general rule of thumb, that landscapes with frequent, stand replacing disturbances are dominated by young even-aged stands of shade-intolerant species such as aspen. Conversely, old stands of shade-tolerant species such as hemlock dominate where major disturbances are rare. However, forest development can be complicated as a result of various combinations of disturbance agents and intensity.

Natural disturbance in the forest can be characterized by 1) the amount of forest removal above the forest floor, 2) frequency or reoccurrence interval of the disturbance, 3) size and shape of the area disturbed, and 4) amount of forest floor vegetation, forest floor, and soil removed. Combinations of the amount of vegetation removed and the recurrence interval could be considered as disturbance regimes which vary from infrequent and at irregular intervals to frequent and at regular intervals (Oliver and Larson, 1996). Disturbance regimes are one of the major forces that structure the mosaic of forest communities across the landscape, therefore, landscape characteristics are sensitive to changes in disturbance regimes (Frelich 2002). Their variability can be a function of the climate and weather, topography and landforms, soil properties, forest composition and age class, wildlife populations, and other factors.

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[3] The Acadian Forest Region (Rowe, 1972) is a transitional forest region between the Boreal and Great Lakes - St. Lawrence Forest Regions characterized by shade tolerant softwood forests of red spruce, eastern hemlock, and white pine and shade tolerant hardwood forests of sugar maple, beech, and yellow birch.

Three disturbance regimes[4] - frequent stand initiating, infrequent stand initiating, and gap dynamic are described for the zonal or mesic[5] forest ecosystems of Nova Scotia. An open seral disturbance regime is described for edaphic[6] site conditions.

Frequent Stand Initiating Disturbance Regime

On zonal sites the disturbance regime is classified as frequent stand initiating[7] when the time interval between stand initiating events typically occurs more frequently than the longevity of the climax species that would occupy the site. Often some of the overstory may survive the disturbance in pockets and as scattered individuals but with insufficient numbers to dominate the structure of the newly developing forest. Depending on the disturbance agent the new forest may establish from pre-existing regeneration, seed from undisturbed adjacent forests, seed from serotinous cones, seed stored in the soil, root suckers, and stump sprouts. Subsequent stand development is usually interrupted with another disturbance before the stand becomes old enough to display uneven-aged characteristics such as gap dynamics in the canopy. The size and severity of stand initiating events is mitigated by several factors including climate, species mix, and the agent. Examples of this disturbance type include spruce budworm infestations in the balsam fir dominated forests of the Cape Breton Highlands Ecoregion or the fire disturbed jack pine ecosystems of Cumberland County.

Edaphic sites of imperfectly and poorly drained mineral soils occupy 25% of the province[8]. These edaphic site conditions usually give rise to forest stands dominated by black spruce, balsam fir, larch, and red maple and are susceptible to frequently occurring natural disturbances. The shallow rooting habit of black spruce allows this species to occupy wet sites not suitable for other species, such as red spruce, hemlock, and sugar maple. However, these black spruce forests are susceptible to blowdown during hurricanes. In addition, many of the imperfect to poorly drained sites occur on shallow soils (<30 cm) over compacted basal tills which experience a moisture deficit during the summer months. The dry soil conditions combined with the flammable make-up of the lesser

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[4]Based on discussions of the Ecological Technical Committee, Renewable Resources Branch, N. S. Dept. of Natural Resources, 1997.

[5] Zonal or mesic refers to sites that have well drained soils with adequate moisture for plant growth.

[6] Edaphic refers to site conditions that limit plant growth, e.g. excessive soil moisture; dry, impoverished soils; severe climatic exposure; organic soils; shallow soils over bedrock.

[7] A disturbance is defined as stand initiating when the intensity results in the rapid mortality of all or most of the existing forest stand to the extent that a new forest of relatively even-age is able to become established and dominate the site.

[8] Percentages derived from the 15 county soil survey reports for Nova Scotia published between 1954 and 1991 by the Canada Dept. of Agriculture.

vegetation, usually ericaceous[9] shrubs, creates sites susceptible to fire. Forests on edaphic sites are usually even-aged since the disturbance agents, fire and wind, result in a significant portion of the canopy being destroyed. In the absence of major disturbance events edaphic site conditions often hasten senescence and tree mortality, over a relatively short period (10-20 years),as the capacity of the site to supply optimum growing conditions is exceeded. This is apparent where the vigour of the overstory species is diminished by site limitations that increase as the forest floor organic matter accumulates, tying up nutrients, moisture, and oxygen (Oliver and Larson 1996).

Infrequent Stand Initiating Disturbance Regime

The disturbance regime is classified as infrequent stand initiating when the time interval between stand initiating events is typically less frequent than the longevity of the climax species that would occupy the site. Subsequently stands develop uneven-aged characteristics, i.e. multi-cohort[10], as trees from the understory are recruited into the overstory as a result of low severity disturbances creating gaps in the canopy. Under this disturbance regime the opportunity for multiple successional stages en route to the climax condition can occur. After periodic catastrophic disturbances forests develop as even-aged stands, but as the interval between these disturbances lengthens and the stand matures, uneven-aged stand structure develops as a result of individual or small patch tree mortality. The longer the disturbance interval the more uneven-aged the stand becomes with increasing composition of long-lived shade tolerant species. Depending on the frequency and severity of the gap disturbances that occur as these stands develop, trees of all cohorts may be evenly distributed throughout, or occur as a mosaic of small single-cohort patches, or as cohort classes distinctive in age and species. The red spruce-white pine-hemlock ecosystems of the Western and Eastern ecoregions are examples of this disturbance regime.

Under mid-successional forest communities, most notably pine and oak, understory or surface fires of low intensity remove susceptible species thereby maintaining this mid-successional stage of development. These stand maintaining disturbances cause light to moderate damage to mature fire-adapted species but kill or injure flame intolerant trees, shrubs and lesser vegetation, and reduce the build-up of slash and litter on the forest floor. The removal of flame intolerant species can shift and sustain the overall species composition to favour fire-adapted species (Oliver and Larson 1996). In a study at Kejimkujik National Park, Basquill *et al.* (2001) conclude that understory fires have served to kill or injure flame intolerant species, shifting seral patterns and favouring fire adapted tree species and post-fire cohorts. Understory fires appear to promote self seeding in red oak, red spruce, white pine, and red pine forests.

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[9] Ericaceous species refers to woody plants of the *Ericaceae* Family and include huckleberry, blueberry, rhodora, kalmia, leather leaf, mayflower, teaberry, Labrador tea.

[10] Cohort is defined as an age class of the same species.

Gap Dynamic Disturbance Regime

Forests that are rarely exposed to stand initiating disturbances characteristically develop overstories that are sustained by processes of canopy gap formation that encourage understory development and overstory recruitment, sustaining an essentially intact forest canopy. Gap dynamic regimes of small scale, continuous disturbances favour the development of uneven-aged stand structure and provide a sense of stability. Mortality is caused by animal or insect predation, disease, lightning, blowdown, senescence, or a combination of several agents. Usually shade tolerant species regenerate under openings (gaps) created in the canopy and as more gaps are created in the over-story this regeneration is released into the canopy and shares the space with surviving older trees. With sufficiently long intervals between stand initiating events the stand develops a structure of mixed-aged trees all younger than the time since the last stand initiating disturbance. Lorimer and Frelich (1994) report that gap formations in mesic (average sites) hardwoods cause nearly complete turnover in the canopy in less than 250 years. An old growth study of the Acadian hardwood climax forest in Nova Scotia by Stewart *et al.* (2003) revealed that very few trees in the sampled stands were older than 300 years.

Event-driven gap disturbances occur when uneven-aged climax mixed forests experience an episode of mortality or decline often affecting an entire species over a wide area creating an influx of coarse woody debris and extensive canopy gaps. In Nova Scotia recent examples of event-driven gap disturbances in the climax sugar maple/yellow birch/beech forests include - widespread mortality of beech due to the beech canker in the early 1900's; yellow birch dieback in the 1940's; and indiscriminate canopy damage and tree mortality during the 2003 ice-storm in Cumberland County. During an event-driven gap disturbance changes in the climax forest leave the post-disturbed stand different in species composition and structure than the pre-disturbed one, and often favours the formation of two-aged and multi-aged stands with distinctive age classes (Oliver and Larson, 1996).

In Nova Scotia the tolerant hardwood forests of the Nova Scotia Uplands ecoregion reflect a forest maintained through the dynamics of gap disturbances.

Open Seral Disturbance Regime

Many terrestrial ecosystems have site conditions (edaphic) that restrict or limit tree growth. These conditions can be inherent to the site such as wet soils or dry, impoverished soils developed over time due to repeated wild fires. Where disturbances have reduced soil fertility or created poor soil structure (e.g. hardpan formation in the soil profile), open woodland ecosystems with stunted trees will develop as would be found on the barrens of southwest Nova Scotia. This condition is further exacerbated by the allopathic effect on coniferous species of extensive cover to ericaceous vegetation (heath-like). Gray (1956) concluded from his studies on the southwest barrens that once heath plants and bracken fern are established in a dominant position, they become a serious limiting factor to tree regeneration. Catling *et al.* (2004) concludes that natural fires contributed to the maintenance of the Annapolis Valley heathlands. Other areas in Nova Scotia have inherent limitations to tree growth through natural processes such as extreme exposure to wind (e.g. krummholtz), seasonal flooding along rivers, and adjacency to tidal waters (salt marshes). Still others are wetland ecosystems (bogs and fens) where tree growth is restricted due to excessive moisture, site conditions such as thick organic peat layers, and ericaceous vegetation. Rowe (1972) states that the combination of moist climate and gentle relief has produced considerable areas of non-forested bogland in the western and eastern ecoregions.

Agents of Natural Disturbance

In Nova Scotia natural forest disturbances may result from fire, wind and ice storms, insects, animal predation, disease, flooding, destructive rock slides, and tree senescence. However, land use activity associated with the start of European settlement and which has continued on to the present has affected the frequency, intensity, and magnitude of natural disturbance processes. Forest fragmentation caused by a period of increased frequency of forest fires (ca1750-1869), continuous timber harvesting, urbanization and land development, and current efforts at fire suppression and exclusion (ca 1900) have altered the dynamics of natural forest disturbance agents.

The historic forest conditions in Nova Scotia observed by the first settlers are described in the 1672 treatise of Nicolas Denys (Ganong, 1908). The coastal forest encountered by this French entrepreneur seems to differ little from what is present today. His description of the inland forests relied on what he learned from the Native population and suggests an older forest but of similar species. He also describes forests of oak, white birch, and pine throughout the Maritimes that may have originated from fires. There is reference to beech and other long-lived species to suggest tracts of less frequently disturbed forests (Neily, 2006). Later Simeon Perkins writes in his diaries of 1766-1812 (Champlain Society, 1948) about the horrific forest fires experienced in south-western Nova Scotia in the 1790's. Some of the earliest, most extensive documentation of the natural history of the province are the accounts of Titus Smith in 1801-1802 as he travelled throughout mainland Nova Scotia (Clark, 1954; Gorham, 1955; Hawboldt, 1955). More recently, pollen studies of lake sediment cores (Cwynar, 2008), dendrochronology (Phillips and Laroque, 2007), and ecosystem archaeology (Ponomarenko, 2007) have provided insight to the composition and disturbance history of the forests before European settlement. It is expected that research will continue to advance the understanding of the natural disturbance ecology of Nova Scotia's portion of the Acadian Forest. A discussion on forest disturbance agents is presented in Appendix III. Other historical reports are listed under Additional Reading and Sources of Information.

Methodology for the Spatial Assignment of Disturbance Regimes

The distribution of tree species and forest communities is closely related to the topographic and soil conditions of the land (Rowe, 1972). However, change in forest structure and composition is accomplished through disturbances and the biological and ecological interactions among species as influenced by climatic conditions. Thus landscape structure and pattern are essentially a product of the underlying geomorphological pattern and the overlying or induced disturbance pattern (Methven and Kendrick, 1995). The former, as expressed by the enduring features of soil, parent material, topography, and landform, exerts its control on species distribution and development rates. The latter, as expressed by forest disturbances, controls age class patches, species composition, and their distribution over space and time. Ecosections of the provincial ELC are mapped units of similar enduring physical attributes repeating throughout larger units of similar physiography (ecodistricts), nested within larger units of similar provincial climate (ecoregions). Therefore, using silvics and site requirements of zonal and edaphic forest associations, it is possible to extrapolate data from intact ecosections that currently support characteristic climax tree species to other similar ecosections within the same ecodistrict. Using this approach, the dominant climax communities characteristic of each ecosection in the province were determined and a natural disturbance regime assigned based primarily on the inherent susceptibility and dependence of the climax community of that ecosection to particular natural disturbance agents and regimes.

The first step of the process, before disturbance regimes could be assigned to the landscape, was to determine the characteristic climax forest species for zonal and edaphic site conditions. Information from the Department of Natural Resources (DNR) digital forest cover layer[11] was used to map the location of late successional species such as hemlock, white pine, and shade tolerant hardwoods, and other species such as jack pine and red pine. The 3250 plots in DNR's Permanent Sample Plot database (Townsend, 2004) was also analyzed to determine the distribution of tree species. Other sources of tree distribution data used to determine characteristic forest species included reports on old growth or old forests (Lynds and Leduc, 1995; Stewart *et al*. 2003); the historical accounts of Nicolas Denys in 1672 (Ganong, 1908), Charles Morris in 1761 (Anonymous, 1905), Titus Smith in 1801-1802 (Hawboldt, 1955), Simeon Perkins in 1766-1812 (Champlain Society, 1948), Fernow (1912), and Nichols (1918); and data from current DNR projects including forest ecosystem classification, old forest and old growth classification, forest research, and forest inventory. The use of current and older (ca 1940) aerial photography and satellite imagery was referenced during the project and local expertise, primarily from DNR staff, was consulted to help validate forest species distribution throughout the province. For comparison the climax forest for the mesic or zonal growing condition as described by Loucks (1962) was summarized for each ecodistrict (Appendix IV). Comparing Loucks' zonal forest species with the ELC based zonal forest species revealed a close correspondence between the two classifications. Only minor discrepancies occurred due primarily to the difficulty in aligning Loucks' forest district mapping with the ELC ecodistrict mapping. To determine characteristic forest species on edaphic sites similar procedures as discussed above were used.

The second step of the process involved determining the assumptions that would guide the mapping of the frequent, infrequent, and gap natural disturbance regimes based on climax and edaphic forest communities. Information on natural disturbances was obtained from historical reports, cited literature, DNR's forest fire, insect, disease records, and annual reports dating back to 1927, and insect and disease reports of the Canadian Forest Service. The stand maintaining natural disturbance regime was not mapped since it compliments the infrequent disturbance regime in the mature pine ecosystems of the Western ecoregion. Ecosections where edaphic site conditions create open woodlands, wetlands, barrens and krummholtz were classified as an open community type. In general, a natural disturbance regime was assigned as follows:

- ecosections with zonal conditions that support the development of climax, uneven-aged forests of shade tolerant hardwood species (sugar maple, beech, yellow birch)

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11 FORCOV, Geographic Information System Digital Database, N.S. Department of Natural Resources, Forestry Division, Truro

were assigned the gap disturbance regime.

- ecosections with zonal conditions that support the development of climax, uneven-aged forests of shade tolerant softwood species (red spruce, hemlock, white pine) were assigned the infrequent disturbance regime.
- ecosections with zonal and edaphic conditions that support even-aged stands of shade intolerant species (jack pine, red pine, white birch), red maple, balsam fir, black spruce, and white pine, and which are subjected to frequent disturbances such as fire, insects, climatic exposure, and wind were assigned the frequent disturbance regime.

The final step involved field work and consultation with regional and planning staff of the Department of Natural Resources to validate the mapping of both the natural disturbance regimes and climax forests. Several other digital and mapped databases were also consulted during this project and included the Biophysical Land Classification[12] (1:50,000 Land systems), soil series maps, e.g. Webb (1990), surficial geology maps (Stea *et al.* 1992), National Topographic Series 1:50,000 mapping, historical township maps, e.g. Church (1864), and historical forest inventory maps (Fernow, 1912).

Results and Discussion

The dominant natural disturbance regimes, regardless of present day land use[13], were mapped on the provincial ecological land classification by ecosection[14] (Appendix V), and summarized by ecoregion (Table 1) and ecodistrict (Appendix VI). Infrequent and/or gap disturbance regimes are dominant on 51% of the landbase and develop forest associations typical of the Acadian Forest. These forests of red spruce, hemlock, white pine, sugar maple, beech, and yellow birch originate or establish from successional processes started by an infrequent or rare stand initiating disturbance. They are maintained as uneven-aged forests by gap disturbances in the canopy until the next stand initiating disturbance. Frequent disturbance regimes are dominant on 43% of the landbase and develop forest associations of balsam fir, black spruce, white spruce, jack pine, red pine, white pine, white birch, and red maple. Whether due to edaphic site conditions or disturbances (fire, insects, wind) these forests are predominantly even-aged and unlikely to succeed to longer-lived late successional associations of the Acadian Forest. The remaining six per cent of the landbase has edaphic site conditions that severely limit tree growth and develop the open seral vegetation communities associated with barrens, sparsely treed bogs and swamps, rockland, and severely exposed sites.

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12 BIOSYS, Geographic Information System Digital Database, N.S. Department of Natural Resources, Forestry Division, Truro

13 Salt marshes, dykelands, coastal beaches, and urban Halifax were excluded from the total landbase.

14 Disturbance regimes by ecosection is available online at: http://www.gov.ns.ca/natr/forestry/ecosystem/elcpg1.htm

Ecoregion and Ecodistrict Comparisons

A comparison of the natural disturbance regimes for the nine ecoregions (Table 1) and thirty-nine ecodistricts (Appendix VI) is summarized as follows and highlights the variability of climate and physiography in Nova Scotia.

Taiga (100) and Atlantic Coastal (800): Forest associations on 72% of the area in both these ecoregions originate from frequent stand level disturbances created by hurricanes and wind storms, insects, senescence, and occasionally fire. Boreal-like forests of balsam fir, white spruce, and black spruce with red maple and white birch occur on the zonal sites. Where soils are imperfectly to poorly drained black spruce and tamarack are found. Elsewhere the combination of extreme climatic conditions and edaphic site conditions creates extensive areas of barrens, wetlands, stunted tree growth (krummholtz), and shrubland.

Cape Breton Highlands (200): In this ecoregion two disturbance regimes create two extremely different forest communities on zonal sites. Balsam fir forests predominate on the zonal ecosections of the plateau portion and cycle through a frequent disturbance regime associated with the spruce budworm. On the slopes and ravines leading to the plateau shade tolerant hardwood forests thrive on the zonal ecosections and are maintained by gap disturbances in the canopy. Between these two zonal forest communities a narrow band of yellow birch and balsam fir create a transitional zonal forest community. The remaining ecosections have edaphic site conditions creating treeless wetlands and barrens on the plateau portion.

Nova Scotia Uplands (300) and Fundy (900): Infrequent and/or gap disturbance regimes dominate the landbase in these ecoregions, 80% and 89% respectively. Uneven-aged zonal forests of primarily shade tolerant hardwoods predominate while red spruce, hemlock, and white pine occur on moist soils of lower slopes and the steep slopes of river ravines. However, at the ecodistrict level, the frequent disturbance regime is prominent in both the St. Mary’s River (370) and Inverness Lowlands (320) ecodistricts, 57% and 49% of the area respectively, due to site conditions which create opportunities for frequent stand initiating disturbances such as fires (dry, shallow soils) and blowdown (moist to wet soils).

Eastern (400): This ecoregion is comprised of five ecodistricts which delineate uplands, drumlin fields and level or undulating topography. Fifty-five percent of the ecoregional landbase is mapped for the frequent disturbance regime, which predominates on the coarse, droughty soils that are found in the Eastern Granite Uplands (430) ecodistrict and on the moist to wet soils that occur in the Eastern Interior (440) ecodistrict. Infrequent and/or gap disturbance regimes are dominant on 41% of the area and develop forest associations typical of the Acadian Forest in the other three ecodistricts, especially on the better drained soils located on hills and drumlins.

Northumberland Bras d’Or (500): This lowland ecoregion has significant area underlain by moist, fine to medium textured soils on level to undulating topography that are susceptible to both drought and excessive moisture. This creates conditions for fire during the dry summer months and blowdown due to hurricanes and wind storms in the fall. These disturbances are frequent and stands of either short-lived intolerant species(jack pine, black spruce, white birch, aspen) or late successional species (red spruce) that seldom achieve their maximum longevity are created on 59% of the landbase . In addition, many areas have edaphic site conditions that favour black spruce and red maple. However, in the Cumberland Hills (540) and St. George's Bay (520) ecodistricts there are significant areas of well-drained soils where late successional forests (red spruce, hemlock, sugar maple, yellow birch) predominate that are infrequently disturbed, 72% and 77% of the landbase respectively, and develop uneven-aged structure through gap processes. These areas were favoured by the early settlers and cleared extensively for farming only to be abandoned in the 1900's and revert back to early successional old field white spruce forest communities.

Central Lowlands (600): This ecoregion is underlain by sedimentary sandstones and is comprised of a complex of rapidly to poorly drained, coarse to fine textured soils on level to gently undulating topography. The forest communities are primarily coniferous but where there is good soil drainage mixed forests of shade tolerant softwood and hardwood species predominate. Softwood forests of black spruce are common on the fine textured, imperfectly drained soils and are susceptible to both fires and wind storms and have been assigned a frequent disturbance regime (41% of the area). The shade tolerant softwood and mixedwood forests on well to moderately- well drained soils are less frequently disturbed and have been assigned the infrequent disturbance regime (46% of the area). On the best drained soils, usually on the steeper slopes, gap disturbed forests of tolerant hardwood will dominate (11% of the area).

Western (700): The province's largest ecoregion supports a predominantly coniferous forest where frequent (37% of the landbase) and infrequent (42% of the landbase) disturbance regimes create forest associations of pine, spruce, and hemlock. The sandy, granitic soils of much of this ecoregion have a low water holding capacity during the growing season and are prone to drought. Both white pine and red pine are adapted to these type of site conditions where frequent fires create suitable seedbeds. Black spruce and ericaceous shrubs are common associates of the pine. Extensive area is also comprised of moist to wet soils where frequent disturbances from hurricanes create forests dominated by red maple and black spruce. On the zonal sites forest associations of hemlock, red spruce, and white pine will develop. Gap disturbed forests of hemlock, red spruce, white pine and the shade tolerant hardwoods occur on 14% of the landbase, primarily the drumlins of the Lahave (740), Clare (730), and South Mountain (720) ecodistricts and on the north facing slopes of the Valley Slope (710) ecodistrict.

Ecosystem-based management incorporates the arrangement and abundance of old growth, age class, patch size, and species composition in order to maintain the natural ecology of a forested landscape. A knowledge of ecosystem dynamics, particularly how forest communities renew themselves after natural disturbances, is a prerequisite to designing appropriate silvicultural systems (Seymour & Hunter, 1999) and is the basis for an ecological forestry approach (Franklin *et al.* 2007). McRae *et al. (*2001) suggest that the recognition that natural forests are maintained by periodic events of stand-replacing disturbance caused by fire, windstorms, insect outbreaks, or pathogens is a cornerstone of ecological management. Franklin *et al.* (2007) further stress the importance of biological legacies, created by a tree regenerating disturbance, and the need to incorporate legacy management into harvesting prescriptions.

Spatial mapping of natural disturbance regimes provides an important tool for strategic forest planning at the landscape level. This mapping also allows forest operational planners to incorporate disturbance ecology into silvicultural prescriptions at the stand level. Matching treatment boundaries with enduring site and ecological features assists in planning for naturally structured landscapes with diverse early successional and multi-aged forest communities. Mapping of disturbance regimes can also be used in computerized models of forest succession where the impacts of forest management decisions can be examined on the future composition of the landscape. Nova Scotia's Ecological Land Classification (NSDNR 2006) and Forest Ecosystem Classification (Keys *et al.* 2003; Neily *et al.* 2006, 2007) can be used to map, plan, and apply forest management treatments reflective of natural disturbances. Adapting this current mapping to incorporate new research results is on-going and supports the concept of adaptive management to modify and improve management interpretations.

Finally, the evidence of impending climatic change is irrefutable. The best strategy for the inevitable changes in disturbance agents and regimes will be to impart ecosystem resilience. The adaptive capacity of ecosystems will be supported if the full range of native biodiversity, natural habitats, and ecological processes appropriate to the current climatic epoch are sustained. This strategy will provide ecosystems a means to maintain productive capacity and to adapt most efficiently and naturally, as the winners and losers of changing climate sort themselves out.

Table 1. Natural disturbance regimes summarized by ecoregion for Nova Scotia.

Ecoregion	Predominant Natural Disturbance Regime								
	Frequent		Infrequent		Gap Dynamic		Open Seral[1]		Total Area*
	ha	%	ha	%	ha	%	ha	%	ha
100 Taiga	30 862	72					12 285	28	43 147
200 C. B. Highlands	162 494	50	173		113 513	35	49 065	15	325 245
300 N. S. Uplands	179 757	19	156 907	16	610 878	64	6 086	1	953 628
400 Eastern	328 108	55	139 261	23	107 145	18	20 342	4	594 856
500 Northumberland Bras d'Or	476 746	59	5 7 148	7	253 032	31	20 452	3	807 378
600 Central Lowlands	157 783	41	175 706	46	41 826	11	8 638	2	383 953
700 Western	569 227	37	653 118	42	215 074	14	112 146	7	1 549 565
800 Atlantic Coastal	312 263	72	2 8 521	7			91 525	21	432 309
900 Fundy Coastal	13 783	10	3 5 957	26	88 204	63	1 025	1	138 969
Total*	2 231 023	43	1 246 791	24	1 429 672	27	321 564	6	5 229 050

[1] Area classified as edaphic conditions supporting community types such as barrens, bogs, swamps, rockland, shrubland, krummholtz.

* Total area does not include salt marshes, coastal beaches, dykelands, urban Halifax or inland water such as lakes, rivers and ponds.

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List of Common and Scientific Names

Trees

Balsam fir	*Abies balsamea* (L.) Mill.
Beech	*Fagus grandifolia* Ehrh.
Black spruce	*Picea mariana* (Mill.) BSP
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Eastern larch	*Larix laricina* (Du Roy) K. Koch.
Ironwood	*Ostrya virginiana* (Miller) K. Koch
Jack pine	*Pinus sylvestris* L.
Red maple	*Acer rubrum* L.
Red oak	*Quercus rubra* L.
Red pine	*Pinus resinosa* Ait.
Red spruce	*Picea rubens* (Sarg.)
Sugar maple	*Acer saccharum* Marsh.
Yellow birch	*Betula alleghaniensis* Britt.
White ash	*Fraxinus americana* L.
White birch	*Betula papyrifera* Marshall
White pine	*Pinus strobus* L.
White spruce	*Picea glauca* (Moench) Voss.
Wire birch	*Betula populifolia* Marshall

Shrubs

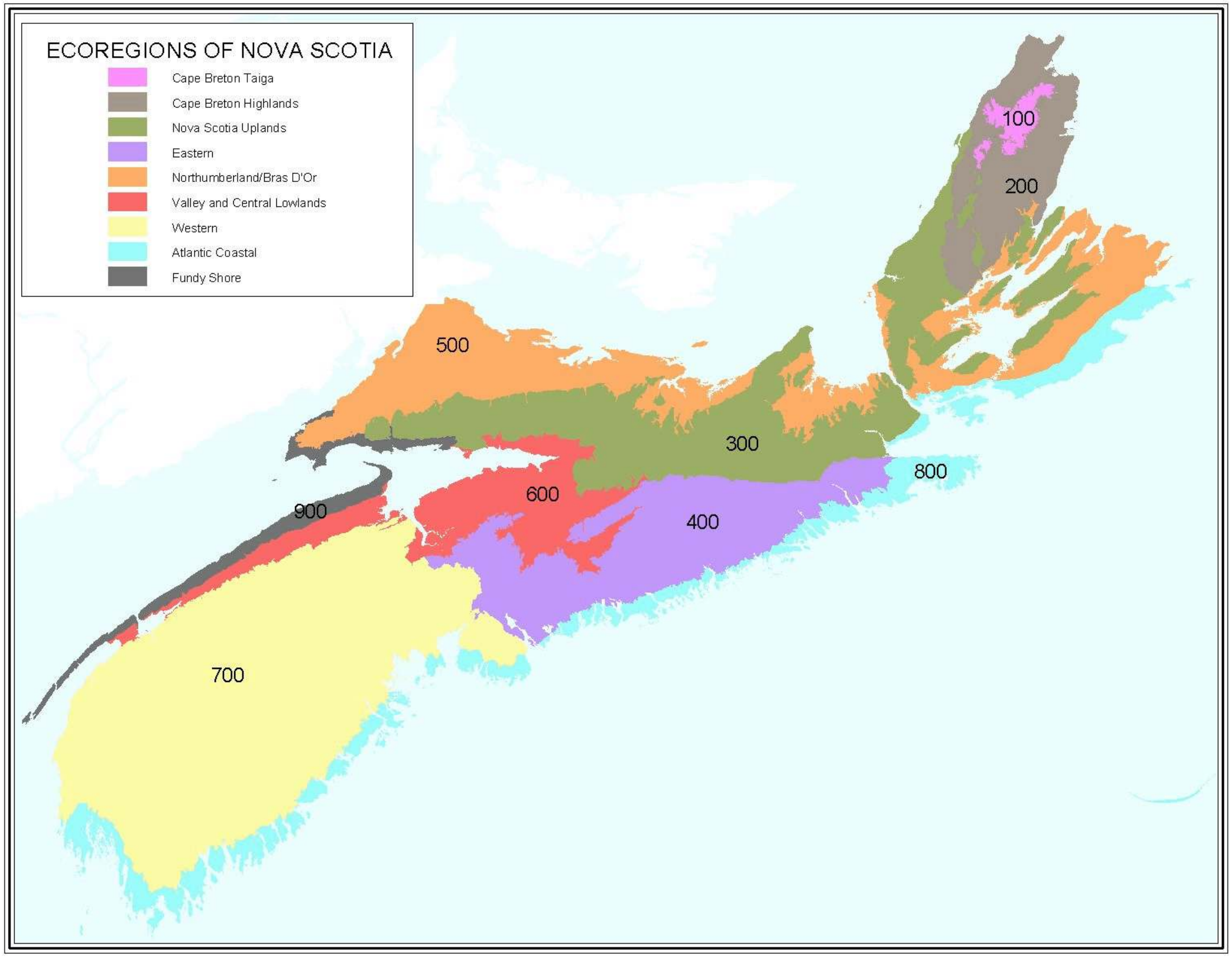
Blueberry	*Vaccinium* L. spp.
Huckleberry	*Gaylussacia baccata* (Wang.) K. Koch.
Kalmia	*Kalmia angustifolia* L. spp.
Labrador tea	*Ledum groenlandicum* Oeder
Rhodora	*Rhododendron canadensis* (L.) Torr.

Insects and Diseases

Beech bark canker	*Nectria coccinea var. faginata* Lohman, Watson & Ayers
Spruce beetle	*Dendroctonus rufipennis* (Kirby)
Spruce budworm	*Choristoneura fumiferana* (Clemens)
White-marked tussock moth	*Orgyia leucostigma* (J.E.Smith)

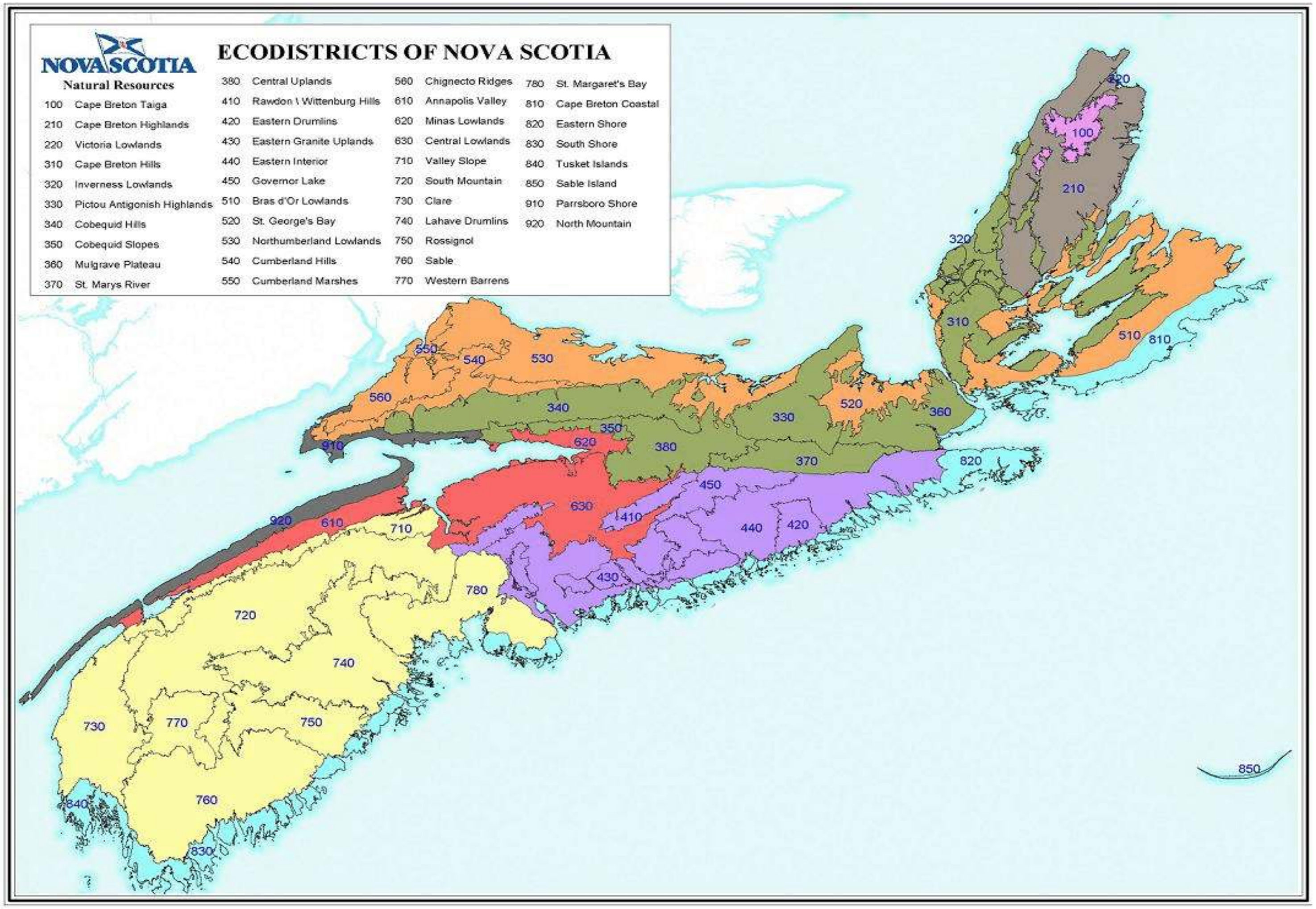
APPENDIX I

Ecoregions of Nova Scotia (NS DNR 2006)



APPENDIX II

Ecodistricts of Nova Scotia (NS DNR 2006)



APPENDIX III

Agents of Natural Disturbance in the Forests of Nova Scotia

Fire

> *From the end of the spring and during the summer and autumn, the thunder falls sometimes in fire and strikes in the woods, where everything is so dry that it continues there some three weeks or a month. Unless rains fall sufficiently to extinguish it, the fire will burn sometimes 10, 12, and 15 leagues of country. At evening and at night, one sees the smoke 10 and a dozen leagues away.*
>
> Nicolas Denys describing forest fires in Acadia (New France), 1672

Forest fires occur in late spring prior to green-up and throughout the summer, especially during periods of lower humidity and dryness. Human activities during these periods increase the probability of forest fires. Most fires kill both overstory and understory species with damage to the forest floor dependent on ground moisture conditions and the amount of fuel buildup.

Fire has been a disturbance agent in the forests of Nova Scotia since the last glaciation and a dominant disturbance since European settlement. Research by Green (1981) suggests that based on pollen and charcoal analyses in cores of sediment taken from lakes in southwestern Nova Scotia, large intense fires occurred 11 000 to 6 000 years before present (BP) with a resultant instability in forest community composition. Wein and Moore (1979) report that almost all paleoecologists who have examined lake sediments or bog profiles in the Maritime Provinces and New England have found evidence of fire in the form of charcoal. The use of fire by native peoples is not well documented and while researching the history of fires in the Kejimikujik National Park, Basquill et al (2001) report that they could find little conclusive information in the literature to confirm the use of fire, by first nations people, outside their encampments.

Generally the barrens of southwestern Nova Scotia have been considered the product of frequent fires, many of them human caused. Research by Strang (1969, 1972) in this area notes that “although fire is undoubtedly a potent factor in maintaining shrub cover, pollen analyses indicate that an open woodland developed many centuries ago in response to the soil conditions and the prevailing climate. The present shrubby vegetation is thus an expression of inherent site factors as well as of the effects of burning.”

Green (1981) concluded that for southwestern Nova Scotia the fire rotation period was about 400 years for the years 6600 to 2200 BP. Ponomarenko (2007) determined from examining soils and charcoal at several sites in Kejimkujik National park that four large-scale fires occurred 1500, 800, 500, and 250 years ago and that these fires occurred shortly after hurricanes and affected 10's of square kilometers. Ponomarenko (2007) reports that a large fire occurred in the eastern part of Kejimkujik between AD 1700-1764 and this supports the observations of Titus Smith who when travelling in Queens and Lunenburg counties, east of Rossignol, in 1801 reports an estimated 150,000 ha burned in 1720. In this case the fire was preceded by a hurricane. Throughout his traverse of western Nova Scotia, Smith repeatedly draws attention to the fire barrens and the extensive areas of burned forest.

The natural cause of ignition in Nova Scotia can be attributed to lightning strikes. Fire records of the Nova Scotia Department of Natural Resources between 1929-1999 (excluding 1931-1936) indicate that 240 forest fires (1%) were attributed to lightning strikes (3.4 forest fires per year). In New Brunswick lightning was the cause of seven percent of the province's forest fires between 1929 to 1975 (Wein and Moore 1977). Environment Canada weather data for 1998-1999 indicates that most of Nova Scotia receives .25 to 0.5 lightning to ground strikes per square kilometer per year with two thirds of all strikes occurring during June, July and August and most of these in the afternoon (Lanken 2000).

Throughout Nova Scotia Loucks (1962) noted the presence of fire origin species such as jack, red and white pine, red maple, wire and white birch, and red oak in his forest districts. Although he acknowledges that the occurrence of fire and its frequency has probably increased since European settlement the conditions conducive to fire are a product of the topography, soils and climate and that these conditions exist mainly in the lowland ecodistricts and western ecoregion. Fernow (1912) states "approximately one-fourth of the present forest area of the Province is semi-barren of commercial trees. This condition has been brought about by repeated fires in situations possessing naturally the coarser soils. Johnson (1986) states that "although most settlers tried to be careful with fire, burning only at what they considered to be safe times, fires often got out of control and burnt extensive areas". In the Atlantic Coastal ecoregion fires have been common but they appear to have been started by settlers to extend their pasture land (Loucks 1962). However, the presence of jack pine in several places on the Canso peninsula, and on Isle de Madame, suggests that the constant winds may create a droughtiness that is conducive to fire.

Insects and Diseases

Populations of native insects and diseases are usually present at low levels causing minor amounts of mortality. However, populations will reach epidemic proportions when trees and stands are weakened by other agents such as wind, fire, senescence, or site conditions and forest losses can be extensive. The severity and frequency of insect and disease epidemics are primarily influenced by climate, age class and species composition and genetics. However, post settlement forest harvesting and fire suppression have altered the patterns of natural disturbance on the landscape by native insects and diseases.

Several pests, for example, the spruce beetle, white- marked tussock moth caterpillar and spruce budworm, have the capability to destroy entire stands. Such population explosions can be responsible for large scale disturbances especially in ecosystems that are comprised, almost entirely, of the preferred food group. The historical records of insect outbreaks are not well recorded since in many cases the susceptible trees, for example, balsam fir, were of little or no use to the early settlers and infestations were ignored. According to federal scientists at the Canadian Forestry Service in Fredericton, there have been several spruce budworm outbreaks in recent times, three in the 1700's, four in the 1800's and three in the 1900's (Johnson 1986).

The spruce budworm and the recurring cyclic nature of infestations has a significant influence on the successional stages and composition of the spruce-fir forests in Nova Scotia. Mature and overmature balsam fir and white spruce are its preferred food source, so are the most susceptible to defoliation. Red spruce and black spruce are less susceptible to defoliation but not immune.

Methven and Kendrick (1995) suggest that the natural rotation cycle for budworm disturbances would be linked to the life span of balsam fir and at a spatial scale of thousands of square kilometers in which the forest would be a single age class of fir that would advance over time until the next outbreak. In Nova Scotia pure balsam fir ecosystems are found primarily in the N.S. Uplands and Cape Breton Highlands ecoregions and occupy approximately 235,000 hectares or 4.5% of the provincial forest.

Forest pathogens in Nova Scotia's forests seldom cause mortality in mature forests but can significantly affect tree growth and development. The numerous blights, rusts and fungal infections present in the forests cause mortality with repeated infection over several years and pathogens generally follow other agents such as insects, environmental and site stresses, or animal predation which have weakened the tree and created conditions that will eventually lead to mortality. As such forest diseases are significant in gap disturbed forests where individual tree mortality creates opportunities for a younger cohort to enter the canopy.

Hurricanes and Windstorms

"the occurrence at times of furious gusts of wind,
which overthrow trees, but they are not of long duration."
Nicolas Denys describing wind storms in Acadia (New France), 1672

As a peninsula jutting out into the Atlantic Ocean, Nova Scotia's forest are vulnerable to storms and hurricanes tracking up the eastern seaboard of North America. The tracks of these hurricanes can include a width of as little as 50 - 75 miles or as wide as 400 miles (Dwyer 1958). Forest damage from storms associated with the provinces's Maritime climate is a year round threat. Forest stands are particularly exposed to hurricanes during the late summer and early fall but hhurricane force winds may be expected at almost any season of the year, and are a threat to all classes of forest (Loucks 1962).

Winds as a natural disturbance cause uprooting and stem breakage in forest stands and are a vital process in the ecology of the provincial forests either as catastrophic stand initiating events or as small, gap-type disturbances in the canopy. Tree susceptibility is dependent on site conditions (soil drainage, slope position/exposure, rooting depth), tree physiology (crown size, crown/diameter ratio), time of year (leaves on or off, snow loads, soil moisture), stand conditions (stocking, openings, edge exposure), and tree vigour (stem rot, disease cankers, root rot). Shallow rooted softwood forests on soils saturated with the fall rains and still unfrozen are particularly vulnerable to extensive blowdown. The intensity of the uprooting is evident in the resulting pit and mound microtopography which remains visible for centuries after the event. On the Cape Breton Highlands, Loucks (1962) observes that the characteristic inverted soil profiles indicate that old growth forests are normally destroyed by wind, if not by insect attack. Other winter storms associated with the freezing and thawing cycles of the Maritime climate and the accompanying freezing rain and snow can cause extensive damage to hardwood forests, especially those at the higher elevations. Ice storms generally occur from late November to late

March. Most damage, because of the weight of the ice, occurs from breakage of limbs or whole trees and is particularly evident in the hardwood forests. In Nova Scotia the situation is aggravated by strong winds which accompany these ice storms or follows shortly thereafter with additional breakage, uprooting and snapping of the stem.

Titus Smith witnessed extensive blowdown on his western tour in 1802 - “in some places, particularly north of St. Margaret’s Bay, there were miles of country where nearly all the trees had been blown down in the Great Storm of September 25, 1798. At times it took Smith and Carter [his assistant] a half hour to travel a hundred yards because of these fallen trees. The forest destruction from this hurricane covered an area of over a million acres, stretching from Porter’s Lake, Halifax County on the east to Shelburne County on the west and north as far as Windsor” (Johnson 1986). Smith also reported of an area 20 miles by 30 miles (east of Rossignol to east of Middle River, Lunenburg County) of even-aged hardwoods, chiefly beech, yellow birch, sugar maple, ironwood and ash [white]. According to the local settler, as told to him by the natives, there had been an extensive blowdown 80 years earlier followed by a large fire the following year. This is an early verification that fire hazard following blowdown is exacerbated by the heavy fuel loads of downed material that dry quickly and become susceptible to ignition by lightning during extended periods of summer dryness. Dwyer (1958) in determining the extent of blowdown in the red spruce forests of the St. Margaret’s Bay area after hurricanes Carol (Sept.7, 1953) and Edna (Sept.11, 1954) reported approximately half of the area affected by the hurricanes received blowdown damage between 20-60% of the stand.

Other Natural Disturbances

Other forms of natural disturbance on forested ecosystems include - environmental stress such as drought and temperature extremes, geological disturbance such as sinkholes and earthquakes, and climatic disturbance such as flooding, snow and ice.

On steep slopes landslides can create mass movements of materials and may occur in the form of a rock fall along a cliff or escarpment, and as a gradual slide or slump. Talus slopes are particularly common on the well drained steep slopes of the Cape Breton Highlands ecodistrict. The Grande Falaise, just North of Cheticamp, is an example. Other areas of talus slope can be noticed along the south facing slope of the North Mountain ecodistrict and throughout the Cobequid Mountains.

Disturbance caused by animals is usually confined to individual trees. Beaver are the most recognizable example of animal disturbance to a forest stand. Their cutting of trees and flooding of land creates scattered pockets of disturbance across most of the province. Other animals frequently causing damage to individual or small patches of trees include porcupines, snowshoe hares, and bear. While damage is not always life threatening it may create a situation where a secondary agent could kill the tree. Recently, moose populations on the Cape Breton Highlands, through excessive browsing of regenerating tree species following the spruce budworm epidemic of the late 1970's, have altered natural succession by creating large areas extensively covered by grass species.

APPENDIX IV
Zonal Forests by Ecodistrict

A correlation of the Ecological Land Classification (ELC) Ecodistrict (NS DNR 2006) with the Forest Districts and Zonal Forest Species from Loucks (1962).

ELC Ecodistrict	Loucks District	Dominant [1] Zonal [2] Ecosections[3]	Zonal Condition %[4]	Loucks Zonal Forest Species[5]	ELC Zonal Forest Species
100 C.B. Taiga	C.B. Plateau	WMKK, WMHO	29	bS, wS, bF, wB	bS, bF, wS
210 C.B. Highlands	C.B. Highland	WMKK, WCKK, WMHO WMDS, WCDS	86	bF, wS, bS sM, yB, Be	bF, wS, bS sM, yB, Be
220 Victoria Lowlands	Guysborough - Bras d"Or	WCHO, WMKK, WCKK, WMHO	71	sM, yB, Be	rO, wS, bF, bS sM, yB, Be
310 C.B. Hills	C.B. Hills	WMKK, WMDS, WMHO, WMRD	64	rM, sM, yB, Be wS, bF	sM, yB, Be
320 Inverness Lowlands	C.B. Hills	WCHO, WMHO, WMKK, WCKK	32	rM, sM, yB, Be wS, bF	sM, yB, Be
330 Pic/Ant Highlands	Pictou Uplands	WCKK, WCHO, WCDS	67	sM, yB, Be	sM, yB, Be, rS, eH
340 Cobequid Hills	Cobequid Mountain	WCKK, WCHO, WCDS	83	sM, yB, Be	sM, yB, Be, rS, eH
350 Cobequid Slopes	Cobequid Mountain	WCKK, WMHO, WMKK, WCHO, WMDS	46	sM, yB, Be	sM, yB, Be, rS, eH, wP
360 Mulgrave Plateau	Guysborough - Bras d"Or	WMKK, WMHO, WMDM	56	sM, yB, Be eH, wP, rS	sM, yB, rM
370 St. Mary's River	St. Mary's River	WMHO, WMDM, WMKK	59	rS, eH, wP	bS, wP, rS, sM, yB, Be
380 Central Uplands	St. Mary's River	WMKK, WMHO, WCKK, WCHO	35	rS, eH, wP	rS, eH, sM, yB, Be
410 Rawdon/W'burg Hills	Musquodoboit Hills	WMKK, WMHO	63	sM, yB, Be	sM, yB, Be, rS, eH, wP
420 Eastern Drumlins	Sheet Harbour	WMDM, WMHO, WMKK, WMRD	27	rS, bF, yB, eH, sM, yB, Be, rM	sM, yB, Be, rS, eH

430 E. Granite Uplands	Sheet Harbour	WCKK, WCRD, WCHO	48	rS, bF, yB, eH, sM, yB, Be, rM	rS
440 Eastern Interior	Sheet Harbour	WMKK, WMHO, WMRD	35	rS, bF, yB, eH, sM, yB, Be, rM	rS, wP
450 Governor Lake	Musquodoboit Hills	WCKK, WMKK, WMHO, WCHO	46	sM, yB, Be	sM, yB, Be, rS, eH
510 Bras d'Or Lowlands	Guysborough - Bras d"Or	WMKK, WMDM, WMHO, WMRD, WCHO	41	sM, yB, Be, eH, wP, rS	sM, yB, Be
520 St. George's Bay	East River - Antigonish	WMHO, WMKK, WCHO, WCKK	18	sM, Be	sM, yB, Be, bS, wP
530 Northumberland L.L.	Northumberland Shore	WMHO, WMKK, WCKK	21	rS, eH, wP	rS, eH, sM, yB, Be
540 Cumberland Hills	Oxford	WCKK, WCHO, WMKK, WMHO	76	sM, yB, Be, eH, rS	rS, eH, sM, yB, Be, wP
550 Cumberland Marshes	Chignecto	WMHO	3	rS	rS
560 Chignecto Ridges	Oxford	WCHO, WCRD	29	sM, yB, Be, eH, rS	rS, bS, wP
610 Annapolis Valley	Annapolis	WMHO	18	rS, eH, wP	rS, eH, wP
620 Minas Lowlands	Windsor - Truro	WMHO, WCHO, WMKK	46	bS, rS, eH, wP, bF, rM, wB	rS, eH, wP sM, yB, Be
630 Central Lowlands	Windsor - Truro	WMKK, WMHO	5	bS, rS, eH, wP, bF, rM, wB	rS, sM, yB, Be
710 Valley Slope	Annapolis	WMHO, WCKK, WMKK, WCHO, WMDS	56	sM, Be, rS, eH	rS, eH, wP sM, yB, Be
720 South Mountain	Fisher Lake - Halifax	WCHO, WCKK	37	rS, eH, wP	rS, eH, wP
730 Clare	Wentworth Lake	WMDM, WMHO	40	sM, Be, rS, eH	sM, Be, rS, eH
740 Lahave Drumlins	Lahave	WMDM, WMHO	34	sM, Be, rO	rS, eH, wP, sM, yB, Be
750 Rossignol	Mersey River	WMHO	43	bS, rS, eH, wP, rP, bF	rS, eH, wP

760 Sable	Clyde River	WMHO, WCHO	14	wP, rO	rO, wP, rP, eH, rS
770 Western Barrens	Fisher Lake - Halifax	WCHO	43	rS, eH, wP	rO, rP, wP
780 St. Margarets Bay	Fisher Lake - Halifax	WCKK, WCHO, WMHO	61	rS, eH, wP	rS, eH, wP
810 Cape Breton Coastal	Eastern Shore	WMKK, WMDM, WMHO	34	bS, bF	bS, wS, bF
820 Eastern Shore	Eastern Shore	WCKK, WMKK, WCHO, WMRD, WMDM, WCRD, WMHO	55	bS, bF	bS, wS, rM, yB
830 South Shore	Cape Sable	WMHO, WMDM, WMRD	19	bS, bF, wS	bS, wS
840 Tusket Islands	Cape Sable	WMHO, WCHO, WMDM	39	bS, bF, wS	bS, rS, wS
910 Parrsboro Shore	Chignecto	WMKK, WCKK, WMDS, WCHO, WCSM, WCRD, WCDS	64	rS, wS, bF	rS, eH, wP, bS sM, yB, Be
920 North Mountain	North Mountain	WMHO, WMKK, WMDS	82	rS, sM, Be	rS, eH, wP, sM, yB, Be

[1] Ecosections occupying more than 2 % of the ecodistrict.
[2] Zonal condition is defined by Loucks (1962) as a well-drained, sandy loam on a mid-slope position.

[3] WCDM - well drained, coarse textured soils on drumlin topography
WCDS - well drained, coarse textured soils on dissected or steep slopes
WCHO - well drained, coarse textured soils on hummocky topography
WCKK - well drained, coarse textured soils on hilly topography
WCRD - well drained, coarse textured soils on ridged topography
WMDM - well drained, medium textured soils on drumlin topography
WMDS - well drained, medium textured soils on dissected or steep slopes
WMHO - well drained, medium textured soils on hummocky topography
WMKK - well drained, medium textured soils on hilly topography
WMRD - well drained, medium textured soils on ridged topography

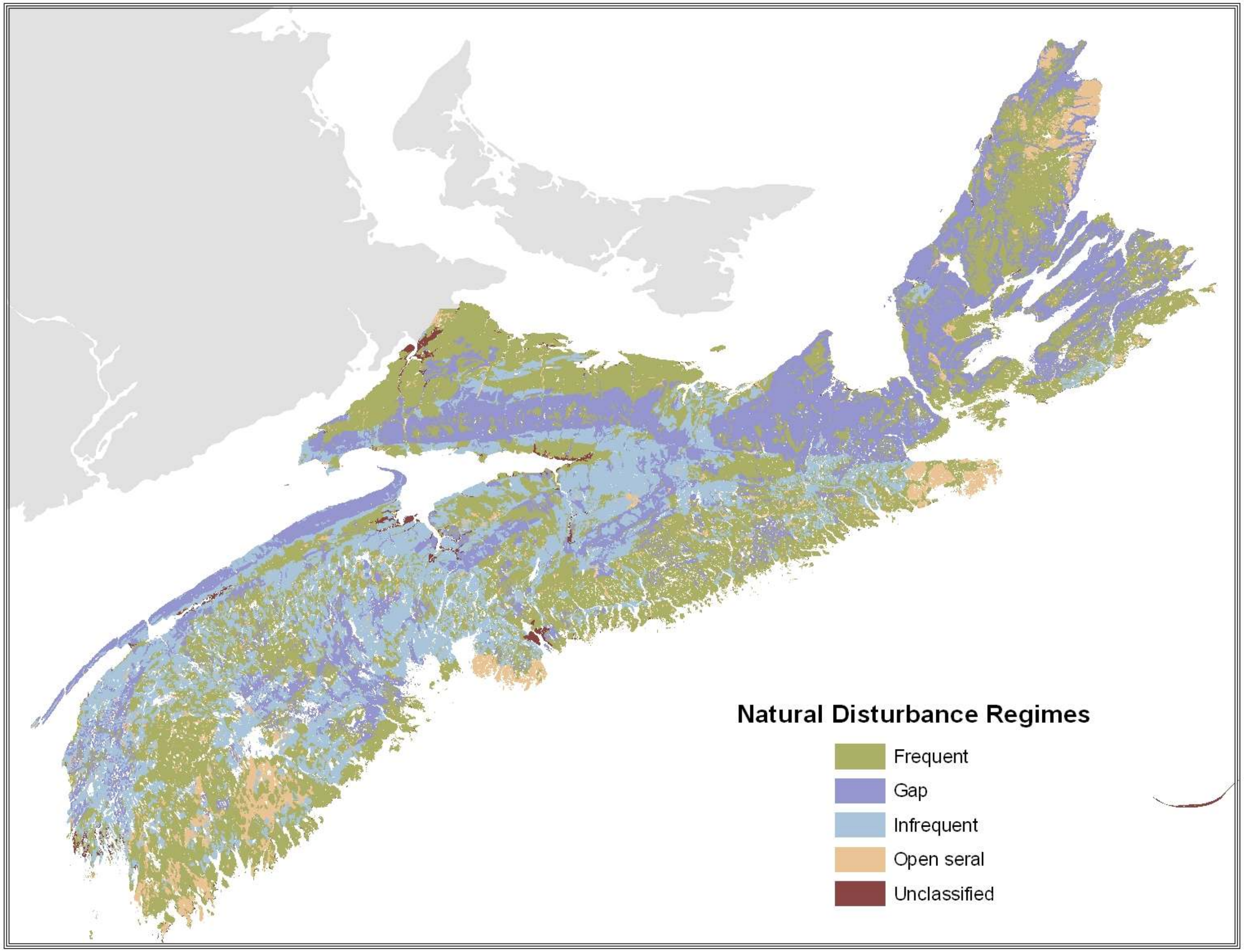
Coarse textured soils are loamy sands and sandy loams to loams.
Medium textured soils are loams to sandy loams and silt loams.

[4] Per cent of ecodistrict in the dominant zonal ecosections.

[5] bF - balsam fir
bS - black spruce
eH - eastern hemlock
rM - red maple
rO - red oak
rS - red spruce
sM - sugar maple
wB - white birch
wP - white pine
wS - white spruce
yB - yellow birch

APPENDIX V

Natural Disturbance Regimes Applied to the Ecological Land Classification for Nova Scotia by Ecosection


Natural Disturbance Regimes
Frequent
Gap
Infrequent
Open seral
Unclassified

APPENDIX VI

Natural Disturbance Regimes Summarized by Ecodistrict

Ecodistrict	Natural Disturbance Regime								
	Frequent		Infrequent		Gap Dynamic		Open Seral [1]		Total Area*
	ha	%	ha	%	ha	%	ha	%	ha
100 C.B. Taiga	30 862	72					12 285	28	43 147
210 C.B. Highlands	162 494	52			101 814	32	49 065	16	313 373
220 Victoria Lowlands			173	1	11 699	99			11 872
310 C.B. Hills	41 803	17	4 326	2	195 792	81	1 183	<1	243 104
320 Inverness Lowlands	20 253	49			19 628	47	1 737	4	41 618
330 Pic/Ant Highlands	20 305	15			112 036	84	347	1	132 688
340 Cobequid Hills	24 228	13	4 427	2	160 755	85	47	<1	189 457
350 Cobequid Slopes	54	<1	27 998	76	8 909	24			36 961
360 Mulgrave Plateau	21 020	21	3 932	4	74 012	74	820	1	99 784
370 St. Mary’s River	46 337	57	22 250	27	11 738	14	1 458	2	81 783
380 Central Uplands	5 757	4	93 974	73	28 008	22	494	1	128 233
410 Rawdon/W’burg Hills			16 798	28	43 966	72	200	<1	60 964
420 Eastern Drumlins	45 105	57	2 587	3	29 571	37	2 168	3	79 431
430 E. Granite Uplands	51 962	97			1 177	3	433	<1	53 572
440 Eastern Interior	212 916	62	93 376	27	19 304	6	15 563	5	341 159
450 Governor Lake	18 125	30	26 500	44	13 127	22	1 978	3	59 730
510 Bras d’Or Lowlands	119 941	45			133 976	50	12 061	5	265 978
520 St. George’s Bay	20 098	23	165	<1	67 346	77	221	<1	87 830
530 Northumberland L.L.	235 919	84	37 046	13	2 825	1	4 644	2	280 434
540 Cumberland Hills	24 648	27	19 056	21	46 343	51	298	<1	90 345
550 Cumberland Marshes	6 309	71	544	6			2 073	23	8 926
560 Chignecto Ridges	69 831	95	337	<1	2 542	3	1 155	2	73 865

	Frequent		Infrequent		Gap Dynamic		Open Seral [1]		Total Area*
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**
610 Annapolis Valley	37 939	45	41 348	49	3 672	4	1 013	1	83 972
620 Minas Lowlands	36 020	93	1 157	3	1 074	3	283	<1	38 534
630 Central Lowlands	83 824	32	133 201	51	37 080	14	7 342	3	261 447
710 Valley Slope	800	<1	64 090	73	22 820	26	370	<1	88 080
720 South Mountain	208 510	49	181 165	43	15 838	4	15 339	4	420 852
730 Clare	16 953	10	95 113	55	52 850	31	7 923	4	172 839
740 Lahave Drumlins	36 762	15	94 075	38	110 198	44	6 425	3	247 460
750 Rossignol	28 048	29	59 173	61	2 471	3	6 648	7	96 340
760 Sable	164 872	59	44 000	16	2 892	1	65 671	24	277 435
770 Western Barrens	68 493	91					6 965	9	75 458
780 St. Margarets Bay	44 789	26	115 502	68	8 005	5	2 805	1	171 101
810 Cape Breton Coastal	90 554	84	12 011	11			5 851	5	108 416
820 Eastern Shore	99 953	62					61 080	38	161 033
830 South Shore	104 936	82					23 042	18	127 978
840 Tusket Islands	16 820	48	16 510	47			1 552	5	34 882
910 Parrsboro Shore	13 783	34	20 170	50	5 941	15	492	1	40 386
920 North Mountain			15 787	16	82 263	83	533	1	98 583
TOTALS	2 231 023	43	1 246 791	24	1 429 672	27	321 564	6	5 229 050

[1] **Area classified as edaphic conditions supporting community types such as barrens, bogs, swamps, rockland, shrubland, krummholtz.**

*** Total area does not include salt marshes, coastal beach, dykeland, urban (Halifax) or inland water such as lakes, rivers and ponds. Data updated December 9, 2005**