Reviews and Comments on

Neily, P.D., E.J. Quigley, B.J. Stewart, and K.S. Keys. 2007. Forest disturbance ecology in Nova Scotia. Nova Scotia Department of Natural Resources (draft).

Dr. Alan S. White, Professor of Forest Ecology, University of Maine

Dr. Robert S. Seymour, Hutchins Professor of Quantitative Silviculture, School of Forest Resources, University of Maine

First, we thank you for inviting us to review your report on natural and anthropogenic disturbances and application of that information to management plans for provincial forest lands. We applaud the effort being made by the province of Nova Scotia in this regard and hope that we can comment in a meaningful way. However, we must admit up front that neither of us is an expert on Nova Scotia's forests but we do have considerable experience in the Acadian Forest of Maine and, secondarily, New Brunswick. Our comments are on general topics; no attempt was made to edit language, punctuation, etc.

- Use of relevant literature is an important component of a report like yours. You have made a good start looking at research in Nova Scotia and nearby. We suggest looking somewhat further at research already done, or in progress, from Maine and New Brunswick, both of which have considerable acreage in the Acadian Forest. You may even have to go further afield for procedural writing. For example, there may be research on the application of natural disturbance regimes to forest management that would be useful even if it is done on another forest type or another region.

- From a reviewer's perspective, you seem to rely heavily on reports, etc. that can be difficult for an outsider to get, and, even if obtained, difficult to evaluate without considerable background in the area, organization, etc. That makes it hard for us to provide much of an opinion on some sections of the report. This "gray" literature can also have errors that might be discovered through an outside peer review. We recognize that a report is the typical endpoint of expectation in the management world and that peer review by people outside the organization may be minimal or nonexistent. In addition, many of these reports do not contain the kinds of information that most journals require. I guess this is just a long-winded way of saying that we recognize our own limitations in this review and urge you to seek out as many local experts as possible, especially those who can provide critical evaluations of the proposed field applications. What you are proposing could have far-reaching effects in both space and time.

- The descriptions of disturbance agents, severity, frequency, etc. are interesting to read. However, they could benefit from clearer organization in several places. For example, your discussion of fire covers many facets, including fire over thousands of years (post-glacial), over hundreds of years (post-European settlement), specific fires, fires started by humans, fires started by lightning, fuel loads, characteristics of the forest when fire occurred, stand-replacing fires, understory fires, etc. Furthermore, this information comes from many sources, including paleoecological research, tree-ring studies, written historical accounts, etc. What is lacking is an organizational framework that supports a clear recommendation, with single or multiple options, for management. The recommendation must be supported by specific information and, equally important, must state why some legitimate alternatives were disregarded. For example, the fire record for pre-settlement is different than that of present day or of the early settlement times, so a current-day proposed policy must be based on some periods but not others. The rationale for your choices must be clearly stated.

- Speaking of different sources of information, we think some of your readers might benefit from a short discussion of the strengths and weaknesses of some of the approaches used to generate

information on disturbances. For example, tree rings have annual resolution but are limited to the longevity of the species (with some exceptions, like going further back in time by crossdating dead wood, if there is any that has not crumbled away). In contrast, pollen analyses are often done on sediment cores, which can span thousands of years but may have a temporal resolution of decades or longer (note that there are some sediments that are varved, having annual resolution, but they are rare and costly to analyze on an annual scale). Thus, we think it is useful to mention at the outset, the techniques that were used. It could be short (a paragraph or two) with references to methods books or articles. There also could be a spatial component, noting, for example (made up for illustration), that archaeological sites were common only in areas A and C or that old-growth sites were located disproportionately in the western third of the province.

- You may have done this already, but you might indicate what areas (geographically and topically) are most in need of study. What do you feel most uneasy about? What additional information is needed now, before the implementation? Presumably some of your information needs will be met best by monitoring your implementation, with an eye towards adaptive management as needed.

- You have done some of this already, but you might be thinking of setting some guidelines as to how to categorize stands with respect to whether they are candidates for immediate development of emulation silvicultural prescriptions versus restoration prescriptions versus something else (for stands that are too altered to be amenable to this from of management, at least for the foreseeable future).

- We are not clear as to why the discussion of fires versus clearcuts but assume that it is the best example of a comparison between the natural process of mortality and a harvesting approach that is supposed to mimic that process. We would add or emphasize two minor points to your discussion: a) chemical processes in the soil change almost immediately following harvest and b) nothing in the "natural" world removes so much biomass from the site as does harvesting, even at the gap level.

-Finally, we can see both pros and cons of making section 7 an independent paper. We think putting together a separate paper for the natural disturbances might clarify some issues that otherwise would further cloud the application side of the process. On the other hand, if they were combined as they are now, it could generate more integration of the two parts. In either case, this topic will most likely need additional depth and breadth because it will attract a lot of attention given that this is rather new in the region and will be doubly scrutinized, once in this report and then on the ground.

Joint submission by (listed alphabetically):

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Comments on: *Forest Disturbance Ecology in Nova Scotia*

General Comments:

- We commend the authors for their efforts at tackling such a comprehensive and important topic. The challenges faced are considerable. Nevertheless, we have deep reservations about the manuscript and its implications.
- This report needs considerable revision and other work before it could be considered suitable for serving as the basis of any workshops.
- A large problem with the manuscript is that its intent and purpose are not explained in the Introduction. Why was the paper written? Is there any hope that it might be used to influence forest planning and policy? If so, this must be explained in the report because it provides such important context for the report and any subsequent exercises.
- This report is structured as an academic-style literature review, but it is lacking in rigor in key subject areas. The specifics of this comment will emerge from the detailed comments, which are listed below.
- The report needs a much more thorough discussion of anthropogenic stressors, emulation of both stand-replacing and gap-phase disturbances, and biodiversity and its conservation (including the role of protected areas). The title of the report is "*Forest Disturbance Ecology in Nova Scotia*, but there is insufficient discussion of anthropogenic influences.
- It is excessively restrictive to focus so strongly on Nova Scotia. Because the specifics of forest ecology have little to do with artificial political boundaries, a more ecoregional approach is necessary. Much that is relevant to Nova Scotian forests can be learned from a thorough examination of research done elsewhere in the Northern Appalachian–Acadian ecoregion, which includes all three Maritime provinces, parts of adjacent Quebec, and areas of the adjacent New England states.
- There should be a section that explains what biodiversity is, at its hierarchical levels, and also discusses the differences between "natural" or "self-organized" ecosystems and those that are created through anthropogenic interventions and management.

- There appears to not be a serious treatment of a key topic area – the natural ecological dynamics and other environmental conditions that are important in the development of older forests dominated by relatively tolerant species of trees. This is an important subject area in any report dealing with historical ecology and the role of disturbances in the development of natural and managed kinds of ecosystems. Because this subject area is not dealt with in a credible manner, the overall report is highly unbalanced.
- The report needs a clearer integration of the analyses that were undertaken to identify the spatial distribution of natural disturbance regimes within the province and its ecosections, supported by the associated literature that helps to validate that methodology. The analyses are critical to many of the conclusions that are made, but the methodology is not available for scrutiny or peer review.
- A key failing in the document is that it does not have a strategic, critical, and focused discussion of protected areas, including the sizes of such areas that would be necessary to conserve forest-community types (including older growth) in the face of regimes of environmental stressors, including disturbances. For the purposes of the Northern Appalachians-Acadian Ecoregional Plan, the Nature Conservancy of Canada, in partnership with The Nature Conservancy (U.S.) and all three Maritime provincial governments, concluded that a protected area block of at least 10,000 ha was needed for a matrix forest block of this sort.
- There are numerous cases where bold statements are made but that require the support of citation of credible literature. Examples are given below under "Specific comments"
- The report is not well written, in terms of scientific style. Considering that this is the 2nd or 3rd version of the manuscript, the poor writing does not inspire confidence. Examples: metric units are not consistently used, poor citation style, poor organization of sections and themes, no or inconsistent use of proper common names and scientific binomials, and tables and figures not correctly referred to and/or missing captions. Also, the report contains numerous punctuation errors and the figures and tables are formatted inconsistently and often inappropriately.
- The report has a disproportionately long section on fire as an agent of forest disturbance. Its detail is out of balance with the amount of space devoted to climatic factors, biotic influences, anthropogenic stressors, and to soil and other geomorphic influences on the forest.
- Frequent and heavy reliance is placed on the work of Basquill *et al* on fire ecology in and around Kejimikujik National Park. Was that study ever published or otherwise subjected to rigorous peer review? Is it a credible enough source for the many bold conclusions that are attributed to it?
- Several e-mail communiqués have suggested that a workshop will be held in Truro, with this manuscript likely being the basis of discussions. In our view, such a workshop should not take place until a more credible manuscript has been prepared and reviewed.

Specific Comments:

- **Section 1. Introduction** – This section should explain why the document has been prepared. Is it an academic manuscript intended for submission to a journal? Is it an

internal report intended to influence policy? An understanding of the purpose of the document would provide essential context against which potential bias in interpretations can be evaluated. It is not appropriate for the Introduction to be silent about this issue.

  - Probably the Introduction should also address issues related to key themes such as ecological integrity, naturalness, and biodiversity.

- Page 3, para 1 – the material on post-glacial revegetation of Nova Scotia should include reference to recent research. Roland and Smith (1969) is an old and non-authoritative source. Much novel palynological research has been done since then, particularly in the past decade or so. This work should be read and integrated. Some of it is associated with Les Cwynar at UNB Fredericton, particularly for the first post-glacial millennia.

  - How is it known that the "*typical herbaceous flora*" of maple-elm-beech-oak also followed? Or is this surmised? Is there palynological or other palaeo evidence of this? Why would it even be assumed that the plant communities of thousands of years ago were similar to those of today?

  - "*During this period natural disturbances varied only as vegetation responded to climate fluctuation, which has not changed drastically since the first trees appeared (Roland and Smith, 1969).*" Is this sentence referring to the past 10k or so years since deglaciation? In any event, this sentence makes little sense – it is a "just so" story that is unlikely to reflect what actually happened during that early postglacial period. There is no evident reason to suggest that climatic change overwhelmed all other causes of ecological stress – severe windstorms and wildfires were also likely factors, although we may not yet have much evidence of their rotations. This apparently blithe acceptance of the broad conclusions of non-palaeo specialists like Roland and Smith is symptomatic of the non-critical style used throughout much of the paper.

    - What is meant by "*varied*" in the context used? Could edaphic properties have changed during this time period, perhaps through acidification and base loss, as is often observed by studies of deglaciation?

    - Is the word "*fluctuation*" being used appropriately here? Has climate fluctuated, or has it changed in an unpredictable manner?

- Page 3, para 2 – "*The development of Acadian forest communities has continued in a more or less steady state with plants distributed according to the ecological conditions to which they were best adapted*." This is another nonsense statement – a just-so story. A steady state is a condition and not a process of gradual change. Why would we conclude that species occur in conditions to which they are "*best adapted*"? In fact, species are often restricted to sub-optimal conditions because of competitive exclusion by other species. And why would we conclude that the recent (say, the past 500 years) and present conditions of species distributions are not dynamic? Only longer-term studies (such as palynological ones) can shed evidence on these issues, and the authors have apparently not examined this important body of literature.

  - Moreover, in view of the well-known influences of plants on their environment, competition, dispersal limitations, and other factors affecting plant distribution, this statement is a huge over-simplification.

- A greater prominence of "*heath plants*" (but which ones?) may have resulted from the leaching and acidification of soil, but post-disturbance community dynamics and disclimaxes may have also played a role, particularly after fire.
- "… *the forests of Nova Scotia had evolved* …" Forests do not evolve. This is a poor and inappropriate use of terminology.
- "*Fernow (1912) estimated that only .68 million acres (5.6%) of the provincial forest was still in a virgin state and most of that (.425 million acres) was … on the Cape Breton Highlands*." This is a critical sentence, but it cannot go unchallenged. Fernow may indeed have made this estimate of "virgin" forests, but what was the basis of his methodology? What were his criteria for "virgin forest"? How much was known at the time about the interior regions of the province? For that matter, how much of Nova Scotia was "virgin forest" in pre-Columbian times? These and other aspects must be examined in a critical analysis, but this was not done by the authors. (In addition, areal data should be reported in hectares, and significant figures should be standardized. This sort of non-scientific style does not inspire confidence.)

- Page 3, last sentence. This sentence briefly states an intent of the report, but the essential context in terms of potentially influencing forest management is not explained even though it is clearly an important intended use of the document and its analyses.

- **Section 2. Disturbance Ecology**

- It seems that many of the references cited, or the way in which they are used, are out of context and potentially misleading. There is on overall impression of credible arguments not being made, and of inappropriate (or lacking) citations in support of key assertions. It is apparent that a limited portion of the literature is being mined to support a view that it is appropriate, from a management perspective, to largely ignore the ecological conditions of the past – particularly in terms of dominant forest types and the environmental dynamics and other factors that allowed them to self-organize. This is especially the case of forest-community types dominated by relatively tolerant, late-successional species of trees, and of the role of gap-phase microdisturbance as an important factor affecting older stands. The approach used is not credible.

- Page 4, para 1 – The point of this first paragraph escapes me. To what ecological region(s) are Foster's suggestions relevant? This is not said, but perhaps we can assume that it is the Northern Appalachian-Acadian Ecoregion? If so, then what is inferred by the statement from Foster that "*there is an absence of baseline established conditions (unchanging "primeval" or "natural" conditions*" ? Does this mean that we do not know what the pre-Columbian baseline conditions might have been (which is not quite the case, because we can infer some aspects from pale ecological studies)? Or does it mean that whatever those baseline conditions were, they were dynamic because of ongoing climate change and various disturbance regimes? If the latter, then so what? No sensible ecologist would suggest that ecosystems were magically stable prior to the European colonization. However, it is obvious that their natural dynamics were being forced by different regimes of environmental stressors than those that are operating today, which are largely anthropogenic.

- On the other hand, if Foster was not referring specifically to NS or the Maritime Provinces or the Northern Appalachian-Acadian Ecoregion, then the applicability of his comments should be discussed.
- It is important to understand that almost all ecologists believe that terms such as "stable" and "equilibrium state" are not very realistic concepts in ecosystem management, in view of the universal dynamics of all ecological systems. In places, the report seems to be flogging these long-dead horses, even though they have had little influence in ecological theory or its applications for decades. Much work on ecosystem-based management concludes that not only is it crucial to take into account pervasive environmental and ecological dynamics when managing landscapes, it is also necessary to *anticipate* them to some degree. For instance, Foster and Motzkin (1998) are among the many authors who have come to these sorts of conclusions. Among the many possible management-related outcomes of this sort of advice, in view of impending climate change, might be a consideration of not favoring the development of extensive stands of boreal species such as bS, wS, and bF. Among the conifers, species such as eH, rS, and wP might be more suited to the warmer environments of the coming future.
- In what regions were hemlock and beech in decline 500 years ago? What is the evidence for this? I presume that it must be a palynological study somewhere, maybe even in Nova Scotia? But what is the spatial reference? New England? Nova Scotia or some part of the province? Or maybe only in a few local areas, such as the near-lake (or near-bog) watersheds where the particular study was done? In any event, 500 years ago includes the height of the Little Ice Age, so maybe those two species were declining because of climatic deterioration? But how could we know this, because no details are given – not even a reference for the palaeo study.
    - It should also be pointed out that, during the past 200 years, these two species have suffered large declines, but the causes are entirely anthropogenic.
- Is Foster actually the source for all of the claims throughout this paragraph? If not, then additional citations may be necessary.

- Page 4, para 2 – There is no reference to Kay et al. (2000) in the bibliography. Perhaps Kay and Regier (2000) is being referred to? If so, the citation is stylistically wrong. In any event, it is a gross simplification and misinterpretation of the thinking of Kay and Regier to suggest that all they consider to be important is "*maintaining the process of self-organization*." Even an abandoned old pasture is capable of self-organizing into something, but it would take a century or more before that sere resulted in a mature forest with a high level of ecological integrity.
    - Frelich (2002) is interpreted as concluding that, because ecosystems are always affected by environmental stressors, including disturbances, then stability is not possible. But as pointed out earlier in our comments, this is a basic ecological tenet – all is unstable and all is impermanent. Nevertheless, there can be profound changes in rates of change over time and in the sorts of variations of environmental stressors that might be causing that to occur. Clearly, in recent

times (particularly in the past century or two), anthropogenic stressors have become increasingly more important.

- What is meant by "*the forester's point of view*"? How is it different from an "ecologist's point of view", other than foresters are presumably interested in harvesting and/or managing some of the economic value of forested landscapes. This begs an important question of context, which should have been highlighted in the preceding Introduction – is this paper written from the point of view of forestry or of ecology? It should be the latter, because the subject matter is inherently about ecology.
- Frelich (2002) is said to believe that "*forest change over time exhibits a punctuated stability phenomenon*." But over what time period? Since deglaciation? It certainly would not be true over the post-Columbian period, during which anthropogenic stressor regimes have changed everything. This same section suggests that there are ecologists who view conditions as being "*stable*." Who are those people, and why would they think such a thing in view of the constant change that all ecosystems have always displayed? Is some sort of irrelevant straw man being erected here for easy and convenient demolition later on?
- "… *paleoecologists may view the temperate forests of eastern North America as unstable since there have been at least three major vegetation shifts in the forest since the last glaciation*". Citations are needed here – is this still Frelich?

- Page 4, para 3 – This paragraph makes more sense. However, the idea is introduced of "*fully restoring the primeval landscape*." Where did that odd and silly idea come from? It would impossible to do, and likely foolish to even try. Are there any serious proponents of this idea? Or is this another straw man?
  - Which studies show wide variations in species composition and abundance in pre-settlement forests, and in what regions? Citations are needed here.
- **Section 2.1. Natural Disturbance Defined**
- Page 4, 1st paragraph, 2nd and 3rd sentences. Where did this idea of "*re-create or preserve the past come from*"? Who is seeking to do that? What is the relationship to the use of relatively natural systems of management, which might include allowing self-organizing ecosystems to develop at the spatial scale of landscape.
  - It is widely acknowledged that, while the past cannot be re-created, there is great merit to being advised by the recent past (say, the last 200-300 years) and to conserving natural ecosystems that are self-organizing and dominated by indigenous species. If forestry is seeking to develop management practices that emulate what we understand about natural influences on forests, then the principles embedded in this model (i.e., in the sentence just above) would be key to success in achieving societal consensus and to the implementation of appropriate ecosystem-based visions of management.
- Page 4, last para – what is meant by "*killing all the existing trees above the forest-floor vegetation*"? Do trees exist beneath that level? Are we speaking about rhizome or root

systems, and if so, is a tree killed if its above-ground tissues are cut off but its below-ground perennating tissues survive the disturbance? Clearly, the genet might survive this sort of injury, so the tree would not be "killed." Also, maybe introduce the phrase "gap-phase disturbance" here, as it is commonly used terminology.

  - Moreover, the delineation of natural disturbances into two categories based on "all" or "some" of the trees being killed is not realistic. In fact, there is a gradient of variation in this sort of ecological response to disturbance. Patches of trees survive fires and windstorms.

- Page 5, same para as the preceding – This section needs a conceptual overview to provide an overarching context. It is necessary to define "disturbance" in terms of timing (duration), physical effects, and biological responses (including successional recovery). The term should also be set into the broader context of other environmental influences that cause changes in communities and ecosystems (collectively, these are all known as environmental "stressors.")
  - What exactly is the "diversity" being referred to in the phrase "*diversity in the landscape is greater with major disturbances at infrequent intervals …*" ? In ecology, diversity is a hierarchical concept that can mean various things – genetic, species richness, patch richness, community or patches, among others. It is now often referred to as "biodiversity." And why is diversity suddenly being introduced as a consideration?
- Page 5, section 2.2, - this section on "*Natural Disturbances in Nova Scotia*" says almost nothing of value. It just presents an uncritical list of the sorts of things that can cause disturbance of the forest. What is needed is information, gleaned from the palaeo literature, of the frequency and extent of the various kinds of disturbances.
  - In what sense is "*animal predation*" a kind of forest disturbance? What animals? What organisms did they predate? Is this referring to ungulate or insect herbivory?
  - Did aboriginal peoples cause anthropogenic disturbances in pre-Columbian times? Were fires ever set to improve game habitat, or to otherwise improve hunting conditions? These actions were commonly undertaken elsewhere in North America, including eastern regions.
  - "*The extent to which it is possible to fully restore the pre-European condition to Nova Scotia has been compromised by human actions …*" Again, I question where this theme of "full restoration" is coming from. What is the context of this phantom idea? Who is proposing to "fully restore" anything?
  - Woodland caribou are by no means extinct. They are, however, extirpated from Nova Scotia.
- **3. Natural Disturbance Regimes**
- Page 6, para 2 – More context is needed for the sentence: "*The distribution of tree species and forest types is closely related to the topographic and soil conditions of the land (Rowe, 1972).*" This sentence does not tell a complete story, because trees and forests are also affected by biogeography, variations of climatic conditions, biological and

ecological interactions amongst species, and other environmental factors. Depending on the circumstances, any of these factors could overwhelm the influences of topography or soil.

- "*The change in forest structure and/or composition is accomplished through disturbances in forest ecosystems* …" While disturbances at various scales may affect these qualities, other factors may also do so. For example, biological interactions such as competition and disease also affect structure and species composition. Neither of these would be properly referred to as "disturbances."
- "*Therefore disturbances are necessary for maintaining species richness and biodiversity*." In and of itself, as a generalization this sentence is nonsense. It must be qualified by reference to time, scale, and other considerations, including the specific elements of biodiversity being referred to. There is no doubt that some elements of forest biodiversity may be threatened by disturbance, particularly if stand-replacing events occur at too short a return interval.
- Mention should be made in this paragraph of the intermediate disturbance hypothesis.

- Page 7, para 2 – Why are black spruce forests being discussed in detail in this section, while other types subject to similar disturbance regimes are only briefly mentioned? Is there context for this?
- Page 7, next para, last sentence – What is the evidence for spruce-pine-hemlock ecosystems being related to this disturbance regime?
- Pages 6-9 – five classes of disturbance regimes are described, and their identification is ascribed to the internal deliberations of an Ecological Technical Committee of DNR. It is not possible to determine from the footnote presented, but I think that an internal report of some sort is being referred to: DNR (1997). Presumably this internal report has not been subjected to an independent and external peer review. However, in a critical review like the one being presented here, it is necessary to have some understanding of the methodology and rigor of the approach used by DNR (1997) in their study. For example:
  - Did the five classes of disturbance regime emerge from some sort of quantitative study of measured patterns in nature?
  - Or did the result (i.e., five regimes) emerge as a consensus from a highly qualified study group that included vegetation ecologists and well as foresters?
  - Or did some individual just think about things for a while, and then decide that there are five kinds of disturbance regime?
  - Because these classes of disturbance regime are likely to be important in the development of any emulation models that might emerge later on in the review, it is crucial that the reader have faith in their veracity. This is why the methodology used in DNR (1997) should be presented in sufficient detail to allow critical evaluation.
    - Having established this point, each of the five classes of disturbance regime are presented as qualitative "just-so" stories. Almost no literature is cited. The descriptions of the environmental factors affecting these types, including the

disturbance regime, may or may not reflect reality. Or they could just be the written ideas of one or several people, apparently not advised by any sort of quantitative supporting analysis.

- Do the five classes represent the apices of various multivariate gradients? In the natural world, do these five types typically present themselves on a regular basis, or is there a continuum of expression amongst them, with five clusters of some undetermined strength.

- Pages 9- 10 – section on Forest Disturbance Agents
  - This section is almost totally non-referenced, other than a few citations related to older work.
  - In the sentence on page 9 dealing with alien forest pathogens, mention should be made of *Tetropium fuscum* (Brown Spruce Longhorn Beetle).
  - Reference is made to the journals of Denys (1967): "*… Denys … describes the coastal forest encountered by the early French settlers which seems to differ little from what is present today*." From what I have seen of Denys, his descriptions are pretty scant and not sufficient to conclude that coastal forest conditions have not changed much. In fact, if he were around today, I think that Denys would be hard pressed to recognize much of the coast that he encountered in the early 17th century. I believe that the point being made about Denys is inaccurate and not sufficiently critical of the veracity of the information used in the comparison.
- Pages 10-12 – section on Fire
  - Page 10 near bottom - "*… Foster at al (2002) … concluded that … marked by two 1000-year periods of remarkably stable forest composition (attributed to on-going disturbance by fire and windstorm)* …). This observation needs additional rationalization. It is not immediately clear how on-going disturbances by fire and windstorm would promote a stable species composition of the forest. These are rather different kinds of disturbances. Also, what is meant by "*stable forest composition*" and what key species were involved?
  - Page 11, same paragraph as above – describe the changes in species composition that began 1500 BP.
  - Page 11, para 2 – several sentences refer to "*those who believe*." Provide references to the literature being cited here.
    - Why is it assumed that the caribou that occurred in Nova Scotia required open habitat? Is it not likely that they were woodland caribou, so that their major habitat requirement was for mature lichen-rich coniferous forest, with some use of open habitats such as partially treed bogs, tundra, and perhaps younger seral stages of disturbed forest. To understand these ecological requirements of caribou, the literature related to relatively southern regions of Quebec, Newfoundland, and Labrador should be examined.,
    - You cite several references in support of the idea that aboriginal peoples did not use fire to manage the habitat of species that they hunted. Are there no references to the opposite idea – that fire was used to manage habitat in pre-Columbian

times? Is there any traditional knowledge about this aspect of aboriginal culture? What evidence is presented by Basquill et al and Parshall and Foster? Did they only report an absence of obvious evidence? If so, should absence of evidence be considered evidence of absence, allowing an easy dismissal of the possible role of aboriginals as land managers?

- Page 11, para 3 – the word "*barrens*" is rather imprecise, as there is a range of shrub-dominated communities in southwestern Nova Scotia. There is no reason to assume that they all have a similar ecological history, or occur under the same biogeoclimatic regime.
    - Regarding Strang (1972), what are "*dissolved humic nutrients*"? I have never seen this term before. How would their leaching contribute to the formation of a hardpan? If a hardpan is largely formed through the precipitation of sesquioxides of iron and aluminum, why is no mention made of environmental influences on the leaching of iron and aluminum ions (e.g., acidification)?
- Pages 12-13 – Fires caused by lightning
    - If only 1% of wildfires were caused by lightning during 1929-1999, then the obvious fact should be stated that the other 99% is apparently anthropogenic.
- Page 13 – **Regional Fire History**
    - The suggestion of Basquill et al of a fire-return interval of only 78 years for the Kejimkujik area seems rather short, even less than that of many boreal regions. Is their estimate based on the typical age of existing forest, which is largely an artifact of wildfires ignited by humans during the past century? Their estimate is so short that it should be explained and rationalized, or disregarded entirely.
- Table 1 – too many significant figures are presented for areas burned
    - Are these data for all of Nova Scotia?
    - Standardize the data to a per-year basis (1999 is only one year)
    - Discuss the apparent rate changes over time
    - Presumably the "*selected*" fires were relatively big ones?
- Figure 1 – this is missing from the manuscript
- Page 13 – Regional Fire History
    - Para 1 – How would frequent fires prevent the germination of viable seeds? Is it by deleting the seedbank or seed rain? Is it because germinated seedlings might have trouble becoming established, for a variety of reasons. Please explain this bit of germination biology, and also mention what species are being referred to here.
        - The fire rotations being mentioned in this paragraph are much shorter that those described earlier. Please explain the apparent discrepancy.
    - Para 2 – jack pine is not only a species associated with fire. It may also occur in bog wetlands. What sort of habitat does it utilize on Isle Madame?
- Page 15, para 3 – if one rod is 5.5 yards, or 5.0 m, then 60 rods would be about 300 m and not 5m as stated

- Pages 14-17 – **Fire Suppression**
    - Table 2 adds little of consequence to the paper and could be removed
    - Figures 2 and 3 could be combined into a single graph
- Pages 18-21 – **Insects and Diseases**
    - It is appropriate to use binomials for the forest pests, but this has not been consistently done for other species mentioned in the manuscript. For instance, the binomials of balsam fir and eastern larch are suddenly provided in this section, even though the species were mentioned earlier on. This is a sloppy application of a scientific style of writing. Maybe add an appendix that lists all proper common names and binomials of species mentioned.
        - The binomial of balsam fir is given in the 2nd paragraph of this section (page 18) and also in the third – it should only be provided the first time the species is mentioned in the entire report (which happened far earlier in the manuscript than this section).
    - Para opposite the map – were the outbreaks of Spruce Budworm really confined to Cape Breton, as stated? Or did they also occur in other regions of the Acadian Forest Region? This sort of ecoregional context is necessary, as Nova Scotia should not be considered in isolation from nearby regions with similar forest.
        - First map – it seems odd (to me) that the outbreak of 1916-1928 apparently did not affect the highlands of Cape Breton.
        - Label the maps, and specifically refer to them in the text
        - The text refers to an affected area (undated) of 629,910 ha. An unrealistically large number of significant figures is being reported here. Change to something like 6.30×10^5 ha.
        - For the most recent outbreak, refer to similar statistics for both Cape Breton Island and Cumberland County, so that comparisons can be made.
        - It is noted that Methven and Kendrick (1995) reported that the return interval had increased. This means that the infestations have been returning after increasingly long intervals during the past century. Is that what you mean to say here?
    - With respect to Larch Sawfly, where are there "*extensive areas of larch forest in Nova Scotia*" ?
        - Provide the binomial for Larch Casebearer (be consistent)
    - Is the Spruce Beetle a native insect? Be specific about this. There is an inference in the text that this beetle is non-native.
    - With respect to Elm, the word "intervale" is spelled incorrectly.
    - The Brown Spruce Longhorn Beetle (an incorrect common name is given in the text) affects species of spruce in addition to Red Spruce

        - Are the locations given in the table (which should be numbered and given a caption) the places where the listed pathogens were first introduced to North America? Please specify this.

- Pages 21-24 – **Hurricanes and Windstorms**
    - "*Tannehill (1956) reported that the frequency of hurricanes originating in the West Indies and subsequently moving up along the eastern seaboard of North America has not changed since the days of Columbus*." This is an astonishing out-dated and non-critical sentence, for many reasons:
        - there has been enormous progress in the science of hurricanes since 1956 (moreover, the authors apparently did not even read Tannehill – the book is cited secondarily)
        - our hurricanes do not necessarily originate in the West Indies, and they do not necessarily move along the eastern seaboard.
        - Some credible people think that the frequency of hurricanes may be increasing.
    - Figure 3 is mis-numbered, and is missing in any event
        - There is a non-titled figure of hurricane tracks, 1851-2000
        - This figure does not contribute much to the document
        - Where did the older tracks come from? Who made the predictions? What is the source of the data used in the figure? Are they actually hurricanes, or are tropical storms also included?
    - Use metric units (not miles)
    - Is Dwyer (1958) the most recent authoritative literature that is relevant to our forests?
    - The 3rd para on page 23 refers to Table 5, but means to refer to Table 3
        - Board feet?
    - Hurricane Juan is the best studied windstorm ever to have affected the forests of Nova Scotia, at least in terms of documentation of the damage
        - Make more use of this recent experience
    - No spatial or ecological reference is provided for the generalizations of Frelich (2002)
        - Didn't Frelich (2002) say anything about the critical importance of the degree of soil saturation at the time of the windstorm?
    - The last sentence of this section makes no sense.
    - Table 3 makes no mention of the importance of the degree of soil saturation at the time of the windstorm. Was the unpublished study of Dwyer (1958) subjected to any sort of critical review? Were credible methodologies used?

  - This section not does not devote sufficient discussion to the role of windstorms in creating gap disturbances

- Pages 25-26 – Other Natural Disturbances
  - Intensive browsing by Moose can cause important damage to the advance regen and post-disturbance regeneration of some species, such as balsam fir. This is considered a management problem in parts of the highlands of Cape Breton and elsewhere.

- Page 26 – Anthropogenic Disturbances
  - A key thesis of the report is confused and appears to be based on faulty logic. A major goal appears to be to assign each ecodistrict in NS to a "natural disturbance regime", as is presented in an appendix. However, the focus of the text of the paper is on "disturbances that have created the *current composition and extent* of forests in Nova Scotia" (page 3). In view of the fact that most of the existing forest of Nova Scotia has suffered from various anthropogenic disturbances and other stressors, including logging, the environmental factors that have most strongly affected the existing forest estate are strongly associated with human influences. As such, assigning a "natural disturbance regime" based substantially on knowledge of what is now present is not logical or fully justified (perhaps the role of enduring features in this process has also been important, but this is not explicitly explained in the report and so it is not assumed). Throughout the report there is confusion about natural and anthropogenic stressors, and they are often discussed together in the same sections. The critical section on "Anthropogenic Disturbances" is only three paragraphs long, and it does not deal with key anthropogenic influences that are not disturbances (e.g., certain kinds of pollution, many aspects of climate change). From both theoretical and practical perspectives, the insufficient attention to anthropogenic stressors, and the frequent confounding of natural and human-associated influences, is a huge deficiency in the present report.
  - The first sentence is confusing
    - This is partly a matter of grammar
    - However, were the pre-Columbian forests "*dominated*" by "*Native Americans*"? What does that mean?
  - This section needs considerable more detail on the causes and ecological consequences of anthropogenic disturbances and how they differ from more natural regimes.
    - What about forestry as a kind of anthropogenic disturbance? What are the key ecological consequences? What percentage of timber harvesting in Nova Scotia is by clear-cutting, and is this appropriate in terms of emulating what we know about natural disturbance regimes?
    - What about consideration of key anthropogenic stressors that do not act as disturbances, such as acidification caused by atmospheric deposition, resulting loss of base cations, air pollution by sulphur dioxide and ozone,

and maybe nutrient deposition associated with oxides of nitrogen? Could these factors also influence successional outcomes?

- The last sentence of the Introduction section (page 3) states "*The intent of this report is to provide information on the disturbances that have created the **current** composition and **extent** of forests in Nova Scotia.*" Given the prevalence of human stressors, a much more thorough discussion of anthropogenic influences on the modern forested landscape is warranted.
- Mention is made of old-field sites and associated tree species, but otherwise there is no discussion of changes in forest composition and structure associated with anthropogenic stressors and activities. Review the relevant literature, including Loo and Ives (2003).
- 2nd paragraph of the section - "*Even after 100-150 years, formerly plowed sites have naturally reforested and now resemble natural forests, however, the soil still retains a distinctive signature of the past in its structure, appearance and chemical composition*." Provide a citation. Describe how these stands may resemble natural forests, and also the differences.

- Pages 26-28 - **Natural Disturbances and Landscape Structure**
  - What is the source of Table 4, or has it emerged from the present manuscript?
    - Table 4 is the first place where the theme of "senescence" as a stand-initiating factor is mentioned. What is being contemplated here? The synchronous senescence of an even-aged cohort? If so, please discuss this idea in the text and provide some examples. Has this phenomenon been noted for any of the species listed in that row of the table?
  - This section would be a good place to discuss the notion of a shifting-mosaic model of stand disturbance and succession.
  - Page 27 - A ranking of factors controlling forest structure and landscape is identified for New England (landform > agricultural history > elevation > hurricane = fire = logging). The suitability of this ranking for NS forests should be discussed. In particular, it is egregiously simplistic to conclude that wildfire is equivalent as clear-cutting and/or hurricanes as an agent of forest disturbance. There are many key differences in these disturbances, as is discussed by McRae et al. (1002) and many others.

- Page 28 – **Forest Management and Natural Disturbances**
  - The notion of "ecosystem-based management" is introduced in the first paragraph. However, this term must be further explained so that its intended meaning is clear.
  - What are the "*climax forest communities representative of the Acadian forest?*" Have these been described previously in the manuscript? What would be their biological and physical attributes, such as species composition and relative dominance, age- and size-spectra of the overstory, and indicator species in the ground vegetation?

- Again the notion of maintaining the characteristics of a primeval landscape comes up. Whose objective is this, and why is that idea being invoked?
- This section reads as though only suitable forestry practices can result in the native biodiversity of Nova Scotian forests being maintained. But this is too simplistic. There is also a key role for protected areas in which forestry is not undertaken. To a much lesser degree, there is also a role for softer management practices in agriculture and for urban naturalization.
- 2nd paragraph of the section - "*the ecological features considered to indicate development under an unchanging environment, such as large and old late successional trees … are in fact the legacy of repeated, intense, often anthropogenic disturbances*". This statement seems counter-intuitive (old trees = human disturbance?) and needs more explanation.
- Considering that the ELC is to form a basis for ecosystem-based management within the province (NSDNR 2004), the designation of natural disturbance regimes to ELC units is a fundamental consideration. There is no discussion about the interpretation involved in assigning disturbance regimes to Ecosections and how these are considered to vary amongst the higher ecosystem groupings.
- "*in many areas of Nova Scotia forest biodiversity still reflects the natural disturbances of the pre-settlement past*". What type of "biodiversity" is being referred to here? Which areas of Nova Scotia? Provide additional detail as to how the present biodiversity still reflects the pre-settlement past. Cite references.
- last sentence of the section - Reference is made to conserving the "*existing level of biodiversity*." What is the context here? Is this desired by the public? By foresters or other land managers? From an ecological perspective, is this an appropriate goal, particularly in view of the already established burden of alien species and pathogens in the presently existing biodiversity of Nova Scotia.?

- Pages 28-30 – **Emulation Silviculture**
  - First sentence - the idea is not to "preserve" biodiversity, but to "conserve" it at viable levels, which is a more realistic aspiration.
  - With respect to emulation silviculture: "*The success of these attempts has been questioned but perhaps they have been more successful than at first thought*." This sentence is confusing. More detail is needed here. Who did the questioning, and what are the indicators of success or failure? Provide some details of the rationale for these odd conclusions, and cite references to back up the several points being made.
  - What is the paleoecological evidence for reduced abundances in Nova Scotia of "*basswood, cedar, and grapes*"? This is an astonishing claim, so please cite the references for it.
  - "…*the forest structure these [natural] disturbances produce, for example, age class distribution, patch size, species composition, and habitat can be approximated through forest management*." This is an astoundingly confident and ecologically arrogant thing to claim. How is it known that these outcomes can be

reliably achieved? What are the risks to some elements of native biodiversity if these predicted extraordinary successes of forestry do not actually occur? Is there any residual role for protected areas, or can forestry do it all?

- This section on emulation silviculture is not satisfying. It is necessary to discuss some commonly used practices in this context. For instance, what about clear-cutting? How does its use on the landscape level emulate the disturbance regime associated with wildfire? In what situations would selection harvesting be appropriate?
- Page 30, 1st paragraph, last sentence – provide a citation.

- Pages 30-31 – **Fire Disturbances and Forest Management**
  - According to Frelich (2002), "*fire is important in maintaining the diversity of tree species even in landscapes where fire is rare*." This makes little sense. How can fire be a key environmental factor if it is so rare as to be inconsequential as a disturbance?
  - This section extensively relies on OMNR (2001) and McRae et al (2001). However, these two documents are substantially in conflict in certain key areas that potentially affect forestry policy and practices. This should be discussed and the reasons briefly explained. Table 6 is entirely based on OMNR (2001), but McRae et al (2001) differ in some of these interpretations.
  - Table 6 – what kind of forest harvesting is being summarized in this table?
    - It is true that fire kills trees relatively quickly, and it oxidizes some of their biomass at that time. However, the event is also followed by up to several decades of further oxidation of the residual dead biomass (by in situ decomposition) until the CO_2 emission becomes counter-balanced by increasing net productivity of the regenerating ecosystem. How does that compare with a forestry-related emulation practice?
    - Which nutrients are being recycled after a fire? Calcium and other bases? What percentage of the total in-tree capital of these nutrients is "recycled" by the fire?
      - What about nutrient "removals"? How much organic-nitrogen is gasified by a wildfire? How much nutrient capital is removed from the site by a clear-cut?
      - Why are no areas of "*wildlife habitat*" protected by a wildfire? Is this really the case?
      - This table is a key part of the manuscript and its conclusions, but it is much too simplistic. Each of the line items should be rationalized in the text.

- Page 32, **Wind disturbance and forest management**

  - Considering that a large amount of forested land in NS is characterized by gap-phase succession, this section could receive much more attention. The extensive literature includes Runkle (1991) and Coates and Burton (1997).

- Page 32 – **Closing**
  - This is a hopeful paragraph, but it will only work out well if the emulations are indeed successful in mimicking natural disturbance regimes to an acceptable degree.
  - What is the role of large protected areas in which forestry and other intensive resource-harvesting practices are not allowed? Can all elements of native biodiversity be accommodated if appropriate systems of protected areas are not also in place?

- Appendix I
  - Many of the notations have no specific reference to ecological damage, which limits the utility of the appendix.
  - Where possible, provide quantitative estimates of damage, e.g., for hurricane Juan
  - Mention the Brown Spruce Longhorn Beetle (*Tetropium fuscum*)
  - Use metric units throughout (can also include non-metrics in brackets)
  - Provide binomials for all pathogens listed under Insects and Diseases

- Appendix II
  - There are to many significant figures
  - Have any of the predictions been checked against the actual land cover? Has any ground truthing been done?

- Appendix III?? – This long table has no title. It is replete with information on Districts and Sections, but no insight is provided as to the genesis of the data.
  - I presume these are just data outputs and will not be part of the report, other than a summary in Table 5.
  - There are too many significant figures
  - The methodology used to develop the information in this appendix is not described is sufficient detail to allow a critical appraisal of the outcomes and data. To what degree were enduring features of site and landscape utilized, and what influence did present stand and forest conditions have? Was a quantitative model used? If so, who developed it and provide a citation. How was the model parameterized – by expert opinion or otherwise? If the former, what individuals participated in the exercise?
  - Was any ground truthing done?
  - Little can be inferred regarding the interpretation used to assign disturbance regimes to Ecosections

- Further discussion is needed of the spatial scale at which disturbance regimes have been identified. Is it appropriate to assign disturbance regimes to Ecosections (given the variation in drainage capabilities within these units, for example) or is more specific spatial delineation required for this – such as Ecosites?

Suggestions for Additional References to Examine

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.

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.

Coates K. D., P. J. Burton. 1997. A gap-based approach for development of silvicultural systems to address ecosystem management objectives. Forest Ecology and Management **99**: 337-354.

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.

Foster, D.R. and Motzkin, G. 1998. Ecology and conservation in the cultural landscape of New England: Lessons from nature's history. Northeastern Naturalist 5(2): 111-126

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.

Loo J. and N. Ives. 2003. The Acadian forest: Historical condition and human impacts. The Forestry Chronicle 79: 462-474.

Loo, J., L. Cwynar, B. Freedman, and N. Ives. 2007. Changing Landscapes in the Atlantic Maritime Ecozone. Pp xx -xx In: McAlpine, D.F. and I. M. Smith (eds). 2007. Biodiversity Assessment of the Atlantic Maritime Ecozone. Biodiversity Monograph Series, National Research Council Press, Ottawa (in review, but a manuscript could be obtained).

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.

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.

Mosseler A., J. Lynds, and J. Major. 2003. Old-growth forests of the Acadian Forest Region. Environ. Rev 11: 1.

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 North America. Ecology 16:403-422.

NSDNR. Nova Scotia's Code of Forest Practice. NSDNR; 2004. Report nr 2004-8. 1 p.

Ponomarenko, E. and S. Ponomarenko 2000. Reconstruction of pre-agricultural vegetation pattern in Kouchibouguac National Park using the ecosystem archaeology method. Parks Canada Unpublished Report, 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. Parks Canada Unpublished Report .

Runkle J. R. 1991. Gap dynamics of old-growth eastern forests: management implications. Natural Areas Journal :19-24.

Russell, E. W. B. 1979. Vegetational change in northern New Jersey since 1500: 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.

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.

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

Su, Q., MacLean, D.A., and Needham, T.D. 1996. The influence of hardwood content on balsam fir defoliation by spruce budworm. Canadian Journal of Forest Research. 26: 1620-1628.

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

Whitney, G.G. 1987. An ecological history of the Great Lakes forest of Michigan. J. Ecology 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.

Williams, J.W., D.M. Post, L.C. Cwynar, A.F. Lothar, and A.J. Ldevesque. 2002. Rapid and widespread vegetation responses to past climate change in the North Atlantic region. Geology, 30: 971-974.

- The following important reference to natural-disturbance regimes in the ecoregion is listed in the reference section, but does not seem to be cited much in the body of the report:

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.

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The following comments represent my personal views and are not necessarily those of Parks Canada.

I am pleased that NS DNR is taking a look at the natural disturbance regimes of NS. This is a very challenging and complex area of research, but an all-important subject to explore and understand. Forest harvest practices that emulate natural disturbance regimes should ultimately produce healthier sustainable forests. Presumably that is a key force behind why this report was written. A statement of long-term goals and/or shorter-term objectives would be a useful clarification. The report reflects a large amount of work, and I hope that the department will forge on to its completion, including pursuing some additional research in order to achieve objective, scientifically-based conclusions/statements on NS disturbance regimes. Having completed similar work, I recognize the effort involved. In the words of Titus Smith (1835), **"*Whenever man neglects the dictates of nature, he is sure to be the sufferer*"**.

- The main issue with this report is that there is almost no original data ("homegrown stuff" from NS!!) to support most of the statements. It is difficult to conclude anything reliable about the characteristic disturbance regimes that operated in NS forests prior to widespread anthropogenic influences, when statements are based on anecdotal historical comments, and research that is either extremely limited, controversial, or non-existent. It is fair to state this information deficit upfront, (since it is not the fault of the authors that there is very little information directly from NS to draw from).

-Some statements are premature, given the lack of scientific evidence. Information gaps should be clearly acknowledged. Areas where research is insufficient to draw any conclusions, can be explored/discussed, but should not mislead the reader to believing that we have sufficient understanding to make sound management decisions. The precautionary principle is the best choice when management decisions have potential to impact terrestrial ecosystems for centuries.

-Formatting- At times the intent of some paragraphs appears to change direction part way through. I suspect that it partly reflects the schism in belief systems of the authors as to whether large frequent fires were natural/not natural. Resolving this question would facilitate writing the report.

Proper referencing is necessary to avoid losing credibility with your readers, (but I understand this is a first draft).

Clearly differentiate those disturbance events that originate from natural disturbances and those that are anthropogenic under separate subheadings. Alternatively, classify them as pre-and post-European disturbances. Otherwise it is very confusing and misleading. Disturbance history is not very meaningful if we cannot discern between what is natural or characteristic versus what was caused by European disturbance.

- A great deal of disturbance information can be deduced from forest composition and structure, particularly from the earliest recorded forests of NS. Former large stands of hemlock and red spruce are not linked with stand-replacement fires, and certainly the large sizes of these trees indicate that intense stand-replacement events were not frequent. We know that such forest types can self-perpetuate indefinitely. Deducing disturbance requirements from the modern

forests (which are the result of repeated human-caused fires and other disturbances) would be a mistake and will drastically reduce the volume of high quality species on the landscape.

Observations of Loucks (1962) are under-utilized. His work indicated that much of the province was dominated by the red spruce-hemlock-pine. We can deduce from the silvics of these species that gap replacement was a major dynamic in such forest types. This is in stark contrast to your map, which would have only a minute proportion of this region (14 %, according to Table 5) under "gap replacement" dynamics. For western NS, Loucks stated "*fire has played a prominent role in the destruction of much of the former forest. But white pine, red spruce, and locally hemlock, are found under the red oak and red maple, suggesting a return to a mainly coniferous forest*". "*Red spruce and hemlock have been depleted* [in this region], *but remnants of old-growth forest indicate the former importance of these two species*" (Loucks 1962). Judging by these records, you should be directing serious consideration toward managing for these species, and also for representing the age classes and structures that NS forests extensively featured up until relatively recently. There are a wealth of species associated with such structures and age classes that are neglected when such forest types disappear. The choice is whether to manage towards characteristic, natural forest types (including age class and structure) or to perpetuate anthropogenically-created forest types. If it is the latter, then let's state it upfront. State that it is not "natural", but perhaps necessary for wood supply, and subsequently change the title of Table 5 (i.e. take out the work "natural").

Loucks (1962) had similar things to say about the Northumberland Strait area of NS (and NB). "*Prior to the repeated burnings, red spruce, hemlock, and white pine were probably more abundant*" (p. 138-139). My research in the Northumberland area have confirmed Loucks' suspicions that eH and rS were indeed much more abundant prior to the extensive impacts of anthropogenic fire. Hemlock was, in fact the second most frequent tree genus encountered after *Picea*. Hemlock that hadn't succumbed to frequent fire and other anthropogenic activities were rapidly logged for the tan bark industry. Mid- to late-successional species were once the dominant forest types, although regional forests are currently dominated by early successional species, such as aspen, white birch and jack pine. In this region, jack pine has, in only 200 years, rose from being a very minor species to becoming dominant. Poplar is now the dominant deciduous species. Wire birch is everywhere. The cause was nearly entirely due to anthropogenic fire at extremely frequent intervals. (So far, we have already had 2 fires in Kouch National Park this year…again, anthropogenically-caused. At this rate we will not return to hemlock-red spruce-white pine dominated forests, even in the national park!) Soils are impoverished from the frequent fires…another long-term consideration for forest management.

- Smith (1835) made some interesting successional statements on eH and bF that are worthy of reflection, such as the resiliency of eH following fire versus successive fires. (This is different than stating that eH "requires" fire, which it does not!!) The resiliency of hemlock had limitations that had perhaps not yet been witnessed by Smith, but was evident roughly half a century later in the eastern US: " *as regards to hemlock, fires kill it out clean, seedlings and seed; and if the 'peelers' and the fires happen to leave any scattering of trees standing, these being more sensitive to changed conditions than pines, are seldom able long to survive as seed bearers*" (Sargent 1884).

Please do not assume that hemlock is somehow a species that requires fire! (Table 4…) There seems to be some thinking toward this end. (I am sending you a list of references on hemlock and its silvic requirements, just in case...)

The Oxford district was also dominated by mid- to late-successional species (sM, yB, eH, rS, Be), as well as bS, bF, but has been altered by fire (Loucks 1962). "*Most of the District has either been cleared or burned*" (Loucks 1962). With that in mind, we cannot base long-term forest management decisions on the present forest types (as they are anthropogenically altered), and so must delve into the field of historical ecology. In my opinion, your map which indicates "frequent" disturbance for the Maritime Lowlands Ecoregion is incorrect. I have data that solidly proves otherwise (at least for the NB portion of the region). Furthermore, the lowlands receives among the lowest incidence of dry lightening strikes, (Jeff Patch, NBDNR.)

- Statements on fire are misleading and are cause for great concern (p. 10. Rephrase: "*Fire* [both naturally-occurring and human-caused] *has been a disturbance agent*…" Second thought; just try to separate natural and human-caused fire before making such sweeping and general statements.) Another example, the manner in which the report addresses the Great Miramichi Fire (p. 11) can cause the uninformed reader to believe that this fire was of natural causes, when, in fact, it was from land clearance fires during a period of rapid European settlement, coinciding with a period of extreme drought. The way in which the report is written, there appears to be some doubt cast that the extensive waves of European land clearance fires were indeed anthropogenic and not natural: E.g. (p. 11) "Some believe that much of the provincial forest reflects the extensive use of fire by settlers…". Are there those who disbelieve that this took place? (I would guess that if such people exist, they may not be well informed on the early history of NS.) References to Sobey (2002; 2006) and my research should help dispel any doubts. Again on page 11, to my knowledge, Basquill *et al*. (2001) did not study the fire barrens, and so the original researcher(s) should be quoted. Reference the original "other researchers". Otherwise, the statement is very weak.

Similarly, Titus Smith's observations could be misinterpreted (p.11) due to the manner they are written. You reference large fires, but the reader can easily get lost into thinking that such fires were from natural causes. Indeed, Smith described "*horrific forest fires*", but it is very evident that most were caused from European settlement activities. The way the paragraph is phrased can mislead the reader to believe that fires were *naturally* frequent and large. Smith (1835) greatly assists with understanding Smith (1857). Note the following: "*The great influx of inhabitants in 1783 produced, in the course of a few years, a complete change in the appearance of the forest. A great number of new settlements were formed. The fires necessary for clearing the land were communicated to the spruce thickets, and spread frequently as far as they extended*." Smith (1835) spoke of "*successive fires, which were usually rekindled every dry season by design or negligence*… […until], *the ground becomes so much exhausted, that it produces only a growth of heathy shrubs, among which the kalmia predominates*…". (Perhaps this causes us to re-think the statement that fire barrens originated before European colonization?)

During my research, I discovered that the impacts on forests from land clearance fires could not be overstated. Land grants clearly stated the terms and conditions in which the forests must be cleared by early settlers. Within five years, grantees must, clear forests and "*work three acres*" for every 50 acres of improvable land (i.e. land fit for cultivation), or else "*clear and drain three acres* [ ] *of swampy or sunken ground, or drain three acres of marsh* [if any marshlands were found within the grant]" (PANB F16303 Vol. D, No. 483). Non-compliance resulted in lands reverting to the crown. Imagine! Settlers, armed with only an axe, found fire to be a necessary tool to clear land and meet the terms of their grants. Countless land clearance fires escaped to

surrounding forests without intervention. As Johnston (1851) travelled about NB, he *"...saw fires burning in the woods in many places, which, in this dry season, only required a little wind to spread in one blaze over the whole forest*". During dry periods numerous small land clearance fires, particularly in areas of rapid settlement, sometimes united into large catastrophic fires (Brunken 1900). As previously mentioned, this was believed to have been the cause of the Great Miramichi fire (Ganong 1902).

Figures 2 and 3: I suspect the large escaped fires from anthropogenic disturbances during the 19th century would add still higher bars on the graph (Fig. 2). Again, this graph could lead the uninformed reader to believe that we must add more fire or other disturbances on the landscape to return to the early 1900s, when most for the area burned was likely due to anthropogenic causes. If we could access the data, I am sure that much higher annual burns existed in the 1800s. What is really required is the fire cycle prior to European contact. What percentage of the fires on the graph from Figure 3 was natural, (i.e., from dry lightening strikes)? 1 %? 2 %?

-Statements must be referenced to have credibility. For e.g. "*There are others who believe that the native peoples used fire to encourage berry production and to maintain browse for the moose and caribou*…" says who? General statements submitted without solid references may be regarded as an attempt to mislead the reader to believe some biases of the author(s). (We all have biases.)

- There is little point in referencing native cultures that are not Mi'kmaq. Agrarian societies used fire. Mi'kmaq were nomadic. Much of their diet (particularly during the "fire season") came from the ocean and rivers (Clermont 1986). The bottom line is we just don't know what kind of fire ignition impact Aboriginal peoples had in NS. If we don't know, it is better to say that we just don't know! This may be an opportunity to invite some Mi'kmaw partners to the table to help with some research. I suggest that if you are to reference native burning, try to obtain information from NS and from the earliest possible periods. Here are some things that I summed up in my thesis: Two main ignition sources existed prior to European contact: (1) fire use by First Nations, namely the Mi'kmaq; and (2) lightning strikes. Records are somewhat contradictory on Mi'kmaq activities as a cause of wildfire. Titus Smith, who was very familiar with wildfire and its affects in the Acadian forest, spoke of the "*habits of the Indians, who carefully avoided setting the woods on fire*" (Smith 1835). Bruncken (1900) was certain that early settlers caused the vast majority of wildfires rather than First Nations peoples: "*Where Indians are present they get most of the blame*", since settlers were reluctant to assume responsibility for fires they caused through their own negligence. "*Forest fires, practically without exception, are the result of human agency*" (Bruncken 1900), (referring to European settlers, not the Mi'kmaq).

-There are many references to fire laced throughout the report. While it probably represents the strongest disturbance force in NS forests, it is only one of several important disturbance agents. Though other agents were acknowledged in the report, they need more "air time". (E.g. The hurricane track map is a good addition to the report, but must be accompanied by wind speeds to be meaningful. Add information on threshold wind speeds required to uproot some species of mature height classes, etc.) Insect damage needs more information. Coprolite research may provide some answers for you. The numerous references to fire could be interpreted as providing a transparent message that the department is grasping at whatever argument can be found to back an economically-driven requirement for large clear-cuts, justified by stating that it

is mimicking "naturally-occurring", large, stand-replacement fires. One might accept this message if there were solid data behind the theory, (which might be gained with a little research).

-Some consideration may be given more generally to ecological processes. For instance, monitoring decay rates in eastern NB forests (which is directly related to fuel buildup = fire hazard potential) is worthy of exploration. After an insect outbreak, how long does the fuel buildup remain before it rots? Research indicates very rapid decomposition for NS (Péch 1993). Other areas with largely continentally influenced climates, (e.g. Ontario) may have much longer decay rates, and therefore greater danger of fuel build-up following insect infestations, and other processes. Again, you need data from NS to base strong conclusions. Parks Canada has begun monitoring decay rates in various parks across the country using wooden tongue depressors placed in various drainage classes. The data may prove useful to your department.

-Section 4.1 Fire: It won't pay to dwell on this section except to say, keep working on it. Organize the thoughts. What is the key message being delivered? I am not sure what is really being communicated here and there. Anthropogenic and natural fires must be clearly distinguished for anything meaningful to be concluded on historical fire regimes. It would be fitting to add a paragraph on forest structure (closely linked to age class and composition) and how it strongly influences fire behavior. Low intensity ground fires, rather than canopy, stand-replacement fires may have been the norm. It is essential to explore this if we truly wish to mimic fire disturbance behavior. Attempts to justify clear-cutting by implying that stand-replacement fires were frequent/widespread without scientific evidence will damage credibility with the public.

-Since forest disturbances from other provinces and states were referenced, you may consider adding some references closer to home:

1. Douglas Sobey reports (there are 3 of them) on historical forests in PEI.
2. Ponomarenko, E. various reports from the maritime provinces… they reveal a lot about pre-European disturbances.
3. Lutz, S. 1997.
4. Mosseler *et al*. 2003
5. My research (Crossland 2006) I am sending you a pdf version.

-Widespread clear-cut practices tend to simplify and "borealize" the Acadian forest. This won't prepare it for pending warming trends, when boreal forest types (and generally less wind-firm spp) may be less suited for the region.

- Use of the term "climax" forests is, to my knowledge, no longer in keeping with what most forest ecologists use today, although the work of Clements is still valued. Forests do not reach "end states" and then just stay there… they remain dynamic, albeit some processes may slow down. It might be more accurate to refer to late-successional forests… or old-growth, late-successional forests, depending on what you are referring to, rather than a "climax state".

- Denys. The report stated (p. 10) that Denys described an "*abundance of oak, white birch and pine in his accounts*". I suggest that direct quotes from historic records be used to avoid biases of various authors. At the very least, rephrase Denys. I believe that the actual quote was "*the trees are beautiful, and in great abundance, such as oaks, birches, beeches, ashes, maples* [ ]" (Denys 1672; *In* Ganong 1908). The birch was not specified as "white birch". Therefore, I don't

believe that you can use Denys' quote to support fire-origin forests. To my knowledge, Denys (1672) identified only two species of birch, black birch (mignogon) and white birch (bouleau). Given that he did not mention yellow birch, which should have been quite common, the species was evidently included as 'black birch', (i.e., old growth yellow birch). Another sign of the advanced age classes and late successional nature of much of the forest. Campbell stated that black birch was abundant. There was "*as much black birch in Nova Scotia and New Brunswick [ ] as would supply all the dock yards in Europe with ship timber, for 100 years, if not for ever*" (Campbell (1793). Entire vessels were built of it (Denys 1672). My suspicion is that yB took the lead over wB….

Be aware of historical bias. The French noted oak often in the earliest documents because they were very interested in its utilitarian purposes. They regarded rO as similar to European oak, which they valued for ship building and barrel-making. They soon lost interest when they found that rO wood properties were not nearly as useful as European oak.

- Table 4. Add rS, eH and wP to "gap dynamics" section.

I am not sure what you mean by "stand-maintaining". It would seem to be redundant for one of the other terms already in use in the table (?).

bS and La could be added to "open seral"?

The last time I checked, the jury was still out concerning the necessity of fire for white pine! If it were simple to grow through burning an area, we would have this valued timber growing extensively throughout our province, and be making lots of money. It can be initiated either through a stand replacement event or gap replacement. Given that it grows on a wide variety of soil types and drainage classes, in either pure even-aged stands or in mixed stands, it is not easy to put in any single slot.

Jack pine in eastern Canada has semi-serotinous cones, and regenerates very well without fire in NB, (and probably NS, too). This is probably an adaptation to longer fire cycles in the east, (prior to European influences). Of course, pure stands require a stand-replacement event, but it can also regenerate without… (Conkey et al. 1995).

- I have recently completed research on the historical forest ecology of Kouchibouguac National Park. Studying historical ecology causes one to often receive smug grins from those who falsely interpret us to be somehow intending to re-create some pre-existing static forest state. My objective was to gain a clear understanding of what the characteristic forest types could be in the region under a more natural disturbance dynamic. Measurement of forest change over the past 200 years was a worthy pursuit, as it allows us to clearly differentiate between natural and anthropogenic disturbance impacts. The Acadian forest was among the earliest forest types to be altered by European influences, and therefore we have to dig a little deeper than in other forest types in Canada to reveal what the composition, structure, and function of this forest really was, or should be today. Since this subject area remains of great interest, I would be happy to help your department in any way that I can in uncovering the disturbance history of NS forests. I am returning to my home province of NS beginning in June 2007. Do not hesitate to contact me if I can be of any assistance on this worthy project.

There may be some real opportunity to work in partnership with other departments, universities, etc. to find the answers on some key ecological questions. I enthusiastically recommend the

research of Dr Ponomarenko in assisting your department with "untangling" the characteristic or natural disturbance regime of NS forests.

Thank you for inviting my comment on your work. Good luck with its completion.

Sincerely,

Donna

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References

Brunken, E. 1900. North American forests and forestry. G.P. Putnam's Sons, NY. 265 pp.

Clermont, N. 1986. L'adaptation maritime au pays des micmacs, *In* : Martijn, Charles A. 1986. Les micmacs et la mer. Recherches amérindiennes au Québec, Montréal, Qué. pp 11-27.

Ganong, W.F. 1902. Great forest fires in New Brunswick. Bulletin of the Natural History Society of New Brunswick, v. 4, no. 20: 434-435.

Ganong, W.F. 1906 b. Notes on the natural history of New Brunswick. 90. On the limits of the great fire of Miramichi of 1825. Bulletin of the Natural History Society of New Brunswick, v.5, no. 24: 410-418.

Johnston, J.F.W. 1851. Notes on North America. Vol. I and II., C.C. Little and J. Brown, Boston. 512 pp

Loucks, O. L. 1962. A Forest Classification for the Maritime Provinces. Proceedings of the Nova Scotian Institute of Science. Vol. 25, Part 2.

Lutz, S.G. 1997. Pre-European settlement and present forest composition in Kings County, New Brunswick, Fac. For. Envir. Mgt. U.N.B., Fredericton, NB. 51 pp.

Mosseler, A., Lynds, A., and Major, J.E. 2003. Old-growth forests of the Acadian Forest Region. Environ. Rev. 11: S47-S

Péch, G. 1993. Fire hazard in budworm-killed balsam fir stands on Cape Breton Highlands, The Forestry Chronicle, 69 (2): 178-186.

Sargent, C.S. 1884. Report on the forests of North America. Dept. of Interior, Census office, Gov. Printing Office, Washington, microfiche CIHM, no. 25264.

Smith, T. 1835. Natural history of Nova Scotia. The magazine of natural history, Dec., vol. VIII:56, p. 641-662.

Smith, T. 1857. A natural resources survey of Nova Scotia 1801-02. Public Archives of Nova Scotia, vol. 380, 179 pp.

Sobey, D. 2002. Early descriptions of the forests of Prince Edward Island: A source book. Part I: The French period- 1534-1758, PEI Dept. Ag. and Forestry, 180 pp.

Sobey, D. 2006. Early descriptions of the forests of Prince Edward Island: A source book. Part II: The British and post-confederation periods- 1758- *c*. 1900, Part A: The Analysis, Part B. The Extracts. PEI Dept. of Envir., Energy and Forestry.

Dr. Chris Miller, Canadian Parks and Wilderness Society, Nova Scotia

March 31, 2007

Dear Peter Neily:

The Nova Scotia Chapter of the Canadian Parks and Wilderness Society (CPAWS-NS) would like to commend the authors for taking on the huge task of assessing forest disturbance patterns in Nova Scotia. The topic is complex and requires a tremendous amount of understanding of the Nova Scotia landscape, not only from today's perspective, but also that of the entire Holocene. We appreciate the opportunity to peer-review the draft manuscript and hope that our suggestions will be well received and incorporated into subsequent versions of the manuscript.

After having reviewed the manuscript, *Forest disturbance ecology in Nova Scotia*, however, CPAWS-NS strongly feels that major revisions are still required before this document is in a suitable condition where it could pass a modest peer review, or more importantly, where it could be responsibly used in formulating public policy or developing management strategies for the forest resource in Nova Scotia. Comments provided by CPAWS-NS are not intended to be critical, but rather to focus attention on key areas of the manuscript requiring further work, so that the final product can be satisfactory, and ultimately useful in guiding management decisions for the maintenance and restoration of the Acadian forest in Nova Scotia.

Once again, thank you for the opportunity to peer-review the draft version of this manuscript. We look forward to reviewing follow-up drafts.

Sincerely,

Signed in original

Christopher A. Miller, Ph.D.
Ecologist, Wilderness Conservation Coordinator, CPAWS-NS

The Nova Scotia Chapter of the Canadian Parks and Wilderness Society (CPAWS-NS) has reviewed the manuscript, *Forest disturbance ecology in Nova Scotia*, by Neily *et al.* 2007, and provides the following comments for your consideration.

Peer review process

Normally, a peer-review process would be handled by a group of individuals that are at arm's length to both the authors and the scientists carrying out the review, such as the board of a peer-reviewed journal. It is somewhat unusual for comments from a peer-review to be sent directly to the authors, without a process in place to independently review those comments or to independently ensure that appropriate suggestions for revisions are followed though in the final version of the manuscript. CPAWS-NS encourages the Department of Natural Resources to develop a more standard peer-review process for the next version of the Neily *et al.* 2007 manuscript; one that involves an independent group of academics overseeing the peer review process.

Anthropogenic disturbances

Given the relatively long history of settlement in Nova Scotia, and the extent to which our forests have been subject to resource extraction, it is reasonable to assume that anthropogenic disturbances have been, and continue to be, one of the predominant contributors to the make-up of the present day forests in Nova Scotia. The extreme limited extent of genuine old-growth forests in Nova Scotia, for instance, is primarily the result of anthropogenic influences and cannot be accounted for solely by natural disturbance regimes. Despite the obvious influence of anthropogenic disturbances on the composition and extent of forests in Nova Scotia, however, the current manuscript only devotes a few paragraphs toward this topic (pg. 26), something which will need to be corrected in the next version of the report.

Since the purpose of the manuscript is stated to be, "*...to provide information on the disturbances that have created the current composition and extent of forests in Nova Scotia*." (pg. 3), it's hard to imagine how this could be achieved without examining, in detail, the role of anthropogenic disturbances in influencing the current condition of the forest. CPAWS-NS asks that this oversight be corrected in the next version of the report, and for it to include a detailed discussion of forest harvesting techniques (spatial extent, and rates of harvesting), silviculture practices, plantations, forest conversions, fragmentation resulting from roads and settlements, and effects of early competition control (including herbicide applications), to name a few. Without such information, it is impossible to tease-out the effects of natural disturbances from those that are primarily caused by human intervention.

Post-glacial recolonization

The manuscript attempts to examine the post-glacial history of forests in Nova Scotia, yet a number of important palynological studies are not cited in the analysis (See: reference list attached). In fact, the authors rely heavily upon the works of Roland and Smith (1969) even though this work is extremely out-of-date, having been published at a time when only a handful of palynological studies had been carried out in Nova Scotia. The study of fossilized pollen has much potential in understanding the nature and rate of disturbances in pre-European forests in Nova Scotia, and CPAWS-NS encourages the authors to further examine the literature in this regard. The current description does not accurately reflect the extent of our knowledge in this field, as it pertains to forests in Nova Scotia.

In certain sections of the report dealing with post-glacial colonization, the choice of text is discomforting from a scientific perspective, such as the sentence "*The development of Acadian forest communities has continued in a more or less steady state with plants distributed according to the ecological conditions to which they were best adapted*" (pg. 3). In fact, the development of the Acadian forest did not occur as a steady change over time. Quite to the contrary, the palynological record from Nova Scotia shows dramatic events having occurred in relatively short periods of time, such as the mid-Holocene die-back of hemlock, or the sudden appearance of boreal forest taxa, or the huge changes in landscape composition that occurred during the Younger-Dryas event, or the sudden change in forest composition at the time of early-European settlement. Also, it should be pointed out that plants do not distribute themselves according to the ecological conditions to which they are best adapted, but rather the environment determines which individuals of a species happen to possess the necessary traits to survive in any particular location at that particular time, and not necessarily at the places in which they are best adapted.

Spatial delineation of disturbances

The manuscript attempts to assign disturbance regimes into spatially continuous data per ecosection (e.g. Table 5, pg 29), yet the authors do not provide sufficient data to support these results. A number of datasets that were used for this analysis are included in Appendix III, but the methods described for this analysis are not sufficient for independent scientists to even attempt to reproduce these results. In other words, the conclusions reached regarding the spatial distributions of disturbance regimes per ecosection in Nova Scotia do not follow logically from the information presented in the manuscript. This will need to be revised.

CPAWS-NS also questions the basis for neatly dividing the landscape into one of several categories of disturbance regimes. This is unlikely to be the case in reality, particularly when longer time frames are applied to the analysis. The landscape should not be viewed as a matrix of mutually exclusive patches that fall into distinct disturbance regime types, such as frequent, infrequent, gap dynamics, or open seral. Ecological interactions affecting Nova Scotia's forests are much more complex than that, and the current approach represented in the manuscript risks oversimplifying the nature and rate of landscape disturbance patterns in Nova Scotia. Moreover, when any given area is disturbed, the resultant community that returns will subsequently influence the nature and rate of future disturbance events, so it is not reasonable to conclude that a given ecosection will always have the same make-up of disturbance regimes at any particular point in time.

Biodiversity and protected areas

The report fails to provide sufficient background information on the biodiversity of Nova Scotia's forests, or indeed, basic principles of community ecology which are relevant to the discussion of natural disturbance regimes in the Acadian forest. Such information should be added to subsequent versions of the report. Research presented in this paper should also be placed in the context of the broader ecoregion, and draw upon a much greater depth and breadth of information and research than is currently available just for Nova Scotia (e.g. Maine, New Brunswick). This will enhance the review of the disturbance regimes.

Similarly, the current manuscript is entirely silent on the role of protected areas in maintaining natural disturbance regimes, as well as curtailing anthropogenic disturbances. Protected areas provide benchmarks for measuring changes to forest ecosystems, and in the context of Nova Scotia, are particularly relevant given the spatial extent of anthropogenic influences in this province. Furthermore, there is ample research in the field of conservation biology and protected areas design that examines natural disturbance patterns, with the minimum area required (MAR) for a protected area generally being determined by the maximum spatial extent of the largest natural disturbance patch. Research carried out in the Northern Appalachian – Acadian Ecoregion has flagged an area of 10,000 hectares in size as a likely minimum threshold in this regard. The authors are encouraged to include discussion of protected areas in future versions of the manuscript, particularly their role in maintaining natural diversity over time and serving as scientific benchmarks for assessing future changes in the composition of the Acadian forest. Assessing the forest without consideration of permanent protected areas is akin to conducting an experiment without a baseline control.

What's the purpose?

It is not entirely clear why the authors are carrying out this review, something which is indicated by the weak conclusions at the end of the report. Is it merely a literature review? Is it a critical analysis of our knowledge of forest disturbance ecology in Nova Scotia (if so, where are the alternate explanations that counter the arguments that are presented)? Is it intended for a scientific journal? Is it an internal government document that will be used to influence forestry practices? Does it reach any novel conclusions? How does it contribute to the body of literature on this topic? Is it intended for scientists, managers, decision-makers, or the general public? Much remains unanswered. Having clearer objectives stated up front, and by incorporating a critical analysis into the review that strives to answer specific questions, should help focus the work presented in this manuscript and make it more relevant to the intended audience.

References

Anderson, T.W. 1985. Late-Quaternary pollen records from eastern Ontario, Quebec, and Atlantic Canada. 281-326. in Bryant, V.M. and R.G. Holloway (eds.). *Pollen records of Late-Quaternary North American sediments*. American Association of Stratigraphic Palynologists, Austin, Texas, U.S.A.

Bennet, K.D. 1985. The spread of *Fagus grandifolia* across eastern North America during the last 18 000 years. *Journal of Biogeography*, **12**:147-164.

Green, D.G. 1982. Fire and stability in the postglacial forests of southwest Nova Scotia. *Journal of Biogeography*, **9**:29-40.

Green, D.G. 1987. Pollen evidence for the postglacial origins of Nova Scotia's forest. *Canadian Journal of Botany*, **65**:1163-1179.

Hadden, K.A. 1975. A pollen diagram from a postglacial peat bog in Hants County, Nova Scotia. *Canadian Journal of Botany*, **53**:39-47.

Jetté, H. and R.J. Mott. 1989. Palynostratigraphie du tardiglaciaire et de l'Holocène de la région du Lac Chance Harbour, Novelle-Écosse. *Géographie Physique et Quaternaire*, **43**:27-38.

King, L.H. 1994. Proposed Younger Dryas glaciation of the eastern Scotian Shelf. *Canadian Journal of Earth Sciences*, **31**:401-417.

King, L.H. 1996. Late Wisconsinan ice retreat from the Scotian Shelf. *Geological Society of America Bulletin*, **108**:1056-1067.

Levesque, A.J., F.E. Mayle, I.R. Walker, and L.C. Cwynar. 1993. A previously unrecognized late-glacial cold event in eastern North America. *Nature*, **361**:623-626.

Mayle, F.E. and L.C. Cwynar. 1995. Impact of the Younger Dryas cooling event upon lowland vegetation of Maritime Canada. *Ecological Monographs*, **65**:129-154.

Mayle, F.E., A.J. Levesque, and L.C. Cwynar. 1993. Accelerator-mass-spectrometer ages for the Younger Dryas event in Atlantic Canada. *Quaternary Research*, **39**:355-360.

Miller, A.A.L., Mudie, P.J., and D.B. Scott. 1982. Holocene history of Bedford Basin, Nova Scotia: foraminifera, dinoflagellate and pollen records. *Canadian Journal of Earth Sciences*, **19**: 2342-2367.

Shaw, J., P.Gareau, and R.C. Courtney. 2002. Palaeogeography of Atlantic Canada 13-0 kyr. *Quaternary Science Reviews*, **21**:1861-1878.

Walker, I.R., R.J. Mott, and J.P. Smol. 1991. Allerød-Younger Dryas lake temperatures from midge fossils in Atlantic Canada. *Science*, **253**:1010-1012.

Dr. Alex Mosseler, Canadian Forest Service

This report surveys the literature to summarize the disturbance forces that have shaped and continue to shape the forests of Nova Scotia. The authors are to be congratulated for preparing an interesting review of the subject. However, I was unsure of the ultimate purpose for this review. If this review was meant to provide some background to assist forest managers in applying forest harvesting regimes to better emulate natural disturbance regimes and thereby ensure that a representative sample of the biodiversity associated with Nova Scotia's forests remains intact and viable, then it seems to me that the authors may have underplayed the important role of gap disturbance ecology in maintaining late-successional forest types on the landscape. It is precisely these late-successional forest types, and more specifically the shade-tolerant or shade-adapted conifer component of such forest types that appears increasingly vulnerable to the clear-cutting that is the prevalent form of forest management across the Maritime Provinces (not just Nova Scotia). The survival and maintenance of shade-adapted conifers such as red spruce (*Picea rubens*) and eastern hemlock (*Tsuga canadensis*) are in decline across their geographic ranges because they are at an interspecific competitive disadvantage under the exposed conditions following clear cut forest harvesting.

When reviewing the ecological implications of forest harvesting regimes on forest biodiversity, the relationship between clear cutting and these late-seral species associations deserves special attention and emphasis; particularly if we want to make recommendations for modifying forestry operations to protect this component of our native forest biodiversity. This report needs to give more attention to this aspect of the ecological impacts of forestry practices on sustainable management of forest resources. The loss of late-successional forest types is a problem of forestry operations across the temperate zone of North America.

At the Canadian Forest Service, we have been studying the ecophysiological adaptations of early- versus late-successional species (e.g., black spruce, *Picea mariana* versus red spruce) and we now have abundant physiological evidence, as well as the anecdotal evidence from field tests (evidence which also appear in the scientific literature on maritime forestry), to draw the attention of the forestry community to the potentially harmful impacts of clear cutting on late-successional conifers.

On a final note, it is important that the forestry community understand that native forest biodiversity is both the foundation for adaptation (in the biological sense) to climate (or any environmental) change and for the economic/commercial future of the forest industry and the many unforeseeable products that may be derived from our forest resources. This report could be more helpful if it included a stronger recognition of the impacts of human activities on biodiversity and particularly the late-successional forest types by recommending more appropriate ways to manage these late-successional communities. In this context, I found the "Closing" remarks rather weak. I think the report could be improved by making some explicit recommendations on **what** "we can learn from natural disturbances" and **how** we can "use them to guide our forest management planning and silvicultural treatments to maintain and conserve the structure and functions of native biodiversity…". Furthermore, the conclusion that "in all but the most extreme cases, nature restores itself and eradicates the traces of man's presence" amounts to a dangerous half-truth that can be used to tell big, fat lies. This statement is only true if the native biodiversity has not been eliminated to the point where the requisite seed sources are no longer available to regenerate the full range of native forest species diversity.

Peter Salonius, Research Scientist, Canadian Forest Service

Hello Peter Neily,

You said on the last page that "In March several small workshops will be held in Truro to discuss the report." I am "interested in attending" -- please let me know the dates of these so that I can choose which one to attend.

I will send you a hard copy of the FDE in NS Draft Report in the mail --- upon which I have made numerous editorial comments that are too numerous to itemize here // suffice it to say that there are at least 11 references in the text that do not appear in Section 9. (Literature cited).

The report repeatedly states that there should be no wish to achieve the impossible goal of recreating exactly the pre-settlement Acadian forest -- or as Tony Pesklevits says we should abolish the wish for "ecological virginity". I don't think most of us are attempting to recreate the pre-settlement Acadian forest exactly and the report's protestations begin to look like attacks on a non existent 'straw man'.

The report insists on differentiating between (see pages 7-8):

3.2 Infrequent Stand Initiating Disturbance Regime - and

3.3 Gap Dynamic Disturbance Regime

--- each of which " develop uneven-aged, multi-cohort characteristics with gap formation as trees from the under story are recruited into the overstory.

NOTE: All forests over the long-term (millennia) experience catastrophic "stand initiating events".

I do not see why the report makes this differentiation, unless it is to give managers the leeway to perform simpler (and somewhat cheaper) large canopy opening harvest management of forests tagged with the infrequent stand initiating disturbance regime handle/// in my view these 'often gap replacement driven' stands should not be submitted to large canopy openings which facilitate the continuing incremental replacement of their temperate, exposure-prone Acadian species assemblage by formerly rare (in these stands) boreal, exposure-resistant species.

Page 8. (section 3.4) Basquill et al.'s finding of an average return interval of 25 years for repeated under-story fires in Keji has to do with post settlement human mischief and should not be taken as a reflection of long-term forest dynamics.

Again we have the report (page 13) 4.1.2. referring to Basquill et al.'s finding of a 78 year overstory fire return in Keji -- this is related to post-settlement human mischief and has little relevance to long-term forest dynamics.

Page 27, Table 4 There is no justification for differentiating 2 and 3. The report (and this table) suggests:

-- that temperate Acadian softwood (red spruce, white pine, hemlock) types are driven by infrequent stand initiating disturbance, while

-- while temperate Acadian hardwood (sugar maple, yellow birch, white ash, beech) types are driven by gap dynamics

The authors should be aware that there was a significant softwood component in almost all temperate hardwood forest types; in most cases the softwood seed source has been eliminated by high-grade harvesting of softwood saw timber.

Both 2. and 3. are Acadian forest types that should be managed by methods that produce post-harvest microclimates that are conducive to the establishment and development of middle and late successional, exposure-prone, long-lived, more valuable Acadian species that have a better chance of adapting to climate warming than the boreal species that will continue to replace them if large canopy, stand replacing harvests continue.

Page 31, Table 6 -- the report says that fire produces "rapid nutrient cycling" while forest harvesting does not.

NOTE: fire creates readily soluble ash (which often moves, in solution, below the rooting layer and into the water table) and is fire is also characterized by the loss of much of the nitrogen and some of the phosphorus into the atmosphere --

--- while forest harvesting produces rapid nutrient cycling that is driven by soil microbes // the warmer the post-harvest soil and the longer it remains without arboreal or shrub canopy cover, the more excess microbial decomposition occurs and the greater is the chance that significant amounts of the soil nutrient capital will be leached below the rooting layer and into the water table ---? Does this sound like a good justification for producing small harvest openings that offer some side shade that will moderate post-harvest soil heating ?

Table 6 also suggests that fine organic material in soil is increased by forest harvesting -- yes there is a dump of harvesting slash (if it is left on site and not removed by feller bunchers and/or litter collection for biomass fuel) -- however any time the forest canopy is opened up there is an increase in soil organic matter decomposition that is more pronounced as the soil heating is more intense and of longer duration.

Page 32 7.1.2 After pages and pages of material on fire ,wind and insect disturbance we have one little paragraph about "gap disturbed forests" and nothing about how to manage them (such management is dealt with at length in Salonius' power point essay that is attached to this message.)

In the first paragraph (page 32) we are told that fire is more suited to regulating the distribution of species across the landscape – my note - maybe true for boreal, exposure-prone, climate sensitive shade intolerant species.

However – my note - I would argue that wind does regulate the distribution of tolerant and intolerant species across the landscape depending upon the size of the canopy opening created by wind (or harvesting). The size of the canopy opening determines which species will establish and thrive after the disturbance.

Page 32 Connor et al. 1984 are quote as concluding that "in all but the more extreme cases, nature restores itself and eradicates the traces of man's presence". This idea does not agree with the paper by McLachlan et al. (2000) , quoted earlier, that suggests human land management takes centuries to obliterate.

NOTE: In much of the Acadian Forest there has been a transition from Acadian temperate to formerly rare boreal species that (unassisted) will require centuries, without large canopy opening harvests to reverse.

Thanks for the opportunity to comment

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March 16, 2005

SUMMARY

(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.

(4) The end result is that it is my belief that a somewhat different paper would be forthcoming if researched by ecologists rather than foresters.

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.

In general terms, there also seems to be a lack of basic ecological and botanical knowledge on the part of the authors. 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 hurricane-generating 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:

Frequent Stand Initiating Disturbances - 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'.

Infrequent Stand Initiating Disturbances - 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.

Gap Dynamics - basically, the definition is okay.

Stand Maintaining - 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.

Insects and Diseases

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 20th 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.

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General thoughts

1) I think the paper's conclusion needs to be clearly stated – unless this is simply a review of some of the relevant literature. I had a hard time understanding the *point* of the paper. After conducting your research, what are your conclusions?

2) It's important to be clear about the differences between natural disturbances and clearcut harvesting. You make the comment several times that natural disturbance removes vegetation – this, of course, isn't the case except in cases of severe fire. One of the papers you quote - McRae et al (2001) – clearly makes this point in reference to forest fires across Canada. (This paper is not terribly applicable to the Acadian Forest region, by the way, but rather to forests ecosystems that are fire dependent.)

3) I don't think you have accurately reflected the causal relationship between vegetation condition (stand and landscape patterns of forest age, stand structure and species composition) and natural disturbance. The impression that I get from your paper is that disturbances happen independently of vegetation, which of course it not the case. To be sure, disturbance does shape the forest, but perhaps most importantly, the forest shapes disturbance – neither is independent of the other.

4) I don't think that you have fully reflected on the literature pertaining to pre-settlement forests – these studies provide important clues to general forest structure in the absence of major human influence. Mosseler et al. (2003) is a paper that should be considered on the topic of Acadian old growth forest. Studies are on-going – Donna Crossland (who is moving to your fair province soon from NB) is close to publishing a study on the pre-settlement forests of eastern NB. She would be an excellent contact person for information on pre-settlement forest conditions. Information about pre-settlement forest conditions is important to a discussion of natural disturbance because, as I have mentioned, disturbance is influenced by forest condition.

5) Perhaps I've misread you, but in quoting McRae et al (2001) and McLachlan *et al* (2000) you seem to be arguing that the restoration of Acadian Forest is not possible. I don't mean to be harsh, but you are setting up a "straw-man argument" here – it's not a rhetorical technique that should be used in a scientific paper. I have never heard the arguement that the Acadian Forest can or should be restored exactly to pre-settlement conditions – indeed, forests are dynamic, and furthermore some components have been forever lost and climatic conditions are altered. But what is possible is to restore some of the ecological (and social and economic) values associated with natural forest conditions. Essentially, it's an awareness that the forest is a complex entity, and that the best management approach is to allow ecosystem connections and processes to unfold in a fashion that approximates natural conditions as far as we can. If you wish to argue against forest restoration, which it appears you do, you should not misrepresent the argument for restoration.

6) I don't believe you have fully addressed the argument presented by Seymour, White, and deMaynadier (2002) that large scale disturbances should not be emulated in the Acadian Forest. By emulating large-scale natural disturbances, we run the risk of adding to disturbance, not replacing it, which would have important consequences for biodiversity.

Consider the following:

"the practice of multi-aged silviculture does not risk loss of early-successional communities that depend on infrequent catastrophic disturbances. Most such disturbances will occur regardless of human activity, so there is no justification for emulating them."

-- R. Seymour, A. White, P. deMaynadier. 2002. Natural disturbance regimes in northeastern North America—evaluating silviculture systems using natural scales and frequencies. Forest Ecology and Management 155.

Perhaps I'm wrong, but it appears that you have ignored this paper in your research, and I'm curious as to the reason for this.

Specific Comments by Section

Section 2.1

1. You state that stand replacing disturbances remove all existing trees about the forest floor. This is not true. Rather, stand replacing disturbances rarely remove or kill all existing trees above forest floor; there is usually a legacy of structure left after disturbance – including standing dead trees, pockets of living trees, damaged but living trees.

The structure provided by legacy dead and living vegetation left after a large-scale natural disturbance is an important factor in subsequent recovery and occupation of the site. I would strongly recommend this section, and wherever else this appears in the paper, be modified to reflect this reality.

2. Similarly, disturbances that leave some trees alive are not necessarily minor, as you have stated. Most disturbances, whether catastrophic or gap, leave some trees alive, so this is not an accurate distinction.

3. Biological diversity is a combination of both stand-level and landscape-level diversity. It is highest with a combination of frequent small scale disturbances and infrequent disturbances. To me, it does not make sense to separate them from each other – the Acadian Forest does not have only one or the other – both are operating at different time scales over the whole forest.

4. You state that disturbance exerts strong control over vegetation. I think that the 'control' actually goes both ways. Vegetation to a large extent influences the type and extent of natural disturbances. Enduring features of the landscape, climate, competition and other ecosystem-level interactions influence where species can grow. Different combinations of species are more and less susceptible to various types of disturbances.

I believe that it is clear that human induced changes in the age structure and species composition of the Acadian Forest has been followed by a changing pattern of disturbance.

Section 2.2

Human-caused changes to disturbance include direct human disturbances (clearing, logging, introduced disease and insects) AND indirect changes through alteration of vegetation (increased amount of even-aged, early successional forest which is more prone to large scale disturbances).

Section 3.0

1. Natural disturbance rarely "removes" forest – rather, canopy openings are created by the death of trees; except in the case of intensive forest fire (a rare event in the Acadian Forest), trees

remain on site. This has important implications for post-disturbance growth – remaining live and dead trees modify the micro-climate, which influences subsequent development.

Why do you repeatedly refer to "vegetation removed"? This is generally *not* the case with natural disturbance.

2. "Disturbance regimes is one of the major forces that structure the forest." Again, I don't think this is entirely accurate. For the most part, disturbance regimes don't just 'happen'; rather, they are intricately connected and influenced by vegetation structure. This is an important point because it means that our influence over forest age and composition is in turn influencing disturbance patterns.

Section 3.1

It's important to note that *dead* trees remaining on a site after a disturbance play an important ecological role.

Section 3.3

"hardwoods are adapted to large-scale disturbance"

I believe this is location-dependent. Shade-tolerant hardwoods are less likely to be present following large scale canopy loss on Maritime sites; they can be replaced with early successional species.

Section 3.4

1. Referring to frequency of fires post 1800 is not terribly relevant in a discussion of natural disturbance. I'm not sure why you include Basquill et al.'s study here. Most fires during this time are likely human-started fires. (perhaps I'm wrong – was this area somehow free of human-caused fires in the 1800s?)

2. A dominance of white pine, red spruce and red oak does not lead me to conclude fire was the dominant disturbance regime in pre-settlement forests. None of these is a fire-dependant species. I'm not sure where your statement is coming from here.

Section 4.0

A large influence on the effect of a disturbance agent is the structure of the stand in question; stand structure, of course, is largely a result of past harvesting events. Ice storm and wind storms, for example, cause more damage to commercially thinned stands; budworm causes more damage in stands that have reduced hardwood content (more so than simply the increased abundance of fir).

Section 4.1

The severity and extent of fire is influenced by harvesting practices; harvesting practices can lead to an abundance of fuel and a stand structure more susceptible to more intense fire (dense, young conifer growth for example). The severity and extent of the Miramichi Fire was likely a consequence of extensive and intensive cutting in the area.

Section 4.1.2

1. Why are you quoting a fire return interval of 78 years? What is the purpose of including post-European settlement fire history?

2. The presence of red pine, white pine, jack pine, red oak, red maple, wire and white birch can be correlated with fire, but for the most part, does not depend on presence of fire. Why are you drawing this conclusion?

Section 4.2

1. The influence of stand structure on susceptibility of stand to budworm damage should be recognized.

2. I'm curious why the budworm infestation was confined to Cape Breton during 1916 – 1928, but then there was a light infestation over much of NS during 1950-57.

I have no idea, but it makes me wonder whether more of mainland NS had been made susceptible to budworm damage due to an increase in food source, and an increase in stand compositions that favours more severe damage? If you have an idea, please let me know!

Section 4.3

This section seems to suggest that windstorms generally lead to even-aged growth; this can happen, but windstorms also lead to uneven-aged forest through blow down of one or several trees at a time. Importantly, a pit and mound structure does not necessarily indicate a stand replacing disturbance, as you suggest. Indeed, pit and mound structure develops extensively over time through small scale wind disturbance events.

And again, the susceptibility of a stand to wind disturbance is influenced by stand structure and therefore past harvesting activities. The same wind storm can lead to either large scale OR small scale disturbance, depending on past land use and harvesting.

Section 6

1. You include the following quote: "natural forests maintained by periodic events of stand-replacing disturbance… is cornerstone of ecosystem management." Why or how is this relevant to the Acadian Forest? Very little of Acadian forest is maintained by stand replacing events. They tend to happen so infrequently that they are not drivers of forest ecosystems. Including this reference, I believe, is misleading.

2. "… the challenge for ecological planners is to suggest how natural disturbances arranged the forests on the landscape"

This statement does not follow logically from the hierarchical presentation of factors you previously noted. Again, it is more likely that enduring features and ecosystem-level interactions influence the presence of forests on the landscape in the Acadian Forest, which in turn "arranges" natural disturbances. I don't see how it could be otherwise, because natural disturbances are not independent of vegetation type and structure.

3. I'm not entirely clear how the relative abundances of forest types have been determined. This seems to be an extremely important point of the paper, therefore the method for determining them should be made clear.

4. "Thus at any one time in history the majority of the province's forests could have been comprised of uneven-aged climax species or conversely, even-aged forests."

I don't understand how you arrived at this conclusion. This is statement has important consequences, and the reasoning and methodology behind it need to be explained and made clear.

5. Referring to your table: The listed natural disturbance regimes do not necessarily result in the corresponding climax species you have list. Some species listed as dependant on large scale disturbance can also be present in forests dominated by other disturbance types and vica-versa.

Section 7.1

Table 5: Natural Disturbance Regime by Ecoregion

How is disturbance regime assigned to acreage? These are important numbers and the methodology to arrive at them should be made clear.

Section 8.

1. I'm not sure that linking evolution and natural disturbance is appropriate – it would be safer to leave this out, or, if you leave it in, to explain how natural disturbance influences evolution.

2. I think you're opening yourselves up to a lot of criticism by referring to Connor *et al,* 1984: "in all but the most extreme cases, nature restores itself and eradicates the traces of man's presence." If this is the case, then I would suggest that "extreme cases" applies to nearly the entire Maritimes!

3. With respect to your reference to the Nova Scotia's Code of Forest Practices (NSDNR 2004), it's important to remember that it is the actual, on-the-ground forest condition in terms of structure, age, and composition that is important. Emulating natural disturbance is just a tool to reach this goal, and is not an end in itself.

Best regards, and respectfully,

Jamie Simpson

Wade Prest, Registered Professional Forester

This review of "Forest Disturbance Ecology in Nova Scotia" (Neily, Quigley, Stewart, and Keys, 2007) by Wade Prest is tendered in response to the authors' request for comments on their work. I am a forestry graduate of the University of New Brunswick (1982), and have been active in management of private woodlots in central Halifax County, Nova Scotia since that time. I will make some general comments, and then give observations on the use of this disturbance theory in the Ecological Land Classification for Nova Scotia. It is through the Ecological Land Classification that disturbance science will most immediately impact forestry practice in Nova Scotia.

"Forest Disturbance Ecology in Nova Scotia"

An earlier version of "Forest Disturbance Ecology in Nova Scotia", dated October 2004, was entitled "Natural Disturbance Ecology in the Forests of Nova Scotia – Applying the Ecological Land Classification for Nova Scotia, Volume 2", dated in October, 2004. The difference in the titles is not subtle. Natural disturbances in our forests, and their effects on consequent successional patterns, can be reasonably assumed to be markedly different than anthropogenic disturbances. Moreover, natural disturbance agents acting within a forest which has previously experienced one or more unnatural events may set the forest on unexpected and unusual successional pathways. There is no clear indication whether "Forest Disturbance Ecology in Nova Scotia" (hereinafter referred to as the "Disturbance Paper") is an investigation of the natural forces which shaped the ecologically–appropriate Acadian Forest that evolved after the last glaciation, or rather an explanation of the character of the forest which exists in the province today. To develop strategies to sustain forest values, we must be able to distinguish among disturbance agents which contribute to, or detract from, the level of ecosystem organization.

In the Disturbance Paper, there is an extraordinary emphasis on the role of fire in our forests. Certainly, fire was a significant event after European settlement. At **Section 4.1 Fire** on page 10, the introductory quotation from Denys could as easily be a description of Armageddon as of the New World in 1672. While this quotation was obviously intended as illustrative only, the tone it sets seems to pervade much of the rest of the discussion. In the pages that follow, there are alternating references to pre- and post- European fire history and events, which give an impression that fire was always quite common throughout the province. I will not pass any opinion on the cited literature, but both the citations and common sense indicate that fire regimes pre- and post-settlement were likely markedly different.

It would seem unlikely that the Acadian Forest as we commonly understand it, characterized by hemlock, white pine, red spruce, sugar maple, yellow birch, beech, and ash, would have come into being in a landscape where naturally-occurring fire was a significant agent of forest disturbance. How would this be probable? The very nature of the Acadian Forest type would seem to preclude fire as a frequent occurrence. The major species are not generally regarded as fire-dependent, and are certainly able to maintain a presence in the Acadian Forest without regular fire events.

The frequency and extent of fire increased dramatically with European settlement, and until effective suppression was introduced in the twentieth century, fire had long-lasting impacts on much of the province's landscape. Fires led to increasing abundance of shorter-lived pioneer species like black spruce, balsam fir, and red maple. As fire control was achieved, increasingly

intensive timber harvesting has accelerated this trend to earlier successional stages. In particular, forests on fragile soils suffered this form of degradation quickly, and the effects have lasted longer on those sites. The barrens of southwest Nova Scotia are an extreme example of possible results, but nevertheless should be acknowledged as extreme.

It is important to understand and distinguish the frequency, extent, and role of natural as opposed to anthropogenic fire on all forest sites. Today, Nova Scotia has detection and suppression capability of the highest caliber, and fire almost certainly will henceforth be a negligible factor in our forests. The question to be posed is then "Is the current fire regime a return to a more natural situation, or is it an artificial condition imposed by man on the Acadian Forest?"

Insects and Diseases **(Section 4.2)** as agents of disturbance are generally presented in context of our altered post-settlement forest. It can be difficult to properly categorize insect disturbance as natural or anthropogenic. Much of the discussion in this section is about the spruce budworm, an insect which, albeit natural in the Acadian Forest of Nova Scotia, is probably a major pest only due to human-induced changes to forest composition and structure since settlement. The same applies to spruce beetle activity in evenaged white spruce stands. It is important that we not design forest management practice based on these unnatural disturbance factors.

The discussion of hurricanes and windstorms as disturbance agents **(Section 4.3)** is inconclusive. There is little presentation of published research on return intervals of stand-replacing storms. The reliability of old texts and anecdotal accounts of windstorm damage in forests is limited, especially in light to our recent experience of Hurricane Juan. Initial impressions, which are not easily erased and soon pass into folklore, are of shock, devastation, and wanton destruction. As time passes, we see things in a more moderate perspective and have a better understanding of the true extent and level of damage.

The damaging effects of wind on the forest stands predominant in Nova Scotia today probably differ from those of pre-settlement times. Our forests are very young, tend to be evenaged, are highly fragmented, and recent forest harvesting operations are dispersed throughout the forest landscape. How does wind impact such unnatural stand characteristics as opposed to a forest untouched by human exploitation? The Acadian Forest evolved under a regime of hurricanes, snow, and ice into a rich and diverse ecosystem. In the big picture, storms and climate acted as positive forces to create a remarkable and valuable resource in the Acadian Forest. We should look to these natural processes and forest structures when developing effective emulation silviculture techniques.

Ecological Land Classification

Most of my forestry practice has been done in the Eastern Drumlins and Eastern Granite Uplands Ecodistricts of the Eastern Ecoregion, and in the Eastern Shore Ecodistrict of the Atlantic Coastal Ecoregion. Data from the NSDNR website indicates how disturbance ecology has been related to ecodistricts and individual ecosites. I have compared the ecological mapping with representative forest areas in these ecodistricts.

I believe the importance of fire as a dominant disturbance agent in these ecodistricts has been overestimated. Fire is indicated as the dominant agent on 43% of the Eastern Drumlins Ecodistrict and on 89% of the Eastern Granite Uplands Ecodistrict. This is at odds with known occurrences of fire in central Halifax County over the past one hundred years. There have been a limited number of fires of any extent, and these have burned a very small percentage of the forest

area. Advances in fire suppression practices have been instrumental only in relatively recent years. Most known substantial fires over the past century are regarded as having known human ignitions. In my own experience, I can count less than ten instances of lightning strikes I have ever found in the woods. I have never found a charred spot where a fire has burned following a lightning strike. Woodsmen with 70 plus years in the woods in this ecodistrict have similar experience. If fire was more prevalent prior to 1900, it would seem that human activity would more often be the cause than lightning strikes. Before settlement of the coast began in the late 1700's, there were limited opportunities for forest fire ignition.

Fire as a dominant agent is strongly associated with the frequent stand initiating disturbance regime, indicated as 57% in the E.Drumlins and 97% in the E. Granite Uplands. This has perhaps been deduced from the current forest cover. However, the species composition of today's forest is not always an indication of natural disturbance regime. The relative abundance of black spruce, balsam fir, red maple, and white birch in today's forest is due largely to harvesting over the past 150 years. In the case of the Atlantic Coastal Ecoregion, harvesting of many of the coastal and near-coastal forests has been ongoing for two hundred years or more. The cumulative effects of one or more harvests and /or fire events on the meagre soils which are common in central Halifax County are reflected by reduced abundance of tolerant long-lived species. These negative consequences of harvesting are magnified as utilization increases and the cutting cycle decreases. Fire following soon after logging can be especially damaging. Forest cover on poor sites does not recover quickly from severe disturbance. Many sites in this area are so deficient of soil that it is not unreasonable to expect to still see the effects of a single fire or harvest event up to two hundred years ago. On the other hand, better sites in these ecodistricts exhibit a remarkable tenacity to retain red spruce, white pine, and hemlock despite repeated disturbance.

Red spruce is the dominant conifer in central Halifax County. It has an ability to perform well on even the poorest of sites once established there. A sequence of conditions or successional path which leads to this desirable situation is unclear, but probably involves an accumulation of organic debris over time that eventually has the capability to support a very impressive stand of timber (a high order ecosystem). A delicate balance is achieved which is easily upset by severe disturbance. Events which remove biomass from the site (fire or harvest) have markedly different outcomes on these stands as compared to windthrow or insect attack, which leave all organic material on the site to supplement previously accumulated biomass.

In this part of Halifax County, red spruce displays a great tenacity to regenerate itself on poor sites as well as on more favorable ground. In absence of severe disturbance, red spruce will regenerate on and eventually dominate sites which may be excessively dry or imperfectly or even poorly drained. This can be observed throughout the forest in this ecoregion, although a history of heavy logging may mean the evidence is scant. It is my belief that harvesting and human induced fire have caused red spruce to be displaced from marginal sites, which are now occupied by black spruce and balsam fir, representing an earlier stage of succession. A return to natural disturbance regimes would enable us to restore a high order, stable, self-sustaining forest.

In this context, I feel that many ecosections within the Eastern Drumlins, the Eastern Granite Uplands and the Eastern Shore are misinterpreted. Ecosections where successional development is limited by frequent stand initiating disturbance (fire and windstorm), treed by black spruce, balsam fir, red maple, and white birch, are much less extensive in area than has been presented in the Ecological Land Classification. Much of the acreage included in these ecosections is red

spruce ground at an earlier stage of development, moved backwards along the successional pathway by unnatural disturbance. Only on a smaller portion of the acreage, where more extreme site limitations prevail, would succession be limited to shorter-lived species under natural disturbance forces. As the time since severe disturbance increases, the total acreage of this site condition decreases, although it would never be eliminated.

In "Forests of Nova Scotia" (1986), Ralph Johnson describes this general trend on Page 325. "As previously discussed, clearcutting of extensive areas in Nova Scotia is second only to fire in being detrimental to the ecosystem, and the greater the percentage of biomass removed, the worse it is. Even where logging debris is left following clearcutting, soil fertility is reduced. … As long as adequate forest cover continues, most sites in Nova Scotia will remain static or improve but the general tendency following clearcutting or fire is towards deterioration, even where planting is undertaken. As mentioned before, in western Nova Scotia clearcutting and fire have resulted in the transition of about 500,000 acres from productive forest land to heath land. As clearcutting continues in succeeding forest generations, the acreage thus degraded increases. This is generally in small patches of a few acres each at first, but subsequent clearcutting or burning tends to enlarge and join these patches."

Johnson's words are an intuitive description based on a lifetime of work in forests throughout Nova Scotia. They suggest this phenomenon is widespread throughout the province, rather than being limited to that portion of Halifax County with which I am familiar.

In the Eastern Shore Ecodistrict of the Atlantic Coastal Ecoregion, there is evidence that a much higher level of forest development occurred much closer to the coastline than is assumed today. Remnants of red spruce, white pine, yellow birch, and red oak are scarce, but nevertheless present, in stands completely devoid of those species today. Red spruce demonstrates the same tenacity to reclaim ground as it does further inland. I strongly feel that the ecosection characteristics applied to the coastal region by the Ecological Land Classification would have been, in pre-settlement times, limited to coastal islands, headlands, and extremely challenged sites. The traditional Acadian Forest would have extended to the water's edge in bays and harbours.

Thank you to Peter, Bruce, Kevin, and Eugene for the opportunity to submit these comments. For an opportunity to show the deficiencies of my reasoning, there is an open invitation to visit.

Dr. Paul Pross, Professor Emeritus, Public Administration, Dalhousie University

Dear Mr. Neilly,

I understand that you are looking for 'peer' comments on the forest disturbances paper. My expertise lies in historical research and policy analysis. Early in my career I did spend two years with the Ontario Department of Lands as the junior author of the Department's centennial history. I also wrote a Ph.D. thesis on Ontario forest policy and spent a year at the Yale School of Forestry as a post-doctoral fellow. Consequently I have some appreciation of forestry issues, but I am confining the following comments to your use of human historical data.

You may have seen the comments I made several years ago on an earlier version of the paper. Those comments were numerous, and strong, because so much of the paper violated my sense of what was appropriate in terms of historical research and in terms of good policy analysis. This version is much more cautious as far as historical research is concerned, and its explicit policy recommendations are few. So these comments are shorter.

Page 1: The presentation appears to me to mis-state critics' views of the condition of the forest at the time of European settlement, suggesting that critics erroneously claim that the forest at that time had reached 'equilibrium', when in fact informed commentaries on older forests generally emphasize that change is a continuing and ever-present force, albeit one that varies in intensity from one period to another.

Page 9 Reference to Denys' account claims that 'the coastal forest encountered by the early French settlers ... seems to differ little from what is present today.'

I can only comment on my own comparison of Nicholas Denys' observations with those that can be made today about the area (Lunenburg) where I live. Denys, in describing the La Have, what is now Riverport, and the immediate Lunenburg area, repeatedly refers to 'abundant' stands of big oaks, and even elm. Today this area is dominated by spruce, fir and, inland a bit, pine. Oak and other hardwoods are present but no longer form a prominent part of the forest. Consequently it is inaccurate to suggest - at least, insofar as this area is concerned - that the present forest differs little from the forest that Denys found.

Page 10 Reference to Perkins' accounts of 'horrific fires' is inserted in a passage that deals primarily with 'natural' disturbances, ignoring the fact that most of the fires described by Perkins were started by settlers.

Page13: The section on 'regional fire history' contains the same reporting problems that were notable in the earlier draft of the paper. Insufficient care is taken to differentiate fires caused by lightning from those caused by humans. The reader is encouraged to infer, from comments such as ...

> 'Basquill et al (2001) describe Western Nova Scotia as one of the more fire prone areas in the Acadian forest'

... that fire is a common occurrence in the lowland ecosystem and western region. Again, though the authors do note that Loucks (1962) and Rowe (1972) associated increased incidence of fire with settlement, they go on to stress that

topographic, soil and climatic conditions are 'conducive' to fire, implying that fire occurs frequently as a natural condition. Yet several paragraphs earlier the authors had cited Green (1981) reporting that cores taken from lakes in southwestern Nova Scotia, [indicated] that the fire rotation period was about 400 years for the years 6600 to 2200 BP.'

Page16: Editorial point: Para. beginning 'Since the inception...' should be separated at 'However, in many parts...' since the latter part of the paragraph introduces a new topic: i.e. the effect of fire suppression, whereas the beginning of the paragraph completes the subject of the previous paragraphs: i.e. the gradual extension of successful fire suppression.

Sections on insect infestation and storm damage: I am not competent to comment on the scientific aspect of these passages. From a policy analysis perspective, I would have liked to have seen more attention paid to the management aspects of blowdowns. While it is noted that harvesting may make stands more vulnerable to blowdown, no reference is made to measures that can be taken through practice and silviculture to minimize that tendency. From an historical perspective I should have liked to know whether the extensive destruction reported by Smith in 1802 can be associated with previous land-clearing by settlers.

Yours truly,

Paul Pross

Minga O'Brien, BSc, MSc, Dalhousie University

Key points:

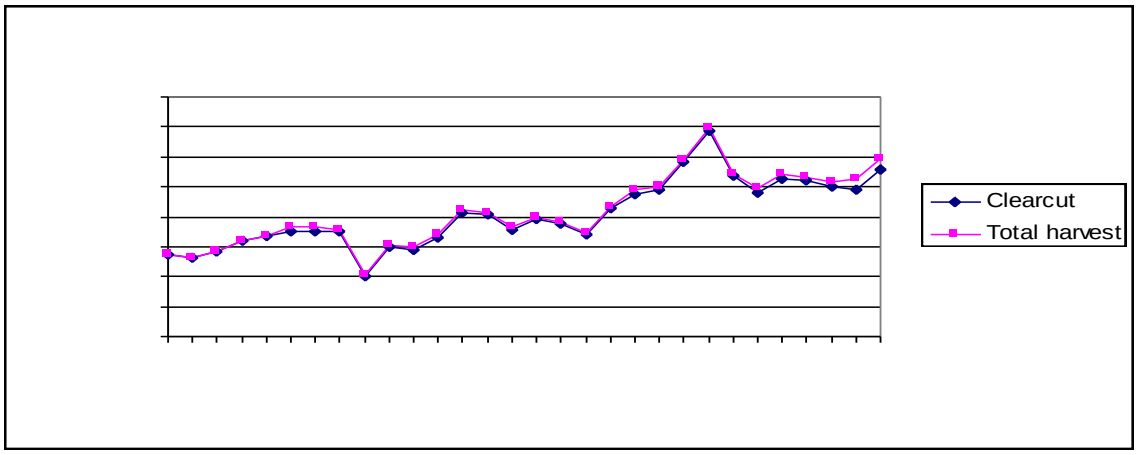
- Earlier drafts of this report attempted to provide guidance on emulation silviculture. However, the intent and future use of this version of the report is not clear; what recommendations will come from it, how will they be determined, and by whom?
- The methodology explaining the assignment of climax forest type and dominant natural disturbance regime in Appendix III is inadequate. It is questionable if others could use this methodology and come up with the same results. The numbers in Table 5 vary considerably from other estimates of the extent and return interval of natural disturbance regimes for this region. No explanation is offered for these discrepancies.
- Ecologists on the government's Ecological Technical Committee have expressed reservations with this report. Extensive comments were submitted to the report's authors, citing much of the relevant literature on this topic. These comments are not reflected in the most recent draft of this report. What is the explanation for this?
- The report makes no reference to the spatial extent of the largest forest disturbance in the province: clearcutting of over 50,000 hectares per year. At this scale and frequency, forest harvesting has done more to shape the composition, age and structure of our forests than any other single disturbance factor.
- Data available from Hurricane Juan should have been used to describe the actual extent of blowdown from one of the largest hurricanes ever to affect Canada.
- The report relies heavily on a study by Basquill et al. (2001) that has questionable methodology and results, and that was never peer-reviewed.
- If this report is a briefing paper, then it should be looking at the key publications from this region. Seymour, White and deMaynadier (2002) is likely the most authoritative publication on natural disturbances and emulation silviculture for the Acadian forest region, but is not cited once in this report. Similarly, Mosseler et al. (2003) is the most credible and comprehensive description of old growth Acadian forests.
- Appendix III indicates that black spruce in Nova Scotia is regenerated exclusively by frequent stand initiating events like wind, insects and fire. Where are the data to support this?

General comments

1. The report does not adequately define what type of disturbance it reviews, switching between *forest* disturbance, apparently including human causes, and *natural* disturbance. For example, these statements appear contradictory: -

"This report describes and summarizes the *natural disturbance* regimes and agents thought to be acting on the forest ecosystems of Nova Scotia."; and "The secondary purpose of the report was to put under one cover a review of the historical records of provincial *forest disturbance*".

2. There is almost no recognition of the effects of forest harvesting on the current composition and age class structure of Nova Scotia forests. Even Appendix 1, which provides "a partial summary of the natural and human-caused disturbances in NS …that have influenced the composition of NS's forests over the last 400 years" manages not to mention forest harvesting. This is remarkable, given the extent to which forest harvesting practices have and continue to alter the composition and extent of Nova Scotia's forests. The area clearcut since 1975 is depicted below (CCFM 2007).



More than 1.25 million hectares have been harvested in NS since 1975, 97.5% by clearcutting (including 1-stage, 2-stage, shelterwood and seed tree cuts). This averages out to almost 42,000 hectares harvested per year since 1975, and over 53,000 hectares clearcut each year since 1995.

The 2004 version of this report had the following text:

> "The area of forest disturbed due to timber harvesting can be roughly calculated using a predetermined volume per hectare and the annual harvest records….. Assuming an average yield of 120 m^3 per hectare it can be calculated that in 1929 nearly 17,000 hectares were harvested (Anon. 2003). By 1981 the annual harvest was derived from 36,000 hectares until in 2003 the calculation indicates that close to 50,000 hectares are used to meet the demand for wood."

If the purpose of this report is to discuss all disturbance agents, it should supply sufficient spatial information that anthropogenic disturbances can be compared to natural disturbances. Was the above information omitted and replaced with one sentence that refers to volumes of wood

harvested in 1929 and 2003? Almost all the other forest disturbance information in this report, including the information summarized in Table 5, is presented in hectares or other spatial units.

3. The authors use phrases and present lists and a map that suggest wind plays a major role in creating frequent, stand initiating natural disturbances in NS. For example, adjectives like 'catastrophic', 'destroyed', 'devastated', 'extensive damage', and 'vulnerable' are peppered throughout, as well as phrases like "Nova Scotia's forests are especially vulnerable to storms and hurricanes"; "Hurricanes and winter storms also played a prominent role in shaping the coastal forests", and "Over the past couple of centuries more than 20 major storms of hurricane intensity have affected NS".

According to the Canadian Hurricane Centre, "Juan was one of the most powerful and damaging hurricanes ever to affect Canada". Yet when the blowdown was quantified, only 5% of the forested portion of the storm swath underwent 30-100% blowdown - or 23,000 ha (roughly 0.55% of Nova Scotia's forests) (NSDNR pers. comm. 2007). If Juan-scale events were to occur every 50 years, on average 0.55%/ 50 or 0.01% (1/10,000) of the province would be affected by moderate-severe (30-100%) blowdown every year. In a review of the existing literature, Seymour et al. (2002) quoted return intervals of 855–14,300 years for stand-replacing wind disturbances.

One must also consider the effects of changes to forest composition and the forested landscape that exacerbate the effects of wind storms, for example, management practices that favour shallow-rooted softwoods, and increased vulnerability to blowdown created by clearcuts, fields, roads, etc.

4. The first quote in the report: 'the larger message is that there was no fixed "original landscape"', and ongoing literature references suggest it is very difficult to characterize the pre-settlement forest as it was unstable. I disagree. Mosseler et al. (2003) did a very fine job of characterizing the pre-settlement Acadian forest. Furthermore, such a suggestion undermines the methodology employed by the report's own authors in assigning climax forest type and natural disturbance regimes (NDR).

The theory behind emulation silviculture and ecological forestry is that any manipulation of a forest ecosystem should emulate the natural disturbance patterns of the region *prior to extensive human alternation*. This is based on the assumption that native species have evolved under these natural disturbance regimes and will be better able to cope with human-induced disturbances such as logging if they are designed to imitate the key characteristics of natural disturbances, including the return interval between disturbances, disturbance severity, and spatial pattern of disturbances (Seymour and Hunter 1999).

As noted throughout this report, and in information obtained through a FOIPOP request, if someone wanted to duplicate their efforts they would first have to produce a potential climax forest table for each of the ecoregions and their ecodistricts, and based on climax forest, assign dominant natural disturbance regime. Presumably, the authors have used enduring features, the existing forest, historical information and other clues to determine climax forest type. Given the significant changes in forest composition and structure in the last 400 years – most of which have been anthropogenic or exacerbated by anthropogenic influences, potential climax forest type is often very different from current forest types. Thus it is difficult to understand why, in the introduction to this report, the authors state they are providing information on the disturbances "that have created the *current* composition and extent of forests in Nova Scotia." If this were

really the case, they should have dedicated the majority of the report to the history of anthropogenic stressors on Nova Scotia's forests.

5. The authors state "The primary purpose of this report is to set the stage for examining the concept of natural disturbance based management for Nova Scotia's forest. The intent of the report was not to provide an exhaustive review of natural disturbance-based management - there are excellent reports already published and peer reviewed on this topic.", and "this review included literature specific to the province or the Maritime portion of the Acadian Forest region." First, there is no excuse for ignoring the most cutting-edge, credible and thorough publications on this topic for our region, such as the 2002 *Forest Ecology and Management* article by Seymour, White and DeMaynadier. Second, there is no sudden change in climate, biophysical features and soils at the Canada/US border. There may even be greater variability in forest composition and dynamics within the Maritimes than between the Maritimes and Maine. By being selective, the authors are choosing to omit research from the Northeastern US, including the University of Maine, which is an epicenter of disturbance ecology and emulation silviculture research in the Acadian Forest region.

In addition to research out of University of Maine, the authors need to be more thorough in their use of research from the Maritimes, such as Bentley and Smith (1956), Blais (1983), Green (1987), Lutz (1996), Morris (1761), Mosseler et al. (2003), Mott (1975), and Ponomarenko (2007, 2000). More recently, Donna Crossland completed an MSc. thesis with the UNB Forestry Department on disturbance ecology in the Northumberland Strait area (Crossland 2006), and Elena Ponomarenko has completed her first year of research reconstructing fire history at Kejimkujik National Park (Ponomarenko 2007).

Instead, the authors rely heavily on Basquill et al. (2001), which reports on the history and ecology of fire at Kejimkujik National Park. There are numerous problems with relying on this study, including:

1) Basquill computed a fire cycle (78 years) that is shorter than what is calculated for boreal forest; it was far too short to produce an old growth hemlock stand, or anything else beyond jack pine, aspen and other early successional spp. It is difficult to take this number seriously.

2) This is not a peer-reviewed report. It was printed "in house" at the Halifax Service Centre. The report does not clearly outline how calculations were used to derive such an exceedingly short fire cycle. Final computations were accepted as is, though it was Basquill's first attempt at researching fire history.

3) This report reveals little about Acadian forest disturbance ecology beyond the fact that fire was frequent during post-European settlement times. The methods provided to researchers at Kejimkujik were inappropriate for researching fire history prior to European contact in eastern Canada. Most trees do not date back to pre-European time, and so fire scar dates will indicate *only* recent fires, the vast majority of which originated from anthropogenic ignition sources. In fact, Basquill et al. (2001) states that "*No very large or old trees were cut in recognition of their rare status*".

4) No radio-carbon dating was carried out to distinguish pre- and post- European fire events. Charcoal found in the soil was linked to the age of dominant forest canopy, and hence computed as "time since the fire event", though the charcoal could have originated

from several tree generations prior to the current forest stand. (Charcoal can endure in the soil indefinitely.)

5) Judging by the methods, all hemlock stands found in Keji were assumed to be post-fire stands. This greatly boosts the calculations. Hemlock is considered by most to be a fire-sensitive, late successional species.

6) Basquill's report proves that fire was on the landscape in Keji, but the report says little about the inherent fire regime that would operate on the Keji landscape without human interference. Large repetitive fires are associated with early European land clearances, and later with the advent of steam engine trains, as well as other anthropogenic ignition sources. The vast majority of the fires that Basquill detected were most likely from these sources.

7) Neily et al. may have believed that a fire history study stemming from a national park implies a non-human altered, natural fire regime. In fact, Kejimkujik National Park (established in 1974) had numerous homesteads and cottages, and was farmed and selectively logged. Many forest stands in Keji are in the process of recovering from extensive human disturbance.

6. For many reviewing this report, its *intent* is still not clear. Earlier versions of this report had a table that recommended silviculture systems for various disturbance regimes (see below). This table is not in the current version of the report, and we're told, instead, "The report provides no conclusions or recommendations, and as such could be seen as a briefing paper. Any course of action resulting from this report will be a product of further discussion within the Department." Emulation silviculture is a key component of ecosystem management. The recommendations and conclusions from this briefing paper need to be transparent and scientifically-sound, and this would suggest they be discussed not just *within* NSDNR. What assurance does the public and the scientific community have that decisions will have scientific merit? Also, if this is a briefing paper, then it should, at a minimum, look at the key publications and documents on natural disturbance ecology from this region. If there are significant disparities with this report, they should be explained.

Table 8 – Applications for silviculture systems that provide structure and processes similar to natural disturbance regimes.

Dominant Disturbance Regime	**Silviculture Systems**	**Provincial Forest***	
		Area (ha)	**(%)**
Frequent Stand Initiating	Clearcut for stand renewal	1 775 000	42
Infrequent Stand Initiating	Clearcut (long rotation) Shelterwood (two-aged, advance regeneration) Selection	1 480 000	35
Gap Dynamics	Selection	972 000	23
Stand Maintaining	Shelterwood/Selection (tending for preferred species)		
	Total	4 227 000	100

Detailed comments

p.4, last paragraph

-disturbances rarely *remove* or kill *all* the existing trees above the forest floor vegetation

-as noted above, Hurricane Juan was one of the most powerful hurricanes ever to hit Canada, and results show that only 5% of the hurricane swath underwent moderate to severe blowdown (30-100% stems downed); similarly, fires are highly variable in intensity and severity of impact

p.5 – reflects on how humans have affected the frequency, intensity and magnitude of natural disturbance processes

- this should give the authors more reason to be cautious with studies and reports that have focused on post-settlement disturbance history, like Basquill et al. (2001)

p.6, first 3 sentences

-natural disturbances do not "remove" forests – to the contrary, they tend to leave behind lots of standing and downed live and dead trees

p.6 second paragraph

-"therefore disturbances are necessary for maintaining species richness and biodiversity"

-this is a loaded statement that is not particularly accurate or well-founded

-frequent disturbances, at a large or small scale, can have severe negative impacts on biodiversity, for example repeated high-intensity fires or repeated short rotation clearcutting

p.7, second paragraph

-black spruce is indeed primarily on imperfectly to poorly drained soils, which typically means bogs, forest swamps and other wet areas

-in Nova Scotia, the very nature of these sites, i.e. they are typically *wet* areas, will reduce fire hazard

-also, wet areas are usually in depressions and hollows, and more protected from strong winds than the surrounding landscape

-in all my travels in the woods in this province I have never seen a burned over black spruce swamp with stumps or fire-scarred snags, or a black spruce forest with significant blow down from strong winds

-I suspect the authors are drawing upon information about boreal black spruce forests, which are not easily compared to NS black spruce forests

p.7, section 3.2

-there appears to be a good case for merging 3.2 with 3.3 as they both tend towards uneven-aged stands

p.8, section 3.4

-as this report acknowledges, fire has been a dominant disturbance at least since European settlement, thus distorting post-settlement data on fire frequency and extent.

p.9, second to last paragraph, and section 4.2 (page 18-20)

-interesting there is no mention of the effects of large areas of managed, even-aged, single-species forest on forest insect epidemics – even NSDNR provincial entomologists have warned that simplifying our forests will make them more vulnerable to insect pests

-nor is there mention of studies in NB showing reduced mortality of balsam fir by spruce budworm as hardwood content increases (Su et al. 1996)

-p.19, 2nd paragraph: there are very few, if any, "pure balsam fir ecosystems", even in the Highlands. Balsam fir, black spruce and white birch are all common, as are other species. Even the second paragraph on the same page notes that the 1970s spruce budworm epidemic increased the hardwood cover type from 16% pre-budworm to 36% post-budworm

p.10, first paragraph

-Perkins and Titus Smith both wrote about our forests 200 years post-settlement

-where is the data from the pollen studies mentioned?

p.12, 3rd paragraph

-whether the fire return interval for Mainland Nova Scotia is 900 years or 2,500 years, both estimates suggest that natural fires do not play a major role in regenerating our forests, and that it would be difficult to characterize our forests as regenerated by frequent, stand initiating fire events

p.21, section 4.3

"Stand renewal is initiated after catastrophic wind events such as hurricanes whereby a significant portion of the stand has been destroyed."

-what is meant by a "significant portion of the stand has been destroyed"? As noted above, Hurricane Juan was one of the biggest hurricanes ever seen in Canada, and yet only 5% of the forested portion of the storm swath experienced moderate to severe blow down

p.23, last paragraph

"The risk of blow down in areas partially harvested, silviculturally treated, along the edges of harvested areas, or in riparian zones has always been a management concern, especially on sites where rooting depth is restricted due to shallow soil depth and/or excessive soil moisture."

-what are the authors saying here? It *sounds* like the authors are suggesting that not cutting *everything* is problematic as what is left may be blown down. To reduce risk of blowdown, it would be better to leave fewer hard edges, like those left behind by clearcutting, and to manage for deep-rooted species in wind-prone areas

p.27

The ranking suggests that hurricanes, fire and logging have equal influence in controlling forest structure and composition. On average, 53,000 hectares were clearcut every year over the past 10 years. This amount dwarfs the effects of other disturbances.

p.27

"Thus at any one time in history the majority of the province's forests could have been comprised of uneven-aged climax species or conversely, even-aged forests."

-how does this statement contribute constructively to this discussion?

Table 4

If infrequent stand initiating disturbances lead to even- and uneven-aged conditions, then gap dynamics would be an appropriate natural disturbance regime for the stand types in this category. Red spruce and hemlock, for example, are very shade tolerant, and, as has been seen in some of the remaining pockets of old growth in NS, are sustained by gap dynamics.

p.29, Table 5

It is interesting to note that the numbers have changed since the 2004 version of this report, and that the amount of forest characterized by frequent stand initiating NDRs has increased from 39% to 43%, while the numbers for infrequent stand initiating NDRs and gap dynamics have decreased, from 26% to 24%, and from 30% to 27% respectively. Did new information emerge to allow the authors to go back to the data and reclassify climax forest type?

p.32

"The Royal Commission on Forestry in Nova Scotia (Connor *et al*, 1984) suggested that forests ought to be seen as part of a dynamic environment subject to biological, industrial and social changes. Some of these changes occur consistently, others unpredictably. Nonetheless, they conclude that the impact of human activities on much of the forest is continuous, but, in all but the most extreme cases, nature restores itself and eradicates the traces of man's presence."

-The Royal Commission was not an ecological study, and its conclusions are irrelevant to a scientific paper.

Concluding remarks

There are serious problems with this report, ranging from the use of hyperbole, selective quotes and data, disproportionate attention to fire, insects, and wind storms, and omission of key information and publications. It is clear that this report is fundamentally flawed and that it cannot be used in its current form for the purposes it attempts to fulfill.

References

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.

Canadian Council of Forest Ministers. 2007. National Forestry Database. Available from http://nfdp.ccfm.org/compendium/data/2006_10/tables/com62e.pdf. Accessed March 21, 2007

Canadian Hurricane Centre. 2007. Available from http://www.atl.ec.gc.ca/weather/hurricane/juan/index.html. Internet accessed March 22, 2007.

Crossland, Donna. 2006. Defining a forest reference condition for Kouchibouguac national park and adjacent landscape in eastern New Brunswick using four reconstructive approaches. MScF. Thesis. University of New Brunswick. December 2006

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

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.

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.

Mosseler, A., Lynds, J., and Major, J. 2003. Old-growth forests of the Acadian Forest Region. Environ. Rev. 11:S47-S77

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

Nova Scotia Department of Natural Resources. 2007. Personal communication (during a telephone conversation) with employee of Forest Inventory Branch. January 17, 2007.

Ponomarenko, E. 2007. Reconstruction of Pre-historical and Early Historical Forest Fires in Kejimkujik National Park and Historic Site, Year One Study. Prepared for Kejimkujik National Park and Historic Site. Ottawa.

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.

Seymour, R.S., Hunter, M.L., Jr., 1999. Principles of ecological forestry. In: Hunter Jr., M.L. (Ed.), Managing Biodiversity in Forest Ecosystems. Cambridge University Press, Cambridge, pp. 22–61.

Su, Q., MacLean, D.A., and Needham, T.D. 1996. The influence of hardwood content on balsam fir defoliation by spruce budworm. *Canadian Journal of Forest Research*. 26: 1620-1628.