Fundy Model Forest

~Partners in Sustainability~

Report Title: Understanding Pre-European Settlement Forest Characterization Methodologies in the Fundy Model Forest

Author: M. Betts, J. Loo, S. Lutz

Year of project: 1997

Principal contact information: University of New Brunswick, Faculty of Forestry
Box 45111
Fredericton N.B.
E3B 6E1 Canada

File Name:
Biodiversity_1997_Betts_Understanding_Pre_European_Settlement_Forest_Characterization_Methodologies_in_the_Fundy_Model_Forest

The Fundy Model Forest…
…Partners in Sustainability

"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

Atlantic Society of Fish and Wildlife Biologists
Canadian Institute of Forestry
Canadian Forest Service
City of Moncton
Conservation Council of New Brunswick
Fisheries and Oceans Canada
Indian and Northern Affairs Canada
Eel Ground First Nation
Elgin Eco Association
Elmhurst Outdoors
Environment Canada
Fawcett Lumber Company
Fundy Environmental Action Group
Fundy National Park
Greater Fundy Ecosystem Research Group
INFOR, Inc.
J.D. Irving, Limited
KC Irving Chair for Sustainable Development
Maritime College of Forest Technology
NB Department of the Environment and Local Government
NB Department of Natural Resources
NB Federation of Naturalists
New Brunswick Federation of Woodlot Owners
NB Premier's Round Table on the Environment & Economy
New Brunswick School District 2
New Brunswick School District 6
Nova Forest Alliance
Petitcodiac Sportsman's Club
Red Bank First Nation
Remsoft Inc.
Southern New Brunswick Wood Cooperative Limited
Sussex and District Chamber of Commerce
Sussex Fish and Game Association
Town of Sussex
Université de Moncton
University of NB, Fredericton - Faculty of Forestry
University of NB - Saint John Campus
Village of Petitcodiac
Washademoak Environmentalists

Natural Resources Canada	Ressources naturelles Canada

Canada

UNDERSTANDING PRE-EUROPEAN SETTLEMENT FOREST CHARACTERIZATION METHODOLOGIES IN THE FUNDY MODEL FOREST

Understanding Pre-European Settlement Forest Characterization Methodologies in the Fundy Model Forest

Matthew Betts[1], Judy Loo[2] and Serge Lutz

[1] Current Address: University of New Brunswick Faculty of Forestry and Environmental Management Box 45111, Fredericton, NB E3B 6E1, Canada
[2] Current Address: Canadian Forest Service Maritimes …

Abstract

The characterization of 'natural' or 'pre-settlement' forest has become a relatively common practice in Canada as forest managers strive toward various conceptions of sustainable forest management. Because several different methods have been developed to undertake characterization, this has led to some confusion about how to define 'pre-settlement forest' and which method will best serve as a basis for management. This paper compares two methods of pre-settlement forest characterization that have been developed and used in the Fundy Model Forest, New Brunswick.

A witness tree method utilized tree species records compiled by18th century land surveyors as samples of forest existing from 1785-1820. Despite several possible biases, this approach provides an extensive sample of mature tree species. The ecological land classification (ELC) method estimated pre-settlement forest based on three factors: (1) ecosite the classification (a function of elevation, slope, soil type and drainage, forest cover, and the existing ELC for ecodistricts), (2) the 1983 New Brunswick provincial forest inventory, and (3) Adjustments made to forest communities to compensate for human disturbance such as farming and stand replacing forestry activity.

While differing methodologies of these two approaches made comparison difficult, several trends were apparent: (1) Both approaches indicated a decline, since pre-settlement, in the predominance of tolerant hardwood forest on rich hardwood ecosites. (2) Both approaches indicated much higher pre-settlement frequencies of eastern cedar

(*Thuja occidentalis*) communities than currently exists. (3) The ELC approach consistently suggested much higher pre-settlement frequencies of balsam fir (*Abies balamea*) than were reported in the witness tree accounts. (4) In most cases, pine (*Pinus*) was reported to be less frequent in the witness tree survey than the ELC account.

Differences in forest community frequencies reported by each pre-settlement forest methodology is probably a result of biases associated with both methods, and poor comparability among data sets. It will be important for forest managers to consider these biases critically when using pre-settlement forest information in management decisions. Work should be undertaken on the reconciliation of the two approaches, and possible means for applying both directly in forest and stand-level management.

1.0 Background

It has become common for forest managers and scientists to define 'sustainable forest management' in relation to a conception of the 'natural' forest. Suggestions have been made to mimic the spatial scale of natural disturbances (e.g. succession, insects, fire, and weather) (Woodley and Forbes 1997), the structures found in unharvested stands (e.g. dead wood, large trees) (Schnitzler and Borlea 1998), and the tree species and community composition of undisturbed forest (Loo 1994). The difficulty is in defining the term 'natural'. For example, Mackey *et al.* (1994) suggested three potential baselines: pre-First Nations; preindustrial; and extant. In developing a set of criteria and indicators for sustainable forest management, the Canadian Council of Forest Ministers (CCFM 1995) adopted the view that the "historical" condition of the forest is the best baseline: "Percentage and extent, in area, of forest types relative to the historical condition and total forest area" (Criterion 1.1.1). A definition of "historical" was not provided.

In 1996 the Fundy Model Forest (FMF) adopted the Canadian Council of Forest Ministers' Criteria and Indictors process as the basis for local level monitoring (Etheridge *et al.* 1999). Fifty-three of the CCFM indicators were selected and refined to fit within the context of the FMF. The criterion relating to historical condition of the forest (CCFM 1.1.1) was restated as: "Percentage and extent in area of forest community and age class by Ecological Land Classification (ELC), *relative to pre-European settlement condition* and total forest area" (Etheridge *et al.* 1999)(emphasis added).

The ecological land classification is a hierarchical method for identifying and mapping terrestrial ecosystems by defining a range of factors that influence their distribution in time and space. The New Brunswick ELC thus provides a description of ecosystem diversity across many scales (ELC Working Group 1996). Ecodistricts are a function of rock formations, elevation, slope and aspect, and fit within the context of ecoregions, which are defined by elevation and climactic variables (ELC Working Group 1996) (Fig. 1). At a finer scale, ecosites are defined by elevation and slope classes, soil type and drainage, and associated forest types (Zelazny *et al.* 1997).

Local forest landowners in the Fundy Model Forest have now begun to use the natural disturbance regimes and community compositions characteristic of ecodistricts and ecosites to serve as the basis for management planning. However, the connection between the ELC and "pre-European settlement condition" has not been explicitly addressed by forest managers.

There have been two attempts at characterizing the pre-settlement forest composition of the FMF region. Zelazny *et al.* (1997) used the ecosite classification and the 1983 forest inventory data to determine the frequency of forest community types. Lutz (1997) examined early land surveyors' records (1785-1820) in Kings County to identify the relative abundance of tree species groups. These separate approaches have led to some confusion within the Model Forest about how to define presettlement forest, and which method will best serve as a basis for management. This paper outlines the methodologies used in each of these analyses and, where possible, compares the results. The strengths and weaknesses of each approach are outlined.

2.0 The Land Survey Record Approach

In order to mark the position of early settlers' land grant boundaries on the ground, surveyors in the late 1700s and early 1800s blazed and noted the species or at least genus of witness trees at regular intervals along the sides of each grant. This process was undertaken primarily in heavily settled counties. Nevertheless, the witness tree records serve as potential samples of tree species frequency at the end of the 18th century. In his analysis, Lutz (1997) examined witness tree records from the land survey records of Kings County, N.B.. Species and location of 3880 witness trees were compared to tree species data from 957 Forest Development Survey (FDS) plots (1986 and 1993) to determine changes in species composition since European colonization. This analysis was conducted on an ecosite basis.

The witness tree method has several drawbacks. In many instances surveyors did not identify trees to species. In these cases Lutz simply identified genera (ash [*Fraxinus*], birch [*Betula*], maple [*Acer*], pine [*Pinus*], and spruce [*Picea*]). Lutz noted several potential biases in the witness tree records. White pine (*Pinus strobus*) may have been avoided due to its extensive use for masts and spars in the British Navy (many white pine were marked and reserved for the British Crown). Nevertheless, Lutz concluded that no potential biases are substantial enough to suggest that the land survey records are not a representative "snapshot" of pre-European settlement.

Advantages:

1. For counties that had a high settlement density in the 19th century, the witness tree method provides a relatively bias-free and extensive sample of mature tree species composition in the 1785-1820 period. This can serve as a 'benchmark' for current management.

2. Relates tree species (or genus) frequency to soil type, drainage, aspect and slope class (ecosite).

Disadvantages:

1. Some trees were only recorded to genus. This ambiguity is of particular concern to managers due to the widely different silvics of some species within the same genus (sugar maple [*Acer sacharum*] vs. red maple [*Acer rubrum*], jack pine [*Pinus banksiana*] vs. red pine [*Pinus resinosa*] and white pine, yellow birch [*Betula alleghaniensis*] vs. white birch [*Betula papyrifera*], white spruce [*Piciea glauca*] vs. red spruce [*Picea rubens*] and black spruce [*Picea mariana*]) (Burns and Honkala 1990).
2. Records indicate individual trees, not community types. In some community types (defined by ecosite), small witness tree sample sizes offer little predictive power about the overall community composition. It is possible that small numbers of surveyors' records might be a reflection of less desirable (less fertile) land from a settlers' standpoint. This may have biased this method in favour of more productive sites[3].
3. This historical approach provides a snap shot but does not offer a method to determine how the forest might have changed naturally over 200 years in the absence of human intervention.

3.0 The Potential Forests/ Ecological Land Classification Approach

Zelazny *et al.* (1997) defined "potential vegetation" as the stand composition and pattern of forest types that *would have existed* before farming, harvesting, and fire and insect suppression began to dominate local forest dynamics. Thus, the ELC group also strived towards determining the pre-settlement condition of the Fundy Model Forest.

As mentioned above, the Ecological Land Classification (ELC Working Group 1996) is a method for identifying and mapping terrestrial ecosystems by defining a range of factors that influence their distribution. By determining the enduring features of the landscape (i.e. climate, topography, bedrock, and soils), Zelazny *et al.* (1996) attempted to reveal the *inherent* pattern of forest distribution. This, combined with natural disturbance regimes such as fire, windstorm, insect disease and individual tree fall, creates the actual forest pattern across landscapes.

To determine the characteristics of pre-settlement forest, the ELC group used the ecosite delineation process. Four geographical information system (GIS) map layers were used: (i) elevation and slope classes, (ii) soil type and soil drainage, (iii) forest cover types, (iv) the existing Ecological Land Classification for ecodistricts. Each of these data layers were divided into classes on the basis of striking differences in occurrences of certain stand types. For example Zelazny *et al.* (1996) noted that black spruce stands disappear at a slope class of 6, whereas tolerant hardwood stands markedly increase in the Anagance Ridge Ecodistrict.

Ecosites were the result of all classes of the four biotic and abiotic data layers being combined to form discreet combinations. For example, 'wet, nutrient rich hardwood' sites were assigned to ecosite 3, whereas dry, nutrient poor softwood sites were assigned to ecosite 1. All nine of these ecosites, along with sub-categories to denote special conditions, (e.g. "c" for calcareous), make up the edatophic grid (Fig. 2).

[3] For further discussion of this potential bias, see Section 5 below.

Once ecosites had been delineated, the 1983 forest inventory data was stratified into seven "forest communities". This was seen as practical for forest management purposes. The seven communities are pine (PINE), black spruce (BS), spruce/fir (SPBF), balsam fir (BF), eastern cedar (EC), mixedwood of tolerant species (MXWD), and tolerant hardwood (TOHW). Stand tally data from 3461 ground plots and photointerpreted forest inventory data were used to determine the frequency of the seven forest communities in each ecosite within each ecodistrict.

In order to compensate for human-induced changes that have occurred since European settlement, Zelazney et al. (1997) made several adjustments. First, as is evident from the above community types, intolerant hardwood (IH) communities were not included in the analysis as a forest community group. The reasoning was that this cover type does not display a strong relationship with environmental variables. The ELC group argued that this is an early successional community that is likely to be a reflection of human disturbance. Second, stands that had grown up on old fields were not included in the analysis. White spruce, poplar, balsam fir, alder and white birch are predominant species on old fields in the Maritimes. As the presence of these species reflects agricultural disturbance rather than enduring features, they would have biased the determination of pre-settlement forest.

The final result of the Potential Forests approach was a series of 'potential forest communities' (e.g. BS, TH, MXWD etc.) by ecosite and Ecodistrict. In summary, these forest communities are based on three factors: (1) ecosite classification, (2) the 1983 forest inventory, and (3) forest community adjustments to compensate for known human disturbance such as farming.

Advantages:

1. The ELC approach provides a characterization of pre-settlement forest communities based on enduring features such as soil and climate rather than ephemeral features such as individual trees. This fits with the concept of *dynamic* (Botkin 1990), rather than stable/ static forest communities (Clements 1970?). It also allows forest managers some flexibility in managing for the frequency of tree species.
2. The ELC approach is spatially-explicit and can thus predict the 'potential forest' stand boundaries across the entire Fundy Model Forest. Managers may be able use ecodistrict and ecosite classification to guide management practices at the landscape and stand levels.

Disadvantages:

1. The ELC approach relies on the 1983 forest inventory to develop ecosite – forest community associations. While some adjustments were made to compensate for human disturbance (removal of old fields and intolerant hardwood from the analysis), it is likely that many other human activities have influenced forest composition since European settlement. For example, certain tree species such as white pine, red spruce, eastern hemlock (*Tsuga canadensis*) and tamarak (*Larix laricina*) have been selectively removed from New Brunswick forests over the past 200 years (Lutz 1997). Budworm suppression may have led to extended longevity of spruce-fir stands allowing these species to regenerate over a larger area (Blais 1983).
2. Lumping all native tree species into seven 'community types' might encourage managers to ignore rarer, less merchantable species such as eastern hemlock and American beech (*Fagus grandifolia*). Zelazny *et al.* (1997) tried to ameliorate this

problem by providing actual species frequencies by ecosite. It will be important for managers to consider these species frequency guidelines in the design of stand-level interventions.

3. While the ELC group emphasized the strong influence of natural disturbance on forest composition, this was not considered as part of the pre-settlement forest analysis. A fire model (FireNB) was used to determine fire return frequency. However, return frequency was not included as a factor affecting community type. While the predominant type of disturbance in most of the FMF ecodistricts may have been individual tree fall (gap-dynamics) (Seymour 1992), it is highly probable that fire, insect infestation, and blowdown acted as significant influences on the characteristics of presettlement forests (Wein and Moore 1977, Zelazny *et al.* 1997). The removal of all early successional stand types (intolerant hardwood) from the analysis probably under-emphasized the role of stand-replacing disturbances.

4.0 Comparing the Results of the Land Survey and Potential Forests Methodologies

Comparing the results of Lutz (1997) and Zelazny *et al.* (1997) is problematic due to the substantial differences in methodologies and terminology (Table 1). For example, Lutz reported tree species or genus frequencies, whereas Zelzany *et al.* (1997) reported community types. Nevertheless, to serve as the basis for a much needed discussion on the role of presettlement forest characterization in forest management, I have attempted a coarse comparison of the results of each study. The following methods were used to allow comparison between the two methods:

1. Species and genera examined by Lutz (1997) were lumped into community types. Ash, maple, birch, and beech were combined to form a single Tolerant Hardwood (TH) category. It is unlikely that all birch and maple were the tolerant/ partly tolerant species of sugar maple and yellow birch. However, because Zelazny *et al.* (1997) did not include intolerant hardwoods in their analysis, this assumption does not result in a biased comparison.
2. Zelazny *et al.*'s (1997) community types SPBF (spruce – balsam fir) and BS (black spruce) were combined and compared to Lutz's (1997) "spruce" category (Table 2). One potential difficulty is the comparison of Lutz's species categories with Zelazny's tolerant mixedwod (MXWD) community type. It is unknown how many witness trees existed in mixedwood communities because no surveyors' records were kept about broad community types.
3. The ecodistricts (used by Zelazny *et al.* 1997) were grouped into ecoregions (the basis for Lutz's analysis) (Table 3). In all cases the boundaries of one or more Ecodistricts were the same as ecoregions.
4. Because Lutz's analysis only covered Kings County (Ecoregion 5 -- Continental Lowlands, Ecoregion 4 -- Fundy Coastal, and Ecoregion 3 -- Southern Uplands), comparisons could only be performed for these portions of the Fundy Model Forest. For the purposes of this analysis only Ecoregion 5 and Ecoregion 3 were examined. These ecoregions are representative of different disturbance regimes. Stand-replacing disturbance (spruce budworm and fire) probably dominated the Continental Lowlands. In the Southern Uplands, gap-replacing disturbances (single tree fall and patchy budworm outbreaks) were more common (Woodley and Forbes 1997). Very

few witness tree records exist for the Fundy Coastal Ecoregion (92 out of 3880), thus less confidence can be placed in Lutz's pre-settlement forest characterization for this area.

5. All species and community types from Lutz (1997), the FDS survey plots, and Zelazny *et al.* (1997) that were not fit into the categories were put into the 'other' category on frequency graphs (Table 2). Since all of Zelazny *et al.*'s (1997) community types were examined except for mixedwood (MXWD), frequencies in the 'other' category for 'Potential' forest can be considered MXWD.

5.0 Results and Discussion: Differences Among Present Forest, Surveyor's Records and ELC 'Potential Forests' Approach.

It is not the purpose of this paper to reiterate the detailed findings of Zelazny *et al.* (1997) and Lutz (1997). However, trends in similarities and differences between these two presettlement forest characterization methodologies are described below. The diversity of ecosites and community types examined makes such generalizations difficult. Nevertheless, several trends are apparent.

(1) In *all* cases, except ecosite 5 ("moist, moderately rich mixedwood") in the Continental Lowlands, balsam fir frequencies were much lower in the ELC analysis (Zelazny *et al.* 1997) and witness tree survey (Lutz *et al.* 1997) than for the present day forest (1993 FDS data) (Fig. 3, Appendix A). This common result in the findings of both presettlement characterization methodologies probably reflects a real change that has occurred over the past two-hundred years. Lutz (1997) suggested that this change is a result of highgrading. Due to the demand for certain softwood

tree species for lumber and the unmerchantability of fir, gaps were created by harvesting, leaving prime growing space for this species. Blais (1983) suggested that budworm cycles, altered by pesticide spraying, also may have increased fir frequency.

(2) The frequency data for tolerant hardwood in ecosites 8 ("moist rich hardwood") and 9 ("dry moderately rich hardwood") are very similar for both presettlement analyses (Fig. 4, Appendix A). The high presettlement values contrast with the 'present' FDS data which indicate much lower TH frequencies (<10%). This is a reflection of the high degree of human intervention on these ecosites. Intolerant hardwood has increased as a result of the high degree of stand-replacing (clearcut) harvest. Old field species such as white spruce have regenerated prolifically after the abandonment of agricultural land.

In all other ecosites in the Continental Lowlands Lutz (1997) and Zelazny *et al.* (1997) reported very different tolerant hardwood frequencies. In each case the tolerant hardwood is reported to be much less common in the Potential Forest analysis. This low frequency is particularly surprising in ecosites 7, 7c, and 6b – all of which are reported to be characterized by rich hardwood or mixedwood. Even if Zelazny *et al.*'s (1997) tolerant mixedwood (MXWD) community type is added to the tolerant hardwood (TH) category in the frequency distribution, it does not match the high frequencies reported by Lutz (1997) (Fig. 5)

(3) In all cases in the Continental Lowlands except for hardwood ridge ecosites (8 and 9), spruce is much more frequent according to the Potential Forest data than the

witness tree accounts or even the present day forest (FDS survey) (Appendix A). It is possible that this discrepancy may reflect differences in the frequency of community types reported by 1993 FDS permanent sample plots (used by Lutz 1997) versus the 1983 FDS air photo inventory used by Zelazny *et al.* (1997).

(4) For most ecosites, Lutz (1997) and Zelazny *et al.* (1997) both reported higher frequencies of cedar than presently exists. This probably reflects human activities such as the clearing and draining of cedar swamps, and the high commercial demand for this species throughout the 19th century (Lutz 1997). It is interesting to note that the cedar community type is absent from the Potential Forests characterization of ecosite 7c ("calcareous, moist, rich mixedwood"). The witness tree survey suggested at least a 5% frequency of this species in this ecosite.

(5) In most cases, pine is reported to be less frequent by the witness tree survey than the Potential Forests analysis. This may reflect the potential bias, noted by Lutz (1997), that surveyors did not mark and record white pine reserved for the British Navy. It is also possible that white pine might have been selectively removed before the occurrence of the witness tree surveys.

5.0 Potential Reasons for Differences in Community Frequencies

While there are a number of similarities among community frequencies in the two presettlement forest characterizations, there are clearly a number of important differences. Several explanations exist for these incongruities. First, as mentioned above, the witness tree surveys might have been biased toward more productive land. Lower quality ecosites may have been underrepresented by witness trees. The examination of witness tree density in the range of ecosites reveals a correlation between density and land productivity[4] (Fig. 6, 7). The scarcity of witness trees in the lower productivity ecosites may have resulted in a less statistically-sound sample of these areas. Also, it may have been possible that surveys were biased toward apparently more productive sites *within* an ecosite. (For example tolerant hardwood stands within ecosite 5 may have been more frequently surveyed than spruce/ balsam fir stands).

A second cause of differing results relates to the poor comparability among data sets. As was emphasized above, Lutz (1997) examined individual species and related these to ecosite. Zelazny *et al.* (1997) examined the frequencies of community types by ecosite. Thus, for example, it would be difficult to determine the proportion of tolerant hardwood witness trees that may actually have been part of a mixedwood community.

Varying frequencies undoubtedly reflects real changes in forest composition that have occurred since European settlement. It is important to remember that the Potential Forest approach is based on the ecosite classification and only two major adjustments for human disturbance: removing (i) old fields and (ii) intolerant hardwood from the analysis. Thus, any other human disturbances that may have altered tree species composition, such as highgrading or clearcut harvesting, are not accounted for in community type frequencies. This could explain the lower frequencies for cedar and tolerant hardwood evident in Zelazny *et al.*'s (1997) results. These species, due to their poor regenerative capacity in open conditions (Burns and Honkala 1990), are not favoured by the large harvest openings that have been common in the Fundy Model Forest region (Zelazny and Veen 1997).

[4] The ecosites rated as "rich" are 9, 8, 7, 7c, and 6b. "Moderately rich" ecosites include 4, 5, and 6. The "poor" ecosites are 1, 2, and 3 (Zelazny *et al.* 1997).

6.0 Conclusion: The Role of Presettlement Characterizations in Forest Management Planning

There has been widespread debate about the role of presettlement forest characterization in forest management. Botkin (1990) argued that to strive towards a historical state is to deny the dynamic nature of forest ecosystems. Indeed, the tree species composition of New Brunswick's forests has changed due to natural processes. Beech bark disease and Dutch elm disease have decreased the frequencies of beech and elm in our forests (Forbes *et al.* 1998). Tree species have also been shown to migrate in response to changing climate (Davis 1983). Even without these real and potential natural changes, humans have exerted such a powerful influence over the Fundy Model Forest region over the past two centuries that attempting a complete return to presettlement forest would be a difficult or impossible goal.

However, there are many advantages to conserving the historical genetic and species diversity of trees. Most of these relate to the *rate* of human-induced change, and the uncertainties associated with forest management outcomes. Tree species frequency is likely to have changed much more quickly over the past 200 years than it has in history. It is possible that the characteristics of our forests are being altered more rapidly than many species' ability to adapt. It is logical that we should attempt to maintain relative species abundances at least until we develop more detailed knowledge about the potentially crucial ecological roles played by certain tree species (Lindenmayer et al. 2000).

Presettlement characterizations provide a benchmark for the frequencies of species or community types that existed before human beings began to exert wide-spread and rapid change on forest ecosystems in North America. While we might not strive towards the precise species compositions reflected by these analyses, they can provide a guide to management so that we do not eradicate species and community types that provide critical ecological services.

This comparative analysis of two presettlement forest characterizations has shown that while some similarities in results are evident, some important differences exist. The question remains; What information should be used as a guide to forest management? Because the two approaches have methodological strengths and weaknesses, the best alternative is probably to use both. The next step should be to engage Fundy Model Forest partners in a discussion on the role of presettlement forest characterizations in forest management. Work should be undertaken on the reconciliation of the two approaches, and possible means for applying both directly in forest and stand-level management.

Literature Cited

Blais, J. 1983. Trends in the frequency, extent and severity of spruce budworm outbreaks in eastern Canada. Canadian Journal of Forest Research 13: 539-547.

Botkin, D. 1990. Discordant Harmonies. A New Ecology for the Twenty-First Century. Oxford University Press.

Burns, R. and D. Honkala. 1990. Silvics of North America. U.S.D.A. Washington, D.C.

CCFM. 1995. Defining Sustainable Management: A Canadian Approach to Criteria and Indicators. Canadian Council of Forest Ministers, Ottawa.

Davis, M. 1983. Holocene vegetational history of the Eastern United States. *In* Late Quarternary Environments of the United States. Wright, H. (ed.) University of Minnesota Press, Minneapolis.

Department of Natural Resources and Energy. 1997. Ecological Land Classification for New Brunswick: Ecoregion, Ecodistrict and Ecosite Levels. DNRE, Fredericton.

ELC Working Group. 1996. An Ecological Land Classification System for New Brunswick. Department of Natural Resources and Energy, Fredericton.

Etheridge, P., K. Pugh, G. Watt, M. Whelan. 1999. Criteria and Inidicator Status Report 1999/2000. Natural Resources Canada.

Forbes, G., H.Veen, V. Zelazny and S. Woodley. 1998. Ecological change in the Greater Fundy Ecosystem.Pp.55-74, *In* State of the Greater Fundy Ecosystem. Woodley, S., G. Forbes, and A. Skibicki (eds.) GFERG, University of New Brunswick, Fredericton, N.B. 215 p.

Lindenmayer, D., C.Margules, and D. Botkin. 2000. Indicators of biodiversity for ecologically sustainable forest management. Conservation Biology 14(4), 941-950.

Loo, J. 1994. Forest biodiversity assessment and monitoring in the Maritimes. *In* Towards a Set of Biodiversity Indicators for Canadian Forests: Proceedings of a Forest Biodiversity Inidicators Workshop. McKenney, D., R. Sims, M. Soulé, B. Mackey, and K. Campbell (eds.), Natural Resources Canada, Sault Ste. Marie.

Lutz, S. 1997. Pre-European Settlement and Present Forest Composition in King's County, New Brunswick, Canada. Master of Forestry Thesis, University of New Brunswick.

Schnitzler, A. and F. Borlea. 1998. Lessons from natural forests as keys for sustainable management and improvement of naturalness in managed broadleaved forests. Forest Ecology and Management 109: 293-303.

Seymour, R. 1992. The red spruce-balsam fir forest of Maine: Evolution of silvicultural practice in response to stand development patterns and disturbances. *In* Kelty, M., B. Larson and c. Oliver (eds.), The ecology and silviculture of mixed-species forests, pp. 217-244. Kluwer Academic Publishers.

Wein, R. and J. Moore. 1977. Fire history and rotations in New Brunswick Acadian Forest. Canadian Journal of Forest Research 7:285-294.

Woodley, S. and Forbes, G. (eds.). 1997. Forest Management Guidelines to Protect Native Biodiversity in the Fundy Model Forest. New Brunswick Cooperative Fish and Wildlife Research Unit, University of New Brunswick, 32 p.

Zelazny, V., H. Veen, and M. Colpitts. 1997. Potential Forests of the Fundy Model Forest. Department of Natural Resources and Energy, Fredericton, N.B.

Zelazny, V. and H. Veen. 1997. The Acadian Forest, past and present. *In* Proceedings of an Ecological Landscape Management Workshop, Fredericton, N.B., Canadian Woodlands Forum, Canadian Pulp and Paper Association, Oct. 1997, pp. 9-13.

Tables

Table 1. Terminological and methodological similarities/ differences between Lutz (1997) and Zelazny *et al.* (1997).

	Surveyor Record Approach	**Potential Forests Approach**
Data sources	Surveyor's witness trees (for presettlement composition), FDS permanent sample plot (PSP) data (for present species composition), ELC (for ecosites)	ELC, FDS data (photo interpreted, PSP)
Sampling intensity	High for Ecoregion 5 (3342 witness trees), low for Ecoregions 3 (245) and 4 (92)	Estimates were based on photo-interpreted stands and then 'adjusted' based on 3461 ground plots.
Unit of examination	Individual species or genus (spruce, birch, beech, fir, poplar, hemlock, maple, cedar)	Community types (BF, TH, SPBF, PINE, BS, MXWD, EC)
Scale of comparison (landscape level)	Ecoregion	Ecodistrict
Scale of comparison (site level)	ecosite	ecosite

Table 2. Species groups (Lutz 1997), equivalent community types (Zelazny *et al.* 1997) and the community types used for comparative analysis.

Witness tree/ FDS survey categories (Lutz 1997)[5]	**Community types (Zelazny *et al* 1997)**	**Comparison community types**
Birch + beech + maple + sugar maple[6] + ash + butternut + ironwood + yellow birch	TH	TH
Fir	BF	Fir
Spruce	SPBF + BS	Spruce
Cedar	EC	Cedar
Poplar + elm + alder + hemlock + tamarack + white birch + willow + 'white maple'	N/A	Other
White pine + pine + "yellow pine"[7]	PINE	Pine
N/A	MXWD	Other

Table 3. Ecoregions and equivilant Ecodistricts

Ecoregion	**Equivilant Ecodistrict(s)**
5, Continental Lowlands	31, Kennebecasis and 29, Anagance Ridge
4, Fundy Coastal	32, Fundy Coastal
3, Southern Uplands	12, Fundy Plateau

[5] Lutz (1997) analyzed 20 species from the surveyors records. Only the commonly recorded ones are listed here.
[6] 'White maple' was not included in this category because this was probably a surveyor reference to either silver maple or red maple (Lutz 1997)..
[7] Lutz (1997) found several species names for witness trees that are different from current species names. In these cases he lumped records into a single category by genera.

Figures

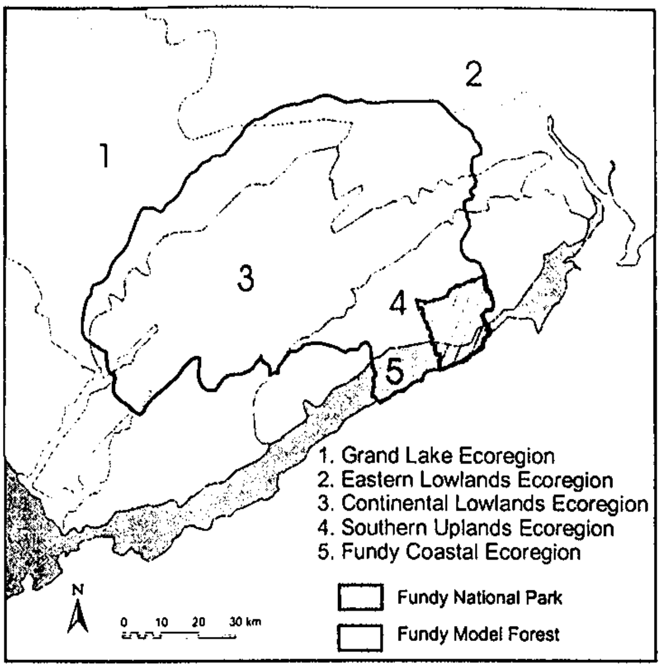

Fig. 1 Ecoregions of encompassing the Fundy Model Forest

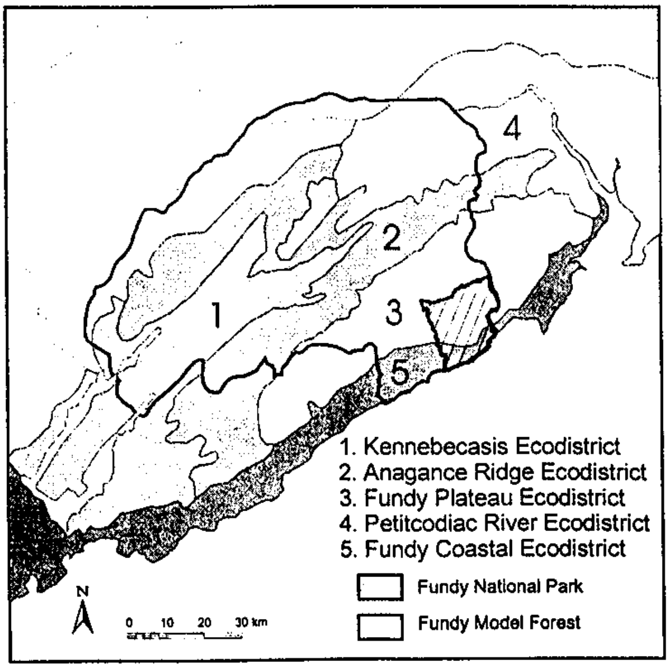

Fig. 2 Ecodidistricts of the Fundy Model Forest

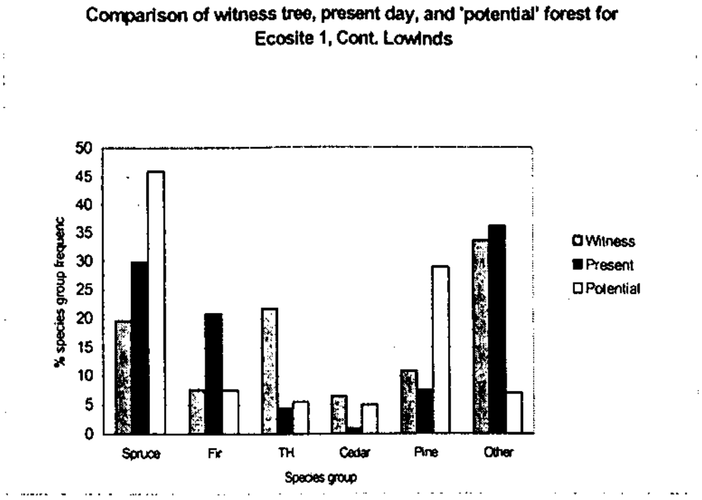

Fig. 3 Comparison of witness tree, present day, and 'potential' forest for ecosite 1, Ecoregion 5 – Continental Lowlands. Note the similar frequencies of fir for both witness tree and 'potential' analyses.

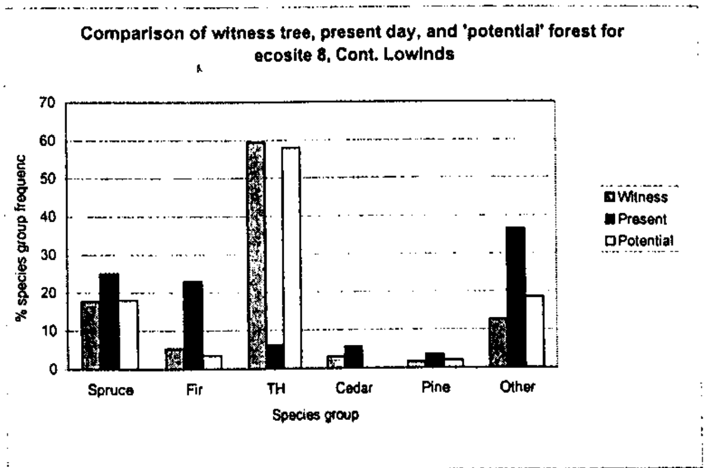

Fig. 4 Comparison of witness tree, present day, and 'potential' forest for ecosite 8, Continental Lowlands. Note simil characterizations.

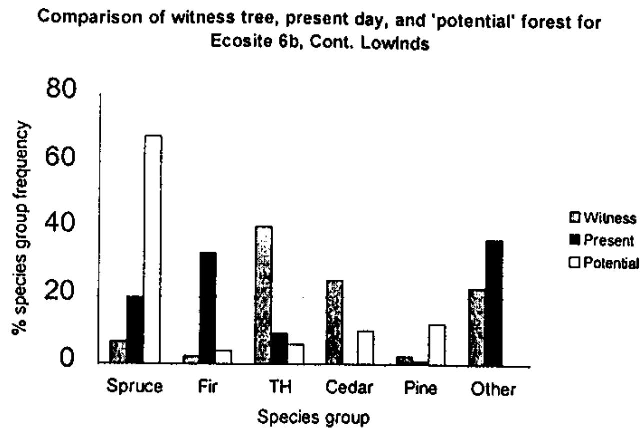

Fig. 5 Comparison of witness tree, present day and 'potential' forest for ecosite 6b, Continental Lowlands. Note much high tree survey

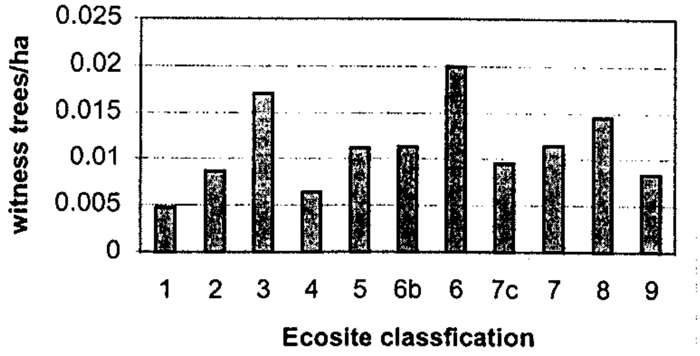

Fig. 6 Witness tree density in ecosites of the Continental lowlands.

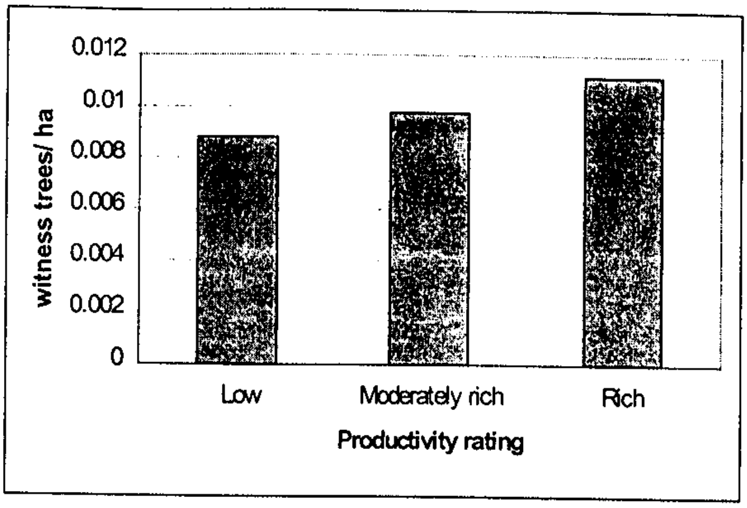

Fig. 7 Witness tree density in ecosites categorized by productivity class.