Peer Review of Draft Document: *Natural Disturbance Ecology in the Forests of Nova Scotia (Neily, Quigley, and Stewart - October, 2004)*

Obtained through Freedom of Information Request to NSDNR, July, 2006

March 16, 2005

SUMMARY (For those of you who do not wish to read the whole review! There is much overlap of information between sections - I apologize for this - I could only work on this review in a piecemeal fashion)

(1) This paper is based on a very selective literature review and therefore one does not appreciate the total scope of the subject
(2) The paper often presents data/information that is contradictory.
(3) The conclusion that nearly 50% of our provincial forested landscape is prone to frequent stand initiating disturbances is very questionable and is challenged in this review document.
Sentence deleted by FOIPOP officer

Introduction

A general comment first - the somewhat detailed references to DNR history, policies, and acts are irrelevant to the topic of this paper and thus should be deleted.

Good science is achieved by building upon the work of previous scientific studies. A key component of this is a comprehensive literature search. The authors of this document did not undertake a comprehensive literature review on this subject; the document is based, in my view, on a very limited and selective literature search. Important scientific information with respect to the state of the pre-European forests is virtually ignored, having a focus on disturbances associated with 400 years of European occupation.

Sentence deleted by FOIPOP officer
For example, the following quote from the document *Forest Ecosystem Management Plan - Mulgrave Plateau Ecodistrict - Draft, July 27, 2004,* as well as in this document under the 'Disturbance Ecology' section: "Natural disturbances are caused by agents that *abruptly* change existing conditions and initiate secondary succession to *create new ecological communities* [italics mine]" indicates an insufficient grounding in 100 years of ecological and botanical research. First, there are gradients of natural disturbances, from inconspicuous endogenous senescence of a single individual to much rarer catastrophic community mortality - in other words, not all disturbances are *abrupt* in the sense that is implied in the above quote. Second, certainly non-catastrophic, and in many cases also catastrophic, disturbances **do not necessarily create** new ecological communities in terms of species composition. There are many factors involved - the size of the disturbance, propagule availability and timing, chance, etc. - in determining the next vegetation type following a particular disturbance. In many cases, the pre-disturbance community type, especially if the more competitive climax species are involved, can perpetuate itself. Many foresters, also recognizing this fundamental ecological process, endeavour to mimic, through shelterwood

harvesting practices, the small-gap to large-gap disturbances for many of our climax forest types (eg. sugar maple; red spruce). In areas where clearcutting and planting inappropriate species has occurred, the pre-disturbance climax species has been observed in mant instances to regenerates and take over the planted seedlings (eg Cobequid Hills tolerant hardwoods and red spruce forest types). As world-renown ecologists Bormann and Likens (1979)(of Hubbards Brook Ecosystem Study fame) states: '...exogenous [from outside the community and typically large-scaled - A.L.] disturbances are not universal and that an environment in which a steady state could occur does in fact exist".

'Disturbance Ecology' **Section**

The authors rely heavily on a single paper - Foster (2000) - in developing this section. Foster (2002) who argues that we can anticipate future changes in the natural environment and that we have no ability to recreate the past. True on the first point but only partially true on the second! It is probably true that the first wave of intensive European activities exterminated some of the rare to uncommon species. These cannot be restored. However, there is ample opportunity in the least disturbed areas of the Province (of which we have many - many regions of the Province were not farmed; several regions have had only one or two episodes of forest harvesting; and much of northern Cape Breton Island is in a virgin state) where we can actively restore the forest ecosystem to something fairly close to the conditions of the pre-European settlement forest simply by favouring the climatic climax tree species. Given time, other life-forms, as well as natural processes, should return to a somewhat similar condition. The reason that restoration is possible is that natural ecosystems are self-organizing entities that have the ability to maintain themselves through positive and negative feedback loops and inherent internal homostasis, despite sometimes dramatic changes in the environment (Kay et. al. 2000). Kay et. al. (2000) state that it is: '...not about maintaining the ecosystem in a specific state or even configuration. Rather it is about maintaining the integrity of the process of self-organization'. As the authors have rightly documented the conclusions of Roland and Smith (1969) - that 'vegetation responded to climate, which has not changed drastically since the first trees appeared'. The ecological amplitude and competitiveness of our temperate climax species have allowed them to maintain dominance over early successional boreal species over much of the provincial landscape. The point is that we are not trying to preserve the pre-European forest but simply to get it back on its natural track or trajectory from which it was derailed for the past 400 years. From this restoration mode, we can then allow the forest ecosystem itself adjust to any future changes in the environment. In fact, this restoration is being carried out at this very moment on many small private woodlots throughout the Maritimes and other jurisdictions across North America.

Much of Foster's paper focusses on New England, much of which is outside of the Acadian Forest Region and thus a very distinct forest region. I would suggest that these two forest regions are not at all similar, from ecological, pre-contact aboriginal land-use, and post-European land-use perspectives. This view is supported by Backman (1984), Cogbill et. al. (2002), and Seymour et. al. (2002), amongst many others. Cogbill et. al. (2002), using original land grant surveys covering much of New England, has been able to document a very distinct 'tension zone' separating northern hardwood (Acadian Forest Region) and central hardwood forests (central and southern New England). Certainly southern and central New England, situated further south, has a warmer and somewhat drier climate, resulting in a greater propensity for natural fires. The region is also closer to the centre of the hurricanegenerating zone than Nova Scotia. Adding other ecological variables to the mix, it becomes clear that this tension zone between the two regions is real.

Pre-contact aboriginal land-use was also significantly different. The aboriginal ‘fishers’ of the Acadian forest were fewer in numbers and nomadic, with little intentional use of fire. Central and southern New England, in contrast, had a much larger native population which were somewhat sedentary as they utilized agriculture and fire to a certain degree. This resulted in a significant pre-contact land-use difference in the natural landscapes of the two forest regions. In Wein and Moore (1979), we find the following: “Although there is much evidence for the use of fire [by the natives] farther south, ‘Evidence for the deliberate use of fire by the Indians in northern New England and the Adirondacks seems to be lacking’ (Day 1953, p. 338). We have found no other information for Nova Scotia that would cause us to disagree with this statement. Livingstone (1968) noted that early human occupation of Nova Scotia had no noticeable effect on forest composition, as measured by pollen analysis in sediments, until recent times when agriculture was introduced by Europeans”.

Most of New England was intensively farmed; for example, by 1875, 68% of Rhode Island was under cultivation (Whitney 1994). At the height of agricultural land-use in Nova Scotia, only 20% was used for that purpose (Fernow 1912).

The so-called ‘pre-European settlement forest’ was certainly a point-in-time; however, it is quite conceivable that it was an extended point-in-time. Our suite of current climatic climax species began entering Nova Scotia fairly early, following the retreat of glacial ice. ‘First appearances’ (years before present [BP]) of our current climatic climax and subclimax species are as follows: eastern hemlock - 10,500 BP; sugar maple - 10,500 BP; American beech - 8,800 BP; ashes - 11,500 BP; red oak - 12,800 BP; and white pine - 12,100 BP (Green 1987). Between 13000 and 9000 years BP, white pine and red oak had become well established in the Province. Hemlock, beech, sugar maple, and elm were firmly entrenched in our area between 9000 and 4000 years BP (reached northern Cape Breton Island 4000 yrs BP.). Obviously, over this time frame, there have been oscillations (eg. decline and resurrection of hemlock between 3000 and 400 BP and of beech between 800-150 BP - declined but still major species in the composition of the forests [Green 1987]; Smith [1801-1802] writes that ‘beech forms the greater part of the woods...what is called hardwood land being generally covered with beech, with smaller proportion of birch [yellow?] and maple [sugar?]’); however, the fact remains that our climatic climax species have persisted and, as best as can be determined, dominated our provincial landscape over the past several millennia (Mott 1975; Green 1987) and are still a significant component of our forests today. Delcourt and Delcourt (1987) summarizes the paleoecological history of northeastern North America: “The last major immigrations of tree taxa resulted in progressive increases in importance of deciduous tree taxa during the last 7000 years....maximum vegetational change, in terms of rate of species turnover, occurred during the early Holocene, with overall forest composition tracking towards equilibrium by late-Holocene. Pollen grain analysis by Toner (1984) concluded that a slight trend towards a more boreal-type forest, due to a cooler climate, was evident in the Isthmus of Chignecto lowlands area but nowhere else in the Maritimes. Thus there is no definitive evidence in the scientific literature that points to a change in the composition of our provincial forest vegetation as a result of a changing natural environment, certainly over short time-frames, and only over much longer time-frames of many tree generations (ie. several millennia). However, over the past 400 years, our forest has changed dramatically due to human interventions, not due to a changing environment. Therefore, our anthropogenically-induced, present-day fire, windthrow, and insect disturbances (Holling

1978; Blais 1983) cannot be considered ‘natural’ in the same sense as their pre-settlement counterparts and as such cannot be used as surrogates. At present, there are a great many ecologists who would only partially agree with Foster’s position. There is an abundance of scientific literature that could be referenced here to argue against fully accepting Foster’s and the authors’ position. Seymour et. al. (2002), in my view, quite rightly “ adopt Hunter’s (1996) definition of ‘natural’ as meaning ‘without human influence, and accept that the condition of the forest before European colonization is the best modern surrogate for this condition [in northeastern North America]”.

The literature suggests that at the time of European settlement, we had a forested landscape dominated by our current climatic climax species, much of which was in an older state of community development. Based on original land grant surveys at or near the time of European settlement, much of northeastern North America (Nichol’s [1935] ‘Hemlock - White Pine - Northern Hardwoods Region which includes the Acadian Forest) was dominated by older, climax species forests. The authors totally omit from their paper the valuable information (contained in the original land grant surveys) regarding the status of the forests prior to pre-European settlement. Studies by Lorimer (1977) in Maine and Lutz (1996) in New Brunswick are but a few examples of this important information source. Original land grant information for Cape Chignecto Provincial Park, while sparse, again follows this same trend. These studies clearly show that the pre-European settlement forest, over virtually the entire northeastern North American continent, consisted of large contiguous tracts of older climax forests.

Another major omission in this document is the historical work of Nicholas Denys. Arriving in the New World in 1632, Denys was a fisheries/timber ‘broker’ for the French government and has been depicted by Ganong (editor of Denys’ book, 1908) as a ‘very matter-of-fact’ person (p. 18). His role in colonizing North America was secondary and thus he made little effort to glamourize the New World in order to seduce Old World citizens to emigrate to the new land of abundance. His primary concern was the economic value of Nova Scotia’s natural resources (‘...it is necessary to speak of the land, of the greater part of the woods which it bears, and of the profits which can be derived from them.’) and as such probably gives a fair assessment of the natural condition of Acadia at the very beginnings of European settlement. While acknowledging destructive disturbances, Denys describes a landscape that is largely forested - with significant forests in terms of abundance, stature, and climax species.

In volume II of his report, Denys describes the natural history of the region. On page 395, he describes what he thinks the natural disturbance regimes types are: “... the occurrence at times of furious gusts of wind, which overthrow trees, but they are not of long duration.”; “...the thunder falls sometimes in fire and strikes the woods, where everything is so dry that it continues there some three weeks or a month. Unless rain falls sufficiently to extinguish it, the fire will burn sometimes ten, twelve, and fifteen leagues of country.” These are his only references to forest disturbance. However, on page 377, Denys provides a general statement regarding the inland forests of the Province: “...they [the coastal forests] are as nothing in comparison with those which are inland and on the upper parts of the rivers....The trees [there] are very much more beautiful in height and thickness.... The lands there are also much better, and easier to clear than on the margins of the sea, and the country is fine.” It is just as conceivable that some of the fires that Denys observed, rather than being of natural causes, were simply the result of escaped native campfires or escaped fires from the burning of French outposts/summer fishing/timber settlements by New England raiders. Coastal forests worldwide, for the most part, are considered much less productive than inland forests due to much harsher environmental conditions. Interestingly, Denys made 40 notations specific to the vegetation character of the Province's coastline. All notations, except three, describe these coastal forests throughout as " fine and good lands, with an abundance of good woods of all kinds [pines, firs (eastern hemlock, all spruce, and balsam fir), maples, birches, and oak are most often cited]"; "very fine and good woods"; the trees are very fine". There are two references to Atlantic coastal islands which have "upon them only moss; others have heathers or low shrubs; others have little firs, very low and much branched". (p. 156-157) The only other area noted by Denys as being of poor quality with respect to forests is the coastline between Cape North and Cheticamp which "is nothing but rocks covered with firs, intermingled with some little birches" (p. 185). Nowhere along the coast does Denys mention the occurrence of fire, windthrow, or barrens.

In summary, Nicholas Denys' historical account of our Province's forests at the beginnings of European settlement, coincides remarkably well with the scientific data available to date - both painting a picture of significant amounts of older climax forests.

***'Natural Disturbance Regimes in Nova Scotia'* Section**

The authors recognize five natural disturbance regimes in the Province. First of all, I would suggest that the fifth disturbance regime - the open seral maintaining disturbance - should be deleted as it is a truly non-forest ecosystem (possible eg. Canso coastal barrens; talus slopes) or should be amalgamated with the frequent stand-initiating disturbance regime (eg. very slowly regenerating Tobeatic barrens).

Second, it has always been my view that frequent stand initiating natural disturbances are very rare in Nova Scotia. For the most part, this disturbance type is confined to the boreal balsam fir forest of the Cape Breton Highlands plateau. In my view, there are only a handful of site types in Nova Scotia where geomorphology, soils, climate, etc., create the conditions that permit the frequent, stand-replacing disturbance of ecological processes and hence produce a non-climatic climax or non-subclimax (eg. edaphic climax) vegetation. Some examples are: jack pine on Target Hill and a few other prominent granitic knobs in Halifax County; the pines on the sand plains of Annapolis Valley; black spruce-jack pine on the sand plain near Oxford; and balsam fir-white birch on exposed spur ends in the steep-sided canyons of northern Cape Breton Island. These, in total, might make up 1 or 2% of the provincial landscape. Basically all other forest types are disturbed by gap dynamics of various sizes. There is virtually no disagreement amongst ecologists that the northern tolerant hardwood forest is subjected to small gap dynamics of the order of <10 sq. m. to 100 sq. m. The debate invariably focusses around our climax coniferous forest. These forests, I believe, are formed as a result of, again, small gap-forming disturbances, as well as larger gap-forming disturbances, such as windstorms, in the range of 1 to 10 ha. (based for the most part on my own observations and not a lot of hard data - more research is urgently needed here!). Insects, a common disturbance of our climax coniferous forests, for the most part, tend to create small- to medium-sized gaps. This perspective is echoed by Seymour and Hunter (1992) who, in Maine (part of the Acadian Forest Region), suggests that gap-dynamics natural disturbance regimes were, by far, the dominant structuring force in the forests of the Region: "...fires of natural origin are much rarer here [700-2000-year return intervals; Lorimer 1977]....Unlike fires, these disturbances [insect outbreaks and windstorms] are usually not completely stand replacing, and thus lead to the development of a wider range of age structures”. This is re-affirmed in Seymour et. al. (2002). Their comprehensive literature review of the natural disturbance regimes of the Acadian forest - northern New England, northern New York, the upper Midwest, and the Maritime Provinces of Canada - resulted in the following findings: (1) ongoing small canopy gaps (4-1135 sq. m. with an overall mean size of 53 sq. m.) were the common to dominant disturbance size in many forest types, especially hardwoods and tolerant conifer-tolerant hardwood forest types; (2) catastrophic, stand replacing disturbances (fire and windstorms) were rare and highly variable in size. They were not nearly as destructive as their counterparts in the boreal forest region which were more frequent and at a much larger scale; (3) biotic disturbance agents (insects and disease), being typically rather host-specific and favouring a certain host condition and because of the diversity of species and their community combinations in the Acadian Forest would have, for the most part, favoured smaller gap scales. Only in certain areas of the Acadian Forest Region do we find natural, large monocultures of boreal species that would be susceptible to larger-scaled, stand-replacing biotic disturbances - extensive spruce-fir flats of northern Maine, jack pine sand plains of northeastern New Brunswick, balsam fir plateau of northern Cape Breton Island; (4) “If the goal is to emulate most northeastern natural disturbance regimes faithfully, then the majority of the landscape must be under some type of continuous-canopy, multi-aged silviculture that maintains ecologically mature [and I hope they mean to include ‘old-growth’ as well - A. L.] structures at a finely patterned scale.” (5) while “disturbances were frequent throughout the presettlement landscape of the northeast....occurred at scales at least one order of magnitude below that of the smallest stands that are presently delineated by foresters for silvicultural purposes. Extensive single cohort stands were uncommon in the presettlement forest of the northeast [with the exceptions noted above - A. L.].... Widespread application of single-cohort silviculture on rotations of under 100 years thus creates a landscape that has no natural precedent for the types of forests we reviewed. Management that deliberately produces such stands thus cannot claim to be emulating natural disturbances”.

To summarize the types of natural disturbances in Nova Scotia, I offer the following:

<u>Frequent Stand Initiating Disturbances</u> - the definition is okay; however, this type of disturbance is only pertinent to the boreal forests of northen Cape Breton Island plateau and possibly some small isolated areas elsewhere in the Province. I definitely strongly disagree with the authors in their portrayal of black spruce swamps/wetlands as being frequently disturbed by fire. These stands, in my view, are gap-disturbed by a limited number of insects, diseases, hydrological fluctuations and, quite often, simply senescence. As to their even-agedness, as pointed out by the authors (personal communications), this is the result, not of past fires but rather of past harvesting activities. In the earlier days of colonization, spinly, tight-ringed swamp black spruce were used for a numbers of purposes. Titus Smith (1835) tells us that ‘Near to the cultivated districts, the wood, in time, becomes scarce; and the swamps are finally attacked by the axe’.

<u>Infrequent Stand Initiating Disturbances</u> - I believe this type of disturbance is part of the gap dynamics disturbance regime and, as such, simply gives that disturbance type regime a broader disturbance size range, as noted above.

<u>Gap Dynamics</u> - basically, the definition is okay.

<u>Stand Maintaining</u> - the definition and description is okay

Open Seral Maintaining - Delete

Note: A point that must be raised is the definition of ‘stand’ or ‘patch’. To determine the appropriate natural patch size for the various disturbance types within the various forest types is, in my view, virtually impossible. Today’s forested landscape patchiness is determined primarily by patterns of property ownership and affiliated forest management practices and not by natural processes. The only possible surrogate for pre-settlement forests patch size determination would be to base it on the ‘ecosite’ level of both the Ecological Land Classification and Natural Landscapes of Nova Scotia classification (eg. top of hill; north-facing slope, etc.).

‘Natural Disturbance Agents in Nova Scotia’ **Section**

Fire

This section starts off, in my view, on an erroneous note in the very first sentence. The literature does **not** support the notion that fire was a major natural disturbance in the pre-European settlement forest. By analysing pollen data, Green (1976) suggests a fire rotation of 400 years for the period 6600 to 2200 years BP in southwestern Nova Scotia. This period, however, coincided with a warm-dry maximum climate. Since that period our climate has gotten a bit cooler and more moist. This is the only reference that I am aware of that suggests a natural fire disturbance rotation time in the pre-European forest. Backman (1984), working in both the Acadian Forest Region (Maine) and in the Central Hardwoods Region (Massachusetts) found that charcoal levels were significantly lower in the pre-European settlement versus post-European settlement landscape; that the charcoal values were greater in the southern coastal areas than in the coastal sites of Maine; and that inland Maine sites showed almost no fires at all. Backman also attributes many of the coastal fires to indigenous peoples utilizing the coastline. All other estimates of the fire rotation cycle are simply extrapolation of post-European settlement data. Even while Denys (1908) acknowledges natural fire on the landscape in the early days of European settlement, he also points out the fact that these newcomers were already having a negative ‘unnatural’ impact on the Provincial landscape: “...not by the fire from the sky, but by the accident of a cannonier, who, drying his powder on Miscou, set it afire in using tobacco, and the fire reduced to cinders a good part of the woods of the island.”

We have very little evidence - other than extrapolating the susceptibilities of various forest types - on which to base any hypothesis with respect to the role of fire on the landscape prior to European occupation. The role of fire, as the authors correctly point out, has played a major role in shaping our present landscape. Again, the authors used Foster and his colleagues (Foster et. al. 2002; Parshall and Foster 2002) for their inspiration, arguing that Nova Scotia is ecologically similar to southern and central New England (eg. Massachusetts - oak-chestnut and pitch pine forests). And again, I would suggest that these areas are not similar (see above).

More recently, soil profiles in the eastern lowlands region of New Brunswick showed very little evidence of fire over several thousand years prior to European settlement (Ponomarenko and Ponomarenko 2000). Ponomarenko and Telka (2004?) suggests that previous studies, in particular Basquill et al. (2001), may have overestimated the fire frequency for southwestern

Nova Scotia. Again, the fault with the Basquill et. al. (2001) study is that it only deals with the most recent 200 years, ie. the effects of post-European settlement.

Wein and Moore (1977; 1979) developed fire rotation cycles for New Brunswick and Nova Scotia based on fire records data (1920 and 1915 respectively) that only reflects the post-European settlement landscape. Interestingly, even this data suggest relatively long fire rotation periods. The following compares the two provinces:

	N.B.	*N.S.*
- fires caused by lightning	7%	1%
- rotation based on mean % annual burn/total land area	650 yrs	1000 yrs
- rotation based on mean % annual burn/forested land base only	1000 yrs	3300 yrs
- mean % annual burn/total land base (before 1915 - based on Fernow)	-	200 yrs
- rotation for spruce-hemlock-pine forest	350 yrs	2000 yrs
- rotation for tolerant hardwood-tolerant softwood forest	625 yrs	2000 yrs
- rotation for spruce-hemlock-pine forest (before 1915 - based on Fernow)	-	65-120 yrs
- rotation for tolerant hardwood-tolerant softwood forest (before 1915 - based on Fernow)	-	160 yrs

This data reveals the following: (1) Nova Scotia, having a maritime-influenced continental climate compared to that of New Brunswick, is less prone to natural fire disturbance; (2) even under the current (post-1915) human-caused fire regime, the length of the fire rotation cycle is still well in excess of current industrial forestry rotations. Pre-1915 conditions cannot even be considered here as it was a period 'when all hell broke lose on the landscape' as a result of extensive intensive human activities. At least the post-1915 period, when fire suppression began to be initiated, moved the current fire cycle towards the natural fire disturbance rotation cycle; (3) the data suggests there is a very distinct difference between New Brunswick and Nova Scotia with respect to the susceptibility of our two major forest types. In Nova Scotia the data suggests that fire is not a major disturbance factor in either forest type. This suggests support for my views on the frequent and infrequent stand initiating natural disturbance regime category as documented above.
Green (1987) suggests that as more less-flammable tolerant hardwoods dominate varied and broken landscape, forest fires become fewer and less intense.

<u>Insects and Diseases</u>

Recent ecological studies throughout the continent are beginning to elucidate the natural conditions under which the pre-European settlement forest developed. The various regions supported different forests as a result of different environmental factors and natural disturbance regimes. Many of these studies have indicated that, unlike the natural factors that influenced the pre-European settlement forest, past and present forest harvesting techniques and fire suppression have significantly increased the frequency and severity of today's pest epidemics (Holling 1978; Blais 1983; Schowalter 1989; Schowalter 1990; Harrington and Sackett 1992; Torgersen 1994; Perry 1994). The authors' draft document certainly does not bring this aspect to the fore as it deserves to be.

Since the European invasion, the vast majority of North America's forests have lost much of their biological and structural diversity. This natural diversity is fundamentally important to the ecological integrity or health of the forest. Prior to the Europeans' arrival, these forests were relatively stable - stable in the sense that they constantly changed, but followed typical patterns that, in most cases, retained the species diversity and structural and functional attributes characteristic of regional forest types for relatively long periods of time. These forests were naturally diverse for a number of reasons, one important reason being that this diversity allowed them to compensate for disturbances and thus maintain stability. Much of the forested landscape prior to European settlement was covered by somewhat diverse old-growth forests of climax and subclimax species (Abrams and McCay 1996; Backman 1984; Bentley and Smith 1956; Denys 1908; Dieffenbacher-Krall 1996; Frelich 1995; Frelich and Lorimer 1991; Keddy 1993; Lorimer 1977; Lutz 1996; Marks et. al. 1992; Morris 1761; Perry 1994; Russell 1979; Russell 1983; Russell et. al. 1993; Simard and Bouchard 1996; Smith 1835; Smith n.d.; Vora 1994; Whitney 1987) containing a full spectrum of pest-controlling predators and parasites. Since the coming of the Europeans, the character of the forest has changed dramatically to one of simplicity which has, in turn, had serious consequences with respect to pest impact. As Graham (1938) stated "Clearing, grazing, burning, and logging without thought of the future have all resulted in almost universal retrogression.... These changes have had a profound effect upon insect populations.... This is to the liking of insect pests of these trees." With selective harvesting, clearcutting, planting, chemical spraying, and initially unrestricted burning and subsequent fire suppression - all tending to create atypical (that is, compositionally and structurally) forest types, spatially atypical of the landscape over the past 200-400 years - diversity has been much reduced or lost altogether and thus has affected the ability of the forest to maintain its stability. During the past several centuries, we have exterminated virtually all old-growth forests in eastern North America and have severely altered the remainder of the forested landscape to the point where much of the typical forested landscape today is dominated by species-poor, pest-prone, early successional tree species, in many cases in the form of monoculture plantations and silviculturally-treated, monospecied, managed stands. This has resulted in highly stressed, unstable forest ecosystems that become prime host to a variety of insect pests. In other words, over time we have removed the natural barriers that have kept these pests under control.

As previously mentioned, insect disturbance tends to create small to medium-sized canopy gaps, depending on the insect involved.

Hurricanes and Windstorms

This report seems to intimate that most even-aged forests of a particular age are the result of hurricane damage. However, in many of the older coniferous forests that I have had the pleasure of visiting over the years, particularly those that are somewhat off the beaten path, one finds a relatively smooth ground surface, without the hummocky micro-topography associated with a lot of hurricane-caused downed woody debris. These older, even-aged forests are, in my opinion, an indication of early intensive forest harvesting. As early as the 1700's, gangs of lumbermen, holed up in camps throughout the Province, had a major impact on the forest ecosystem. The eighteenth century was “a century of immense growth for the province. Various waves of settlers came, bringing with them rich heritages and new ideas. Roads opened up the interior and the lumbering and shipbuilding industries began to flourish” (Johnson 1986). Approximately 90 sawmills were located in the Province (McLeod 1903 - in Wein and Moore 1979). In other words, it is thus equally feasible that these old, even-aged forests are of an anthropogenic nature.

The pit-and mound topography of the forest floor cannot solely be attributed to catastrophic windthrow as suggested by the authors. In many cases, windthrow, and hence pit-and-mound production, is the result of another anthropogenic influence - the escalation of native organisms due, for the most part, to human manipulations of the forest ecosystem and/or the introduction of alien organisms. For example, Clattenburg (1962) attributes the significant amount of pit-and-mound ground topography in the deciduous forests of Cape Breton Island as the result of beech mortality caused by the beech bark disease. Even native insect species, which occasionally develop into significant infestations (again, in part, caused by human activities), can produce large amounts of coarse woody debris on the ground.

The significant damage caused by hurricanes, as documented in this paper, is based solely on our (European) tenure of the Province. In other words, the documentation of the damaging effects of past hurricanes was wrought upon an anthropogenically-altered landscape, not on a natural landscape. It is interesting that Denys (1908) found ‘beautiful and abundant’ forests along virtually the entire coast of Nova Scotia but did not make a single reference to windthrow, the natural disturbance bane of coastal areas worldwide.

Dwyer (1958), in documenting two of the Province’s most significant hurricanes, Carol (1953) and Edna (1954) states: “Damage was in the form of scattered trees being blown down to areas where practically all trees were down. This damage occurred in both undisturbed forests as well as partially cut areas. ‘Carol’ of 1953 blew down timber in partially cut areas, especially where the cut exceeded 30% removed by volume. Johnson (1955) states that ‘there was some damage in previously undisturbed stands but it was not severe.’” This suggests, contrary to the forest industry’s claims, that mature /old-growth forests are no more susceptible to hurricanes than managed forests and thus do not need to be liquidated. If one looks at the distribution and size of blowdown areas (Dwyer1958 - Figure V) caused by hurricanes Carol and Edna in Bowater’s Tobeatic-Rossignol region, one can readily see that, on a landscape basis, the impact was relatively minor.

Much study has been focussed on the rotation time for major windstorms. The authors quote Methven and Kendrick (1995) who suggest the windstorm rotation for New Brunswick exceeds one thousand years. Lorimer (1977) has estimated the return time for wind storms in northeastern Maine, a coastal jurisdiction like Nova Scotia, to be approximately 1,150 years. This is in sharp contrast to Dwyer’s (1958) estimation of a *‘possible’* [my italics] 80-year cycle for Nova Scotia. Dwyer (1958) immediately goes on to say: “This [80-year cycle] is also in accordance with suggested forestry practice in the province”. However, many of the historical records used by Dwyer and the authors of this paper are not quantitative in their documentation of the damage caused by hurricanes. For example, many of the hurricane and windstorms listed in Appendix I of this paper either make no reference to forest damage, describe only damage to human infrastructures and adjacent trees (eg. along road corridors), or qualitative descriptions such as ‘extensive damage to trees and forests’.

The majority of the hurricane-disturbed natural forests stands documented in Dwyer (1958) are directly associated with distinct edges - roads, wetlands, previous forest harvesting, etc. These stands were therefore susceptible to windthrow as a result of natural and anthropogenic edge effects. Clearcutting, highgrading, unnatural edge formations, as a result of land ownership patterns, and road construction can significantly contribute to an altered pattern and intensity of impacts from this disturbance agent. One can, therefore, justifiably argue that hurricane damage would be much less in a landscape free of extensive, intensive human activity.

Dwyer also tries to correlate older, even-aged forest stands with known dated of hurricanes. Obviously, some of the correlations are correct. However, as previously mentioned, a correlation between these forest stands and past extensive harvesting beginning in the early eighteenth century or human-caused fires going back even prior to the settling of Port Royal in 1604 is just as feasible.

One also has to question the validity of suggested damage in terms of tree volume destroyed. In virtually all damage reports of various hurricanes since European settlement, there have been conflicting estimates of the volume of timber lost. Even the recent Hurricane Juan has produced a suite of ever-changing estimates. Most of the estimates today are simply a guestimate based on air-photo interpretation. How could accurate measures of volume lost be generated in the old days when modern technology and accessibility was unavailable? I would suggest that, as with many other forestry issues, the worst-case situations and dire consequences are put forward.

Some of the examples used in this section are inappropriate. For example, the blowdown in the Christmas Mountain area of New Brunswick can only be related to the balsam fir forests of the Cape Breton Highlands, both considered boreal forests and not Acadian forests.

Forest damage from freezing rain and snow generally results in limb/twig breakage rather than mortality and therefore no/little change in species composition. As such, it should not be considered a disturbance in the same light as fire, windthrow, and insects.

In summary, therefore, one cannot say positively that the destruction caused by hurricanes is indicative of the true natural disturbance regime.

Other Natural Disturbances

I guess it might be appropriate to mention them but all of them are so rare or insignificant in the restructuring of the forest ecosystem, why waste the readers' time mentioning them!

Natural Disturbance and Forest Structure

Probably a better title for this section would '...Forest Landscape Structure' as it deals with the disturbance of forest stands over the wider landbase rather than the structure of an individual stand.

The authors contradict themselves with respect to fire rotations. In this section they state that Wein and Moore (1979) determined a fire rotation of 200 years for pre-European settlement forest. This is incorrect. Wein and Moore (1979) stated that the fire rotation at the turn of the 20^{th} century, not the pre-settlement forest, was 200 years. The authors got it right in the 'Natural Disturbance Agents - fire' section.

This section is very short, but also very disturbing. I do not agree with the idea that only 58% of our forested landscape can support climatic climax forest types. As I mentioned earlier, jack pine and red pine ecosystems are rare in this Province. With the exception of the highlands of Cape Breton Island, balsam fir invariably is replaced by climatic climax species. Red oak is a long-lived species and has intermediate shade tolerance and as such is considered a mid-climax species like white pine and yellow birch and part of the climatic climax complex. The early successional aspens, white birch, and red maple do form forest types on frequently disturbed (predominantly anthropogenic rather than natural) or degraded sites but these sites do regenerate back to the climatic (or edaphic) climax or, if seed source is unavailable, can be restored to such a condition by afforestation or reforestation. For example, the fire barrens and degraded maple-oak-birch forests of southwestern Nova Scotia are very slowly returning, on their own, to the climax spruce-hemlock-pine-oak forest. The reference for the 42% forest land that is maintained in early successional species is Steward et. al. (2003). That paper does not provide the criteria for the determination of climatic climax versus early successional sites, so it is difficult to understand the rationale behind the determinations. Looking at the provincial forest cover type maps, most of the areas are imperfectly to well drained forest land - capable of supporting climax species - and in many cases, climatic climax species are recorded in varying amounts. This would suggest that these areas are capable of returning to a climatic climax condition.

References

Abrams, M. D. and D. M. McCay. 1996. Vegetation-site relationships of witness trees (1780-1856) in the presettlement forests of eastern West Virginia. Can. J. For. Res. 26:217-224.

Backman, A. E. 1984. 1000-year record of fire-vegetation interactions in the northeastern United States: A comparison between coastal and inland regions. MSc. Thesis. University of Massachusetts. 99 pp.

Basquill, S. P., S. J. Woodley, and A. B. Pardy. 2001 The history and ecology of fire in Kejimkujik National Park. Parks Canada, Tech. Reps. in Ecosyt. Sci., Rep. 029.

Bentley, P. A. and E. C. Smith. 1956. The forests of Cape Breton in the seventeenth and eighteenth centuries. Proc. N. S. Instit. Sci. 20:1-15.

Blais, J .R. 1983. Trends in the frequency, extent, and severity of spruce budworm outbreaks in eastern Canada. Can. J. For. Res. 13: 539-547.

Bormann, F. H. and G. E. Likens. 1979. Catastrophic disturbance and the steady state in northern hardwood forests. Amer. Scient. 67:660-669.

Clattenburg, R. E. 1962. A study of the deciduous forest associations in Cape Breton. MSc. Thesis, Acadia University, Wolfville, Nova Scotia

Cogbill, C. V., J. Burk, and G. Motzkin. 2002. The forests of presettlement New England, USA: spatial and compositional patterns based on town proprietor surveys. J. Biogeog. 29:1279.

Delcourt, P. A. and H. R. Delcourt. 1987. *Long-term Forest Dynamics of the Temperate Zone: A Case of Late-Quaternary Forests in Eastern North America.* Springer-Verlag, New York. 439 pp.

Denys, N. 1908. The description and natural history of the coasts of North America (Acadia). Champlain Soc., Toronto. 381 pp.

Dieffenbacher-Krall, A. C. 1996. Paleo- and historical ecology of the Cutler Grasslands, Cutler, Maine (U.S.A.): Implications for future management. Natural Areas J. 16:3-13.

Dwyer, G. D. 1958. A study of blowdown in Nova Scotia. Unpublished. University of New Brunswick, Fredericton. 57 pp. + Appendices and Illustrations.

Fernow, B. E. 1912. Forest conditions of Nova Scotia. Can. Comm. of Conserv., Ottawa. 93pp.

Foster, D. R. 2000. Conservation lessons and challenges from ecological history. Forest History Today. Fall 2000:2-11

Foster, D. R., S. Clayden, D. A. Orwig, B. Hall, and S. Barry. 2002. Oak, chestnut and fire: climatic and cultural controls of long-term forest dynamics in New England, USA. J. Biogeog. 29:1359.

Frelich, L. E. 1995. Old forest in the Lake States today and before European settlement. Nat. Areas J. 15:157-167.

Frelich, L. E. and C.G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the upper Great Lakes region. Ecol. Monog. 61:145-164.

Graham, S. A. 1938. Relation of insects to primitive and present-day forests. J. For. 36:998-1004.

Green, D. G. 1976. Nova Scotia forest history - Evidence from statistical analysis of pollen data. PH.D. Thesis. Dalhousie University, Halifax. 155pp.

Green, D. G. 1987. Pollen evidence for the postglacial origins of Nova Scotia's forests. Can. J. Bot. 65:1163-1179.

Harrington, M. G. and S. S. Sackett. 1992. Past and present fire influences on southwestern ponderosa pine old-growth. p. 44-50. In: M. R. Kaufmann, W. H. Moir, and R. L. Bassett (co-ordin.). *Old-growth Forests in the Southwest and Rocky Mountain Regions*. Proc. of Wksp., March 9-13, 1992, Portal, Ariz. USDA For. Serv., Gen. Tech. Rep. RM-213.

Holling, C.S. 1978. Forest insects, forest fires, and resilience. p. 445-464. In: *Fire Regimes and Ecosystem Properties*. U.S.D.A., For. Serv., Gen. Tech. Rep. WO-26.

Hunter, M. L. 1996. Benchmarks for managing ecosystems: are human activities natural? Conserv. Biol. 10:695-697.

Johnson, R. S. 1986. *Forests of Nova Scotia: a History.* Four East Publications, Halifax.

Kay, J. and H. Regier. 2000. Uncertainty, complexity, and ecological integrity: Insights from an ecosystem approach. In: P. Crabbe, A. Holland, L. Ryszkowski, and L. Westra (eds.) *Implementing Ecological Integrity: Restoring Regional and Global Environmental and Human Health.* Kluwer, NATO Science Series, Environmental Security. pp121-156.

Keddy, C. 1993. Forest history of eastern Ontario. Info. Rep. No. 1, Eastern Ontario Model Forest, Kemptville, Ont. 41 pp.

Lorimer, C. G. 1977. The presettlement forest and natural disturbance cycle of northeastern Maine. Ecol, 58:139-148.

Lutz, S. G. 1996. Pre-European settlement and present forest composition in King's County, New Brunswick, Canada. MsF Thesis. University of New Brunswick, Fredericton.

Marks, P. L., S. Gardescu, and F. K. Seischab. 1992. Late eighteenth century vegetation of central and western New York state on the basis of original land survey records. New York State Mus., Bull. No. 484. Albany, N.Y. 53 pp.

Methven, I. And M. Kendrick. 1995. A disturbance history analysis of the Fundy Model Forest Area. 16pp.

Morris, C. 1761. Description and state of the new settlements in Nova Scotia in 1761, by the Chief Surveyor. In: 4-5 Edward VII. Sessional Paper No. 18. A. 1905.

Mott, R. J. 1975. Palynological studies of lake sediment profiles from southwestern New Brunswick. Can. J. Earth Sci. 12:273-288.

Nichols, G. E. 1935. The hemlock-white pine-northern hardwood region of eastern Noth America. Ecology 16:403-422.

Parshall, T. and D. R. Foster. 2002. Fire on the New England landscape: regional and temporal variation, cultural and environmental controls. J. Biogeog. 29:1305

Perry, D. A. 1994. *Forest Ecosystems.* John Hopkins Univ. Press, Baltimore. 649 pp.

Ponomarenko, E. and S. Ponomarenko 2000. Reconstruction of pre-agricultural vegetation pattern in Kouchibouguac National Park using the ecosystem archaeology method. Preliminary Study. Parks Canada, Ecosystem Branch, Gatineau, Que. Unpublished.

Ponomarenko, E. and A. Telka. 2004 (?). Paleoentomological investigation of forest insect influences on older growth eastern hemlock in Kejimkujik National Park and Historic Site. Unpublished Report (?).

Roland, A. E. and E. C. Smith. 1969. The flora of Nova Scotia. Part 2. The dicotyledons. Proc. N. S. Inst. Sci., Halifax. Vol. 26, Part 4:277-743

Russell, E. W. B. 1979. Vegetational change in northern New Jersey since 1500 A. D.: A palynological, vegetational, and historical synthesis. PhD Thesis. Rutgers University, New Brunswick, New Jersey. 234 pp.

Russell, E. W. B. 1983. Indian-set fires in the forests of the northeastern United States. Ecol. 64:78-88.

Russell, E. W. B., R. B. Davis, R. S. Anderson, T. E. Rhodes, and D. S. Anderson. 1993. Recent centuries of vegetational change in the glaciated north-eastern United States. J. Ecol. 81:647-664.

Schowalter, T. D. 1989. Canopy arthropod community structure and herbivory in old-growth and regenerating forests in western Oregon. Can. J. For. Res. 19: 318-322.

Schowalter, T. 1990. Differences and consequences for insects. pp. 91-108. In: *Forests - Wild and Managed: Differences and Consequences*. Students for Forestry Awareness Conference, January 19-20, 1990, University of British Columbia.

Seymour, R. S. and M. L. Hunter. 1992. New forestry in eastern spruce-fir forests: principles and applications to Maine. College of Forest Resources, University of Maine, Orono.

Seymour, R. S., A. S. White, and P. G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America - evaluating silvicultural systems using natural scales and frequencies. For. Ecol. and Mgmt. 155:357-367.

Simard, H. and A. Bouchard. 1996. The precolonial 19th century forest of the Upper St. Lawrence Region of Quebec: a record of its exploitation and transformation through notary deeds of wood sales. Can. J. For. Res. 26:1670-1676.

Smith, T. n. d. A natural resources survey of Nova Scotia: 1801-1802. Publ. Arch. of N. S. 380

Smith, T. 1835. Original communications. Mag. of Nat. Hist., Vol. VIII - p. 651; London.

Smith, T. n. d. A natural resources survey of Nova Scotia: 1801-1802. Publ. Arch. of N. S. 380

Steward, B. J., P. D. Neily, E. J. Quigley, A. P. Duke, and L. K. Benjamin. 2003. Selected Nova Scotia old-growth forests: Age, ecology, structure, scoring. For. Chron. 79:632-644.

Toner, T. P. 1984. Pollen-based forest groupings in the Maritime Provinces. MES Thesis. Dalhousie University, Halifax, Nova Scotia.

Togersen, T.R. 1994. Natural enemies in forest insect regulation. p. 108-111. In: M. Pilarski (ed.). *Restoration Forestry: An International Guide to Sustainable Forestry Practices.* Kivaki Press, Durango, Colorado.

Vora, R. S. 1994. Integrating old-growth forest into managed landscapes: A northern Great Lakes perspective. Nat. Areas J. 14:113-123.

Wein, R. W. and J. M. Moore. 1977. Fire history and rotations in the New Brunswick Acadian Forest. Can. J. For. Res. 7:285-294.

Wein, R. W. and J. M. Moore. 1979. Fire history and recent fire rotation periods in the Nova Scotia Acadian Forest. Can. J. For. Res. 9:166-178.

Whitney, G.G. 1987. An ecological history of the Great Lakes forest of Michigan. J. Ecol 75:667-684.

Whitney, G. G. 1994. *From Coastal Wilderness to Fruited Plain: A History of Environmental Change in Temperate North America 1500 to the Present.* Cambridge University Press, Cambridge. 451 pp.

f:\natdistrev.wpd