C12B

FUNDY MODEL FOREST
YEAR END REPORT
1995

PROJECT: Effects of Forestry Practices on Species Composition, Diversity, Stand Structure and Succession

M.R. Roberts, Faculty of Forestry and Environmental Management, University of New Brunswick

---

GOALS:

1. Enhance the capability to predict and minimize the impact of forestry practices on the ecosystem.

2. Establish the knowledge base necessary to develop forest management systems that more closely approximate natural disturbance regimes in terms of impacts on biodiversity.

3. Develop practical forest management guidelines for conserving biodiversity.

OBJECTIVES:

1. Assess response of herbaceous species to harvesting with and without site preparation.

2. Determine effects of different disturbance severities on herbaceous layer species composition and diversity.

PROJECT DESCRIPTION:

Phase 1:

The overall project was initiated in 1993 with the following objectives: 1) Compare effects of human and natural disturbances on plant species composition, alpha diversity and structural diversity, and 2) Determine changes in composition and diversity of vascular plant species and stand structure with successional time in response to human disturbance *vis a vis* spruce budworm disturbance.

A chronosequence for each of the human-caused disturbance scenarios on poor-moist sites was selected (Appendix 1). Three black spruce plantations in each of three age classes (5-7, 10-12, and 14-16 years) were sampled (total of 9 plantations). Three multi-aged stands of spruce budworm origin and 3 naturally regenerated clearcuts (7, 18 and 38 years) were sampled. The naturally disturbed (spruce budworm origin) stands are being used as a control for comparison with the human-caused disturbances.

Changes in structural diversity with spatial scale (10X10m to 60X60m) and stand age have been analyzed and compared among the three disturbances. The measures used are the coefficient of variation of stem density, tree diameter, height, crown length and basal area, and diversity indices for each structural variable based on the number of density or size classes present (Appendix 2).

The disturbance history of each stand has been documented (Appendix 3) and the effect of treatment and stand age on diversity (Shannon-Wiener index, Simpson index and species richness) of ground vegetation is currently being analyzed (Appendix 4). Analysis of changes in species composition of the dominant species and rare species in the ground layer is also in progress. Coarse woody debris has been sampled in each stand and analysis is in progress. A refereed journal article is in press (Ecological Applications) and other papers based on this work have been presented at meetings of the Model Forest Network, the Greater Fundy Ecosystem Research Group, and meetings of several other national and international ecological organizations. Final results on stand structural diversity were published in a M.Sc. theses this year. Two B.Sc. senior theses, which summarize results on taxonomic diversity and coarse woody debris, will be completed in May 1996.

The key findings from Phase 1 of this study with respect to structural diversity are as follows:

1. Based on the coefficient of variation of the structural variables used in this study, structural diversity in 5-16 year-old plantations may equal or exceed that in natural stands.

2. Residual stems (larger and older stems which survived the disturbance) are an important source of structural variability.

3. Structural diversity in natural stands was related to the wide range in stem sizes resulting from the spruce-budworm outbreak.

4. Structural diversity in young plantations was related to the presence of residual stems. Decreases in diversity with plantation age were apparently related to the mortality of many residual stems.

5. In addition to the coefficient of variation, absolute stem densities and sizes should also be considered for a clearer picture of stand structural diversity.

The key findings with respect to species composition and diversity are as follows:

1. There were no obvious effects of time and treatment on species diversity and composition in cutover stands.

2. There were noticeable differences in species composition and diversity in response to changes in site conditions from VT-2 to VT-7.

3. Cutovers were dominated by Sphagnum spp., bunchberry (Cornus canadensis), Schreber's moss (Pleurozium schreberi), and haircap moss (Polytrichum spp.). Budworm-origin stands were much the same, with the addition of Dryopteris spp.

Phase 2:

The second phase of this study was established in 1995, within the Hayward Brook Watershed (south of Petitcodiac in the Fundy Model Forest) to assess effects of treatments in the first year after disturbance (Appendix 1). This study is integrated with bryophyte studies at UNBSJ (Department of Biology). The objectives are to assess the response of herbaceous species to harvesting with and without site preparation and to assess effects of different disturbance severities on herbaceous layer species composition and diversity. This portion of the study complements the first phase by providing information on initial response of herbaceous layer species following harvesting.

A total of 169, $5m^2$ herb plots were located in two distinct blocks separated by a branch of the Hayward Brook (Appendix 5). The harvested blocks covered approximately 55ha. Plots were placed on transects which started in the riparian buffer strip and ran upslope. The spacing between plots was 50m and approximately 50m between the transects. The overstorey and understorey of each stand in the harvest blocks were sampled and each stand was assigned to a site class (Appendix 6).

All sample plots were established and sampled before harvest from May 16 to July 14, 1995. The area was harvested August 1-19 and portions were scarified on September 19-22. Post-disturbance measurements will be done next year due to the late date of site preparation this season. Some plots located in buffer zones and in the uncut stand surrounding of the harvested site will be used as controls for this study.

For sampling the pre-harvest herbaceous layer, each $5m^2$ herb plot was divided into four quadrats. Percent cover of all species of vascular plants was estimated by quadrat. A preliminary list of the species found before harvest is given in Appendix 7.

Environmental data collected on each plot included macrotopography, microtopography, crown closure, and nutrient availability. Macrotopography consisted of slope, slope position, aspect, stand type and substrate. The microtopography measured in each quadrat included forest floor depth, forest floor composition (coniferous, deciduous or moss), slope and slope position. Crown closure was estimated with a densiometer in quadrats one and three based on the average of two readings from two different observers. Adjacent to all the quadrats, litter, soil and plant tissue (Maianthemum canadense) samples were collected for laboratory analysis. Samples were gathered in brown paper bags, and air dried (soil and forest floor) or oven dried (plant tissue).

The following laboratory analyses were conducted on the mineral soil and forest floor samples: pH, carbon-nitrogen (C/N) ratio, organic matter content (OM)., concentrations (meq/100g) of calcium (Ca), potassium (K), magnesium (Mg) and concentration (ppm) of phosphate (P). Soil texture (proportion of silt, clay and sand), was also assessed for 88 sample plots located on every second transect.

Maianthemum canadense was chosen for plant tissue analysis because it was a ubiquitous species within the study area. Tissue nutrient concentrations provide another measure of nutrient availability in addition to forest floor and mineral soil nutrients. Approximately 20 leaves were collected outside each plot within a 3m radius. Plant tissue analysis was conducted for Ca, K, Mg, P and N concentrations.

All laboratory analyses have been completed. Analysis of data collected during the 1995 field season is in progress. The main topic of a B.Sc. Honors Thesis in Biology is the pre-harvest species composition in the sample plots and how it is related to variation in the environmental (site) factors. These results will establish the baseline information needed to assess post-disturbance vegetation response.

The schedule below was followed during the 1995 field season:

- May 16 / June 1
  - Layout of 169 permanent sample plots
- June 1 / June 12
  - Overstorey sampling and site classification
- June 13 / July 14
  - Pre-harvest inventory
  - Collection of litter, soil, plant samples

° July 15 / August 31
  - Laboratory analysis of litter, soil and plant samples
  - Computer data entry

° August 31 / Present
  - Data analysis

DELIVERABLES:

The deliverables for Phase 1 of the project (see 1994 proposal) are stated below:

1. Graphs of changes in species richness and diversity indices over time on each of the human disturbances.

2. Graphs of changes in stand structure variability over time on each of the human disturbances.

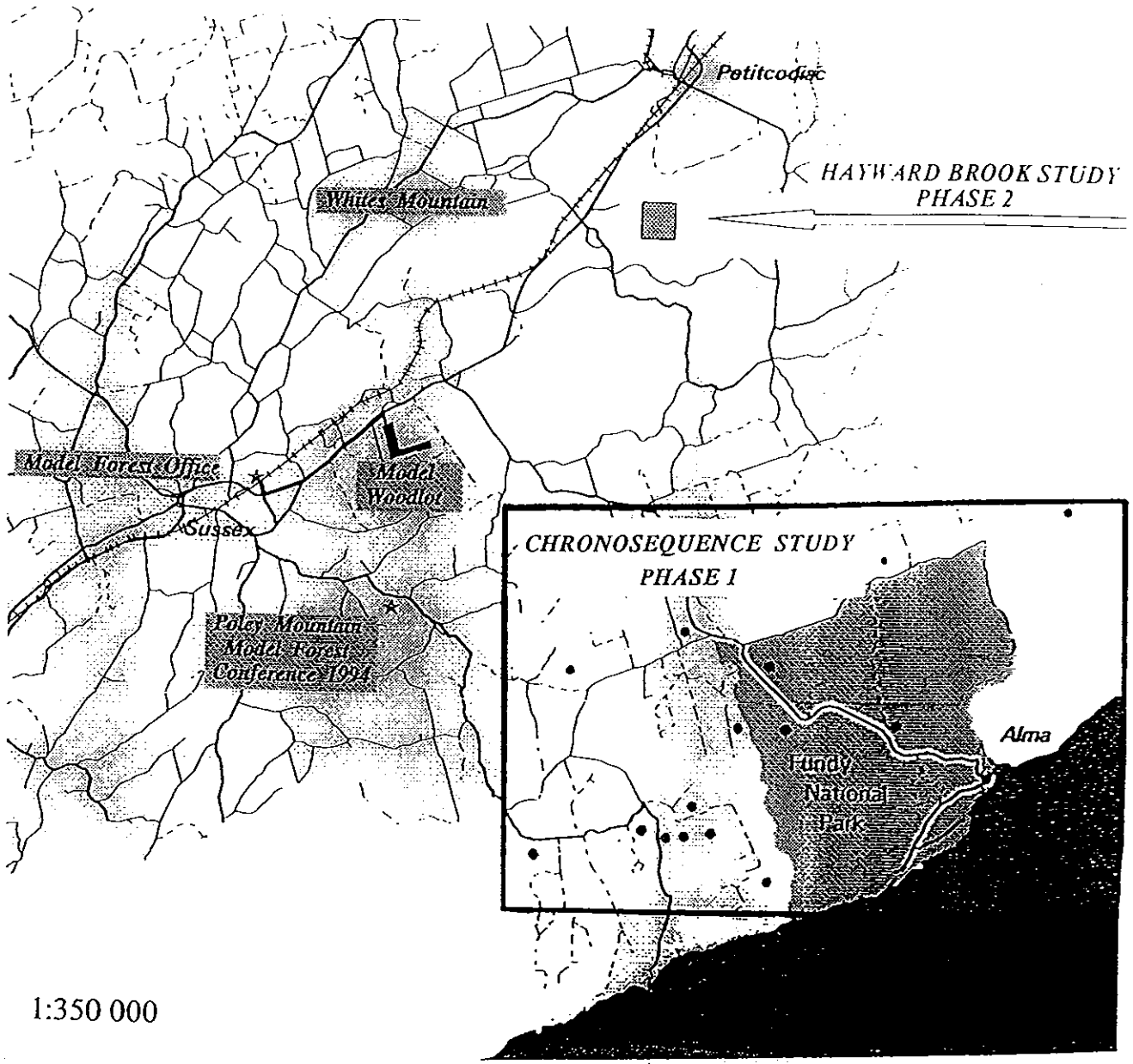
3. Comparisons of species diversity and structural diversity after human disturbances with spruce budworm disturbance.

All deliverables have been completed in full and results are presented in Appendices 2 and 4. It was not possible to assess changes over time in the naturally regenerated clearcuts because an insufficient number of stands of different ages was available to construct a chronosequence.

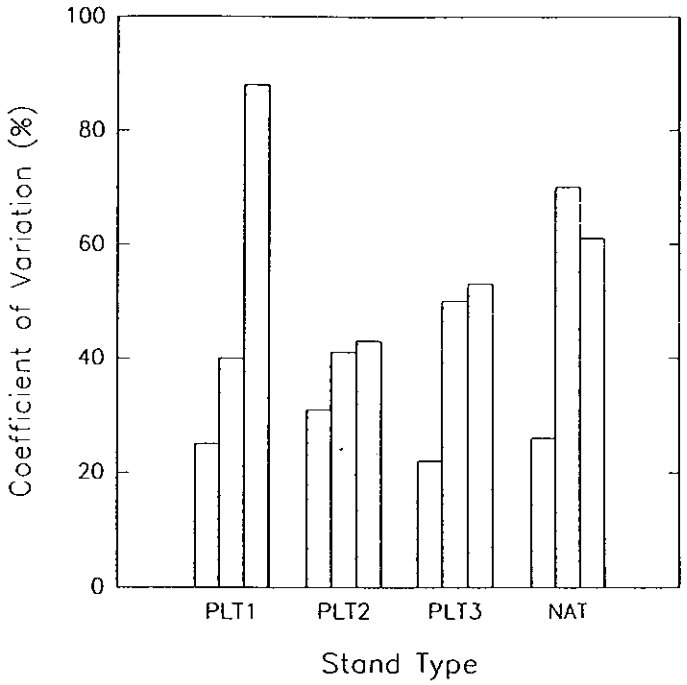
Deliverables for the first year of Phase 2 of the project will be completed by the end of the annual funding period (March 31, 1996).

APPENDIX 1

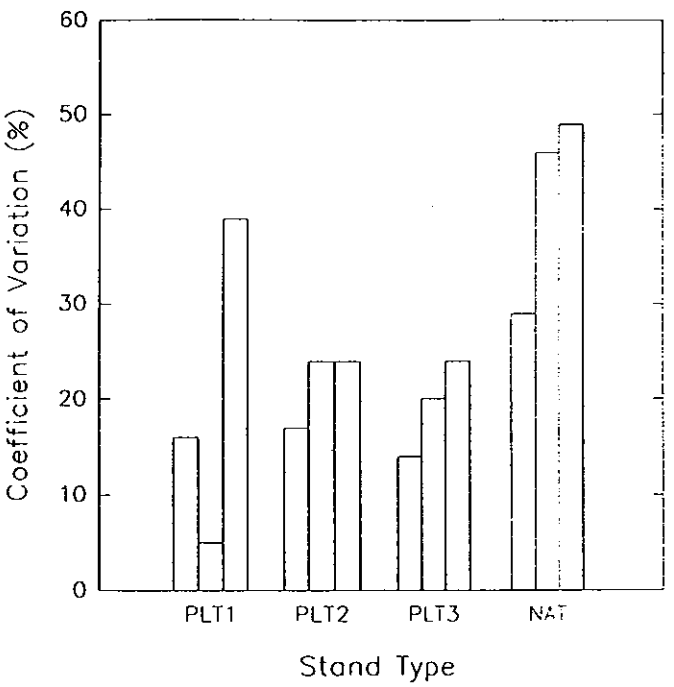
STUDY AREA



APPENDIX 2



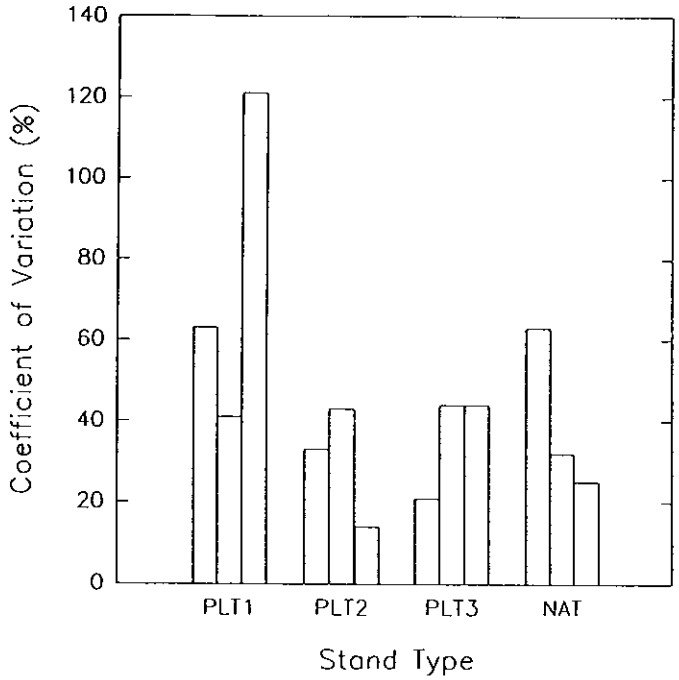
COEFFICIENT OF VARIATION FOR DENSITY IN INDIVIDUAL STANDS BY STAND TYPE.



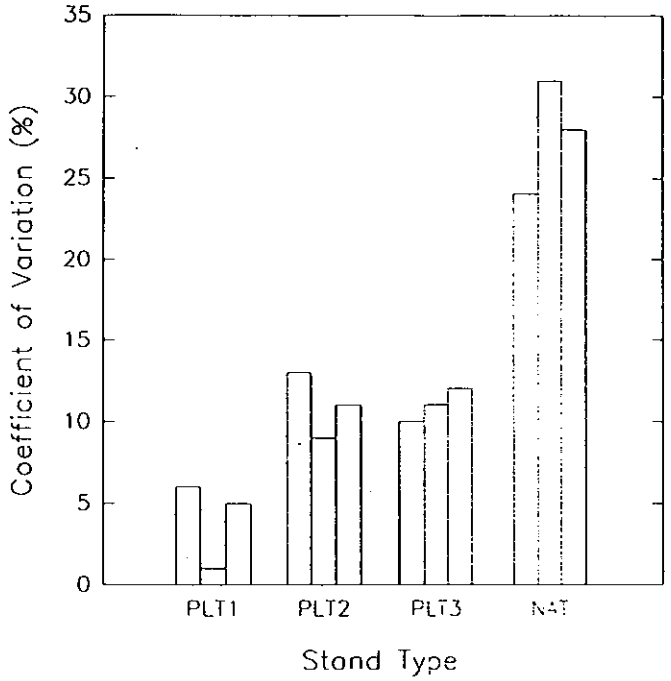
COEFFICIENT OF VARIATION FOR DBH IN INDIVIDUAL STANDS BY STAND TYPE.

LEGEND

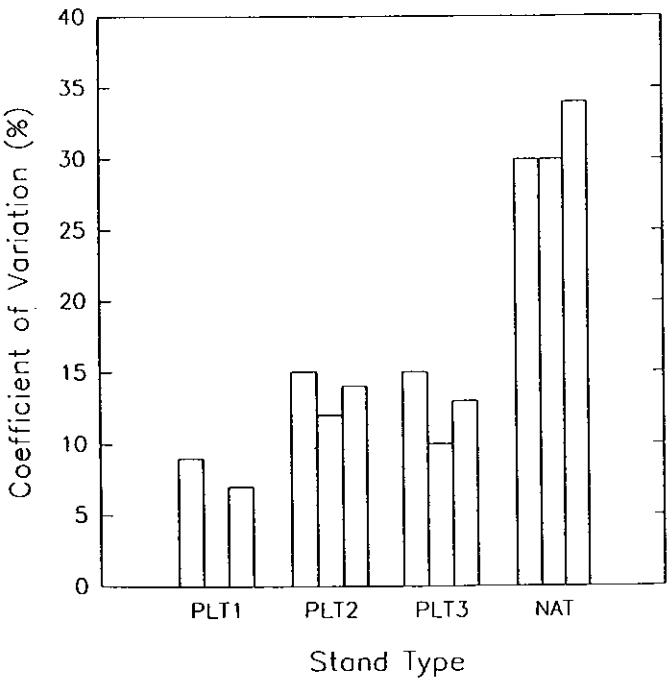
PLT1 - PLANTATIONS, 5-7 YEARS-OLD
PLT2 - PLANTATIONS, 10-12 YEARS-OLD
PLT3 - PLANTATIONS, 14-16 YEARS-OLD
NAT - NATURAL STANDS OF SPRUCE-BUDWORM ORIGIN



COEFFICIENT OF VARIATION FOR BASAL AREA IN INDIVIDUAL STANDS BY STAND TYPE.



COEFFICIENT OF VARIATION FOR HEIGHT IN INDIVIDUAL STANDS BY STAND TYPE.



COEFFICIENT OF VARIATION FOR CROWN LENGTH IN INDIVIDUAL STANDS BY STAND TYPE.

LEGEND

PLT1 - PLANTATIONS, 5-7 YEARS-OLD
PLT2 - PLANTATIONS, 10-12 YEARS-OLD
PLT3 - PLANTATIONS, 14-16 YEARS-OLD
NAT - NATURAL STANDS OF SPRUCE-BUDWORM ORIGIN

APPENDIX 3

Disturbance history and site information by study stand of (A) artificially regenerated clearcuts, (B) naturally regenerated clearcuts, and (C) stands of spruce-budworm origin

Stand no.	Treatment (date, type)	Scarification (date, type)	Date and species planted[a]	Herbicide (date, type)	Veg. type[b]	Soil type[b]	Slope (%)	Aspect (°Az)	Elev. (m)
A. Artificially regenerated clearcuts									
9091	1987 Clearcut	1987 Light chains	1988 NS	1990 Vision	2	1,2	3		270
6211	1984 Clearcut	1985 Chains	1986 bS	1988 Vision	6	1	4	250	270
5134	1983 Clearcut	1985 Chains	1987 bS	1988 Vision	2		1-5	90	290
3153	1981 Clearcut	1982 Crusher	1983 wS	1986 Vision	6	2,4,7	5		270
4744	1982 Clearcut	1982 Barrel and chain	1983 wS	1986 Vision	2	4	1-2		270
6244	1978-'80 Clearcut	1980 Barrel and chain	1981 bS	1983 245-T 1985 Vision	2	3,4	1-5		260
3818	1975-'76 Clearcut	1978 Barrel and chain	1979 bS	1983 245-T	7	1	2-3	80	270

APPENDIX 3 (continued)

Stand no.	Treatment (date, type)	Scarification (date, type)	Date and species planted	Herbicide (date, type)	Veg. type	Soil type	Slope (%)	Aspect (°Az)	Elev. (m)
A. Artificially regenerated clearcuts									
7509	1973 Clearcut	1978 Barrel and chains	1979 bs		2		4	136	290
3676	1976 Clearcut	1976[b] Barrel and chains[b]	1977 bS		2	1,6			300
B. Naturally regenerated clearcuts									
9054	1986 Clearcut				3	1	1		270
2889	1975 Partial clearcut			1985 Vision	2	1	1	44-240	270
8560	1955 Clearcut[d]				7	4,6	10	210	290

APPENDIX 3 (continued)

Stand no.	Treatment (date, type)	Scarification (date, type)	Date and species planted	Herbicide (date, type)	Veg. type	Soil type	Slope (%)	Aspect (°Az)	Elev. (m)
C. Stands of spruce budworm origin									
"FNP X"	Budworm origin				2	2	1- 3	60-340	300
"FNP XII"	Budworm origin				2		1-10	60-240	290
"FNP XIII"	Budworm origin				2	2	1		320

[a]Species codes: NS=Norway spruce (*Picea abies* (L.) Karst.); bS=black spruce; wS=white spruce.
[b]From NBDNRE site classification system (Zelazny *et al.* 1989).
[c]Approximate date and most probable treatment and apparatus.
[d]Naturally regenerated pasture.

APPENDIX 4

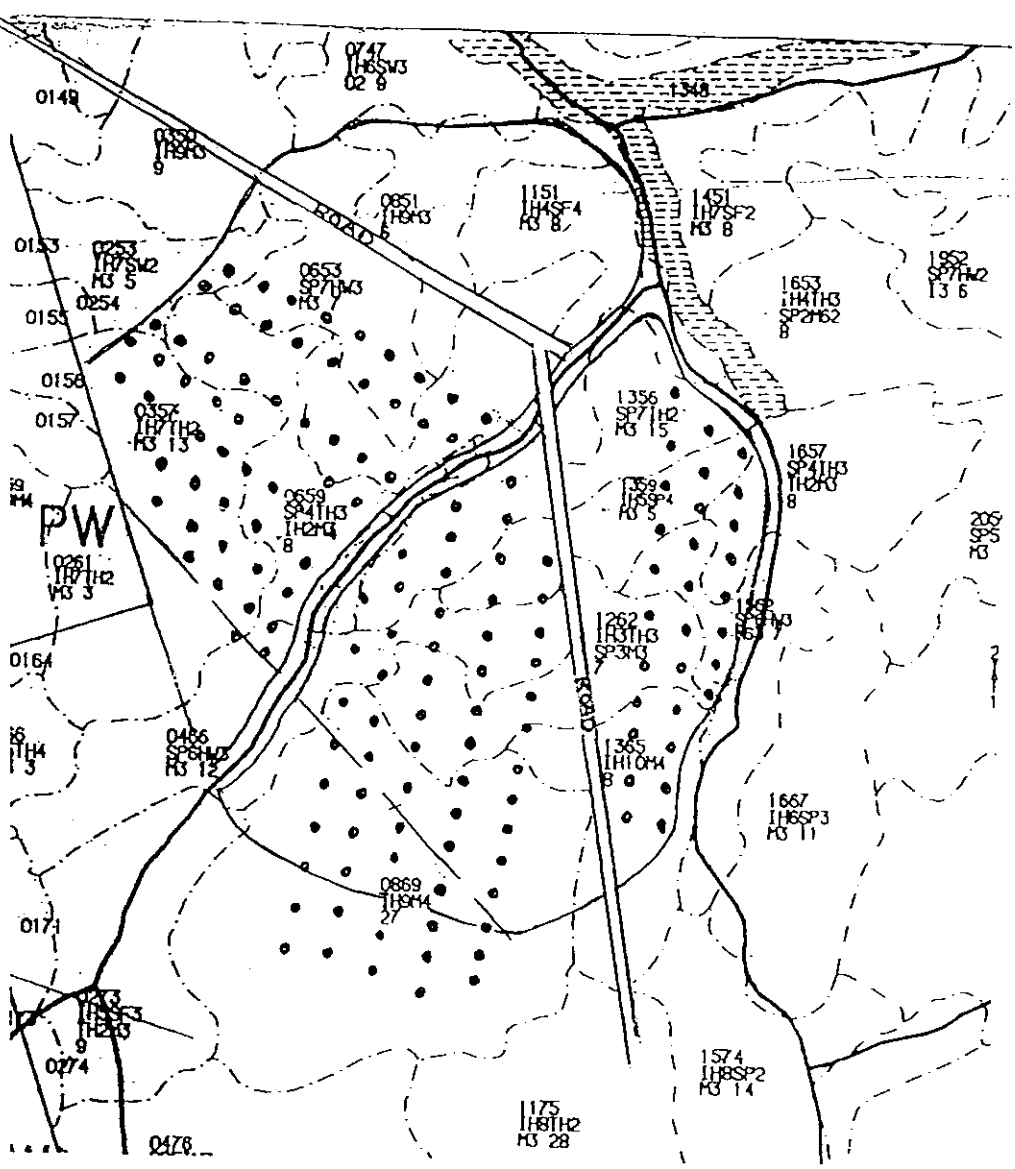
Effect of treatment and time on stand composition (below one meter) as measured by three diversity indices

TREATMENT DATE	SHANNON INDEX	RECIPROCAL SIMPSON INDEX	SPECIES RICHNESS	MAP-STAND NUMBER
Herbicided plantations*				
1983	2.27	5.33	100	6058-3818
1985	1.77	3.37	65	6058-6244
1986	2.05	4.34	113	6058-3153
1986	1.82	3.25	74	6058-4744
1988	1.52	2.41	76	6057-5134
1988	3.00	10.91	112	6156-6211
Non-herbicided plantations*				
1973	1.95	3.45	75	5957-7509
1976	2.24	5.74	69	6056-3676
1987	2.24	6.28	64	6058-9091
Naturally regenerated clearcut				
1986	2.84	10.24	83	5958-9054
Naturally regenerated un-cultivated old field				
1955	2.86	8.62	110	6255-8560
Budworm origin				
Not Applicable	1.93	3.05	77	Fundy Park
Not Applicable	2.17	5.36	48	Fundy Park
Not Applicable	2.25	5.49	72	Fundy Park

*Stands listed by date of herbicide treatment or date of scarification

APPENDIX 5

HAYWARD BROOK WATERSHED
STUDY AREA



APPENDIX 6

HAYWARD BROOK
STAND OVERSTOREY AND UNDERSTOREY COMPOSITION

STAND NO.	OVERSTOREY [1]				UNDERSTOREY [2]	SITE CLASS [3]		
	Dominant Species	Basal area m²/ha	Density #tree/ha	Mean dbh cm	Density # tree/ha	VT	ST	TU
1356	BS [4]	12.00	1207	15.11	800	7	3	10
	RM	6.67	345	15.56	0			
	RS	6.00	196	7.04	100			
466/1562/1657	BS	16.00	1226	13.41	1200	5	3	7
	WB	6.00	514	15.28	0			
	RS	3.50	146	9.42	1250			
1365/869	WB	11.50	848	10.75	0	8	6	12
	RM	7.50	1497	7.15	50			
	TA	4.50	212	14.75	0			
653	RM	8.00	318	20.07	0	7	5	12
	RS	8.00	265	22.60	267			
	TA	5.33	83	30.00	0			
1359	RM	6.00	405	15.67	0	7	3	10
	WB	6.00	393	11.11	0			
	TA	3.33	50	19.67	0			
1262	TA	10.00	198	26.53	0	5	6	6
	WB	8.67	627	15.67	0			
	RM	4.00	537	10.67	33			
659	WS	13.33	320	26.90	133	11	2	9
	RM	10.00	496	20.81	0			
	BF	5.33	459	17.33	2300			
357	WB	21.33	1158	17.20	0	9	5	12
	RM	14.00	2237	10.67	33			
	WP	2.00	14	32.33	33			

1. Based on the average of 3 to 4 prism sample plots (stems ≥ 5 cm dbh).
2. Based on the average of 3 to 4 , 5.64 m radius sample plots (stems < 5cm dbh).
3. Vegetation type (VT), soil type (ST) and treatment unit (TU) determined from the Field Guide to Forest Site Classification in New Brunswick, Harvey-Harcourt site region.
4. Species codes:

BF: Balsam fir	TA: Trembling aspen
BS: Black spruce	WB: White birch
RM: Red maple	WP: White pine
RS: Red spruce	WS: White spruce

APPENDIX 7

HAYWARD BROOK WATERSHED - PRE-HARVEST SPECIES LIST

Abies balsamea
Acer pensylvanicum
Acer rubrum
Acer saccharum
Acer spicatum
Achillea millefolium
Actaea rubra
Alnus rugosa
Amelanchier spp.
Antennaria spp.
Apocynum androsaemifolium
Aralia nudicaulis
Aster acuminatus
Aster ciliolatus
Aster lateriflorus
Aster macrophyllus
Aster umbellatus
Athyrium filix-femina
Betula papyrifera
Botrychium matricariaefolium
Brachyelytrum erectum
Carex Arctata
Carex spp.
Carex umbellata
Chimaphila umbellata
Circaea alpina
Clintonia borealis
Coptis trifolia
Cornus canadensis
Corylus cornuta
Cypripedium acaule
Dalibarda repens
Dennstaedtia punctilobula
Dryopteris cristata
Dryopteris spinulosa
Equisetum sylvaticum
Fagus grandifolia
Fraxinus americana
Fragaria vesca
Galium circaezans
Galium triflorum
Gaultheria hispidula
Gaultheria procumbens
Goodyera tesselata
Poaceae
Gymnocarpium dryopteris
Hamamelis virginiana
Kalmia angustifolia
Lichens
Linnaea borealis
Lonicera canadensis
Luzula acuminata
Lycopodium annotinum
Lycopodium clavatum
Lycopodium complanatum
Lycopodium dendroides
Lycopodium lucidulum
Maianthemum canadense
Medeola virginiana
Melampyrum lineare
Mitella nuda
Mitchella repens
Moneses uniflora
Monotropa hypopithys
Orthilia secunda
Oryzopsis asperifolia
Osmunda cinnamomea
Osmunda claytoniana
Osmunda spp.
Oxalis montana
Picea glauca
Picea mariana
Picea rubens
Pinus strobus
Populus grandidentata
Populus tremuloides
Prenanthes spp.
Prunus virginiana
Prunella vulgaris
Pteridium aquilinum
Pyrola americana
Pyrola chlorantha
Pyrola elliptica
Ranunculus acris
Ribes americanum
Ribes lacustre
Rubus pubescens
Solidago flexicaulis
Solidago puberula
Sphagnum spp.
Streptopus amplexifolius
Streptopus roseus
Thelypteris noveboracensis
Thelypteris phegopteris
Trientalis borealis
Trillium undulatum
Vaccinium angustifolium
Vaccinium myrtilloides
Vaccinium vitis-idaea
Veronica officinalis
Viburnum cassinoides
Viola spp.