Fundy Model Forest

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Report Title: Hayward Brook Watershed 1995-1996

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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."

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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
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NB Department of Natural Resources
NB Federation of Naturalists
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New Brunswick School District 2
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HAYWARD BROOK WATERSHED STUDY-INTERIM REPORT
DECEMBER 30,1995

G205D

Hayward Brook Watershed Study - Interim Report
December 30, 1995

This year (1995-96) represents the third in the 5-year study of forested buffer strips at Hayward Brook. The Hayward Brook study is one part of the research agenda of the Fundy Model Forest. It is an integrated experimental approach at measuring the responses of terrestrial and aquatic systems to timber harvesting and the retention of stream buffers of different widths and treatments. The study team includes scientists from government and university.

Following 2 years of resource calibration, 1995-96 was the year of treatment, i.e. timber was harvested and buffer strips established. Because of the disturbance, field studies were adjusted accordingly. We continued to monitor water quality and flow, and collect aquatic invertebrates. Fish populations were also studied. Breeding bird populations were not censused. Those surveys will continue during the final 2 years of post-treatment response measurement (1996-97 and 1997-98). In 1995-96, avifaunal studies focused on learning more about the cavity nesting species in the study area. A graduate student at Universite de Moncton completed field studies and will have a thesis completed by spring, 1996. An interim report on those studies is included. As well, a brief study on the feeding preferences of cavity nesters was conducted on several of the Hayward Brook plots by a B.Sc. student from the Universite de Moncton. A preliminary report on that study is also included.

In summary, during 1995-96 the Hayward Brook study progressed as planned. As in the previous 2 years, winter studies (January-March) will be conducted to measure use of the study plots by wintering birds and mammals. As well, winter data from the previous 2 years are now being analysed and aquatic invertebrates being identified. Results of those 2 projects should be available by spring, 1996.

Submitted by:

Gerry Parker
Coordinator
Hayward Brook Study

Cavity-nest research at the Hayward Brook study area - Fundy Model Forest

Summary report (Fall 1995)

November 20, 1995

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Introduction

This is an update report on the progression of cavity-nester study that I have been working on for the past year and a half. It briefly summarizes the work done at the Hayward Brook study area during the 1995 field season and also gives a tentative schedule for the fall of 1995 as well as for the winter of 1996. An appendix containing variables used for analysis as well as some tables and graphs can be found at the end of the document.

Overview of 1995 field season

Cavity searches

Cavity searches for 1995 were begun on 2 May and concluded on 6 July. They were briefly interrupted for two days during the first week by a late snow storm that left 5 to 10 cm of snow on the study area. This snow persisted for almost two weeks and seemed to lessen our search efficiency. Cavity searching was the only field work done during the first three weeks of May: vegetation sampling could not be initiated for lack of deciduous foliage.

Active cavities (n = 34) were located by criss-crossing the breeding bird sample plots and, to a greater extent than in 1994, the forest adjacent to these plots. Fewer nests were found than last year (n = 57) for the following reasons: 1) field personnel numbers were in smaller numbers this year than in 1994 (2 vs. 4), and 2) harvesting operations began in early June, considerably shortening the cavity search period. Breeding chronologies were conducted as in 1994 but could not be completed for some nest sites. Harvesting operations began before some birds could successfully fledge their young. Trees and snags used as cavity-nesting substrate in 1993 and in 1994 were revisited throughout the summer to determine degree of re-use. A total of 9 of these trees and snags were re-used from the preceding nesting seasons.

Global Positioning of nest sites and random sites

Coordinates of some nest sites and random sites (n = 74) were determined with the help of a GPS device in mid-December of 1994. During the 1995 cavity search period, all remaining 1993 and 1994 nest sites and random sites not sampled during the 1994 season (n = 100) were geographically located using the GPS device lent by Neil Burgess of the Canadian Wildlife Service. Coordinates of these sites were determined from 3 May to 6 May 1995. Coordinates of 1995 nest sites and of their respective random sites were defined as they were sampled. All nest site and random site coordinates have been digitized into the Fundy Model Forest GIS at Sussex. GIS analyses are currently underway with help from the ARC/VIEW program.

Habitat sampling

Sampling of habitat surrounding nest trees and random trees was begun on 22 May and concluded on 11 July 1995. Nest-sites used in 1993 and in 1994 as well as random sites that were put in place during the fall of 1994 were all relocated. Vegetation sampling that could not be performed during the 1994 field season due to insufficient time allocation were completed. All 1995 sites were also sampled during the field season. Habitat sampling was conducted as quickly as possible so that it could be completed before prescribed harvesting operations would begin in late May or early June. Luckily, poor soil drainage, frequent rain in May and fluctuating wood market demands pushed back harvesting dates to early July. This enabled us to complete all habitat sampling before most of the harvesting operations began.

Harvesting error on plot 3

While conducting small mammal trapping on July 26, it was noticed that pink flagging tape had been put in place on the southern side of plot 3. Efforts were made that day to contact Chris Celest to obtain information on the presence of this flagging tape. Repeated efforts to contact Mr. Celest failed. Upon arriving at the same location the next day, a feller-buncher could be heard harvesting on plot 3. It had already entered plot 3 and was approximately 50 m from the stream. It had followed a line almost parallel to plot lines P and Q, cutting out a corridor roughly 40 m wide (Figure 1). We contacted the cutting foreman who eventually came on site to assess the situation. The accidental harvesting on plot 3 stemmed from a mutual misunderstanding between the riparian research group and J.D. Irving Ltd.: they thought our control plot was farther upstream than it actually is. Harvesting along plot 3 was postponed until the situation could be resolved. After receiving the go ahead, field personnel abundantly reflagged the cut block limits on both sides of plot 3 so that the situation would not repeat itself.

Small mammal trapping

Small mammal trapping began on 12 July and was concluded on 14 August 1995. Unlike the past two years, traps were only laid on some of the ten breeding bird survey plots. Plots 3, 4, 6, 9 and 10 were used for trapping while the remaining plots were not sampled. Plots 1 and 2 were not sampled because of cutting operations underway during the sample period. Plot 5 was not sampled because the buffer strip manipulation (harvesting outside the 30 m buffer zone) was already finished by the time small mammal trapping had begun. Plots 7 and 8 were not sampled due to their being dropped from part of the Buffer Strip management scheme.

Fall work

All field data gathered from habitat sampling have been entered into database form and are ready for analysis. A copy of the data set, consisting of six files (three files for cavity sites and three files for random sites), was handed over to Jacques Allard on 2 October 1995 for preliminary analyses. However, due to a very busy schedule, Mr. Allard has yet to make suggestions on how to best analyze the data. I would greatly appreciate suggestions on how to go about analyzing the important quantities of data that I now have and that are still coming in from the GIS analysis.

All nest and random site coordinates have been entered into the GIS database with the help of Walter Emrich of the Sussex planning office. These coordinates will be used to study the spatial relationships of nest and random sites to certain landscape features such as streams, logging roads and forest stands. These relationships are presently being measured with the help of ARC/VIEW. Results are slowly coming in, for I am just getting initiated to using this program. Data and results from this analysis should be complete by mid-December.

Preliminary results of this research project were presented during the ASFWB meeting held at Liscombe Lodge in Liscomb, Nova Scotia on 17 October. Other participants at the meeting seemed generally interested in the project and in what we were attempting to do with it. I am also glad to state that my presentation won first prize for the best overall student presentation. On 2 November, I received an interesting document from Julie Towers of the Nova Scotia Department of Natural Resources. She had seen my presentation but had not had a chance to speak with me at the meeting. She sent me a draft copy of a woodpecker nest tree study that was realized right here in the Maritime provinces. This project, entitled "Cavity nest tree characteristics for six maritime woodpecker species", was prepared for the St. Mary's River-Forestry-Wildlife Project Steering Committee. It deals with various characteristics of woodpecker nest trees found within the Maritime provinces. Some data was collected in the field (n = 31) while most of it (n = 731) comes from the Maritimes Nest Records Scheme (MNRS) maintained by the Canadian Wildlife Service. This paper will give me a chance to compare some of my findings with other results emanating from our region.

I have just completed the first draft on the "Study Area and Methods" section of my thesis. The following step will be to start writing the "Introduction" section and continuing work on tables and graphs. I will also be continuing my ARC/VIEW analysis. I am continuing my readings and ordering new articles for my bibliography. New articles concerning cavity-nester habitat use are quite rare. Most of the articles that I have been ordering lately concern forest habitat and forest resource management. I am also working as laboratory demonstrator for two undergraduate courses this semester. The work load demanded by these two demonstrations is between 5 and 8 hours a week, which offers me more than enough time to work on my thesis. After Christmas, I will only be applying for one laboratory demonstration (BI-3264, Biologie des vertébrés). This will give me more time to work on my data analysis and on my thesis composition. I am also working on a french slide show of my study that I want to present to the Shediac naturalist club. This presentation will only be given after Christmas.

Some preliminary results

A total of 121 active cavities from 7 cavity-nester species were found over the three field seasons (Table 1). The Yellow-bellied Sapsucker was the most common species with a total of 67 nests. Of all tree species used as cavity trees, Trembling Aspen was by far the favoured species, accounting for 79.3% of all nesting cavities found from 1993 to 1995 (Figure 2). Yellow-bellied sapsuckers have been shown to nest frequently in Trembling Aspen in the northeastern United States (Runde and Capen 1987, Kilham 1971). Since much of the study area contains rather large trees (25 to 45 cm dbh) of this species, it is possible that is offers suitable habitat for this species of woodpecker. Further analyses of the data should enable to determine if this is the case. The importance of Trembling Aspen as nesting substrate is very apparent. Other trees were used as cavity excavating substrate, but no trends are presently visible due to lack of analysis.

I have drawn up three tables comparing results of tree dbh (Table 2), cavity tree height (Table 3) as well as cavity height (Table 4) from research done East from Arizona to Vermont. These three tables were drawn to give an idea how results from the Hayward Brook study area compare to those of other studies.

Conclusion

There is much analysis to be done before other discussions may be undertaken. Analyses of data will be continued this fall and winter as will be thesis work. I am looking forward to being able to begin the main analyses and to get this project rolling full steam. I would also appreciate more frequent meetings (formal and informal) with steering committee members during the following months. The guidance and encouragement would be greatly appreciated. Enclosed is a tentative schedule for the work to be done over the next few months.

Tentative work schedule (order of events reflects priority)

November 1995

- Begin primary analyses from recommendations given by J. Allard
- Continue GIS analysis with ARC/VIEW

December 1995

- Continue primary analyses from recommendations given by J. Allard
- Finish GIS analysis with ARC/VIEW
- Begin writing of "Introduction" section of thesis
- Rewrite "Study Area and Methods" following recommendations of steering committee members

January

- Continue primary analyses from recommendations given by J. Allard and analysis of GIS data
- Finish writing "Introduction" section of thesis and submit copies to steering committee members as first draft
- Graphical representations of results as graphs and tables

Table 1- Number of nests for each of the seven cavity-nester species found to be nesting in the Hayward Brook study area from 1993 to 1995.

Species	1993	1994	1995	Total
Black-capped Chickadee *Parus articapillus*	0	2	2	4
Downy Woodpecker *Picoides pubescens*	0	6	0	6
Hairy Woodpecker *Picoides villosus*	4	5	3	12
Northern Flicker *Colaptes auratus*	0	4	2	6
Pileated Woodpecker *Dryocopus pileatus*	0	3	1	4
Red-breasted Nuthatch *Sitta canadensis*	6	9	7	22
Yellow-bellied Sapsucker *Sphyrapicus varius*	20	28	19	67
Total	30	57	34	121

Table 2- Comparison of mean diameter at breast height (dbh in cm) of nest trees for the seven cavity-nesting bird species studied at the Hayward Brook study area from 1993 to 1995.

Species	Mean	SE	Range	n	Source
Black-capped Chickadee	16.8	1.55	14.0 - 21.0	4	Doucette (199?)
	15.8	1.2	?	44	Runde and Capen (1987)
Downy woodpecker	45.0	5.95	31.0 - 65.0	6	Doucette (199?)
	27.6	?	15.0 - 43.0	7	Towers et al. (1992)
	35.7	2.51	?	3	Li and Martin (1991)
	40.9	4.5	?	29	Gutzwiller and Anderson (1987)
	30.7	5.3	?	7	Runde and Capen (1987)
	31.8	?	15.0 - 66.0	15	Conner et al. (1975)
	26.2	?	21.1 - 30.2	11	Lawrrence (1967)
Hairy Woodpecker	32.6	2.96	22.0 - 57.0	12	Doucette (199?)
	32.8	?	12.0 - 91.4	26	Towers et al. (1992)
	37.1	11.14	?	8	Li and Martin (1991)
	27.1	1.3	?	21	Runde and Capen (1987)
	40.6	?	20.3 - 63.5	10	Conner at al. (1975)
	28.2	?	25.4 - 34.8	11	Lawrence (1967)
Northern Flicker	36.8	5.25	26.0 - 60.0	6	Doucette (199?)
	33.0	?	15.2 - 77.0	29	Towers et al. (1992)
	44.9	8.45	?	37	Li and Martin (1991)
	46.3	4.1	?	28	Gutzwiller and Anderson (1987)
	36.8	?	30.0 - 46.0	6	Conner et al. (1975)
	27.4	?	21.6 - 33.5	25	Lawrence (1967)
Pileated Woodpecker	40.2	2.98	36.0 - 49.0	4	Doucette (199?)
	44.5	?	25.4 - 61.0	10	Towers et al. (1992)
	54.6	?	33.0 - 91.0	14	Conner et al. (1975)

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Table 2- (continued)

Species	Mean	SE	Range	n	Source
Red-breasted Nuthatch	21.4	0.99	16.0 - 31.0	22	Doucette (199?)
	48.4	21.78	?	14	Li and Martin (1991)
Yellow-bellied Sapsucker	35.9	1.07	23.0 - 61.0	67	Doucette (199?)
	31.3	?	16.5 - 76.2	41	Towers et al. (1992)
	33.6	2.4	?	38	Runde and capen (1987)
	29.7	?	21.6 - 42.7	42	Lawrence (1967)

Table 3- Comparison of mean tree height (m) of nest trees for the seven cavity-nesting bird species studied at the Hayward Brook study area from 1993 to 1995.

Species	Mean	SE	Range	n	Source
Black-capped Chickadee	3.35	0.98	1.6 - 6.0	4	Doucette (199?)
	3.8	0.7	?	44	Runde and Capen (1987)
	2.2	2.1	?	25	Stauffer and Best (1982)
Downy Woodpecker	16.83	1.51	13.5 - 22.0	6	Doucette (199?)
	6.76	?	1.7 - 18.5	8	Towers et al. (1992)
	19.7	2.4	?	7	Runde and Capen (1987)
	10.2	5.6	?	30	Stauffer and Best (1982)
	8.3	?	1.5 - 19.8	15	Conner et al. (1975)
	9.0	?	3.7 - 13.8	11	Lawrence (1967)
Hairy Woodpecker	19.29	1.13	12.0 - 27.0	12	Doucette (199?)
	9.31	?	2.2 - 17.5	15	Towers et al. (1992)
	17.5	1.2	?	21	Runde and Capen (1987)
	12.9	?	3.9 - 26.4	10	Conner et al. (1975)
	10.7	?	4.6 - 13.8	11	Lawrence (1967)
Northern Flicker	11.83	1.78	6.0 - 17.0	6	Doucette (199?)
	7.04	?	0.6 - 18.0	35	Towers et al. (1992)
	12.4	?	9.1 - 15.8	6	Conner et al. (1975)
	8.1	3.2	?	31	Stauffer and Best (1982)
	7.0	?	2.5 - 13.8	25	Lawrence (1967)
Pileated Woodpecker	22.38	3.14	13.0 - 26.0	4	Doucette (199?)
	11.10	?	9.2 - 13.8	4	Towers et al. (1992)
	20.3	?	10.7 - 36.6	14	Conner et al. (1975)
Red-breasted Nuthatch	9.60	0.52	5.5 - 15.5	22	Doucette (199?)
Yellow-bellied Sapsucker	21.52	0.51	10.5 - 29.0	67	Doucette (199?)
	12.30	?	5.5 - 18.5	21	Towers et al. (1992)
	19.4	0.8	?	38	Runde and Capen (1987)
	9.0	?	3.1 - 13.8	42	Lawrence (1967)

Table 4- Comparison of mean nesting-cavity height (m) for the seven cavity-nesting bird species studied at the Hayward Brook study area from 1993 to 1995.

Species	Mean	SE	Range	n	Source
Black-capped Chickadee	3.12	0.95	1.4 - 2.4	4	Doucette (199?)
	2.5	0.3	?	44	Runde and Capen (1987)
	2.2	2.1	?	25	Stauffer and Best (1987)
Downy Woodpecker	11.00	2.43	3.0 - 18.5	6	Doucette (199?)
	5.30	?	1.2 - 15.4	43	Towers et al. (1992)
	13.55	4.77	?	3	Li and Martin (1991)
	6.9	0.7	?	29	Gutzwiller and Anderson (1987)
	9.3	1.2	?	7	Runde and Capen (1987)
	6.1	3.1	?	30	Stauffer and Best (1987)
	4.7	?	1.0 - 11.6	15	Conner et al. (1975)
Hairy Woodpecker	10.49	0.60	7.5 - 15.5	12	Doucette (199?)
	6.51	?	1.5 - 15.4	101	Towers et al. (1992)
	15.2	6.44	?	8	Li and Martin (1991)
	8.3	0.8	?	21	Runde and Capen (1987)
	8.8	?	2.4 - 19.8	10	Conner et al. (1975)
Northern Flicker	7.92	1.27	5.5 - 13.5	6	Doucette (199?)
	4.25	?	0.5 - 15.4	170	Towers et al. (1992)
	16.3	5.03	?	37	Li and Martin (1991)
	7.3	0.6	?	28	Gutzwiller and Anderson (1987)
	8.1	3.2	?	31	Stauffer and Best (1982)
	8.5	?	6.1 - 11.9	6	Conner et al. (1975)
Pileated Woodpecker	9.72	1.60	8.0 - 14.5	4	Doucette (199?)
	7.38	?	3.1 - 18.5	22	Towers et al. (1992)
	13.6	?	9.1 - 19.2	14	Conner et al. (1975)
Red-breasted Nuthatch	8.03	0.47	5.0 - 12.0	22	Doucette (199?)
	12.2	4.35	?	14	Li and Martin (1991)

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Table 4- (continued)

Species	Mean	SE	Range	n	Source
Yellow-bellied Sapsucker	9.69	0.34	3.2 - 16.0	67	Doucette (199?)
	7.30	?	1.8 - 16.9	81	Towers et al. (1992)
	8.6	0.5	?	38	Runde and Capen (1987)

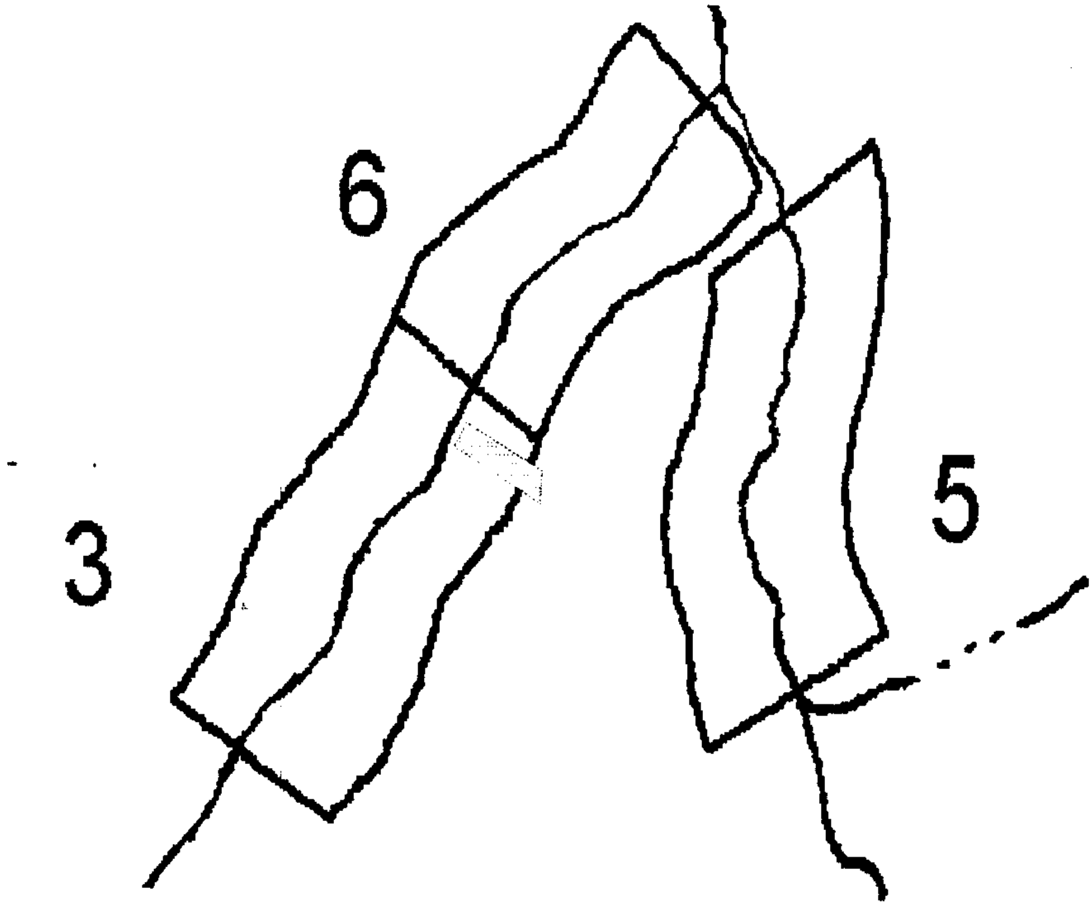

Figure 1- Map of breeding bird census plots 3, 5 and 6. The shaded area indicates approximately the location of the encroachment onto plot 3. This plot is a control that should have not undergone any harvesting interventions. The area of forest removed is approximately 40 m wide by 100 m long (0.4 ha) or 2% of plot 3.

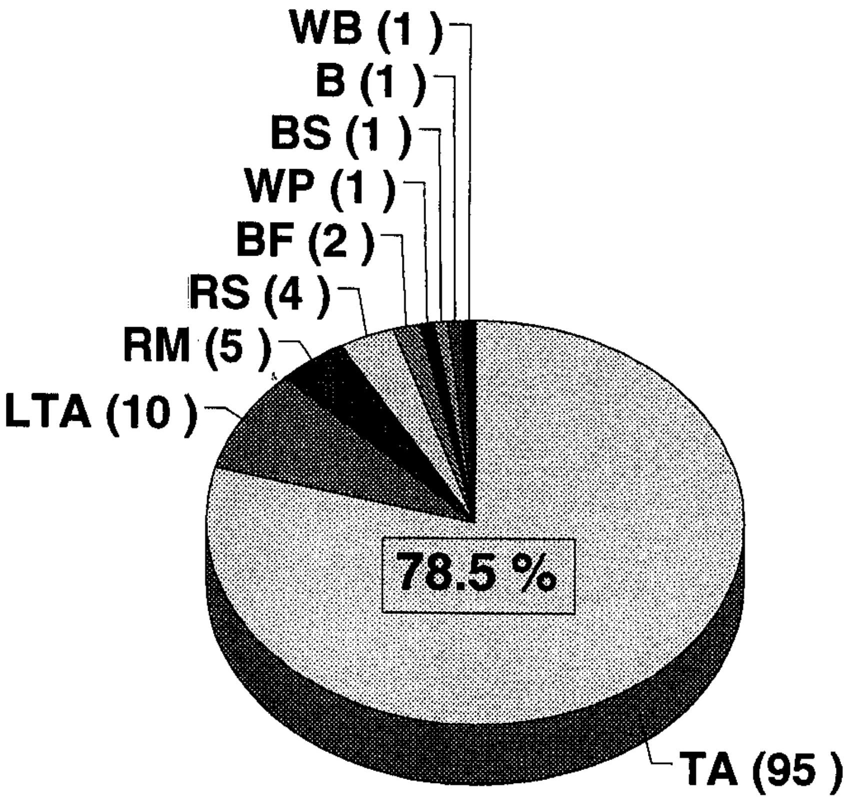

Figure 2- Tree species used as nest trees by cavity-nesting birds found at the Hayward Brook study area.

1995 PROGRESS REPORT FOR THE WATER RESOURCE COMPONENT OF THE HAYWARD BROOK WATERSHED STUDY

Joseph Pomeroy , Environment Canada, Environmental Conservation Branch
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Since July 1993 Environment Canada in Moncton and Fredericton have been participating in Fundy Model Forest by conducting research on the water resource in the Hayward Brook Waterdshed Study (HBWS). The focus of the water component is to determine how forest practices may affect the export of forest nutrients, the soil weathering rates, the mobilization of heavy metals, and the rate of discharge in surrounding watersheds. The results from this research will be integrated with results from 6 other HBWS researchers for input to a best management plan.

The water resource project is lead by the Environmental Conservation Branch in Moncton, but with substantial support from the Atmospheric Environmental Branch in Fredericton, New Brunswick. The project started in July 1993 and at this time consisted of surface water grab samples at 8 selected research plots. As the project progressed a decision was made by the members of the HBWS to relocate 2 plots. The new plots were located in Holmes Brook, which runs adjacent to Hayward Brook. In March of 1994 four automated wat watershed. In April 1995 another automatic monitoring station was located on Holmes Brook as the result of the redirection of the forest road construction.

The monitoring stations collect water quality data hourly and water quantity data every 30 minutes. This accounts for 8600 hourly readings for five water quality variables in 1995 and twice that amount for 3 quantity readings. In addition to the automatic data, surface water grab samples are being collected and analyzed for water chemistry and suspended solids at Environment Canada's Environmental Quality Laboratory in Moncton. Originally the schedule for the collection of grab samples was monthly or bimonthly and more often depending on weather conditions. Since June 1995 surface water grab samples have been collected weekly. The change in frequency is necessary in order to quantify changes as a result of harvesting. To date 264 surface water samples have been collected. The automatic stream stage or height data collected at the monitoring stations are also supported by manually collected velocity measurements. The measurements are used to establish a height-discharge relationship and finally produce a discharge curve.

Over the past year the stations have generally worked quite well. During the winter and spring of 1995 a problem with batteries going dead continued, and this required more trips to the site than expected. This problem appears to have been solved by allowing more sun shine to directly hit the solar panel. The direct sun maintains a higher current in the charging system which is required to maintain the voltage. Over the last four months the stations have operated without significant errors.

To date the discharge curves for 1994 have been completed and the curves for 1995 are expected by March- April 1996. The discharge data require a full year of data before curves can be corrected and approved. The water quality samples continue to be analyzed at the laboratory and the data from the automatic stations are currently being approved using CompuMod Pilot System II software.

Results

The water data from this project will be interpreted in segments. Presently the pre-harvest data which considers data up to June 15, 1995 is in a first draft. Preliminary conclusions from this report will be summarized in the following sections. The streams being monitored in this project are located in 1 of the 8 research plots located in the HBWS. The water sample sites are identified by these same numbers.

Results from the surface grab samples indicate that the sample sites 1,2,3 and 10 have similar physical variable concentrations, but these are different from sites 4,5,6,and 9.

The former group are headwater sites and the conductivity range for these is between 20-70 usie/cm. The latter group which are near the tributaries outlets have a conductivity range which runs between 20 to 160usie/cm. The higher concentrations occur in the summer when ground water in the dominate source of water. The range of pH among the sites also indicates a similar grouping of stations. pH ranges between 6.7 and 7.2 for the headwater sites and between 6.8 and 7.8 for the other sites. Site 4 could be considered an outlier in the pH grouping because it displays low pH reading during the drier months. Site 4 is interesting because the upper reaches go dry in the summer and cause the alkalinity to drop and as a consequence pH drops. This relationship suggest that the upper reaches contain the source of alkalinity.

The major ion analysis indicate that the main ions found at all sites are calcium and sulphate. These ions are also the quickest to respond to discharge. Sodium and chloride concentrations are half those found for the above ions. Magnesium and potassium are present in low concentrations at all sites. At sites 5 and 6 the main ions are sulphate and calcium. At sites 4 and 9 the main ions are sodium and calcium. The different ions suggest that the streams are influenced by different deposits in the area. The abundance of geological calcium is of interest because calcium is the one nutrient which is present at higher concentrations in the tree trunk than in the crown. Even though the trunks are removed from the site the calcium requirement for new growth is not depleted.

The nutrients phosphorus and nitrate-nitrogen were generally low at all sites. Occasionally a peak would occur, but these were always associated with high turbidity. Phosphorus was usually below 0.01 mg/L and nitrate-nitrogen was below 0.02 mg/L. The low concentrations are expected in a natural stream as these nutrients are in high demand by vegetation. Higher concentrations were detected in the fall than in the summer and this is a result of uptake in the summer during maximum vegetation growth and higher release of nutrients in the fall during vegetation decay and high amounts of rain.

The most common metals at all sites were iron, aluminum and manganese. These metals are geological in origin and their concentrations are a result of the stream bed type. Site 6 had the highest peak concentrations of all sites as a result of its sand-loan stream bed and the short lag-time for rain events which results in a quick runoff. Sites1,4,9, and 10 are similar to site 6 although the maximum concentrations of peaks in the metals are lower. Site 4 which is similar in size and stream bed type to 6 has higher concentrations throughout the year which suggest a groundwater source. Sites 5,2, and 3 have similar stream beds which are rocky-pebbles and contain vegetation. Site 5 is numerous times larger than the other sites but the concentrations of metals at these sites are below 0.05 mg/L except for peaks. The heavy metal zinc was only found above the 0.01 mg/L detection limit at site 6. Zinc concentrations jumped from 0.01 mg/L to 0.03 mg/L in June 1995 after a galvanized culvert was used in a haul road to cross the stream. This increase was expected, for galvanized metal is known for leaching.

Another observation made in November of 1995 was the high amount of turbidity at site 6. Although the new culvert above site 6 was likely contributing sediment to the stream further observations found the major source was from a old road which is located between sites 3 the stream during heavy rains.

Over the next year the water component will continue to collect data on surface water and incorporate variable loadings into the database. A report on the preharvest data will be completed and interpretation of the harvest data will be ongoing with a report completed by the end of next year.

In addition to water data Abbey Ouellet, Gerry Parker and I have been collecting benthic invertebrate samples from sites in each of the research plots. For two years 9 sites in each of the 8 plots were sampled bimonthly. During the past season streams 4 and 3 were collected. During the winter of 1995 a contract let by Gerry Parker will have the 400 + samples taxonomicaly identified and populations determined.

FORAGING ACTIVITIES OF SELECTED WOODPECKER SPECIES AT HAYWARD BROOK STUDY AREA, NB

Preliminary report

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Produced in fulfilment of
Statement of Requirement KR203-5-0028
Canadian Wildlife Service
Sackville, NB

November 1995

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Introduction

The main objective of the research project described in this preliminary report was to determine the foraging substrat preferred by five woodpecker species living in southeastern New Brunswick: the Pileated, Hairy, Downy and Black-backed Woodpeckers, as well as the Yellow-bellied Sapsucker. The study was conducted in a mixed, mature forest where woodpecker density was high.

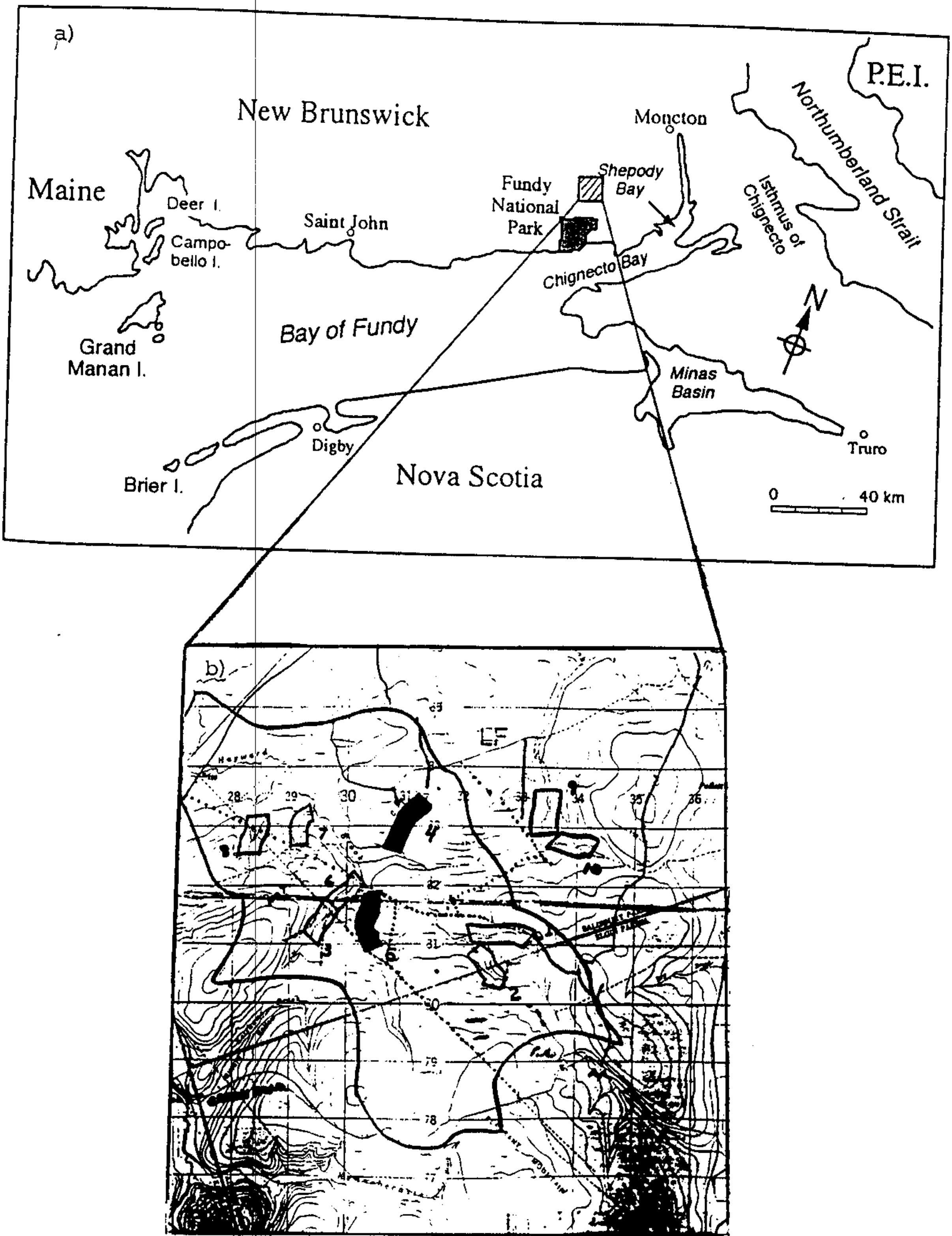
Woodpeckers are very important forest engineers. They play a big part in the construction of shelters for many mammals and birds (Jones et al., 1994). They also help control populations of wood-boring insects in the forest (MacLellan, 1959). For these reasons, it is important to analyse and understand the different conditions that make an habitat suitable or not for the woodpeckers, and to see how we can optimize those conditions. Since the availability of food is a major factor for the establishment of a woodpecker territory, it is essential to know the requirements of woodpeckers at this level, to apply them in future management plans of our forests.

This study is complementary to the one conducted by Denis Doucette (M. Sc. student, Université de Moncton) on the characteristics of nesting habitat used by the same woodpeckers as in my study.

Study area and Methods

Data were collected in southeastern New Brunswick, within the Fundy Model Forest (45°50'N, 65°10'W), Canada (Fig 1a). From 21 May 1995 to 25 July 1995, two forest plots totalling approximately 20 ha were surveyed (Fig 1b). These plots were selected because they showed signs of intense woodpecker activity (D.Doucette, pers. comm.). The vegetation is caracterized by mature forest, dominated by red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), along with white birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*) and red maple (*Acer rubrum*). There is also a large number of spruce and balsam fir snags, as a result of a severe defoliation by spruce budworm (*Choristoneura fumiferana*) in 1979.

A direct and indirect approach were considered for data collection. The direct approach consisted of following the woodpeckers to record data on their foraging substrates, whether they were seen leaving the nest, tapping, gleaning or feeding. For all the woodpecker species considered, the sample obtained from that method (15 birds) was insufficient for the purpose of this research, so I used an indirect approach. This approach consisted in making a complete inventory of all trees showing signs of utilization for feeding purposes by any of the woodpecker species observed in the study plots. These species were the Pileated (*Dryocopus pileatus*), Hairy (*Picoides villosus)* and Downy Woodpeckers (*Dendrocopos pubescens*), Yellow-bellied Sapsucker (*Sphyrapicus varius*) and the Black-backed Woodpecker (*Picoides arcticus*). The advantages of this approach is that it provides a larger sample per unit of time spent in the field and that feeding is automatically confirmed. Its main disadvantage is that we cannot confirm which individual fed on a certain tree, and therefore this approach does not permit us to



Southeastern New Brunswick as shown in figure 1 a), where plot 4 and 5 of figure 1 b) were surveyed.

analyze the relationship between the position of a woodpecker's nest and the feeding locations of the pair.

To collect data on trees used by woodpeckers, I walked along flagged transects in each study plot and searched for signs of woodpecker activity on the snags and living trees located within a 25 m strip on either side of a transect. These transects were 300 m long, flagged every 12.5 m. They were perpendicular to a permanent stream and extended 150 m on either side of it, with a 50 m distance between them. The position of the feeding trees found was recorded on a map of the area. For each tree, I recorded the tree species, its diameter at breast height (dbh), condition and height. I also recorded the degree of use, age of woodpecker signs, the woodpecker species that fed on it and the section of tree that was most heavily used.

The feeding cavities or other signs were related to a woodpecker species based on their shape and/or their diameter. Holes that were relatively big and/or square-shaped were attributed to Pileated woodpecker, and those that were smaller and/or round were attributed to Hairy woodpecker or Downy woodpecker. Small cavities arranged in rows were attributed to Yellow-bellied Sapsucker. Finally, peeled bark on conifers was attributed to Black-backed woodpecker.

The age of woodpecker signs was categorized as : 1) recent (wood still fresh, light color), 2) intermediate (wood beginning to take a greyish color), 3) old (wood dark grey to black), 4) recent and intermediate (combination of 1 and 2), 5) recent and old (combination of 1 and 3), 6) intermediate and old (combination of 2 and 3) and 7) recent, intermediate and old (combination of 1, 2 and 3) (Doucette, pers. comm.).

The degree of use showed on the tree was categorized as: 1) minimal (< 20% of the surface used), 2) intermediate (20 - 40%), 3) heavy use (40 - 60%) and 4) very heavy (≥ 60%) (D. Doucette, pers. comm.).

I estimated tree height visually. My relative error was calculated by comparing visual estimates to clinometer measurements for 100 test trees (Appendix 1). Tree condition was classified as: 1) alive, 2) partially dead, 3) dead, 4) loose bark, 5) clean, 6) broken (relatively close to the bottom of the tree) and 7) decomposed (Hunter, 1990). In intermediate cases, I recorded the most advanced stage of decomposition .

Finally, the section of tree most heavily utilized was classified as: 1) top, 2) middle, 3) bottom, or a combination of two or more of them.

Preliminary Results

The preliminary results presented in this report are frequency tables, to give an overview of the tendencies and preferences of each woodpecker species studied, for each characteristics data collected on foraged trees. In a further final report, more statistical tests will be done on those data, to have more details on these tendencies and preferences.

There were points of confusion where, on some trees, I didn't know if they were foraged by a Pileated Woodpecker (1) , Hairy and Downy Woodpeckers (4) or Yellow-bellied Sapsuckers (2). In a further report it will be determined if there are signicant similarities between those uncertainties and one of the three groups (1, 2 or 4) to categorize them, or if I won't be able to include them in my data base.

The availability versus utilization by woodpeckers of different snags species will also be analysed in details further on.

Characteristics of trees used by Pileated Woodpeckers

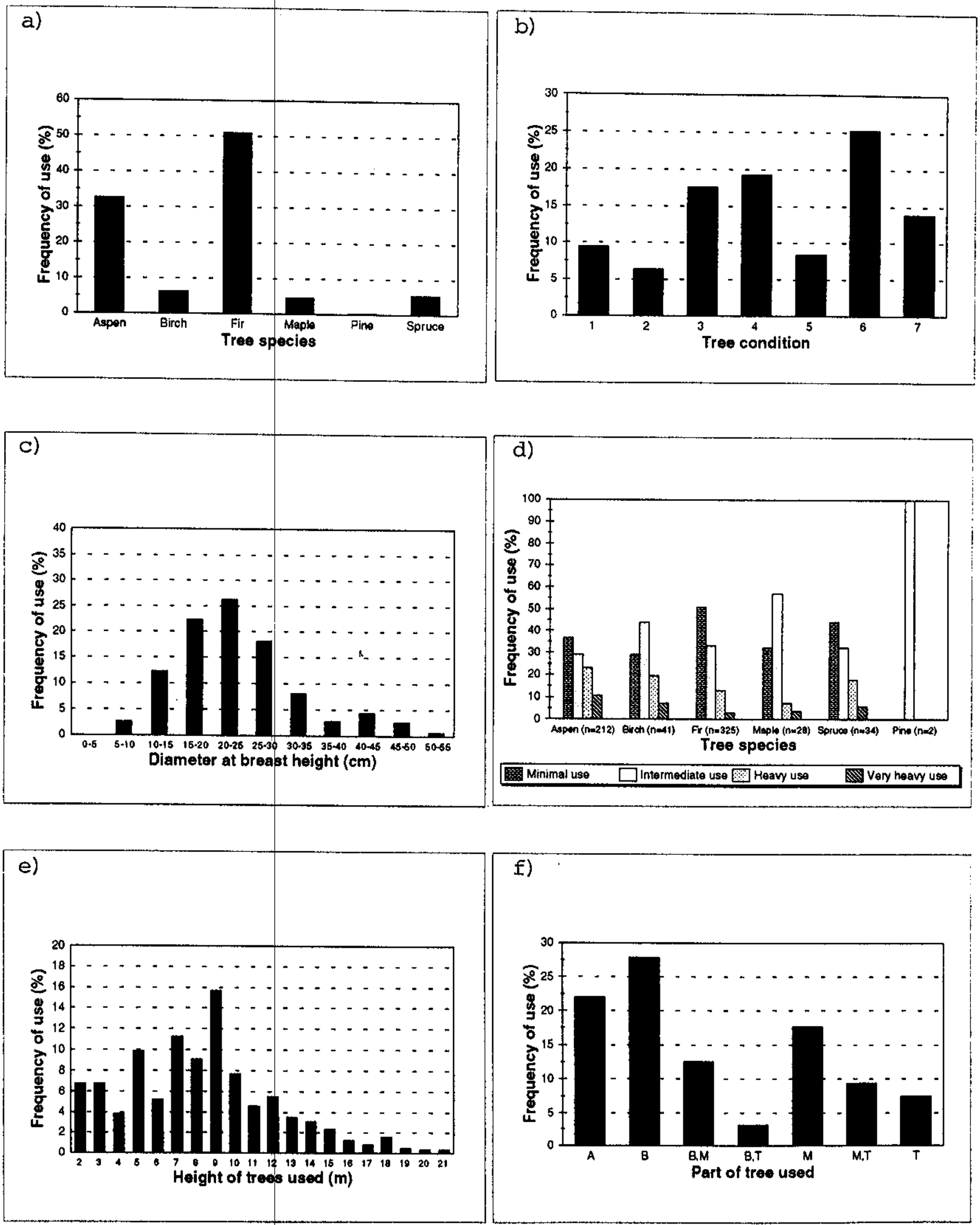


Figure 1 shows for plot #4 a) the tree species most used; b) the condition of trees used, where 1=alive, 2=partially dead, 3=dead, 4=loose bark, 5=clean, 6=broken and 7=decomposed; c) the DBH in centimeters; d) the degree of use for each tree species used; e) the height of the trees used in meters, and finally f) the part of tree most used, where A=all parts of tree, B=bottom, M=middle, T=top with combinations between some of them.

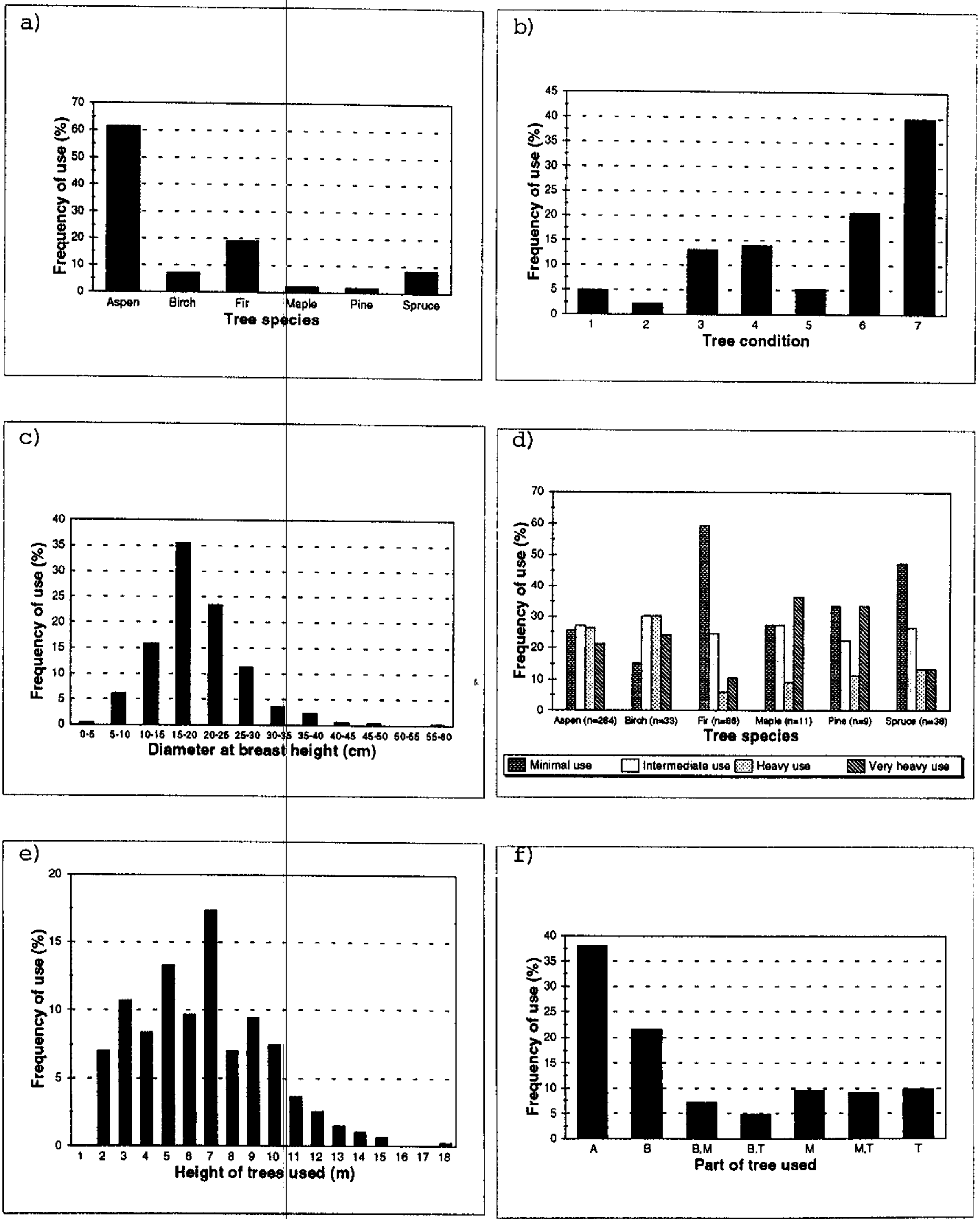
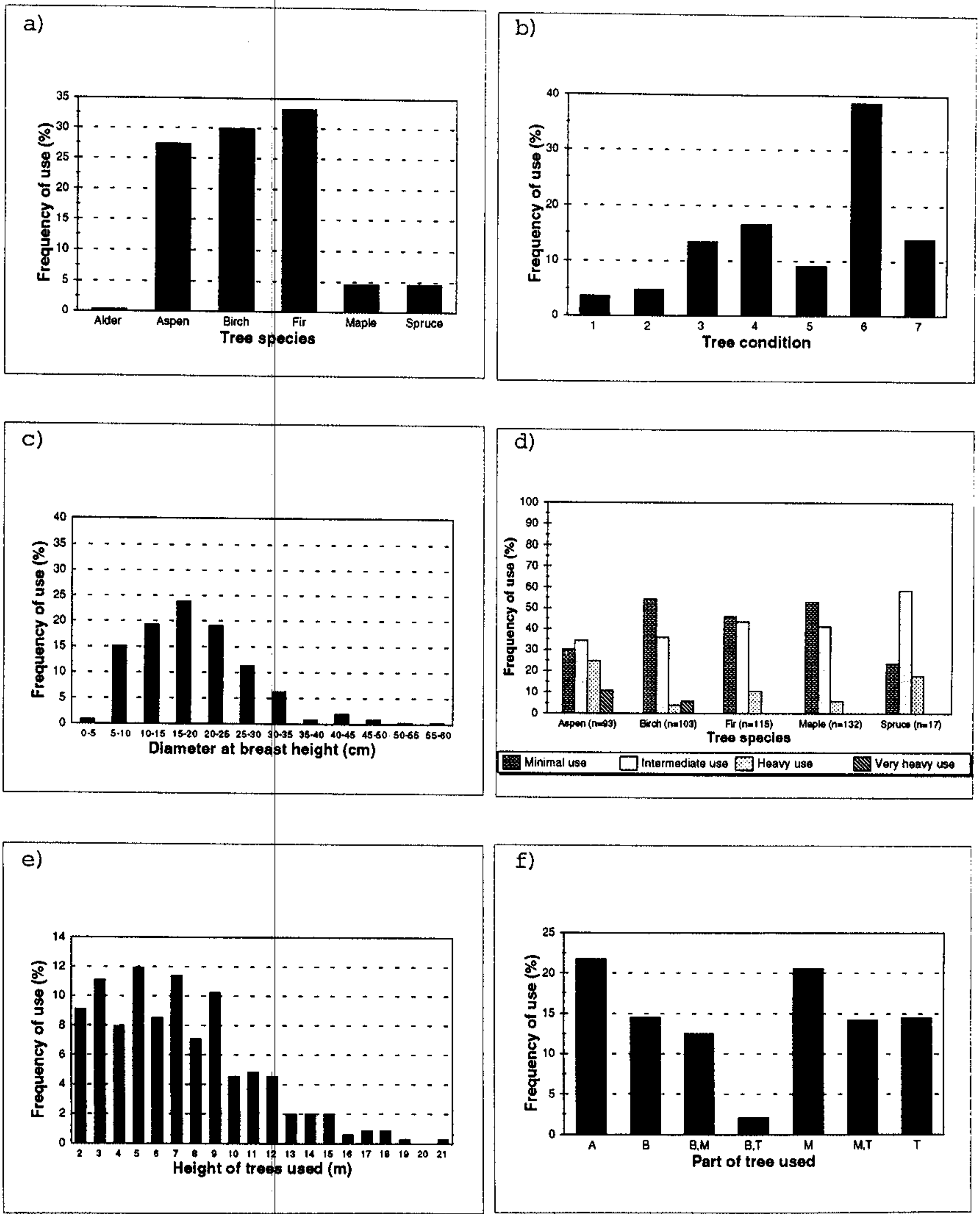


Figure 2 shows for plot #4 a) the tree species most used; b) the condition of trees used, where 1=alive, 2=partially dead, 3=dead, 4=loose bark, 5=clean, 6=broken and 7=decomposed; c) the DBH in centimeters; d) the degree of use for each tree species used; e) the height of the trees used in meters, and finally f) the part of tree most used, where A=all parts of tree, B=bottom, M=middle, T=top with combinations between some of them.

Characteristics of trees used by Hairy and Downy Woodpeckers



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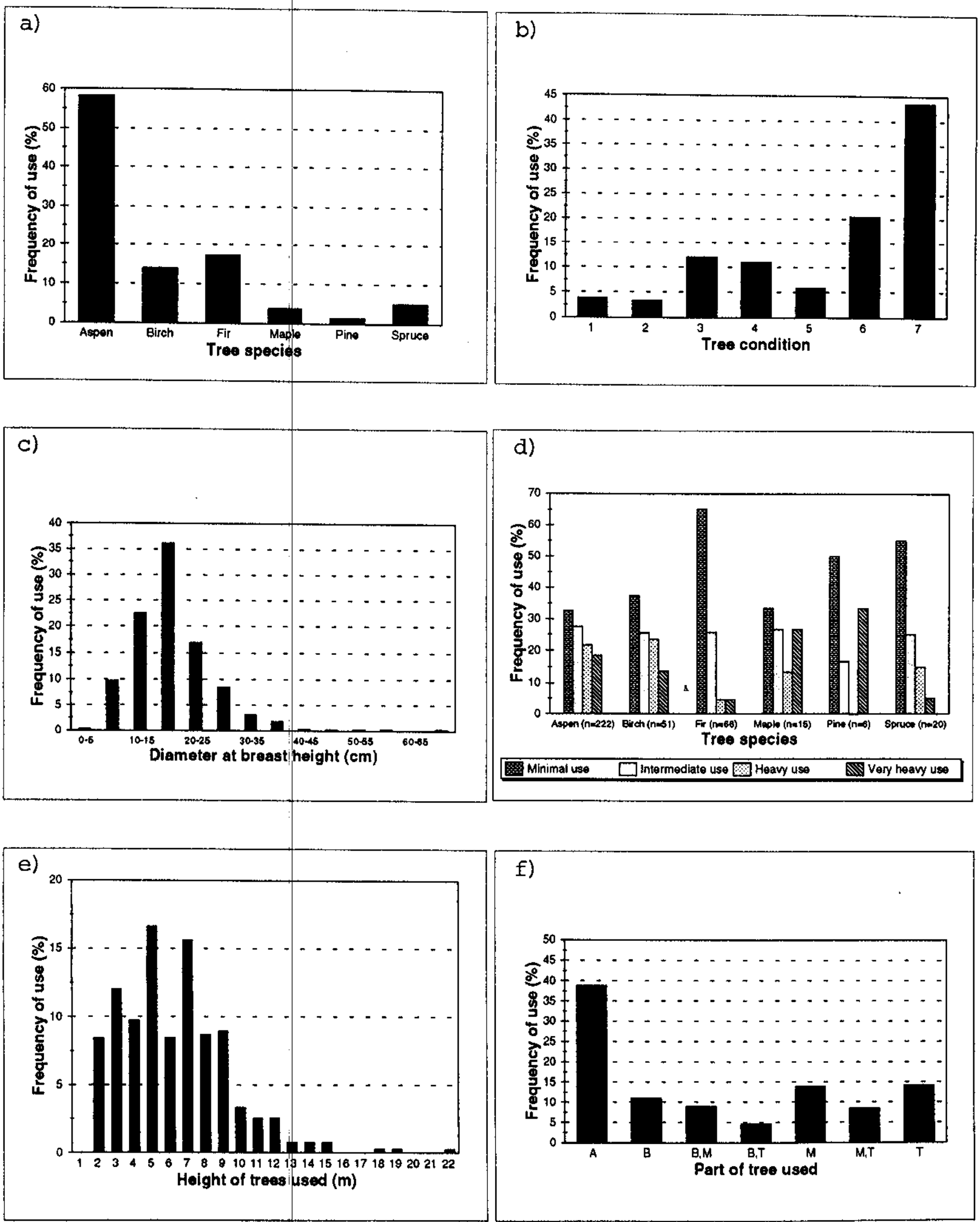

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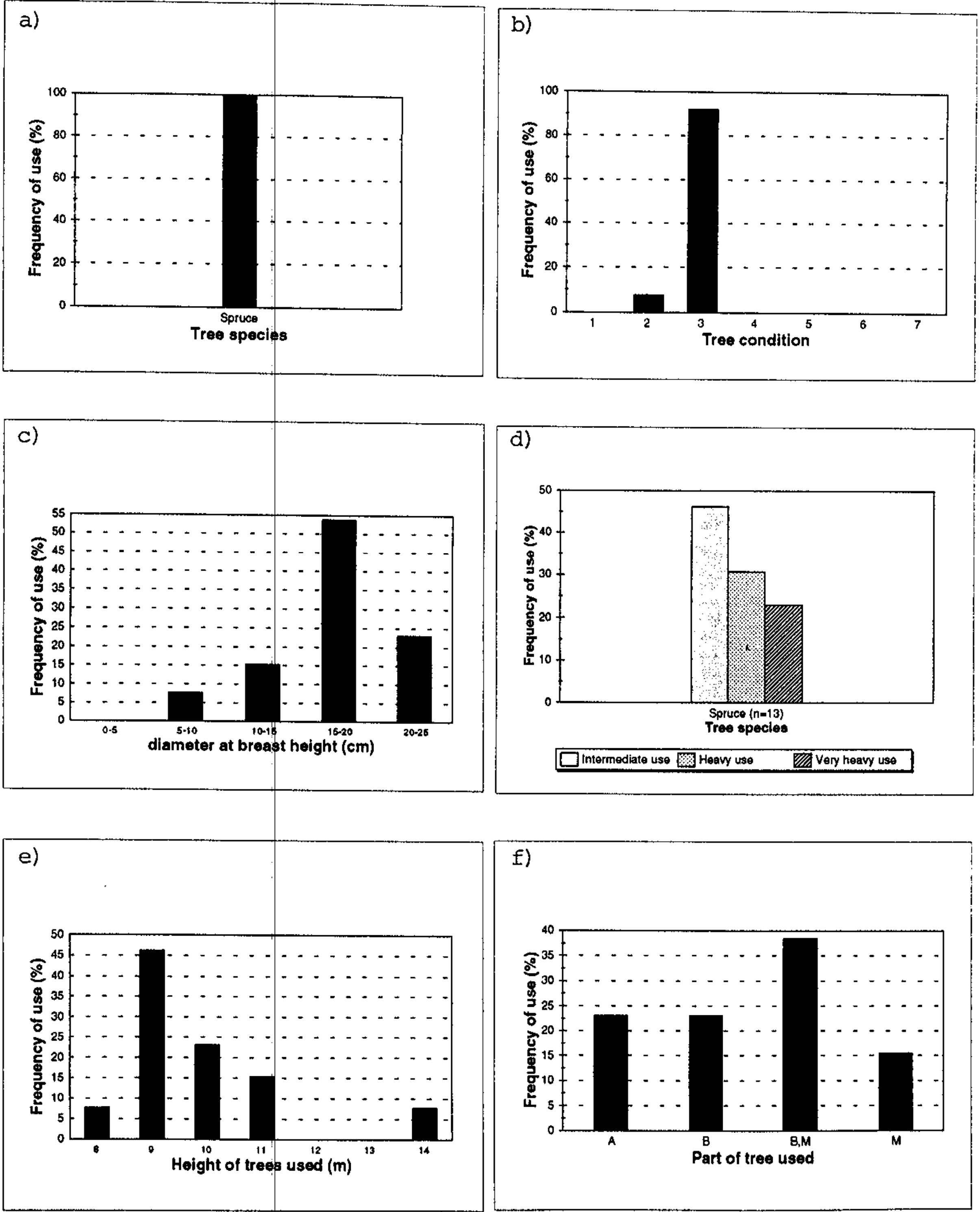
Characteristics of trees used by Black-backed Woodpeckers



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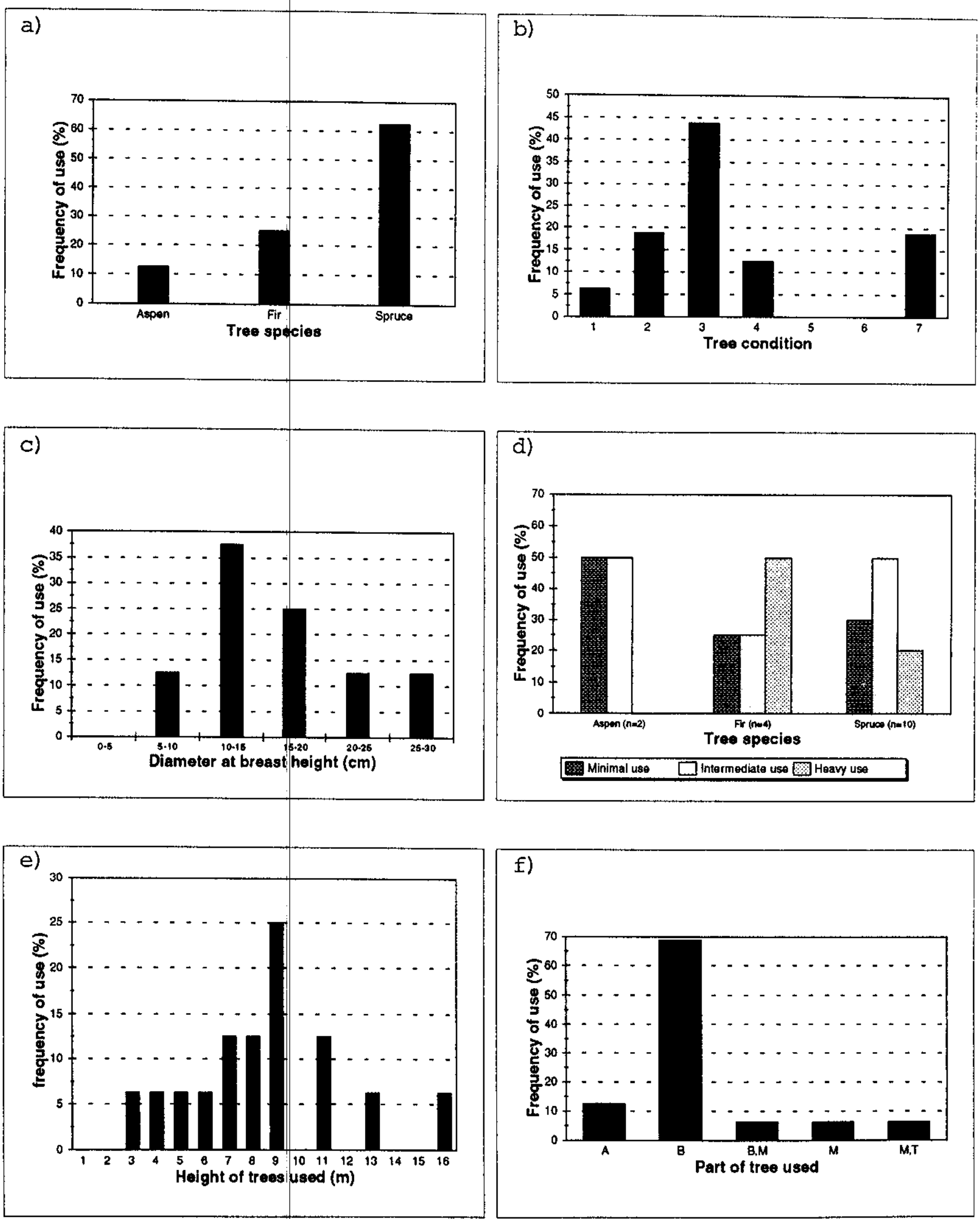


Figure 2 shows for plot #4 a) the tree species most used; b) the condition of trees used, where 1=alive, 2=partially dead, 3=dead, 4=loose bark, 5=clean, 6=broken and 7=decomposed; c) the DBH in centimeters; d) the degree of use for each tree species used; e) the height of the trees used in meters, and finally f) the part of tree most used, where A=all parts of tree, B=bottom, M=middle, T=top with combinations between some of them.

Characteristics of trees used by Yellow-bellied Sapsuckers

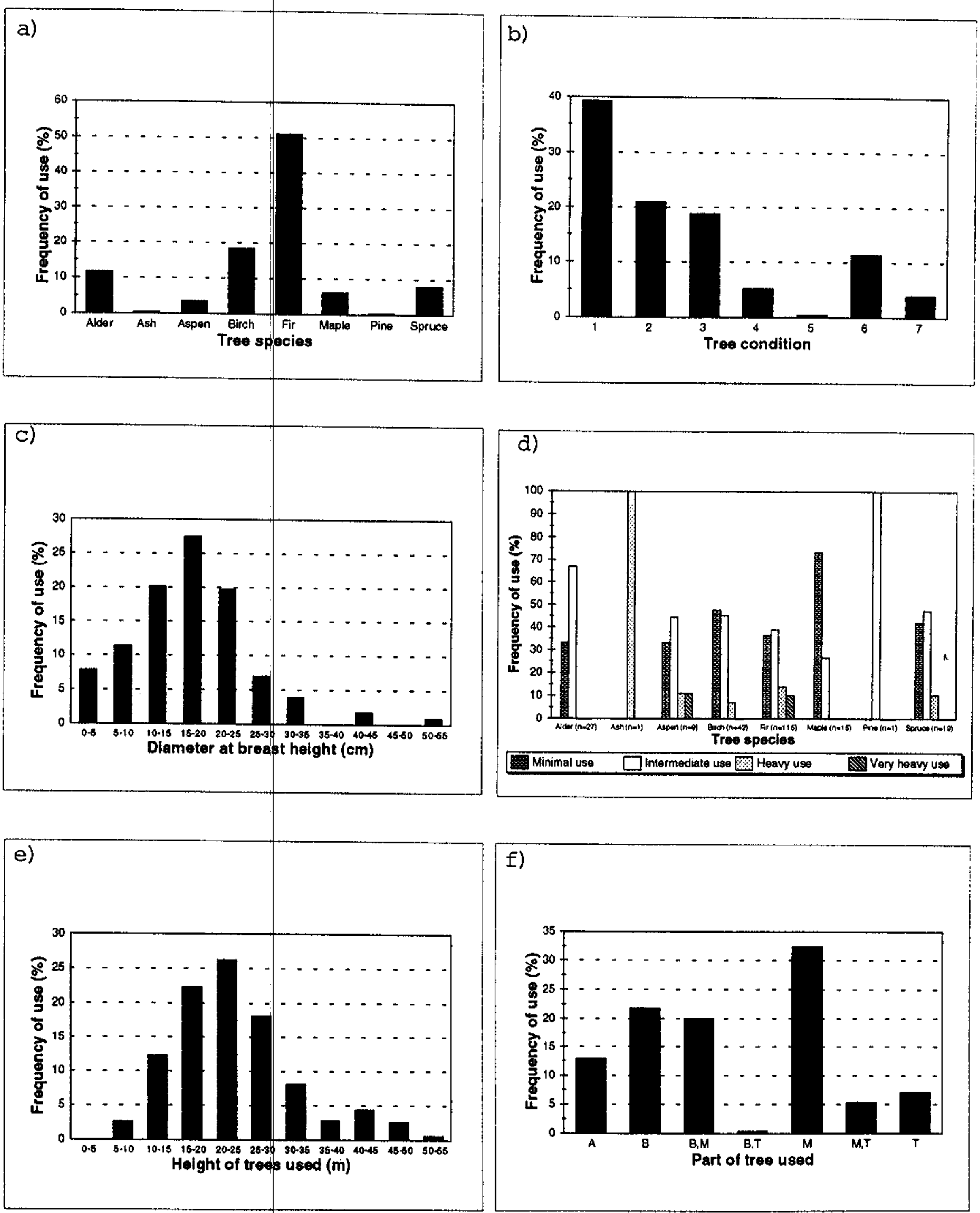
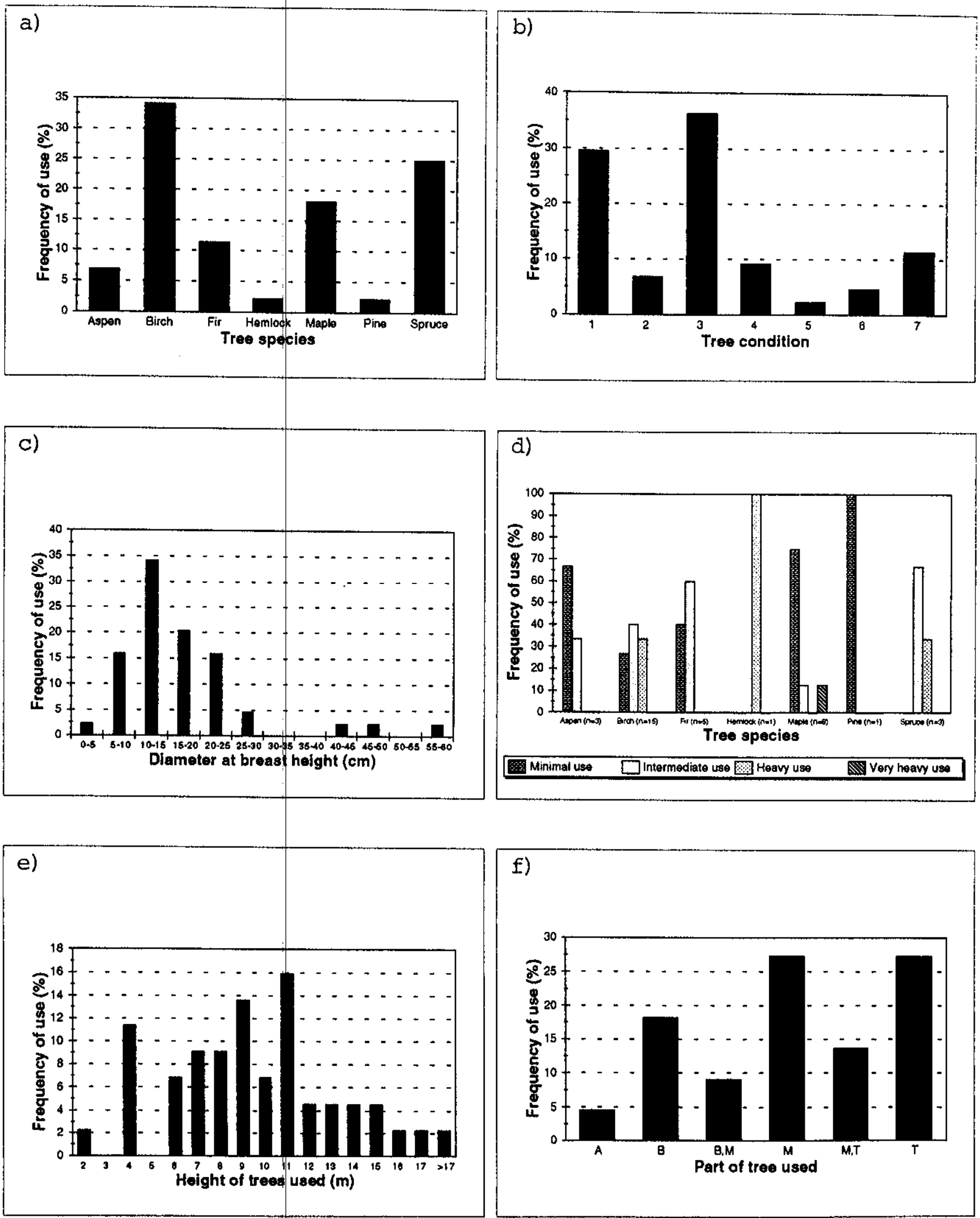


Figure 1 shows for plot #4 a) the tree species most used; b) the condition of trees used, where 1=alive, 2=partially dead, 3=dead, 4=loose bark, 5=clean, 6=broken and 7=decomposed; c) the DBH in centimeters; d) the degree of use for each tree species used; e) the height of the trees used in meters, and finally f) the part of tree most used, where A=all parts of tree, B=bottom, M=middle, T=top with combinations between some of them.



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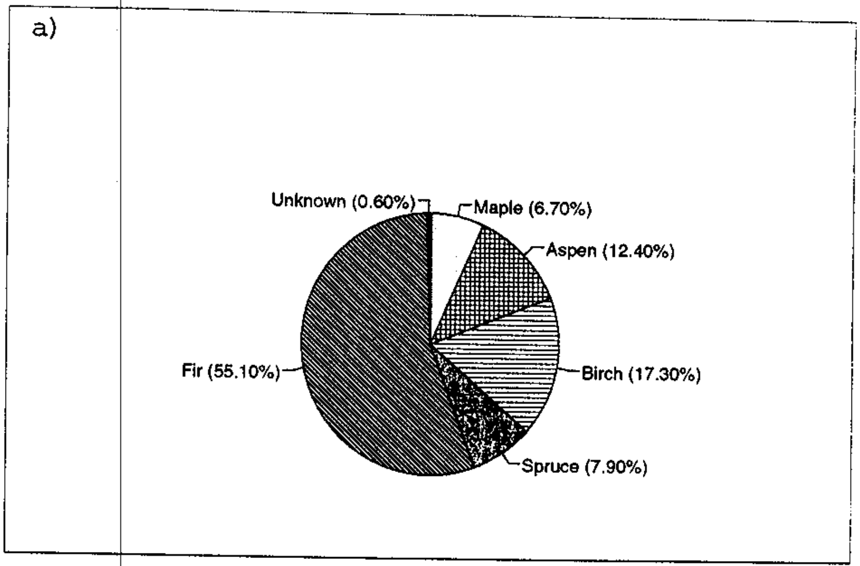


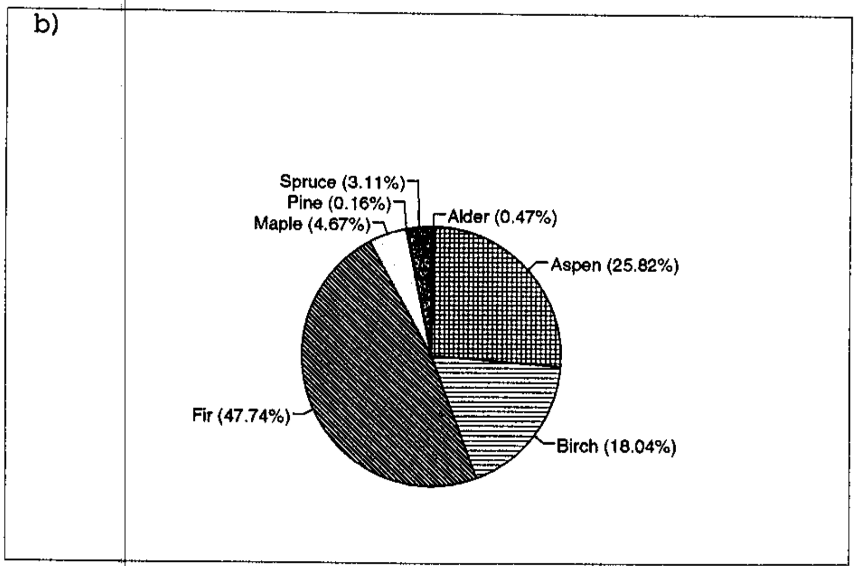


Figure 3 a) shows the availability of different snags species on plot #4 and figure 3 b) shows the different snags species used by woodpeckers on plot #4.

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.

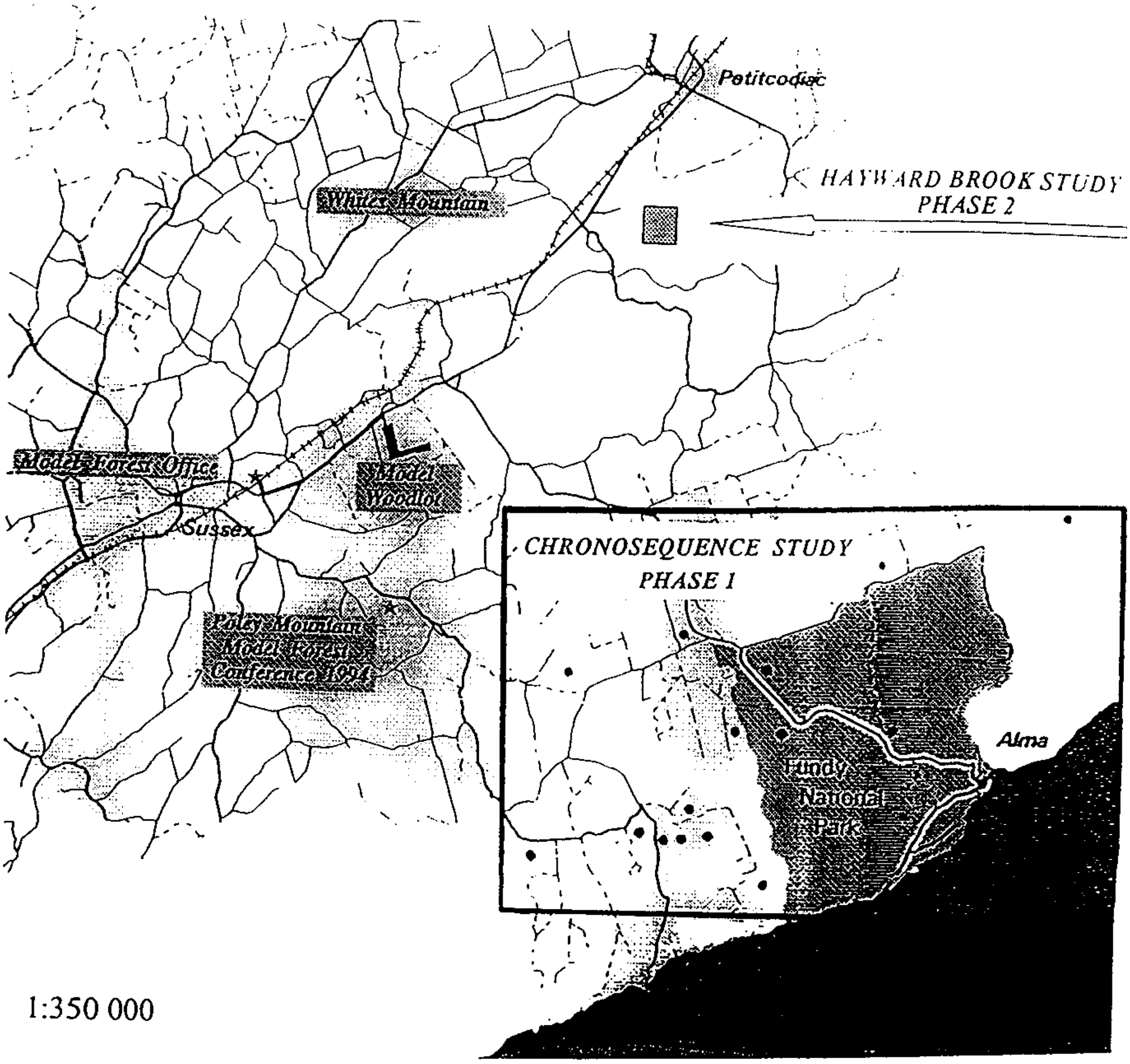
3. Comparisons of species diversity and structural diversity after human disturbances with spruce budworm disturbance.

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



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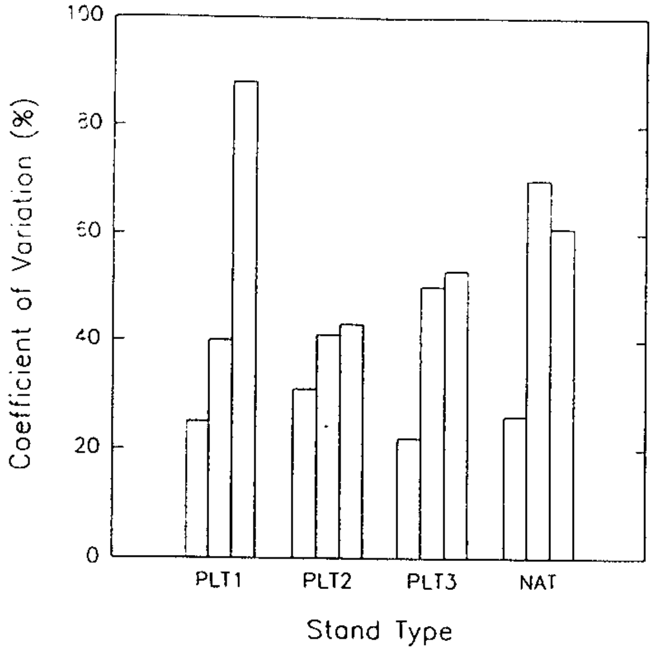
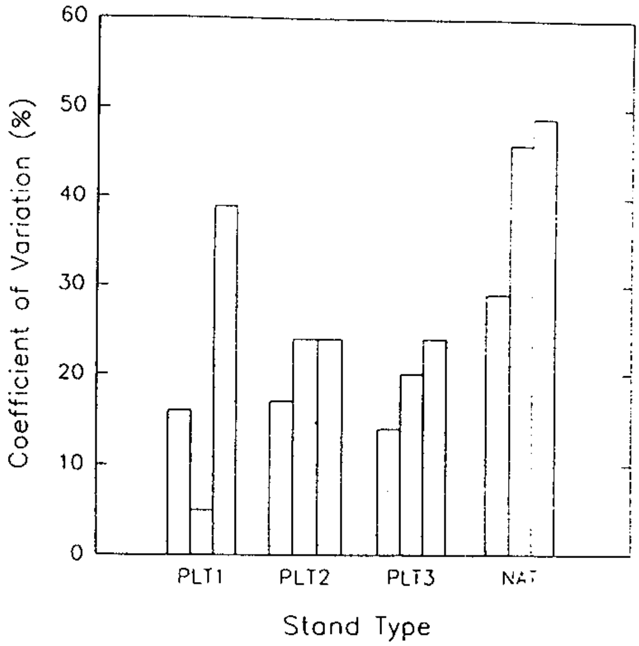
APPENDIX 2



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

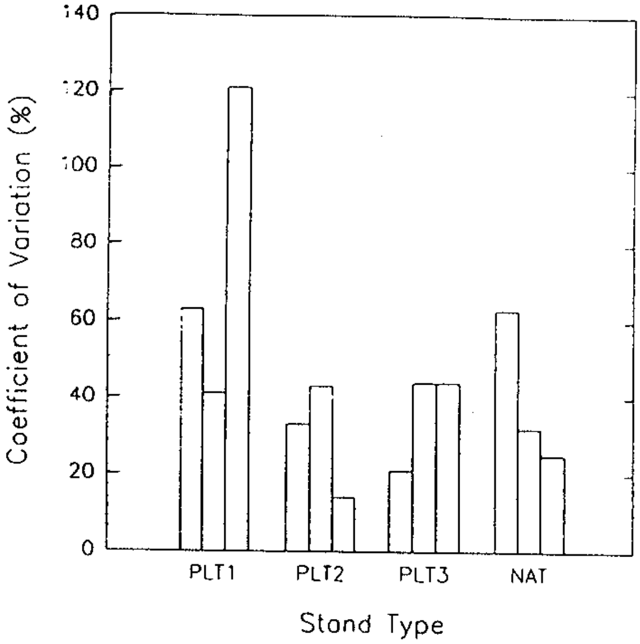


COEFFICIENT OF VARIATION FOR DBH IN INDIVIDUAL STANDS BY STAND TYPE.

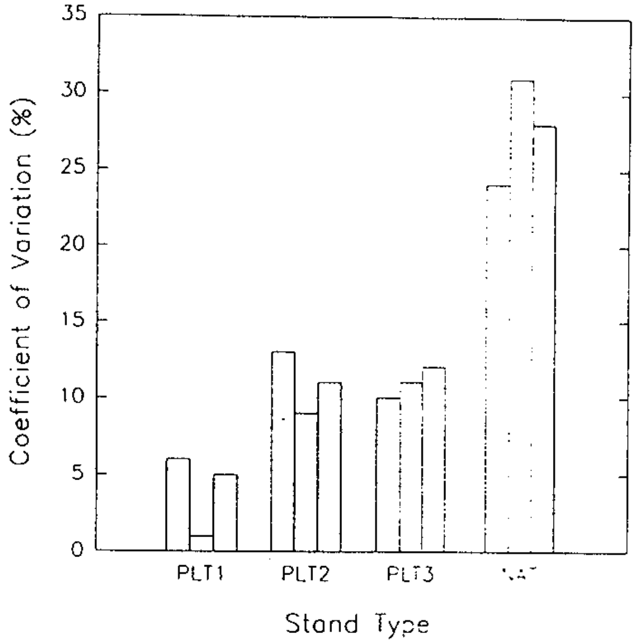
LEGEND

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

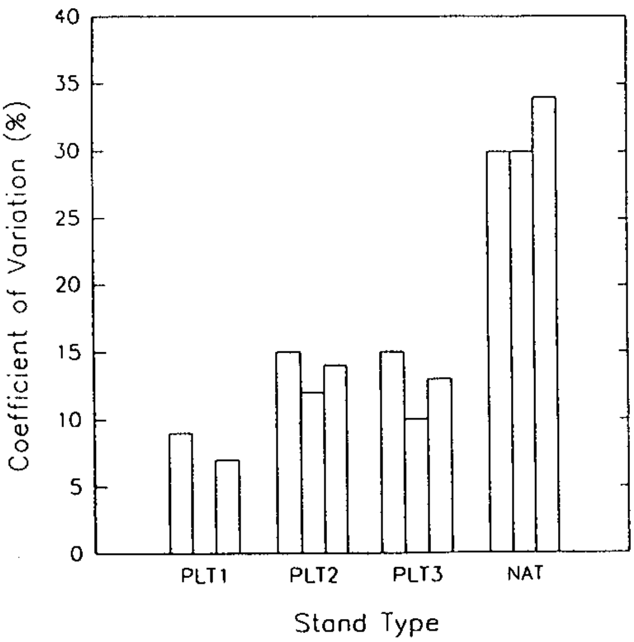
APPENDIX 2 (continued)



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 4

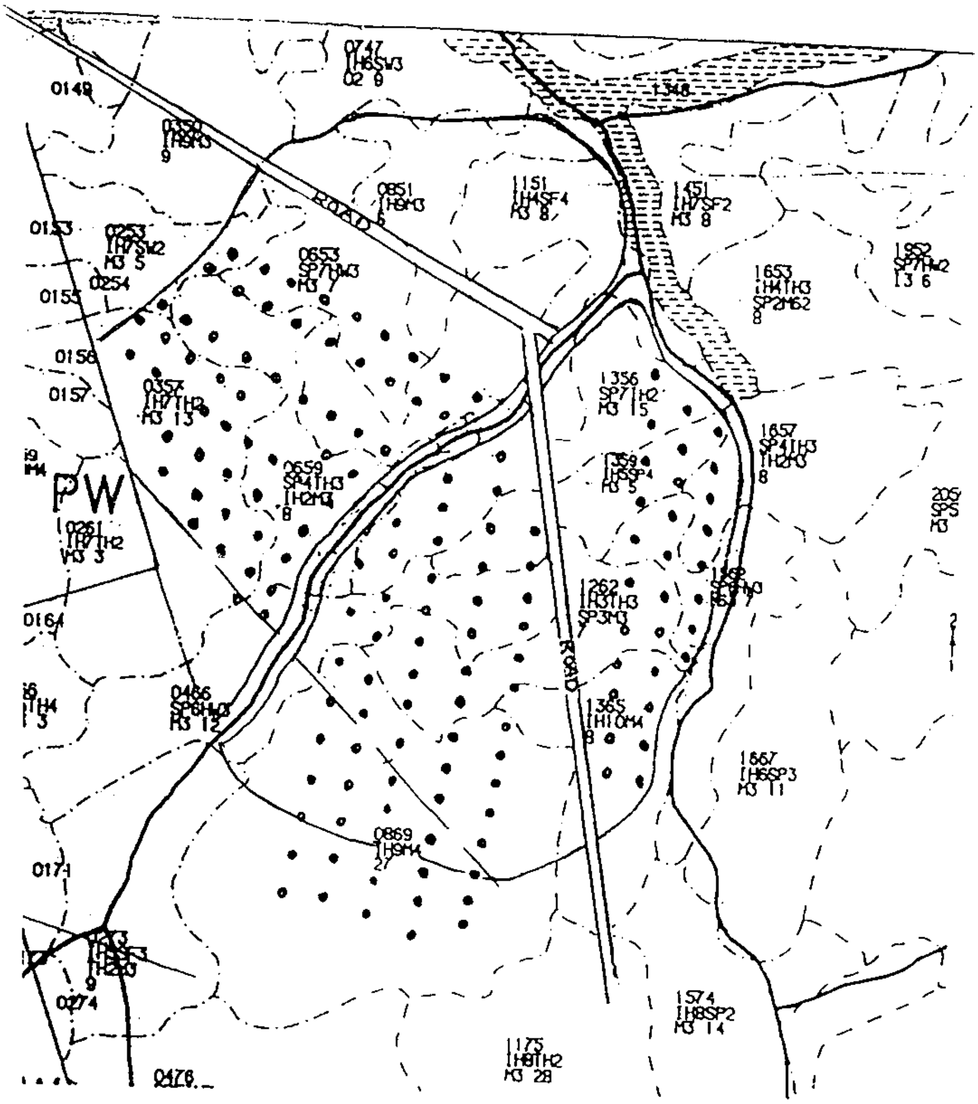
Effect of treatment and time on stand composition (below one meter) as measured by three diversity indices

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 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 6

HAYWARD BROOK
STAND OVERSTOREY AND UNDERSTOREY COMPOSITION

STAND NO.	Dominant Species [4]	OVERSTOREY [1] Basal area m²/ha	Density #tree/ha	Mean dbh cm	UNDERSTOREY [2] Density # tree/ha	SITE CLASS [3] VT	ST	TU
1356	BS	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
BS: Black spruce
RM: Red maple
RS: Red spruce
TA: Trembling aspen
WB: White birch
WP: White pine
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.